Technical Support Document for Total Maximum Daily Loads for Dissolved Oxygen and pH in Adams Bayou, Cow Bayou, and Associated Tributaries

Segments 0508, 0508C, 0511, 0511A, 0511B, 0511C

Assessment Units 0508_01, 0508_02, 0508_03, 0508_04, 0508C_01, 0511_02, 0511_03, 0511_04, 0511A_02, 0511B_01, 0511C_01

Adams Bayou at FM 3247

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This report represents a major revision of a previous report. That report was co-authored by Dr. Kirk Dean and Ms. Monica Suarez of Parsons Corporation and provided to TCEQ as a draft final on October 29, 2015. The report is titled: *Technical Support Document for the Cow and Adams Bayou Total Maximum Daily Loads*. Much of the material in the present report is taken directly from the earlier report, and the basic construct of the present report is almost entirely based on the earlier report. The modeling system, which is a major theme of both reports, was developed by Parsons Corporation.

The authors are extremely grateful for the previous efforts by Dr. Dean and Ms. Suarez and their patience in answering questions after the modeling system was transferred to TIAER.

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Abbreviations

°C	degrees Celsius
°F	degrees Fahrenheit
ADP	Acoustic Doppler Profiler
ANOSIM	Analysis of Similarity
ASAE	American Society of Agricultural Engineers
AU	assessment unit
BOD	biochemical oxygen demand (general term)
BOD_5	five-day biochemical oxygen demand
cBOD	carbonaceous biochemical oxygen demand (general term)
$cBOD_5$	five-day carbonaceous biochemical oxygen demand
cfs	cubic feet per second
chla	chlorophyll-a
cm^3	cubic centimeters
cms	cubic meters per second
CWA	Clean Water Act
DO	dissolved oxygen
EPA	United States Environmental Protection Agency
FG	future growth
ft	feet
g	gram
hr	hour
HSPF	Hydraulic Simulation Program – Fortran
IH	interstate highway
ILS	impervious land surface
in	inch
K_a	reaeration coefficient
kg	kilogram
K_L	oxygen transfer coefficient
L	liter
lb	pound
m	meter
MAE	mean absolute error
ME	mean error
mg	milligrams
MGD	million gallons per day
mph	miles per hour
MS4	municipal separate storm sewer system

NCDC	National Climatic Data Center
NHD	National Hydraulic Dataset
NH_3N	ammonia nitrogen
NLCD	National Land Cover Dataset
NOAA	National Oceanic and Atmospheric Administration
NO_3N	nitrate nitrogen
NPDES	National Pollutant Discharge Elimination System
NPS	non-point source
NRCS	Natural Resource Conservation Service
NSE	Nash-Sutcliffe model efficiency
OrgC	organic carbon
OrgN	organic nitrogen
OrgP	organic phosphorus
OSSF	on-site sewerage facility
PLS	pervious land surface
PO_4P	orthophosphate phosphorus
POTW	publicly owned treatment works
PS	point source
ppt	parts per thousand
QAPP	quality assurance project plan
r^2	coefficient of determination
RMSE	root mean square error
s	second (of time)
SH	state highway
SOD	sediment oxygen demand
SWQMIS	Surface Water Quality Monitoring Information System
TAC	Texas Adminstrative Code
TCEQ	Texas Commission on Environmental Quality
TIAER	Texas Institute for Applied Environmental Research
TMDL	Total Maximum Daily Load
TOC	total organic carbon
TP	total phosphorus
TPDES	Texas Pollutant Discharge Elimination System
TSS	total suspended solids
UBOD	ultimate carbonaceous biochemical oxygen demand
USDA	United States Department of Agriculture
USGS	United States Geological Survey
WASP	Water Quality Analysis Simulation Program
WWTF	wastewater treatment facility

Technical Support Document for Total Maximum Daily Loads for Dissolved Oxygen and pH in Adams Bayou, Cow Bayou, and Associated Tributaries

1. Background and Introduction

1.1 Regulatory Background

Water quality standards serve the dual purposes of establishing the water quality goals for a specific water body and providing the regulatory basis for the establishment of water-quality-based treatment controls and strategies (40 CFR 131.10). Water quality standards are established to support designated uses and are comprised of water quality criteria. The federal Clean Water Act (CWA) requires that states designate, for each water body, desirable and appropriate uses to be achieved and protected. These designated beneficial uses of water bodies include recreation in and on the water, public water supply, navigation, agricultural and industrial water supply, and protection and propagation of fish, shellfish and wildlife. States must then set water quality criteria to support the standards necessary to protect those designated uses. Criteria are expressed as constituent concentrations, levels, or narrative statements representing a quality of water that supports a particular use. When criteria are met, water quality will generally protect the designated use (40 CFR 131.3).

Water bodies, such as rivers, lakes, and estuaries, are divided by the State of Texas into Segments. Classified Segments are those defined in Appendix A of Texas Surface Water Quality Standards (30 Texas Adminstrative Code [TAC] §307.1-307.7), which also defines their designated uses and water quality criteria. They are assigned an identification number. For example, the classified segment named "Cow Bayou Tidal" has the identification number "0511". Water bodies not defined in Appendix A of Texas Surface Water Quality Standards are called "unclassified" water bodies. Their reference number refers to the downstream classified segment that they flow into, with an additional letter designation. For example, Cow Bayou Above Tidal is assigned the identification number "0511A".

The federal CWA requires all States to assess water quality and identify water bodies with impaired designated uses that do not meet, or are not expected to meet, applicable water quality standards. The list of impaired water bodies is known as the CWA §303(d) List. Texas assesses compliance with water quality standards using a geographic unit called an Assessment Unit (AU), which is defined as the smallest geographic area of use support reported in the assessment. Often there are several AUs within a large Segment. The naming convention for AUs includes the Segment number with an appended AU sequence number. For example, classified segment 0511 is divided into four AUs, 0511_01 to 0511_04, numbered sequentially from downstream to upstream. Water quality within an AU may be assessed using data from a single representative monitoring station, or combined from several stations.

States must develop a total maximum daily load (TMDL) for each pollutant that contributes to the impairment of a designated use of a listed water body. A TMDL is an allocation of allowable point and nonpoint source pollutant loadings that will enable the water body to meet water quality standards when implemented. The Texas Commission on Environmental Quality (TCEQ) is responsible for ensuring that TMDLs are developed for impaired surface waters in Texas.

1.2 Water Body Descriptions and Assessments

Adams Bayou and Cow Bayou are sluggish streams that flow into the Sabine River (U.S. Geological Survey [USGS] Hydrologic Unit Code 12010005) just upstream of Sabine Lake in Orange County, Texas. Adams Bayou extends from its confluence with the Sabine River in a northerly direction across Orange County to near the Newton County Line (Figure 1-1). Adams Bayou previously extended to a greater extent into southern Newton County, but flow from this upper section has been redirected eastward to the Sabine River for flood control purposes. Cow Bayou extends from its confluence with the Sabine River in a northerly direction, roughly parallel to, but west of Adams Bayou, across Orange County to southern Jasper County southeast of Evadale.

The lower portions of both bayous have been channelized, straightened, and dredged for navigation, creating numerous oxbows in the former, more sinuous, channels. Both bayous are under tidal influence below and a short distance above Interstate Highway (IH)-10. The tidal portions of Adams and Cow Bayous extend approximately 8 and 20 miles, respectively, above their confluences with the Sabine River. In Texas Surface Water Quality Standards (30 TAC §§307.1 – 307.10), the term "tidal" is defined as "descriptive of coastal waters that are subject to the ebb and flow of tides. For purposes of standards applicability, tidal waters are considered to be saltwater."

A USGS gauging station measures flow in Cow Bayou Above Tidal at the State Highway (SH) 12 bridge near Mauriceville. The period of record of this guague is from 1952 to 1986, and again from October of 2002 to the present time. For the recent 16-year period of January 2003 through December 2018, the daily average, maximum, and minimum flow at this site were 131.7 cubic feet per second (cfs), 21,700 cfs, and 0 cfs, respectively. The above tidal reaches are considered intermittent with pools.

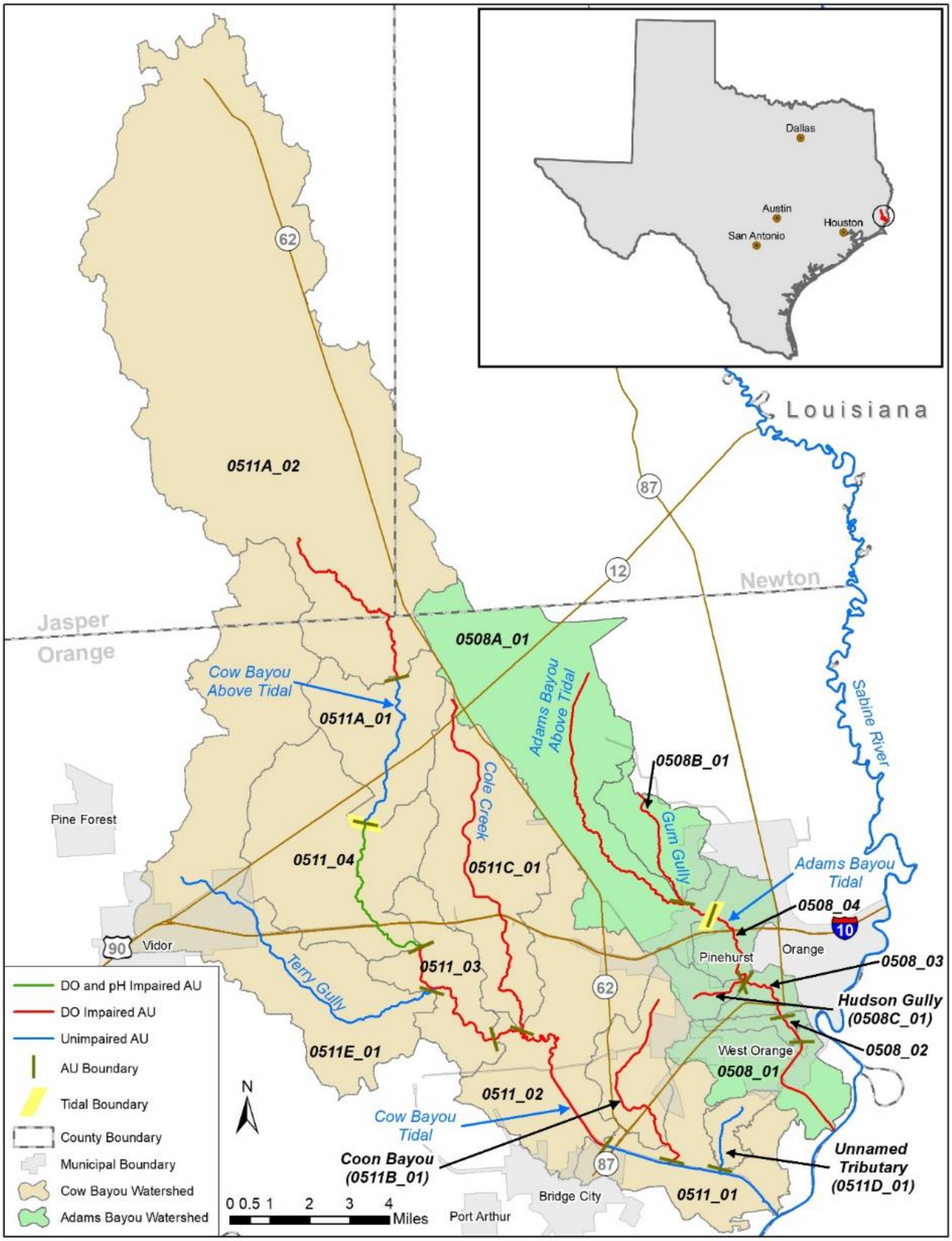

Figure 1-1 Location of Adams and Cow Bayous in southeast Texas showing impaired AU for depressed dissolved oxygen (DO) and pH

There is no flow gauging station on Adams Bayou, but field surveys indicate that under low-flow conditions there is essentially no base flow (TWC, 1986). Under these conditions, water movement occurs due to tidal ebb and flow and wastewater discharges to the bayou. The upper reaches of Adams Bayou and non-tidal tributaries are considered to be intermittent streams with pools.

The Adams Bayou watershed of 46.355 square miles (29,667 acres) is almost entirely within Orange County with a small portion of its upper watershed in Newton County. The Cow Bayou watershed comprises 198.765 square miles (127,210 acres) covering substantial portions of Orange and Jasper Counties, as well as a small corner of Newton County.

Further details of water bodies and watershed properties are described in later chapters related to model development.

Cow Bayou, Adams Bayou, and several of their tributaries have been identified by the State of Texas as not meeting water quality standards for support of aquatic life due to depressed dissolved oxygen (DO) levels. The impaired AUs for depressed DO include:

AU	Description
0508_01	Adams Bayou Tidal (lower 3 miles of segment)
0508_02	Adams Bayou Tidal (2 mile reach near Western Avenue)
0508_03	Adams Bayou Tidal (1 mile reach near Green Avenue)
0508_04	Adams Bayou Tidal (Upper 2 miles of tidal segment)
0508A_01 *	Adams Bayou Above Tidal (entire bayou above tidal; 8.8 miles)
0508B_01 *	Gum Gully (entire creek; 3.4 miles)
0508C_01	Hudson Gully (entire creek; 1.5 miles)
0511_02	Cow Bayou Tidal (6 mile reach near FM 105)
0511_03	Cow Bayou Tidal (5 mile reach near FM 1442 [north crossing])
0511_04	Cow Bayou Tidal (upper 4 miles of tidal segment)
0511A_02	Cow Bayou Above Tidal (upper 5.3 miles of above tidal reach)
0511B_01	Coon Bayou (entire tidal reach; 5.2 miles)
0511C_01	Cole Creek (entire tidal reach; 10.6 miles)

* An aquatic life use attainability analysis is to be conducted for AUs 0508A_01 and 0508B_01. If the finding of this analysis indicates either or both AUs require a TMDL, then the impairment will be addressed by TCEQ through Texas' Water Quality Management Plan update process.

These impaired water bodies include all of the AUs that were assessed in the Adams Bayou system. In the Cow Bayou system, AU 0511_01 (lower 5 miles of Cow Bayou Tidal) met water quality standards, and, while there was concern over depressed DO in Terry Gully (AU 0511E_01), this water body is not listed as impaired for depressed DO. Other AUs, such as

0511A_01 and 0511D_01, were not assessed due to lack of data and are therefore considered unimpaired. The history of the appearances of these water bodies on the State of Texas' Clean Water Act Section 303(d) list begins in 1992 with Adams Bayou Tidal (AUs 0508_01, 0508_02, 0508_03, and 0508_04). In 1994, TCEQ added Cow Bayou Tidal (AUs 0511_02, 0511_03, and 0511_04) to the Texas 303(d) List. Then in 2000, TCEQ added Adams Bayou Above Tidal (AU 0508A_01), Gum Gully (AU 0508B_01), Cow Bayou Above Tidal (AU 0511A_02), Coon Bayou (AU 0511B_01), and Cole Creek (AU 0511C_01) to the State of Texas 303(d) List. Hudson Gully (AU0508C_01) first appeared on the 2002 Texas 303(d) list.

This document will also consider impairments in 1 water body (segment) and 1 AU for low pH. The water body and its identifying AU number is shown below:

AU	Description
0511_04	Cow Bayou Tidal (upper 4 miles of tidal segment)

The pH-impaired AU 0511_04 was added to the Texas 303(d) List in 2000. In the 2006 Texas Water Quality Inventory, AU 0511_03 was listed as a "concern" for pH. Because AU 0511_03 was listed at the concern level and not as impaired, TCEQ made the decision to proceed withTMDL development only for Cow Bayou Tidal AU 0511_04.

1.3 Past TMDLs

From 2003 to 2007, Adams Bayou and Cow Bayou were the subject of a TMDL project of TCEQ. The project included development of water quality models to link point and nonpoint sources of pollution to instream conditions (Parsons, 2006a, 2006b); and data collection to quantify pollutant sources and instream processes, and to provide data for model calibration and validation (Parsons, 2003a, 2003b).

Based on this work, TCEQ adopted TMDLs for DO and pH in Adams Bayou, Cow Bayou, and their tributaries on June 13, 2007, and the United States Environmental Protection Agency (EPA) approved these TMDLs on August 28, 2007. The adopted and approved TMDL document also included TMDLs for indicator bacteria impairments in a number of the segments within the watersheds of Adams Bayou and Cow Bayou.

Since the models were developed, there have been a number of changes in the watershed, including new and eliminated permitted discharges, and expansions in the availability of centralized wastewater collection and treatment. Additional changes in wastewater discharge permit limits have been proposed. TCEQ adopted an approach of subdividing segments into AUs for TMDLs that was not entirely consistent with the existing model segmentation. The TMDL was also determined by model scenarios involving reductions from existing loading, rather than from a fully permitted scenario. This existing-loading approach is not consistent with current practice. Thus, an update of the models and TMDLs was needed.

Due to the complexity of the modeling system, and because these models are not the typical tools used by TCEQ in evaluating water quality permits, TCEQ requested assistance from a Texas Institute of Applied Environmental Research (TIAER)/Parsons team in providing an updated and fully documented modeling system. The modeling system is intended to provide TCEQ with a tool to use in water quality permitting, specifically, to set permit limits for DO and oxygen-demanding substances consistent with the TMDLs for Adams Bayou and Cow Bayou, and their tributaries.

1.4 Document Summary

This document first summarizes the comprehensive modeling system developed to link instream DO to point-source (PS) and nonpoint-source (NPS) loads of oxygen demanding substances in the Adams and Cow Bayou systems, then describes various loading scenarios and their impact on instream dissolved oxygen, and finally describes development of updated TMDLs for oxygen-demanding substances in the impaired water bodies.

The document also provides an explanation of the environmental linkage of low pH in the upper reaches of Cow Bayou Tidal to the depressed DO that occurs in the water body. Further, this linkage is used to update the TMDL for low pH in the single pH-impaired AU of Cow Bayou Tidal.

2. Summary of Modeling System Developed for Linkage Analysis

The modeling system used in the TMDL revisions was developed under a quality assurance project plan (QAPP) for modeling titled "Technical Support for Revision and Documentation of Watershed and In-Stream Water Quality Models Used to Establish Total Maximum Daily Loads (TMDLs) for Dissolved Oxygen in Adams and Cow Bayous and Associated Tributaries." The QAPP was approved by TCEQ on May 6, 2013 and re-issued on May 5, 2014, revised on February 3, 2015, and amended with minor revisions to staff responsibilities, on June 17, 2015. The QAPP was re-issued as Revision # 3 on February 4, 2016, and thereafter annual renewals occurred on January 18, 2017, January 18, 2018, January 9, 2019, and January 7, 2020. With Revision #3, pH and bacteria investigations were incorporated into the QAPP and the title changed to "Technical Support for Revision and Documentation of Watershed and In-Stream Water Quality Models Used to Establish Total Maximum Daily Loads (TMDLs) for Dissolved Oxygen, pH and Bacteria in Adams and Cow Bayous and Associated Tributaries."

The separate Adams Bayou and Cow Bayou modeling systems consists of the same fundamental components tailored to the features of each water body and watershed:

- An Hydrologic Simulation Program - Fortran (HSPF) hydrologic and water quality model of the watershed and above tidal reaches,
- an RMA2 hydrodynamic model for the tidal reaches,
- a Water Quality Analysis Simulation Program (WASP) water quality model for the tidal reaches,
- accessory programs to link the models,
- a user interface to edit model inputs and review model outputs

Figure 2-1 illustrates the basic structure of the modeling system. The HSPF model serves as the hydrologic and water quality model for the above tidal reaches of Adams Bayou, Cow Bayou, and their tributaries. HSPF does not have the capacity to simulate tidal flows and water quality. HSPF sub-basins and reaches are split near the upper tidal boundary of each stream and major tributary, and the RMA2 and WASP models extend to just above this tidal boundary. At this tidal boundary, the HSPF-simulated instream flows serve as boundary flow conditions for the RMA2 hydrodynamic model. Similarly, the HSPF-simulated loads of water quality constituents serve as boundary input loads to the WASP water quality model. The HSPF watershed model also simulates runoff flows and water quality constituents to portions of the watershed that run off directly to the tidal reaches of Adams Bayou and Cow Bayou and their tributaries. The model linkages of HSPF output involve straightforward spatial and temporal aggregations, unit conversions, and data format modifications. The RMA2 linkage to WASP includes these, as well as conversions from water velocity to flow based on cross-sectional area. The linkages were created using utility programs.

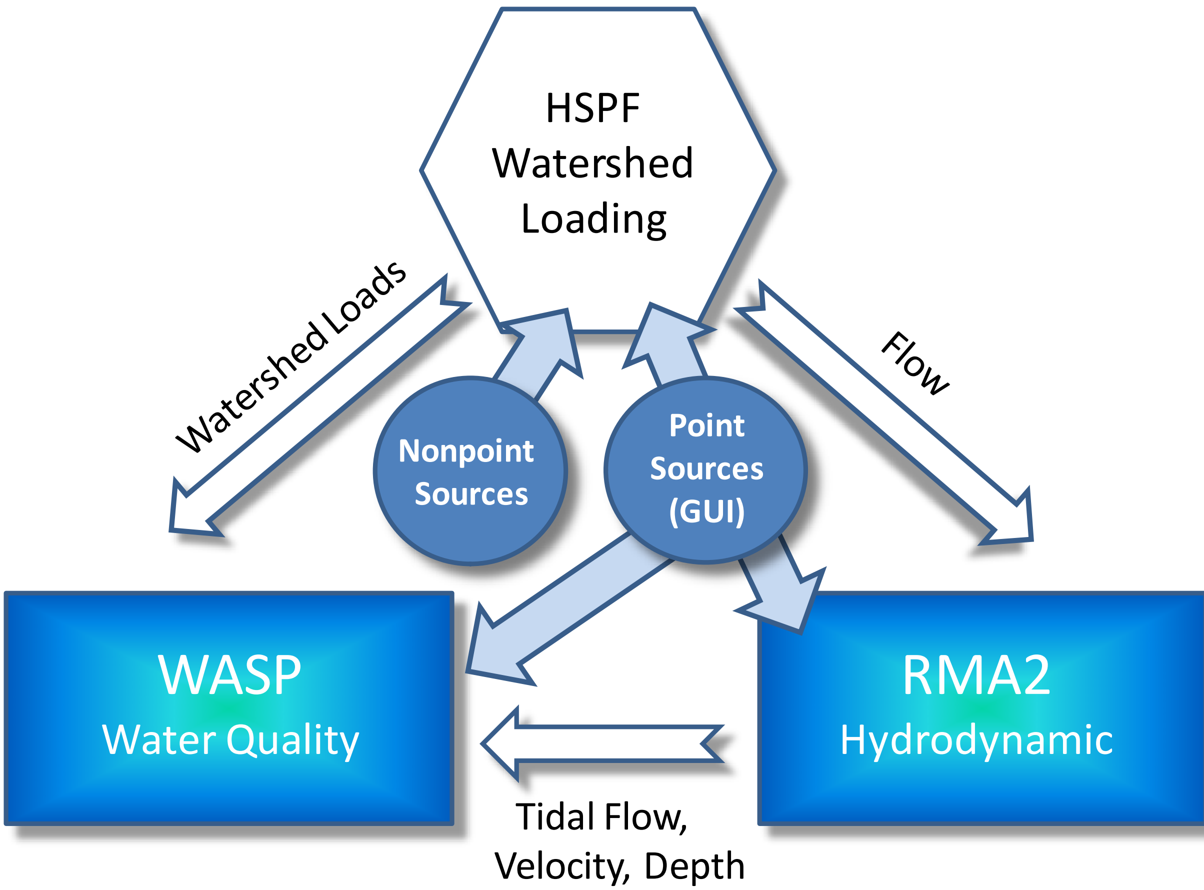

Figure 2-1 Schematic of modeling system

3. HSPF Hydrologic and Water Quality Model

The HSPF models of the Adams Bayou and Cow Bayou watersheds were developed to be run under HSPF version 12.0, either as the stand-alone executable program or using WinHSPF version 2.3 or WinHSPFLt, which are components of the EPA's BASINS modeling software. The models utilize algorithms developed for version 12.0 for high water table, low topography conditions, and will not run under older versions of HSPF.

3.1 HSPF Model Description

In HSPF, the watersheds were first divided spatially into sub- basins based on topography; a 10-m resolution digital elevation model was used for this purpose. Key model characteristics are summarized in Table 3-1. There are 12 sub-basins in the Adams Bayou watershed model (Figure 3-1)[1], and 18 sub-basins in the larger Cow Bayou watershed model (Figure 3-2). Next, the watersheds were further sub-divided into a series of land segments, either pervious land surface (PLS) or impervious land surface (ILS), based on land cover. Pervious land surfaces allow water to pass through to the sub-surface, while ILS's such as concrete or asphalt do not. Land within a PLS or ILS is considered to have similar characteristics, though not necessarily nearby or connected. In each model, there are 17 PLS and 4 ILS. Most of the PLS and ILS correspond to land cover categories from the 2006 National Land Cover Dataset (NLCD). However, one PLS (PERLND 117) is reserved for future use, and another (PERLND 116) is a sub-set of the pervious low-density residential land use that is attributed to malfunctioning on-site sewerage facilities (OSSFs). The four "developed" land cover categories were divided into PLS and ILS based on the assumption that impervious surfaces comprised 11 percent of the open developed land, 31 percent of the low-density developed land, 62 percent of the medium-density developed land, and 88 percent of the high-density developed lands. These percentages were calculated in a geographic information system by intersecting the 2006 NLCD impervious land cover dataset

[1] The northern portion of the Adams Bayou watershed, as included in HSPF Subbasin 2, was refined from its definition in Dean et al. (2015). A 2015 report by the consulting firm of Carroll and Blackman, Inc. contained information on a flood planning study performed for the Orange County Drainage District and the Texas Water Development Board (Carroll & Blackman, 2015). The report provided information from topographic data supplemented with actual physical survey data resulting in a significantly different delineation of this portion of the watershed from that used in the initial HSPF model of Adams Bayou watershed (Parsons, 2006a). The refined Adams Bayou delineation from Carroll & Blackman (2015) was subsequently agreed to by TCEQ and Sabine River Authority. The source of the differences in watershed boundaries is a flood diversion canal, which diverts water eastward directly to the Sabine River. The actual drainage of the Adams Bayou watershed that is intercepted by the diversion canal was difficult to accurately determine absent actual physical survey data obtained for the flood planning study.

with the land cover classes from the land cover dataset. All other land use categories were assumed to be 100 percent pervious.

Table 3-1 HSPF model summary

Version/Date	**WinHSPF Version 2.3 Build 30 (5/13/2008 12:22 PM)**
Model Period	1/1/2001 – 12/31/2012 (2001 is spin-up period)
Time Step	1 hour
Sub-basins	18 (Cow Bayou); 12 (Adams Bayou)
Pervious Land Categories	17: corresponding to 2006 NLCD land cover categories, plus a "failing OSSF" PERLND (116) carved from low-density residential and a currently unused category (117) to facilitate BMP evaluation or future land use changes
Impervious Land Categories	4; corresponding to fractions of 2006 NLCD "developed" land cover categories
Reaches	18 (Cow Bayou); 12 (Adams Bayou)
Active Modules and Sections	PERLND: PWATER, ATEMP, SEDMNT, PSTEMP, PWTGAS, PQUAL IMPLND: IWATER, ATEMP, SOLIDS, IWTGAS, IQUAL RCHRES: HYDR, ADCALC, HTRCH, SEDTRN, OXRX, NUTRX, PLANK
Sub-basin Constituents	runoff; temperature; TSS; NH_3N; NO_3N; PO_4P; cBOD
Reach Constituents	flow; temperature; DO, TSS (as sand, silt, & clay); NH_3N; NO_3N; PO_4P; cBOD; OrgN, OrgP, and OrgC; chla; detritus
Meteorology Inputs	precipitation, air temperature, dew point temperature, wind speed, potential evapotranspiration, pan evaporation, cloud cover, solar radiation
Point Source Discharge Placeholders	18 (Cow Bayou); 12 (Adams Bayou): There is 1 PS discharge input placeholder to each sub-basin. However, most of these are inactive, with no flow or loads, and inserted as placeholders for future modifications or scenario runs. All PS discharges to a given reach are summed.

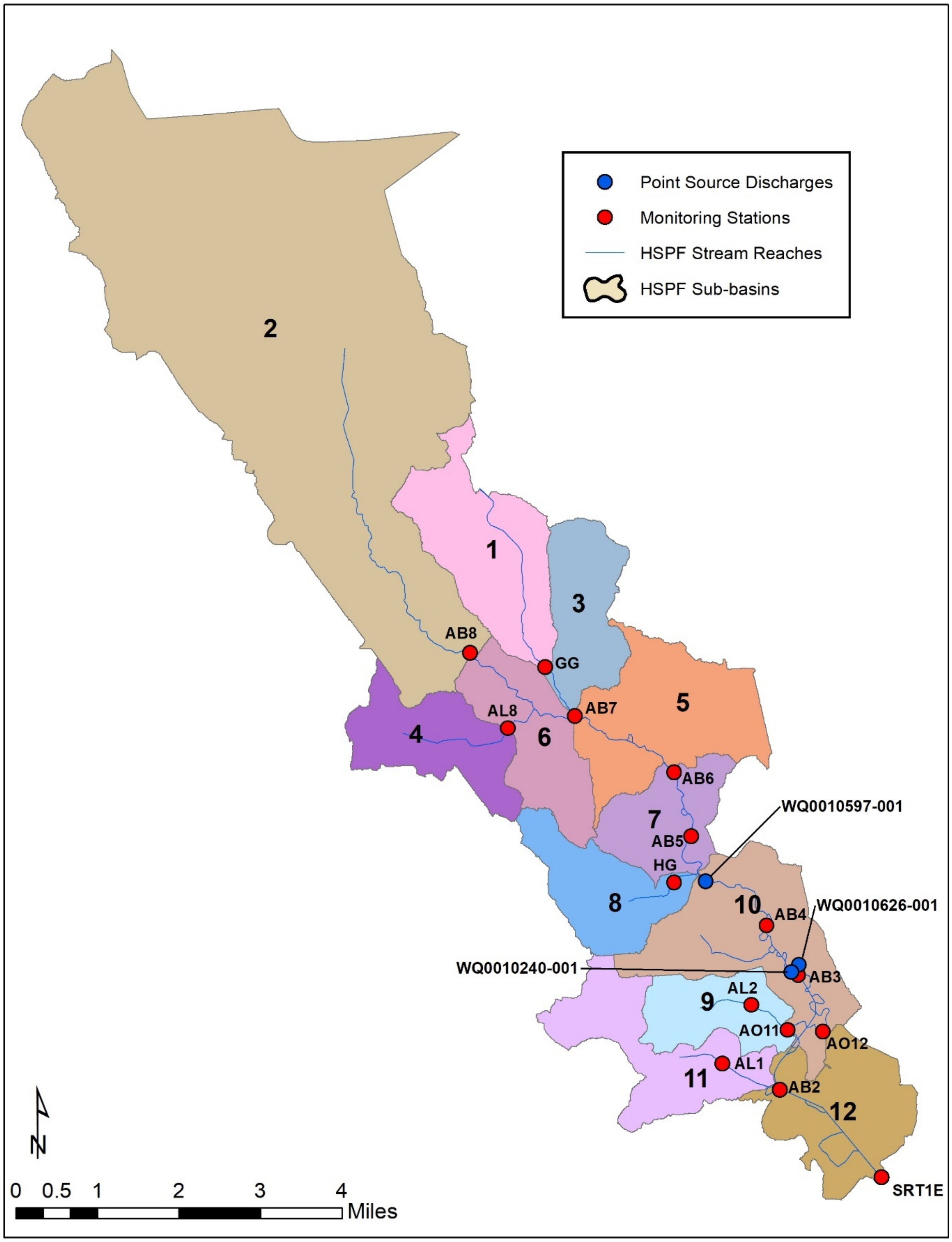

Figure 3-1 Adams Bayou sub-basins in HSPF

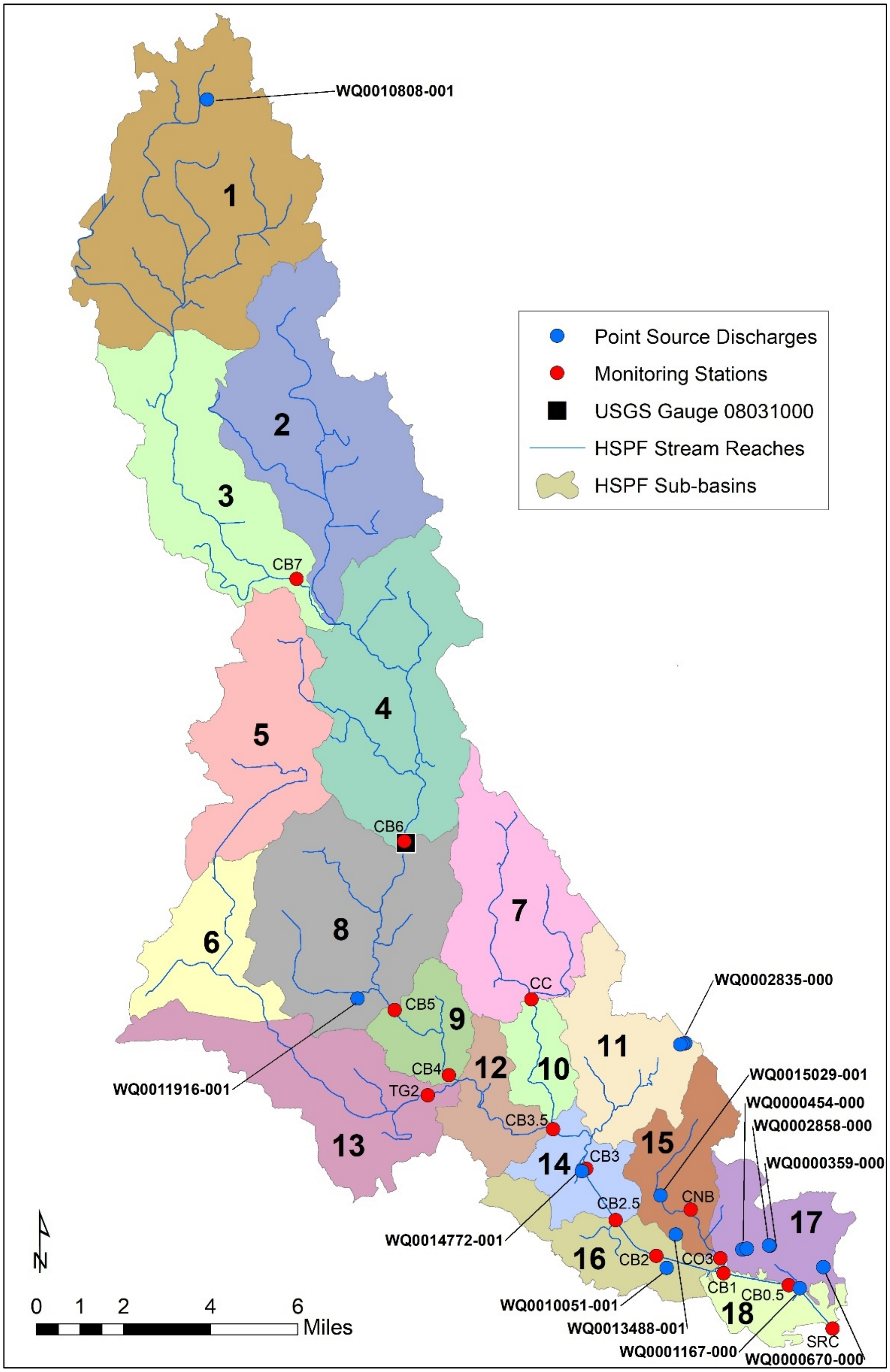

Figure 3-2 Cow Bayou sub-basins in HSPF

In HSPF, the PERLND module simulates water quantity and quality for each PLS, and the IMPLND module simulates water quantity and quality for each ILS. Runoff from each PLS and ILS is routed to a reach or reservoir in the RCHRES module. The RCHRES module simulates unidirectional flow and water quality in an open or closed channel as a stream or mixed reservoir. Upstream reaches are also routed to downstream reaches.

The model is based on English units. The active modules for pervious land use categories include:

- ATEMP (air temperature elevation difference),
- PWATER (water budget pervious),
- SEDMNT (production and removal of sediment),
- PSTEMP (soil temperature),
- PWTGAS (water temperature and dissolved gas concentrations), and
- PQUAL (quality constituents using simple relationships).

The active modules for impervious land use categories included:

- ATMP (air temperature elevation difference),
- IWATER (water budget impervious),
- SOLIDS (accumulation and removal of solids),
- IWTGAS (water temperature and dissolved gas concentrations), and
- IQUAL (washoff of quality constituents using simple relationships).

The active modules for the RCHRES (stream) sections include:

- HYDR (hydraulic behavior),
- ADCALC (advection of fully entrained constituents),
- HTRCH (heat exchange and water temperature)
- SEDTRN (behavior of inorganic sediment)
- OXRX (primary carbonaceous biochemical oxygen demand [cBOD] and DO balances)
- NUTRX (primary inorganic nitrogen and phosphorus balances)
- PLANK (plankton populations and associated reactions)

Key water quality constituents simulated in the model include DO, cBOD, nitrate nitrogen (NO_3N), ammonia nitrogen (NH_3N), organic nitrogen (OrgN), orthophosphate phosphorus (PO_4P), and total suspended solids (TSS). Chlorophyll-*a* (chla), detritus (non-living particulate organic matter), organic phosphorus (OrgP), and organic carbon (OrgC) were also simulated, but were not calibrated because of a lack of data. The cBOD parameter simulated in HSPF was the commonly measured 5-day cBOD($cBOD_5$).

The new high water table, low-gradient algorithms incorporated into version 12 of HSPF were applied to herbaceous wetlands in the Adams Bayou and Cow Bayou models. These algorithms were developed for wetland environments. Wetlands appear to exert a controlling influence on the hydrology of Cow Bayou. In essence, the wetlands act like a sponge, absorbing rainfall with little or no runoff until the sponge is saturated. For this reason, there is often very little flow in Cow Bayou in the summer, when evaporation and evapotranspiration by plants speeds the drying of the wetlands. To represent the pervious soil environment, the new HSPF algorithms keep track of the groundwater levels (top of saturated zone) and the interaction between the saturated and unsaturated zone. Also, surface flow in herbaceous wetlands is simulated as a power function of the water storage on the land surface, rather than the traditional approach based on the length, slope, and roughness of the overland flow plane.

3.2 Inputs, Data Sources and Assumptions

Each model has specific data requirements compiled from various data sources. In some cases, it was necessary to establish certain assumptions when data were lacking or to clarify data interpretation. As a watershed loading model, data inputs for HSPF include information that influences the transport of stormwater runoff and groundwater filtration to each receiving stream. The data inputs used for this HSPF model include: meteorology, land use/land cover, landscape physiography, numerous categories of NPS pollution including atmospheric deposition, PS discharges, flow, and meteorology.

3.2.1 Climate and Meteorology

Adams Bayou and Cow Bayou experience a subtropical humid climate. The average temperature varies from 50 degrees Fahrenheit in January to 83 degrees in August. Rain is abundant in this corner of Texas, with an average annual rainfall of almost 60 inches. The frequency of significant rainfall (one half inch or more in a 24-hour period) has averaged approximately 3.2 days per month, or roughly 1 in 10 days, over the last 30 years. Seasonal variations in precipitation frequency and magnitude are not great. June, July and September have the most frequent rainfall, and February, March, and April have the least frequent.

Meteorological inputs required by the HSPF model are described in Table 3-2. Most data were available on an hourly basis. Pan evaporation and potential evapotranspiration were measured daily, and disaggregated to hourly using the time series utility program WDMutil. Also, during the validation period of the Adams Bayou model, daily rainfall totals measured in the watershed differed significantly from those at Southeast Texas Regional Airport and also decreased in a southeast to northwest direction across the watershed (PRISM, 2017). The daily rainfall totals for the centroid of the Adams Bayou watershed were used for the May – June 2004 precipitation input to HSPF. These daily rainfall total were estimated using the Oregon State University PRISM Climate Group (PRISM, 2017), which was disaggregated into hourly data.

Table 3-2 Meteorological inputs to the HSPF models

Data Type	Frequency	Cow Bayou Dataset Number	Adams Bayou Dataset Number	Source
Precipitation	Hourly	35	27	Southeast Texas Regional Airport (Port Arthur), except for Adams Bayou calibration and validation period (May-June 2004) used daily data from NRCS High Resolution Climatic Data
Precipitation	Hourly (disaggregated from daily)	NA	27	PRISM Climate Data (May – June 2004)
Air Temperature	Hourly	36	28	Southeast Texas Regional Airport (Port Arthur)
Dew Point Temperature	Hourly	39	29	Southeast Texas Regional Airport (Port Arthur)
Cloud Cover	Hourly	41	30	Southeast Texas Regional Airport (Port Arthur)
Potential Evapotranspiration	Hourly (disaggregated from daily)	42	31	Texas A&M University Research Center (Beaumont)
Pan Evaporation	Hourly (disaggregated from daily)	43	34	Texas A&M University Research Center (Beaumont)
Wind Speed	Hourly	38	25	TCEQ Continuous Air Monitoring Station (West Orange)
Solar Radiation	Hourly	40	26	TCEQ Continuous Air Monitoring Station (West Orange)

3.2.2 Land Use and Land Cover

Land use in the Adams and Cow Bayou watersheds is illustrated in Figure 3-3, from the Multi-Resolution Land Cover Consortium's 2006 NLCD. This land use classification is based on satellite imagery from approximately 2006. Overall, 32 percent of the Adams Bayou watershed and 16 percent of the Cow Bayou watershed were considered developed or built-up land (Table 3-3). Approximately 23 percent of the Cow Bayou watershed, and 9 percent of the Adams Bayou watershed, is covered by forest. Approximately 9 percent of the Cow Bayou watershed and 22 percent of the Adams Bayou watershed is used for pasture or hay production for grazing animals. Water and wetlands comprise approximately 38 percent and 27 percent, respectively, of the Cow and Adams Bayou watersheds.

The 2006 land use was selected for use in developing input to HSPF because these data characterize conditions for roughly the temporal midpoint of the 2002 through 2012 time period used for hydrologic model verification. Further, the 2006 land use represents conditions near the 2004 time period of the intensive surveys for collection of water quality data in the watersheds of Adams Bayou and Cow Bayou used for verification of the water quality model components of HSPF and WASP.

Table 3-3 Land use/land cover in the Adams and Cow Bayou watersheds

NLCD Land Cover Category†	Adams Bayou	Cow Bayou
Open Water	1.48%	0.79%
Developed, Open Space	12.00%	8.08%
Developed, Low Intensity	15.07%	5.65%
Developed, Medium Intensity	2.92%	1.19%
Developed, High Intensity	1.74%	0.69%
Barren Land	0.03%	0.05%
Deciduous Forest	0.50%	0.08%
Evergreen Forest	4.16%	12.41%
Mixed Forest	4.60%	10.90%
Shrub/Scrub	2.75%	6.41%
Grassland/Herbaceous	4.73%	6.45%
Pasture Hay	22.16%	9.27%
Cultivated Crops	2.79%	1.24%
Woody Wetlands	20.06%	34.13%
Emergent Herbaceous Wetlands	5.02%	2.67%

†from 2006 NLCD

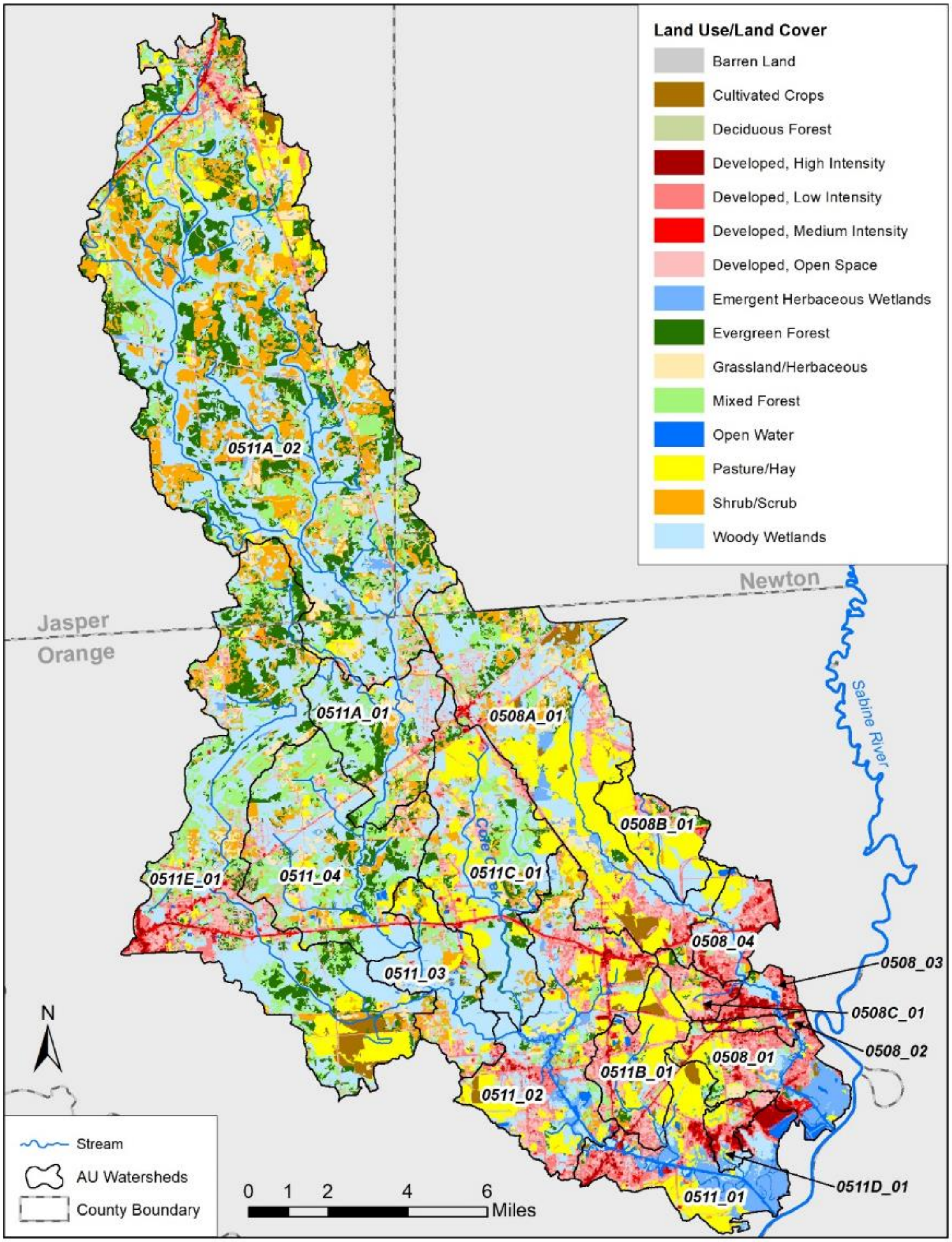

Figure 3-3 2006 land use/land cover in the Adams and Cow Bayou watersheds

3.2.3 Geology, Topography, and Soils

Adams Bayou and Cow Bayou are located in the Gulf of Mexico coastal plain. The southeastern parts of their watersheds lie in the Texas ecological region known as Gulf prairies and marshes, while the northwestern parts lie in the piney woods region. The terrain is level and low. The elevation of Adams Bayou varies from sea level at the Sabine River to 4.5 feet (ft) at its uppermost extent (TWC, 1986), with an average slope of only 6 cm/km, or 0.006 percent. The elevation of Cow Bayou varies from sea level at the Sabine River to 7 ft at its uppermost extent (TWC, 1986), and also has an average slope of 6 cm/km (TWC, 1988).

Sedimentary rocks comprise the geologic base of the watersheds of Adams Bayou and Cow Bayou. The Beaumont Clay is the surface formation over the entire watershed. It is composed of mixed sand, silt, clay and gravel. The soils are primarily fine sands, silts, and clays. Most are fine-textured, have high water holding capacity, and very slow water permeability. Soils also tend to be acidic and have high organic matter content in the surface layer. Some soils have frequent flooding and/or surface ponding of water for long durations in the cooler months of the year. Finally, many of the soils are saturated in the cooler months, with water tables at or near the surface. Together with the low and level topography, these soil properties give rise to an abundance of wetlands within the watersheds. Table 3-4 describes some of the properties of the major soil map units found in the watersheds of Adams Bayou and Cow Bayou.

3.2.4 Nonpoint Sources of Pollutants

A non-point pollutant source inventory was developed for each watershed and sub-watershed using a system of linked Microsoft Excel™ spreadsheets. This tool was adapted from the Bacterial Indicator Tool developed by the EPA (2000). The tool provides estimates of loading of $cBOD_5$, PO_4P, NH_3N, and NO_3N for the HSPF model based on land use, livestock and wildlife populations, waste management practices, and other watershed properties. This “Loading Tool” spreadsheet was modified to address watershed-specific conditions. In HSPF, the parameter ACQOP describes the accumulation rate for each water quality constituent on pervious and impervious land cover categories in pounds per acre per day. The ACQOP values in the HSPF model are taken from the “Summary” worksheet in the Loading Tool spreadsheet. Although not dynamically linked to the HSPF input file, the HSPF model can be manually modified if the loading assumptions in the spreadsheet are modified.

Table 3-4 Selected properties of major soil map units of Adams and Cow Bayou watersheds

(Information provided for soil map units comprising >2 percent of either Adams Bayou watershed or Cow Bayou watershed)

Map Unit Name	Area %		Runoff	Flooding	Surface Ponding	High Water Table		Hydraulic Permeability
	Adams	Cow	Potential	Frequency	Frequency	Depth (ft)	months	Percolation
Anahuac-Aris complex	2.5%	0.6%	medium	none	none	4-6	Nov-Apr	very slow
Bleakwood loam	0.0%	2.3%	negligible	frequent	none	0-1.5	Nov-May	moderate
Camptown silt loam	2.9%	0.9%	negligible	none	frequent	0	Dec-Aug	very slow
Craigen loamy fine sand	0.0%	2.9%	very low	none	none	3-5	Jan-Apr	moderate
Evadale silt loam	0.0%	6.7%	very high	none	none	0-1.5	Dec-Apr	very slow
Evadale-Gist complex	0.0%	20%	very high	none	none	0-1.5	Dec-Apr	very slow
Evadale-Vidrine complex	2.6%	3.4%	high	none	none	0-1.5	Dec-Apr	very slow
Fausse clay	2.1%	0.0%	negligible	frequent	frequent	0-1.5	all year	very slow
Labelle silt loam	10.2%	2.0%	high	none	none	0.5-1.5	Jan-Mar	very slow
Labelle-Levac complex	4.4%	1.0%	high	none	none	0.5-1.5	Jan-Mar	very slow
Leerco muck	3.7%	0.0%	negligible	frequent	frequent	0	all year	very slow
Malbis-Kirbyville association	0.0%	4.6%	medium	none	none	2.5-4.0	Dec-Mar	slow
Orcadia silt loam	1.9%	2.6%	very high	none	none	0.8-1.5	Jan-Mar	very slow
Orcadia-Anahuac complex	17.3%	5.9%	high	none	none	0.8-1.5	Jan-Mar	very slow
Orcadia-Aris complex	6.6%	6.7%	medium	none	none	0.8-1.5	Jan-Mar	very slow
Orcadia-urban land complex	18.4%	3.4%	very high	none	none	0.8-1.5	Jan-Mar	very slow
Texla silt loam	15.1%	3.2%	high	none	none	0.5-1.5	Jan-Mar	very slow
Texla-Evadale complex	1.5%	14%	high	none	none	0.5-1.5	Jan-Mar	very slow
Texla-Gist complex	6.8%	3.6%	high	none	none	0.5-1.5	Jan-Mar	very slow

3.2.4.1 Agricultural Sources

The major agricultural activities within the watersheds include beef cattle ranching and hay production. The 2007 U.S. Department of Agriculture (USDA) census of agriculture provides a more detailed inventory of agricultural activities at the county level (Tables 3-5 through 3-7). In addition to hay and other forage, the other major crop in Orange County is rice, but this is primarily outside the watersheds of Adams Bayou and Cow Bayou. Cattle are the most abundant livestock by a large margin. Other abundant livestock include chickens, sheep, goats and horses.

The 2007 USDA census of agriculture was selected for use in developing input to HSPF because these data characterize conditions for roughly the temporal midpoint of the 2002 through 2012 time period used for hydrologic model verification. The 2007 USDA agricultural census also represents conditions near the 2004 time period of the intensive surveys for collection of water quality data in the watersheds of Adams Bayou and Cow Bayou used for verification of the water quality model components of HSPF and WASP.

Table 3-5 Count of farms/production operations by county and type: 2007 agricultural census

Type	Orange	Jasper	Newton
Farms	675	920	403
Acres harvested	5,046	11,399	4050
Irrigated farms	35	32	10
Oilseed and grain farming	-	-	-
Vegetable and melon farming	15	31	9
Fruit and tree nut farming	18	32	12
Greenhouse, nursery, and floriculture production	12	30	6
Sugarcane farming, hay farming, and all other crop farming	76	181	57
Beef cattle ranching and farming	349	435	210
Cattle feedlots	6	6	4
Dairy cattle and milk production	6	3	1
Hog and pig farming	5	2	26
Poultry and egg production	19	30	15
Sheep and goat farming	38	29	14
Animal aquaculture and other animal production	131	141	49

Table 3-6 Crops planted by county, in acres: 2007 agricultural census

Crop	Orange	Jasper	Newton
Rice	D	-	-
Forage - hay and hay land, grass silage, and greenchop	4,442	9,764	3,894
Vegetables	50	170	15
Orchards	59	422	22
Corn for grain	-	23	D
Wheat for grain	-	-	-
Soybeans	D	-	-
Potatoes	2	4	1
Sugarcane	-	-	-

D - Withheld to avoid disclosing data from individual farms
- represents zero

Table 3-7 Domestic livestock populations by county: 2007 agricultural census

Type	Orange	Jasper	Newton
Cattle and calves*	8,528	13,657	5,354
Hogs/pigs	176	100	65
Horses/ponies	1,427	1,826	714
Sheep/lamb	150	201	54
Goats	838	853	713
Mules/burros/donkeys	201	168	62
Rabbits	112	66	33
Deer	342	504	114
Chickens/layers and pullets	1,707	2,444	1,839
Chickens/broilers	460	153	40
Turkeys	D	10	D
Pheasants	D	D	D
Pigeons and squab	D	D	D
Quail	D	-	-
Ducks	688	265	142
Geese	80	58	27
Other poultry	D	229	99

* all were beef cattle except a few dairy cows in Orange County
D -Withheld to avoid disclosing data from individual farms
- represents zero

Livestock fecal waste may serve as a major nonpoint source pollutant, either by runoff of manure directly deposited by grazing animals on pasture, rangeland, or in water, or by application of manure from confined animals to fields as fertilizer. Manure production by livestock was estimated based on the animal population estimate from the 2007 USDA Census of Agriculture multiplied by the American Society of Agricultural Engineers (ASAE) estimated average daily manure production (ASAE, 1998). Ammonia nitrogen and phosphorus production estimates were also derived from published ASAE estimates. Table 3-8 provides a summary of the estimated pollutant productions rates from the manure of various livestock.

Manure from cattle, horses, sheep, and goats was assumed to be directly deposited to pastureland. Because there are few if any dairy cattle in the watersheds, and other cattle are not confined, it was assumed that no cattle manure was collected and spread on cropland as fertilizer. However, manure from swine and poultry within the watershed was assumed to be collected and applied to cropland as fertilizer.

Table 3-8 Pollutant production rates of livestock in manure

Animal	BOD† Production (lb/animal/day)	NH_3N Production (lb/animal/day)	PO_4P Production (lb/animal/day)	Solids Production (lb/animal/day)
Beef cow	1.28	0.069	0.074	6.8
Hog	0.42	0.039	0.024	1.5
Sheep	0.07	0.005	0.005	0.66
Horse	1.70	0.079	0.071	15
Goat	0.07#	0.005#	0.005#	0.66#
Chicken	0.02	0.001	0.001	0.06
Turkey	0.03	0.001	0.004	0.18

All values from ASAE (1998) or Shaffer et al (2005) except where otherwise noted.
† 5-day biochemical oxygen demand without nitrogen inhibition
# best professional judgment – no data exist

3.2.4.2 On-site Sewerage Facilities

OSSFs, such as septic tanks, can serve as nonpoint sources of pollutants. Malfunctioning septic tanks are those that have been improperly engineered or installed, poorly maintained, or where soils do not permit the sanitary absorption of septic effluent. In rural and some suburban areas of Adams Bayou and Cow Bayou, conventional septic tanks serve as the primary mechanism for sewage disposal. The most recent available data on the abundance of septic tanks in the watersheds comes from the 1990 decennial federal census. In the long questionnaire given to roughly 1 in 6 households, respondents were asked to identify the sewage disposal method of their housing unit as either "public sewer", "septic tank or cesspool", or "other means". In the Adams Bayou watershed, 6,754 housing units (88 percent) were connected to a public sewer, 888 units (12 percent) used septic tanks or cesspools for sewage disposal, and 20 units reported an "other" sewage disposal method. In the Cow Bayou watershed, 2,205 housing units (28 percent) were connected to a public sewer, 5,582 units (71 percent) used septic tanks or cesspools, and 108 units (1 percent) reported an "other" sewage disposal method.

The 1990 federal census information was used to develop a map showing the density of the pre-1991 households with conventional septic systems, which represent those OSSFs with the highest likelihood of failure (Figure 3-4). The 1990 federal census information was used at the census-block level with the associated census responses to OSSF presence or absence in developing this figure.

In the 2000 and 2010 federal censuses, the questionnaire did not include a question on sewage disposal. Since 1991, when Orange County adopted its OSSF program, it has been a requirement that a soil survey must be performed before installation of an OSSF. Given that almost all soils in the watersheds are unsuitable for conventional septic systems, in most cases an aerobic OSSF must be installed. Thus, since 1991 new housing in areas not served by public sewers has generally required aerobic OSSF systems, and the number of housing units utilizing conventional septic systems has likely not increased.

The Orangefield Water Supply Corporation was established in 1995 and in recent years began to provide sanitary sewer service to portions of the Cow Bayou watershed. By 2013, their 0.75 million gallons per day (MGD) wastewater treatment facility (WWTF) was treating wastewater from 1,000 connections in the Cow Bayou watershed that previously used OSSFs (Morton, 2013). These 1,000 connections were removed from the 1990 inventory of OSSFs in each Cow Bayou sub-basin based on the portion of each Cow Bayou sub-basin within the Orangefield Water Supply Corporation service area.

Conventional septic tank systems rely on absorption fields to disperse liquid components of sewage into the soil, after solids have settled into the tank. Several factors affect the suitability of soils for septic tank absorption fields (NRCS, 2004). These factors include:

1) frequency and duration of flooding

   Flooding here indicates the temporary inundation of an area caused by overflowing streams, tides, or runoff from adjacent slopes. Flooding may allow the widespread contamination of surface waters with septic tank effluent.

2) frequency and duration of ponding

   Ponding is standing water in a closed depression. Ponding may allow the localized contamination of surface waters with septic tank effluent.

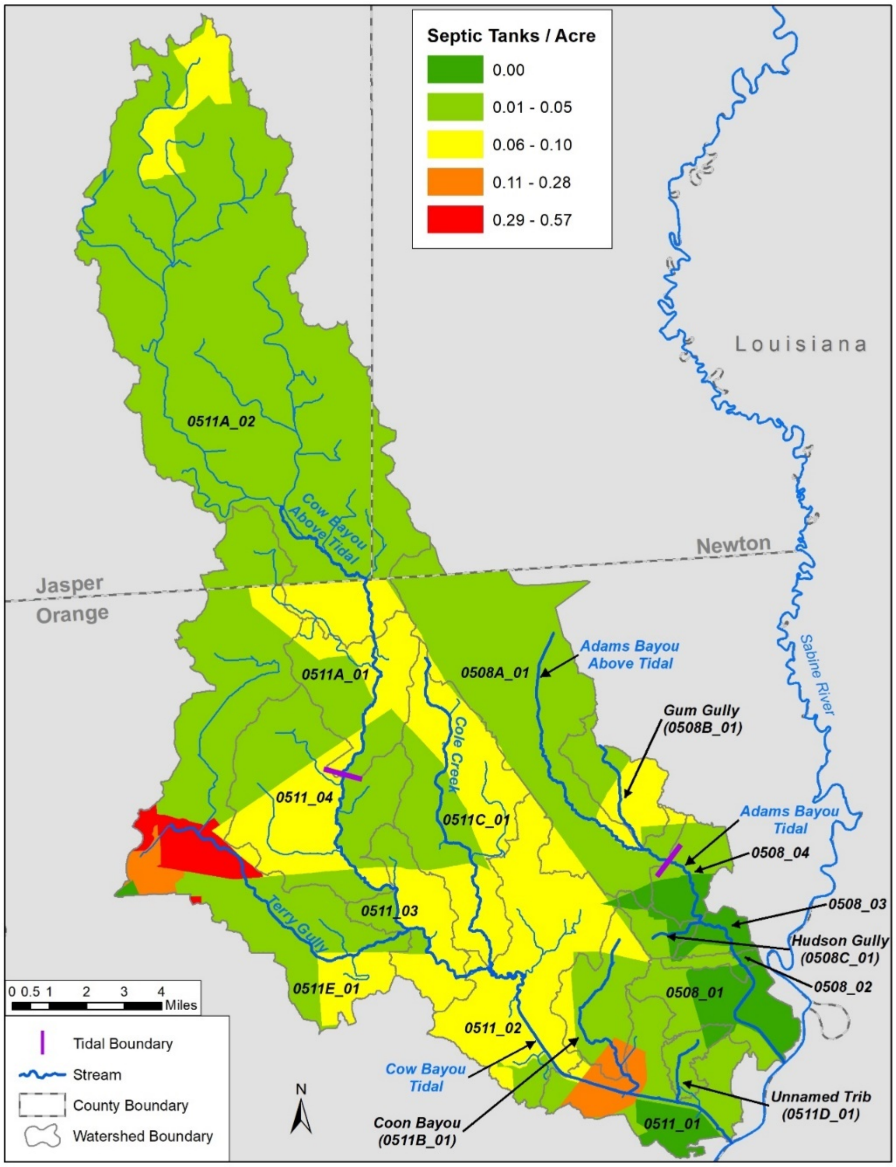

Figure 3-4 Septic tank density within the Adams Bayou and Cow Bayou watersheds based on 1990 federal census data

3) frequency and duration of flooding

   Flooding here indicates the temporary inundation of an area caused by overflowing streams, tides, or runoff from adjacent slopes. Flooding may allow the widespread contamination of surface waters with septic tank effluent.

4) frequency and duration of ponding

   Ponding is standing water in a closed depression. Ponding may allow the localized contamination of surface waters with septic tank effluent.

5) soil water permeability

   Limited soil water permeability limits the rate at which the septic field can absorb and transmit septic effluent. The soil hydrologic group indicates the soil water permeability.

6) depth to the saturated zone

   The saturated zone refers to the depth from the land surface down to where the soil is saturated with ground water. Shallow saturated zones may lead to contamination of ground water. Most of the soils in the Adams and Cow Bayou tend to be saturated near the surface at least part of the year, which makes them inappropriate for septic fields.

7) tendency for subsidence

   Soil subsidence may cause leaks or other malfunctions in the septic tank. Subsidence is not a major problem for many of the soils in these watersheds

Based on one or more of these factors, almost all of the soils in the Adams Bayou and Cow Bayou watersheds are very limited in their utility for septic tank absorption fields (Figure 3-5), according to the Soil Survey Geographic Database developed by the NRCS of the USDA (NRCS, 2016). Extensive site engineering may minimize the effects of some of these factors. A survey of septic tank failure in Texas (Reed Stowe and Yanke, 2001) estimated that the overall chronic malfunction rate of OSSF systems in east Texas was 19 percent, more than any other region in the state. The estimated chronic malfunction rate rose to 54 percent for systems installed in the fine-textured, clayey soils common in the Adams Bayou and Cow Bayou watersheds. In this region, the factor reported to have the highest impact on malfunction was unsuitable soils, followed by the high water table, then system age. Project stakeholders with knowledge of the watersheds, including septic system inspectors, believe that the actual rate of malfunction of conventional septic systems in these watersheds is close to 100 percent. They cited observations that almost all conventional systems had the cap removed from the septic field drain line, essentially conveying the septage directly from the tank to the ditch. In accordance with these estimates, it was assumed in the HSPF model that 95 percent of the conventional septic systems in these watersheds are malfunctioning.

Properly functioning conventional septic tank systems and aerobic systems were assumed to produce no pollutant loads to the bayous, while loads from malfunctioning septic tank systems were included in the HSPF model as loads to land and to the bayous. Flows from septic systems were estimated based on an average of 2.5 persons per household and 70 gallons of wastewater produced per person per day (Horsely and Whitten, 1996). Pollutant concentrations in septic tank effluent (Table 3-9) were estimated based on data provided by Metcalf and Eddy (1991) for medium strength waste.

In the HSPF model, data set numbers 8111 to 8115 represent the loads of cBOD, solids, water (flow), NH_3N, and PO_4P from a single failing OSSF. Ninety percent of the pollutant load from failing

OSSFs is applied to pervious land use category 116, present in the HSPF model at an amount of 0.1 acre per failing OSSF. The other 10 percent of the pollutant load from failing OSSFs is a direct load to surface water reaches.

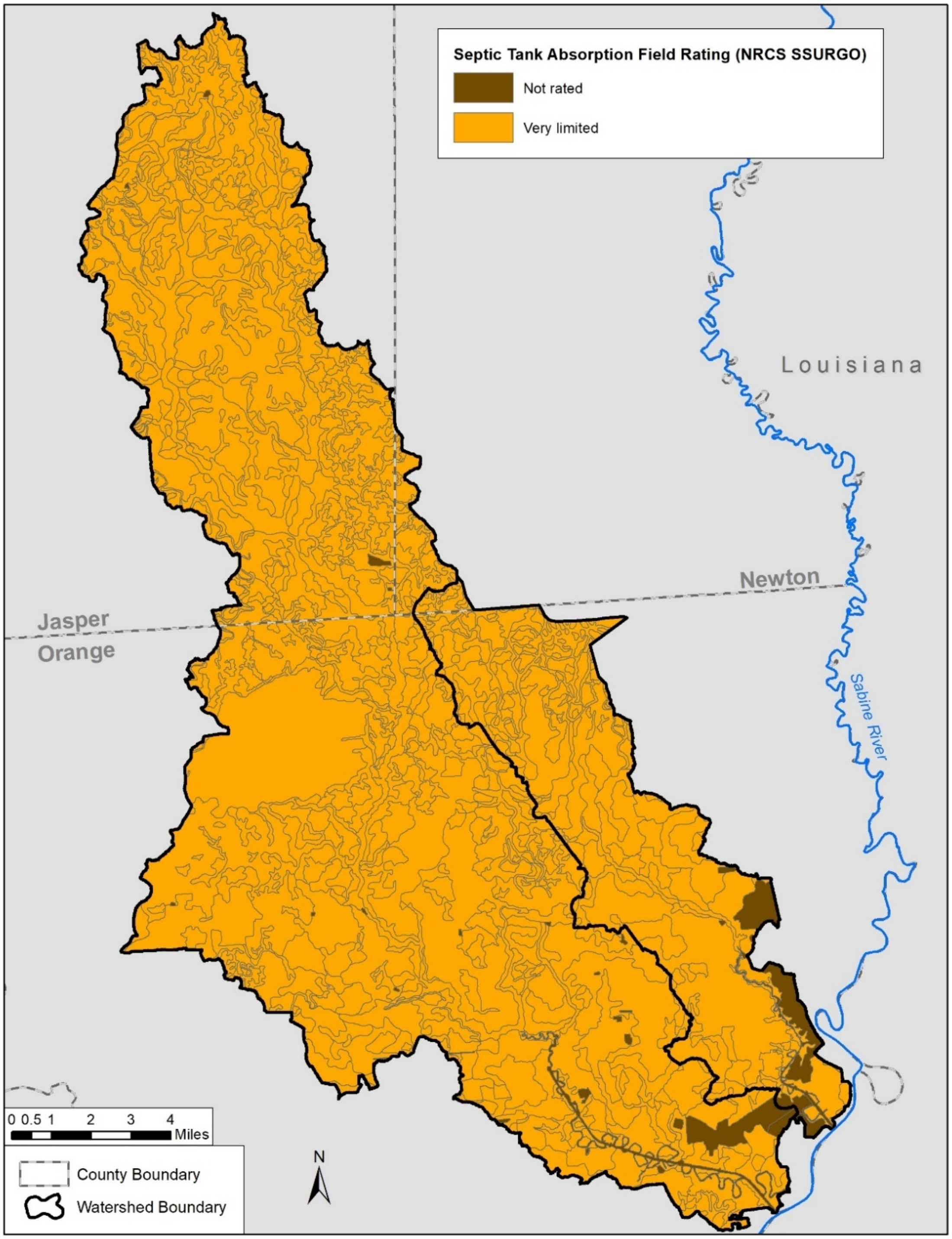

Figure 3-5 Soil suitability for septic fields in the Adams Bayou and Cow Bayou watersheds (USDA, 2016)

Table 3-9 Assumed pollutant concentrations in malfunctioning septic tank effluent

Parameter	Concentration
$cBOD_5$	190 mg/L
TSS	210 mg/L
NH_3N	25 mg/L as N
PO_4P	5 mg/L as P

3.2.4.3 Wildlife

Very few data exist on the population size of wildlife species in the watersheds. The whitetail deer population in Jasper County has hovered around 50 per 1,000 acresand, in Newton County, the dear population has stayed closer to 30 per 1,000 acres, according to information obtained from the Texas Parks and Wildlife Department website and reported in the initial HSPF modeling report (Parsons, 2006a). No deer population estimates were found for Orange County, which has a greater urban influence, and less forest. As with land use and agricultural census data, the wildlife data used where those thought to reflect conditions existing during model verification.

Wildlife were assumed to contribute pollutants to all land use categories and subwatersheds. The assumed populations of wildlife are shown in Table 3-10. Pollutant production rates of wildlife (Table 3-11) were estimated based on Schueler (2001) and other references in the Bacterial Indicator Tool (EPA, 2000). In cases where pollutant production rates from wildlife species were not available, they were estimated by multiplying the manure production rate estimate for the animal by the average pollutant concentration in manure for other animal species. While the levels of uncertainty in the wildlife populations and pollutant production rates are very large, sensitivity analyses showed that varying these numbers had little effect on the model outcome as wildlife were a relatively minor source.

Table 3-10 Assumed wildlife population densities for various land use categories

Species	Population Density (animals/ square mile)					
	Cropland	Wetlands	Pasture	Forest	Grassland	Residential
Deer	20	50	20	50	10	40
Waterfowl	10	128	10	0	0	0
Other birds	100	1,500	1,000	1,500	1,500	1,500
Opossum	20	100	50	100	20	50
Raccoon	4	100	4	100	20	50
Rodents	2,000	2,000	2,000	2,000	2,000	2,000

Table 3-11 Pollutant production rates of wildlife

Animal	$cBOD_5$ Production (lb/animal/day)	NH_3N Production (lb/animal/day)	PO_4P Production (lb/animal/day)
Deer	0.050	3.3E-3	3.2E-3
Waterfowl	0.011	7.4E-4	7.1E-4
Other birds	0.0006	3.7E-5	3.5E-5
Opossum	0.028	1.8E-3	1.8E-3
Raccoon	0.10	6.5E-3	6.3E-3
Rodents	0.0027	1.8E-4	1.7E-4

3.2.4.4 Atmospheric Deposition

Atmospheric deposition was assumed to contribute NH_3N and NO_3N to all land uses via wet (precipitation) and dry (particle) deposition. Annual wet and dry deposition rates of ammonia and nitrate nitrogen for the project watersheds were estimated from isopleth maps prepared by the National Atmospheric Deposition Program (NADP, 2005). and summarized in Table 3-12.

Table 3-12 Total average atmospheric loadings of pollutants

Year	NO_3N (lb/acre/yr)	NH_3N (lb/acre/yr)
2001	2.58	2.08
2002	2.80	2.57
2003	2.32	2.64
2004	2.32	2.29
2005	2.14	2.22
2006	2.22	2.50
2007	2.24	2.29
2008	1.87	2.01
2009	1.55	2.08
2010	1.29	1.32
2011	1.39	1.87
2012	2.06	2.17

3.2.4.5 Forest Leaf Litter

Forest leaf litter deposition can be a nonpoint source of nitrogen, phosphorus, and cBOD to waters. An estimated 30 pounds of nitrogen and 2 pounds of phosphorus are deposited in leaf litter per acre of forest per year, based on the measurements of Finzi et al. (2001) for a mature loblolly pine/hardwood forest, similar to the dominant type in the Adams and Cow Bayou watersheds. The nitrogen was assumed to be NH_3N, phosphorus assumed to be PO_4P, and a $cBOD_5$/nitrogen ratio of 5.0 was used to estimate the $cBOD_5$ content. Evergreen forests were assumed to deposit leaf litter evenly throughout the year, while litter fall from deciduous forests was assumed to occur primarily in October and November, and mixed forests leaf litter combined the aspects of evergreen and deciduous forests.

3.2.4.6 Residential Area Nonpoint Sources

Potential nutrient pollutant sources in residential areas that were considered in the model include malfunctioning septic systems, dog and cat fecal waste, wildlife fecal waste, and lawn fertilizer. Malfunctioning septic systems were described previously and incorporated in the model independently. The populations of dogs and cats were estimated based on the number of households in each subwatershed, along with the national average numbers of 0.58 dogs and 0.66 cats per household, from the American Veterinary Medicine Association (AVMA, 2002). As with land use and agricultural census data and wildlife population data, the household pet population data used where those thought to reflect conditions existing during model verification period. Estimates of pollutant loadings to residential land in pet fecal waste are summarized in Table 3-13. It was assumed that 100 percent of dog feces and 50 percent of cat feces was applied outdoors. Of the outdoor applied dog feces, 20 percent was assumed to be collected and removed to a landfill.

Table 3-13 Pollutant production rates of dogs and cats

Animal	BOD_5 Production (lb/animal/day)	NH_3N Production (lb/animal/day)	PO_4P Production (lb/animal/day)
Dog	0.10	6.5E-3	6.3E-3
Cat	0.028	1.8E-3	1.8E-3

To estimate the amount of commercial fertilizer applied to lawns, it was assumed that:

- 50 percent of the residential land was covered by turf grasses,
- nitrogen was applied to turf at the rate of 4 lbs of NH_3N per 1,000 square feet (ft^2) per year, and
- phosphorus was applied at a rate of 2 lbs of PO_4P per 1,000 ft^2 per year.

These assumptions are in line with the low end of Texas Agricultural Extension recommendations for St. Augustine and Bermuda grass lawns in eastern Texas. It was assumed that 49 percent of the applied nutrients were collected and removed to the landfill each year as grass clippings and other yard waste (Baker et al., 2001).

3.2.5 Permitted PS Discharge Facilities

There are only two active Texas Pollution Discharge Elimination System (TPDES) permitted facilities discharging into the above tidal reaches of Cow Bayou, and none in the above tidal reaches of Adams Bayou. These facilities are

- TPDES WQ0010808-001 – Jasper County Water Control and Improvement District 1
- TPDES WQ0002835-000 – Miller Waste Mills, Inc. (three outfalls)

These facilities occur in sub-basins 1 and 11, respectively, of the Cow Bayou HSPF model. Point source flows and loadings of cBOD, NH_3N, and DO in discharges from these facilities were set in the model at their actual self-reported discharges for calibration runs, and at the discharge limits in their TPDES permits for non-calibration scenarios. All of the other existing PS discharges are to tidal reaches of the bayous and, as such, they are incorporated into the RMA2 hydrodynamic and WASP water quality models rather than the HSPF model. However, a placeholder for future point sources to above tidal reaches has been included in each sub-basin in the HSPF model.

3.2.6 Municipal Separate Stormwater Systems

In 1990, EPA developed Phase I of the National Pollutant Discharge Elimination System (NPDES) Stormwater Program for Municipal Separate Storm Sewer Systems (MS4s). A MS4 is defined in 40 CFR 122.26(b)(8) as "a conveyance or system of conveyances (including roads with drainage systems, municipal streets, catch basins, curbs, gutters, ditches, man-made channels, or storm drains):

(i) Owned or operated by a State, city, town, borough, county, parish, district, association, or other public body (created by or pursuant to State law)...including special districts under State law such as a sewer district, flood control district or drainage district, or similar entity, or an Indian tribe or an authorized Indian tribal organization, or a designated and approved management agency under section 208 of the Clean Water Act that discharges into waters of the United States.

(ii) Designed or used for collecting or conveying stormwater;

(iii) Which is not a combined sewer; and

(iv) Which is not part of a Publicly Owned Treatment Works (POTW) as defined at 40 CFR 122.2.

The NPDES Stormwater program was designed to prevent harmful pollutants in MS4s from being washed by stormwater runoff into local water bodies (EPA, 2005). Phase I of the program required operators of medium and large MS4s (those generally serving populations of 100,000 or greater) to implement a stormwater management program as a means to control polluted discharges. Approved stormwater management programs for medium and large MS4s are required to address a variety of water quality-related issues, including roadway runoff management, municipal-owned operations, and hazardous waste treatment. There are no Phase I MS4s in the watersheds of Adams Bayou or Cow Bayou.

In 1999, Phase II began requiring certain small regulated MS4s located in "urbanized areas" to comply with the NPDES stormwater program. Small MS4s are defined as any MS4 that is not a medium or large MS4 covered by Phase I of the NPDES Stormwater Program. The boundaries of "urbanized areas" are defined by the U.S Bureau of the Census, and generally involve a population density of at least 1,000 people per square mile and a total population of at least 10,000 people. Phase II requires operators of regulated small MS4s to obtain NPDES permits and develop a stormwater management program. The programs are designed to reduce discharges of pollutants to the "maximum extent practicable," to protect water quality, and to satisfy appropriate water quality requirements of the CWA. Phase II MS4 stormwater programs must address the following six minimum control measures:

- Public Education,Outreach, and Involvement
- Illicit Discharge Detection and Elimination
- Construction Site Runoff Control
- Post- Construction Stormwater Management in New Development and Redevelopment
- Pollution Prevention and Good Housekeeping for Municipal Operators
- Industrial stormwater Sources

Discharges of stormwater from a Phase II MS4 areas are required to be covered under TPDES general permit TXR040000. There are five Phase II MS4 authorizations within the Adams Bayou watershed and two within the Cow Bayou watershed. The area within each HSPF model sub-basin that is within each MS4 is listed in Table 3-14 (Adams Bayou) and Table 3-15 (Cow Bayou). Most of these MS4s are discrete cities, but the Orange County Drainage District and Orange County jointly address those portions of the urbanized areas that do not fall within city limits.

For the purpose of TMDL load allocations, MS4s are treated as point sources of pollutants even though they originate from diffuse locations.

Table 3-14 Areas of Adams Bayou watersheds within MS4s, in acres

<table>
<tr><th>Sub-basin</th><th>Total Sub-basin Area</th><th>Urbanized Area</th><th>City of Orange (TXR040430)</th><th>City of Pinehurst (TXR040428)</th><th>City of West Orange (TXR040431)</th><th>Orange County (TXR040030)</th><th>Orange County Drainage District (TXR040029)</th></tr>
<tr><td>1</td><td>1,864</td><td>18</td><td>6</td><td></td><td></td><td colspan="2">12</td></tr>
<tr><td>2</td><td>13,584</td><td>0</td><td></td><td></td><td></td><td colspan="2"></td></tr>
<tr><td>3</td><td>1,144</td><td>53</td><td>49</td><td></td><td></td><td colspan="2">4</td></tr>
<tr><td>4</td><td>1,268</td><td>86</td><td>77</td><td></td><td></td><td colspan="2">9</td></tr>
<tr><td>5</td><td>2,019</td><td>962</td><td>861</td><td>101</td><td></td><td colspan="2"></td></tr>
<tr><td>6</td><td>1,311</td><td>476</td><td>397</td><td>53</td><td></td><td colspan="2">26</td></tr>
<tr><td>7</td><td>1,051</td><td>1,068</td><td>369</td><td>699</td><td></td><td colspan="2"></td></tr>
<tr><td>8</td><td>1,180</td><td>1,170</td><td>1046</td><td>100</td><td></td><td colspan="2">24</td></tr>
<tr><td>9</td><td>932</td><td>730</td><td></td><td></td><td>717</td><td colspan="2">13</td></tr>
<tr><td>10</td><td>2,217</td><td>2,217</td><td>1229</td><td>255</td><td>733</td><td colspan="2"></td></tr>
<tr><td>11</td><td>1,490</td><td>1,012</td><td>243</td><td></td><td>524</td><td colspan="2">245</td></tr>
<tr><td>12</td><td>1,601</td><td>505</td><td>224</td><td></td><td>49</td><td colspan="2">232</td></tr>
</table>

Table 3-15 Areas of Cow Bayou watersheds within MS4s, in acres

<table>
<tr><th>Sub-basin</th><th>Total Sub-basin Area</th><th>Urbanized Area</th><th>City of Orange (TXR040430)</th><th>City of Vidor (TXR040028)</th><th>City of West Orange (TXR040431)</th><th>City of Bridge City (TXR040429)</th><th>Orange County (TXR040030)</th><th>Orange County Drainage District (TXR040029)</th></tr>
<tr><td>1</td><td>17,801</td><td>0</td><td></td><td></td><td></td><td></td><td colspan="2"></td></tr>
<tr><td>2</td><td>13,389</td><td>0</td><td></td><td></td><td></td><td></td><td colspan="2"></td></tr>
<tr><td>3</td><td>10,036</td><td>0</td><td></td><td></td><td></td><td></td><td colspan="2"></td></tr>
<tr><td>4</td><td>12,487</td><td>0</td><td></td><td></td><td></td><td></td><td colspan="2"></td></tr>
<tr><td>5</td><td>8,600</td><td>0</td><td></td><td></td><td></td><td></td><td colspan="2"></td></tr>
<tr><td>6</td><td>5,063</td><td>2,859</td><td></td><td>1,702</td><td></td><td></td><td colspan="2">1,157</td></tr>
<tr><td>7</td><td>8,288</td><td>0</td><td></td><td></td><td></td><td></td><td colspan="2"></td></tr>
<tr><td>8</td><td>11,740</td><td>631</td><td></td><td>150</td><td></td><td></td><td colspan="2">481</td></tr>
<tr><td>9</td><td>2,913</td><td>0</td><td></td><td></td><td></td><td></td><td colspan="2"></td></tr>
<tr><td>10</td><td>2,160</td><td>3</td><td>3</td><td></td><td></td><td></td><td colspan="2"></td></tr>
<tr><td>11</td><td>5,641</td><td>533</td><td>334</td><td></td><td></td><td></td><td colspan="2">199</td></tr>
<tr><td>12</td><td>2,993</td><td>0</td><td></td><td></td><td></td><td></td><td colspan="2"></td></tr>
<tr><td>13</td><td>8,609</td><td>1,239</td><td></td><td>1,184</td><td></td><td></td><td colspan="2">55</td></tr>
<tr><td>14</td><td>3,013</td><td>6</td><td></td><td></td><td></td><td></td><td colspan="2">6</td></tr>
<tr><td>15</td><td>4,074</td><td>1,118</td><td>243</td><td></td><td>4</td><td></td><td colspan="2">871</td></tr>
<tr><td>16</td><td>4,011</td><td>1,524</td><td></td><td></td><td></td><td>856</td><td colspan="2">669</td></tr>
<tr><td>17</td><td>4,049</td><td>1,537</td><td>7</td><td></td><td>59</td><td></td><td colspan="2">1,471</td></tr>
<tr><td>18</td><td>2,302</td><td>52</td><td></td><td></td><td></td><td>6</td><td colspan="2">46</td></tr>
</table>

3.3 HSPF Model Verification

Model calibration and validation, which collectively are referred to as verification, are defined as follows:

- Calibration—The first stage testing and tuning of a model to a set of observational data, such that the tuning results in a consistent and rational set of theoretically defensible input parameters.
- Validation—Subsequent testing of a calibrated model to additional observational data to further examine model validity and preferably under different external conditions from those used during calibration (Thomann and Mueller, 1987).

The HSPF models were hydrologically calibrated to measured daily flows from USGS gauge 08031000 on Cow Bayou near Mauriceville (Figure 3-2). This is the only flow gauge within either watershed. The flow calibration period was from October 1, 2002 through December 31, 2012. Model calibration statistics such as the coefficient of determination (r^2), mean error (ME), mean absolute error (MAE), root-mean-square error (RMSE), and Nash-Sutcliffe modeling efficiency (NSE) (Nash and Sutcliffe, 1970), were used as quantitative measures of model fit to supplement the visual evaluation of fit. The formulas for model fit statistics are provided below, where y_i is the measured value, $\hat{y}_i$ is the model predicted value, an overscore indicates a mean value, and n is the number of measurements.

Coefficient of Determination

$$r^2 = \left\{ \frac{\sum_{i=1}^{n} (y_i - \bar{y})(\hat{y}_i - \bar{\hat{y}})}{\left[\sum_{i=1}^{n} (y_i - \bar{y})^2\right]^{0.5} * \left[\sum_{i=1}^{n} (\hat{y}_i - \bar{\hat{y}})^2\right]^{0.5}} \right\}^2$$

Root Mean Square Error

$$RMSE = \left\{ \left[\sum (y_i - \hat{y}_i)^2 \right] / n \right\}^{0.5}$$

Nash-Sutcliffe Efficiency

$$\mathrm{NSE} = \mathbf{1} - \sum_{i=\mathbf{1}}^{n} (y_i - \hat{y}_i)^2 / \sum_{i=\mathbf{1}}^{n} (y_i - \bar{y})^2$$

Mean Error

$$ME = \left(\sum_{i=1}^{n} (y_i - \hat{y}_i) \right) / n$$

Mean Absolute Error $$MAE = \left(\sum_{i=1}^{n} \left| y_i - \hat{y}_i \right| \right) / n$$

The primary calibration targets were the flow duration curve (percentiles of the flow distribution), annual, seasonal, and monthly flows. The calibration fits are illustrated in Figures 3-6 to 3-9. The primary model calibration goal was a NSE and r^2 value for simulated and observed daily flow of greater than 0.4. Also, simulated and observed total and seasonal (monthly) flows were to agree within 20 percent. All calibration targets were met. Hydrologic goodness-of-fit is summarized in Table 3-16.

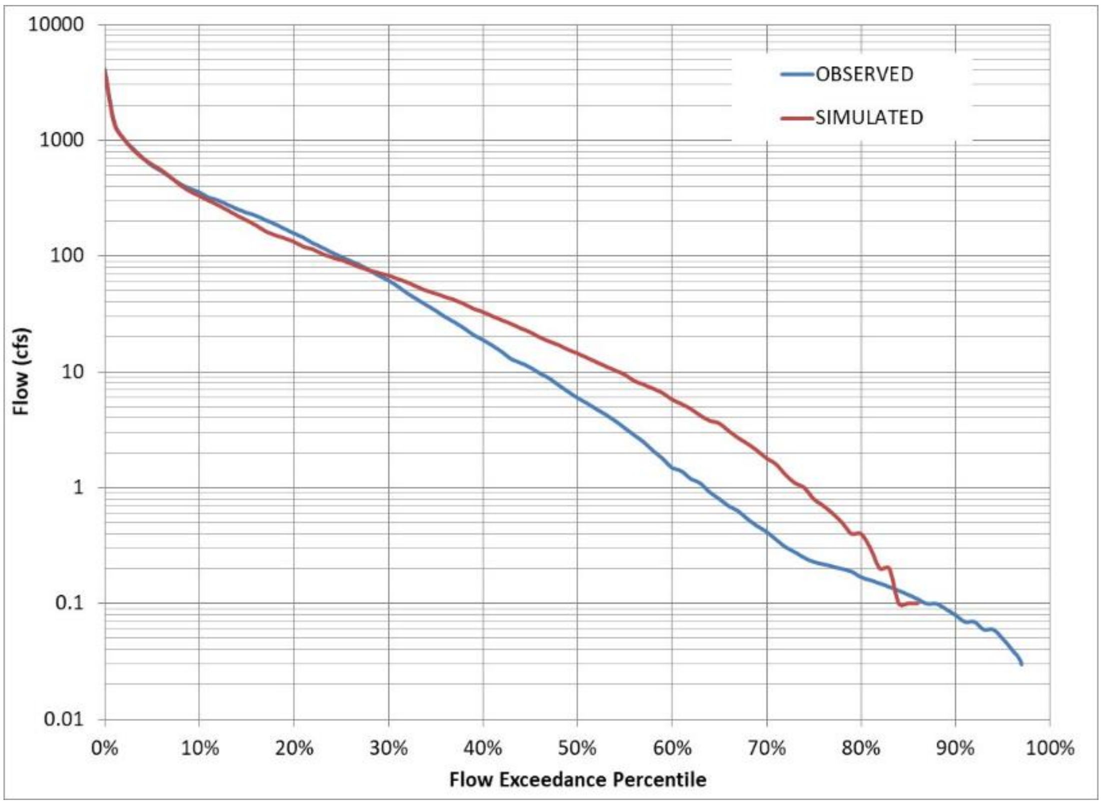

Figure 3-6 Observed and simulated flow duration curves for Cow Bayou

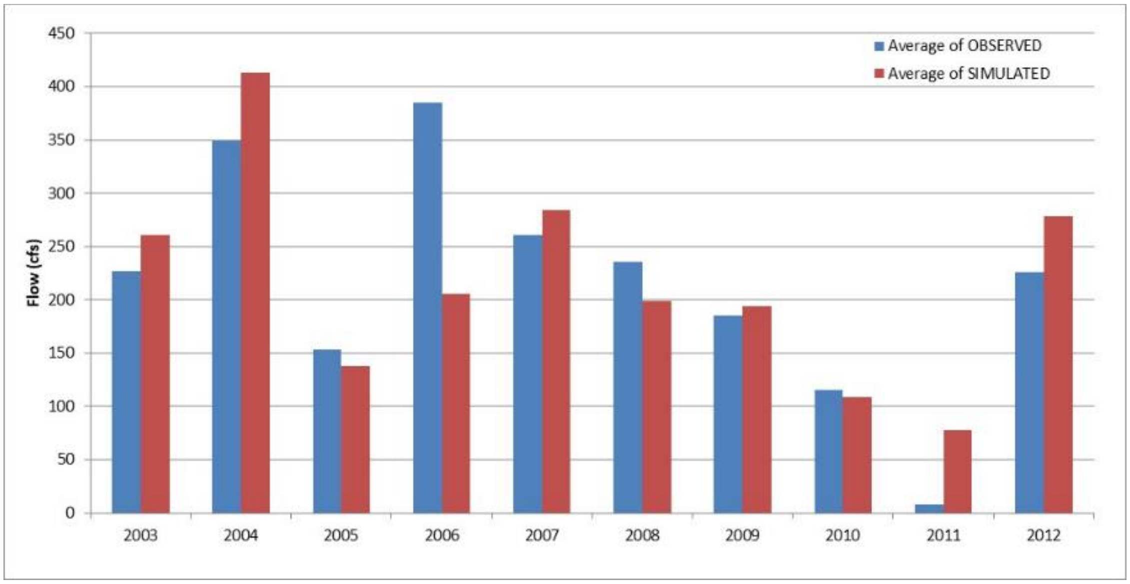

Figure 3-7 Observed and simulated annual average flows for Cow Bayou

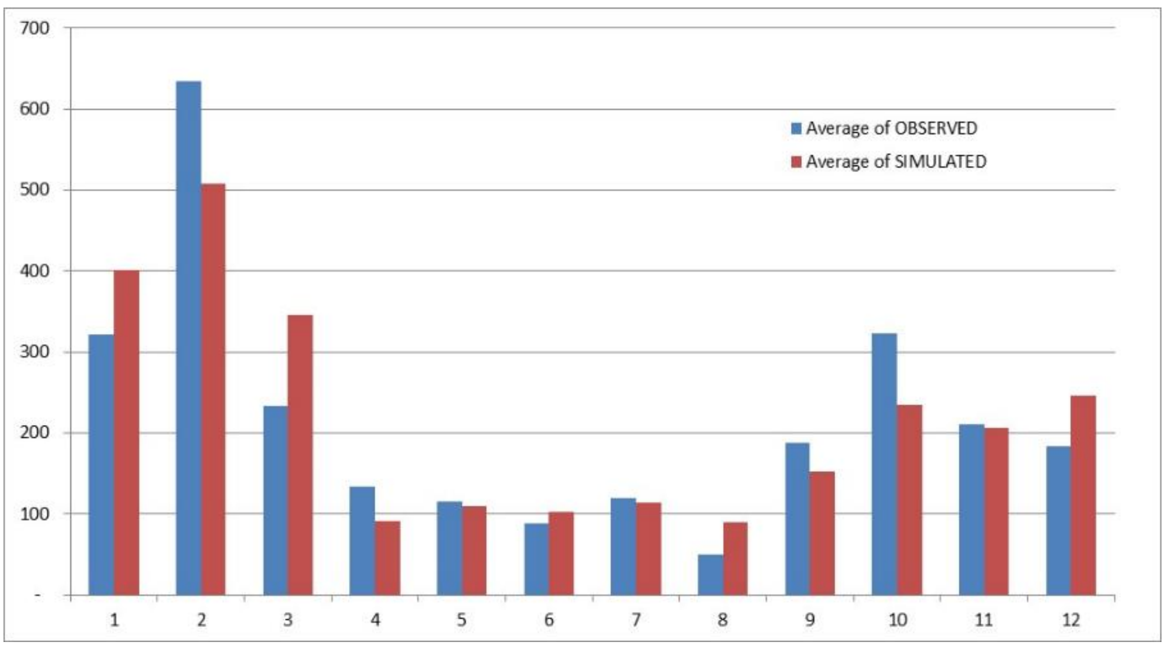

Figure 3-8 Observed and simulated average monthly flows for Cow Bayou

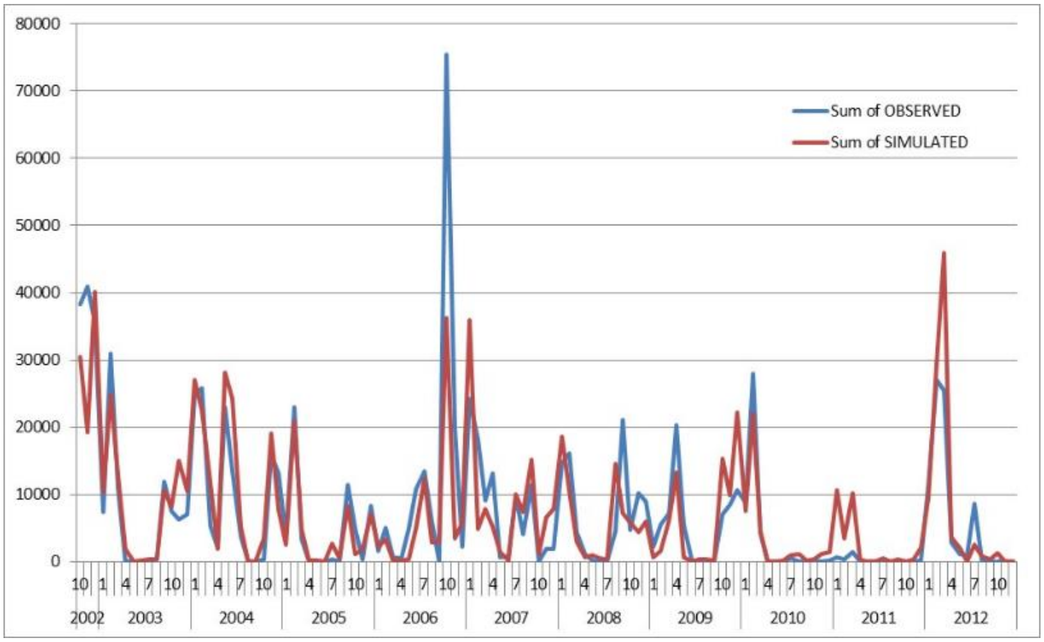

Figure 3-9 Observed and simulated total monthly flows for Cow Bayou

Table 3-16 Goodness-of-fit for HSPF Cow Bayou model hydrologic calibration

Period	Quantity	Percent Difference	Statistic			
			MAE (cfs)	RMSE (cfs)	NSE	r^2
Daily	Flow		4.71	7.51	0.405	0.529
Monthly	Flow		1.27	1.34	0.807	0.808
Annual	Flow		1.48	2.13	0.559	0.579
Winter	Total Flow	+5.72%				
Spring	Total Flow	-10.34%				
Summer	Total Flow	-0.27%				
Autumn	Total Flow	-4.05%				
Full Period	Total Flow	-2.40%				

Water quality calibration of the HSPF model was performed by comparing model-predicted water quality to water quality data collected during stormwater runoff events. There were three monitoring stations in the Adams Bayou subwatersheds and three in the Cow Bayou subwatersheds. The data that served for calibration were collected on January 8 - 10 and June 16 - 17, 2004. The data used for validation were collected January 11 - 23 and November 2 - 4, 2004.

The calibration was limited by a dearth of runoff events and scarcity of water quality monitoring stations on non-tidal reaches. Model parameters were adjusted within physically realistic ranges used in prior modeling studies to ensure that the average model concentrations were similar to the average of measured concentrations, and that the range of model concentrations encompassed the measured concentrations. A quantitative calibration target was that average predicted concentrations of TSS, $cBOD_5$, NH_3N, NO_3N, PO_4P, and DO fall within a range calculated as the mean of the observed concentrations plus or minus two standard deviations. These calibration and validation goals were met (Table 3-17).

Concentration time series comparisons indicate that the model captures the typical levels of water quality constituents, but does not precisely match every storm event at every station. Given the uncertainties in the rainfall data and other model input data, the HSPF model is not designed to reliably simulate pollutant concentration time series for individual storm events, but rather to simulate pollutant loadings over a longer period of time. Thus, the model was deemed to meet project objectives.

Table 3-17 Calibration and validation of HSPF model for water quality (Cow and Adams Bayous considered jointly)

Parameter	Event	Measured					Simulated			
		N	Min	Max	Mean	SD	Min	Max	Mean	Meets?
TSS	Cal	17	11	85	31	21	0.4	162	40	Yes
TSS	Ver	20	10	154	39	41	0.1	230	47	Yes
cBOD	Cal	17	<2	6	3.8	1.3	1.8	16	4.6	Yes
cBOD	Ver	20	<2	4	3.0	0.7	2.3	9	3.6	Yes
NH_3N	Cal	17	.02	0.41	0.18	0.09	0.06	0.99	0.26	Yes
NH_3N	Ver	20	.04	0.46	0.14	0.10	0.09	0.70	0.23	Yes
NO_3N	Cal	17	.04	0.23	0.09	.06	0	0.45	0.10	Yes
NO_3N	Ver	20	.04	0.21	0.08	.06	0	0.27	0.10	Yes
OrgN	Cal	17	0.41	1.49	0.90	0.23	0.34	1.94	0.72	Yes
OrgN	Ver	20	0.38	1.73	0.94	0.31	0.34	1.06	0.57	Yes
PO_4P	Cal	17	0.04	0.56	0.15	0.15	0.01	0.88	0.16	Yes
PO_4P	Ver	20	.04	0.53	0.16	0.13	0.01	0.41	0.09	Yes
DO	Cal	17	3.7	9.6	7.1	2.0	4.5	10.9	7.1	Yes
DO	Ver	20	4.4	9.4	6.4	1.3	4.8	9.8	6.6	Yes

The User Control Input files (UCI) for the HSPF models, listing all calibrated and non-calibrated parameters, are provided in their entirety in Appendix A (Adams Bayou) and Appendix B (Cow Bayou).

4. RMA2 Hydrodynamic Model

RMA2 is a two-dimensional, vertically averaged, finite element hydrodynamic model supported by the U.S. Army Corps of Engineers. It computes water surface elevations and horizontal velocities for subcritical, free-surface two-dimensional flows. The RMA2 model is comprised of elements and nodes. Elements represent a finite stretch of the channel of a bayou, and hold water. Each element is composed of three or more nodes. Nodes are the points where water surface elevation and velocity calculations are performed, and all linkages between elements occur at nodes. The elements have a trapezoidal shape with characteristic channel bottom width and side slope, which may vary by element to reflect the local shape of the channel (Figure 4-1). Elements may also have off-channel water storage, which is useful for simulating inundated areas such as wetlands, or oxbow channels and reservoirs linked to the bayous. The depth-dependent geometry of the off-channel storage may also be varied to reflect the actual geometry.

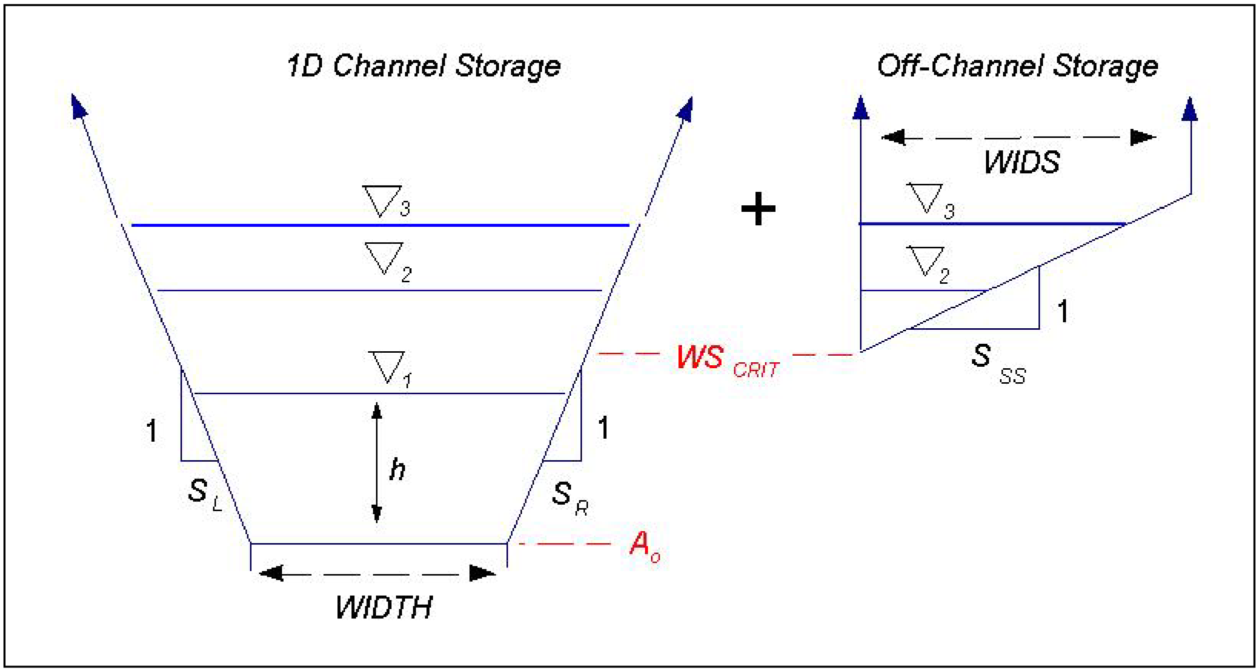

Figure 4-1 RMA2 element (channel) geometry

4.1 RMA2 Model Description

Separate hydrodynamic models were developed for the Adams Bayou and Cow Bayou systems. Both models extend from the Sabine River (the downstream boundary) to near the upstream limits of tidal influence of each bayou and their tributaries. Oxbow channels were also included in the model, either explicitly modeled as discrete elements or included as off-channel water storage attached to the main channel. Figures 4-2 (a-c) and 4-3 (a-e) illustrate the RMA2 model segmentation of Adams Bayou and Cow Bayou, respectively. Adams Bayou and Cow Bayou were simulated with 1-dimensional model elements for simplicity. Table 4-1 includes a summary of RMA2 model segmentation and key parameters.

Table 4-1 RMA2 model summary

Item	Description
Version/Date	RMA2 version 4.5 (5/16/2013 3:08 PM)
Model Period	1/1/2002 – 12/31/2012
Time Step	half-hour
Number of Nodes	153 (Adams Bayou); 159 (Cow Bayou)
Number of Elements	76 (Adams Bayou); 80 (Cow Bayou)
Units	Metric
Friction	Calibrated using Manning's n (values from 0.03 to 0.11 depending on channel properties and water depth)

The key RMA2 model input files include a geometry file and a run control file that lists boundary condition time series. These model files are provided in Appendix C (Adams Bayou) and Appendix D (Cow Bayou).

4.2 RMA2 Inputs and Data Sources

The bottom elevations of the bayous were estimated from measurements made during the field intensive surveys.

Tidal water surface oscillations in the Sabine River drive tidal water movements through the Adams Bayou and Cow Bayou systems. Tide height data from a continuous gauge at the Rainbow Bridge (where SH 87 crosses the Neches River just upstream from Sabine Lake) were used as the Sabine River downstream boundary water surface elevation condition in the models. Water elevations measured with tide gauges deployed near the mouth of Adams and Cow Bayou during the field intensive surveys were not significantly different from those recorded at the Rainbow Bridge gauge. The average daily tidal range at the Rainbow Bridge is 0.284 m (0.93 ft).

Upstream inflows to the model from above tidal reaches were predicted by the calibrated HSPF watershed models and entered as boundary inflows to a number of tributaries. The locations of HSPF inputs are shown in Tables 4-2 and 4-3, which list the linkages of the RMA2 models systems for Adams and Cow Bayous, respectively. Point source discharge inflows were included in the RMA2 model as boundary inflows in the locations identified in Figures 4-2 and 4-3.

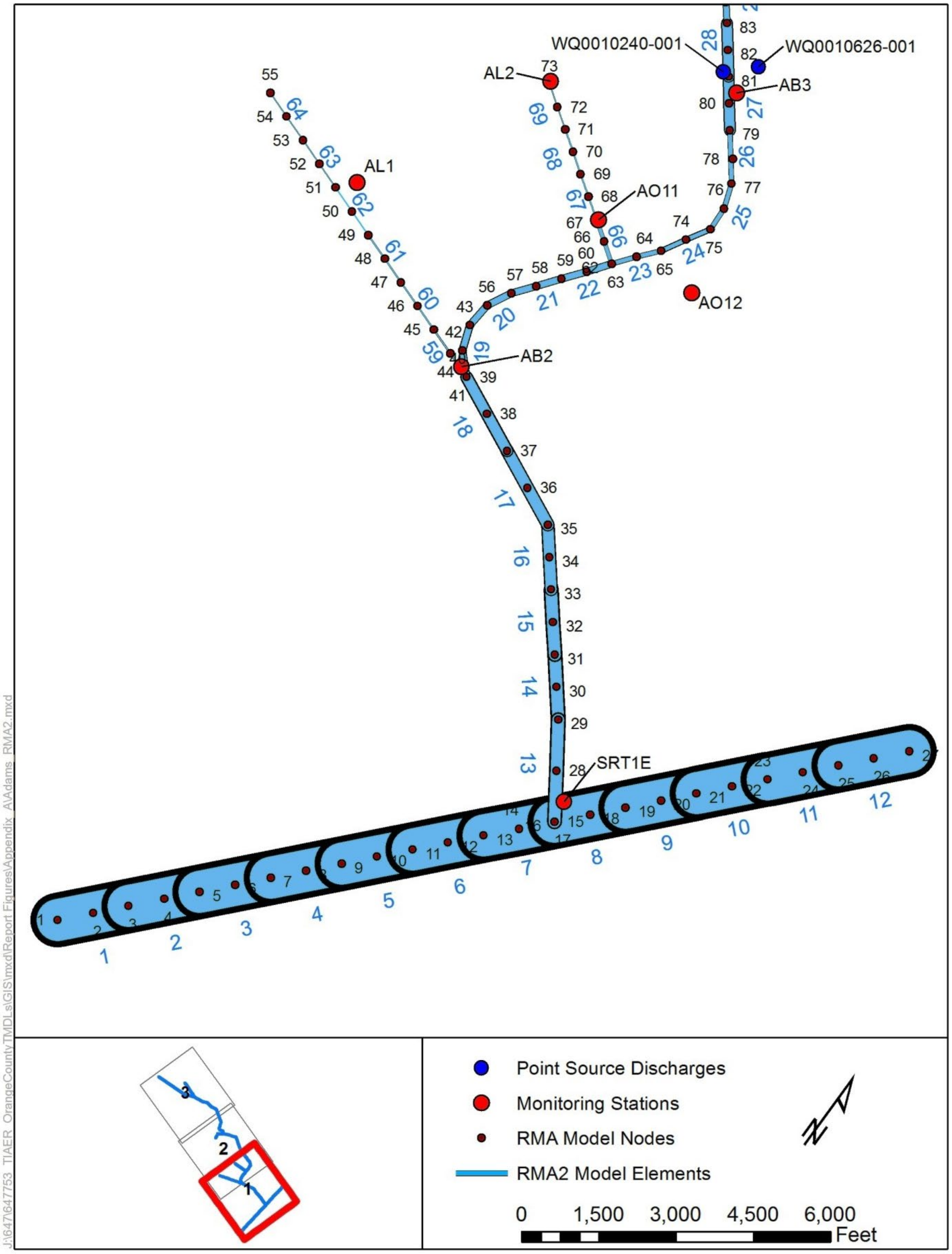

Figure 4-2a Adams Bayou RMA2 model segmentation

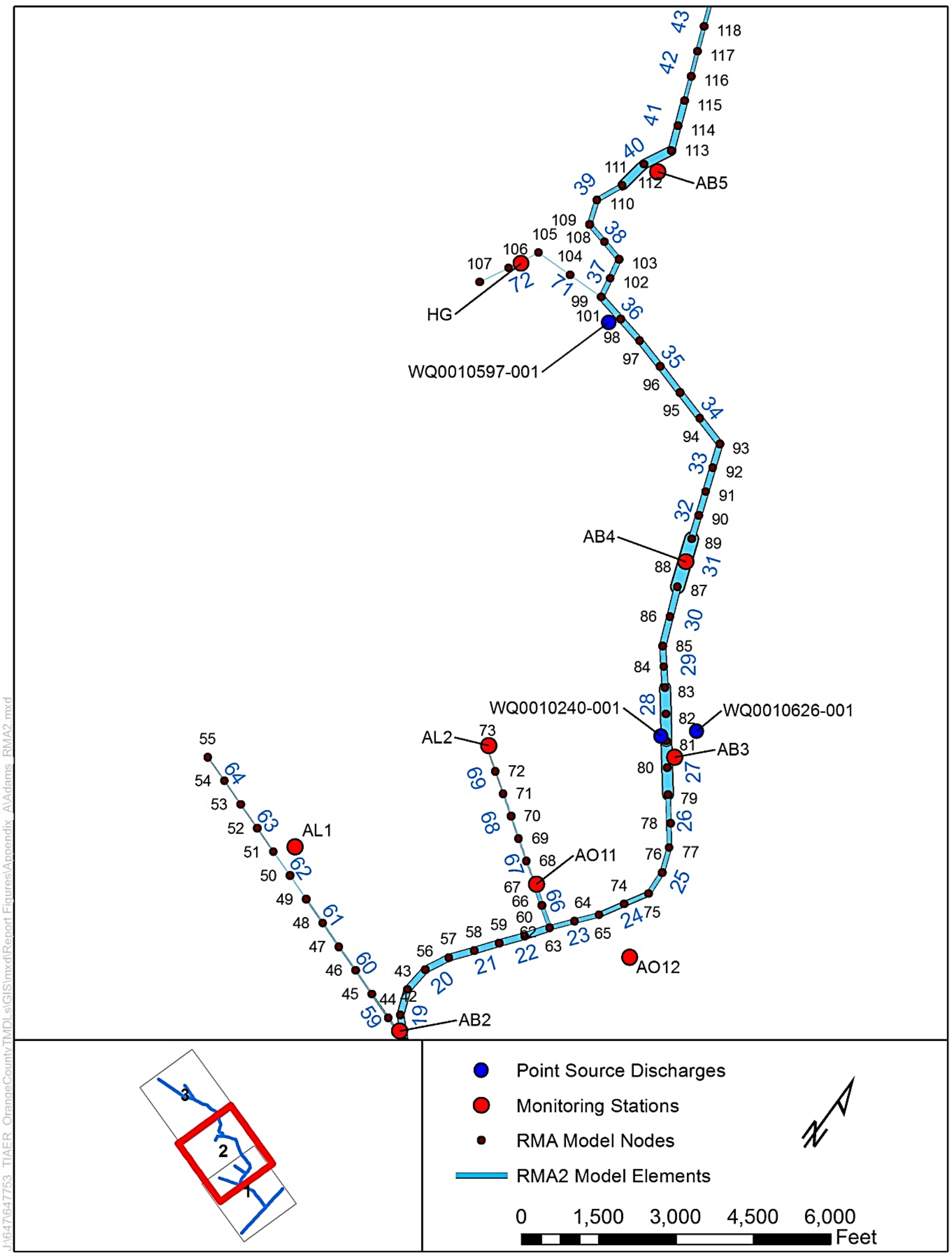

Figure 4-2b Adams Bayou RMA2 model segmentation

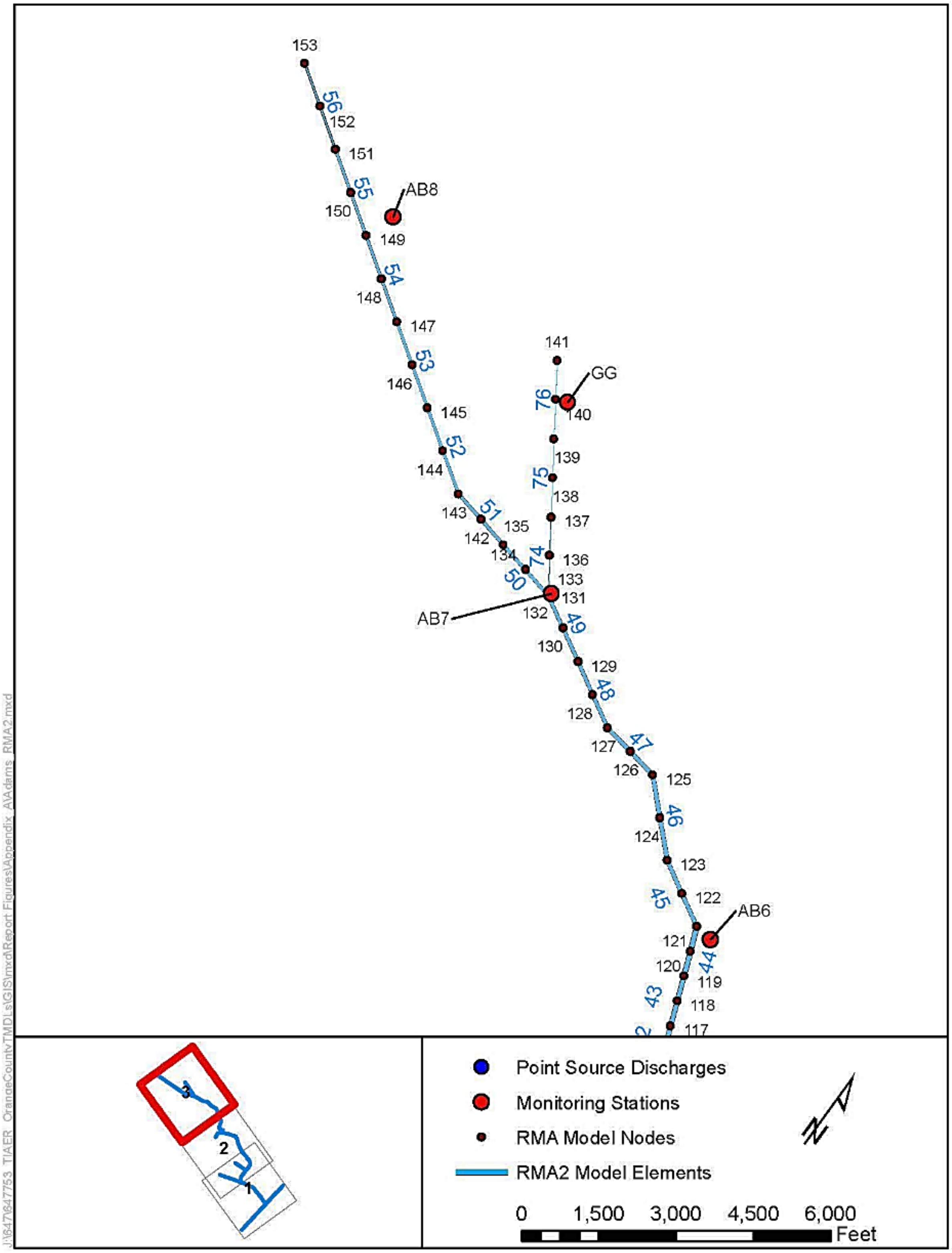

Figure 4-2c Adams Bayou RMA2 model segmentation

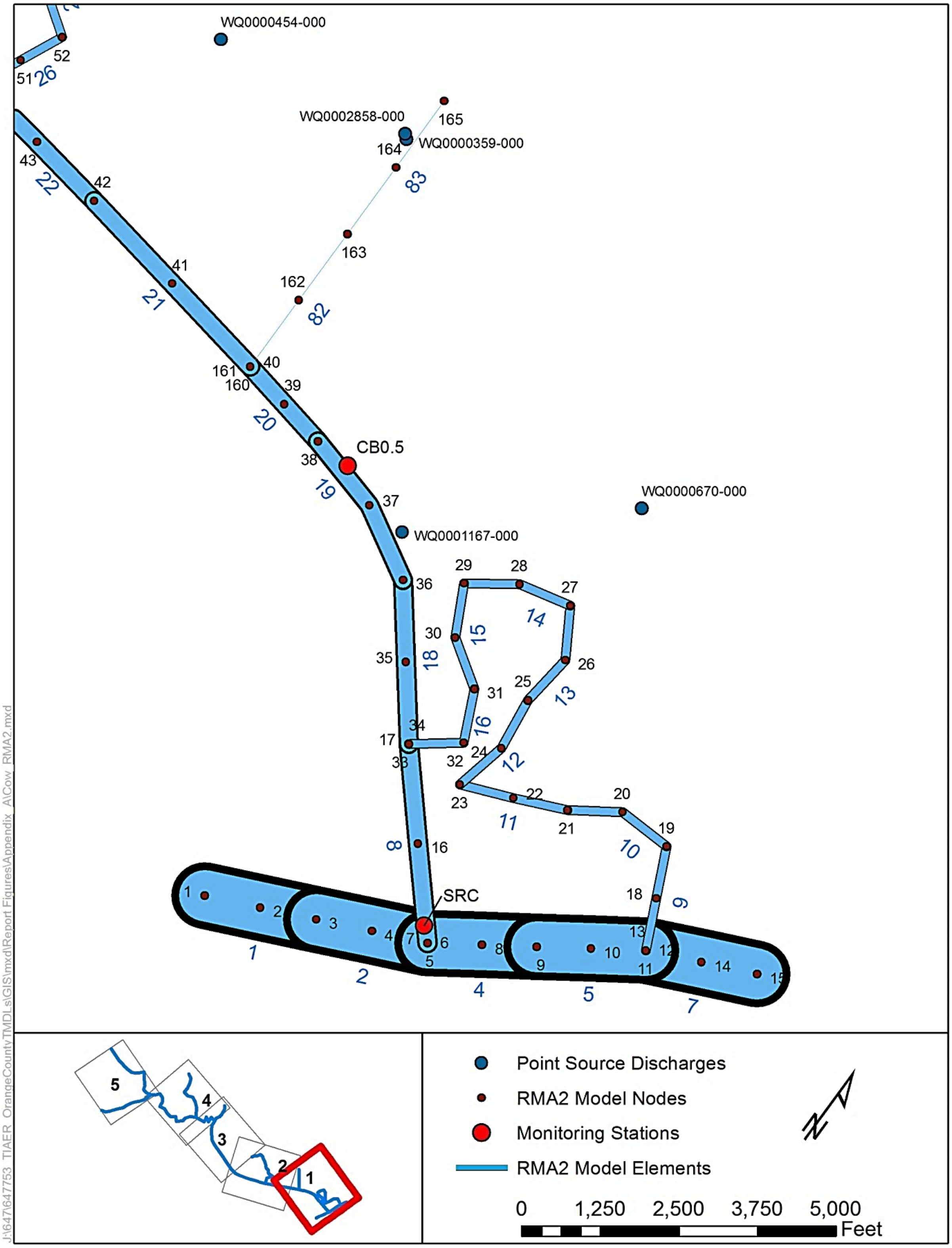

Figure 4-3a Cow Bayou RMA2 model segmentation

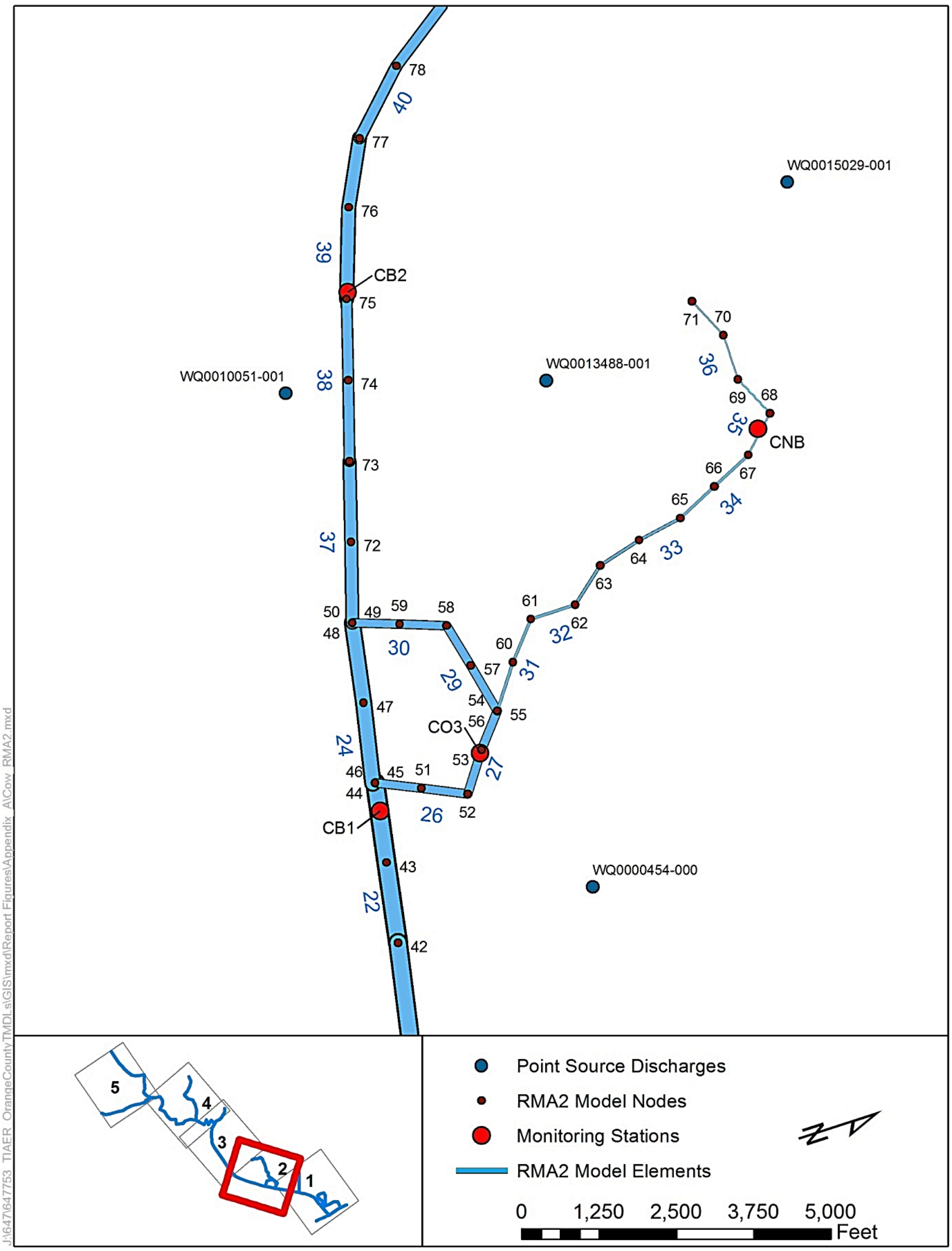

Figure 4-3b Cow Bayou RMA2 model segmentation

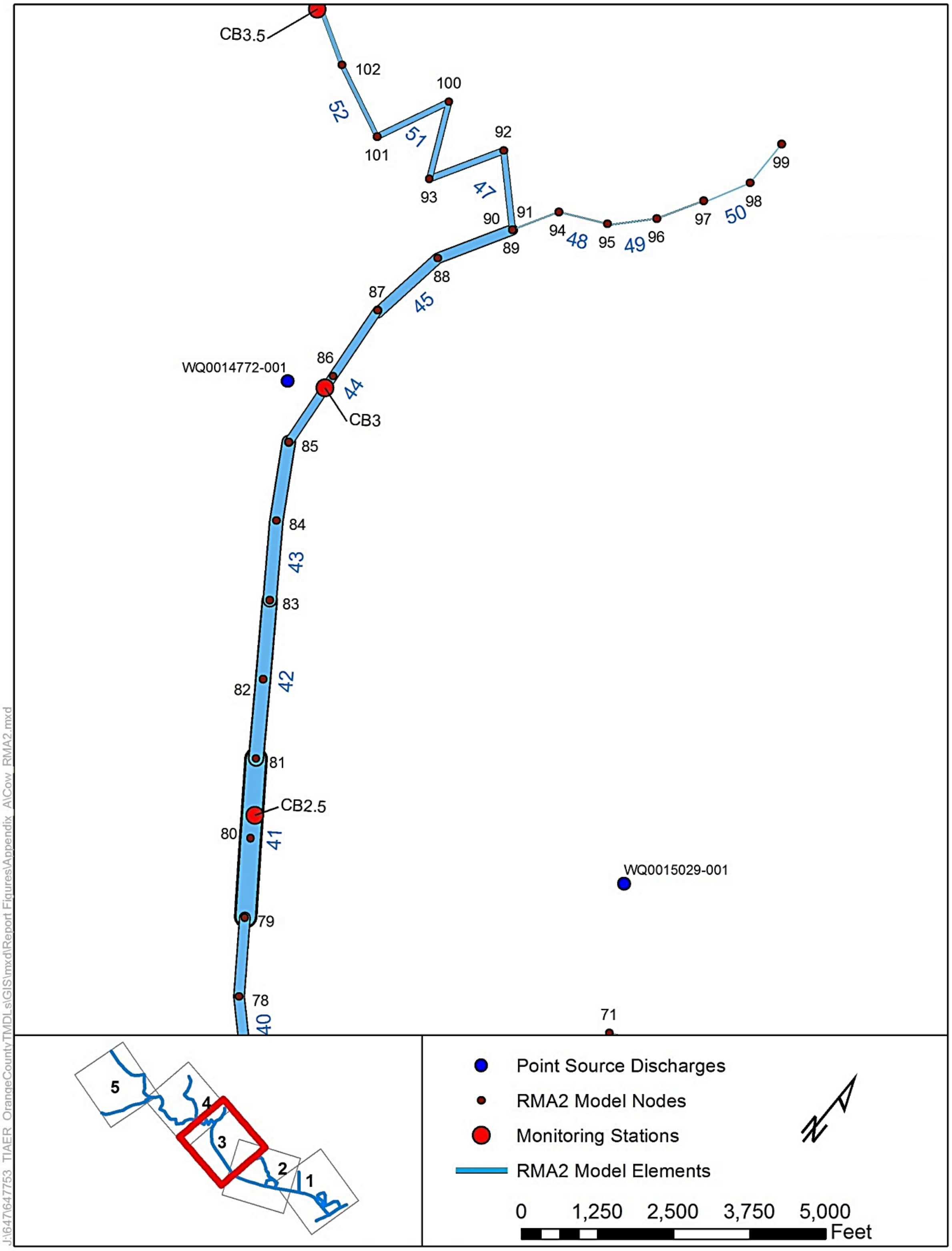

Figure 4-3c Cow Bayou RMA2 model segmentation

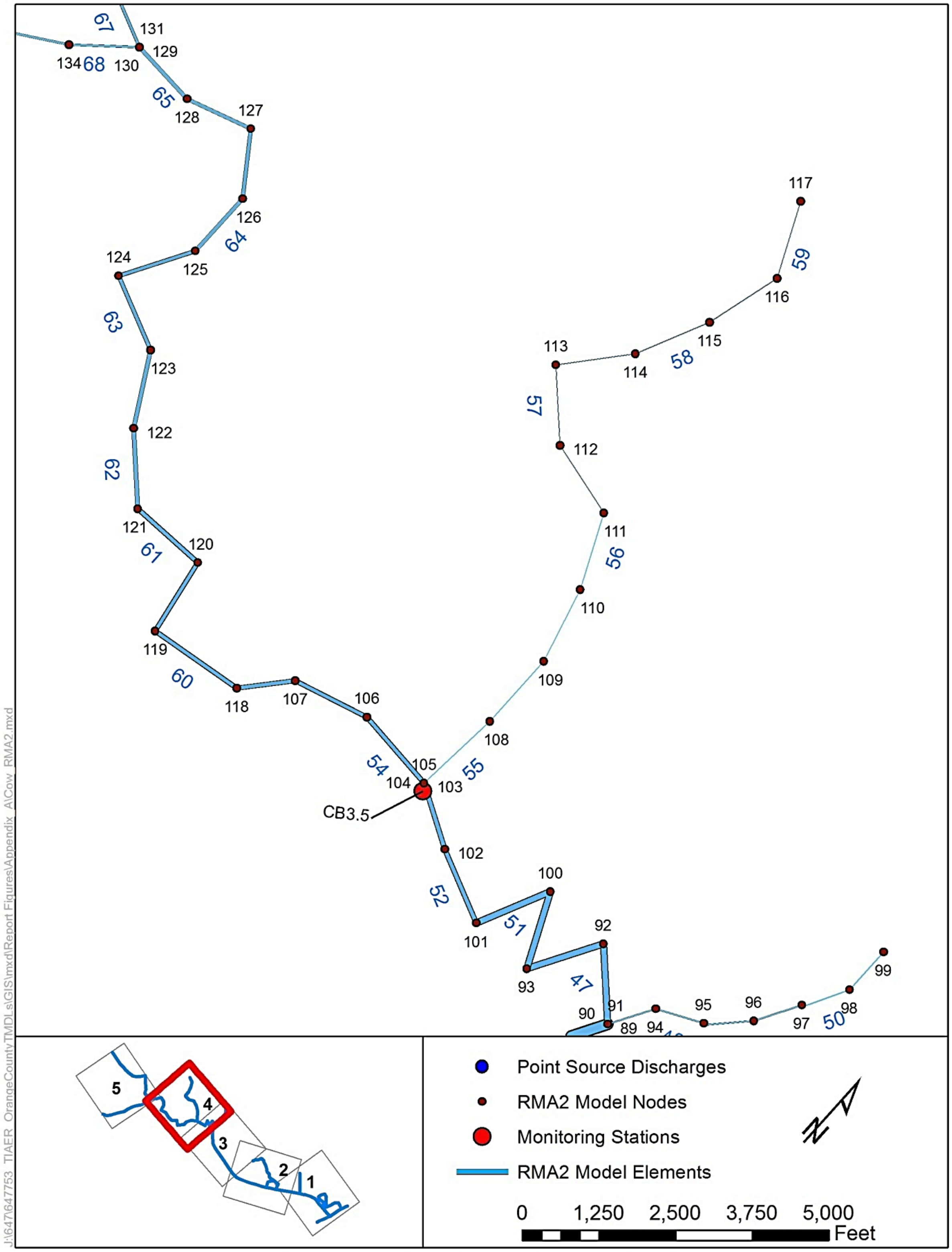

Figure 4-3d Cow Bayou RMA2 model segmentation

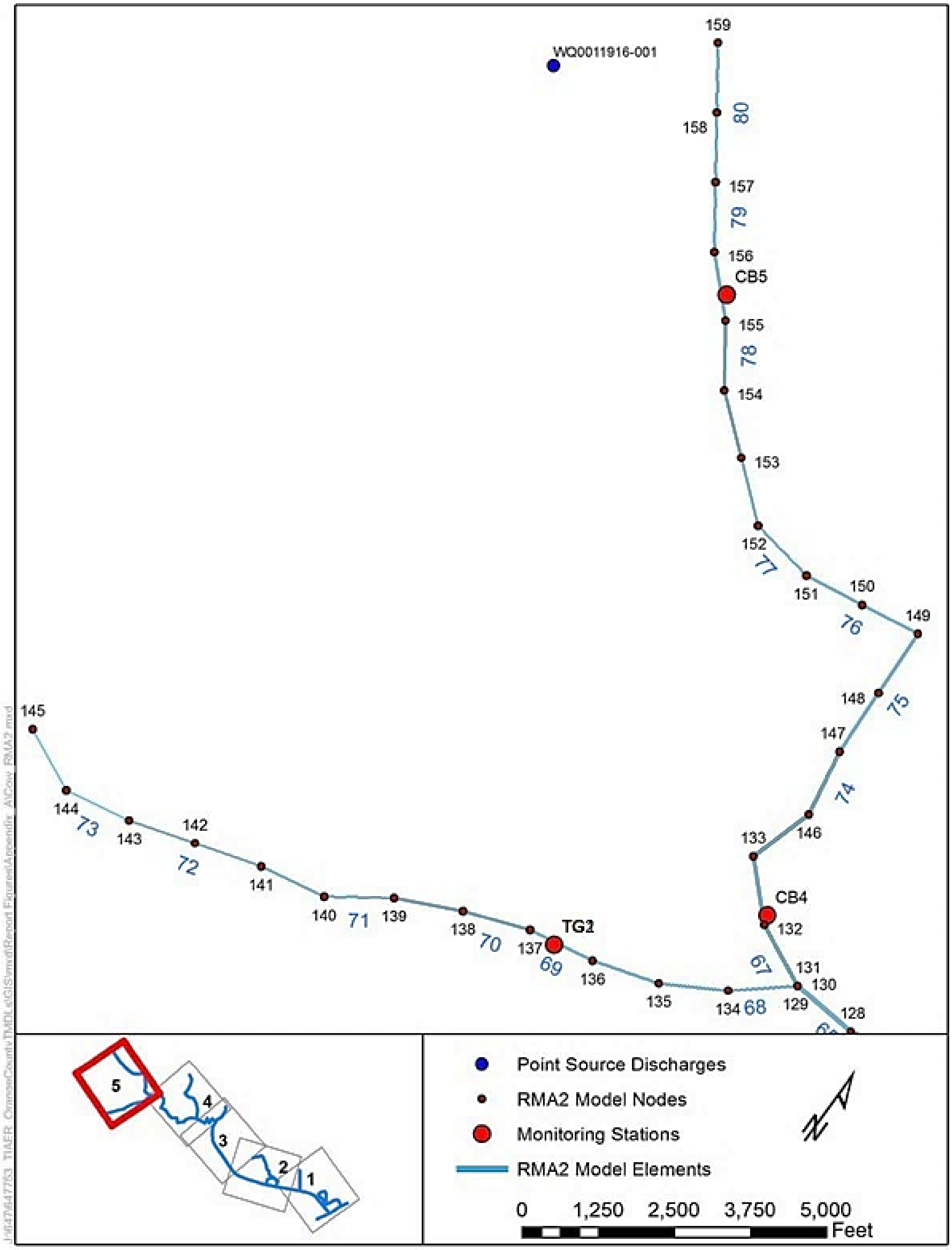

Figure 4-3e Cow Bayou RMA2 model segmentation

Table 4-2 Flow/elevation linkages for the Adams Bayou RMA2 model

Source	Type	RMA Linkage	Frequency	Fraction of Total Flow to Node/Element	Assessment Unit or Location Description
HSPF Sub-basin 1	Inflow	Node 141	Hourly	1.000	0508B_01
HSPF Sub-basin 2	Inflow	Node 153	Hourly	1.000	0508A_01
HSPF Sub-basin 3	Inflow	Element 74	Hourly	1.000	0508B_01
HSPF Sub-basin 4	Inflow	Element 51	Hourly	1.000	0508A_01
HSPF Sub-basin 5	Inflow	Element 47	Hourly	0.696	0508_04
		Element 49	Hourly	0.304	0508A_01
HSPF Sub-basin 6	Inflow	Element 50	Hourly	1.000	0508A_01
HSPF Sub-basin 7	Inflow	Element 41	Hourly	1.000	0508_04
HSPF Sub-basin 8	Inflow	Element 72	Hourly	1.000	0508C_01
HSPF Sub-basin 9	Inflow	Node 73	Hourly	1.000	0508_01
HSPF Sub-basin 10	Inflow	Element 25	Hourly	0.183	0508_01
		Element 27	Hourly	0.294	0508_02
		Element 35	Hourly	0.523	0508_03
HSPF Sub-basin 11	Inflow	Node 55	Hourly	1.000	0508_01
HSPF Sub-basin 12	Inflow	Element 15	Hourly	1.000	0508_01
USGS Gauge 08030500	Inflow	Node 27	Daily	1.000	Sabine River near Ruliff
WQ0010597-001	Inflow	Element 36	Constant	1.000	City of Pinehurst
WQ0010626-001	Inflow	Element 28	Constant	1.000	City of Orange
WQ0010240-001	Inflow	Element 28	Constant	1.000	Orange County WCID 2
Rainbow Bridge water level	boundary elevation	Node 1	30 minutes	Not Applicable	Downstream boundary

Table 4-3 Flow/elevation linkages for the Cow Bayou RMA2 model

Source	Type	RMA Linkage	Frequency	Fraction of Total Flow to Node/Element	Assessment Unit or Location Description
HSPF sub-basin 7	Inflow	Node 117	Hourly	1.000	0511C_01
HSPF sub-basin 8	Inflow	Element 78	Hourly	0.131	0511_04
		Node 159	Hourly	0.869	0511A_01
HSPF sub-basin 9	Inflow	Element 74	Hourly	0.698	0511_03
		Element 75	Hourly	0.302	0511_04
HSPF sub-basin 10	Inflow	Element 58	Hourly	1.000	0511C_01
HSPF sub-basin 11	Inflow	Node 99	Hourly	1.000	0511_02
HSPF sub-basin 12	Inflow	Element 54	Hourly	0.079	0511_02
		Element 64	Hourly	0.921	0511_03
HSPF sub-basin 13	Inflow	Node 145	Hourly	1.000	0511E_01
HSPF sub-basin 14	Inflow	Element 43	Hourly	1.000	0511_02
HSPF sub-basin 15	Inflow	Node 71	Hourly	1.000	0511B_01
HSPF sub-basin 16	Inflow	Element 40	Hourly	0.383	0511_01
		Element 45	Hourly	0.617	0511_02
HSPF sub-basin 17	Inflow	Element 22	Hourly	0.715	0511_01
		Element 82	Hourly	0.285	0511D_01
HSPF sub-basin 18	Inflow	Element 18	Hourly	1.000	0511_01
USGS gauge 08030500	Inflow	Node 15	Daily	1.000	Sabine River near Ruliff
WQ0000670-000	Inflow	Element 14	Constant	1.000	Honeywell International
WQ0001167-000	Inflow	Element 19	Constant	1.000	ARLANXEO USA, LLC
WQ0000454-000	Inflow	Element 21	Constant	1.000	Lion Elastomers
WQ0000359-000	Inflow	Element 83	Constant	1.000	Chevron Phillips Chem.
WQ0002858-000	Inflow	Element 83	Constant	1.000	Printpack, Inc.
WQ0015029-001	Inflow	Element 36	Constant	1.000	Bayou Pines, LLC
WQ0013488-001	Inflow	Element 33	Constant	1.000	Gulflander Partners Group, LP
WQ0010051-001	Inflow	Element 38	Constant	1.000	City of Bridge City
WQ0014772-001	Inflow	Element 44	Constant	1.000	Orangefield WSC
WQ0011916-001	Inflow	Element 79	Constant	1.000	PCS Development Co.
Rainbow Bridge water level	boundary elevation	Node 1	30 minutes	Not Applicable	Downstream boundary

4.3 RMA2 Calibration and Validation

The hydrodynamic models were calibrated to quality-assured water level and flow data collected during an intensive survey performed during the late spring and summer of 2004. The calibration was then verified by comparison to data from a second intensive survey performed approximately one month after the first. Each survey lasted more than 48 hours, covering multiple tidal cycles.

Water levels and water quality were measured and recorded periodically (every 10 to 30 minutes) at 15 stations using sondes that incorporated vented pressure transducers. Because the primary mission of these sondes was to measure water quality mid-channel at approximately 1-m deep, the sondes were deployed in mid-channel secured on chains between an anchor and a float. The float was deployed below the surface to maintain a taut chain. The measured pressures were converted to depths based on internal algorithms programmed in the sonde, which were verified by manual measurements on deployment and retrieval. The depths were then converted to approximate elevations based on comparison of site-measured depths across the tidal cycle to measured elevations at the Rainbow Bridge tide gauge of the National Oceanic and Atmospheric Administration. Although this approach generally resulted in good quality water elevation data, in most cases there were some minor shifts in depth due to movement of the anchor. There was also some correlation between level and flow rate caused by slight “play” in the chain in concert with deflection of the float by the current. In a few cases, the water elevation data or a portion thereof was not usable because of movement by the anchor, tangling of the chain with stream-borne debris, or vandalism to the float. It should also be noted that not all sondes deployed had pressure transducers. Model calibration and validation was performed only with quality-assured data that had been validated in accordance with the QAPP.

Flow was measured by two methods. If a monitoring station was wadeable or easily accessible from a bridge, flow was measured using a Marsh-McBirney electronic meter according to TCEQ standard procedures (TCEQ, 2012). At deeper or less accessible spots, flow was measured using a boat-mounted Sontek™ Acoustic Doppler Profiler (ADP). The Marsh-McBirney measurements involve a single stream transect comprised of many individual point velocity measurements. The ADP measurements involved averaging several complete transects with continuous depth-integrated velocity measurements. In each case, the flow measurement required from 15 to 30 minutes from start to completion. Flow was constantly changing in this tidal system, and the flow measurements should be considered as 30-minute average flows over this period rather than instantaneous flows. Often, flow direction reversed during a measurement, or flow direction changed with depth or position along the transect.

Time series plots (provided in Appendix E for Adams Bayou and Appendix F for Cow Bayou) of observed and modeled water elevations and flow were used to visually evaluate model performance during calibration. Model calibration statistics such as the r^2, ME, MAE, RMSE, and

NSE were used as quantitative measures of model fit to supplement the visual evaluation of fit. The measured flow according to the end time of measurement, was matched with the model-predicted flow for the nearest previous model time step. The model time step was 30 minutes, consistent with the approximate measurement period, but the time differential between observed and model time varied up to 30 minutes. Thus, model fit statistics in time of high flow and elevation changes may indicate a worse fit than a visual comparison implies.

During the calibration process, the primary model parameters that were adjusted were the Manning's roughness coefficients for vegetated and non-vegetated channels. In a few places, the off-channel storage volumes that were not estimable from field measurements were also modified to improve calibration. In the Adams Bayou dredged channels, Manning's roughness was calibrated to 0.06 for both vegetated and non-vegetated channels. For other channels, a Manning's roughness coefficient of 0.09 was applied, gradually increasing to 0.11 at depths less than 2 m. In Cow Bayou, the Manning's roughness coefficient was calibrated to 0.03 in the broad dredged channels, increasing to 0.04 at depths less than 2 m. In the natural channels, the coefficient was calibrated to 0.04 increasing to 0.05 depending on depth. In narrow channels of less than 10-m width, the Manning's roughness coefficient was calibrated to 0.06, increasing to 0.07 at shallow depths.

From the QAPP, the acceptance targets for goodness-of-fit of RMA2 simulation of tidal water levels and flow were as follows:

- The RMSE of simulated tidal water levels to be less than 33 percent of the observed daily tidal range for the calibration and validation periods.
- The RMSE of simulated tidal flows to be less than 33 percent of the range of measured flows at each site where the flow range is greater than 2 cubic meter per second (cms), and less than 50 percent of the range of measured flows at each site where the flow range is 2 cms or less for the calibration and validation periods.

Tables 4-4 and 4-5 provide the model calibration and validation statistics for water elevation at Adams Bayou and Cow Bayou locations. For Adams Bayou locations, the RMSE was on average approximately 0.03 m, or 1.2 inch. The error in the validation model run was slightly higher than that from the calibration period, but still within acceptable limits given a tidal range of more than one foot. It was also noticeable that the model error tended to be greater in the more upstream tidal portions of the system during the validation run. In part, this may be due to a major rainfall event before the second intensive survey, which caused large freshwater inflows. It appears that the HSPF model may have under simulated the runoff from this rainfall event due to inaccuracies in the precipitation input. The influence of runoff and tributary inflow, relative to tide-driven flow, is greater in the narrow and shallow upstream reaches of the bayous. The goodness-of-fit RMSE target was met at all monitoring stations.

Table 4-4 Water level error statistics for the RMA2 hydrodynamic model of Adam Bayou

Acceptable RMSE/Range values in black font and unacceptable values in bold **red** font

Monitoring Station	Calibration Period (May 25 - 28, 2004)								Validation Period (June 28 – July 1, 2004)							
	N†	r^2	Range‡	ME	MAE	NSE	RMSE	RMSE/ Range	N	r^2	Range	ME	MAE	NSE	RMSE	RMSE/ Range
	none	none	m	m	m	None	m	%	none	none	m	m	m	None	m	%
AB2	-	-	-	-	-	-	-	-	246	0.964	0.32	-0.008	0.021	0.920	0.028	8.6%
AB3	242	0.904	0.33	0.018	0.026	0.845	0.029	9.0%	250	0.981	0.32	-0.005	0.015	0.961	0.019	5.9%
AB4	114	0.931	0.24	0.017	0.020	0.818	0.027	11.6%	254	0.978	0.33	0.000	0.015	0.961	0.019	5.8%
AB6	-	-	-	-	-	-	-	-	125	0.954	0.32	0.022	0.026	0.891	0.031	9.5%
AB8	235	0.878	0.30	-0.005	0.023	0.873	0.028	9.4%	250	0.868	0.39	0.081	0.083	0.209	0.090	22.8%
Gum Gully	252	0.912	0.40	-0.005	0.021	0.908	0.025	6.4%	-	-	-	-	-	-	-	-

†number of measurements

‡ maximum measured value – minimum measured value

Table 4-5 Water level error statistics for the RMA2 hydrodynamic model of Cow Bayou

Acceptable RMSE/Range values in black font and unacceptable values in bold **red** font

Monitoring Station	Calibration Period (July 19 – 22, 2004)								Validation Period (August 23 – 26, 2004)							
	N†	r^2	Range‡	ME	MAE	NSE	RMSE	RMSE/ Range	N	r^2	Range	ME	MAE	NSE	RMSE	RMSE/ Range
	none	none	m	m	m	None	m	%	none	none	m	m	m	None	m	%
CB0.5	-	-	-	-	-	-	-	-	133	0.969	0.43	0.001	0.021	0.966	0.025	5.9%
CB1	248	0.959	0.39	-0.003	0.018	0.958	0.021	5.4%	263	0.938	0.44	0.001	0.033	0.936	0.039	8.9%
CB2	249	0.922	0.39	-0.001	0.023	0.924	0.029	7.5%	261	0.968	0.44	0.000	0.023	0.966	0.026	5.9%
CB3	252	0.952	0.42	-0.001	0.020	0.951	0.024	5.8%	260	0.957	0.44	0.000	0.026	0.954	0.030	6.9%
CB3.5	255	0.948	0.42	-0.001	0.019	0.952	0.024	5.8%	-	-	-	-	-	-	-	-
CB4	238	0.814	0.41	0.001	0.036	0.810	0.046	11.2%	254	0.888	0.44	-0.001	0.043	0.878	0.048	11.0%
CB5	256	0.912	0.38	0.001	0.023	0.907	0.029	7.5%	265	0.966	0.44	0.006	0.021	0.960	0.026	5.9%
Coon Bayou	140	0.959	0.34	0.000	0.016	0.959	0.019	5.6%	253	0.971	0.46	0.002	0.020	0.973	0.025	5.4%
Terry Gully	-	-	-	-	-	-	-	-	254	0.865	0.30	-0.029	0.053	0.583	0.066	22.1%

†number of measurements

‡ maximum measured value – minimum measured value

On average, the RMSE was approximately 0.025 m, or 1 inch for Cow Bayou (Table 4-5), similar to that for the Adams Bayou model. Also similar to the Adams Bayou model, error was greater in the upstream portions of the model. The goodness-of-fit RMSE target was met at all monitoring stations.

Tables 4-6 and 4-7 present the error statistics for model flow predictions for Adams Bayou and Cow Bayou, respectively. At most sites the model errors were small relative to the range of flows observed. It was interesting to note that all Adams Bayou sites, including sites considered by TCEQ to be representative of Adams Bayou Above Tidal, exhibited tidal flow patterns. The goodness-of-fit RMSE target was met at all monitoring stations of the Adams Bayou system.

The goodness-of-fit RMSE target (RMSE/measured range), however, was not met at all monitoring stations of the Cow Bayou system. The RMSE values in the Cow Bayou system not meeting the target are provided in bold **red** font in Table 4-7. For monitoring stations CB4, CB5, and Coon Bayou, the missed RMSE target can reasonably attributed as an artifact of the monitoring. At all three of these monitoring stations, only three flow measurements were made and each occurred on ebb (or downstream-directed flow) for the simulated period in which the performance target was not met. The flow monitoring at these stations resulted in an artificially small flow range during these periods, which explains why the target was missed and could not be met through reasonable adjustments during the calibration process. Also of note at these three stations, water-level tidal fluctuations were well simulated and the flow RMSE target was meet during the other simulated period (either calibration or validation) where measured flow data provided a more reasonable range.

This explanation of limited flow measurements cannot explain the missed RMSE target at Terry Gully, where seven measurements were made during the calibration period and eight measurements were made during the validation period. The model performance and measured data at the Terry Gully site remained an anomaly without ready explanation. Water levels were only measured during the validation period at Terry Gully (Table 4-5). During this period, the measured Terry Gully water levels show a low-water bench below which levels do not drop in an uncharacteristic manner (Figure F-34) compared to all other measured water levels of Cow Bayou stations and, also, Adams Bayou stations. The measured water-level response seems to indicate some type of obstruction, such as a sedimentation sill, that precludes the decrease of water levels beyond some minimum elevation of around -0.25 ft relative to mean sea level. The absence of a measured flow reversal with no upstream directed flows (Figures F-33 and F-35) further supports something obstructing tidal propagation into Terry Gully.

Table 4-6 Flow error statistics for the RMA2 hydrodynamic model of Adams Bayou

Acceptable RMSE/Range values in black font and unacceptable values in bold **red** font

Monitoring Station	Calibration Period (May 25 - 28, 2004)								Validation Period (June 28 – July 1, 2004)							
	N†	r^2	Range‡	ME	MAE	NSE	RMSE	RMSE/ Range	N	r^2	Range	ME	MAE	NSE	RMSE	RMSE/ Range
	None	None	cms	cms	cms	None	cms	%	None	None	cms	cms	cms	None	cms	%
AB2	7	0.909	38.62	-0.72	2.12	0.89	3.50	9.1%	8	0.909	38.62	-0.67	2.76	0.87	3.39	8.8%
AB3	7	0.759	26.36	-0.95	2.53	-0.55	3.35	12.7%	8	0.650	26.36	1.54	3.77	0.49	4.63	17.6%
AB4	4	0.741	19.00	-1.43	1.43	0.33	2.32	12.2%	8	0.824	19.00	1.38	2.85	0.68	3.45	18.2%
AB5	3	0.964	16.14	-0.37	0.66	0.91	0.90	5.6%	8	0.864	16.14	1.03	2.32	0.74	2.61	16.2%
AB6	8	0.864	8.66	-0.04	0.70	0.15	0.77	8.9%	8	0.840	8.66	1.41	1.63	0.49	1.84	21.2%
AB7	9	0.191	5.55	-0.49	0.79	-4.33	0.95	17.1%	9	0.665	5.55	0.42	0.95	0.49	1.10	19.9%
AB8	9	0.416	3.80	-0.15	0.20	-0.05	0.23	6.2%	9	0.885	3.80	0.56	0.87	0.29	1.02	26.9%
Gum Gully	5	0.585	0.96	-0.02	0.02	-0.46	0.03	3.1%	5	0.100	0.96	-0.22	0.29	-0.47	0.36	37.1%
Hudson Gully	9	0.203	0.20	0.01	0.03	-0.36	0.04	18.2%	7	0.489	0.20	0.04	0.04	-0.43	0.05	26.2%

† number of measurements

‡ maximum measured value minus minimum measured value

Table 4-7 Flow error statistics for the RMA2 hydrodynamic model of Cow Bayou

Acceptable RMSE/Range values in black font and unacceptable values in bold **red** font

Monitoring Station	Calibration Period (May 25 - 28, 2004)								Validation Period (June 28 – July 1, 2004)							
	N†	r^2	Range‡	ME	MAE	NSE	RMSE	RMSE/ Range	N	r^2	Range	ME	MAE	NSE	RMSE	RMSE/ Range
	None	None	cms	cms	cms	None	cms	%	None	None	cms	cms	cms	None	cms	%
CB0.5	4	0.933	77	7.30	8.87	0.80	12.88	16.8%	7	0.736	78.86	4.79	18.24	0.72	21.63	27.4%
CB1	5	0.857	67	0.46	8.25	0.85	8.84	13.1%	7	0.888	60.94	3.05	7.26	0.85	10.17	16.7%
CB2	5	0.838	46	2.37	6.22	0.79	7.26	16.0%	7	0.778	46.07	-0.45	7.69	0.77	8.92	19.4%
CB2.5	5	0.955	24	-2.25	3.00	0.86	3.30	13.7%	7	0.945	28.23	1.80	3.19	0.89	3.56	12.6%
CB3	6	0.938	20	-1.23	2.69	0.80	2.82	13.9%	7	0.828	21.78	-0.68	4.55	0.70	4.71	21.6%
CB3.5	5	0.763	9	0.00	1.15	0.75	1.54	17.5%	7	0.786	12.52	0.16	2.41	0.74	2.62	21.0%
CB4	4	0.570	1.1	-0.30	0.33	-0.60	0.39	34.3%	3	0.632	0.69	-0.30	0.33	-0.60	0.39	**56.3%**
CB5	3	0.995	0.1	-0.05	0.10	-1.12	0.10	**66.6%**	6	0.340	0.64	0.06	0.19	0.18	0.24	37.3%
Coon Bayou	3	0.183	0.5	-0.13	0.25	-0.68	0.26	**55.7%**	5	0.466	0.86	-0.03	0.22	0.42	0.24	27.4%
Terry Gully	7	0.773	0.5	-0.43	0.43	-8.91	0.50	**98.4%**	8	0.664	0.41	-0.22	0.30	-6.64	0.48	**117.8%**

†number of measurements

‡ maximum measured value minus minimum measured value

No obstruction could be documented along Terry Gully based on review of digital elevation model datafiles, satellite and aerial imagery, nor in the input data used in the flood plain studies of Carroll and Blackmann (Carroll and Blackmann, 2015). Communications with Orange County Drainage District staff also failed to produce any evidence of an obstruction in Terry Gully. It would be highly likely that modifying the RMA2 model to represent a physical obstruction between the Terry Gully monitoring station and its downstream entry into Cow Bayou would have benefitted the model performance. There was, however, no justification for making such a modification to the model other than what the measured data showed. Since Terry Gully (AU 0511E_01) is not impaired for depressed DO and, therefore, not an area of focus in the modeling system, the decision was made to leave the RMA2 model as it was constructed based on best available data and to accept the poor performance at this location regarding flow.

Tables 4-8 and 4-9 show the model parameters used for the Adams Bayou and Cow Bayou RMA2 models, respectively.

Table 4-8 Parameters of the Adams Bayou RMA2 model

Parameter	Units	Source[1]	Value or Range
EX - Turbulent Exchange Coefficient, X-direction	Pascal-second	L	5000
EY - Turbulent Exchange Coefficient, Y-direction	Pascal-second	L	5000
AO - bottom elevation	m	F	-15.0 – -1.3
WIDTH - channel width at zero depth	m	F	2 - 43
SS1 - left side slope	m	F	0.5 – 19.7
SS2 - right side slope	m	F	0.5 – 19.7
WIDS - off-channel storage width	m/m	F	0 – 200
WSCRIT – water surface elevation to activate off-channel storage	m	F	-2.4 – 0
SSS - side slope for off channel storage	m	F	0 - 200
RDR0 – maximum Manning's "n"[2] value for non-vegetated water	complex	C	0.06 – 0.09
RDD0 – depth at which vegetation affects roughness	m	L	2
RDRM – Manning's n-value for vegetated water	complex	C	0.06 – 0.11
RDCOEF – roughness by depth coefficient	none	L	1E-14
DSET – depth at which nodes are considered dry and deactivated	m	L	0.084
DSETD – depth at which nodes become active when rewetted	m	L	0.183

[1] F = collected data, L = literature, C=calibration
[2] automatic roughness assignment based on depth

Table 4-9 Parameters of the Cow Bayou RMA2 model

Parameter	Units	Source[1]	Value or Range
EX - Turbulent Exchange Coefficient, X-direction	Pascal-second	L	5000
EY - Turbulent Exchange Coefficient, Y-direction	Pascal-second	L	5000
AO - bottom elevation	m	F	-15.0 – -1.1
WIDTH - channel width at zero depth	m	F	1 – 100
SS1 - left side slope	m	F	0.5 – 10
SS2 - right side slope	m	F	0.5 – 10
WIDS - off-channel storage width	m/m	F	0 – 200
WSCRIT – water surface elevation to activate off-channel storage	m	F	-10 – 0
SSS - side slope for off channel storage	m	F	0 – 200
RDR0 – maximum Manning's "n"[2] value for non-vegetated water	complex	C	0.03 – 0.06
RDD0 – depth at which vegetation affects roughness	m	L	2
RDRM – Manning's n-value for vegetated water	complex	C	0.04 – 0.07
RDCOEF – roughness by depth coefficient	none	L	1E-14
DSET – depth at which nodes are considered dry and deactivated	m	L	0.084
DSETD – depth at which nodes become active when rewetted	m	L	0.183

[1] F = collected data, L = literature, C=calibration
[2] automatic roughness assignment based on depth

5. WASP Water Quality Model

WASP is a generalized framework for simulating water quality in surface waters and the underlying sediments. It can be applied in one, two or three dimensions. The time-varying processes of advection, dispersion, point- and nonpoint-source pollutant loading, and boundary exchange are included in the basic program. Several independent WASP modules are provided. The EUTRO module is designed to simulate nutrients, DO, and eutrophication. The advanced eutrophication module also simulates nutrients, DO, and eutrophication, but also permits simulation of three groups of phytoplankton and cBOD, periphyton, and includes a linked sediment diagenesis module. The TOXI module simulates organic contaminant fate and transport. The HEAT module simulates temperature and salinity. The mercury module simulates various mercury species and sediment balances.

5.1 WASP Model Description

For this project, the eutrophication module in WASP version 7.52 was applied to simulate DO in two separate models, one for each bayou system. Table 5-1 summarizes key WASP modeling parameters. Figures 5-1 (a-c) and 5-2 (a-e) show the segmentation of the Adams and Cow models, respectively, and Tables 5-2 and 5-3 describe the physical dimensions of WASP reaches. Segmentation of the RMA2 and WASP models was based on the TCEQ boundary map of AUs allowing association of the segmentation to the representation of each AU in the boundary map.

Table 5-1 WASP model summary

Item	Description
Version/Date	WASP 7.52 (1/24/2013 2:10 PM)
Model Period	1/1/2002 – 12/31/2012
Time Step	dynamic; input frequency varies; set to output daily
Segments	118 (Adams Bayou); 136 (Cow Bayou)
Simulated constituents	Salinity, TSS, NH_3N, NO_3N, OrgN, Detrital N, PO_4P, OrgP, Detrital P, CBOD (ultimate), Detrital C, Phytoplankton Chla, DO
Point source wastewater discharges	Active: 2 to Adams Bayou (WQ0010626-001 and WQ0010240-001 are combined since they discharge to the same WASP segment). 9 to Cow Bayou (WQ0010808-001 and WQ WQ0002835-000 are included in the HSPF model and WQ0000359-000 and WQ0002858-000 are combined since they discharge to the same WASP segment).

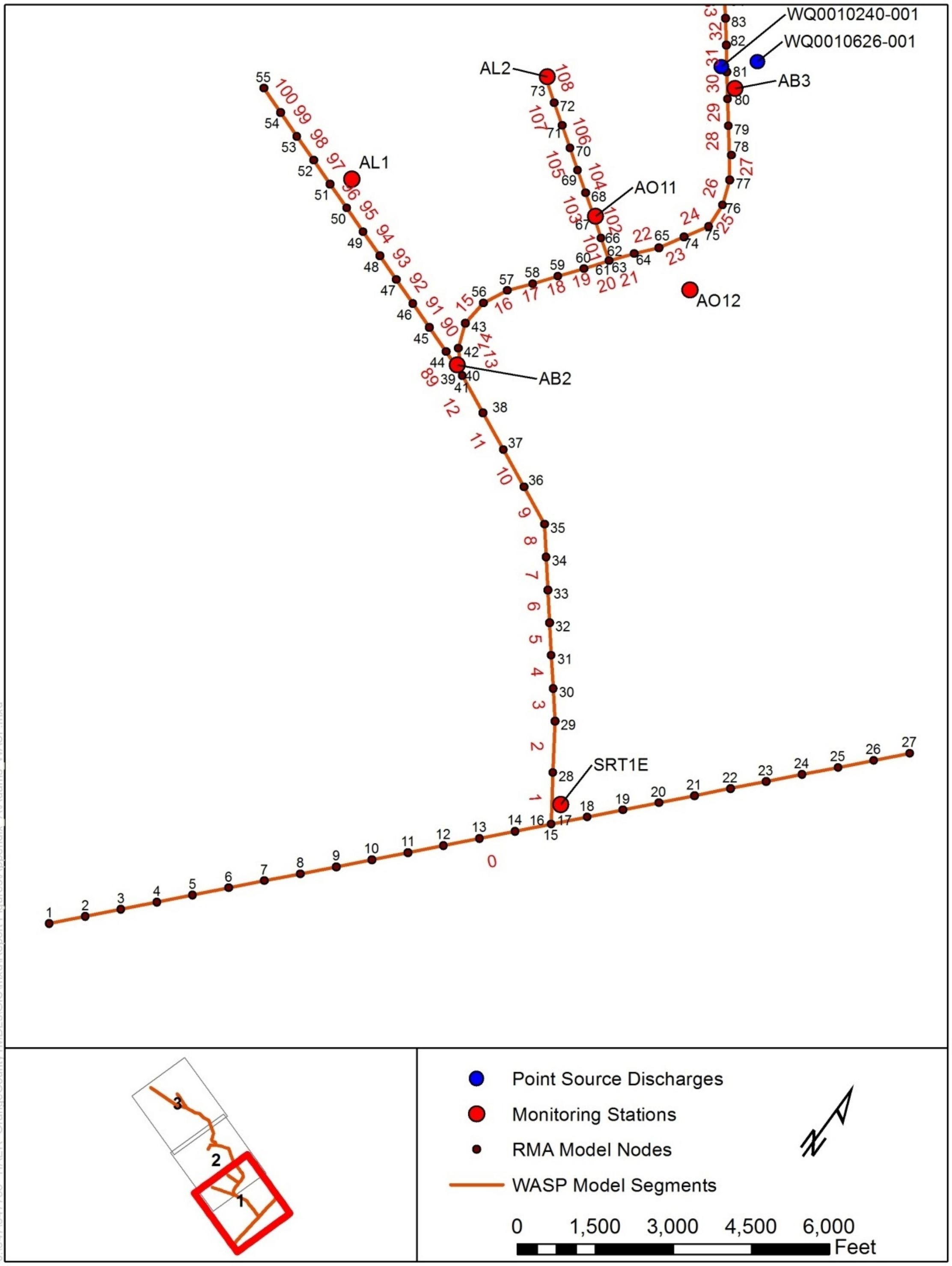

Figure 5-1a Adams Bayou WASP model segments

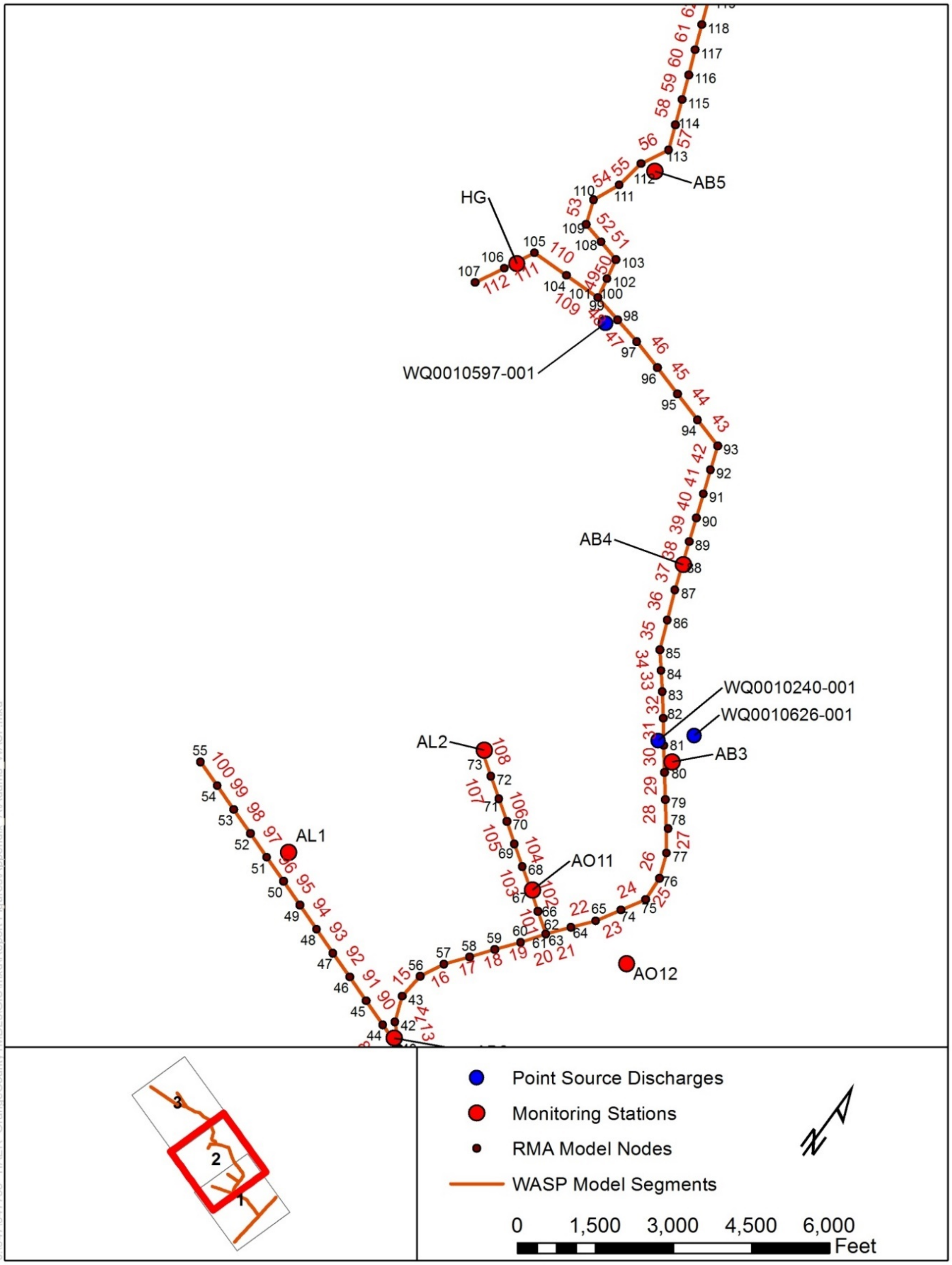

Figure 5-1b Adams Bayou WASP model segments

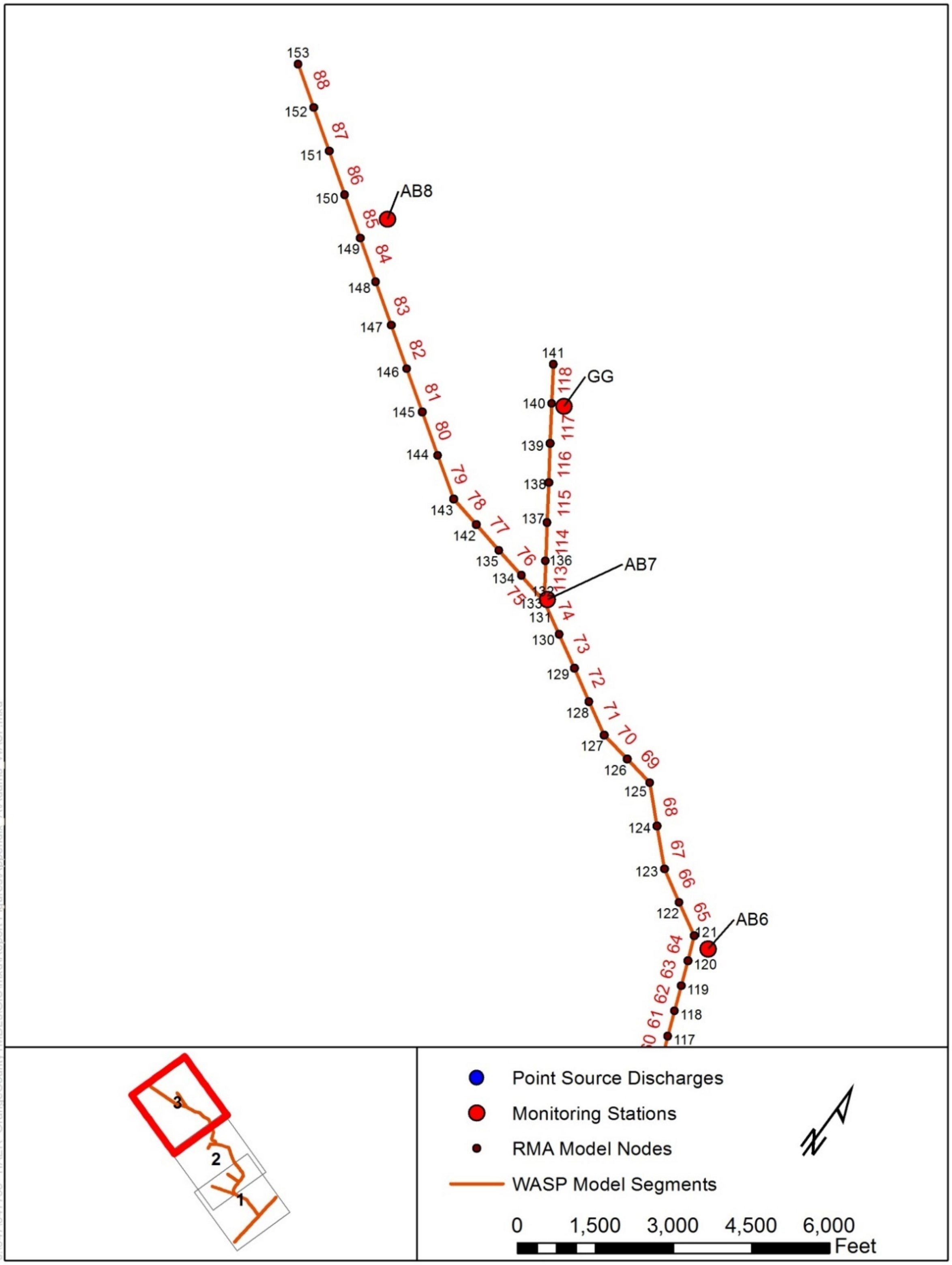

Figure 5-1c Adams Bayou WASP model segments

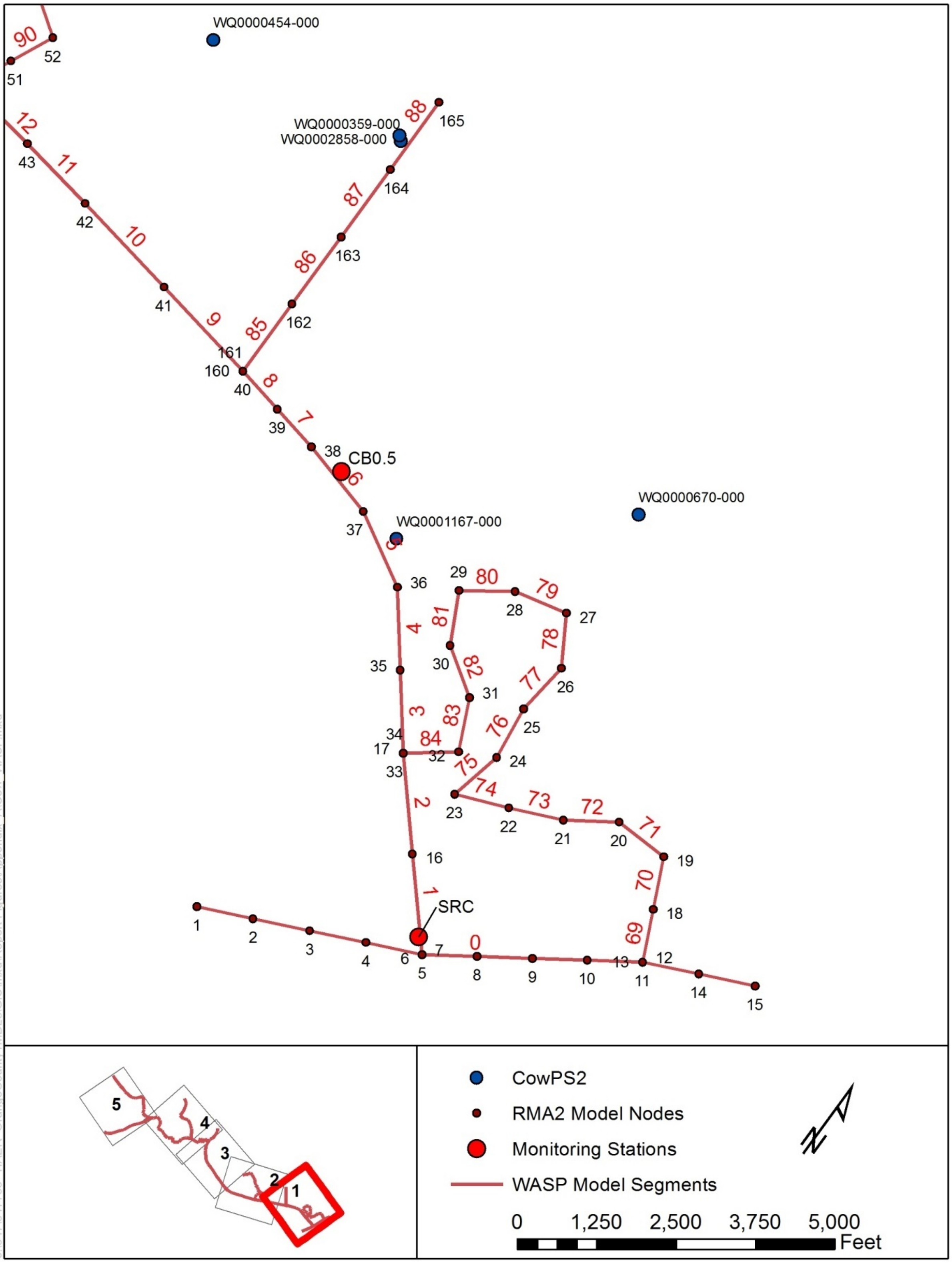

Figure 5-2a Cow Bayou WASP model segments

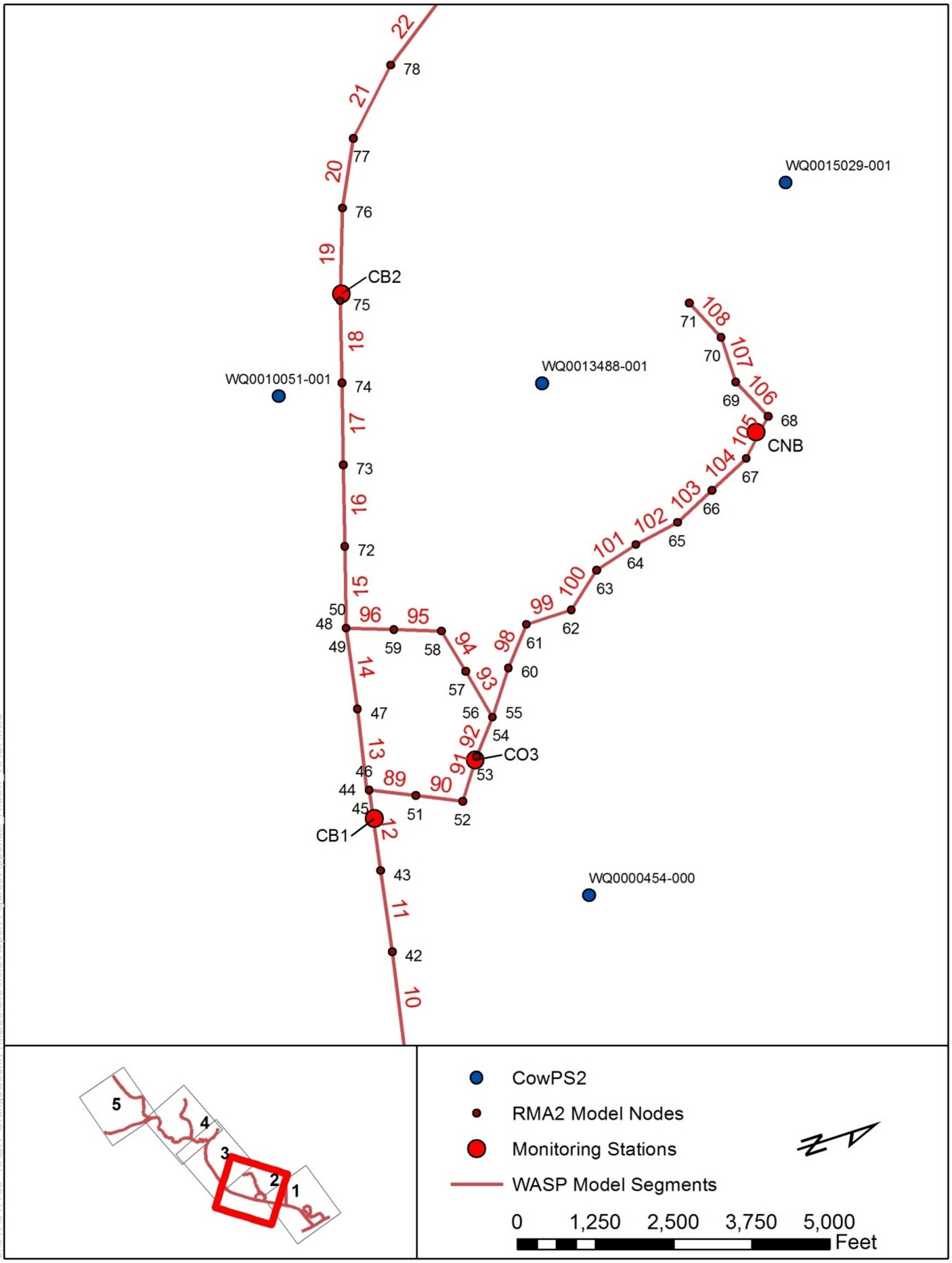

Figure 5-2b Cow Bayou WASP model segments

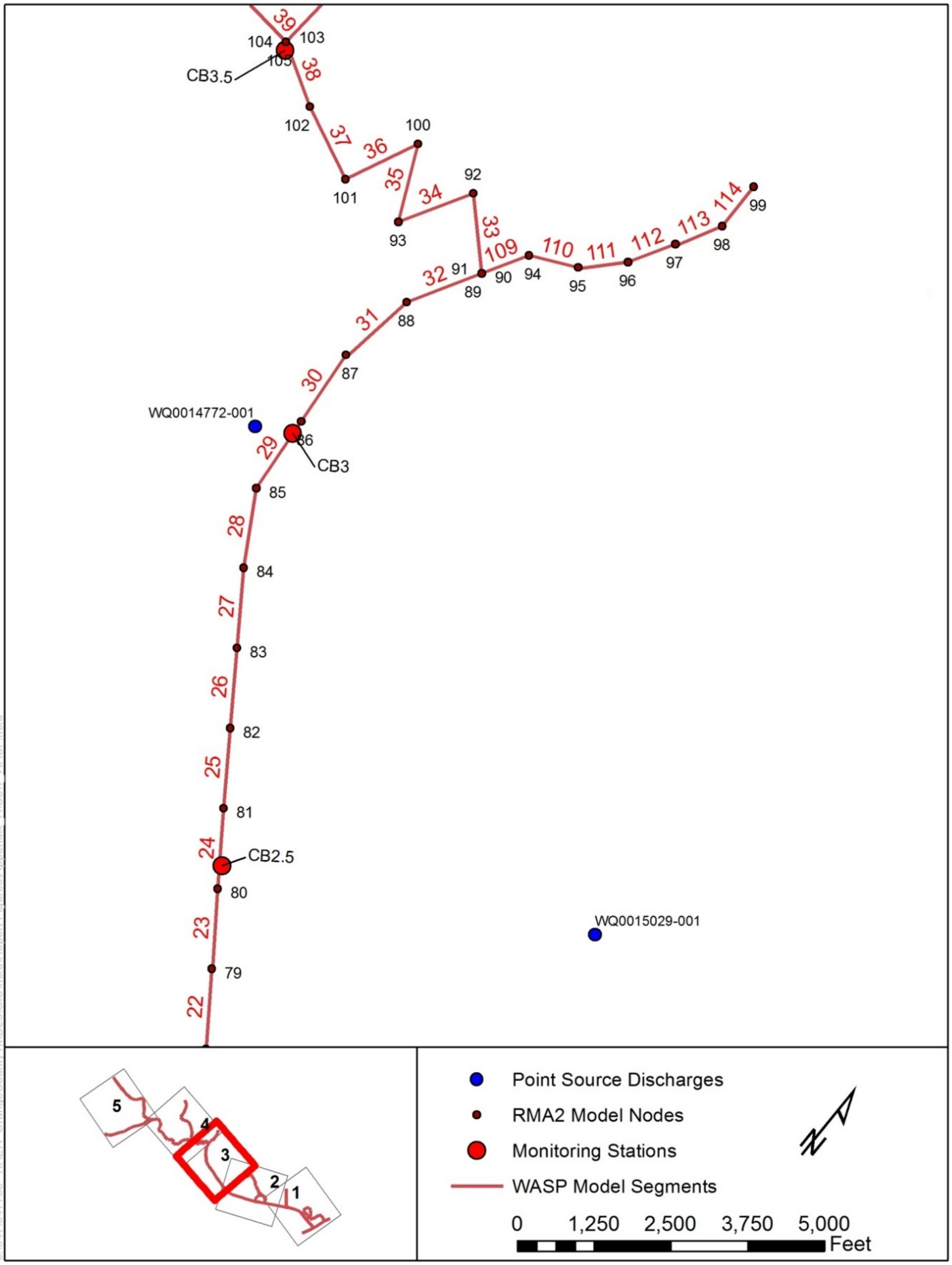

Figure 5-2c Cow Bayou WASP model segments

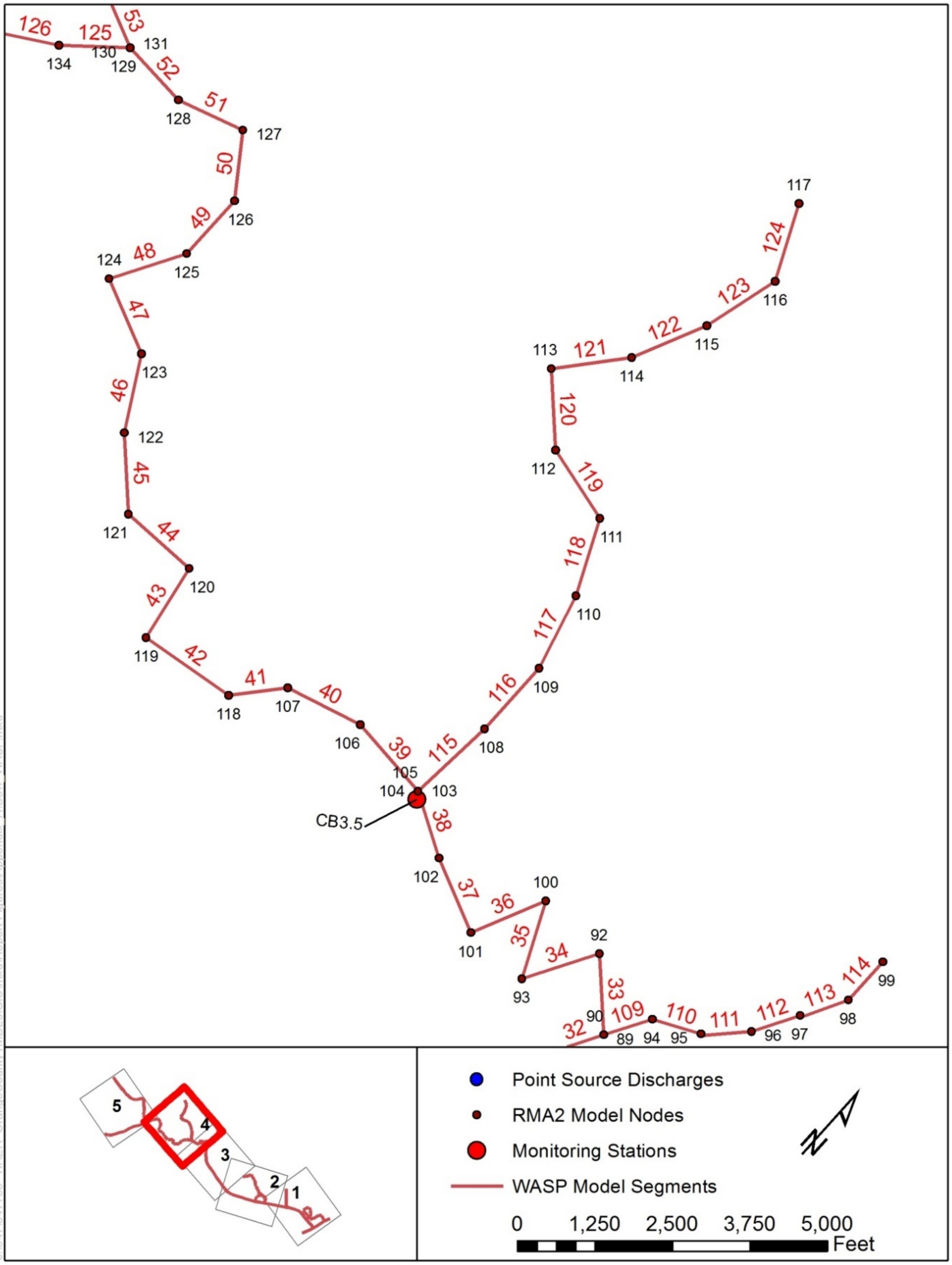

Figure 5-2d Cow Bayou WASP model segments

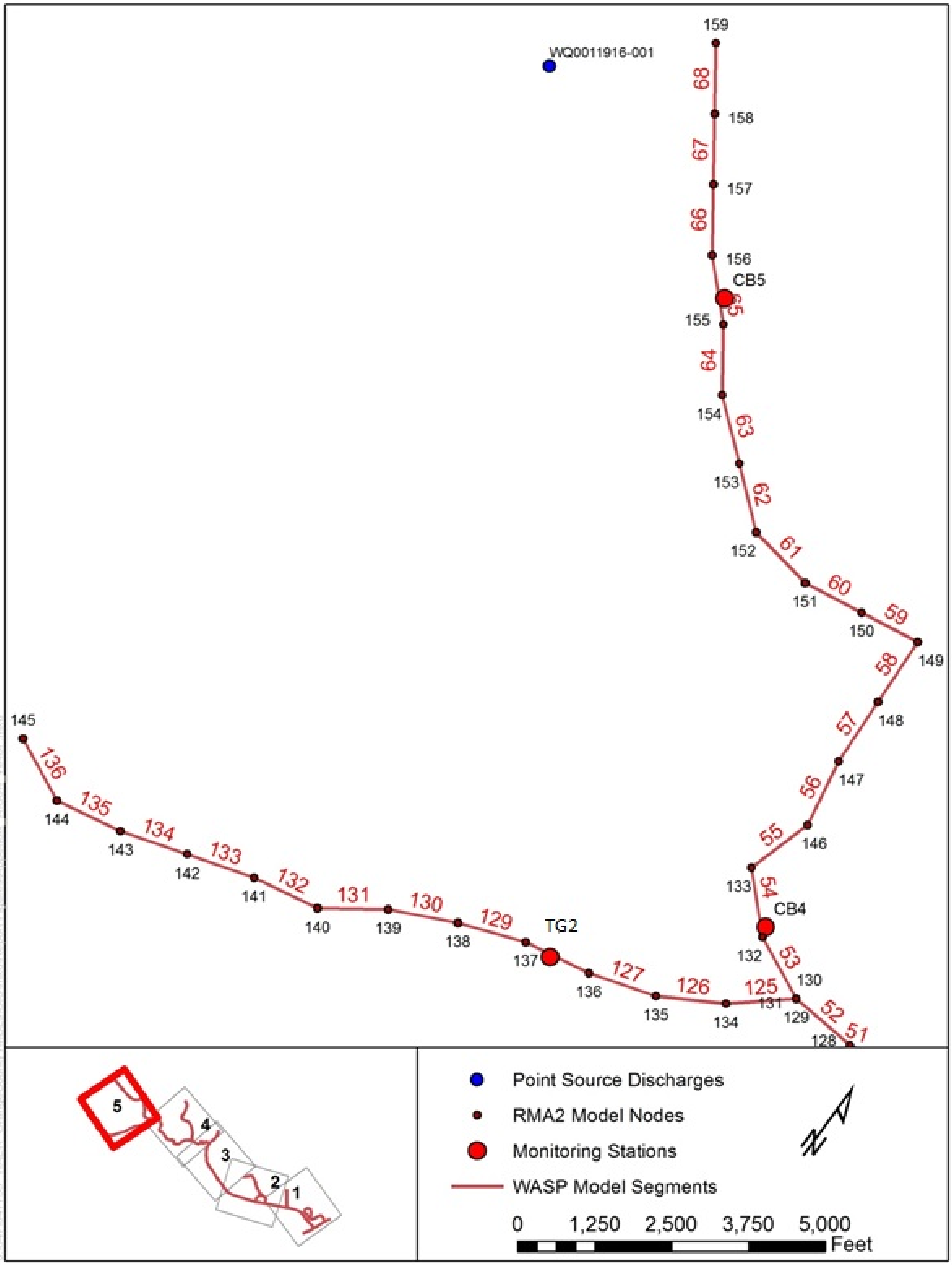

Figure 5-2e Cow Bayou WASP model segments

Table 5-2 Physical properties of Adams Bayou WASP model segments

Segment	Segment Name	AU	TCEQ Monitoring Site ID (Label)	Volume (m^3)	Average Maximum Segment Depth below Mean Sea Level (m)	Length (m)	Width (m)
1	Adams Bayou Tidal	0508_01		144,552	5.2	413	43
2	Adams Bayou Tidal	0508_01		60,247	4.8	193	43
3	Adams Bayou Tidal	0508_01		108,436	4.8	193	43
4	Adams Bayou Tidal	0508_01		137,354	4.8	193	43
5	Adams Bayou Tidal	0508_01		118,074	4.8	193	43
6	Adams Bayou Tidal	0508_01		118,074	4.8	193	43
7	Adams Bayou Tidal	0508_01		99,993	4.8	193	39
8	Adams Bayou Tidal	0508_01		81,913	4.8	193	35
9	Adams Bayou Tidal	0508_01		105,899	4.8	249	35
10	Adams Bayou Tidal	0508_01		102,972	4.8	249	33
11	Adams Bayou Tidal	0508_01		118,739	4.8	249	30
12	Adams Bayou Tidal	0508_01		132,371	4.7	249	27
13	Adams Bayou Tidal	0508_01	10441 (AB2)	52,491	4.7	160	21
14	Adams Bayou Tidal	0508_01		46,019	4.7	155	18
15	Adams Bayou Tidal	0508_01		38,509	4.7	158	18
16	Adams Bayou Tidal	0508_01		30,271	4.6	158	18
17	Adams Bayou Tidal	0508_01		29,124	4.6	154	18
18	Adams Bayou Tidal	0508_01		29,141	4.5	156	18
19	Adams Bayou Tidal	0508_01		28,991	4.5	157	18
20	Adams Bayou Tidal	0508_01		28,469	4.4	156	18
21	Adams Bayou Tidal	0508_01		26,315	4.4	153	15
22	Adams Bayou Tidal	0508_01		33,235	4.3	149	12
23	Adams Bayou Tidal	0508_01		47,094	4.3	161	11
24	Adams Bayou Tidal	0508_01		45,879	4.3	157	10
25	Adams Bayou Tidal	0508_01		35,827	4.3	149	10
26	Adams Bayou Tidal	0508_01		28,848	4.2	153	10
27	Adams Bayou Tidal	0508_01		27,419	4.2	146	10
28	Adams Bayou Tidal	0508_02		33,314	4.2	172	11
29	Adams Bayou Tidal	0508_02		37,885	4.2	158	13.5
30	Adams Bayou Tidal	0508_02	10442 (AB3)	44,178	4.2	158	15
31	Adams Bayou Tidal	0508_02		44,182	4.2	158	15

Segment	Segment Name	AU	TCEQ Monitoring Site ID (Label)	Volume (m^3)	Average Maximum Segment Depth below Mean Sea Level (m)	Length (m)	Width (m)
32	Adams Bayou Tidal	0508_02		38,566	4.2	158	12.5
33	Adams Bayou Tidal	0508_02		32,620	3.9	158	10
34	Adams Bayou Tidal	0508_02		16,922	3.6	87	10
35	Adams Bayou Tidal	0508_03		35,895	3.6	217	10
36	Adams Bayou Tidal	0508_03		24,167	3.6	147	10
37	Adams Bayou Tidal	0508_03		25,541	3.6	147	7.5
38	Adams Bayou Tidal	0508_03	16059 (AB4)	24,217	3.5	147	5.0
39	Adams Bayou Tidal	0508_03		21,856	3.6	147	5.0
40	Adams Bayou Tidal	0508_03		19,495	3.7	147	5.0
41	Adams Bayou Tidal	0508_03		19,494	3.7	147	5.0
42	Adams Bayou Tidal	0508_03		16,559	3.7	147	5.0
43	Adams Bayou Tidal	0508_03		17,945	3.7	193	5.0
44	Adams Bayou Tidal	0508_03		17,944	3.7	193	5.0
45	Adams Bayou Tidal	0508_03		17,944	3.7	193	5.0
46	Adams Bayou Tidal	0508_03		17,944	3.7	193	5.0
47	Adams Bayou Tidal	0508_03		17,944	3.7	193	5.0
48	Adams Bayou Tidal	0508_03		14,094	3.7	152	5.0
49	Adams Bayou Tidal	0508_04		25,602	3.8	145	5.0
50	Adams Bayou Tidal	0508_04		17,718	3.8	105	5.0
51	Adams Bayou Tidal	0508_04		22,799	3.9	135	5.0
52	Adams Bayou Tidal	0508_04		23,233	4	135	5.0
53	Adams Bayou Tidal	0508_04		33,832	4.1	151	5.0
54	Adams Bayou Tidal	0508_04		47,414	4.1	172	5.0
55	Adams Bayou Tidal	0508_04		55,263	4.1	182	4.5
56	Adams Bayou Tidal	0508_04	14990 (AB5)	50,431	4.1	180	4.0
57	Adams Bayou Tidal	0508_04		32,653	4.1	152	4.5
58	Adams Bayou Tidal	0508_04		30,400	4.1	152	5.0
59	Adams Bayou Tidal	0508_04		21,403	4.1	152	5.0
60	Adams Bayou Tidal	0508_04		11,264	4.1	152	5.0
61	Adams Bayou Tidal	0508_04		10,124	4.1	152	5.0
62	Adams Bayou Tidal	0508_04		10,367	4.1	152	5.0
63	Adams Bayou Tidal	0508_04		10,899	3.9	152	7.4

Segment	Segment Name	AU	TCEQ Monitoring Site ID (Label)	Volume (m^3)	Average Maximum Segment Depth below Mean Sea Level (m)	Length (m)	Width (m)
64	Adams Bayou Tidal	0508_04	10443 (AB6)	12,708	3.6	152	9.8
65	Adams Bayou Tidal	0508_04		18,062	3.6	215	7.4
66	Adams Bayou Tidal	0508_04		13,595	3.5	215	5.0
67	Adams Bayou Tidal	0508_04		11,483	3.4	215	6.5
68	Adams Bayou Tidal	0508_04		16,389	3.3	308	8.6
69	Adams Bayou above Tidal	0508A_01		9,978	3.2	198	9.1
70	Adams Bayou above Tidal	0508A_01		10,373	3.1	215	9.1
71	Adams Bayou above Tidal	0508A_01		9,744	3.1	215	8.8
72	Adams Bayou above Tidal	0508A_01		9,356	3.1	215	8.5
73	Adams Bayou above Tidal	0508A_01		9,357	3	215	8.5
74	Adams Bayou above Tidal	0508A_01	15107 (AB7)	9,812	2.8	224	9.9
75	Adams Bayou above Tidal	0508A_01		7,603	2.5	193	9.9
76	Adams Bayou above Tidal	0508A_01		7,047	2.3	200	8.5
77	Adams Bayou above Tidal	0508A_01		6,520	2.2	200	8.5
78	Adams Bayou above Tidal	0508A_01		9,064	2.1	200	8.5
79	Adams Bayou above Tidal	0508A_01		11,343	2	271	8.3
80	Adams Bayou above Tidal	0508A_01		6,548	1.9	271	8.0
81	Adams Bayou above Tidal	0508A_01		6,136	1.8	271	8.0
82	Adams Bayou above Tidal	0508A_01		5,734	1.7	271	8.0
83	Adams Bayou above Tidal	0508A_01		5,344	1.6	271	8.0
84	Adams Bayou above Tidal	0508A_01		4,964	1.5	271	8.0

Segment	Segment Name	AU	TCEQ Monitoring Site ID (Label)	Volume (m^3)	Average Maximum Segment Depth below Mean Sea Level (m)	Length (m)	Width (m)
85	Adams Bayou above Tidal	0508A_01	14964 (AB8)	4,777	1.5	271	8.0
86	Adams Bayou above Tidal	0508A_01		4,686	1.5	271	8.0
87	Adams Bayou above Tidal	0508A_01		4,152	1.5	271	7.0
88	Adams Bayou above Tidal	0508A_01		7,600	1.4	271	5.0
89	Adams Bayou Lateral 1			11,665	2.5	171	6.3
90	Adams Bayou Lateral 1			11,358	2.4	171	6.3
91	Adams Bayou Lateral 1			7,973	2.3	171	6.3
92	Adams Bayou Lateral 1			4,768	2.2	171	6.3
93	Adams Bayou Lateral 1			3,667	2.1	171	6.3
94	Adams Bayou Lateral 1			2,584	2	171	6.3
95	Adams Bayou Lateral 1			2,370	1.9	171	6.3
96	Adams Bayou Lateral 1		16057 (AL1)	2,170	1.8	171	6.3
97	Adams Bayou Lateral 1			3,031	1.7	171	6.2
98	Adams Bayou Lateral 1			2,832	1.6	171	5.9
99	Adams Bayou Lateral 1			1,578	1.5	171	5.7
100	Adams Bayou Lateral 1			3,169	1.4	171	5.3
101	Adams Bayou Lateral 2			7,098	1.8	140	8.0
102	Adams Bayou Lateral 2			7,098	1.8	140	8.0
103	Adams Bayou Lateral 2			4,531	1.7	140	7.3
104	Adams Bayou Lateral 2			1,865	1.6	140	6.6
105	Adams Bayou Lateral 2			1,674	1.5	140	6.6
106	Adams Bayou Lateral 2			1,499	1.4	140	6.6
107	Adams Bayou Lateral 2			1,398	1.4	140	6.6
108	Adams Bayou Lateral 2		16053 (AL2)	1,701	1.4	140	6.6
109	Hudson Gully	0508C_01		3,231	1.7	247	5.0
110	Hudson Gully	0508C_01		2,479	1.6	212	5.0
111	Hudson Gully	0508C_01	16041 (HG)	2,139	1.5	198	4.3
112	Hudson Gully	0508C_01		2,021	1.4	192	3.6
113	Gum Gully	0508B_01		2,568	1.8	223	2.0

Segment	Segment Name	AU	TCEQ Monitoring Site ID (Label)	Volume (m^3)	Average Maximum Segment Depth below Mean Sea Level (m)	Length (m)	Width (m)
114	Gum Gully	0508B_01		2,235	1.7	232	2.0
115	Gum Gully	0508B_01		1,715	1.6	232	2.0
116	Gum Gully	0508B_01		1,239	1.5	232	2.0
117	Gum Gully	0508B_01	16049 (GG)	1,065	1.5	232	1.9
118	Gum Gully	0508B_01		2,888	1.4	232	1.8

Table 5-3 Physical properties of Cow Bayou WASP model segments

Segment	Segment Name	AU	TCEQ Monitoring Site ID (Label)	Volume (m^3)	Average Maximum Depth below Mean Sea Level (m)	Length (m)	Width (m)
1	Cow Bayou Tidal	0511_01		164,093	5.0	488	101
2	Cow Bayou Tidal	0511_01		185,222	4.8	488	99
3	Cow Bayou Tidal	0511_01		136,426	4.8	400	73
4	Cow Bayou Tidal	0511_01		282,546	4.8	400	98
5	Cow Bayou Tidal	0511_01		148,982	4.9	400	98
6	Cow Bayou Tidal	0511_01	18374 (CB0.5)	286,623	4.9	400	99
7	Cow Bayou Tidal	0511_01		95,051	5.0	245	100
8	Cow Bayou Tidal	0511_01		180,669	5.1	245	102
9	Cow Bayou Tidal	0511_01		220,288	5.2	554	101
10	Cow Bayou Tidal	0511_01		412,392	5.3	554	99
11	Cow Bayou Tidal	0511_01		160,334	5.4	400	99
12	Cow Bayou Tidal	0511_01	10449 (CB1)	301,587	5.4	400	100
13	Cow Bayou Tidal	0511_01		141,528	5.0	400	91
14	Cow Bayou Tidal	0511_01		375,692	4.9	400	86
15	Cow Bayou Tidal	0511_01		115,974	4.8	400	78
16	Cow Bayou Tidal	0511_01		305,722	4.7	400	69
17	Cow Bayou Tidal	0511_01		101,260	4.7	400	64
18	Cow Bayou Tidal	0511_01		296,860	4.7	400	58
19	Cow Bayou Tidal	0511_01	10451 (CB2)	111,046	4.6	400	66
20	Cow Bayou Tidal	0511_02		260,026	4.5	455	75
21	Cow Bayou Tidal	0511_02		111,809	4.5	347	68

Segment	Segment Name	AU	TCEQ Monitoring Site ID (Label)	Volume (m^3)	Average Maximum Depth below Mean Sea Level (m)	Length (m)	Width (m)
22	Cow Bayou Tidal	0511_02		320,678	4.4	400	64
23	Cow Bayou Tidal	0511_02		135,228	4.4	400	93
24	Cow Bayou Tidal	0511_02	10452 (CB2.5)	339,272	4.3	400	119
25	Cow Bayou Tidal	0511_02		146,274	4.3	400	101
26	Cow Bayou Tidal	0511_02		339,446	4.3	400	101
27	Cow Bayou Tidal	0511_02		120,413	4.3	400	97
28	Cow Bayou Tidal	0511_02		295,014	4.3	400	73
29	Cow Bayou Tidal	0511_02	10453 (CB3)	82,120	4.8	400	60
30	Cow Bayou Tidal	0511_02		68,926	5.3	400	60
31	Cow Bayou Tidal	0511_02		67,187	4.8	400	65
32	Cow Bayou Tidal	0511_02		62,876	4.3	400	58
33	Cow Bayou Tidal	0511_02		41,187	4.0	400	46
34	Cow Bayou Tidal	0511_02		41,470	3.9	400	35
35	Cow Bayou Tidal	0511_02		38,385	3.8	400	35
36	Cow Bayou Tidal	0511_02		38,780	3.7	400	34
37	Cow Bayou Tidal	0511_02		33,303	3.7	400	30
38	Cow Bayou Tidal	0511_02	10454 (CB3.5)	27,713	3.6	345	26
39	Cow Bayou Tidal	0511_02		31,188	3.5	435	25
40	Cow Bayou Tidal	0511_02		43,458	3.4	400	25
41	Cow Bayou Tidal	0511_02		19,530	3.3	293	25
42	Cow Bayou Tidal	0511_03		51,461	3.2	496	24
43	Cow Bayou Tidal	0511_03		24,687	3.1	400	24
44	Cow Bayou Tidal	0511_03		30,695	3.0	400	24
45	Cow Bayou Tidal	0511_03		22,810	2.9	400	23
46	Cow Bayou Tidal	0511_03		24,360	2.8	400	22
47	Cow Bayou Tidal	0511_03		20,179	2.7	400	22
48	Cow Bayou Tidal	0511_03		20,596	2.6	400	22
49	Cow Bayou Tidal	0511_03		15,581	2.5	350	22
50	Cow Bayou Tidal	0511_03		16,573	2.4	350	21
51	Cow Bayou Tidal	0511_03		14,159	2.4	350	21
52	Cow Bayou Tidal	0511_03		13,664	2.3	350	21
53	Cow Bayou Tidal	0511_03		10,279	2.3	350	18

Segment	Segment Name	AU	TCEQ Monitoring Site ID (Label)	Volume (m^3)	Average Maximum Depth below Mean Sea Level (m)	Length (m)	Width (m)
54	Cow Bayou Tidal	0511_03	13781 (CB4)	9,998	2.2	350	16
55	Cow Bayou Tidal	0511_03		9,383	2.2	350	16
56	Cow Bayou Tidal	0511_03		8,750	2.1	350	16
57	Cow Bayou Tidal	0511_03		8,270	2.0	355	15
58	Cow Bayou Tidal	0511_03		7,706	2.0	355	14
59	Cow Bayou Tidal	0511_04		6,488	1.9	315	14
60	Cow Bayou Tidal	0511_04		10,273	1.9	315	13
61	Cow Bayou Tidal	0511_04		6,362	1.8	350	12
62	Cow Bayou Tidal	0511_04		10,380	1.7	350	11
63	Cow Bayou Tidal	0511_04		5,683	1.7	350	12
64	Cow Bayou Tidal	0511_04		10,378	1.6	350	13
65	Cow Bayou Tidal	0511_04	10457 (CB5)	5,822	1.7	350	13
66	Cow Bayou Tidal	0511_04		11,320	1.7	350	13
67	Cow Bayou Tidal	0511_04		6,552	1.7	350	13
68	Cow Bayou Tidal	0511_04		40,414	1.7	350	13
69	Cow Bayou Oxbow 1			40,650	3.7	258	48
70	Cow Bayou Oxbow 1			63,783	3.7	258	48
71	Cow Bayou Oxbow 1			39,925	3.7	271	48
72	Cow Bayou Oxbow 1			57,988	3.7	268	48
73	Cow Bayou Oxbow 1			39,359	3.7	267	48
74	Cow Bayou Oxbow 1			57,935	3.7	268	48
75	Cow Bayou Oxbow 1			39,473	3.7	268	48
76	Cow Bayou Oxbow 1			57,736	3.7	267	48
77	Cow Bayou Oxbow 1			39,313	3.7	267	48
78	Cow Bayou Oxbow 1			65,724	3.7	266	48
79	Cow Bayou Oxbow 1			39,568	3.7	269	48
80	Cow Bayou Oxbow 1			58,005	3.7	268	48
81	Cow Bayou Oxbow 1			39,303	3.7	267	48
82	Cow Bayou Oxbow 1			57,980	3.7	2688	48
83	Cow Bayou Oxbow 1			39,254	3.7	267	48
84	Cow Bayou Oxbow 1			57,548	3.7	266	48
85	Unnamed Tributary to Cow Bayou Tidal	0511D_01		5,894	1.4	400	14.2

Segment	Segment Name	AU	TCEQ Monitoring Site ID (Label)	Volume (m^3)	Average Maximum Depth below Mean Sea Level (m)	Length (m)	Width (m)
86	Unnamed Tributary to Cow Bayou Tidal	0511D_01		3,805	1.3	400	11.1
87	Unnamed Tributary to Cow Bayou Tidal	0511D_01		3,525	1.3	400	8.9
88	Unnamed Tributary to Cow Bayou Tidal	0511D_01		5,769	1.2	400	8.2
89	Cow Bayou Oxbow 3			19,581	2.3	230	47
90	Cow Bayou Oxbow 3			23,488	2.3	230	47
91	Cow Bayou Oxbow 3			19,595	2.3	230	47
92	Cow Bayou Oxbow 3			28,086	2.3	208	47
93	Cow Bayou Oxbow 3			35,167	2.3	260	47
94	Cow Bayou Oxbow 3			19,601	2.3	230	47
95	Cow Bayou Oxbow 3			27,197	2.3	232	47
96	Cow Bayou Oxbow 3			19,770	2.3	232	47
97	Coon Bayou	0511B_01		8,475	2.3	253	16.5
98	Coon Bayou	0511B_01		28,155	2.2	231	16.3
99	Coon Bayou	0511B_01		7,156	2.2	230	16.2
100	Coon Bayou	0511B_01		12,225	2.1	230	16.0
101	Coon Bayou	0511B_01		6,446	2.0	230	15.9
102	Coon Bayou	0511B_01		11,516	1.9	230	15.6
103	Coon Bayou	0511B_01		4,883	1.8	230	15.3
104	Coon Bayou	0511B_01		12,114	1.7	230	12.9
105	Coon Bayou	0511B_01	16052 (CNB)	3,374	1.6	230	10.6
106	Coon Bayou	0511B_01		11,275	1.5	231	9.8
107	Coon Bayou	0511B_01		2,513	1.4	230	8.4
108	Coon Bayou	0511B_01		24,479	1.3	230	7.6
109	Sandy Creek			3,397	1.8	250	9.4
110	Sandy Creek			3,039	1.7	250	8.8
111	Sandy Creek			2,679	1.6	250	8.3
112	Sandy Creek			2,344	1.5	250	7.8
113	Sandy Creek			2,096	1.4	250	7.3
114	Sandy Creek			4,821	1.3	250	6.8
115	Cole Creek	0511C_01		3,086	2.0	449	4.9

Segment	Segment Name	AU	TCEQ Monitoring Site ID (Label)	Volume (m^3)	Average Maximum Depth below Mean Sea Level (m)	Length (m)	Width (m)
116	Cole Creek	0511C_01		2,487	1.9	400	4.5
117	Cole Creek	0511C_01		2,244	1.8	400	4.4
118	Cole Creek	0511C_01		2,017	1.7	400	4.1
119	Cole Creek	0511C_01		1,885	1.7	400	3.9
120	Cole Creek	0511C_01		1,762	1.7	400	3.7
121	Cole Creek	0511C_01		1,641	1.6	400	3.6
122	Cole Creek	0511C_01		1,529	1.6	400	3.4
123	Cole Creek	0511C_01		1,519	1.6	400	3.2
124	Cole Creek	0511C_01		7,151	1.5	400	3.0
125	Terry Gully	0511E_01		7,652	1.8	350	13.1
126	Terry Gully	0511E_01		7,199	1.7	350	13.0
127	Terry Gully	0511E_01		6,989	1.7	350	12.8
128	Terry Gully	0511E_01		6,778	1.6	350	12.8
129	Terry Gully	0511E_01	18377 (TG2)	6,286	1.6	350	12.4
130	Terry Gully	0511E_01		5,808	1.6	350	11.6
131	Terry Gully	0511E_01		5,116	1.5	350	11.0
132	Terry Gully	0511E_01		4,429	1.5	350	10.5
133	Terry Gully	0511E_01		3,948	1.5	350	9.5
134	Terry Gully	0511E_01		3,461	1.5	350	8.5
135	Terry Gully	0511E_01		3,117	1.5	350	7.5
136	Terry Gully	0511E_01		31,391	1.5	350	6.5

In WASP, the eutrophication module can be run with various levels of complexity, simulating the transport and transformations of up to 28 state variables. A listing of these state variables is included in Table 5-4, with those actively simulated in the Adams Bayou and Cow Bayou models noted.

Table 5-4 WASP state variables

Variable	Units	Active
salinity	ppt	✓
pH	standard units	×
alkalinity	mg/L as CaCO3	×
DO	mg/L	✓
cBOD group 1 (cBOD1)	mg/L	✓
cBOD group 2 (cBOD2)	mg/L	×
cBOD group 3 (cBOD3)	mg/L	×
NH_3N	mg/L	✓
NO_3N	mg/L	✓
OrgN	mg/L	✓
PO_4P	mg/L	✓
OrgP	mg/L	✓
inorganic silica	mg/L	×
dissolved organic silica	mg/L	×
phytoplankton group 1	µg/L as chla	✓
phytoplankton group 2	µg/L as chla	×
phytoplankton group 3	µg/L as chla	×
detrital nitrogen (DETN)	mg/L	✓
detrital phosphorus (DETP)	mg/L	✓
detrital carbon (DETC)	mg/L	✓
detrital silica	mg/L	×
total detritus	mg/L	✓
inorganic suspended solids group 1 (sand)	mg/L	✓
inorganic suspended solids group 2 (silt)	mg/L	✓
inorganic suspended solids group 3 (clay)	mg/L	✓
benthic algae	g/m^2	×
periphyton cell quota nitrogen	mg/g	×
periphyton cell quota phosphorus	mg/g	×

Two issues associated with the reaeration computations in WASP7.52 necessitate discussion at this point in the report. First, WASP7.52 restricts the user to input of a single minimum for the reaeration rate (K_a) with the units of day^{-1} that is applicable to all model segments. It is the long-standing practice of TCEQ to compute the minimum K_a based on a minimum value of the oxygen transfer coefficient (K_L) of 0.6 m day^{-1}. Under this practice, the minimum K_a would be computed as $K_a = K_L$/water depth and would vary with the simulated depths of each model segment. Since Ka cannot be varied across WASP segments, it is not possible to tailor the minimum K_a to individual WASP segments through the input options available in the software. The minimum K_a will either be close to correct for the deepest portions of the channel and too small for the shallower portions, or about correct for shallow portions and too small for the deeper portions.

Second, K_a is being computed for this WASP application under the model option to use the larger of the K_a value determined from wind-induced oxygen transfer or flow-induced (water velocity) oxygen transfer. It was discovered during the modeling process, and confirmed in December 2018 by EPA Region 4 staff who oversaw the WASP modeling software, that the wind-induced K_a was incorrectly programmed in WASP, and that the error was that the computation did not include division by water depth. Thus, the model was computing wind-induced K_a values that were too large for all water depths > 1 m. The WASP software was, in fact, computing K_L, the oxygen transfer coefficient instead of K_a. Average water depths along the tidal portions of Adams and Cow Bayous range from 2 m to 5 m (Tables 5-2 and 5-3) resulting in an appreciable over prediction in the model's computation of wind-induced K_a. For many stream systems, the wind-induced K_a is not important, because water velocities are sufficiently high that the flow-induced K_a values are predominately greater than the wind-induced values, and the higher flow-induced values are used by the model. However, Adams and Cow Bayous are, in essence, tidal backwater systems with low streamflows relative to stream cross-sectional area, which results in low water velocities under many circumstances. Thus, computed flow-induced K_a is often less than wind-induced K_a, and the wind-induced K_a becomes an important term in the model for Adams and Cow Bayous.

Since the source code to the old version of WASP could not be corrected, the initial approach to the second issue was to use a newer version of WASP (i.e., version 8.3) for which the error in computation of the wind-induced K_a had been corrected. However, even with assistance from EPA Region 4 staff, the conversion of the input data being used in this modeling effort into WASP version 8.3 was unsuccessful and a working model in the latest version could not readily be developed without extensive rework and substantial time and resource expenditures. Even with this newer version of WASP, the first issue regarding definition of a minimum K_a consistent with TCEQ protocol would not have been addressed (i.e., a single K_a is still applicable to all WASP 8.3 model segments). Therefore, the approach shifted to adjusting input to the existing WASP 7.52 model to compensate for the global K_a limitation in WASP and to correct for the error in computing wind-induced K_a.

Both of these reaeration issues in WASP7.52 were addressed through user modifications to the wind input to the model, which included a time series of wind speed and a multiplier to the wind speed that can be specified by model segment. To address the minimum K_a issue, a wind speed was determined that provided a K_L value of 0.6 m day^{-1}. Wind-induced K_a in WASP is computed using one of three formulas that are a function of wind speed, air and water temperature, and, if programmed correctly, water depth. For wind speeds < 6 m/s, the formula used is a linear function of wind speed with some slight non-linearities due to air and water temperature. For wind speeds > 6 m/s, the formulas involve non-linear functions of wind speed that resulted in values increasing with wind speed faster than the linear function. WASP output of wind-induced K_a was analyzed for multiple segments having a range of depths. These wind-induced K_a values were actually K_L values because of the coding error wherein the computations did not include division by depth. Visual review of scatterplots of K_L (corrected to 20 °C) with wind speed, indicated that a value of K_L = 0.6 m day^{-1} occurred at very close to the same wind speed regardless of segment selection and occurred in the linear portion of the graph for wind speeds < 6 m/s. Highly significant linear regression equations with r^2 > 0.98 were developed for each segment investigated representing the range in depths in the WASP models, and each regression equation indicated that a wind speed of 2.5 m/s (5.6 mph) resulted in computation of a K_L = 0.6 m day^{-1}.

To address the first issue regarding appropriate computation of a minimum K_a, the correction was relatively simple. Since the WASP option selected for K_a was to use the maximum of the wind-induced or flow-induced K_a, limiting the wind-induced K_a to a minimum giving a K_L = 0.6 m day-1 provided the needed adjustment. This adjustment was implemtented by setting the minimum wind speed model input for any hour to 2.5 m/s. Therefore, the minimum K_a was being specified by restricting the computation of the wind-induced K_a to the value obtained from the minimum wind speed.

The remaining issue was how to correct the wind-induced K_a computed in the model for the mistake wherein division did not occur by segment water depth. Because of the coding error, WASP version 7.52 is actually computing wind-induced K_L and not wind-induced K_a. To address the error in coding, the segment-level wind multiplier input option was used. The reciprocal of the median depth of each segment was used to compute the wind multiplier for each segment. The median depth was computed using hourly output of the water depth of each segment in the Adams Bayou and Cow Bayou models for the simulated period of January 1, 2002 through December 31, 2012, or about 100,000 individual depths per segment. The wind multiplier essentially results in the computed wind-induced K_L being divided by depth, thus, giving the desired K_a. This correction through the wind multiplier provides a very workable solution to overcome the coding error in WASP; however, this is not a perfect solution. The simulated water levels of each segment are not static, but time varying. Using the median depth to compute the multiplier, therefore, means that half the time this correction gives K_a values that are too large and half the time the values are too small. Because the domain of the WASP model is the tidal streams of the Adams Bayou and Cow Bayou watersheds where stream cross-sectional areas are large compared to streamflows under most conditions and tidal fluctuations are relatively weak, for the majority of segments in both models, 90 percent of the simulated depths of each segment were determined to be within +/- 0.35 m of the median depth, and 50 percent of the simulated depths were within +/- 0.13 m of the median depth. Not to minimize the limitations of the single wind multiplier correction for each segment, for the majority of the simulation period, the errors introduced by using the wind multiplier correction are not highly significant, because of the relatively narrow range of water depth variations in the tidal system.

5.2 WASP Input Data

Dynamic WASP model inputs include the hydrodynamic parameters generated by the RMA2 model, water quality constituent concentrations at upstream and downstream boundaries, loads of water quality constituents from point and nonpoint sources, and meteorological data.

5.2.1 Lower Boundary Condition

The concentrations of water quality constituents at the lower (Sabine River) boundary of the models were estimated based on concentrations reported to the TCEQ Surface Water Quality Monitoring Information System (SWQMIS). Primarily, this consisted of routine water quality measurements collected monthly by the Sabine River Authority or TCEQ regional office at one or more of the following stations:

Station ID	Description
Station ID 10391	Sabine River at channel CAN 3 1866 M downstream from mouth of new Cow Bayou
Station ID 10392	Sabine River at Cow Bayou confluence
Station ID 10393	Sabine River at channel light 13 2030 M upstream from mouth of new Cow Bayou
Station ID 18055	Sabine River at channel light 20 495 M upstream of the confluence of Adams Bayou and 70 M from the east bank

For most water quality constituents, the reported concentrations from these stations were averaged over the simulation period and this average concentration was used as a constant boundary condition in the WASP models. However, salinity exhibited a statistically significant relationship with flow, and a simple power function was developed to explain the majority of the variance in salinity:

$$\text{Salinity} = 2338 * Q_7\text{\^{}}{-1.571}$$

where Q_7 is the average flow (in cms) over the preceding 7-day period. The predicted salinity from this relationship was manually limited to the range 0.05 to 20 parts per thousand (ppt) to reflect natural limits. At times the relationship predicted salinities that deviated substantially from measured values, so this predicted salinity time series was averaged with a second time series of measured salinity values, with the values for dates between measurements interpolated between them.

5.2.2 Carbonaceous Biochemical Oxygen Demand

As is typical, most laboratory measurements of cBOD were 5-day measurements (cBOD5) at 20°C with suppression of nitrification. However, the WASP model simulates ultimate cBOD (UBOD), the total oxygen demand for biochemical conversion of all organic carbonaceous material to oxidized forms. Ultimate cBOD was estimated in the following manner. In a subset of 14 ambient water samples from several locations on each bayou on several dates, cBOD was measured after incubations of 5, 15, and 20 days. The 20-day cBOD was assumed to be equivalent to UBOD. A first-order rate curve was then fit to the data. Figure 5.3 illustrates the measured cBOD after these three periods. Figure 5.4 illustrates the range of cBOD decay rates estimated from these samples from the first-order rate equation $\ln(C/C_0) = -k*t$. The ratio of UBOD:cBOD$_5$ ranged from 1.06 to 5.75, with an average of 3.0 and a standard deviation of 1.3. The rate of cBOD decay averaged 0.097 day^{-1} with a standard deviation of 0.044 day^{-1}. A conversion factor of 3 was applied to all point source loads and measured ambient concentrations to convert from cBOD$_5$ to UBOD. The variability in this conversion factor, as well as the frequency of censored data (e.g., <3 mg/L cBOD$_5$) in the analytical dataset, provided a challenge to calibration.

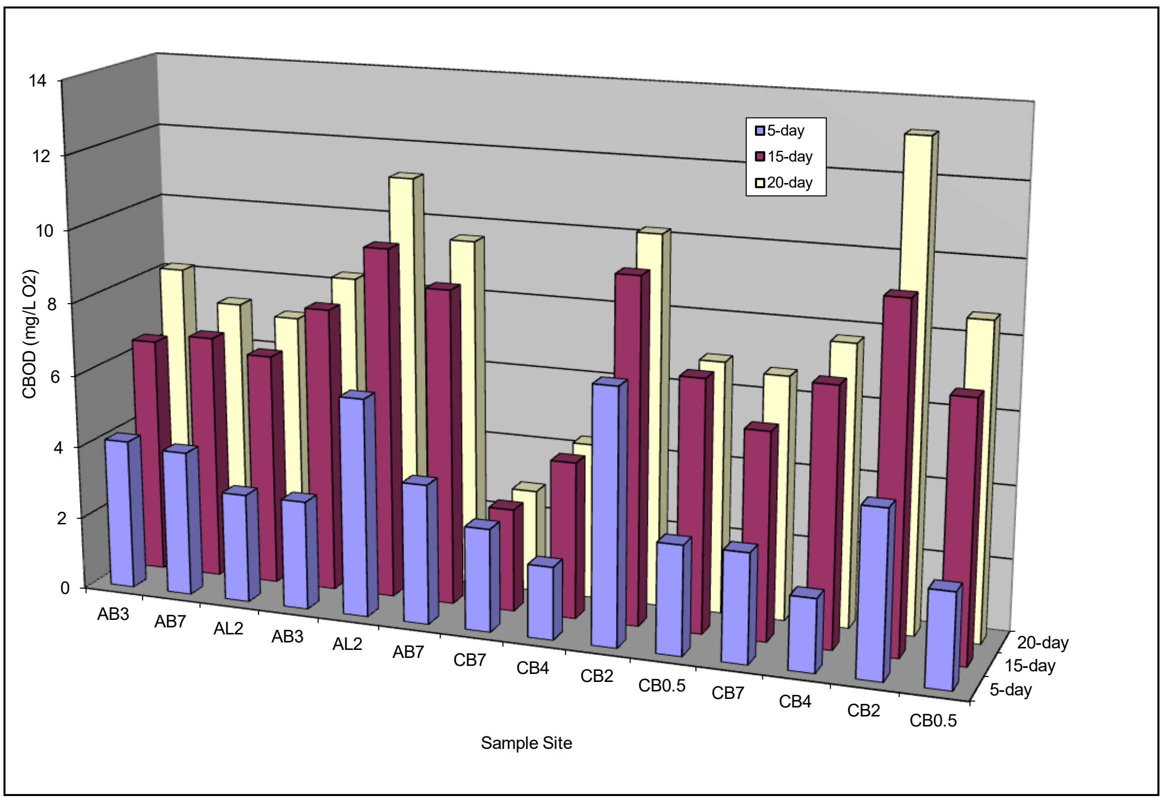

Figure 5.3 Carbonaceous BOD after 5, 15, and 20 days

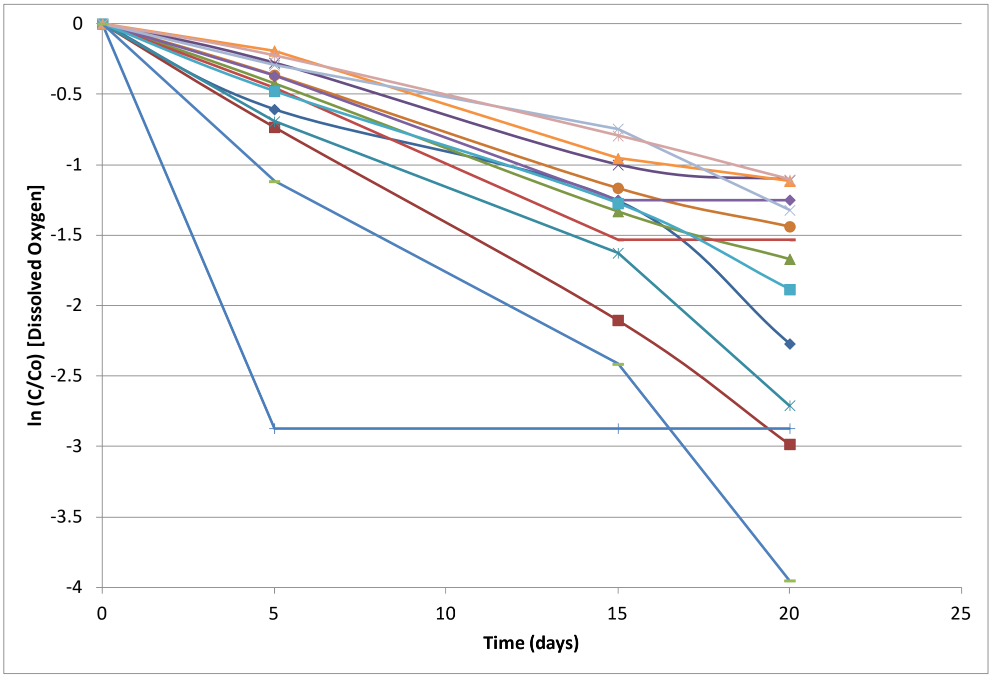

Figure 5.4 Measured rates of cBOD decay in laboratory incubations

5.2.3 WASP Linkage to the RMA2 Hydrodynamic Model

Due to the influence of tides on hydrodynamics in the bayous, an external hydrodynamic model was required to simulate water movement through the system. Historically, the external hydrodynamic model used with WASP was DYNHYD. Due to the limitations of DYNHYD, other models such as EFDC and RMA2 have been used with WASP. The hydrodynamic inputs to WASP are the segment volumes at the beginning of each time step, the average inter-segment flows during each time step, and average segment depths and velocities. WASP uses the inter-segment flows to calculate mass transport, and the volumes to calculate concentrations. The segment depths and velocities are used in calculating sediment transport, volatilization, and reaeration.

RMA2 is a link-node hydrodynamic model with a spatial network and temporal resolution equivalent to the WASP model. The RMA2 solution file reports, for each node and time step, the depth, x-velocity, and y-velocity. An RMA2 post-processor performs the tasks of calculating from these outputs the segment volumes and inter-segment flows, mapping the RMA2 nodes to WASP segments, and re-writing the output to a binary format external hydrodynamic file required by WASP model. It also performs some other useful diagnostic functions. WASP also requires that the hydrodynamic file be in a specific binary format. A utility program named Hydrolink, provided with WASP, performs the conversion from an ASCII-based hydrodynamic file to a binary format.

5.2.4 WASP Linkage to the HSPF Model and Point-Source Loads

The HSPF model is linked to the WASP model in multiple ways. First, the HSPF model is linked to the WASP model indirectly, through the RMA2 hydrodynamic model. HSPF also directly provides

WASP with the boundary water quality constituent concentrations at all upstream tidal segments of the WASP models. HSPF also provides the loads of NPS water quality constituents in middle reaches. Finally, HSPF provides a water temperature simulation that is an input to WASP. The HSPF inputs to WASP are shown in Table 5-5 (Adams Bayou) and Table 5-6 (Cow Bayou).

Point-source loads are imported into WASP via a Microsoft Excel™ spreadsheet. The input loads for point sources to the HSPF reaches are shown in Table 5-5 (Adams Bayou) and Table 5-6 (Cow Bayou).

Table 5-5 External inputs for the Adams Bayou WASP model

Source	Type	WASP Segment	Frequency	Fraction of Total Load	Assessment Unit or Location Description
HSPF Sub-basin 1	Boundary Concentration	118	Daily	1	0508B_01
HSPF Sub-basin 2	Boundary Concentration	88	Daily	1	0508A_01
HSPF Sub-basin 3	NPS Load	113	Daily	1	0508B_01
HSPF Sub-basin 4	NPS Load	77	Daily	1	0508A_01
HSPF Sub-basin 5	NPS Load	70	Daily	0.696	0508_04
		73	Daily	0.304	0508A_01
HSPF Sub-basin 6	NPS Load	75	Daily	1	0508A_01
HSPF Sub-basin 7	NPS Load	57	Daily	1	0508_04
HSPF Sub-basin 8	Boundary Concentration	112	Daily	1	0508C_01
HSPF Sub-basin 9	Boundary Concentration	108	Daily	1	0508_01
HSPF Sub-basin 10	NPS Load	25	Daily	0.183	0508_01
		29	Daily	0.294	0508_02
		35	Daily	0.523	0508_03
HSPF Sub-basin 11	Boundary Concentration	100	Daily	1	0508_01
HSPF Sub-basin 12	NPS Load	5	Daily	1	0508_01
WQ0010597-001	PS Load	48	Constant	1	City of Pinehurst
WQ0010626-001	PS Load	31	Constant	1	City of Orange
WQ0010240-001	PS Load	31	Constant	1	Orange County WCID 2
Sabine River	Boundary Concentration	1	Half Hour	Not Applicable	Downstream boundary

Table 5-6 External inputs to the Cow Bayou WASP model

Source	Type	WASP Segment	Frequency	Fraction of Total Load	Assessment Unit or Location Description
HSPF sub-basin 7	NPS Load	124	Daily	1	0511C_01
HSPF sub-basin 8	NPS Load	64	Daily	0.131	0511_04
	Boundary Concentration	68	Daily	0.869	0511A_01
HSPF sub-basin 9	NPS Load	55	Daily	0.698	0511_03
		58	Daily	0.302	0511_04
HSPF sub-basin 10	NPS Load	122	Daily	1	0511C_01
HSPF sub-basin 11	NPS Load	114	Daily	1	0511_02
HSPF sub-basin 12	NPS Load	40	Daily	0.079	0511_02
		50	Daily	0.921	0511_03
HSPF sub-basin 13	NPS Load	136	Daily	1	0511E_01
HSPF sub-basin 14	Boundary Concentration	28	Daily	1	0511_02
HSPF sub-basin 15	NPS Load	108	Daily	1	0511B_01
HSPF sub-basin 16	NPS Load	22	Daily	0.383	0511_01
		31	Daily	0.617	0511_02
HSPF sub-basin 17	NPS Load	11	Daily	0.715	0511_01
		86	Daily	0.285	0511D_01
HSPF sub-basin 18	Boundary Concentration	3	Daily	1	0511_01
WQ0000670-000	PS Load	79	Constant	1	Honeywell International
WQ0001167-000	PS Load	5	Constant	1	ARLANXEO USA LLC
WQ0000454-000	PS Load	10	Constant	1	Lion Elastomers Orange, LLC
WQ0000359-000	PS Load	88	Constant	1	Chevron Phillips Chemical
WQ0002858-000	PS Load	88	Constant	1	Printpack, Inc.
WQ0015029-001	PS Load	107	Constant	1	Bayou Pines
WQ0013488-001	PS Load	101	Constant	1	Gulflander Partners Group
WQ0010051-001	PS Load	17	Constant	1	City of Bridge City
WQ0014772-001	PS Load	29	Constant	1	Orangefield WSC
WQ0011916-001	PS Load	67	Constant	1	PCS Development Group
Sabine River	Boundary Concentrations	1 & 69	30 minutes	Not Applicable	Downstream boundary

5.3 Calibration and Validation of the WASP Models

The WASP models were calibrated primarily to data collected during intensive surveys of Adams Bayou and Cow Bayou on May 23 - 28, 2004 and July 17 - 22, 2004, respectively. The models were also compared to other quality-assured water quality data found in TCEQ SWQMIS database from Adams and Cow Bayous from 2002 to 2012. In most years, routine monitoring by the Sabine River Authority has been limited to a single station in Adams Bayou (AB2, also known as TCEQ SWQM station 10441) and a single station in Cow Bayou (CB1, also known as TCEQ SWQM station 10449), but the Texas Parks and Wildlife Department also performed water quality monitoring of four other stations on Cow Bayou on a monthly basis during 2003 and 2004 as part of a Use Attainability Study. Water quality calibration of WASP was done in the following order:

1. salinity
2. cBOD
3. OrgN
4. NH_3N, NO_3N, and PO_4P
5. Chla
6. DO

However, there were multiple iterations of calibration. Also, model predictions of TSS were compared to measured levels after salinity calibration. The WASP eutro model does not offer parameters to adjust TSS calibration, but a fixed sedimentation flux from the water column to sediments was added.

Longitudinal plots by station with simulated and observed data and observed and modeled averages were used to visually evaluate model performance during calibration.

During the calibration process, the model parameters to which the model was most sensitive were adjusted within literature-recommended ranges or as indicated from watershed specific data. The most important model parameter was DO. The model performance target for DO was an overall RMSE of less than 1.5 mg/L for the separate calibration and validation periods. Other targets included salinity (overall RMSE < 0.6 ppt) , TSS (overall RMSE < 50% of the observed average concentration or 5 mg/L, whichever is greater), and NH_3N, NO_3N, OrgN, and PO_4P (overall RMSE < 50% of the observed average concentration or 0.25 mg/L, whichever is greater).

Following calibration, the simulation results for each calibrated model were validated by comparison to data from a second intensive survey on each bayou. These intensive surveys were performed June 29 - July 1, 2004 (Adams Bayou) and August 24 - 26, 2004 (Cow Bayou). The model performance targets for the validation period were identical to the calibration targets.

Antecedent rainfall and flow conditions were different between the two surveys on each bayou. For some parameters, the initial calibration did not result in good fit to the validation dataset. While in most cases the validation criteria were met, the models were often re-calibrated in an attempt to achieve a good fit to both of the intensive surveys (and the other datasets). There were many iterations to achieve what the modelers believes was the best practical fit.

Figures 5-5 and 5-6 illustrate the goodness of fit of the WASP DO simulation. Statistical summaries of model goodness-of-fit for Adams Bayou are included in Tables 5-7 through 5-9. Table 5-10 lists the key parameters for the Adams Bayou WASP model. Additional graphical presentations of water quality comparisons of model predicted results and measured data are provided in Appendix G.

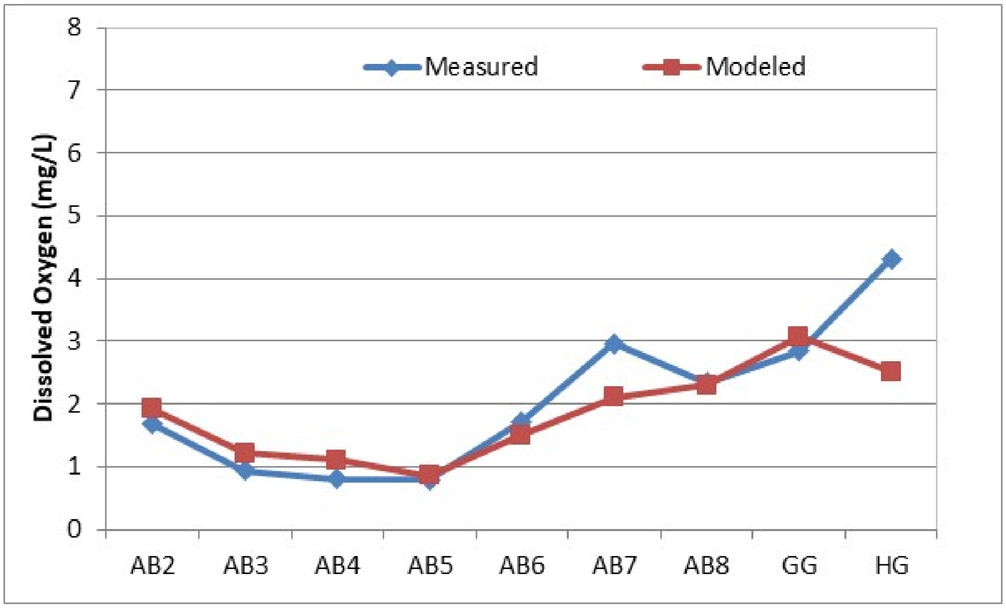

Figure 5-5 **Longitudinal model fit of Adams Bayou daily average DO for the calibration period**

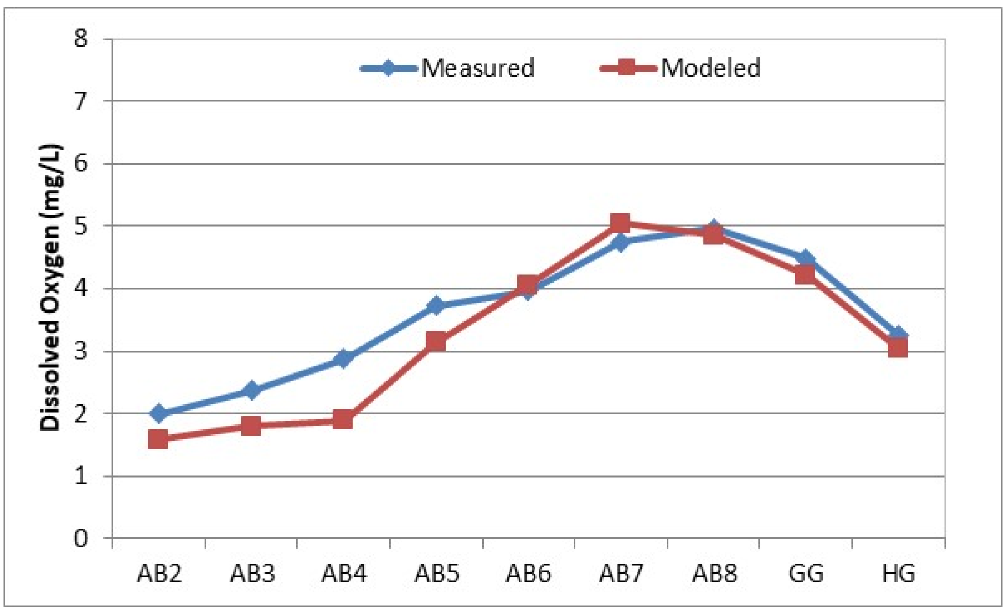

Figure 5-6 **Longitudinal model fit of Adams Bayou daily average DO for the validation period**

Table 5-7 Model fit statistics for daily average DO in Adams Bayou

Model performance targets based on RMSE and any station's RMSE not meeting the target is in bold **red** font.

Period	Station	n	Measured Average (mg/L)	Model Average (mg/L)	ME (mg/L)	MAE (mg/L)	RMSE (mg/L)
Calibration	All	18	2.04	1.85	-0.20	0.45	0.69
Validation	All	16	3.60	3.29	-0.31	0.39	0.48
All Data	AB2	4	1.84	1.75	-0.09	0.32	0.38
All Data	AB3	4	1.66	1.51	-0.15	0.43	0.52
All Data	AB4	4	1.84	1.50	-0.34	0.65	0.77
All Data	AB5	4	2.26	2.00	-0.26	0.32	0.44
All Data	AB6	4	2.84	2.79	-0.05	0.40	0.46
All Data	AB7	4	3.85	3.58	-0.28	0.86	0.93
All Data	AB8	4	3.65	3.58	-0.10	0.36	0.37
All Data	GG	2	3.67	3.65	-0.02	0.41	0.49
All Data	HG	4	3.79	2.78	-1.01	1.01	1.28

Table 5-8 Calibration statistics for the Adams Bayou WASP model

Model performance targets based on RMSE and any parameter's RMSE not meeting the target is in bold **red** font.

Parameter	Measured Average	Model Average	ME	MAE	RMSE
Salinity (ppt)	0.10	0.05	-0.05	0.06	0.09
TSS (mg/L)	10.20	5.58	-4.62	4.62	**6.96**
cBOD (ultimate, mg/L)	10.08	10.96	0.89	3.50	4.76
OrgN (mg/L)	1.23	1.12	-0.11	0.29	0.35
NH_3N (mg/L)	0.18	0.21	0.04	0.07	0.08
NO_3N (mg/L)	0.04	0.09	0.05	0.05	0.06
PO_4P (mg/L)	0.31	0.29	-0.02	0.07	0.08
Chla (µg/L)	13.80	9.62	-4.17	8.25	9.01

Table 5-9 Validation statistics for the Adams Bayou WASP model

Model performance targets based on RMSE and any parameter's RMSE not meeting the target is in bold **red** font.

Parameter	Measured Average	Model Average	ME	MAE	RMSE	
Salinity (ppt)	0.04	0.05	0.01	0.02	0.02	
TSS (mg/L)	27.16	15.97	-11.19	11.19	13.07	
cBOD (ultimate, mg/L)	10.87	10.58	-0.28	1.27	1.57	
OrgN (mg/L)	0.79	0.90	0.11	0.18	0.25	
NH_3N (mg/L)	0.07	0.18	0.10	0.11	0.12	
NO_3N (mg/L)	0.04	0.14	0.10	0.10	0.11	
PO_4P (mg/L)	0.18	0.20	0.02	0.05	0.05	
Chla (µg/L)	5.19	7.82	2.63	4.11	5.49	

Table 5-10 Key parameters of the Adams Bayou WASP model

In the Source Column: F = collected data, L = literature, C=calibrated, Cf = calibrated within range of field collected data

Parameter Description	Units	Source	Value or Range
dispersion coefficient between adjacent segments	m^2/day	C	0.25 – 5.0
dispersion coefficient for pore water	cm^2/day	L	$3x10^{-5}$
segment scale factor for wind	none	F	0.4 – 1.0
theta – reaeration temperature coefficient	none	L	1.022
minimum oxygen transfer coefficient (set using wind scale factors and specifiying a minimum wind speed of 2.5 m/s in time seris input)	1/day	L	≈0.6
maximum allowable calculated reaeration rate	1/day	L	10
cBOD decay rate constant @ 20°C	1/day	Cf	0.12
cBOD decay temperature coefficient	none	L	1.047
segment cBOD decay rate scale factor	none	C	1 – 2.5
cBOD decay rate constant in sediments @ 20°C	1/day	L	$4x10^{-4}$
cBOD decay in sediments temperature coefficient	none	L	1.08
BOD half-saturation oxygen limit	mg/L O_2	L	0 – 2.0
fraction of detritus dissolution to cBOD	none	L	1
fraction of cBOD carbon source for denitrification	none	L	1
detritus dissolution rate	1/day	C	0.4
detritus dissolution temperature coefficient	none	L	1.047

Parameter Description	Units	Source	Value or Range
OrgN mineralization rate constant (dissolved) @ 20°C	1/day	C	0.02
OrgN mineralization (dissolved) temperature coefficient	none	L	1.07
OrgN mineralization rate constant (sediments) @ 20°C	1/day	L	0.015
OrgN mineralization (in sediments) temperature coefficient	none	L	1.047
fraction of phytoplankton death recycled to OrgN	none	L	1
OrgP mineralization rate constant (dissolved) @ 20°C	1/day	C	0.15
OrgP mineralization (dissolved) temperature coefficient	none	L	1.08
OrgP mineralization rate constant (sediments) @ 20°C	1/day	L	0.015
OrgP mineralization rate (sediments) temperature coefficient	none	L	1.047
fraction of phytoplankton death recycled to OrgP	none	L	1
nitrification rate constant @ 20°C	1/day	C	0.35
nitrification temperature coefficient	none	L	1.08
half-saturation for nitrification	mg/L O_2	L	2
segment benthic NH_3N flux	mg/m^2-day	C	0 - 310
denitrification rate constant @ 20°C	1/day	C	1
denitrification temperature coefficient	none	L	1.08
half-saturation for denitrification	mg/L O_2	L	5
segment benthic PO_4P flux	mg/m$_2$-day	C	0 - 31
phytoplankton maximum growth rate constant @ 20°C	1/day	C	2
phytoplankton growth temperature coefficient	none	L	1.068
algal self-shading coefficient	none	L	0.048
algal self-shading exponent	none	L	1
phytoplankton carbon to chlorophyll ratio	none	L	35
phytoplankton half-saturation constant for nitrogen uptake	mg N/L	L	0.05
phytoplankton half-saturation constant for phosphorus uptake	mg P/L	L	0.01
phytoplankton endogenous respiration rate constant @ 20°C	1/day	C	0.075
phytoplankton respiration temperature coefficient	none	L	1.045
phytoplankton non-predatory mortality rate constant	1/day	L	0.02
phytoplankton zooplankton grazing rate constant	1/day	L	1.5
phytoplankton decay rate constant in sediments	1/day	L	0.02
phytoplankton decay in sediments temperature coefficient	none	L	1.08
phytoplankton phosphorus to carbon ratio	none	L	0.02
phytoplankton nitrogen to carbon ratio	none	L	0.25

Parameter Description	Units	Source	Value or Range
phytoplankton half-saturation for recycle of OrgN and OrgP	mg TOC/L	L	0.2
phytoplankton maximum quantum yield	Langley/day	L	720
phytoplankton optimal light saturation	Langley/day	L	360
detritus and solids light extinction multiplier	1/m	C	0.2
fraction light intercepted by canopy	none	F	0 – 0.5
segment zooplankton population	mg TOC/L	C	0.05 – 0.5
oxygen to carbon stoichiometric ratio	none	L	2.67
sediment oxygen demand (SOD)	g/m^2-day	F	1 – 4.1
temperature correction for SOD	none	L	1.047

Figures 5-7 and 5-8 illustrate the goodness of fit of the WASP DO simulation. Statistical summaries of overall model goodness-of-fit for Cow Bayou are included in Tables 5-11 through 5-13. Table 5-14 lists the key parameters for the Cow Bayou WASP model. Additional graphical presentations of water quality comparisons of model predicted results and measured data are provided in Appendix H.

For the most part, the WASP model also performed well in predicting water quality conditions in the tidal portion of Cow Bayou and its tidal tributaries. Based on goodness-of-fit targets in the QAPP, the WASP results met the DO target of RMSE < 1.5 mg/L specified for the combination of all station for the separate calibration and validation periods (Table 5-11). If this RMSE target is extended more narrowly than intended to the individual station level, the target is not met at three stations: CB2.5, CB3, and TG2. Stations CB2.5 and CB3 are located in AU 0511_02 of Cow Bayou Tidal, which is impaired for depressed DO and is located between the immediately downstream, unimpaired AU 0511_01 and impaired AUs 0511_03 and 0511_04, which are directly upstream of AU 0511_02. WASP results appear to be less robust in simulating the DO in this transition zone between depressed DO and acceptable DO. The third station with a missed DO performance target was station TG2, which is located in Terry Gully (0511E_01); an AU that is not impaired for depressed DO. The graphical presentation of results for the calibration period (Figure 5-7) and the validation period (Figure 5-8) further illustrate the reasonable predictions of DO by WASP with the less robust simulation apparent around stations CB2.5 and CB3.

For the other water quality parameters, which were based on RMSE values being less than 50 percent of the observed average for all stations, the performance targets were met for all parameters during both the calibration and validation periods (Tables 5-12 and 5-13), except for TSS during the validation period and OrgN during the calibration and validation periods. As with Adams Bayou, the results provided are after a concerted effort to improve TSS predictions.

Because TSS has only secondary implications on the primary parameter, DO, when compared to the primary parameters of cBOD and NH3N, this missed target should have negligible implications on the ability of WASP to predict DO. OrgN does have implications on NH_3N concentration, since OrgN mineralizes into NH_3N. While the RMSE performance target was not met for OrgN, the average simulated concentrations for both the calibration and validation periods are close to the measured concentrations and on average the simulated concentrations are slightly higher affording slightly conservative precitions.

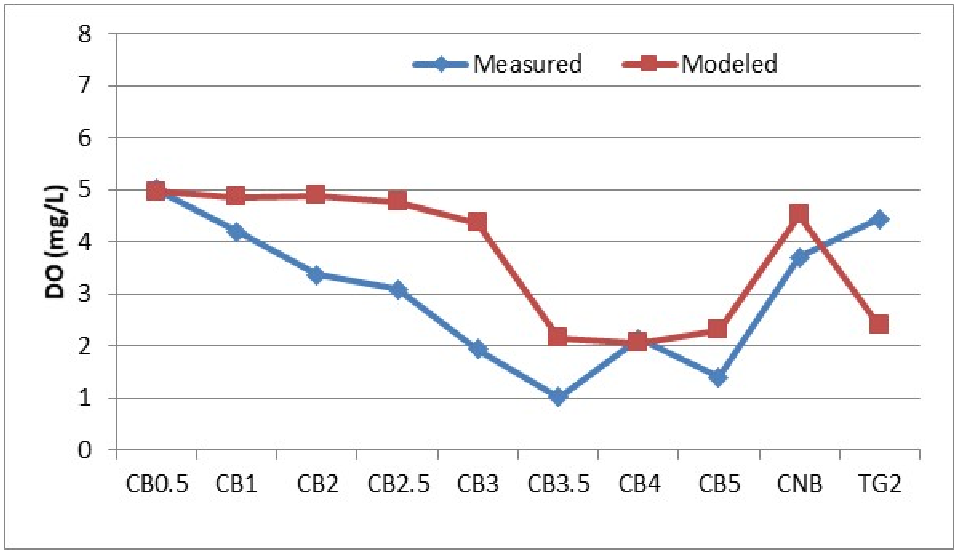

Figure 5-7 Longitudinal model fit of Cow Bayou daily average DO for the calibration period

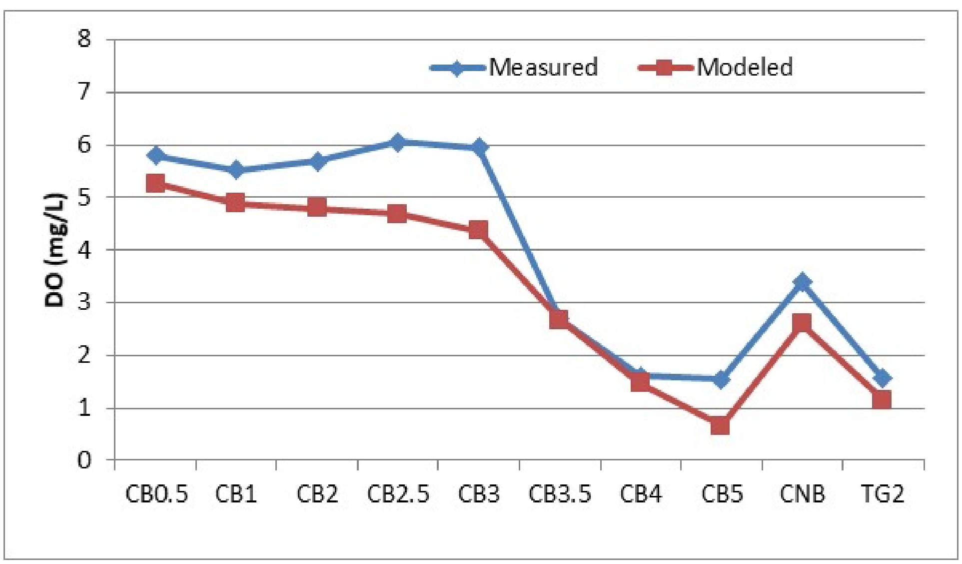

Figure 5-8 Longitudinal model fit of Cow Bayou daily average DO for the validation period

Table 5-11 Model fit statistics for daily average DO (mg/L) in Cow Bayou

Model performance targets based on RMSE and any station's RMSE not meeting the target is in bold **red** font.

Period	Station	n	Measured Average (mg/L)	Model Average (mg/L)	ME (mg/L)	MAE (mg/L)	RMSE (mg/L)
Calibration	All	20	3.01	3.74	0.73	1.12	1.34
Validation	All	20	4.00	3.25	-0.76	0.76	0.89
All Data	CB0.5	4	5.43	5.12	-0.31	0.38	0.43
All Data	CB1	4	4.88	4.87	-0.01	0.66	0.69
All Data	CB2	4	4.55	4.83	0.28	1.22	1.27
All Data	CB2.5	4	4.58	4.73	0.15	1.55	**1.57**
All Data	CB3	4	3.95	4.36	0.41	2.02	**2.07**
All Data	CB3.5	4	1.86	2.41	0.55	0.63	0.81
All Data	CB4	4	1.84	1.76	-0.08	0.42	0.51
All Data	CB5	4	1.46	1.49	0.03	0.91	0.95
All Data	CNB	4	3.54	3.56	0.02	0.99	1.34
All Data	TG2	4	2.96	1.78	-1.18	1.21	**1.74**

Table 5-12 Calibration statistics for the Cow Bayou WASP model

Model performance targets based on RMSE and any parameter's RMSE not meeting the target is in bold **red** font.

Parameter	Measured Average	Model Average	ME	MAE	RMSE
Salinity (ppt)	0.13	0.25	0.12	0.12	0.15
TSS (mg/L)	9.92	6.59	-2.54	3.62	4.20
cBOD (ultimate, mg/L)	11.12	9.90	-1.22	3.95	4.59
OrgN (mg/L)	0.87	0.95	0.08	0.42	**0.49**
NH_3N (mg/L)	0.14	0.09	-0.05	0.06	0.07
NO_3N (mg/L)	0.14	0.07	-0.06	0.07	0.08
PO_4P (mg/L)	0.06	0.10	0.04	0.05	0.07
Chla (µg/L)	25.42	26.96	1.55	17.28	21.92

Table 5-13 Validation statistics for the Cow Bayou WASP model

Model performance targets based on RMSE and any parameter's RMSE not meeting the target is in bold **red** font.

Parameter	Measured Average	Model Average	ME	MAE	RMSE
Salinity (ppt)	1.32	1.29	-0.03	0.27	0.35
TSS (mg/L)	9.29	12.53	3.24	3.92	**6.30**
cBOD (ultimate, mg/L)	8.09	10.90	2.82	4.53	6.83
OrgN (mg/L)	0.60	0.61	0.01	0.28	**0.36**
NH_3N (mg/L)	0.08	0.16	0.08	0.12	0.19
NO_3N (mg/L)	0.08	0.11	0.02	0.05	0.06
PO_4P (mg/L)	0.03	0.20	0.17	0.17	0.21
Chla (μg/L)	18.54	8.54	-10.01	10.97	15.62

Table 5-14 Key parameters of the Cow Bayou WASP model

In the Source Column: F = collected data, L = literature, C=calibrated, Cf = calibrated within range of field collected data

Parameter Description	Units	Source	Value or Range
dispersion coefficient between adjacent segments	m^2/day	C	5 – 50
dispersion coefficient for pore water	cm^2/day	L	$3x10^{-5}$
segment scale factor for wind	none	C	0.4 – 1.1
theta – reaeration temperature coefficient	none	L	1.022
minimum oxygen transfer coefficient (set using wind scale factors and specifiying a minimum wind speed of 2.5 m/s in time seris input)	1/day	L	≈0.6
maximum allowable calculated reaeration rate	1/day	L	10
cBOD decay rate constant @ 20°C	1/day	Cf	0.1
cBOD decay temperature coefficient	none	L	1.047
segment cBOD decay rate scale factor	none	C	0.4 – 3.0
BOD half-saturation oxygen limit	mg/L O_2	L	0.5
fraction of detritus dissolution to cBOD	none	L	1
detritus dissolution rate	1/day	C	0.5
detritus dissolution temperature coefficient	none	L	1.047
OrgN mineralization rate constant (dissolved) @ 20°C	1/day	C	0.15
OrgN mineralization (dissolved) temperature coefficient	none	L	1.08
OrgN mineralization rate constant (sediments) @ 20°C	1/day	L	$4x10^{-2}$
OrgN mineralization (in sediments) temperature coefficient	none	L	1.047

Parameter Description	Units	Source	Value or Range
OrgP mineralization rate constant (dissolved) @ 20°C	1/day	C	0.22
OrgP mineralization (dissolved) temperature coefficient	none	L	1.08
OrgP mineralization rate constant (sediments) @ 20°C	1/day	L	$4x10^{-4}$
OrgP mineralization rate (sediments) temperature coefficient	none	L	1.047
fraction of phytoplankton death recycled to OrgP	none	C	0
nitrification rate constant @ 20°C	1/day	C	0.35
nitrification temperature coefficient	none	L	1.08
half-saturation for nitrification	mg/L O_2	L	2
segment benthic NH_3N flux	mg/m^2-day	C	-100 – 100
half-saturation for denitrification	mg/L O_2	L	5
denitrification rate constant @ 20°C	1/day	C	0.6
denitrification temperature coefficient	none	L	1.045
segment benthic PO_4P flux	mg/m_2-day	C	-10
phytoplankton maximum growth rate constant @ 20°C	1/day	C	1.4
phytoplankton growth temperature coefficient	none	L	1.068
algal self-shading coefficient	none	L	0.048
algal self-shading exponent	none	L	1
phytoplankton carbon to chlorophyll ratio	none	L	36
phytoplankton half-saturation constant for nitrogen uptake	mg N/L	L	0.05
phytoplankton half-saturation constant for phosphorus uptake	mg P/L	L	0.01
phytoplankton endogenous respiration rate constant @ 20°C	1/day	C	.075
phytoplankton respiration temperature coefficient	none	L	1.045
phytoplankton non-predatory mortality rate constant	1/day	L	0.2
phytoplankton phosphorus to carbon ratio	none	C	0.025
phytoplankton nitrogen to carbon ratio	none	L	0.25
phytoplankton maximum quantum yield	Langley/day	L	720
phytoplankton half-saturation for recycle of OrgN and OrgP	mg/L TOC	L	0.2
phytoplankton optimal light saturation	Langley/day	L	360
detritus and solids light extinction multiplier	1/m	C	0.2
fraction light intercepted by canopy	none	F	0 – 0.4
oxygen to carbon stoichiometric ratio	none	L	2.69
sediment oxygen demand	g/m^2-day	F	0.5 – 4.5
temperature correction for SOD	none	L	1.047

6. Existing Conditions and Water Quality Targets

Following calibration and validation of the modeling system, simulations were performed to evaluate the reach-specific status with respect to existing impairments of water quality criteria. These simulations were performed for the 11-year period January 1, 2002 through December 31, 2012. This long simulation period ensures that inter-annual and seasonal variability is addressed adequately. The simulations were performed using the existing HSPF NPS and, existing permit point source loads, and full permitted point source loads.

The NPS and MS4 loads simulated in HSPF were based on the 2006 NLCD land use and land cover, which provided a good basis of information for the calibration and validation, which was based predominately on data collected in 2004. Since the 2006 NLCD, the 2011 and 2016 NLCD have been developed and released. A comparison of land use and land cover from the 2006 and 2016 NLCD indicates that some land use changes are indicated to have occurred in the Adams and Cow Bayou watersheds (Table 6.1). Some of the greatest percent change has occurred for land cover categories with small acreages, e.g., barren and deciduous forest, and are largely inconsequential in the overall land cover characteristics of the watersheds. Further, the changes in certain land cover categories between the two NLDCs could be real, since there has been some small rate of population growth in the watersheds; however, some of the changes could be related to technology advances or interpretive decisions of the images used in the classification. An example of the latter is the aggregated developed land cover, which shows a small percent decrease from 2006 to 2016 in both the Adams and Cow Bayou watersheds. Such a decline seems most likely explained by changes in interpretive algorithms or imagery resolution than an actual physical decrease in developed area. Regardless, the decision was made to not go through the tedious task of updating the PERLND and IMPLND characteristics of each sub-basin within the Adams Bayou and Cow Bayou HSPF models to reflect the characteristics of the 2016 NLCD, because these changes were not considered substantial enough to warrant the resource commitment given the limited change in HSPF output expected from the land use and land cover changes.

Table 6-1 Comparison of the 2006 and 2016 NLCD land use and land cover in the Adams Bayou and Cow Bayou watersheds

NLCD Land Cover Category	Adams Bayou 2006 NLCD (acres)	Adams Bayou 2016 NLCD (acres)	Adams Bayou Percent Change 2006 to 2016 (%)	Cow Bayou 2006 NLCD (acres)	Cow Bayou 2016 NLCD (acres)	Cow Bayou Percent Change 2006 to 2016 (%)
Open Water	439	517	17.8%	1,005	1,241	23.5%
Developed, Open Space	3,560	3,264	-8.3%	10,278	8,575	-16.6%
Developed, Low Intensity	4,470	3,981	-10.9%	7,186	6,800	-5.4%
Developed, Medium Intensity	866	1,068	23.3%	1,514	1,853	22.4%
Developed, High Intensity	516	607	17.6%	878	966	10.0%
Barren Land	9	33	266.7%	64	80	25.0%
Deciduous Forest	148	10	-93.2%	102	222	117.6%
Evergreen Forest	1,234	1,216	-1.5%	15,785	18,816	19.2%
Mixed Forest	1,364	1,319	-3.3%	13,864	13,973	0.8%
Shrub/Scrub	816	700	-14.2%	8,153	7,189	-11.8%
Grassland/Herbaceous	1,403	478	-65.9%	8,204	4,059	-50.5%
Pasture Hay	6,574	7,861	19.6%	11,791	17,043	44.5%
Cultivated Crops	828	377	-54.5%	1,577	310	-80.3%
Woody Wetlands	5,951	6,495	9.1%	43,412	40,849	-5.9%
Emergent Herbaceous Wetlands	1,489	1,741	16.9%	3,397	5,234	54.1%
Aggregated Categories [1]						
Developed	9,412	8,920	-5.2%	19,856	18,194	-8.4%
Forest	2,746	2,545	-7.3%	29,751	33,011	11.0%
Agriculture	8,805	8,716	-1.0%	21,572	21,412	-0.7%
Wetlands	7,440	8,236	10.7%	46,809	46,083	-1.6%

[1] Deveoped = combined Open Space Developed, Low Intentisty Developed, and High Intensity Developed
Forest = combined Deciduous Forest, Evergreeen Forest, and Mixed Forest
Agriculture = combined Grassland/Herbaceous, Pasture Hay, and Cultivated Crops
Wetlands = combined Woody Wetlands and Emergent Herbaceous Wetlands

6.1 Methodology for Calculating Pollutant Loads at AU Level

Because some HSPF sub-basins are spatially located in more than one AU in both the Adams Bayou and Cow Bayou models, the following methodology was used to map HSPF sub-basin-level loads into the proper AUs. Most sub-basins were located in a single AU, and for those sub-basins the entire loading for the HSPF sub-basin was added to that single AU. Some sub-basins, however, were geographically located in two or, in one instance, three AUs. The HSPF predicted loads of $cBOD_5$ and NH_3N were proportioned to the AUs using the percent of the sub-basin area in each AU. The percentages used to separate HSPF sub-basin-level pollutant loads into AUs of the Adams Bayou and Cow Bayou watersheds are provided in Table 6-2.

Table 6-2 Percentages used to separate HSPF sub-basin-level pollutant loads into AUs

HSPF Sub-basin	Percent Contribution of Sub-basin to AU	AU
Adams 1	100.0%	0508B_01
Adams 2	100.0%	0508A_01
Adams 3	100.0%	0508B_01
Adams 4	100.0%	0508A_01
Adams 5	69.6%	0508_04
	30.4%	0508A_01
Adams 6	100.0%	0508A_01
Adams 7	100.0%	0508_04
Adams 8	100.0%	0508C_01
Adams 9	100.00%	0508_01
Adams 10	18.3%	0508_01
	29.4%	0508_02
	52.3%	0508_03
Adams 11	100.0%	0508_01
Adams 12	100.0%	0508_01
Cow 1	100.0%	0511A_02
Cow 2	100.0%	0511A_02
Cow 3	100.0%	0511A_02
Cow 4	36.9%	0511A_01
	63.1%	0511A_02
Cow 5	100.0%	0511E_01
Cow 6	100.0%	0511E_01
Cow 7	100.0%	0511C_01
Cow 8	88.4%	0511_04
	11.6%	0511A_01
Cow 9	68.8%	0511_03
	30.2%	0511_04
Cow 10	100.0%	0511C_01
Cow 11	100.0%	0511_02
Cow 12	7.9%	0511_02
	92.1%	0511_03

HSPF Sub-basin	Percent Contribution of Sub-basin to AU	AU
Cow 13	100.0%	0511E_01
Cow 14	100.0%	0511_02
Cow 15	100.0%	0511B_01
Cow 16	38.3%	0511_01
	61.7%	0511_02
Cow 17	71.5%	0511_01
	28.5%	0511D_01
Cow 18	100.0%	0511_01

6.2 Water Quality Targets

The tidal AUs have a "high" aquatic life use, and the water quality criteria require that daily average DO at any site be at least 4 mg/L, with a daily minimum of at least 3 mg/L (Table 6-3). In order for water quality standards to be judged as fully supported, no more than 10 percent of daily average DO measurements can fall below this 4 mg/L daily-average criterion.

The above tidal reaches in these systems are considered intermittent water bodies with perennial pools. A "limited" aquatic life use is assumed for these water bodies, with a daily average criterion of 3 mg/L DO and a daily minimum criterion of 2 mg/L DO. In order for water quality standards to be judged as fully supported, no more than 10 percent of daily average DO measurements can fall below 3 mg/L daily-average DO.

The daily average DO criteria for aquatic life served as the instream target for calculating the necessary pollutant load reductions required by TMDLs for the tidal AUs. The daily minimum DO criterion was not evaluated, because the model was not set up or calibrated to predict diurnal fluctuations in DO, but was calibrated to simulate daily average DO.

The WASP model daily average DO results were used to assess tidal stream AUs by averaging the daily average DO results of all the segment used to represent each AU (Table 6-3). The HSPF model daily average DO reults were used to assess above tidal stream AUs in a similar manner. A complicating factor is that the tidal/nontidal boundary in water bodies of the Adams Bayou and Cow Bayou systems is variable and not precisely determined. Some upstream portions of the WASP model segments are considered to be located in above tidal AUs based on water quality AU definitions in the Texas Surface Water Quality Standards; whereas the upstream segmentation of the RMA2 and WASP models, which were defined by field measurements of tidla influence observed during the intensive surveys used in model verification, included the downstream reaches of some above tidal AUs. Adams Bayou Above Tidal (AU 0508A_01), Gum Gully (AU 0508B_01), and Terry Gully (AU 0511E_01) are the above tidal water bodies that field measurements indicated have tidal influences in their more downstream reaches, and these three AUs were, therefore, assessed using both WASP and HSPF DO results. For these three AUs, the assessment process used the daily average DO predictions from WASP and HSPF and the fraction of the length of the AU represented in WASP, with the remaining fraction of the AU assumed to be represented in HSPF. For each day of the 11-year simulated period, a daily average DO was computed for each of these AUs based on multiplying WASP derived daily average DO by the fraction of the AU length represented in WASP and adding to that value the HSPF derived daily average DO multiplied by the fraction of the AU length represented in HSPF.

Furthermore, in the WASP model, the most upstream segment in each tributary was not included in the assessment of compliance because they are heavily influenced by model boundary conditions and do not respond appropriately to changes in loading. It should be noted that extra segments were added to the upstream ends of tributaries during model development to provide a buffer to minimize the boundary effects on scenario evaluation.

Individual AUs were evaluated for compliance with the DO criteria specified in Table 6-3. In order for water quality standards to be judged as fully supported, no more than 10 percent of the model-predicted daily average DO measurements averaged across all model elements within each AU, over the period January 1, 2002 to December 31, 2012, can fall below the DO criterion specified in Table 6-3.

Table 6-3 DO criteria and modeling system connections for DO assessment

Waterbody Name	AU	Aquatic Life Use	Type	Model Element or Reach	Model	AVG/MIN DO criteria (mg/L)
Adams Bayou Tidal	0508_01	High	Tidal stream	2-27	WASP	4/3
	0508_02	High	Tidal stream	28-34	WASP	4/3
	0508_03	High	Tidal stream	35-48	WASP	4/3
	0508_04	High	Tidal stream	49-68	WASP	4/3
Adams Bayou Above Tidal	0508A_01	Limited	Intermittent with pools	2	HSPF	3/2
				69-87	WASP	3/2
Gum Gully	0508B_01	Limited	Intermittent with pools	1	HSPF	3/2
				113-117	WASP	3/2
Hudson Gully	0508C_01	High	Tidal stream	109-111	WASP	4/3
Cow Bayou Tidal	0511_01	High	Tidal stream	2-19	WASP	4/3
	0511_02	High	Tidal stream	20-41	WASP	4/3
	0511_03	High	Tidal stream	42-58	WASP	4/3
	0511_04	High	Tidal stream	59-67	WASP	4/3
Cow Bayou Above Tidal	0511A_01	Limited	Intermittent with pools	4	HSPF	3/2
	0511A_02	Limited	Intermittent with pools	1,3	HSPF	3/2
Coon Bayou	0511B_01	High	Tidal stream	97-107	WASP	4/3
Cole Creek	0511C_01	High	Tidal stream	115-123	WASP	4/3
Unnamed Trib to Cow Bayou Tidal	0511D_01	High	Tidal stream	85-87	WASP	4/3
Terry Gully	0511E_01	Limited	Intermittent with pools	6,13	HSPF	3/2
				125-135	WASP	3/2

6.3 Full Permitted Pollutant Loads

Existing pollutant loads were calculated as the average of the daily NPS loads for the entire simulation period (January 1, 2002 to December 31, 2012) and the current full permitted TPDES loads for point source discharges. Note that in addition to cBOD and NH_3N, OrgN also influences DO upon decay, but there are no permit limits or monitoring requirements for OrgN in TPDES permitted PS discharges for the Adams Bayou and Cow Bayou watersheds. For permitted municipal discharges without NH_3N permit limits, a concentration of 12 mg/L was assumed, which is what TCEQ uses in permit evaluations. For industrial facilities without NH_3N limits, a limit of 1.0 mg/L was used if historical discharge monitoring report data indicated reported concentrations not exceeding that limit. The exceptions on the industrial permits was Chevron Phillips Chemical Company, where the discharge monitoring report data supported a limit of 0.8 mg/L, and Printpak, Inc., where the data for this facility indicated higher concentrations resulting in a limit for NH_3N of 3 mg/L.

In the absence of permit limits, the following assumed values for OrgN concentrations were applied in wastewater discharges, based on best professional judgement and through consultation with TCEQ:

Domestic Facilities	
If BOD_5/$cBOD_5$ <7 **and** NH_3N < 7	OrgN = 1 mg/L
If BOD_5/$cBOD_5$ <11 **and** NH_3N < 7	OrgN = 2 mg/L
If BOD_5/$cBOD_5$ <11 **or** NH_3N < 7	OrgN = 3 mg/L
Otherwise	OrgN = 4 mg/L
Industrial Facilities	
If measured/reported in permit application	Use average reported
Otherwise	OrgN = 0.1 mg/L

The City of Orange (TPDES Permit 10626-001) typically discharges through outfall 001 to the Sabine River. The permit allows the city to discharge through outfall 002 to Adams Bayou only if, as a result of wet weather conditions, the average discharge from the facility exceeds 11,111 gallons per minute. The City of Orange is required by their permit to provide, in their monthly discharge monitoring report, the maximum daily and average daily discharge through outfall 002. These discharge monitoring report data were used to define that dates of discharge within the 11-year simulation period. Since the available data on the discharge through outfall 002 did not provide an exact day within the month for the discharge nor the number of days of discharge, these two assumptions were made in order to define the discharge for the modeling system: (1) the discharge for any month was assigned to begin the day of maximum daily precipitation within that month based on the precipitation input record to the modeling system,(2) whenever the reported daily maximum and daily average discharge were different values, then the discharge was assumed to occur over two successive days at the average flow. For most months in the simulation period of 2002 – 2012, the daily maximum and daily average discharge was reported as the same values, which, while not definitive, is a strong indication of only one day of discharge. There were 23 months with reported discharge over the 132 month simulated period, and in 15 of those months the reported daily maximum and average were the same value.

Table 6-4 summarizes the currently actuve TPDES permitted PS discharges and currently proposed Bayou Pines TPDES permitted PS discharges for selected parameters related to the DO impairments. The TPDES point source load information for municipal and industrial facilities in Table 6-4 were used as input to the modeling system. The TPDES point source loads represent the daily average full permitted loads for NH_3N and $cBOD_5$.

Tables 6-5 and 6-6 summarize the full permitted loads for NH_3N and $cBOD_5$, the key pollutants most closely related to DO impairments, in Adams Bayou and Cow Bayou, respectively. Loads are summarized at the individual AU level based on HSPF sub-basin output using the methodology presented in Section 6.1 and the percentage of the area of individual AUs within the HSPF subbasins. These total runoff loads are separated into unregulated and regulated stormwater components according to on the percent of each AU that is regulated stormwater area. Note that details on the estimation of the regulated area are provided in the bacteria technical support document for the Adams Bayou and Cow Bayou watershed (Hauck and Adams, 2020 [Section 2.6.1 - Regulated Sources]). The daily simulated HSPF sub-basin loads for NH_3N and $cBOD_5$ for the 11-year period are averaged to give a daily average load prior to being proportioned into the respective AUs.

Table 6-4 Existing full-permitted TPDES daily average PS loads to Adams and Cow Bayous

Permit	Outfall	Assessment Unit	WASP Segment	RMA2 Element	HSPF Sub-Basin	Flow MGD	$BOD_5/cBOD_5$ mg/L (lb/day)	NH_3N mg/L (lb/day)	DO[1] mg/L (lb/day)
Adams Bayou									
WQ0010597-001 City of Pinehurst	001	0508_03	48	BQE 36	NA	**0.5**	**20 (83)**	12 [2] (50.1)	**3.0** (12.5)
WQ0010240-001 Orange County WCID 2	001	0508_02	31	BQE 28	NA	**1.22** [3]	**10 (102)**	12 [2] (153.7)	**4.0** (40.7)
WQ0010626-001 City of Orange	002	0508_02	31	BQE 28	NA	**7.0** [4]	**20 (1,168)**	12 [2] (701)	**2.0** (116.8)
Cow Bayou									
WQ0001167-000 ARLANXEO USA LLC	001	0511_01	5	BQE 19	NA	**6.0**	3.5 (**176**)	1 [10] (50.1)	2.0 [2] (100.1)
WQ0000670-000 Honeywell International Inc.	001	0511_01	79	BQE 14	NA	**1.4**	10 (**117**)	1 [10] (11.7)	2.0 [2] (23.3)
WQ0000454-000 Lion Elastomers Orange, LLC	001 002 [5]	0511_01	10	BQE 21	NA	**1.202** –	11 (**110**) –	2 (**20**) –	2.0 [2] (20) –
WQ0000359-000 Chevron Phillips Chemical Company LP	001	0511D_01	88	BQE 83	NA	**3.15**	17.5 (**460**)	0.8 [10] (21.0)	2.0 [2] (20.0)
WQ0002858-000 Printpack, Inc.	001 101 [6]	0511D_01	88	BQE 83	NA	**0.085** –	10 [8] (7.1) –	3 [10] (2.1) –	2.0 [2] (1.4) –
WQ0010051-001 City of Bridge City	001	0511_01	17	BQE 38	NA	**1.6** [3]	**10 (133)**	12 [2] (160)	**4.0** (53.4)
WQ0014772-001 Orangefield Water Supply Corporation	001	0511_02	29	BQE 44	NA	**0.75**	**10 (63)**	**2 (13)**	**4.0** (25)
WQ0015029-001 (proposed) Bayou Pines	001	0511B_01	107	BQE 36	NA	**0.009**	**30** (2.3)	**8** (0.6)	**4.0** (0.3)

Permit	**Outfall**	**Assessment Unit**	**WASP Segment**	**RMA2 Element**	**HSPF Sub-Basin**	**Flow MGD**	**BOD_5/$cBOD_5$ mg/L (lb/day)**	**NH_3N mg/L (lb/day)**	**DO[1] mg/L (lb/day)**
WQ0013488-001 Gulflander Partners Group, L.P.	001	0511B_01	101	BQE 33	NA	**0.01**	**20 (1.7)**	12 [2] (1.0)	**2.0** (0.17)
WQ0011916-001 P C S Development Company	001	0511_04	67	BQE 79	NA	**0.09**	**20 (15)**	12 [2] (9)	**2.0** (1.5)
WQ0002835-000 Miller Waste Mills, Inc.	001 [5] 002 003 [7]	0511_02	NA	NA	11	– 0.116 [11] –	– **20 [9]** (16.9) –	– 1 [8] (1.0) –	– 2.0 [2] (1.9) –
WQ0010808-001 Jasper County WCID 1	001	0511A_02	NA	NA	1	**0.41**	**30 (103)**	**6 (21)**	**4.0** (13.7)

Table Notes:

NA = not applicable

Bold values represent quantities specified as limits in the permit.

[1] Permit limits for DO are applied as a minimum, rather than a daily average.

[2] Default value based on TCEQ guidance and values assumed in TCEQ permit evaluations.

[3] Annual average flow in MGD.

[4] Intermittent discharge. The permittee is authorized to discharge from Outfall 002 only if, as a result of wet weather conditions, the average discharge from the facility exceeds 11,111 gallons per minute. Combined average annual discharge of Outfalls 001 and 002 is not to exceed 7.0 MGD. Simulated as 7.0 MGD on all days of discharge indicated in the discharge monitoring report data for the period of January 1, 2002 – December 31, 2012. Outfall 001 discharges to the Sabine River.

[5] Stormwater only outfall; not included as direct point source in modeling system; included through land use in HSPF model.

[6] Internal outfall that is included in Outfall 001.

[7] Based on discharge monitoring report data, discharges from Outfall 003 have never been reported; outfall not included in modeling effort.

[8] Estimate based on permit renewal information.

[9] Permit has a daily maximum limit of 26 mg/L; daily average BOD_5 based on ratio of permit limits for daily average and daily maximum total organic carbon and the daily maximum BOD_5 limit.

[10] Value determined based on evaluation of discharge monitoring report data.

[11] Average of 2017 – 2018 discharge monitoring report data.

Table 6-5 Summary of daily average NH_3N and cBOD loads under full permitted conditons to the Adams Bayou system

Load units expressed in lbs/day; total runoff load = unregulated stormwater load + regulated stormwater load

AU	Total Runoff Load			Unregulated Stormwater Load		TPDES Point Source Load		Regulated Stormwater Load		Total Load	
	$cBOD_5$	NH_3N	Regulated Stormwater Area (%)	$cBOD_5$	NH_3N	$cBOD_5$	NH_3N	$cBOD_5$	NH_3N	$cBOD_5$	NH_3N
0508_01	268.70	21.89	59.87	107.83	8.78	0.00	0.00	160.87	13.11	268.70	21.89
0508_02	49.19	4.15	99.85	0.07	0.01	1,270.11[1]	823.15[1]	49.12	4.14	1,319.30	827.30
0508_03	79.02	6.66	100.00	0.00	0.00	83.45	50.07	79.02	6.66	162.47	56.73
0508_04	325.14	26.97	76.46	76.54	6.35	0.00	0.00	248.60	20.62	325.14	26.97
0508A_01	586.33	43.50	4.21	561.65	41.67	0.00	0.00	24.68	1.83	586.33	19.73
0508B_01	100.29	7.30	2.33	97.95	7.13	0.00	0.00	2.34	0.17	100.29	7.30
0508C_01	105.47	8.71	99.32	0.72	0.06	0.00	0.00	104.75	8.65	105.47	8.71
System Total	1,514.14	119.18	NA[2]	844.76	64.00	1,353.56	873.22	669.38	55.18	2,867.70	968.63

[1] Includes the loads from intermittent discharge from the City of Orange WWTF based on a flow of 7.0 MGD, though that flow only occurs infrequently during the 2001 – 2012 simulated period.

[2] N/A – not applicable. Adams Bayou watersheds is represented by multiple sub-basins in HSPF with each sub-basin containing a unique composition of land uses that result in differing runoff loads of $CBOD_5$ and NH_3N by area. Also, the loads from each sub-basin are proportioned unregulated and regulated stormwater components for individual AUs based on the percent of the sub-basin in each AU and the regulated stormwater area percent of each AU. The differing land uses comprising HSPF sub-basins and subsequent differing runoff loads by area result in spatial variability that does not allow a unique watershed-wide percent of regulated stormwater to be computed that is correct for both $CBOD_5$ and NH_3N runoff loads.

Table 6-6 Summary of daily average NH_3N and cBOD loads under full permitted conditon to the Cow Bayou system

Load units expressed in lbs/day; total runoff load = unregulated stormwater load + regulated stormwater load

Sub-basin, TPDES permit, or AU	Total Runoff Load			Unregulated Stormwater Load		TPDES Point Source Load		Regulated Stormwater Load		Total Load	
	$cBOD_5$	NH_3N	Regulated Stormwater Area (%)	$cBOD_5$	NH_3N	$cBOD_5$	NH_3N	$cBOD_5$	NH_3N	$cBOD_5$	NH_3N
0511_01	222.25	17.68	29.30	157.13	12.50	535.61	241.90	65.12	5.18	757.86	259.58
0511_02	362.92	28.31	9.02	330.18	25.76	81.90	13.48	32.74	2.55	444.82	41.79
0511_03	132.53	9.20	2.23	129.57	8.99	0.00	0.00	2.96	0.21	132.53	9.20
0511_04	67.46	4.54	5.61	63.68	4.29	15.01	9.01	3.78	0.25	82.47	13.55
0511A_01	613.96	40.58	1.17	606.78	40.11	0.00	0.00	7.18	0.47	613.96	40.58
0511A_02	1,059.52	69.64	0.34	1,055.92	69.40	102.58	20.52	3.60	0.24	1,162.10	90.16
0511B_01	140.19	11.11	27.87	101.12	8.01	3.92	1.60	39.07	3.10	144.11	12.71
0511C_01	297.45	20.15	1.63	292.60	19.82	0.00	0.00	4.85	0.33	297.45	20.15
0511D_01	43.61	3.76	60.52	17.22	1.48	466.83	23.15	26.39	2.28	510.44	26.91
0511E_01	657.15	45.06	18.40	536.23	36.77	0.00	0.00	120.92	8.29	657.15	45.06
System Total	3,597.04	250.03	NA[1]	3,290.43	227.13	1,205.85	309.66	306.61	22.90	4,802.89	559.69

[1] N/A – not applicable. Cow Bayou watersheds is represented by multiple sub-basins in HSPF with each sub-basin containing a unique composition of land uses that result in differing runoff loads of $CBOD_5$ and NH_3N by area. Also, the loads from each sub-basin are proportioned unregulated and regulated stormwater components for individual AUs based on the percent of the sub-basin in each AU and the regulated stormwater area percent of each AU. The differing land uses comprising HSPF sub-basins and subsequent differing runoff loads by area result in spatial variability that does not allow a unique watershed-wide percent of regulated stormwater to be computed that is correct for both $CBOD_5$ and NH_3N runoff loads.

6.4 Assessment of Compliance with Water Quality Standards under Existing Conditions and Full Permitted Conditions

Modeling system simulations of existing conditions (i.e., existing HSPF NPS and MS4 pollutant loads and existing permitted point source pollutant loads) and TPDES full permitted conditions were performed. For the existing condition scenario, the TPDES domestic and industrial WWTF discharge inputs to the modeling system were based on discharge monitoring report data and data collected during the intensive surveys used for model verification. The full permitted condition scenario was performed using the same input as the existing conditions scenarios, except the TPDES domestic and industrial WWTF discharge input were based on the information in Table 6-4. Modeling system results were post-processed to determine daily average DO concentrations for each WASP segment and each HSPF sub-basin comprising either the Adams Bayou watershed modeling system or the Cow Bayou watershed modeling sytstem

Statistics were calculated for each AU using the daily average DO data to quantify the:

- number of days with DO concentration less than appropriate daily average criterion for each AU during the entire simulation period;
- the 10th percentile DO concentrations during the entire simulation period; and
- average DO concentrations during the entire simulation period.

Results from both the existing conditions and full permitted conditions scenario predicted that none of the Adams Bayou system water bodies on the CWA Section 303(d) List were expected to be in compliance with water quality standards for DO for the 11-year period simulated (Table 6-7). Compliance with the waer quality standards occurs when 10 percent or less of the simulated days experience depressed average DO concentrations when evaluated at the AU level. The WASP model prediction that all AUs within the Adams Bayou watershed experience depressed DO is agreement with the TCEQ assessed condtions that all the Adams Bayou watershed AUs are impaired.

In the Cow Bayou system, the DO results for the existing conditions and full permitted conditions scenario are provide inTable 6-8. The modeling system predictions of depressed DO are in agreement with the TCEQ assessment of AUs impaired because of depressed DO. Further, for AUs not considered by TCEQ as impaired, the simulated results were in agreement under the existing condtions scenario with AUs 0511_01, 0511A_01, 0511D_01, and 0511E_01 indicated to have depressed DO occurring less than 10 percent of the time. AU 0511D_01, the Unnamed Tributary to Cow Bayou Tidal was simulated as having depressed DO above 10 percent (at 27 percent) under the full permitted condition scenario. As a qualifier, it should be noted that some of the AUs assessed as unimpaired by TCEQ did not have sufficient data for proper assessment.

Table 6-7 Simulated compliance with criteria under existing conditions and full permit conditions for the Adams Bayou system

Values under Days Not Meeting Average DO Criterion that exceed 10% are shown in bold **red** font.

Waterbody Name	AU	Model Element or Reach	Model	24-hour Average DO criterion (mg/L)	Existing Permit Load Scenario			Full Permitted Load Scenario		
					Average DO (mg/L)	10th Percentile DO (mg/L)	Days Not Meeting Average DO Criterion (%)	Average DO (mg/L)	10th Percentile DO (mg/L)	Days Not Meeting Average DO Criterion (%)
Adams Bayou Tidal	0508_01	2-27	WASP	4	3.0	1.2	71	2.5	0.9	**85**
	0508_02	28-34	WASP	4	1.7	0.1	91	1.0	0.1	**97**
	0508_03	35-48	WASP	4	1.5	0.1	91	1.0	0.1	**95**
	0508_04	49-68	WASP	4	1.4	0.0	89	1.2	0.0	**90**
Adams Bayou Above Tidal	0508A_01	Combined WASP & HSPF		3	2.8	0.4	57	2.6	0.2	**59**
Gum Gully	0508B_01	Combined WASP & HSPF		3	4.2	1.5	24	2.9	0.2	**50**
Hudson Gully	0508C_01	109-111	WASP	4	1.8	0.2	88	1.5	0.1	**90**

Table 6-8 Simulated compliance with criteria under existing conditions and full permit conditions for the Cow Bayou system

Values under Days Not Meeting Average DO Criterion that exceed 10% are shown in bold **red** font.

Waterbody Name	AU	Model Element or Reach	Model	24-hour Average DO criterion (mg/L)	Existing Permit Load Scenario			Full Permitted Load Scenario		
					Average DO (mg/L)	10th Percentile DO (mg/L)	Days Not Meeting Average DO Criterion (%)	Average DO (mg/L)	10th Percentile DO (mg/L)	Days Not Meeting Average DO Criterion (%)
Cow Bayou Tidal	0511_01	2-19	WASP	4	5.9	4.4	1	5.7	4.2	5
	0511_02	20-41	WASP	4	5.2	3.1	27	5.0	2.9	**32**
	0511_03	42-58	WASP	4	4.9	1.1	40	4.7	1.0	**42**
	0511_04	59-67	WASP	4	5.3	0.9	37	5.0	0.7	**41**
Cow Bayou Above Tidal	0511A_01	4	HSPF	3	8.2	6.1	0	8.0	5.9	0
	0511A_02	1,3	HSPF	3	5.2	0.0	26	6.1	1.5	**16**
Coon Bayou	0511B_01	97-107	WASP	4	5.3	3.0	25	5.1	2.8	**29**
Cole Creek	0511C_01	115-123	WASP	4	5.8	1.8	30	5.7	1.7	**32**
Unnamed Trib to Cow Bayou Tidal	0511D_01	85-87	WASP	4	7.7	5.2	0	6.1	3.2	**27**
Terry Gully	0511E_01	Combined HSPF & WASP		3	6.5	4.5	3	6.4	4.4	3

7. DO and pH TMDL Allocations

A series of water quality loading scenarios were simulated using the calibrated modeling system to identify their impact on compliance with water quality standards for DO. The pH impairment and load reductions requirements associated with that impairment are addressed separately from the DO impairment and are provided at the end of this section.

7.1 DO Modeling Scenarios

It was assumed that reductions in loads of cBOD and OrgN would ultimately result in reductions in SOD, because SOD is derived from oxidation of settled organic matter. Similarly, reductions in the fluxes of NH_3N from sediments to the water column were assumed to result from reductions in external loading of organic matter. Modeling scenarios involving changes in loading were a two-step process. In the first step, the models were run with external load modifications of cBOD and NH_3N. In the second step, the SOD and internal fluxes of NH_3N and PO_4P from sediments to the water column were modified by a percentage equal to the percent change in the dissolved cBOD concentration in the water column. However, SOD was not reduced below a minimum level of 0.35 $g/m^2/day$. This 0.35 $g/m^2/day$ is an estimate of background SOD, based on a memorandum of understanding between EPA and TCEQ on water quality permitting (TCEQ, 2010).

7.1.1 No Load Scenario

This scenario involved setting all PS and NPS loads to zero. Under this loading scenario, all AUs were in compliance with water quality standards except Cow Bayou Above Tidal AU 0511A_02 (Table 7-1). An evaluation of the HSPF daily average DO results for AU 0511A_02 indicated that when simulated streamflows became low, the DO in this AU was often below the 24-hour average criterion resulting in noncompliance with water quality standards. This scenario explores the physical factors constraining dissolved oxygen dynamics in the Adams Bayou and Cow Bayou stream systems. It does not represent a realistic condition, but is useful for reference purposes.

7.1.2 Pristine Condition Scenario

This scenario involved setting all PS loads to zero and setting all land uses in HSPF to a perceived "natural" condition. For this scenario, all developed land classes, cropland, pasture/hay, and septic fields were converted to the grassland/herbaceous land use category in sub-basins occurring primarily below I-10, and to mixed forest for sub-basins occurring primarily north of IH-10. Thus, there were no anthropogenic pollutant loads, but there were natural non-point source loads corresponding to a likely pre-settlement and pre-development condition. Results of pristine condition modeling scenario are presented in Table 7-2.

Table 7-1 Results of No Load Scenario

Values under Days Not Meeting Average DO Criterion that exceed 10% are shown in bold red font.

Waterbody Name	AU	Model Sub-basin or Reach	Model	24-hour Average DO criterion (mg/L)	Average DO (mg/L)	10th Percentile DO (mg/L)	Days Not Meeting Average DO Criterion (%)
Adams Bayou Tidal	0508_01	2-27	WASP	4	7.0	5.2	0
	0508_02	28-34	WASP	4	8.1	6.5	0
	0508_03	35-48	WASP	4	8.5	7.0	0
	0508_04	49-68	WASP	4	8.9	7.4	0
Adams Bayou Above Tidal	0508A_01	Combined HSPF & WASP		3	7.5	6.2	0
Gum Gully	0508B_01	Combined HSPF & WASP		3	7.3	6.2	2
Hudson Gully	0508C_01	109-111	WASP	4	7.6	6.2	0
Cow Bayou Tidal	0511_01	2-19	WASP	4	7.0	5.2	0
	0511_02	20-41	WASP	4	7.8	6.0	0
	0511_03	42-58	WASP	4	8.8	7.2	0
	0511_04	59-67	WASP	4	8.9	7.3	0
Cow Bayou Above Tidal	0511A_01	4	HSPF	3	8.5	6.8	0
	0511A_02	1,3	HSPF	3	6.5	0.1	**18**
Coon Bayou	0511B_01	97-107	WASP	4	7.6	6.1	0
Cole Creek	0511C_01	115-123	WASP	4	7.6	5.1	3
Unnamed Trib to Cow Bayou Tidal	0511D_01	85-87	WASP	4	8.2	5.5	0
Terry Gully	0511E_01	Combined HSPF & WASP		3	8.1	7.1	3

Under these pristine conditions, the WASP model results show Adams Bayou Above Tidal (0508A_01), Gum Gully (0508B_01), Cow Bayou Above Tidal (0511A_02), and Terry Gully (0511E_01) are not in compliance with water quality standards. Based partly on these model results and partly on the lack of data and information available, the TCEQ decided that, for AUs 0508A_01 and 0508B_02 located in above tidal portions of the Adams Bayou watershed, additional data and analysis should be conducted, including an aquatic life use attainability analysis, prior to proceeding with a TMDL. Therefore, no further modeling of load reductions were performed except to the extent that they were necessary to achieve water quality standards in downstream AUs. For the upstream AU of Cow Bayou Above Tidal, 0511A_02, similar to the no load scenario, simulated low DO occurred during simulated low flow conditions. Terry Gully (0511E_01) was not assessed by TCEQ as impaired due to depressed DO and was not indicated in the existing permit load and full permit load scenarios as experiencing depressed DO (Table 6-8). The noncompliance for Terry Gully under the pristine conditions scenario is also indicated to be a result of the simulated low DO occurring under low flow conditions.

Table 7-2 Results of Pristine Condition Scenario

Values under Days Not Meeting Average DO Criterion that exceed 10% are shown in bold **red** font.

Waterbody Name	AU	Model Sub-basin or Reach	Model	24-hour Average DO criterion (mg/L)	Average DO (mg/L)	10th Percentile DO (mg/L)	Days Not Meeting Average DO Criterion (%)
Adams Bayou Tidal	0508_01	2-27	WASP	4	5.8	4.3	3
	0508_02	28-34	WASP	4	6.5	5.2	0
	0508_03	35-48	WASP	4	6.8	5.5	0
	0508_04	49-68	WASP	4	7.0	5.7	1
Adams Bayou Above Tidal	0508A_01	Combined HSPF & WASP		3	5.8	2.4	**19**
Gum Gully	0508B_01	Combined HSPF & WASP		3	5.3	0.7	**21**
Hudson Gully	0508C_01	109-111	WASP	4	6.0	3.2	8
Cow Bayou Tidal	0511_01	2-19	WASP	4	6.6	5.3	0
	0511_02	20-41	WASP	4	6.5	5.0	2
	0511_03	42-58	WASP	4	7.3	5.2	2
	0511_04	59-67	WASP	4	7.9	5.9	1
Cow Bayou Above Tidal	0511A_01	4	HSPF	3	8.3	6.2	0
	0511A_02	1,3	HSPF	3	5.3	0.0	**34**
Coon Bayou	0511B_01	97-107	WASP	4	6.9	5.5	1
Cole Creek	0511C_01	115-123	WASP	4	7.6	5.4	2
Unnamed Trib to Cow Bayou Tidal	0511D_01	85-87	WASP	4	7.0	5.6	0
Terry Gully	0511E_01	Combined HSPF & WASP		3	7.2	2.7	**10.4**

7.1.3 TMDL Scenarios

A series of scenarios were performed to quantify the assimilative capacity of individual AUs while simultaneously demonstrating compliance for the AUs of the Adams Bayou and Cow Bayou systems. The starting point for these scenarios was the full permit condition represented by the full permit scenario daily average loads from 2002 through 2012 for all nonpoint and MS4 sources (Tables 6-5 and 6-6) and "full permitted" conditions for all TPDES-permitted facilities, as summarized in Table 6-4. Fully permitted loads represent discharge permit limits for NH3N and cBOD5 (or BOD5 where permits are written for that parameter). Loads of cBOD5 and NH3N to each AU were then progressively reduced in the manner shown in Table 7-3, focusing on "hot spots" of low DO, in an iterative fashion until the given AU reached attainment of the DO standard. Minor modifications were then performed to locally optimize the quantification of allowable loading.

Table 7-3 Load Reduction Progression

NPS* Reduction in NH_3N and $CBOD_5$	Industrial PS Reduction NH_3N and BOD_5/$CBOD_5$	Domestic PS Concentration	
		NH_3N(mg/L)	$cBOD_5$ (mg/L)
0% Reduction	0% Reduction	12	20
20% Reduction	20% Reduction	12	10
40% Reduction	40% Reduction	3	10
60% Reduction	60% Reduction	2	10
70% Reduction	70% Reduction	2	7
80% Reduction	80% Reduction	2	7
90% Reduction	90% Reduction	2	5
95% Reduction	95% Reduction	1	5
100% Reduction	100% Reduction	No Discharge	No Discharge

* The term NPS is used here to represent pollutants from regulated and unregulated sources in rainfall runoff.

Additional explanations of the approach taken to reduce $CBOD_5$ and NH_3N loads in the scenario simulations of impaired AUs include the following:

- The reduction in industrial PS loadings was set equal to the reduction in NPS loadings; for these cases, $cBOD_5$ (or BOD_5) and NH_3N were reduced by the same percentage.
- The reductions in domestic PS loadings was performed according to the discrete effluent concentration hierarchy shown in Table 7-3.
- Domestic WWTF loadings were not relaxed from limits in existing permits. The input loads for the WWTFs were specified as the more stringent of (1) existing permit limits (or, in the absence of permit limits, values used to represent permit limits) or (2) the limits specified in Table 7.3.

- For domestic WWTF loadings, the level of required treatment did not increase until the next percent reduction level was reached in Table 7-3. For example, at runoff (NPS) and industrial WWTF reductions from 40 to 59 percent, the municipal permit limits are NH_3N equal to 3 mg/L and $CBOD_5$ equal to 10 mg/L and, for reductions between 60 and 69 percent, the limits are NH_3N equal to 2 mg/L and $CBOD_5$ equal to 10 mg/L;
- The minimum DO concentration specified in permits for industrial or domestic PS was assumed to be increased to 5 mg/L in all AUs for which load reductions were required;
- OrgN was not directly reduced in equal proportion to $cBOD_5$ and NH_3N, because it is not subject to effluent limitations in water quality permits, but was instead adjusted in accordance with the assumptions listed in Section 6.2.

The runoff (NPS) from HSPF and industrial WWTF outfalls permitted for combined stormwater and industrial process wastewater results in a duplicate representation of the stormwater component of these industrial TPDES permitted outfalls (Table 6-4) in the modeling system. Industrial outfalls that are only permitted for stormwater are represented in HSPF. Industrial outfalls that include stormwater and process wastewater are included in HSPF and specified as WWTF inputs into the modeling system. The inability to separate the flows from these industrial outfalls into distinct stormwater and process wastewater components makes this duplication unavoidable. The amount of land area actually contributing through these combined outfalls is estimated to be less than one percent of the 127,210 acres comprising the Cow Bayou watershed. There are no TPDES permitted industrial facilities in the Adams Bayou watershed. Further, the majority of the industrial facilities in the Cow Bayou watershed discharge into unimpaired AUs in the lower portion of Cow Bayou Tidal, where historical data indicate no DO impairments and where the modeling system scenarios give similar results of no DO impairments. Therefore, the duplication is not significantly impacting results and represents a conservative feature of the modeling effort.

The TMDL scenario for the Adams Bayou system involved:

- Unregulated NPS and regulated stormwater load reductions of 45 percent for Adams Bayou Tidal AU 0508_01.
- Unregulated NPS and regulated stormwater load reductions of 40 percent for Adams Bayou Tidal AUs 0508_02 and 0508_03.
- Unregulated NPS and regulated stormwater load reductions of 60 percent for Adams Bayou Tidal AU 0508_04.
- Unregulated NPS and regulated stormwater load reductions of 80 percent for Hudson Gully AU 0508C_01.
- All TPDES municipal WWTFs with daily average effluent limits at 10 mg/L $CBOD_5$ and 3 mg/L NH_3N, and minimum DO at 5 mg/L based on the 40 percent runoff reduction required in AUs 0508_02 and 0508_03.
- No assimilative capacity afforded for future growth.

The TMDL scenario for the Cow Bayou system involved:

- Unregulated NPS and regulated stormwater load reductions of 0 percent for Cow Bayou Tidal AU 0511_02.
- Unregulated NPS and regulated stormwater load reductions of 50 percent for Cow Bayou Tidal AU 0511_03.
- Unregulated NPS and regulated stormwater load reductions of 60 percent for Cow Bayou Tidal AU 0511_04.
- Unregulated NPS and regulated stormwater load reductions of 50 percent for Cow Bayou Above Tidal AU 0511A_02.
- Unregulated NPS and regulated stormwater load reductions of 50 percent for Coon Bayou AU 0511B_01.
- Unregulated NPS and regulated stormwater load reductions of 50 percent for Cole Creek AU 0511C_01.
- Each TPDES municipal or industrial WWTFs effluent limit was based on the runoff percent reductions computed for the AU in which the facility is located. (The AU location of each facility is in Table 6-4.) The exception was for the two industrial facilities located in 0511D_01 for which the simulation indicated that if the assumed DO in the effluent was 5 mg/L, instead of the 2 mg/L assumed in TCEQ modeling, then depressed DO was avoided in this water body. Therefore, for the two industrial facilities in 0511D_01, an effluent minimum DO of 5 mg/L was assigned to their permits for modeling purposes. $CBOD_5$ and NH_3N effluent limits assigned to these two industrial facilities, for modeling purposes, are based on the permit limits provided in Table 6-4.
- An assimilative capacity for future growth of 10 percent of existing loads was available for industrial and municipal facilities in AUs 0511_01, 0511_02, and 0511D_01.

A summary of the DO results for the TMDL scenario is provided in Table 7-4 for all AUs assessed by TCEQ as impaired for DO as shown on Figure 1-1**.** The results in Table 7-4 are provided as two sets of columns representing with and without consideration of future growth in Cow Bayou Tidal AUs 0511_01 and 0511_02. The allowance for future growth is further explained in Section 7.3.3.

Table 7-4 Results of TMDL Scenarios for conditions with and without future growth for DO impaired AUs of Adams Bayou and Cow Bayou watersheds

AUs 0511_01 and 0511D_01 are not impaired for DO but are included in this table for the purpose of showing the implications of future growth on DO in these AUs.

Waterbody Name	AU	Model Sub-basin or Reach	Model	24-hour Average DO criterion (mg/L)	Without Future Growth			With Future Growth		
					Average DO (mg/L)	10th Percentile DO (mg/L)	Days Not Meeting Average DO Criterion (%)	Average DO (mg/L)	10th Percentile DO (mg/L)	Days Not Meeting Average DO Criterion (%)
Adams Bayou Tidal	0508_01	2-27	WASP	4	5.6	4.0	9.2	NA	NA	NA
	0508_02	28-34	WASP	4	6.0	4.5	1.2	NA	NA	NA
	0508_03	35-48	WASP	4	6.2	4.7	1.0	NA	NA	NA
	0508_04	49-68	WASP	4	5.9	4.1	7.1	NA	NA	NA
Hudson Gully	0508C_01	109-111	WASP	4	5.8	4.2	6.9	NA	NA	NA
Cow Bayou Tidal	0511_01	2-19	WASP	4	6.1	4.5	0.1	6.0	4.4	1.0
	0511_02	20-41	WASP	4	6.3	4.2	4.5	6.2	4.0	7.7
	0511_03	42-58	WASP	4	6.9	4.1	7.9	6.9	4.0	9.9
	0511_04	59-67	WASP	4	7.3	4.1	8.2	7.3	4.1	9.1
Cow Bayou Above Tidal	0511A_02	1,3	HSPF	3	7.1	3.4	8.4	7.1	3.4	8.4
Coon Bayou	0511B_01	97-107	WASP	4	6.2	4.1	8.4	6.1	4.0	9.7
Cole Creek	0511C_01	115-123	WASP	4	7.3	4.1	8.6	7.2	4.0	9.7
Unnamed Trib to Cow Bayou Tidal	0511D_01	85-87	WASP	4	7.2	4.1	6.0	7.1	4.0	8.5

NA = not applicable, no FG available for Adams Bayou system

7.2 Margin of Safety for DO TMDLs

The MOS is used to account for uncertainty in the analysis used to develop TMDLs and thus provides a higher level of assurance that the goal of the TMDLs will be met. According to EPA guidance (EPA, 1991), the MOS can be incorporated into the TMDL using two methods:

1. Implicitly incorporating the MOS using conservative model assumptions to develop allocations; or
2. Explicitly specifying a portion of the TMDL as the MOS and using the remainder for allocations.

The margin of safety is designed to account for any uncertainty that may arise in specifying water quality control strategies for the complex environmental processes that affect water quality. Accounting for this uncertainty, to the extent possible, is the basis for assigning a margin of safety.

The DO TMDLs incorporate an implicit MOS based on conservative model assumptions. The conservative model assumptions include:

- The fact that the evaluation was performed under full permitted limits for point source discharges, which are seldom reached in practice.
- The models predict that DO levels are greater than required to meet water quality standards in most AUs. That is, in order to meet the criteria 90 percent of the time in several of the impaired AUs, the DO levels in adjacent AUs meet the criteria more than 90 percent of the time.
- A multiplier of 3.0 was used to convert $CBOD_5$ to ultimate carbonaceous biochemical oxygen demand for all TPDES municipal and industrial WWTFs inputs included in the modeling system. A default value of 2.3 is used as the multiplier in TCEQ permit evaluations. The multiplier of 3.0 was based on statistical analysis of simultaneously collected five, fifteen, and twenty-day carbonaceous biochemical oxygen demand in ambient water samples obtained during the intensive surveys used for verification of the modeling systems.
- Stormwater runoff loads for some industrial facilities are accounted for in both the HSPF and WASP models.

7.3 Pollutant Load Allocation for DO

The TMDL represents the maximum amount of a pollutant that the stream can receive in a single day without exceeding water quality standards. The pollutant load allocations for the selected scenarios were calculated using the TMDL equation, repeated here for clarity:

TMDL = WLA + LA + FG + MOS

Where:

WLA = wasteload allocation, the amount of pollutant allowed by regulated dischargers

LA = load allocation, the amount of pollutant allowed by unregulated sources

FG = loadings associated with future growth from potential regulated facilities

MOS = margin of safety load

As stated in 40 CFR 130.2(i), TMDLs can be expressed in terms of mass per time, toxicity, or other appropriate measures. For DO impairments, TMDLs are expressed as pounds per day of pollutants affecting DO dynamics and represent the maximum one-day load the water body can assimilate while still attaining the DO criteria specified in the Texas Surface Water Quality Standards.

The TMDL component for each impaired AU covered in this report is derived using the daily average loads from the 11-year simulations of flow and water quality in the streams of Adams Bayou and Cow Bayou watersheds. The pollutant load reduction scenarios of each watershed, for which DO conditions are summarized in Table 7-4, provides the basis of the DO TMDLs. The following sections will present an explanation of each TMDL component first, followed by the TMDL results.

7.3.1 Wasteload Allocation for DO

As previously mentioned, the WLA consists of two parts—the wasteload that is allocated to TPDES-regulated WWTFs (WLA_{WWTF}) and the wasteload that is allocated to regulated stormwater dischargers (WLA_{SW}).

$$WLA = WLA_{WWTF} + WLA_{SW}$$

7.3.1.1 WWTFs

TPDES-permitted WWTFs are allocated a daily wasteload (WLA_{WWTF}) in pounds per day (lbs/day) for $CBOD_5$ and NH_3N calculated as the full permitted discharge in MGD multiplied by the permit limit in mg/L determined from application of the TMDL modeling system for the pollutant load reduction scenarios. This is expressed in the following equation:

$$WLA_{WWTF} = Flow * Permit\ Limit * Conversion\ Factor$$

Where:

Flow (MGD) = full permitted flow

Permit limit for $CBOD_5$, NH_3N, or DO in mg/L

Conversion factor (to lbs/day) = 3.78541E6 (L/day)/MGD * 2.20462E-6 lbs/mg = 8.34 lbs/(mg/L)/MGD

7.3.1.2 Regulated Stormwater

Stormwater discharges from MS4, industrial, and construction areas are considered regulated point sources. Therefore, the WLA calculations must also include an allocation for regulated stormwater discharges (WLA_{SW}). A simplified approach for estimating the WLA for these areas was used in the development of these TMDLs because the modeling system output for stormwater is at the HSPF subbasin level, which includes both regulated and unregulated land areas.

The determination of WLA_{SW} from the HSPF subbasin level simulations occurred through a two-step process. First, the stormwater load output from each HSPF subbasin is proportioned into the AUs represented in the subbasin based on the percentage of the AUs in each subbasin. The total stormwater load for each AU is computed as the sum of the component parts from each HSPF subbasin in which the AU was located. Second, the percentage of each AU watershed that is under the jurisdiction of stormwater permits is used to estimate the amount of the overall runoff load to be allocated as the regulated stormwater contribution in the WLA_{SW} component of the TMDL. The percentage of each AU watershed that is under the jurisdiction of stormwater permits is based on the information in Section 2.6.1.3 and Table 10 of the bacteria technical support document (Hauck and Adams, 2020).

7.3.2 Load Allocation

As with the WLA_{SW} component, LA is computed at the AU level for the AUs impaired for depressed DO. The LA component of the TMDL corresponds to the unregulated portion of the direct nonpoint runoff and is the difference between the total load from stormwater runoff from HSPF simulations and the portion allocated to WLA_{SW}.

7.3.3 Allowance for Future Growth for DO TMDLS

The FG component of the TMDL equation addresses the necessity to explore for the effects of future loadings that may occur due to population growth, changes in community infrastructure, and development. Specifically, this TMDL component takes into account the probability that new flows from WWTF discharges may occur in the future. Any allowance for future growth will result in protection of existing uses and conform to Texas's antidegradation policy.

In AUs that required load reductions as indicated by TMDL modeling system simulations, no allowance for FG was assigned. Nevertheless, in some of these AUs there is some room for future loading increases in localized areas. However, the amount of the permissible additional loading depends on the location of the discharge within the AU. Any proposed additional loading must be evaluated using the TMDL models to ensure that it will not result in non-compliance with water quality standards. Similarly, there is flexibility to modify the permitted loading of $CBOD_5$ or NH_3N, provided that either constituent's impacts on DO are balanced by reductions of one versus the other. These evaluations must be performed via model simulations.

In AUs for which no load reductions were required in the TMDL modeling system simulations, FG loads were added into the simulations. This was only the case for Cow Bayou watershed AUs 0511_01, 0511_02, and 0511D_01, where no load reductions were required in the simulations to meet the DO criterion. For the purposes of the TMDL, the flow of each municipal and industrial WWTF within these AUs was increased by 10 percent, representing a commensurate 10 percent increase in loading of $CBOD_5$ and NH_3N, as well as, DO. As noted above, any proposed additional loadings from either permit expansions or new permits must be evaluated using the modeling system to ensure that compliance with water quality standards is maintained. Nonetheless, for AUs 0511_01, 0511_02, and 0511D_01, an FG component is provided in the TMDL allocations. Also, the FG of 10 percent for existing TPDES permitted facilities is for illustrative purposes to demonstrate capacity and should not be interpreted as being assigned solely to each facility.

7.3.4 TMDL Calculations for DO

Based on the assigned permit limits for municipal and industrial WWTFs used as input into the pollutant load allocations, wasteload loadings can be assigned to each WWTF in lbs/day. The WLA_{WWTF} assigned to each facility, including $CBOD_5$ and NH_3N, as well as DO, are provided in Table 7-5 for municipal WWTFs and Table 7-6 for industrial WWTFs. In Tables 7-5 and 7-6, the $CBOD_5$, NH_3N, and DO concentrations are provided in addition to the WLA_{WWTF} load.

The regulated stormwater (WLA_{SW}) and unregulated stormwater (LA) components of the TMDL are provided in Table 7-7 based on the 11-year simulation results from the HSPF watershed models. To maintain a watershed approach, certain AUs include upstream AUs, if those upstream AUs were not impaired due to depressed DO. In the Adams Bayou watershed, 0508_04 also includes 0508A_01 and 0508B_01. In the Cow Bayou watershed, 0511_04 includes 0511A_01 and 0511_03 includes 0511E_01 as upstream contributing AUs that were not impaired due to depressed DO. For each of the impaired AUs, the regulated stormwater area percent in Table 7-7 was based on the combined areas of the impaired AU and all upstream unimpaired AUs.

Table 7-5 Wasteload allocations for regulated domestic WWTFs in the Adams Bayou and Cow Bayou watersheds

Permit	TPDES No. (NPDES No.)	AU	Outfall	Daily Average Flow (MGD)	Daily Average $CBOD_5$ mg/L (lbs/day)	Daily Average NH_3N mg/L (lbs/day)	Minimum DO mg/L (lbs/day)
Jasper County WCID 1	WQ0010808001 (TX0021300)	0511A_02	001	0.41	10 (34.19)	3 (10.26)	5 (17.10)
Orangefield Water Supply Corporation	WQ0014772001 (TX0129313)	0511_02	001	0.75	10 (62.55)	2 (12.51)	4 (25.02)
PCS Development Company	WQ0011916001 (TX0074250)	0511_04	001	0.09	10 (7.51)	2 (1.50)	5 (3.75)
Bayou Pines LLC	WQ0015029001 (TX0133418)	0511B_01	001	0.009	10 (0.75)	3 (0.23)	5 (0.38)
Gulflander Partners Group, L.P.	WQ0013488001 (TX0106437)	0511B_01	001	0.01	10 (0.83)	3 (0.25)	5 (0.42)
City of Bridge City	WQ0010051001 (TX0025500)	0511_01	001	1.6[1]	10 (133.44)	12 (160.13)[2]	4 (53.38)
City of Pinehurst	WQ0010597001 (TX0024171)	0508_03	001	0.5	10 (41.70)	3 (12.51)	5 (20.85)
City of Orange[3]	WQ0010626001 (TX0073423)	0508_02	002	7.0[3]	10 (583.80)	3 (175.14)	5 (291.90)
Orange County WCID 2	WQ0010240001 (TX0054810)	0508_02	001	1.22[1]	10 (101.75)	3 (30.52)	5 (50.87)

[1] Annual average flow in MGD.

[2] Determined using a default value assumed in TCEQ permit evaluations.

[3] Intermittent discharge. The permittee is authorized to discharge from Outfall 002 only if, as a result of wet weather conditions, the average discharge from the facility exceeds 11,111 gallons per minute. Combined average annual discharge of Outfalls 001 and 002 is not to exceed 7.0 MGD. Simulated as 7.0 MGD on all days of discharge indicated in the DMR data for the period of January 1, 2002 – December 31, 2012. Outfall 001 discharges to the Sabine River.

Table 7-6 Wasteload allocations for regulated industrial WWTFs in the Adams Bayou and Cow Bayou watersheds

Permit	TPDES No. (NPDES No.)	AU	Outfall	Daily Average Flow (MGD)	Daily Average $CBOD_5$ mg/L (lbs/day)	Daily Average NH_3N mg/L (lbs/day)	Minimum DO mg/L (lbs/day)
Miller Waste Mills, Inc.	WQ0002835000 (TX0104710)	0511_02	001 [1] 002 003 [2]	- 0.116 [3] -	- 20 (19.35) -	- 1 (0.97) -	- 2 (1.93) -
Lion Elastomers Orange, LLC	WQ0000454000 (TX0002968)	0511_01	001 002 [1]	1.202 -	11 (110.27) -	2 (20.05) -	2 (20.05) -
Chevron Phillips Chemical Company LP	WQ0000359000 (TX0004839)	0511D_01	001	3.15	17.5 (459.74)	0.8 (21.02)	5 (131.36)
Printpack, Inc.	WQ0002858000 (TX0101192)	0511D_01	001 101 [4]	0.085 -	10 (7.09) -	3 (2.13) -	5 (3.54) -
Honeywell International Inc.	WQ0000670000 (TX0007897)	0511_01	001	1.4	10 (116.76)	1 (11.68)	2 (23.35)
ARLANXEO USA LLC	WQ0001167000 (TX0003654)	0511_01	001	6.0	3.5 (175.14)	1 (50.04)	2 (100.08)

[1] Stormwater only outfall; not included as direct point source in modeling system; no new limits assigned in the pollutant load reduction scenario.

[2] Based on DMR data, discharge from Outfall 003 has not occurred; therefore, discharge has never been reported; no new limits assigned in the pollutant load reduction scenario.

[3] Average of 2017 – 2018 DMR data.

[4] Internal outfall that is included in Outfall 001; no new limits assigned in the pollutant load reduction scenario.

Table 7-7 Regulated and unregulated stormwater calculations for impaired AUs of Adams Bayou, Cow Bayou and associated tributaries

All loads expressed in lbs/day.

AU	Total Runoff $CBOD_5$	Total Runoff NH_3N	Regulated Stormwater Area (%)	WLA_{SW} $CBOD_5$	WLA_{SW} NH_3N	LA $CBOD_5$	LA NH_3N
0508_01	177.29	14.53	59.87	106.14	8.7	71.15	5.83
0508_02	47.41	4.00	99.85	47.34	3.99	0.07	0.01
0508_03	84.34	7.11	100.00	84.34	7.11	0.00	0.00
0508_04	348.46	26.37	11.93	41.57	3.15	306.89	23.22
0508C_01	21.10	1.74	99.32	20.96	1.73	0.14	0.01
Adams Bayou Total	**678.60**	**53.75**	**NA[1]**	**300.35**	**24.68**	**378.25**	**29.07**
0511_01[2]	222.25	17.68	29.30	65.12	5.18	157.13	12.50
0511_02	359.70	28.08	9.02	32.44	2.53	327.26	25.55
0511_03	394.82	27.16	15.54	61.36	4.22	333.46	22.94
0511_04	191.41	12.71	4.07	7.79	0.52	183.62	12.19
0511A_02	613.40	40.33	0.34	2.09	0.14	611.31	40.19
0511B_01	70.11	5.56	27.87	19.54	1.55	50.57	4.01
0511C_01	148.72	10.05	1.63	2.42	0.16	146.30	9.89
0511D_01[2]	43.61	3.76	60.52	26.39	2.28	17.22	1.48
Cow Bayou Total	**2,044.02**	**145.32**	**NA[1]**	**217.15**	**16.58**	**1,826.87**	**128.75**

[1] N/A – not applicable. Adams Bayou and Cow Bayou watersheds are each represented by multiple sub-basins in HSPF with each sub-basin containing a unique composition of land uses that result in differing runoff loads of $CBOD_5$ and NH_3N by area. Also, the loads from each sub-basin are proportioned into WLA_{SW} and LA terms for individual AUs based on the percent of the sub-basin in each AU and the regulated stormwater area percent of each AU. The differing land uses comprising HSPF sub-basins and subsequent differing runoff loads by area result in spatial variability that does not allow a unique watershed-wide percent of regulated stormwater to be computed that is correct for both $CBOD_5$ and NH_3N loads.

[2] AUs 0511_01 and 0511D_01 are not impaired for DO and are included for purposes of showing implications of future growth on DO in these AUs.

7.3.5 Summary of TMDL Calculations for DO

Table 7-8 summarizes the TMDL calculations for the five impaired AUs of the Adams Bayou watershed and the six impaired AUs of the Cow Bayou watershed. The TMDLs were calculated based on the application of the TMDL modeling system of the Adams Bayou watershed and the TMDL modeling system of the Cow Bayou watershed. The values are based on the reductions required to support a high aquatic life use for all tidal streams with a 24-hour daily average DO criterion of 4 mg/L and a limited aquatic life use for freshwater streams with a 24-hour daily average DO criterion of 3 mg/L. The summary of TMDL calculations includes AUs 0511_01 and 0511D_01 to illustrate the FG term for AU 0511_01 and because the TMDL modeling system showed exceedance of the DO criterion in 0511D_01 at the fully permitted loads scenario, requiring permitted DO effluent loadings for facilities discharging to this AU (0511D_01).

The final TMDL allocations needed to comply with the requirements of 40 CFR 130.7 (Table 7-9) include the FG component within the WLA_{WWTF} and excludes Cow Bayou Tidal 0511_01, which is unimpaired for DO and in which the TMDL modeling system showed additional capacity to assimilate $CBOD_5$ and NH_3N loads while complying with the 24-hour daily average DO criterion.

7.4 Pollutant Load Allocations for pH

As a measure of the hydrogen ion content (acidity) of water, pH is also an impairment in Cow Bayou Tidal AU 0511_04 requiring a TMDL. General water quality uses are not met due to observed pH levels below the acceptable range of water quality criteria (6.0–8.5) for AU 0511_04. Five of the 23 pH measurements (22 percent) taken in AU 0511_04 from 1994 to 1999 in the upper tidal reaches of Cow Bayou were lower than the minimum of 6.0, resulting in the non-support listing.

It is difficult to simulate pH through water quality modeling. A large number of natural processes affect pH levels—watershed soil and bedrock type, watershed vegetation type, loading of organic matter, wastewater effluent discharges, temperature, seasonality, photosynthesis by phytoplankton and other aquatic plants, and respiration of organic matter. Algal photosynthesis consumes hydrogen ions, raising the pH. Respiration reverses this process, releasing hydrogen ions and lowering pH. The pH parameter varies less as alkalinity (buffering capacity) increases, but these bayous have low levels of alkalinity. In particular, at approximately 22 km upstream of the Sabine River, the median levels of total alkalinity are 20 mg/L as calcium carbonate. Further, the lower tidal portions of both bayous are more strongly buffered by the salts found in seawater.

Table 7-8 TMDL allocation summary for AUs of Adams Bayou, Cow Bayou and associated tributaries

All loads expressed in lbs/day.

Columns for $CBOD_5$ and NH_3N MOS not included; implicit MOS based on conservative model system assumptions.

AU	TMDL $CBOD_5$	TMDL NH_3N	WLA_{WWTF} $CBOD_5$	WLA_{WWTF} NH_3N	WLA_{SW} $CBOD_5$	WLA_{SW} NH_3N	LA $CBOD_5$	LA NH_3N	FG $CBOD_5$	FG NH_3N
0508_01	177.29	14.53	0.00	0.00	106.14	8.70	71.15	5.83	0.00	0.00
0508_02	732.96	209.66	685.55	205.66	47.34	3.99	0.07	0.01	0.00	0.00
0508_03	126.04	19.62	41.70	12.51	84.34	7.11	0.00	0.00	0.00	0.00
0508_04	348.46	26.37	0.00	0.00	41.57	3.15	306.89	23.22	0.00	0.00
0508C_01	21.10	1.74	0.00	0.00	20.96	1.73	0.14	0.01	0.00	0.00
Adams Bayou Total	1,405.85	271.92	727.25	218.17	**300.35**	**24.68**	**378.25**	**29.07**	0.00	0.00
0511_01[1]	811.40	283.75	535.61	241.90	65.12	5.18	157.13	12.50	53.54	24.17
0511_02	449.79	42.90	81.90	13.48	32.44	2.53	327.26	25.55	8.19	1.34
0511_03	394.82	27.16	0.00	0.00	61.36	4.22	333.46	22.94	0.00	0.00
0511_04	198.92	14.21	7.51	1.50	7.79	0.52	183.62	12.19	0.00	0.00
0511A_02	647.59	50.59	34.19	10.26	2.09	0.14	611.31	40.19	0.00	0.00
0511B_01	71.69	6.04	1.58	0.48	19.54	1.55	50.57	4.01	0.00	0.00
0511C_01	148.72	10.05	0.00	0.00	2.42	0.16	146.30	9.89	0.00	0.00
0511D_01[1]	557.13	29.22	466.83	23.15	26.39	2.28	17.22	1.48	46.69	2.31
Cow Bayou Total	**3,280.06**	**463.92**	**1,127.62**	**290.77**	**217.15**	**16.58**	**1,826.87**	**128.75**	**108.42**	**27.82**

[1] AUs 0511_01 and 0511D_01 are not impaired for DO and are included for purposes of showing implications of future growth on DO in these AUs.

Table 7-9 Final TMDL allocations for impaired AUs of Adams Bayou, Cow Bayou and associated tributaries

All loads expressed in lbs/day.

Columns for $CBOD_5$ and NH_3N MOS not included; implicit MOS based on conservative model system assumptions.

AU	TMDL $CBOD_5$	TMDL NH_3N	WLA_{WWTF} $CBOD_5$ [1]	WLA_{WWTF} NH_3N [1]	WLA_{SW} $CBOD_5$	WLA_{SW} NH_3N	LA $CBOD_5$	LA NH_3N
0508_01	177.29	14.53	0.00	0.00	106.14	8.70	71.15	5.83
0508_02	732.96	209.66	685.55	205.66	47.34	3.99	0.07	0.01
0508_03	126.04	19.62	41.70	12.51	84.34	7.11	0.00	0.00
0508_04	348.46	26.37	0.00	0.00	41.57	3.15	306.89	23.22
0508C_01	21.10	1.74	0.00	0.00	20.96	1.73	0.14	0.01
Adams Bayou Total	**1,405.85**	**271.92**	**727.25**	**218.17**	**300.35**	**24.68**	**378.25**	**29.07**
0511_02	449.79	42.90	90.09	14.82	32.44	2.53	327.26	25.55
0511_03	394.82	27.16	0.00	0.00	61.36	4.22	333.46	22.94
0511_04	198.92	14.21	7.51	1.50	7.79	0.52	183.62	12.19
0511A_02	647.59	50.59	34.19	10.26	2.09	0.14	611.31	40.19
0511B_01	71.69	6.04	1.58	0.48	19.54	1.55	50.57	4.01
0511C_01	148.72	10.05	0.00	0.00	2.42	0.16	146.30	9.89
Cow Bayou Total [2]	**1,911.53**	**150.95**	**133.37**	**27.06**	**125.64**	**9.12**	**1,652.52**	**114.77**

[1] WLAWWTF includes the FG component.

[2] $CBOD_5$ and NH_3N loads for unimpaired AUs 0511_01 and 0511D_01 are excluded from this table, though these loads were provided in Table 7-8.

HSPF and more recent versions of the WASP do simulate pH. To properly and accurately simulate pH, the modeling system would have necessitated including not only pH as a state variable in both models, but also adding carbon dioxide, total inorganic carbon, and alkalinity. Including pH to simulation capabilities was not reasonable due to data constraints for proper model development. Instead an indirect approach based on well understood water-chemistry processes was applied to address the pH issuess of Cow Bayou Tidal AU 0511_04.

The primary process responsible for lower pH in many systems is the respiration of organic matter. Primary production by aquatic plants, on the other hand, is the key process raising the pH level in many systems. Low pH levels tend to occur in poorly buffered systems where respiration exceeds primary production. Another potential source of low pH is un-neutralized point source discharges, though such a source is not known to occur in the areas of impairment.

The modeling conducted as part of this TMDL exercise shows the source of low pH in Cow Bayou Tidal AU 0511_04 appears to be the degradation of organic matter, which is also the primary source of low DO levels. Figure 7-1 shows that the changes in average pH levels with distance downstream in Cow Bayou vary inversely with the cBOD levels. Thus, the low pH values tend to occur where cBOD levels are highest, likely due to the degradation of the organic matter comprising cBOD. For this reason, it is reasonable to assume that the same measures intended to raise DO levels will also raise pH values to meet water quality standards.

Given that the DO criteria are not met in Cow Bayou far more frequently than the pH criteria, it follows logically that a TMDL involving sufficient reductions in oxygen demanding organic matter to meet water quality standards for DO will in all likelihood also lead to attainment of the pH standard. Therefore, the TMDL for attainment of the pH criteria in Cow Bayou Tidal requires the same allocations for cBOD and NH_3N for attainment of the DO criteria (Tables 7-8 and 7-9).

7.5 Consideration of Seasonal Variation for DO and pH

Previous studies conducted on Adams Bayou and Cow Bayou have examined seasonal variation in water quality parameters, including DO and pH. A 2002 historical review of water quality data collected on Adams Bayou, Cow Bayou and associated tributaries concluded that DO levels were lowest during the summer season when water temperatures are higher and stream flows are lower (Parsons, 2002). The report, which looked at historical data from 1969 to 2002, also showed seasonal variation in pH, with the lowest pH values occurring in mid to late summer. In 2008, Contreras and Whisenant used Analysis of Similarity (ANOSIM), a nonparametric statistical test analogous to the parametric-based ANOVA test, to analyze seasonality in water quality data collected during the aquatic life use attainability analysis conducted on Cow Bayou. Cow Bayou samples were different among seasons as revealed by the results of the ANOSIM test (Global R value was 0.234, p value was less than 0.001). The difference is driven primarily by the disparity between spring and summer samples, with the lowest DO and pH values occurring in summer samples when elevated water temperatures and higher specific conductance values are also most prevalent (TPWD, 2008).

The time period modeled by the Adams Bayou and Cow Bayou TMDL modeling system (January 1, 2002 through December 31, 2012) includes over a decade of seasonal variation. By simulating a complete 11-year period, the modeling system and TMDLs implicitly consider inter-annual and seasonal variation.

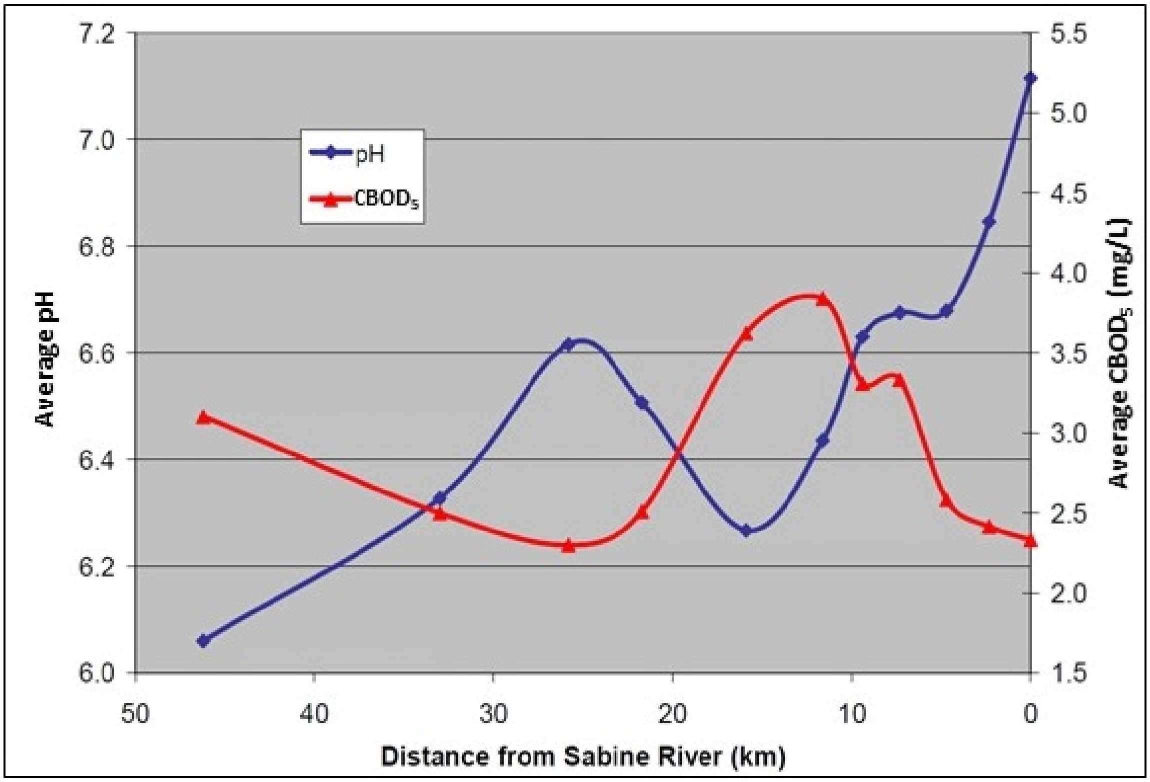

Figure 7-1 Average measured pH and cBOD$_5$ in Cow Bayou with distance upstream during the summer 2004 summer intensive surveys used for RMA2 and WASP validation

8. References

American Veterinary Medical Association. 2002. *U.S. Pet Ownership and Demographics Sourcebook (2002 edition)*. Schaumberg, IL.

ASAE (American Society of Agricultural Engineers). 1998. *ASAE Standards, 45th edition: Standards, Engineering Practices, Data*. St. Joseph, MI.

Baker, LA, D Hope, Y Xu, J Edmonds, and L. Lauver. 2001. Nitrogen Balance for the Central Arizona – Phoenix (CAP) Ecosystem. *Ecosystems* 4: 582-602.

Carroll and Blackmann (Carroll and Blackmann, Inc.). 2015. Flood Protection Planning Study – Cow Bayou & Adams Bayou – Orange County – Final Report. Prepared for Orange County Drainage District and Texas Water Development Board.

Dean, K, and M. Suarez, and L. Hauck. 2015. Technical Support Document for Cow and Adams Bayou Total Maximum Daily Loads. Parson Corporation, Austin, TX.

EPA (United States Environmental Protection Agency). 1991. Guidance for Water Quality-Based Decisions: The TMDL Process. Retrieved Dec 5, 2019, from <www.epa.gov/sites/production/files/2018-10/documents/guidance-water-tmdl-process.pdf>

EPA (United Stated Environmental Protection Agency). 2000. *Bacterial Indicator Tool*. EPA-823-B-01-003. Office of Water. Washington, DC.

EPA. 2005. *Stormwater Phase II Final Rule*; *Small MS4 Stormwater Program Overview*. Office of Water, EPA 833-F-00-002 Fact Sheet 2.0. Retreived March 10, 2020, from <www.epa.gov/npdes/pubs/fact2-0.pdf>

Finzi, AC, AS Allen, EH Delucia, DS Ellsworth, and WH Schlesinger. 2001. Forest Litter Production, Chemistry, and Decomposition Following Two Years of Free-Air CO2 Enrichment. *Ecology* 82: 470-484.

Hauck, L. and T. Adams. 2020. Technical Support Document for Total Maximum Daily Loads for Indicator Bacteria in Adams Bayou, Cow Bayou, and Associated Tributaries. TR1806. Texas Instittute for Applied Environmental Research, Tarleton State University, Stephenville, TX.

Horsely and Whitten. 1996. Identification and Evaluation of Nutrient and Bacteriological Loadings to Maquoit Bay, Brunswick, and Freeport, Maine. Final Report. Casco Bay Estuary Project, Portland, ME.

Metcalf & Eddy. 1991. *Wastewater Engineering: Treatment, Disposal and Reuse. Third edition.* George Tchobanoglous and Franklin L. Burton, Eds. McGraw-Hill, New York.

Morton, Joe (Orangefield Water Supply Corporation). 2013. Letter to Jerry Wiegreffe (Sabine River Authority of Texas) providing comments on the Cow Bayou TMDL Implementation Plan, June 21, 2013.

NADP (National Atmospheric Deposition Program). 2005. National Atmospheric Deposition Program 2004 Annual Summary. Retrieved March 16, 2020, from <nadp.slh.wisc.edu/lib/data/2004as.pdf>

NRCS (Natural Resources Conservation Service). 2004. Soil Survey Geographic (SSURGO) database for Jefferson and Orange Counties, Texas. U.S. Department of Agriculture. Fort Worth, Texas.

NRCS. (Natural Resources Conservation Service). 2016. 2016. Geospatial Data Gateway: Soils Data SSURGO. Retrieved July 17, 2016, from <datagateway.nrcs.usda.gov/>

Nash, J.E., and J.V. Sutcliffe. 1970. River flow forecasting through conceptual models part I – A discussion of principles. *Journal of Hydrology*, 10 (3): 282-290.

Parsons. 2003a. Sampling plan for modeling to support TMDL development in Adams Bayou tidal (Segment 0508), Cow Bayou tidal (Segment 0511) and their tributaries. Prepared for the Texas Commission on Environmental Quality. February 2003.

Parsons. 2002. Assessment of Water Quality Impairments in Adams Bayou Tidal (Segment 0508), Cow Bayou Tidal (Segment 0511) and Their Tributaries: Orange County Total Maximum Daily Load Project. Report prepared for: Texas Commission on Environmental Quality as a deliverable for contract 582-02-48662.

Parsons. 2003b. Orange County TMDL Project Quality Assurance Project Plan.

Parsons. 2006a. Nonpoint Source Modeling of the Watersheds of Adams and Cow Bayous. Prepared for the Texas Commission on Environmental Quality. January 2006. Retreived March 10, 2020, from <www.tceq.texas.gov/waterquality/tmdl/37-orangecounty.html#documents>

Parsons. 2006b. Water quality modeling of Adams and Cow Bayous. Prepared for the Texas Commission on Environmental Quality. September 2006. Retreived March 10, 2020, from <www.tceq.texas.gov/waterquality/tmdl/37-orangecounty.html#documents>

PRISM Climate Group at Oregon State University. 2016. PRISM Data Explorer. Time Series Values for Individual Locations. Retrieved November 16, 2017 from <www.prism.oregonstate.edu/explorer/>

Reed Stowe and Yanke. 2001. Study to Determine the Nagnitude of, and Reasons for, Chronically Malfunctioning On-site Sewage Facility Systems in Texas. Austin, Texas, September 2001.

Schueler, TR. 2000. Microbes and Urban Watersheds: Concentrations, Sources, and Pathways. In *The Practice of Watershed Protection,* TR Schueler and HK Holland, eds. Center for Watershed Protection, Ellicott City, MD.

Shaffer, KA, and C. Hudak-Wise. 2005. *Livestock Manure Production Rates and Nutrient Content*. In 2005 Agricultural Chemicals Manual. College of Agriculture and Life Sciences, North Carolina State University. Raleigh, NC.

TCEQ (Texas Commission on Environmental Quality). 2004. 2004 Water Quality Inventory, Fact Sheet and Assessment Data for Segment 0511 – Cow Bayou Tidal. Retrieved on September 20, 2019 from <www.tceq.texas.gov/waterquality/assessment/04twqi/basins/sabine.html>

TCEQ (Texas Commission on Environmental Quality). 2007. Seventeen TMDLs for bacteria, dissolved oxygen, and pH in Adams Bayou, Cow Bayou, and their tributaries. Texas Commission on Environmental Quality. June 2007.

TCEQ (Texas Commission on Environmental Quality). 2010. Procedures to Implement the Texas Surface Water Quality Standards (RG-194). Retreived December 11, 2019, from <www.tceq.texas.gov/assets/public/permitting/waterquality/standards/docs/june_2010_ip.pdf>.

TCEQ (Texas Commission on Environmental Quality). 2012. Surface Water Quality Monitoring Procedures, Volume 1: Physical and Chemical Monitoring Methods (RG-415). Retreived March 11, 2020, from <www.tceq.texas.gov/publications/rg/rg-415>.

Thomann, R.V. and J.A. Mueller. 1987. Principles of Surface Water Quality Modeling and Control. Harper & Row Publishers, New York, NY

TPWD (Texas Parks and Wildlife Department). 2008. Cow Bayou Tidal (Segment 0511) Use Attainability Analysis. Water Quality Technical Series WQTS-2008-02. Retrieved December 25, 2019, from <https://tpwd.texas.gov/publications/pwdpubs/media/pwd_rp_v3400_1674_1.pdf>

TWC (Texas Water Commission). 1986. Waste Load Evaluation for Adams Bayou Tidal in the Sabine River Basin, Segment 0508. Austin, TX.

TWC (Texas Water Commission). 1988. Waste Load Evaluation for Cow Bayou Tidal in the Sabine River Basin, Segment 0511. Draft subject to revision. Austin, TX.

USDA (United States Department of Agriculture). 1992. *Agricultural Waste Management Field Handbook*. Part 651. Washington, DC.

Appendix A Adams Bayou HSPF User Control Interface File

Note: The annotations that were added to this print version for clarity <u>may</u> prevent it from running. It may be necessary to strip out some comment lines that begin with three asterisks.

```
RUN

GLOBAL
  UCI Created by KIRK DEAN/Nabin Basnet for the Adams Bayou watershed
  START       2001/01/01 00:00  END    2012/12/31 23:00
  RUN INTERP OUTPT LEVELS    3    3
  RESUME     0 RUN     1                         UNITS    1
END GLOBAL

FILES
<FILE>  <UN#>***<----FILE NAME------------------------------------------------->
MESSU      24   adams_lt.ech
           91   adams_lt.out
WDM1       25   adams_out1.wdm
WDM2       26   adams_meteorol.wdm
BINO       92   adams_meteorol.hbn
WDM3       27   adams_source.wdm
END FILES

OPN SEQUENCE
    INGRP              INDELT 01:00
      PERLND     101
      PERLND     102
      PERLND     103
      PERLND     104
      PERLND     105
      PERLND     106
      PERLND     107
      PERLND     108
      PERLND     109
      PERLND     110
      PERLND     111
      PERLND     112
      PERLND     113
      PERLND     114
      PERLND     115
      PERLND     116
      PERLND     117
      IMPLND     101
      IMPLND     102
      IMPLND     103
      IMPLND     104
      RCHRES       1
      RCHRES       2
      RCHRES       3
      RCHRES       4
      RCHRES       6
      RCHRES       5
      RCHRES       7
      RCHRES       8
      RCHRES       9
      RCHRES      10
      RCHRES      11
```

```
      RCHRES      12
      COPY         1
      COPY         2
      COPY         3
      COPY         4
      COPY         5
      COPY         6
      COPY         7
      COPY         8
      COPY         9
      COPY        10
      COPY        11
      COPY        12
    END INGRP
END OPN SEQUENCE

PERLND
  ACTIVITY
*** <PLS >              Active Sections                               ***
*** x -  x ATMP SNOW PWAT  SED  PST  PWG PQAL MSTL PEST NITR PHOS TRAC ***
  101  117    1    0    1    1    1    1    1    0    0    0    0    0
  END ACTIVITY

  PRINT-INFO
*** < PLS>                      Print-flags                           PIVL  PYR
*** x  - x ATMP SNOW PWAT  SED  PST  PWG PQAL MSTL PEST NITR PHOS TRAC
  101  117    4    4    4    4    4    4    4    4    4    4    4    4    1   12
  END PRINT-INFO

  BINARY-INFO
*** < PLS>              Binary Output Flags                           PIVL  PYR
*** x  - x ATMP SNOW PWAT  SED  PST  PWG PQAL MSTL PEST NITR PHOS TRAC
  101  117    4    4    4    4    4    4    4    4    4    4    4    4    1   12
  END BINARY-INFO

  GEN-INFO
***             Name                  Unit-systems   Printer BinaryOut
*** <PLS >                                t-series Engl Metr Engl Metr
*** x -  x                                 in  out
  101     Developed Open Space              1    1    0    0   92    0
  102     Developed Low Intens              1    1    0    0   92    0
  103     Developed Medium Int              1    1    0    0   92    0
  104     Developed High Inten              1    1    0    0   92    0
  105     Barren                            1    1    0    0   92    0
  106     Deciduous Forest                  1    1    0    0   92    0
  107     Evergreen Forest                  1    1    0    0   92    0
  108     Mixed Forest                      1    1    0    0   92    0
  109     Pasture/Hay                       1    1    0    0   92    0
  110     Cropland                          1    1    0    0   92    0
  111     Grassland/Herbaceous              1    1    0    0   92    0
  112     Shrub/Scrub                       1    1    0    0   92    0
  113     Open Water                        1    1    0    0   92    0
  114     Woody Wetlands                    1    1    0    0   92    0
  115     Herbaceous Wetlands               1    1    0    0   92    0
  116     Septic Fields                     1    1    0    0   92    0
  117     Future Unused 2                   1    1    0    0   92    0
  END GEN-INFO

  ATEMP-DAT
*** <PLS >     ELDAT    AIRTEMP
*** x -  x      (ft)    (deg F)
  101  117       -6.        33.
  END ATEMP-DAT
```

```
  PWAT-PARM1
*** <PLS >                    Flags
*** x -  x CSNO RTOP UZFG  VCS  VUZ  VNN VIFW VIRC  VLE IFFC  HWT IRRG IFRD
  101  114    0    1    1    1    1    0    0    0    1    0    0    0    0
  115         0    2    1    1    0    0    0    0    1    0    1    0    0
  116  117    0    1    1    1    1    0    0    0    1    0    0    0    0
  END PWAT-PARM1

  PWAT-PARM2
*** < PLS>    FOREST      LZSN    INFILT      LSUR     SLSUR     KVARY     AGWRC
*** x  - x                (in)   (in/hr)      (ft)              (1/in)   (1/day)
  101             0.        5.      0.25      500.     0.002        5.      0.96
  102             0.        5.      0.25      500.     0.002        5.      0.96
  103             0.        5.      0.25      500.     0.002        5.      0.96
  104             0.        5.      0.25      500.     0.002        5.      0.96
  105             0.        5.      0.25      500.     0.002        5.      0.96
  106             0.        5.      0.25      500.     0.002        5.      0.96
  107             0.        5.      0.25      500.     0.002        5.      0.96
  108             0.        5.      0.25      500.     0.002        5.      0.96
  109             0.        5.      0.25      500.     0.002        5.      0.96
  110             0.        5.      0.25      500.     0.002        5.      0.96
  111             0.        5.      0.25      500.     0.002        5.      0.96
  112             0.        5.      0.25      500.     0.002        5.      0.96
  113             0.        5.      0.25      200.     0.001        5.      0.96
  114             0.        5.      0.25      500.     0.002        5.      0.96
  115             0.        5.      0.25      500.     0.001        5.      0.96
  116             0.        5.      0.25      500.     0.002        5.      0.96
  117             0.        5.      0.25      500.     0.002        5.      0.96
  END PWAT-PARM2

  PWAT-PARM3
*** < PLS>    PETMAX    PETMIN    INFEXP    INFILD    DEEPFR    BASETP    AGWETP
*** x  - x   (deg F)   (deg F)
  101            40.       35.        2.        2.      0.10      0.10       0.2
  102            40.       35.        2.        2.      0.10      0.10       0.2
  103            40.       35.        2.        2.      0.10      0.10       0.2
  104            40.       35.        2.        2.      0.10      0.10       0.2
  105            40.       35.        2.        2.      0.10      0.10       0.2
  106            40.       35.        2.        2.      0.10      0.10       0.2
  107            40.       35.        2.        2.      0.10      0.10       0.2
  108            40.       35.        2.        2.      0.10      0.10       0.2
  109            40.       35.        2.        2.      0.10      0.10       0.2
  110            40.       35.        2.        2.      0.10      0.10       0.2
  111            40.       35.        2.        2.      0.10      0.10       0.2
  112            40.       35.        2.        2.      0.10      0.10       0.2
  113            40.       35.        2.        2.      0.10      0.10       0.2
  114            40.       35.        2.        2.      0.10      0.10       0.2
  115            40.       35.        2.        2.      0.10      0.10       0.2
  116            40.       35.        2.        2.      0.10      0.10       0.2
  117            40.       35.        2.        2.      0.10      0.10       0.2
  END PWAT-PARM3

  PWAT-PARM4
*** <PLS >     CEPSC      UZSN      NSUR     INTFW       IRC     LZETP
*** x -  x      (in)      (in)                       (1/day)
  101           0.15       0.6       0.4       10.      0.75       0.5
  102           0.15       0.6       0.4       10.      0.75       0.5
  103           0.15       0.6       0.4       10.      0.75       0.5
  104           0.15       0.6       0.4       10.      0.75       0.5
  105           0.15       0.6       0.4       10.      0.75       0.5
  106           0.15       0.6       0.4       10.      0.75       0.5
  107           0.15       0.6       0.4       10.      0.75       0.5
```

```
  108          0.15       0.6       0.4       10.      0.75       0.5
  109          0.15       0.6       0.4       10.      0.75       0.5
  110          0.15       0.6       0.4       10.      0.75       0.5
  111          0.15       0.6       0.4       10.      0.75       0.5
  112          0.15       0.6       0.4       10.      0.75       0.5
  113          0.01       0.6       0.4       10.      0.75       0.5
  114          0.15       0.6       0.4       10.      0.75       0.5
  115          0.15       0.6       0.4       10.      0.75       0.5
  116          0.15       0.6       0.4       10.      0.75       0.5
  117          0.15       0.6       0.4       10.      0.75       0.5
  END PWAT-PARM4

  PWAT-PARM6
*** <PLS >     MELEV      BELV    GWDATM       PCW       PGW      UPGW
*** x -  x      (ft)      (ft)      (ft)
  101           53.      37.3        0.       0.3       0.1      0.15
  102           53.      37.3        0.       0.3       0.1      0.15
  103           53.      37.3        0.       0.3       0.1      0.15
  104          51.3      37.3        0.       0.3       0.1      0.15
  105          45.6      37.3        0.       0.3       0.1      0.15
  106          41.9      37.3        0.       0.3       0.1      0.15
  107          45.8      37.3        0.       0.3       0.1      0.15
  108          43.5      37.3        0.       0.3       0.1      0.15
  109           53.      37.3        0.       0.3       0.1      0.15
  110           53.      37.3        0.       0.3       0.1      0.15
  111           53.      37.3        0.       0.3       0.1      0.15
  112           53.      37.3        0.       0.3       0.1      0.15
  113          41.1      37.3        0.       0.3       0.1      0.15
  114          39.4      37.3        0.       0.3       0.1      0.15
  115           44.      37.3        0.       0.3       0.1      0.15
  116           53.      37.3        0.       0.3       0.1      0.15
  117           50.      37.3        0.       0.3       0.1      0.15
  END PWAT-PARM6

  PWAT-PARM7
*** < PLS>    STABNO      SRRC     SREXP     IFWSC     DELTA    UELFAC    LELFAC
*** x  - x               (/hr)                (in)      (in)
  101            0.       0.1        1.       0.5     0.002        4.       2.5
  102            0.       0.1        1.       0.5     0.002        4.       2.5
  103            0.       0.1        1.       0.5     0.002        4.       2.5
  104            0.       0.1        1.       0.5     0.002        4.       2.5
  105            0.       0.1        1.       0.5     0.002        4.       2.5
  106            0.       0.1        1.       0.5     0.002        4.       2.5
  107            0.       0.1        1.       0.5     0.002        4.       2.5
  108            0.       0.1        1.       0.5     0.002        4.       2.5
  109            0.       0.1        1.       0.5     0.002        4.       2.5
  110            0.       0.1        1.       0.5     0.002        4.       2.5
  111            0.       0.1        1.       0.5     0.002        4.       2.5
  112            0.       0.1        1.       0.5     0.002        4.       2.5
  113            0.       0.1        1.       0.5     0.002        4.       2.5
  114            0.       0.1        1.       0.5     0.002        4.       2.5
  115            0.       0.1        1.       0.5     0.002        4.       2.5
  116            0.       0.1        1.       0.5     0.002        4.       2.5
  117            0.       0.1        1.       0.5     0.002        4.       2.5
  END PWAT-PARM7

  PWAT-STATE1
*** < PLS>  PWATER state variables (in)
*** x  - x      CEPS      SURS       UZS      IFWS       LZS      AGWS      GWVS
  101  117      0.01      0.01       0.1       0.1        4.       2.5        0.
  END PWAT-STATE1

  MON-INTERCEP
```

```
*** <PLS >  Interception storage capacity at start of each month (in)
*** x -  x  JAN  FEB  MAR  APR  MAY  JUN  JUL  AUG  SEP  OCT  NOV  DEC
  101      0.05 0.05 0.05 0.09 0.11 0.15 0.15 0.15 0.15 0.13 0.09 0.05
  102      0.05 0.05 0.05 0.09 0.11 0.15 0.15 0.15 0.15 0.13 0.09 0.05
  103      0.05 0.05 0.05 0.09 0.11 0.15 0.15 0.15 0.15 0.13 0.09 0.05
  104      0.05 0.05 0.05 0.09 0.11 0.15 0.15 0.15 0.15 0.13 0.09 0.05
  105      0.01 0.01 0.01 0.01 0.01 0.01 0.01 0.01 0.01 0.01 0.01 0.01
  106      0.03 0.03 0.05 0.18 0.26 0.28 0.28 0.28 0.28 0.25 0.18 0.03
  107      0.10 0.10 0.10 0.15 0.20 0.25 0.25 0.25 0.25 0.20 0.15 0.10
  108      0.05 0.05 0.07 0.16 0.23 0.26 0.26 0.26 0.26 0.22 0.16 0.05
  109      0.05 0.05 0.06 0.08 0.12 0.15 0.15 0.15 0.15 0.10 0.08 0.05
  110      0.01 0.01 0.04 0.08 0.12 0.15 0.15 0.15 0.15 0.05 0.01 0.01
  111      0.05 0.05 0.06 0.10 0.15 0.20 0.20 0.20 0.20 0.15 0.10 0.05
  112      0.03 0.03 0.06 0.12 0.22 0.22 0.22 0.22 0.18 0.16 0.12 0.05
  113      0.01 0.01 0.01 0.01 0.01 0.01 0.01 0.01 0.01 0.01 0.01 0.01
  114      0.05 0.05 0.07 0.16 0.20 0.22 0.22 0.22 0.22 0.20 0.16 0.05
  115      0.05 0.05 0.06 0.08 0.12 0.15 0.15 0.15 0.15 0.10 0.08 0.05
  116      0.05 0.05 0.05 0.09 0.11 0.15 0.15 0.15 0.15 0.13 0.09 0.05
  117      0.05 0.05 0.05 0.09 0.11 0.13 0.13 0.13 0.13 0.13 0.09 0.05
  END MON-INTERCEP

  MON-UZSN
*** <PLS >  Upper zone storage at start of each month  (inches)
*** x -  x  JAN  FEB  MAR  APR  MAY  JUN  JUL  AUG  SEP  OCT  NOV  DEC
  101  117  0.5  0.1  0.1  0.4  0.7  1.0  1.2  1.3  1.2  1.0  1.0  1.0
  END MON-UZSN

  MON-LZETPARM
*** <PLS >  Lower zone evapotransp param at start of each month
*** x -  x  JAN  FEB  MAR  APR  MAY  JUN  JUL  AUG  SEP  OCT  NOV  DEC
  101  117 0.10 0.10 0.17 0.69 0.86 0.90 0.90 0.90 0.90 0.49 0.26 0.10
  END MON-LZETPARM

  SED-PARM1
*** <PLS >  Sediment parameters 1
*** x -  x  CRV VSIV SDOP
  101  115    1    0    1
  END SED-PARM1

  SED-PARM2
*** <PLS >      SMPF      KRER      JRER     AFFIX     COVER      NVSI
*** x -  x                                  (/day)           lb/ac-day
  101  105        1.      0.43        2.      0.01      0.88        1.
  106  107        1.      0.43        2.     0.002      0.88        2.
  108             1.      0.43        2.     0.002      0.88        2.
  109             1.      0.43        2.      0.01      0.88        1.
  110             1.      0.43        2.      0.01      0.88        2.
  111             1.      0.43        2.      0.01      0.88        1.
  112             1.      0.43        2.      0.01      0.88        1.
  113             1.      0.43        2.     0.002      0.88        0.
  114             1.      0.28        2.     0.002      0.88        2.
  115             1.      0.43        2.     0.002      0.88        1.
  116             1.      0.43        2.      0.01      0.88        1.
  117             1.      0.43        2.      0.01      0.88        1.
  END SED-PARM2

  SED-PARM3
*** <PLS >  Sediment parameter 3
*** x -  x      KSER      JSER      KGER      JGER
  101           0.50        2.        0.        2.
  102           0.50        2.      0.01        2.
  103           0.62        2.      0.07        2.
  104           0.84        2.     0.125        2.
```

```
  105          5.00        2.      0.25        2.
  106          0.55        2.        0.        2.
  107          0.55        2.        0.        2.
  108          0.55        2.        0.        2.
  109          1.60        2.       0.3        2.
  110          5.00       1.3        5.       1.3
  111          0.80        2.        0.        2.
  112          1.00        2.        0.        2.
  113          0.00        2.        0.        2.
  114          0.50        2.        0.        2.
  115          0.50        2.        0.        2.
  116          0.50        2.      0.01        2.
  117          0.50        2.        0.        2.
  END SED-PARM3

  MON-COVER
*** <PLS >  Monthly values for erosion related cover
*** x -  x  JAN  FEB  MAR  APR  MAY  JUN  JUL  AUG  SEP  OCT  NOV  DEC
  101  103 0.90 0.90 0.90 0.91 0.93 0.93 0.93 0.93 0.93 0.91 0.90 0.90
  104      0.90 0.90 0.90 0.91 0.93 0.93 0.93 0.93 0.93 0.91 0.90 0.90
  105      0.01 0.01 0.01 0.01 0.01 0.01 0.01 0.01 0.01 0.01 0.01 0.01
  106      0.80 0.80 0.80 0.94 0.97 0.97 0.97 0.97 0.97 0.97 0.91 0.85
  107      0.97 0.97 0.97 0.97 0.97 0.97 0.97 0.97 0.97 0.97 0.97 0.97
  108      0.94 0.94 0.94 0.95 0.97 0.97 0.97 0.97 0.97 0.97 0.96 0.94
  109      0.90 0.90 0.90 0.91 0.92 0.93 0.92 0.91 0.90 0.90 0.90 0.90
  110      0.70 0.70 0.50 0.50 0.60 0.75 0.80 0.90 0.90 0.70 0.70 0.70
  111      0.90 0.90 0.90 0.91 0.92 0.93 0.94 0.94 0.93 0.92 0.91 0.90
  112      0.80 0.80 0.80 0.91 0.92 0.93 0.94 0.94 0.93 0.92 0.91 0.85
  113      1.00 1.00 1.00 1.00 1.00 1.00 1.00 1.00 1.00 1.00 1.00 1.00
  114      0.97 0.97 0.97 0.97 0.97 0.97 0.97 0.97 0.97 0.97 0.97 0.97
  115      0.90 0.90 0.90 0.91 0.93 0.93 0.94 0.94 0.93 0.92 0.91 0.90
  116      0.90 0.90 0.90 0.91 0.93 0.93 0.93 0.93 0.93 0.91 0.90 0.90
  117      0.90 0.90 0.90 0.91 0.93 0.93 0.93 0.93 0.93 0.91 0.90 0.90
  END MON-COVER

  SED-STOR
*** <PLS >  Detached sediment storage (tons/acre)
*** x -  x      DETS
  101            0.4
  102            0.4
  103            0.4
  104            0.4
  105            0.5
  106            0.1
  107            0.1
  108            0.1
  109            0.2
  110            0.5
  111            0.2
  112            0.1
  113             0.
  114            0.1
  115            0.1
  116            0.4
  117            0.4
  END SED-STOR

  PSTEMP-PARM1
*** <PLS >  Flags for section PSTEMP
*** x -  x SLTV ULTV LGTV TSOP
  101  117    0    0    0    1
  END PSTEMP-PARM1
```

```
  PSTEMP-PARM2
*** <PLS >      ASLT      BSLT     ULTP1     ULTP2     LGTP1     LGTP2
*** x -  x   (deg F)   (deg F)             (deg F)             (deg F)
  101  117       35.       0.4       40.       0.3       65.        0.
  END PSTEMP-PARM2

  PSTEMP-TEMPS
*** <PLS >  Initial temperatures (deg F)
*** x -  x     AIRTC     SLTMP     ULTMP     LGTMP
  101  117       40.       45.       50.       69.
  END PSTEMP-TEMPS

  PWT-PARM1
*** <PLS >  Flags for section PWTGAS
*** x -  x  IDV  ICV  GDV  GVC
  101  117    0    0    0    0
  END PWT-PARM1

  PWT-PARM2
***         Second group of PWTGAS parms
*** <PLS >      ELEV     IDOXP     ICO2P     ADOXP     ACO2P
*** x -  x      (ft)    (mg/l)  (mg C/l)    (mg/l)  (mg C/l)
  101  117       25.       4.0      0.15       4.0      0.15
  END PWT-PARM2

  PWT-TEMPS
*** <PLS >    Initial water temperatures (deg F)
*** x -  x     SOTMP     IOTMP     AOTMP
  101  117       45.       50.       69.
  END PWT-TEMPS

  PWT-GASES
***                   Initial DO and CO2 concentrations
*** <PLS >     SODOX     SOCO2     IODOX     IOCO2     AODOX     AOCO2
*** x -  x    (mg/l)  (mg C/l)    (mg/l)  (mg C/l)    (mg/l)  (mg C/l)
  101  117       8.8      0.15       4.0      0.15       4.0      0.15
  END PWT-GASES

  NQUALS
*** <PLS >
*** x -  xNQUAL
  101  117    4
  END NQUALS

  PQL-AD-FLAGS
***                        Atmospheric Deposition Flags
*** < PLS>  QUAL1  QUAL2  QUAL3  QUAL4  QUAL5  QUAL6  QUAL7  QUAL8  QUAL9 QUAL10
*** x  - x <F><C> <F><C> <F><C> <F><C> <F><C> <F><C> <F><C> <F><C> <F><C> <F><C>
  101  117  -1  0  -1  0   0  0   0  0   0  0   0  0   0  0   0  0   0  0   0  0
  END PQL-AD-FLAGS

  QUAL-PROPS
*** <PLS >  Identifiers and Flags
*** x -  x    QUALID      QTID  QSD VPFW VPFS  QSO  VQO QIFW VIQC QAGW VAQC
  101  117NH3+NH4         LBS     0    0    0    1    0    1    0    1    0
  END QUAL-PROPS

  QUAL-INPUT
***         Storage on surface and nonseasonal parameters
***            SQO   POTFW   POTFS   ACQOP  SQOLIM   WSQOP    IOQC    AOQC
*** <PLS >  qty/ac qty/ton qty/ton    qty/  qty/ac   in/hr qty/ft3 qty/ft3
*** x -  x                          ac.day
  101          0.1      0.      0.  0.0817     0.3     1.2 1.6E-05 4.0E-06
```

```
  102          0.1      0.        0.  0.0841     0.3     1.2 1.6E-05 4.0E-06
  103          0.1      0.        0.  0.0846     0.3     1.2 1.6E-05 4.0E-06
  104          0.1      0.        0.  0.0860     0.3     1.2 1.6E-05 4.0E-06
  105          0.0      0.        0.  0.0010     0.1     0.4 1.6E-05 4.0E-06
  106          0.1      0.        0.  0.0900     0.2     1.4 1.6E-05 4.0E-06
  107          0.1      0.        0.  0.0900     0.2     1.4 1.6E-05 4.0E-06
  108          0.1      0.        0.  0.0900     0.2     1.4 1.6E-05 4.0E-06
  109          0.1      0.        0.  0.0140     0.1     1.2 1.6E-05 4.0E-06
  110          0.1      0.        0.  0.0140     0.3     0.4 1.6E-05 4.0E-06
  111          0.1      0.        0.  0.0140     0.1     1.2 1.6E-05 4.0E-06
  112          0.1      0.        0.  0.0140     0.1     1.2 1.6E-05 4.0E-06
  113         0.01      0.        0.  0.0010     0.1     0.4 1.6E-05 4.0E-06
  114          0.1      0.        0.  0.0900     0.2     1.4 1.6E-05 4.0E-06
  115          0.1      0.        0.  0.0140     0.1     1.4 1.6E-05 4.0E-06
  116          1.0      0.        0.  0.0841     3.0     1.2 1.6E-04 4.0E-05
  117          0.1      0.        0.  0.0817     0.3     1.2 1.6E-05 4.0E-06
  END QUAL-INPUT

  QUAL-PROPS
*** <PLS >  Identifiers and Flags
*** x -  x    QUALID      QTID  QSD VPFW VPFS  QSO  VQO QIFW VIQC QAGW VAQC
  101  117NO3             LBS     0    0    0    1    0    1    0    1    0
  END QUAL-PROPS

  QUAL-INPUT
***         Storage on surface and nonseasonal parameters
***            SQO   POTFW   POTFS   ACQOP  SQOLIM   WSQOP    IOQC    AOQC
*** <PLS >  qty/ac qty/ton qty/ton    qty/  qty/ac   in/hr qty/ft3 qty/ft3
*** x -  x                          ac.day
  101  117    0.05      0.        0.  0.0057     0.1     0.7 6.2E-06 6.2E-06
  END QUAL-INPUT

  QUAL-PROPS
*** <PLS >  Identifiers and Flags
*** x -  x    QUALID      QTID  QSD VPFW VPFS  QSO  VQO QIFW VIQC QAGW VAQC
  101  117ORTHO P         LBS     0    0    0    1    0    1    0    1    0
  END QUAL-PROPS

  QUAL-INPUT
***         Storage on surface and nonseasonal parameters
***            SQO   POTFW   POTFS   ACQOP  SQOLIM   WSQOP    IOQC    AOQC
*** <PLS >  qty/ac qty/ton qty/ton    qty/  qty/ac   in/hr qty/ft3 qty/ft3
*** x -  x                          ac.day
  101          0.1      0.        0.  0.0750     0.2     1.2 3.2E-06 1.0E-06
  102          0.1      0.        0.  0.0770     0.2     1.2 3.2E-06 1.0E-06
  103          0.1      0.        0.  0.0780     0.2     1.2 3.2E-06 1.0E-06
  104          0.1      0.        0.  0.0800     0.2     1.2 3.2E-06 1.0E-06
  105          0.1      0.        0.  0.0010     0.1     0.4 3.2E-06 1.0E-06
  106  107     0.1      0.        0.  0.0076     0.1     1.4 3.2E-06 1.0E-06
  108          0.1      0.        0.  0.0076     0.1     1.4 3.2E-06 1.0E-06
  109          0.1      0.        0.  0.0088     0.1     1.2 3.2E-06 1.0E-06
  110          0.1      0.        0.  0.0088     0.1     0.4 3.2E-06 1.0E-06
  111  112     0.1      0.        0.  0.0088     0.1     1.2 3.2E-06 1.0E-06
  113         0.01      0.        0.  0.0010     0.1     1.2 3.2E-06 1.0E-06
  114          0.1      0.        0.  0.0076     0.1     1.4 3.2E-06 1.0E-06
  115          0.1      0.        0.  0.0088     0.1     1.4 3.2E-06 1.0E-06
  116          1.0      0.        0.  0.0770     2.0     1.2 3.2E-05 1.0E-05
  117          0.1      0.        0.  0.0770     0.2     1.2 3.2E-06 1.0E-06
  END QUAL-INPUT

  QUAL-PROPS
*** <PLS >  Identifiers and Flags
*** x -  x    QUALID      QTID  QSD VPFW VPFS  QSO  VQO QIFW VIQC QAGW VAQC
```

```
  101  117BOD            LBS     0    0    0    1    0    1    0    1    0
  END QUAL-PROPS

  QUAL-INPUT
***         Storage on surface and nonseasonal parameters
***            SQO   POTFW   POTFS   ACQOP  SQOLIM   WSQOP    IOQC    AOQC
*** <PLS >  qty/ac qty/ton qty/ton    qty/  qty/ac   in/hr qty/ft3 qty/ft3
*** x -  x                          ac.day
  101           1.      0.      0.    0.65      5.     0.7 2.5E-04 6.2E-05
  102           1.      0.      0.    0.69      5.     0.7 2.5E-04 6.2E-05
  103           1.      0.      0.    0.70      5.     0.7 2.5E-04 6.2E-05
  104           1.      0.      0.    0.73      5.     0.5 2.5E-04 6.2E-05
  105          0.1      0.      0.    0.03      1.     0.5 2.5E-04 6.2E-05
  106           1.      0.      0.    0.43      5.     1.4 2.5E-04 6.2E-05
  107           1.      0.      0.    0.43      5.     1.4 2.5E-04 6.2E-05
  108           1.      0.      0.    0.43      5.     1.4 2.5E-04 6.2E-05
  109           1.      0.      0.    0.19      3.     0.7 2.5E-04 6.2E-05
  110           1.      0.      0.    0.19      5.     0.7 2.5E-04 6.2E-05
  111           1.      0.      0.    0.19      3.     0.7 2.5E-04 6.2E-05
  112           1.      0.      0.    0.19      3.     0.7 2.5E-04 6.2E-05
  113          0.1      0.      0.    0.01     0.1     0.7 2.5E-04 6.2E-05
  114           1.      0.      0.    0.43      5.     1.4 2.5E-04 6.2E-05
  115           1.      0.      0.    0.19      3.     1.4 2.5E-04 6.2E-05
  116          10.      0.      0.    0.69     50.     0.7 2.5E-03 6.2E-04
  117           1.      0.      0.    0.69      5.     1.1 2.5E-04 6.2E-05
  END QUAL-INPUT

END PERLND

IMPLND
  ACTIVITY
*** <ILS >               Active Sections
*** x -  x ATMP SNOW IWAT  SLD  IWG IQAL
  101  104    1    0    1    1    1    1
  END ACTIVITY

  PRINT-INFO
*** <ILS > ******** Print-flags ******** PIVL  PYR
*** x -  x ATMP SNOW IWAT  SLD  IWG IQAL *********
  101  104    4    4    4    4    4    4    1   12
  END PRINT-INFO

  BINARY-INFO
*** <ILS > **** Binary-Output-flags **** PIVL  PYR
*** x -  x ATMP SNOW IWAT  SLD  IWG IQAL *********
  101  104    4    4    4    4    4    4    1   12
  END BINARY-INFO

  GEN-INFO
***             Name             Unit-systems   Printer BinaryOut
*** <ILS >                           t-series Engl Metr Engl Metr
*** x -  x                            in  out
  101     Developed Open Space        1    1    0    0   92    0
  102     Developed Low Intens        1    1    0    0   92    0
  103     Developed Medium Int        1    1    0    0   92    0
  104     Developed High Inten        1    1    0    0   92    0
  END GEN-INFO

  ATEMP-DAT
*** <ILS >     ELDAT    AIRTEMP
*** x -  x      (ft)    (deg F)
  101  104       -6.        33.
  END ATEMP-DAT
```

```
  IWAT-PARM1
*** <ILS >        Flags
*** x -  x CSNO RTOP  VRS  VNN RTLI
  101  104    0    1    0    0    0
  END IWAT-PARM1

  IWAT-PARM2
*** <ILS >      LSUR     SLSUR      NSUR     RETSC
*** x -  x      (ft)                          (in)
  101  104      100.    0.0028      0.07      0.07
  END IWAT-PARM2

  IWAT-PARM3
*** <ILS >    PETMAX    PETMIN
*** x -  x   (deg F)   (deg F)
  101  104       40.       35.
  END IWAT-PARM3

  IWAT-STATE1
*** <ILS >  IWATER state variables (inches)
*** x -  x      RETS      SURS
  101  104        0.        0.
  END IWAT-STATE1

  SLD-PARM1
*** <ILS >     Flags
*** x -  x VASD VRSD SDOP
  101  104    0    0    1
  END SLD-PARM1

  SLD-PARM2
***             KEIM      JEIM    ACCSDP    REMSDP
*** <ILS >                         tons/      /day
*** x -  x                        ac.day
  101  104       0.2        2.     0.010      0.01
  END SLD-PARM2

  SLD-STOR
*** <ILS >  Solids storage (tons/acre)
*** x -  x
  101  104      0.01
  END SLD-STOR

  IWT-PARM1
*** <ILS >  Flags for section IWTGAS
*** x -  x WTFV CSNO
  101  104    0    0
  END IWT-PARM1

  IWT-PARM2
***         Second group of IWTGAS parms
*** <ILS >      ELEV      AWTF      BWTF
*** x -  x      (ft)   (deg F) (deg F/F)
  101  104       20.       40.       0.3
  END IWT-PARM2

  NQUALS
*** <ILS >
*** x -  xNQUAL
  101  104    4
  END NQUALS
```

```
  IQL-AD-FLAGS
***                        Atmospheric Deposition Flags
*** < ILS>  QUAL1  QUAL2  QUAL3  QUAL4  QUAL5  QUAL6  QUAL7  QUAL8  QUAL9 QUAL10
*** x  - x <F><C> <F><C> <F><C> <F><C> <F><C> <F><C> <F><C> <F><C> <F><C> <F><C>
  101  104  -1  0  -1  0   0  0   0  0   0  0   0  0   0  0   0  0   0  0   0  0
  END IQL-AD-FLAGS

  QUAL-PROPS
*** <ILS >    Identifiers and Flags
*** x -  x      QUALID    QTID  QSD VPFW  QSO  VQO
  101  104NH3+NH4         LBS     0    0    1    0
  END QUAL-PROPS

  QUAL-INPUT
***         Storage on surface and nonseasonal parameters
***            SQO   POTFW   ACQOP  SQOLIM   WSQOP
*** <ILS >  qty/ac qty/ton    qty/  qty/ac   in/hr
*** x -  x                  ac.day
  101  104    0.10      0.    0.08     0.3     0.3
  END QUAL-INPUT

  QUAL-PROPS
*** <ILS >    Identifiers and Flags
*** x -  x      QUALID    QTID  QSD VPFW  QSO  VQO
  101  104NO3             LBS     0    0    1    0
  END QUAL-PROPS

  QUAL-INPUT
***         Storage on surface and nonseasonal parameters
***            SQO   POTFW   ACQOP  SQOLIM   WSQOP
*** <ILS >  qty/ac qty/ton    qty/  qty/ac   in/hr
*** x -  x                  ac.day
  101  104    0.10      0.    0.01    0.20     0.2
  END QUAL-INPUT

  QUAL-PROPS
*** <ILS >    Identifiers and Flags
*** x -  x      QUALID    QTID  QSD VPFW  QSO  VQO
  101  104ORTHO P         LBS     0    0    1    0
  END QUAL-PROPS

  QUAL-INPUT
***         Storage on surface and nonseasonal parameters
***            SQO   POTFW   ACQOP  SQOLIM   WSQOP
*** <ILS >  qty/ac qty/ton    qty/  qty/ac   in/hr
*** x -  x                  ac.day
  101  104    0.10      0.    0.08    0.20     0.3
  END QUAL-INPUT

  QUAL-PROPS
*** <ILS >    Identifiers and Flags
*** x -  x      QUALID    QTID  QSD VPFW  QSO  VQO
  101  104BOD             LBS     0    0    1    0
  END QUAL-PROPS

  QUAL-INPUT
***         Storage on surface and nonseasonal parameters
***            SQO   POTFW   ACQOP  SQOLIM   WSQOP
*** <ILS >  qty/ac qty/ton    qty/  qty/ac   in/hr
*** x -  x                  ac.day
  101  104     1.0      0.    0.70      5.     0.3
  END QUAL-INPUT
```

```
END IMPLND

RCHRES
  ACTIVITY
*** RCHRES  Active sections
*** x -  x HYFG ADFG CNFG HTFG SDFG GQFG OXFG NUFG PKFG PHFG
    1   12    1    2    0    1    1    0    1    1    1    0
  END ACTIVITY

  PRINT-INFO
*** RCHRES  Printout level flags
*** x -  x HYDR ADCA CONS HEAT  SED  GQL OXRX NUTR PLNK PHCB PIVL  PYR
    1   12    4    4         4    4         4    4    4         1   12
  END PRINT-INFO

  BINARY-INFO
*** RCHRES  Binary Output level flags
*** x -  x HYDR ADCA CONS HEAT  SED  GQL OXRX NUTR PLNK PHCB PIVL  PYR
    1   12    4    4         4    4         4    4    4         1   12
  END BINARY-INFO

  GEN-INFO
***              Name        Nexits   Unit Systems   Printer
*** RCHRES                               t-series  Engl Metr LKFG
*** x -  x                                 in  out
    1     Gum Gully               1         1    1   91    0    0   92    0
    2     Adams Headwaters        1         1    1   91    0    0   92    0
    3     Gum Gully Lower Rch     1         1    1   91    0    0   92    0
    4     Adams Lateral 8         1         1    1   91    0    0   92    0
    5     Adams Bayou abv I10     1         1    1   91    0    0   92    0
    6     Adams abv confl Gum     1         1    1   91    0    0   92    0
    7     Adams Bayou abv Park    1         1    1   91    0    0   92    0
    8     Hudson Gully            1         1    1   91    0    0   92    0
    9     Adams Lateral 2         1         1    1   91    0    0   92    0
   10     Adams above Western     1         1    1   91    0    0   92    0
   11     Adams Lateral 1         1         1    1   91    0    0   92    0
   12     Adams Bayou mouth       1         1    1   91    0    0   92    0
  END GEN-INFO

  HYDR-PARM1
***        Flags for HYDR section
***RC HRES  VC A1 A2 A3  ODFVFG for each *** ODGTFG for each     FUNCT  for each
*** x  - x  FG FG FG FG  possible   exit *** possible   exit     possible   exit
    1   12   0  1  1  1    4  0  0  0  0       0  0  0  0  0       1  1  1  1  1
  END HYDR-PARM1

  HYDR-PARM2
*** RCHRES FTBW FTBU       LEN     DELTH     STCOR        KS      DB50
*** x -  x              (miles)     (ft)      (ft)                 (in)
    1        0.   1.      1.85        9.       3.2       0.5     0.004
    2        0.   2.      5.75       15.       3.2       0.5     0.004
    3        0.   3.       0.6       0.1       3.2       0.5     0.004
    4        0.   4.       1.5       9.5       3.2       0.5     0.004
    5        0.   5.      1.41       2.8       3.2       0.5     0.004
    6        0.   6.      1.09       0.1       3.2       0.5     0.004
    7        0.   7.      2.03       0.2       3.2       0.5     0.004
    8        0.   8.      0.98       6.9       3.2       0.5     0.004
    9        0.   9.       1.4        4.       3.2       0.5     0.004
   10        0.  10.      3.25       1.6       3.2       0.5     0.004
   11        0.  11.      2.43       7.5       3.2       0.5     0.004
   12        0.  12.      2.42       0.1       3.2       0.5     0.004
  END HYDR-PARM2
```

```
  HYDR-INIT
***        Initial conditions for HYDR section
***RC HRES       VOL  CAT Initial value  of COLIND     initial  value  of OUTDGT
*** x  - x     ac-ft      for each possible   exit  for each possible exit,ft3
    1   12      0.01       4.2  4.5  4.5  4.5  4.2       2.1  1.2  0.5  1.2  1.8
  END HYDR-INIT

  ADCALC-DATA
*** RCHRES  Data for section ADCALC
*** x -  x     CRRAT       VOL (ac-ft)
    1   12       1.7      100.
  END ADCALC-DATA

  HT-BED-FLAGS
*** RCHRES Bed Heat Conductance Flags
*** x -  x BDFG TGFG TSTP
    1   12    1    3   55
  END HT-BED-FLAGS

  HEAT-PARM
*** RCHRES      ELEV     ELDAT    CFSAEX    KATRAD     KCOND     KEVAP
*** x -  x      (ft)      (ft)
    1             0.      -16.      0.05      9.37      6.12      2.24
    2             0.      -16.      0.35      9.37      6.12      2.24
    3             0.      -16.      0.15      9.37      6.12      2.24
    4             0.      -16.      0.25      9.37      6.12      2.24
    5             0.      -16.      0.45      9.37      6.12      2.24
    6             0.      -16.      0.45      9.37      6.12      2.24
    7             0.      -16.      0.45      9.37      6.12      2.24
    8             0.      -16.      0.25      9.37      6.12      2.24
    9             0.      -16.      0.25      9.37      6.12      2.24
   10             0.      -16.      0.65      9.37      6.12      2.24
   11             0.      -16.      0.25      9.37      6.12      2.24
   12             0.      -16.      0.75      9.37      6.12      2.24
  END HEAT-PARM

  HT-BED-PARM
***        Bed Heat Conduction Parameters for Single and Two-layer Methods
*** RCHRES    MUDDEP     TGRND      KMUD     KGRND
*** x -  x      (ft)   (deg F)      (kcal/m2/C/hr)
    1   12       0.8       70.       20.       1.4
  END HT-BED-PARM

  MON-HT-TGRND
*** RCHRES  Monthly values of ground temperatures (deg F)
*** x -  x  TG1  TG2  TG3  TG4  TG5  TG6  TG7  TG8  TG9 TG10 TG11 TG12
    1   12  56.  55.  58.  63.  68.  74.  79.  82.  81.  75.  68.  60.
  END MON-HT-TGRND

  HEAT-INIT
*** RCHRES        TW    AIRTMP
*** x -  x   (deg F)   (deg F)
    1   12       48.       40.
  END HEAT-INIT

  SANDFG
*** RCHRES
*** x -  x SNDFG
    1   12    3
  END SANDFG

  SED-GENPARM
*** RCHRES    BEDWID    BEDWRN       POR
```

```
*** x -  x       (ft)       (ft)
    1          13.         6.       0.3
    2          40.         6.       0.3
    3          14.         6.       0.3
    4          12.         6.       0.3
    5          90.         6.      0.35
    6          60.         6.      0.28
    7         190.         6.      0.43
    8          16.         6.       0.3
    9          25.         6.       0.3
   10         230.         6.      0.49
   11          22.         6.       0.3
   12         220.         6.      0.55
  END SED-GENPARM

  SAND-PM
*** RCHRES          D          W        RHO      KSAND    EXPSND
*** x -  x       (in)  (in/sec)  (gm/cm3)
    1        0.0100        1.0       2.65        0.8       3.2
    2        0.0100        1.0       2.65        0.8       3.2
    3        0.0100        1.0       2.65        0.8       3.2
    4        0.0100        1.0       2.65        0.8       3.2
    5        0.0100        1.0       2.65        0.8       3.2
    6        0.0100        1.0       2.65        0.8       3.2
    7        0.0100        1.0       2.65        0.8       3.2
    8        0.0100        1.0       2.65        0.8       3.2
    9        0.0100        1.0       2.65        0.8       3.2
   10        0.0100        1.0       2.65        0.8       3.2
   11        0.0100        1.0       2.65        0.8       3.2
   12        0.0100        1.0       2.65        0.8       3.2
  END SAND-PM

  SILT-CLAY-PM
*** RCHRES          D          W        RHO      TAUCD     TAUCS         M
*** x -  x       (in)  (in/sec)     gm/cm3     lb/ft2    lb/ft2  lb/ft2.d
    1       0.00063      0.003       2.20       0.02     0.050      0.05
    2       0.00063      0.003       2.20       0.02     0.050      0.05
    3       0.00063      0.003       2.20       0.01     0.020      0.05
    4       0.00063      0.003       2.20       0.02     0.050      0.05
    5       0.00063      0.003       2.20       0.02     0.050      0.05
    6       0.00063      0.003       2.20       0.02     0.050      0.05
    7       0.00063      0.003       2.20       0.02     0.050      0.05
    8       0.00063      0.003       2.20       0.02     0.050      0.05
    9       0.00063      0.003       2.20       0.02     0.050      0.05
   10       0.00063      0.003       2.20       0.02     0.050      0.05
   11       0.00063      0.003       2.20       0.02     0.050      0.05
   12       0.00063      0.003       2.20       0.02     0.050      0.05
  END SILT-CLAY-PM

  SILT-CLAY-PM
*** RCHRES          D          W        RHO      TAUCD     TAUCS         M
*** x -  x       (in)  (in/sec)     gm/cm3     lb/ft2    lb/ft2  lb/ft2.d
    1       0.00006    0.00002       2.00      0.015     0.045      0.05
    2       0.00006    0.00002       2.00      0.015     0.045      0.05
    3       0.00006    0.00002       2.00      0.010     0.020      0.05
    4       0.00006    0.00002       2.00      0.015     0.045      0.05
    5       0.00006    0.00002       2.00      0.015     0.045      0.05
    6       0.00006    0.00002       2.00      0.015     0.045      0.05
    7       0.00006    0.00002       2.00      0.015     0.045      0.05
    8       0.00006    0.00002       2.00      0.015     0.045      0.05
    9       0.00006    0.00002       2.00      0.015     0.045      0.05
   10       0.00006    0.00002       2.00      0.015     0.045      0.05
   11       0.00006    0.00002       2.00      0.015     0.045      0.05
```

```
   12        0.00006   0.00002      2.00     0.015     0.045      0.05
  END SILT-CLAY-PM

  SSED-INIT
*** RCHRES     Suspended sed concs (mg/l)
*** x -  x      Sand      Silt      Clay
    1   12        1.        5.       10.
  END SSED-INIT

  BED-INIT
*** RCHRES    BEDDEP  Initial bed composition
*** x -  x      (ft)      Sand      Silt      Clay
    1            1.5      0.96      0.02      0.02
    2            1.5      0.96      0.02      0.02
    3            1.5      0.50      0.25      0.25
    4            1.5      0.96      0.02      0.02
    5            1.5      0.70      0.15      0.15
    6            1.5      0.70      0.15      0.15
    7            1.5      0.66      0.15      0.19
    8            1.5      0.96      0.02      0.02
    9            1.5      0.96      0.02      0.02
   10            1.5      0.63      0.08      0.29
   11            1.5      0.86      0.05      0.09
   12            1.5      0.36      0.10      0.54
  END BED-INIT

  BENTH-FLAG
*** RCHRES  Benthic release flag
*** x -  x BENF
    1   12    1
  END BENTH-FLAG

  OX-FLAGS
*** RCHRES Oxygen flags
*** x -  x REAM
    1   12    2
  END OX-FLAGS

  OX-GENPARM
*** RCHRES    KBOD20     TCBOD    KODSET    SUPSAT
*** x -  x       /hr               ft/hr
    1   12     0.002     1.047     0.001        1.
  END OX-GENPARM

  OX-BENPARM
*** RCHRES     BENOD     TCBEN     EXPOD  BRBOD(1)  BRBOD(2)   EXPREL
*** x -  x  mg/m2.hr                      mg/m2.hr  mg/m2.hr
    1   12      150.     1.074      1.22       0.1       0.1      2.82
  END OX-BENPARM

  OX-TCGINV
*** RCHRES    Temperature Correction Coefficient
*** x -  x    TCGINV
    1   12     1.047
  END OX-TCGINV

  OX-INIT
*** RCHRES       DOX       BOD     SATDO
*** x -  x      mg/l      mg/l      mg/l
    1   12        8.       3.5      13.5
  END OX-INIT

  NUT-FLAGS
```

```
*** RCHRES  Nutrient flags
*** x -  x  NH3  NO2  PO4  AMV  DEN ADNH ADPO PHFL
    1   12    1    0    1    0    1    0    1    2
  END NUT-FLAGS

  CONV-VAL1
*** RCHRES      CVBO     CVBPC     CVBPN    BPCNTC
*** x -  x     mg/mg  mols/mol  mols/mol
    1   12      1.63      106.       16.       49.
  END CONV-VAL1

  NUT-BENPARM
*** RCHRES  BRNIT(1)  BRNIT(2)  BRPO4(1)  BRPO4(2)     ANAER
*** x -  x  mg/m2.hr  mg/m2.hr  mg/m2.hr  mg/m2.hr      mg/l
    1   12        0.        0.        0.        0.       0.1
  END NUT-BENPARM

  NUT-NITDENIT
*** RCHRES    KTAM20    KNO220     TCNIT    KNO320     TCDEN    DENOXT
*** x -  x       /hr       /hr                 /hr                mg/l
    1   12      0.01     0.002      1.07      0.02      1.04        5.
  END NUT-NITDENIT

  NUT-ADSPARM
*** RCHRES       Partition coefficients for NH4 AND PO4  (ml/g)
*** x -  x  NH4-sand  NH4-silt  NH4-clay  PO4-sand  PO4-silt  PO4-clay
    1   12     1E-10     1E-10     1E-10     1E-10       0.1       50.
  END NUT-ADSPARM

  NUT-DINIT
*** RCHRES       NO3       TAM       NO2       PO4     PHVAL
*** x -  x      mg/l      mg/l      mg/l      mg/l
    1   12       0.1       0.1      0.01      0.05        7.
  END NUT-DINIT

  PLNK-FLAGS
*** RCHRES Plankton flags
*** x -  x PHYF ZOOF BALF SDLT AMRF DECF NSFG ZFOO  BNP
    1   12    1    0    1    0    0    1    1    2    0
  END PLNK-FLAGS

  PLNK-PARM1
***RC HRES    RATCLP    NONREF    LITSED     ALNPR      EXTB     MALGR    PARADF
*** x  - x                       l/mg.ft                 /ft       /hr
    1   12      0.68       0.5        0.      0.75       0.3     0.085        1.
  END PLNK-PARM1

  PLNK-PARM2
***RC HRES     CMMLT      CMMN     CMMNP      CMMP    TALGRH    TALGRL    TALGRM
*** x  - x    ly/min      mg/l      mg/l      mg/l     deg F     deg F     deg F
    1   12      0.01     0.025    0.0001     0.005       95.      -20.       86.
  END PLNK-PARM2

  PLNK-PARM3
*** RCHRES     ALR20      ALDH      ALDL     OXALD     NALDH     PALDH
*** x -  x       /hr       /hr       /hr       /hr      mg/l      mg/l
    1   12     0.005     0.020     0.001      0.03     0.010     0.002
  END PLNK-PARM3

  PHYTO-PARM
*** RCHRES      SEED    MXSTAY      OREF    CLALDH    PHYSET    REFSET
*** x -  x      mg/l      mg/l     ft3/s      ug/l     ft/hr     ft/hr
    1   12        1.        2.      100.       20.     0.020     0.025
```

```
  END PHYTO-PARM

  BENAL-PARM
***RC HRES      MBAL    CFBALR    CFBALG    MINBAL     CAMPR     FRAVL    NMAXFX
*** x  - x     mg/m2                         mg/m2      mg/l                 mg/l
    1   12     2500.      0.35        1.    0.0001     0.001        0.       10.
  END BENAL-PARM

  PLNK-INIT
*** RCHRES     PHYTO       ZOO     BENAL       ORN       ORP       ORC
*** x -  x      mg/l     org/l     mg/m2      mg/l      mg/l      mg/l
    1   12       0.5      0.03     2500.       0.5       0.1       0.5
  END PLNK-INIT

END RCHRES

FTABLES

  FTABLE      1
 rows cols                               ***
    8    4
     depth      area    volume  outflow1 ***
        0.        0.        0.        0.
        1.      0.45       0.2        0.
        2.      1.39       1.1        0.
        3.      1.61       2.6       0.1
        5.       3.6       7.8        3.
        6.       4.5      11.9       37.
        8.      44.8      61.2      410.
       11.     112.1     296.7     3969.
  END FTABLE  1

  FTABLE      2
 rows cols                               ***
    8    4
     depth      area    volume  outflow1 ***
        0.        0.        0.        0.
        1.        6.        3.        0.
        2.      22.3      17.1        0.
        3.      25.8      41.2       0.1
        5.      32.1       99.        3.
        8.      41.8     209.9      211.
       11.     348.5     795.3     1712.
       14.      697.    2363.5    10173.
  END FTABLE  2

  FTABLE      3
 rows cols                               ***
    8    4
     depth      area    volume  outflow1 ***
        0.        0.        0.        0.
        1.      0.15       0.1        0.
        2.      0.45       0.4        0.
        3.      0.52       0.9      1.18
        5.       1.2       2.5       11.
        6.       1.5       3.9       37.
        8.      14.5      19.9      410.
       11.      36.4      96.2     3969.
  END FTABLE  3

  FTABLE      4
 rows cols                               ***
    8    4
```

```
    depth      area    volume  outflow1 ***
       0.        0.        0.        0.
       1.      0.36       0.2        0.
       2.      1.13       0.9        0.
       3.      1.31       2.1       0.1
       5.       2.9       6.4        3.
       6.       3.6       9.6       37.
       8.      36.4      49.6      410.
      11.      90.9     240.5     3969.
  END FTABLE  4

  FTABLE      6
 rows cols                             ***
   9    4
    depth      area    volume  outflow1 ***
       0.        0.        0.        0.
       1.      3.17        2.        0.
       2.      3.57       5.4        0.
       3.      5.95      10.1       0.7
       5.       7.3      23.3       18.
       7.       8.5       39.       89.
       9.       9.5       57.      302.
      12.      79.3     190.2     2159.
      15.     158.5     546.9    12419.
  END FTABLE  6

  FTABLE      5
 rows cols                             ***
  11    4
    depth      area    volume  outflow1 ***
       0.        0.        0.        0.
       1.       6.3       2.6        0.
       2.       7.7       9.6        0.
       4.      10.2      27.5        0.
       6.       12.      49.7        0.
       8.      12.8      74.5        0.
      10.      14.2     101.5        0.
      12.      16.4     132.1       77.
      14.      18.8     167.3      294.
      17.      68.4     298.1     1221.
      20.     170.9      657.     7688.
  END FTABLE  5

  FTABLE      7
 rows cols                             ***
  11    4
    depth      area    volume  outflow1 ***
       0.        0.        0.        0.
       1.      3.42       1.7        0.
       2.      5.98       6.4        0.
       4.      8.55      20.9        0.
       6.      19.7      49.1        0.
       8.      27.3      96.1        0.
      10.      34.2     157.7        0.
      12.      37.8     229.6      134.
      14.      68.4     335.8      589.
      17.     136.7     643.4     2635.
      20.     170.9    1104.8    12929.
  END FTABLE  7

  FTABLE      8
 rows cols                             ***
   7    4
```

```
    depth      area    volume  outflow1 ***
       0.        0.        0.        0.
       1.      1.88       1.7        0.
       2.      1.92       3.6        0.
       3.      2.14       5.6      4.71
       5.       2.4      10.1       26.
       6.      35.6      29.1      172.
       8.     118.8     183.5     3090.
 END FTABLE  8

 FTABLE      9
rows cols                               ***
   7    4
    depth      area    volume  outflow1 ***
       0.        0.        0.        0.
       1.      4.24       3.9        0.
       2.      4.41       8.2        0.
       4.      4.58      17.2     10.15
       6.       5.1      26.9       48.
       8.      33.9      65.9      272.
      10.      84.8     184.7     2177.
 END FTABLE  9

 FTABLE     10
rows cols                               ***
  11    4
    depth      area    volume  outflow1 ***
       0.        0.        0.        0.
       1.      5.13       2.6        0.
       2.     11.96      11.1        0.
       4.     15.38      38.5        0.
       6.      23.9      77.8        0.
       8.      27.3      129.        0.
      10.      37.6      194.        0.
      12.       41.      273.      160.
      14.      44.4      358.      629.
      17.      68.4      527.     2160.
      22.     256.4     1339.    15670.
 END FTABLE 10

 FTABLE     11
rows cols                               ***
   9    4
    depth      area    volume  outflow1 ***
       0.        0.        0.        0.
       1.      3.83       1.8        0.
       2.      6.19       6.8        0.
       3.      6.48      13.1        0.
       5.       6.8      26.4        9.
       7.       7.1      40.2       41.
       9.       8.8      56.1      133.
      11.     117.8     182.8      931.
      14.     235.6     712.9     7262.
 END FTABLE 11

 FTABLE     12
rows cols                               ***
  11    4
    depth      area    volume  outflow1 ***
       0.        0.        0.        0.
       1.       4.1       2.1        0.
       2.      5.98       7.1        0.
       4.      8.55      21.6        0.
```

```
        6.      11.1      41.3        0.
        8.      20.5      72.9        0.
       10.      23.9     117.3        0.
       12.      28.2     169.5       99.
       14.        33.    230.6      405.
       17.     102.5     433.9     1777.
       22.     341.8    1544.8    18078.
  END FTABLE 12
END FTABLES

COPY
  TIMESERIES
  Copy-opn***
*** x -  x  NPT  NMN
    1   12    0    7
  END TIMESERIES

END COPY

EXT SOURCES
<-Volume-> <Member> SsysSgap<--Mult-->Tran <-Target vols> <-Grp> <-Member-> ***
<Name>   x <Name> x tem strg<-factor->strg <Name>   x   x        <Name> x x ***
*** Met Seg ORANGE
WDM2    27 PREC     ENGL              SAME PERLND 101 117 EXTNL  PREC
WDM2    28 ATEM     ENGL              SAME PERLND 101 117 EXTNL  GATMP
WDM2    29 DEWP     ENGL              SAME PERLND 101 117 EXTNL  DTMPG
WDM2    25 WIND     ENGL              SAME PERLND 101 117 EXTNL  WINMOV
WDM2    26 SOLR     ENGL              SAME PERLND 101 117 EXTNL  SOLRAD
WDM2    31 PEVT     ENGL              SAME PERLND 101 117 EXTNL  PETINP
*** Met Seg ORANGE
WDM2    27 PREC     ENGL              SAME IMPLND 101 104 EXTNL  PREC
WDM2    28 ATEM     ENGL              SAME IMPLND 101 104 EXTNL  GATMP
WDM2    29 DEWP     ENGL              SAME IMPLND 101 104 EXTNL  DTMPG
WDM2    25 WIND     ENGL              SAME IMPLND 101 104 EXTNL  WINMOV
WDM2    26 SOLR     ENGL              SAME IMPLND 101 104 EXTNL  SOLRAD
WDM2    31 PEVT     ENGL              SAME IMPLND 101 104 EXTNL  PETINP
*** Met Seg ORANGE
WDM2    27 PREC     ENGL              SAME RCHRES   1  12 EXTNL  PREC
WDM2    28 ATEM     ENGL              SAME RCHRES   1  12 EXTNL  GATMP
WDM2    29 DEWP     ENGL              SAME RCHRES   1  12 EXTNL  DEWTMP
WDM2    25 WIND     ENGL              SAME RCHRES   1  12 EXTNL  WIND
WDM2    26 SOLR     ENGL              SAME RCHRES   1  12 EXTNL  SOLRAD
WDM2    30 CLOU     ENGL              SAME RCHRES   1  12 EXTNL  CLOUD
WDM2    34 EVAP     ENGL              SAME RCHRES   1  12 EXTNL  POTEV
WDM3  8011 BOD      ENGL           9.9DIV  RCHRES   1     INFLOW OXIF   2
WDM3  8012 TSS      ENGL           9.9DIV  RCHRES   1     INFLOW ISED   2
WDM3  8014 DNH3     ENGL           9.9DIV  RCHRES   1     INFLOW NUIF1  2
WDM3  8015 DPO4     ENGL           9.9DIV  RCHRES   1     INFLOW NUIF1  4
WDM3  7001 FLOW     ENGL             0DIV  RCHRES   1     INFLOW IVOL
WDM3  7002 BOD      ENGL             0DIV  RCHRES   1     INFLOW OXIF   2
WDM3  7003 DNH3     ENGL             0DIV  RCHRES   1     INFLOW NUIF1  2
WDM3  8011 BOD      ENGL          54.3DIV  RCHRES   2     INFLOW OXIF   2
WDM3  8012 TSS      ENGL          54.3DIV  RCHRES   2     INFLOW ISED   2
WDM3  8014 DNH3     ENGL          54.3DIV  RCHRES   2     INFLOW NUIF1  2
WDM3  8015 DPO4     ENGL          54.3DIV  RCHRES   2     INFLOW NUIF1  4
WDM3  7001 FLOW     ENGL             0DIV  RCHRES   2     INFLOW IVOL
WDM3  7002 BOD      ENGL             0DIV  RCHRES   2     INFLOW OXIF   2
WDM3  7003 DNH3     ENGL             0DIV  RCHRES   2     INFLOW NUIF1  2
WDM3  8011 BOD      ENGL           8.3DIV  RCHRES   3     INFLOW OXIF   2
WDM3  8012 TSS      ENGL           8.3DIV  RCHRES   3     INFLOW ISED   2
WDM3  8014 DNH3     ENGL           8.3DIV  RCHRES   3     INFLOW NUIF1  2
WDM3  8015 DPO4     ENGL           8.3DIV  RCHRES   3     INFLOW NUIF1  4
WDM3  7001 FLOW     ENGL             0DIV  RCHRES   3     INFLOW IVOL
```

```
WDM3  7002 BOD      ENGL            0DIV  RCHRES   3     INFLOW OXIF   2
WDM3  7003 DNH3     ENGL            0DIV  RCHRES   3     INFLOW NUIF1  2
WDM3  8011 BOD      ENGL          8.2DIV  RCHRES   4     INFLOW OXIF   2
WDM3  8012 TSS      ENGL          8.2DIV  RCHRES   4     INFLOW ISED   2
WDM3  8014 DNH3     ENGL          8.2DIV  RCHRES   4     INFLOW NUIF1  2
WDM3  8015 DPO4     ENGL          8.2DIV  RCHRES   4     INFLOW NUIF1  4
WDM3  7001 FLOW     ENGL            0DIV  RCHRES   4     INFLOW IVOL
WDM3  7002 BOD      ENGL            0DIV  RCHRES   4     INFLOW OXIF   2
WDM3  7003 DNH3     ENGL            0DIV  RCHRES   4     INFLOW NUIF1  2
WDM3  8011 BOD      ENGL          6.2DIV  RCHRES   6     INFLOW OXIF   2
WDM3  8012 TSS      ENGL          6.2DIV  RCHRES   6     INFLOW ISED   2
WDM3  8014 DNH3     ENGL          6.2DIV  RCHRES   6     INFLOW NUIF1  2
WDM3  8015 DPO4     ENGL          6.2DIV  RCHRES   6     INFLOW NUIF1  4
WDM3  7001 FLOW     ENGL            0DIV  RCHRES   6     INFLOW IVOL
WDM3  7002 BOD      ENGL            0DIV  RCHRES   6     INFLOW OXIF   2
WDM3  7003 DNH3     ENGL            0DIV  RCHRES   6     INFLOW NUIF1  2
WDM3  8011 BOD      ENGL          3.2DIV  RCHRES   5     INFLOW OXIF   2
WDM3  8012 TSS      ENGL          3.2DIV  RCHRES   5     INFLOW ISED   2
WDM3  8014 DNH3     ENGL          3.2DIV  RCHRES   5     INFLOW NUIF1  2
WDM3  8015 DPO4     ENGL          3.2DIV  RCHRES   5     INFLOW NUIF1  4
WDM3  7001 FLOW     ENGL            0DIV  RCHRES   5     INFLOW IVOL
WDM3  7002 BOD      ENGL            0DIV  RCHRES   5     INFLOW OXIF   2
WDM3  7003 DNH3     ENGL            0DIV  RCHRES   5     INFLOW NUIF1  2
WDM3  8011 BOD      ENGL          0.1DIV  RCHRES   7     INFLOW OXIF   2
WDM3  8012 TSS      ENGL          0.1DIV  RCHRES   7     INFLOW ISED   2
WDM3  8014 DNH3     ENGL          0.1DIV  RCHRES   7     INFLOW NUIF1  2
WDM3  8015 DPO4     ENGL          0.1DIV  RCHRES   7     INFLOW NUIF1  4
WDM3  7001 FLOW     ENGL            0DIV  RCHRES   7     INFLOW IVOL
WDM3  7002 BOD      ENGL            0DIV  RCHRES   7     INFLOW OXIF   2
WDM3  7003 DNH3     ENGL            0DIV  RCHRES   7     INFLOW NUIF1  2
WDM3  8011 BOD      ENGL          3.3DIV  RCHRES   8     INFLOW OXIF   2
WDM3  8012 TSS      ENGL          3.3DIV  RCHRES   8     INFLOW ISED   2
WDM3  8014 DNH3     ENGL          3.3DIV  RCHRES   8     INFLOW NUIF1  2
WDM3  8015 DPO4     ENGL          3.3DIV  RCHRES   8     INFLOW NUIF1  4
WDM3  7001 FLOW     ENGL            0DIV  RCHRES   8     INFLOW IVOL
WDM3  7002 BOD      ENGL            0DIV  RCHRES   8     INFLOW OXIF   2
WDM3  7003 DNH3     ENGL            0DIV  RCHRES   8     INFLOW NUIF1  2
WDM3  8011 BOD      ENGL          0.1DIV  RCHRES   9     INFLOW OXIF   2
WDM3  8012 TSS      ENGL          0.1DIV  RCHRES   9     INFLOW ISED   2
WDM3  8014 DNH3     ENGL          0.1DIV  RCHRES   9     INFLOW NUIF1  2
WDM3  8015 DPO4     ENGL          0.1DIV  RCHRES   9     INFLOW NUIF1  4
WDM3  7001 FLOW     ENGL            0DIV  RCHRES   9     INFLOW IVOL
WDM3  7002 BOD      ENGL            0DIV  RCHRES   9     INFLOW OXIF   2
WDM3  7003 DNH3     ENGL            0DIV  RCHRES   9     INFLOW NUIF1  2
WDM3  8011 BOD      ENGL          0.7DIV  RCHRES  10     INFLOW OXIF   2
WDM3  8012 TSS      ENGL          0.7DIV  RCHRES  10     INFLOW ISED   2
WDM3  8014 DNH3     ENGL          0.7DIV  RCHRES  10     INFLOW NUIF1  2
WDM3  8015 DPO4     ENGL          0.7DIV  RCHRES  10     INFLOW NUIF1  4
WDM3  7001 FLOW     ENGL            0DIV  RCHRES  10     INFLOW IVOL
WDM3  7002 BOD      ENGL            0DIV  RCHRES  10     INFLOW OXIF   2
WDM3  7003 DNH3     ENGL            0DIV  RCHRES  10     INFLOW NUIF1  2
WDM3  8011 BOD      ENGL          1.9DIV  RCHRES  11     INFLOW OXIF   2
WDM3  8012 TSS      ENGL          1.9DIV  RCHRES  11     INFLOW ISED   2
WDM3  8014 DNH3     ENGL          1.9DIV  RCHRES  11     INFLOW NUIF1  2
WDM3  8015 DPO4     ENGL          1.9DIV  RCHRES  11     INFLOW NUIF1  4
WDM3  7001 FLOW     ENGL            0DIV  RCHRES  11     INFLOW IVOL
WDM3  7002 BOD      ENGL            0DIV  RCHRES  11     INFLOW OXIF   2
WDM3  7003 DNH3     ENGL            0DIV  RCHRES  11     INFLOW NUIF1  2
WDM3  8011 BOD      ENGL          0.1DIV  RCHRES  12     INFLOW OXIF   2
WDM3  8012 TSS      ENGL          0.1DIV  RCHRES  12     INFLOW ISED   2
WDM3  8014 DNH3     ENGL          0.1DIV  RCHRES  12     INFLOW NUIF1  2
WDM3  8015 DPO4     ENGL          0.1DIV  RCHRES  12     INFLOW NUIF1  4
WDM3  7001 FLOW     ENGL            0DIV  RCHRES  12     INFLOW IVOL
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WDM3  7002 BOD      ENGL            0DIV  RCHRES  12     INFLOW OXIF   2
WDM3  7003 DNH3     ENGL            0DIV  RCHRES  12     INFLOW NUIF1  2
*** 6205 and 6206 are atmospheric deposition loads of NH3N and NO3N
WDM3  6206 NO3N     ENGL             DIV  PERLND 101     EXTNL  PQADFX 2 1
WDM3  6205 NH3N     ENGL             DIV  PERLND 101     EXTNL  PQADFX 1 1
WDM3  6206 NO3N     ENGL             DIV  PERLND 102     EXTNL  PQADFX 2 1
WDM3  6205 NH3N     ENGL             DIV  PERLND 102     EXTNL  PQADFX 1 1
WDM3  6206 NO3N     ENGL             DIV  PERLND 103     EXTNL  PQADFX 2 1
WDM3  6205 NH3N     ENGL             DIV  PERLND 103     EXTNL  PQADFX 1 1
WDM3  6206 NO3N     ENGL             DIV  PERLND 104     EXTNL  PQADFX 2 1
WDM3  6205 NH3N     ENGL             DIV  PERLND 104     EXTNL  PQADFX 1 1
WDM3  6206 NO3N     ENGL             DIV  PERLND 105     EXTNL  PQADFX 2 1
WDM3  6205 NH3N     ENGL             DIV  PERLND 105     EXTNL  PQADFX 1 1
WDM3  6206 NO3N     ENGL             DIV  PERLND 106     EXTNL  PQADFX 2 1
WDM3  6205 NH3N     ENGL             DIV  PERLND 106     EXTNL  PQADFX 1 1
WDM3  6206 NO3N     ENGL             DIV  PERLND 107     EXTNL  PQADFX 2 1
WDM3  6205 NH3N     ENGL             DIV  PERLND 107     EXTNL  PQADFX 1 1
WDM3  6206 NO3N     ENGL             DIV  PERLND 108     EXTNL  PQADFX 2 1
WDM3  6205 NH3N     ENGL             DIV  PERLND 108     EXTNL  PQADFX 1 1
WDM3  6206 NO3N     ENGL             DIV  PERLND 109     EXTNL  PQADFX 2 1
WDM3  6205 NH3N     ENGL             DIV  PERLND 109     EXTNL  PQADFX 1 1
WDM3  6206 NO3N     ENGL             DIV  PERLND 110     EXTNL  PQADFX 2 1
WDM3  6205 NH3N     ENGL             DIV  PERLND 110     EXTNL  PQADFX 1 1
WDM3  6206 NO3N     ENGL             DIV  PERLND 111     EXTNL  PQADFX 2 1
WDM3  6205 NH3N     ENGL             DIV  PERLND 111     EXTNL  PQADFX 1 1
WDM3  6206 NO3N     ENGL             DIV  PERLND 112     EXTNL  PQADFX 2 1
WDM3  6205 NH3N     ENGL             DIV  PERLND 112     EXTNL  PQADFX 1 1
WDM3  6206 NO3N     ENGL             DIV  PERLND 113     EXTNL  PQADFX 2 1
WDM3  6205 NH3N     ENGL             DIV  PERLND 113     EXTNL  PQADFX 1 1
WDM3  6206 NO3N     ENGL             DIV  PERLND 114     EXTNL  PQADFX 2 1
WDM3  6205 NH3N     ENGL             DIV  PERLND 114     EXTNL  PQADFX 1 1
WDM3  6206 NO3N     ENGL             DIV  PERLND 115     EXTNL  PQADFX 2 1
WDM3  6205 NH3N     ENGL             DIV  PERLND 115     EXTNL  PQADFX 1 1
*** FAILING OSSF LOADS TO PERLND 116
*** 0.9 multiplier is fraction not flowing direct via pipe to ditch & stream
WDM3  8011 BOD      ENGL          0.9DIV  PERLND 116     EXTNL  SLIQO  4
WDM3  8012 TSS      ENGL          0.9DIV  PERLND 116     EXTNL  SLSED  1
WDM3  8013 FLOW     ENGL          0.9DIV  PERLND 116     EXTNL  SURLI  1
WDM3  8014 DNH3     ENGL          0.9DIV  PERLND 116     EXTNL  SLIQO  1
WDM3  8015 DPO4     ENGL          0.9DIV  PERLND 116     EXTNL  SLIQO  3
*** 6205 and 6206 are atmospheric deposition loads of NH3N and NO3N
WDM3  6206 NO3N     ENGL             DIV  PERLND 116     EXTNL  PQADFX 2 1
WDM3  6205 NH3N     ENGL             DIV  PERLND 116     EXTNL  PQADFX 1 1
WDM3  6206 NO3N     ENGL             DIV  PERLND 117     EXTNL  PQADFX 2 1
WDM3  6205 NH3N     ENGL             DIV  PERLND 117     EXTNL  PQADFX 1 1
WDM3  6206 NO3N     ENGL             DIV  IMPLND 101     EXTNL  IQADFX 2 1
WDM3  6205 NH3N     ENGL             DIV  IMPLND 101     EXTNL  IQADFX 1 1
WDM3  6206 NO3N     ENGL             DIV  IMPLND 102     EXTNL  IQADFX 2 1
WDM3  6205 NH3N     ENGL             DIV  IMPLND 102     EXTNL  IQADFX 1 1
WDM3  6206 NO3N     ENGL             DIV  IMPLND 103     EXTNL  IQADFX 2 1
WDM3  6205 NH3N     ENGL             DIV  IMPLND 103     EXTNL  IQADFX 1 1
WDM3  6206 NO3N     ENGL             DIV  IMPLND 104     EXTNL  IQADFX 2 1
WDM3  6205 NH3N     ENGL             DIV  IMPLND 104     EXTNL  IQADFX 1 1
END EXT SOURCES

SCHEMATIC
***SOURCE                        ACRES     TARGET      MASS_LINKAGE
PERLND 101                         212     RCHRES   1       2
PERLND 102                          87     RCHRES   1       2
PERLND 103                           2     RCHRES   1       2
PERLND 104                           0     RCHRES   1       2
PERLND 105                           3     RCHRES   1       2
PERLND 106                           0     RCHRES   1       2
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PERLND	107	75	RCHRES	1	2
PERLND	108	18	RCHRES	1	2
PERLND	109	1127	RCHRES	1	2
PERLND	110	7	RCHRES	1	2
PERLND	111	0	RCHRES	1	2
PERLND	112	49	RCHRES	1	2
PERLND	113	14	RCHRES	1	2
PERLND	114	181	RCHRES	1	2
PERLND	115	7	RCHRES	1	2
PERLND	116	10	RCHRES	1	2
IMPLND	101	26	RCHRES	1	1
IMPLND	102	42	RCHRES	1	1
IMPLND	103	4	RCHRES	1	1
IMPLND	104	0	RCHRES	1	1
PERLND	101	931	RCHRES	2	2
PERLND	102	385	RCHRES	2	2
PERLND	103	26	RCHRES	2	2
PERLND	104	2	RCHRES	2	2
PERLND	105	0	RCHRES	2	2
PERLND	106	6	RCHRES	2	2
PERLND	107	778	RCHRES	2	2
PERLND	108	919	RCHRES	2	2
PERLND	109	3425	RCHRES	2	2
PERLND	110	500	RCHRES	2	2
PERLND	111	1044	RCHRES	2	2
PERLND	112	743	RCHRES	2	2
PERLND	113	22	RCHRES	2	2
PERLND	114	3792	RCHRES	2	2
PERLND	115	608	RCHRES	2	2
PERLND	116	54	RCHRES	2	2
IMPLND	101	115	RCHRES	2	1
IMPLND	102	182	RCHRES	2	1
IMPLND	103	41	RCHRES	2	1
IMPLND	104	11	RCHRES	2	1
PERLND	101	27	RCHRES	3	2
PERLND	102	64	RCHRES	3	2
PERLND	103	4	RCHRES	3	2
PERLND	104	0	RCHRES	3	2
PERLND	105	0	RCHRES	3	2
PERLND	106	0	RCHRES	3	2
PERLND	107	87	RCHRES	3	2
PERLND	108	37	RCHRES	3	2
PERLND	109	421	RCHRES	3	2
PERLND	110	0	RCHRES	3	2
PERLND	111	26	RCHRES	3	2
PERLND	112	2	RCHRES	3	2
PERLND	113	0	RCHRES	3	2
PERLND	114	417	RCHRES	3	2
PERLND	115	10	RCHRES	3	2
PERLND	116	8	RCHRES	3	2
IMPLND	101	3	RCHRES	3	1
IMPLND	102	31	RCHRES	3	1
IMPLND	103	7	RCHRES	3	1
IMPLND	104	0	RCHRES	3	1
RCHRES	1		RCHRES	3	3
PERLND	101	242	RCHRES	4	2
PERLND	102	164	RCHRES	4	2
PERLND	103	6	RCHRES	4	2
PERLND	104	1	RCHRES	4	2
PERLND	105	0	RCHRES	4	2
PERLND	106	0	RCHRES	4	2
PERLND	107	0	RCHRES	4	2
PERLND	108	0	RCHRES	4	2

PERLND 109	277	RCHRES	4	2
PERLND 110	253	RCHRES	4	2
PERLND 111	22	RCHRES	4	2
PERLND 112	1	RCHRES	4	2
PERLND 113	0	RCHRES	4	2
PERLND 114	159	RCHRES	4	2
PERLND 115	14	RCHRES	4	2
PERLND 116	8	RCHRES	4	2
IMPLND 101	30	RCHRES	4	1
IMPLND 102	74	RCHRES	4	1
IMPLND 103	9	RCHRES	4	1
IMPLND 104	8	RCHRES	4	1
PERLND 101	283	RCHRES	6	2
PERLND 102	240	RCHRES	6	2
PERLND 103	24	RCHRES	6	2
PERLND 104	2	RCHRES	6	2
PERLND 105	0	RCHRES	6	2
PERLND 106	0	RCHRES	6	2
PERLND 107	30	RCHRES	6	2
PERLND 108	13	RCHRES	6	2
PERLND 109	75	RCHRES	6	2
PERLND 110	30	RCHRES	6	2
PERLND 111	8	RCHRES	6	2
PERLND 112	0	RCHRES	6	2
PERLND 113	0	RCHRES	6	2
PERLND 114	409	RCHRES	6	2
PERLND 115	0	RCHRES	6	2
PERLND 116	6	RCHRES	6	2
IMPLND 101	35	RCHRES	6	1
IMPLND 102	105	RCHRES	6	1
IMPLND 103	38	RCHRES	6	1
IMPLND 104	13	RCHRES	6	1
RCHRES 2		RCHRES	6	3
RCHRES 4		RCHRES	6	3
PERLND 101	274	RCHRES	5	2
PERLND 102	331	RCHRES	5	2
PERLND 103	36	RCHRES	5	2
PERLND 104	4	RCHRES	5	2
PERLND 105	3	RCHRES	5	2
PERLND 106	0	RCHRES	5	2
PERLND 107	5	RCHRES	5	2
PERLND 108	12	RCHRES	5	2
PERLND 109	501	RCHRES	5	2
PERLND 110	0	RCHRES	5	2
PERLND 111	1	RCHRES	5	2
PERLND 112	10	RCHRES	5	2
PERLND 113	37	RCHRES	5	2
PERLND 114	504	RCHRES	5	2
PERLND 115	30	RCHRES	5	2
PERLND 116	3	RCHRES	5	2
IMPLND 101	34	RCHRES	5	1
IMPLND 102	143	RCHRES	5	1
IMPLND 103	60	RCHRES	5	1
IMPLND 104	31	RCHRES	5	1
RCHRES 6		RCHRES	5	3
RCHRES 3		RCHRES	5	3
PERLND 101	216	RCHRES	7	2
PERLND 102	215	RCHRES	7	2
PERLND 103	32	RCHRES	7	2
PERLND 104	6	RCHRES	7	2
PERLND 105	0	RCHRES	7	2
PERLND 106	0	RCHRES	7	2
PERLND 107	10	RCHRES	7	2

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PERLND 108                            90     RCHRES   7       2
PERLND 109                            28     RCHRES   7       2
PERLND 110                             0     RCHRES   7       2
PERLND 111                            18     RCHRES   7       2
PERLND 112                             0     RCHRES   7       2
PERLND 113                            25     RCHRES   7       2
PERLND 114                           190     RCHRES   7       2
PERLND 115                             5     RCHRES   7       2
PERLND 116                             0     RCHRES   7       2
IMPLND 101                            27     RCHRES   7       1
IMPLND 102                            92     RCHRES   7       1
IMPLND 103                            52     RCHRES   7       1
IMPLND 104                            45     RCHRES   7       1
RCHRES   5                                   RCHRES   7       3
PERLND 101                           296     RCHRES   8       2
PERLND 102                           289     RCHRES   8       2
PERLND 103                            25     RCHRES   8       2
PERLND 104                             5     RCHRES   8       2
PERLND 105                             0     RCHRES   8       2
PERLND 106                             0     RCHRES   8       2
PERLND 107                            59     RCHRES   8       2
PERLND 108                            39     RCHRES   8       2
PERLND 109                           141     RCHRES   8       2
PERLND 110                             0     RCHRES   8       2
PERLND 111                            61     RCHRES   8       2
PERLND 112                             0     RCHRES   8       2
PERLND 113                             1     RCHRES   8       2
PERLND 114                            20     RCHRES   8       2
PERLND 115                             1     RCHRES   8       2
PERLND 116                             3     RCHRES   8       2
IMPLND 101                            37     RCHRES   8       1
IMPLND 102                           125     RCHRES   8       1
IMPLND 103                            40     RCHRES   8       1
IMPLND 104                            38     RCHRES   8       1
PERLND 101                           153     RCHRES   9       2
PERLND 102                           244     RCHRES   9       2
PERLND 103                            20     RCHRES   9       2
PERLND 104                             2     RCHRES   9       2
PERLND 105                             0     RCHRES   9       2
PERLND 106                            99     RCHRES   9       2
PERLND 107                             5     RCHRES   9       2
PERLND 108                            54     RCHRES   9       2
PERLND 109                           129     RCHRES   9       2
PERLND 110                             9     RCHRES   9       2
PERLND 111                            31     RCHRES   9       2
PERLND 112                             0     RCHRES   9       2
PERLND 113                             0     RCHRES   9       2
PERLND 114                            14     RCHRES   9       2
PERLND 115                             0     RCHRES   9       2
PERLND 116                             0     RCHRES   9       2
IMPLND 101                            19     RCHRES   9       1
IMPLND 102                           104     RCHRES   9       1
IMPLND 103                            33     RCHRES   9       1
IMPLND 104                            16     RCHRES   9       1
PERLND 101                           251     RCHRES  10       2
PERLND 102                           658     RCHRES  10       2
PERLND 103                            90     RCHRES  10       2
PERLND 104                            25     RCHRES  10       2
PERLND 105                             0     RCHRES  10       2
PERLND 106                            20     RCHRES  10       2
PERLND 107                            48     RCHRES  10       2
PERLND 108                            27     RCHRES  10       2
PERLND 109                            26     RCHRES  10       2
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PERLND 110                         0     RCHRES  10       2
PERLND 111                        30     RCHRES  10       2
PERLND 112                         1     RCHRES  10       2
PERLND 113                       133     RCHRES  10       2
PERLND 114                       209     RCHRES  10       2
PERLND 115                        37     RCHRES  10       2
PERLND 116                         1     RCHRES  10       2
IMPLND 101                        31     RCHRES  10       1
IMPLND 102                       282     RCHRES  10       1
IMPLND 103                       148     RCHRES  10       1
IMPLND 104                       200     RCHRES  10       1
RCHRES   7                               RCHRES  10       3
RCHRES   8                               RCHRES  10       3
PERLND 101                       225     RCHRES  11       2
PERLND 102                       155     RCHRES  11       2
PERLND 103                        20     RCHRES  11       2
PERLND 104                         4     RCHRES  11       2
PERLND 105                         1     RCHRES  11       2
PERLND 106                        24     RCHRES  11       2
PERLND 107                       119     RCHRES  11       2
PERLND 108                       148     RCHRES  11       2
PERLND 109                       384     RCHRES  11       2
PERLND 110                         0     RCHRES  11       2
PERLND 111                       152     RCHRES  11       2
PERLND 112                        11     RCHRES  11       2
PERLND 113                         1     RCHRES  11       2
PERLND 114                        41     RCHRES  11       2
PERLND 115                        45     RCHRES  11       2
PERLND 116                         2     RCHRES  11       2
IMPLND 101                        28     RCHRES  11       1
IMPLND 102                        67     RCHRES  11       1
IMPLND 103                        33     RCHRES  11       1
IMPLND 104                        30     RCHRES  11       1
PERLND 101                        76     RCHRES  12       2
PERLND 102                       188     RCHRES  12       2
PERLND 103                        50     RCHRES  12       2
PERLND 104                         8     RCHRES  12       2
PERLND 105                         1     RCHRES  12       2
PERLND 106                         0     RCHRES  12       2
PERLND 107                        20     RCHRES  12       2
PERLND 108                        15     RCHRES  12       2
PERLND 109                         8     RCHRES  12       2
PERLND 110                        27     RCHRES  12       2
PERLND 111                         6     RCHRES  12       2
PERLND 112                         6     RCHRES  12       2
PERLND 113                       205     RCHRES  12       2
PERLND 114                        16     RCHRES  12       2
PERLND 115                       739     RCHRES  12       2
PERLND 116                         0     RCHRES  12       2
IMPLND 101                         9     RCHRES  12       1
IMPLND 102                        81     RCHRES  12       1
IMPLND 103                        81     RCHRES  12       1
IMPLND 104                        65     RCHRES  12       1
RCHRES  10                               RCHRES  12       3
RCHRES  11                               RCHRES  12       3
RCHRES   9                               RCHRES  12       3
***Sum the loads from all land segments in subbasin 1
PERLND 101                       212     COPY     1       4
PERLND 102                        87     COPY     1       4
PERLND 103                         2     COPY     1       4
PERLND 104                         0     COPY     1       4
PERLND 105                         3     COPY     1       4
PERLND 106                         0     COPY     1       4
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PERLND 107                     75     COPY     1      4
PERLND 108                     18     COPY     1      4
PERLND 109                   1127     COPY     1      4
PERLND 110                      7     COPY     1      4
PERLND 111                      0     COPY     1      4
PERLND 112                     49     COPY     1      4
PERLND 113                     14     COPY     1      4
PERLND 114                    181     COPY     1      4
PERLND 115                      7     COPY     1      4
PERLND 116                     10     COPY     1      4
IMPLND 101                     26     COPY     1      5
IMPLND 102                     42     COPY     1      5
IMPLND 103                      4     COPY     1      5
IMPLND 104                      0     COPY     1      5
***Sum the loads from all land segments in subbasin 2
PERLND 101                    931     COPY     2      4
PERLND 102                    385     COPY     2      4
PERLND 103                     26     COPY     2      4
PERLND 104                      2     COPY     2      4
PERLND 105                      0     COPY     2      4
PERLND 106                      6     COPY     2      4
PERLND 107                    778     COPY     2      4
PERLND 108                    919     COPY     2      4
PERLND 109                   3425     COPY     2      4
PERLND 110                    500     COPY     2      4
PERLND 111                   1044     COPY     2      4
PERLND 112                    743     COPY     2      4
PERLND 113                     22     COPY     2      4
PERLND 114                   3792     COPY     2      4
PERLND 115                    608     COPY     2      4
PERLND 116                     54     COPY     2      4
IMPLND 101                    115     COPY     2      5
IMPLND 102                    182     COPY     2      5
IMPLND 103                     41     COPY     2      5
IMPLND 104                     11     COPY     2      5
***Sum the loads from all land segments in subbasin 3
PERLND 101                     27     COPY     3      4
PERLND 102                     64     COPY     3      4
PERLND 103                      4     COPY     3      4
PERLND 104                      0     COPY     3      4
PERLND 105                      0     COPY     3      4
PERLND 106                      0     COPY     3      4
PERLND 107                     87     COPY     3      4
PERLND 108                     37     COPY     3      4
PERLND 109                    421     COPY     3      4
PERLND 110                      0     COPY     3      4
PERLND 111                     26     COPY     3      4
PERLND 112                      2     COPY     3      4
PERLND 113                      0     COPY     3      4
PERLND 114                    417     COPY     3      4
PERLND 115                     10     COPY     3      4
PERLND 116                      8     COPY     3      4
IMPLND 101                      3     COPY     3      5
IMPLND 102                     31     COPY     3      5
IMPLND 103                      7     COPY     3      5
IMPLND 104                      0     COPY     3      5
***Sum the loads from all land segments in subbasin 4
PERLND 101                    242     COPY     4      4
PERLND 102                    164     COPY     4      4
PERLND 103                      6     COPY     4      4
PERLND 104                      1     COPY     4      4
PERLND 105                      0     COPY     4      4
PERLND 106                      0     COPY     4      4
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PERLND 107                     0     COPY     4       4
PERLND 108                     0     COPY     4       4
PERLND 109                   277     COPY     4       4
PERLND 110                   253     COPY     4       4
PERLND 111                    22     COPY     4       4
PERLND 112                     1     COPY     4       4
PERLND 113                     0     COPY     4       4
PERLND 114                   159     COPY     4       4
PERLND 115                    14     COPY     4       4
PERLND 116                     8     COPY     4       4
IMPLND 101                    30     COPY     4       5
IMPLND 102                    74     COPY     4       5
IMPLND 103                     9     COPY     4       5
IMPLND 104                     8     COPY     4       5
***Sum the loads from all land segments in subbasin 5
PERLND 101                   274     COPY     5       4
PERLND 102                   331     COPY     5       4
PERLND 103                    36     COPY     5       4
PERLND 104                     4     COPY     5       4
PERLND 105                     3     COPY     5       4
PERLND 106                     0     COPY     5       4
PERLND 107                     5     COPY     5       4
PERLND 108                    12     COPY     5       4
PERLND 109                   501     COPY     5       4
PERLND 110                     0     COPY     5       4
PERLND 111                     1     COPY     5       4
PERLND 112                    10     COPY     5       4
PERLND 113                    37     COPY     5       4
PERLND 114                   504     COPY     5       4
PERLND 115                    30     COPY     5       4
PERLND 116                     3     COPY     5       4
IMPLND 101                    34     COPY     5       5
IMPLND 102                   143     COPY     5       5
IMPLND 103                    60     COPY     5       5
IMPLND 104                    31     COPY     5       5
***Sum the loads from all land segments in subbasin 6
PERLND 101                   283     COPY     6       4
PERLND 102                   240     COPY     6       4
PERLND 103                    24     COPY     6       4
PERLND 104                     2     COPY     6       4
PERLND 105                     0     COPY     6       4
PERLND 106                     0     COPY     6       4
PERLND 107                    30     COPY     6       4
PERLND 108                    13     COPY     6       4
PERLND 109                    75     COPY     6       4
PERLND 110                    30     COPY     6       4
PERLND 111                     8     COPY     6       4
PERLND 112                     0     COPY     6       4
PERLND 113                     0     COPY     6       4
PERLND 114                   409     COPY     6       4
PERLND 115                     0     COPY     6       4
PERLND 116                     6     COPY     6       4
IMPLND 101                    35     COPY     6       5
IMPLND 102                   105     COPY     6       5
IMPLND 103                    38     COPY     6       5
IMPLND 104                    13     COPY     6       5
***Sum the loads from all land segments in subbasin 7
PERLND 101                   216     COPY     7       4
PERLND 102                   215     COPY     7       4
PERLND 103                    32     COPY     7       4
PERLND 104                     6     COPY     7       4
PERLND 105                     0     COPY     7       4
PERLND 106                     0     COPY     7       4
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PERLND 107                        10     COPY     7      4
PERLND 108                        90     COPY     7      4
PERLND 109                        28     COPY     7      4
PERLND 110                         0     COPY     7      4
PERLND 111                        18     COPY     7      4
PERLND 112                         0     COPY     7      4
PERLND 113                        25     COPY     7      4
PERLND 114                       190     COPY     7      4
PERLND 115                         5     COPY     7      4
PERLND 116                         0     COPY     7      4
IMPLND 101                        27     COPY     7      5
IMPLND 102                        92     COPY     7      5
IMPLND 103                        52     COPY     7      5
IMPLND 104                        45     COPY     7      5
***Sum the loads from all land segments in subbasin 8
PERLND 101                       296     COPY     8      4
PERLND 102                       289     COPY     8      4
PERLND 103                        25     COPY     8      4
PERLND 104                         5     COPY     8      4
PERLND 105                         0     COPY     8      4
PERLND 106                         0     COPY     8      4
PERLND 107                        59     COPY     8      4
PERLND 108                        39     COPY     8      4
PERLND 109                       141     COPY     8      4
PERLND 110                         0     COPY     8      4
PERLND 111                        61     COPY     8      4
PERLND 112                         0     COPY     8      4
PERLND 113                         1     COPY     8      4
PERLND 114                        20     COPY     8      4
PERLND 115                         1     COPY     8      4
PERLND 116                         3     COPY     8      4
IMPLND 101                        37     COPY     8      5
IMPLND 102                       125     COPY     8      5
IMPLND 103                        40     COPY     8      5
IMPLND 104                        38     COPY     8      5
***Sum the loads from all land segments in subbasin 9
PERLND 101                       153     COPY     9      4
PERLND 102                       244     COPY     9      4
PERLND 103                        20     COPY     9      4
PERLND 104                         2     COPY     9      4
PERLND 105                         0     COPY     9      4
PERLND 106                        99     COPY     9      4
PERLND 107                         5     COPY     9      4
PERLND 108                        54     COPY     9      4
PERLND 109                       129     COPY     9      4
PERLND 110                         9     COPY     9      4
PERLND 111                        31     COPY     9      4
PERLND 112                         0     COPY     9      4
PERLND 113                         0     COPY     9      4
PERLND 114                        14     COPY     9      4
PERLND 115                         0     COPY     9      4
PERLND 116                         0     COPY     9      4
IMPLND 101                        19     COPY     9      5
IMPLND 102                       104     COPY     9      5
IMPLND 103                        33     COPY     9      5
IMPLND 104                        16     COPY     9      5
***Sum the loads from all land segments in subbasin 10
PERLND 101                       251     COPY    10      4
PERLND 102                       658     COPY    10      4
PERLND 103                        90     COPY    10      4
PERLND 104                        25     COPY    10      4
PERLND 105                         0     COPY    10      4
PERLND 106                        20     COPY    10      4
```

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PERLND 107                        48     COPY    10       4
PERLND 108                        27     COPY    10       4
PERLND 109                        26     COPY    10       4
PERLND 110                         0     COPY    10       4
PERLND 111                        30     COPY    10       4
PERLND 112                         1     COPY    10       4
PERLND 113                       133     COPY    10       4
PERLND 114                       209     COPY    10       4
PERLND 115                        37     COPY    10       4
PERLND 116                         1     COPY    10       4
IMPLND 101                        31     COPY    10       5
IMPLND 102                       282     COPY    10       5
IMPLND 103                       148     COPY    10       5
IMPLND 104                       200     COPY    10       5
***Sum the loads from all land segments in subbasin 11
PERLND 101                       225     COPY    11       4
PERLND 102                       155     COPY    11       4
PERLND 103                        20     COPY    11       4
PERLND 104                         4     COPY    11       4
PERLND 105                         1     COPY    11       4
PERLND 106                        24     COPY    11       4
PERLND 107                       119     COPY    11       4
PERLND 108                       148     COPY    11       4
PERLND 109                       384     COPY    11       4
PERLND 110                         0     COPY    11       4
PERLND 111                       152     COPY    11       4
PERLND 112                        11     COPY    11       4
PERLND 113                         1     COPY    11       4
PERLND 114                        41     COPY    11       4
PERLND 115                        45     COPY    11       4
PERLND 116                         2     COPY    11       4
IMPLND 101                        28     COPY    11       5
IMPLND 102                        67     COPY    11       5
IMPLND 103                        33     COPY    11       5
IMPLND 104                        30     COPY    11       5
***Sum the loads from all land segments in subbasin 12
PERLND 101                        76     COPY    12       4
PERLND 102                       188     COPY    12       4
PERLND 103                        50     COPY    12       4
PERLND 104                         8     COPY    12       4
PERLND 105                         1     COPY    12       4
PERLND 106                         0     COPY    12       4
PERLND 107                        20     COPY    12       4
PERLND 108                        15     COPY    12       4
PERLND 109                         8     COPY    12       4
PERLND 110                        27     COPY    12       4
PERLND 111                         6     COPY    12       4
PERLND 112                         6     COPY    12       4
PERLND 113                       205     COPY    12       4
PERLND 114                        16     COPY    12       4
PERLND 115                       739     COPY    12       4
PERLND 116                         0     COPY    12       4
IMPLND 101                         9     COPY    12       5
IMPLND 102                        81     COPY    12       5
IMPLND 103                        81     COPY    12       5
IMPLND 104                        65     COPY    12       5
END SCHEMATIC

EXT TARGETS
<-Volume-> <-Grp> <-Member-><--Mult-->Tran <-Volume-> <Member> Tsys Aggr Amd ***
<Name>   x        <Name> x x<-factor->strg <Name>   x <Name>qf  tem strg strg***
*** INSTREAM CONCENTRATIONS in mg/L except CHLA(ug/L), TEMP(deg F), Flow(cfs)
RCHRES   1 HYDR   RO     1 1          AVER WDM1  2001 RO     1 METR AGGR REPL
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RCHRES   1 OXRX   DOX    1 1          AVER WDM1  3001 DO     1 ENGL AGGR REPL
RCHRES   1 OXRX   DOX    1 1          MIN  WDM1  4001 DO     1 ENGL AGGR REPL
RCHRES   1 SEDTRN SSED   1 1          AVER WDM1  1505 SAND   1 ENGL AGGR REPL
RCHRES   1 SEDTRN SSED   2 1          AVER WDM1  1506 SILT   1 ENGL AGGR REPL
RCHRES   1 SEDTRN SSED   3 1          AVER WDM1  1507 CLAY   1 ENGL AGGR REPL
RCHRES   1 OXRX   BOD    1 1          AVER WDM1  1404 BOD    1 ENGL AGGR REPL
RCHRES   1 NUTRX  DNUST  1 1          AVER WDM1  1401 DNO3   1 ENGL AGGR REPL
RCHRES   1 NUTRX  DNUST  2 1          AVER WDM1  1402 DNH3   1 ENGL AGGR REPL
RCHRES   1 NUTRX  DNUST  4 1          AVER WDM1  1403 DPO4   1 ENGL AGGR REPL
RCHRES   1 PLANK  PHYCLA 1 1          AVER WDM1  1406 CHLA   1 ENGL AGGR REPL
RCHRES   1 PLANK  PKST3  4 1          AVER WDM1  1407 ORGN   1 ENGL AGGR REPL
RCHRES   1 PLANK  PKST3  5 1          AVER WDM1  1408 ORGP   1 ENGL AGGR REPL
RCHRES   1 PLANK  PKST3  1 1          AVER WDM1  1601 DETN   1 ENGL AGGR REPL
RCHRES   1 PLANK  PKST3  2 1          AVER WDM1  1602 DETP   1 ENGL AGGR REPL
RCHRES   1 PLANK  PKST3  3 1          AVER WDM1  1603 DETC   1 ENGL AGGR REPL
RCHRES   1 SEDTRN SSED   4 1          AVER WDM1  1021 TSS    1 ENGL AGGR REPL
RCHRES   2 HYDR   RO     1 1          AVER WDM1  2002 RO     1 METR AGGR REPL
RCHRES   2 OXRX   DOX    1 1          AVER WDM1  3002 DO     1 ENGL AGGR REPL
RCHRES   2 OXRX   DOX    1 1          MIN  WDM1  4002 DO     1 ENGL AGGR REPL
RCHRES   2 SEDTRN SSED   1 1          AVER WDM1  1508 SAND   1 ENGL AGGR REPL
RCHRES   2 SEDTRN SSED   2 1          AVER WDM1  1509 SILT   1 ENGL AGGR REPL
RCHRES   2 SEDTRN SSED   3 1          AVER WDM1  1510 CLAY   1 ENGL AGGR REPL
RCHRES   2 OXRX   BOD    1 1          AVER WDM1  1414 BOD    1 ENGL AGGR REPL
RCHRES   2 NUTRX  DNUST  1 1          AVER WDM1  1411 DNO3   1 ENGL AGGR REPL
RCHRES   2 NUTRX  DNUST  2 1          AVER WDM1  1412 DNH3   1 ENGL AGGR REPL
RCHRES   2 NUTRX  DNUST  4 1          AVER WDM1  1413 DPO4   1 ENGL AGGR REPL
RCHRES   2 PLANK  PHYCLA 1 1          AVER WDM1  1416 CHLA   1 ENGL AGGR REPL
RCHRES   2 PLANK  PKST3  4 1          AVER WDM1  1417 ORGN   1 ENGL AGGR REPL
RCHRES   2 PLANK  PKST3  5 1          AVER WDM1  1418 ORGP   1 ENGL AGGR REPL
RCHRES   2 PLANK  PKST3  1 1          AVER WDM1  1604 DETN   1 ENGL AGGR REPL
RCHRES   2 PLANK  PKST3  2 1          AVER WDM1  1605 DETP   1 ENGL AGGR REPL
RCHRES   2 PLANK  PKST3  3 1          AVER WDM1  1606 DETC   1 ENGL AGGR REPL
RCHRES   2 SEDTRN SSED   4 1          AVER WDM1  1045 TSS    1 ENGL AGGR REPL
RCHRES   3 HYDR   RO     1 1          AVER WDM1  2003 RO     1 METR AGGR REPL
RCHRES   3 OXRX   DOX    1 1          AVER WDM1  3003 DO     1 ENGL AGGR REPL
RCHRES   3 OXRX   DOX    1 1          MIN  WDM1  4003 DO     1 ENGL AGGR REPL
RCHRES   4 HYDR   RO     1 1          AVER WDM1  2004 RO     1 METR AGGR REPL
RCHRES   4 OXRX   DOX    1 1          AVER WDM1  3004 DO     1 ENGL AGGR REPL
RCHRES   4 OXRX   DOX    1 1          MIN  WDM1  4004 DO     1 ENGL AGGR REPL
RCHRES   6 HYDR   RO     1 1          AVER WDM1  2006 RO     1 METR AGGR REPL
RCHRES   6 OXRX   DOX    1 1          AVER WDM1  3006 DO     1 ENGL AGGR REPL
RCHRES   6 OXRX   DOX    1 1          MIN  WDM1  4006 DO     1 ENGL AGGR REPL
RCHRES   5 HYDR   RO     1 1          AVER WDM1  2005 RO     1 METR AGGR REPL
RCHRES   5 OXRX   DOX    1 1          AVER WDM1  3005 DO     1 ENGL AGGR REPL
RCHRES   5 OXRX   DOX    1 1          MIN  WDM1  4005 DO     1 ENGL AGGR REPL
RCHRES   7 HYDR   RO     1 1          AVER WDM1  2007 RO     1 METR AGGR REPL
RCHRES   7 OXRX   DOX    1 1          AVER WDM1  3007 DO     1 ENGL AGGR REPL
RCHRES   7 OXRX   DOX    1 1          MIN  WDM1  4007 DO     1 ENGL AGGR REPL
RCHRES   8 HYDR   RO     1 1          AVER WDM1  2008 RO     1 METR AGGR REPL
RCHRES   8 OXRX   DOX    1 1          AVER WDM1  3008 DO     1 ENGL AGGR REPL
RCHRES   8 OXRX   DOX    1 1          MIN  WDM1  4008 DO     1 ENGL AGGR REPL
RCHRES   8 SEDTRN SSED   1 1          AVER WDM1  1511 SAND   1 ENGL AGGR REPL
RCHRES   8 SEDTRN SSED   2 1          AVER WDM1  1512 SILT   1 ENGL AGGR REPL
RCHRES   8 SEDTRN SSED   3 1          AVER WDM1  1513 CLAY   1 ENGL AGGR REPL
RCHRES   8 OXRX   BOD    1 1          AVER WDM1  1212 BOD    1 ENGL AGGR REPL
RCHRES   8 NUTRX  DNUST  1 1          AVER WDM1  1209 DNO3   1 ENGL AGGR REPL
RCHRES   8 NUTRX  DNUST  2 1          AVER WDM1  1210 DNH3   1 ENGL AGGR REPL
RCHRES   8 NUTRX  DNUST  4 1          AVER WDM1  1211 DPO4   1 ENGL AGGR REPL
RCHRES   8 PLANK  PHYCLA 1 1          AVER WDM1  1215 CHLA   1 ENGL AGGR REPL
RCHRES   8 PLANK  PKST3  4 1          AVER WDM1  1236 ORGN   1 ENGL AGGR REPL
RCHRES   8 PLANK  PKST3  5 1          AVER WDM1  1101 ORGP   1 ENGL AGGR REPL
RCHRES   8 PLANK  PKST3  1 1          AVER WDM1  1607 DETN   1 ENGL AGGR REPL
RCHRES   8 PLANK  PKST3  2 1          AVER WDM1  1608 DETP   1 ENGL AGGR REPL
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RCHRES   8 PLANK  PKST3  3 1          AVER WDM1  1609 DETC    1 ENGL AGGR REPL
RCHRES   8 SEDTRN SSED   4 1          AVER WDM1  1093 TSS     1 ENGL AGGR REPL
RCHRES   9 HYDR   RO     1 1          AVER WDM1  2009 RO      1 METR AGGR REPL
RCHRES   9 OXRX   DOX    1 1          AVER WDM1  3009 DO      1 ENGL AGGR REPL
RCHRES   9 OXRX   DOX    1 1          MIN  WDM1  4009 DO      1 ENGL AGGR REPL
RCHRES   9 SEDTRN SSED   1 1          AVER WDM1  1514 SAND    1 ENGL AGGR REPL
RCHRES   9 SEDTRN SSED   2 1          AVER WDM1  1515 SILT    1 ENGL AGGR REPL
RCHRES   9 SEDTRN SSED   3 1          AVER WDM1  1516 CLAY    1 ENGL AGGR REPL
RCHRES   9 OXRX   BOD    1 1          AVER WDM1  1448 BOD     1 ENGL AGGR REPL
RCHRES   9 NUTRX  DNUST  1 1          AVER WDM1  1445 DNO3    1 ENGL AGGR REPL
RCHRES   9 NUTRX  DNUST  2 1          AVER WDM1  1446 DNH3    1 ENGL AGGR REPL
RCHRES   9 NUTRX  DNUST  4 1          AVER WDM1  1447 DPO4    1 ENGL AGGR REPL
RCHRES   9 PLANK  PHYCLA 1 1          AVER WDM1  1450 CHLA    1 ENGL AGGR REPL
RCHRES   9 PLANK  PKST3  4 1          AVER WDM1  1451 ORGN    1 ENGL AGGR REPL
RCHRES   9 PLANK  PKST3  5 1          AVER WDM1  1452 ORGP    1 ENGL AGGR REPL
RCHRES   9 PLANK  PKST3  1 1          AVER WDM1  1610 DETN    1 ENGL AGGR REPL
RCHRES   9 PLANK  PKST3  2 1          AVER WDM1  1611 DETP    1 ENGL AGGR REPL
RCHRES   9 PLANK  PKST3  3 1          AVER WDM1  1612 DETC    1 ENGL AGGR REPL
RCHRES   9 SEDTRN SSED   4 1          AVER WDM1  1117 TSS     1 ENGL AGGR REPL
RCHRES  10 HYDR   RO     1 1          AVER WDM1  2010 RO      1 METR AGGR REPL
RCHRES  10 OXRX   DOX    1 1          AVER WDM1  3010 DO      1 ENGL AGGR REPL
RCHRES  10 OXRX   DOX    1 1          MIN  WDM1  4010 DO      1 ENGL AGGR REPL
RCHRES  10 HTRCH  TW     1 1          AVER WDM1  1296 TW      1 METR AGGR REPL
RCHRES  11 HYDR   RO     1 1          AVER WDM1  2011 RO      1 METR AGGR REPL
RCHRES  11 OXRX   DOX    1 1          AVER WDM1  3011 DO      1 ENGL AGGR REPL
RCHRES  11 OXRX   DOX    1 1          MIN  WDM1  4011 DO      1 ENGL AGGR REPL
RCHRES  11 SEDTRN SSED   1 1          AVER WDM1  1517 SAND    1 ENGL AGGR REPL
RCHRES  11 SEDTRN SSED   2 1          AVER WDM1  1518 SILT    1 ENGL AGGR REPL
RCHRES  11 SEDTRN SSED   3 1          AVER WDM1  1519 CLAY    1 ENGL AGGR REPL
RCHRES  11 OXRX   BOD    1 1          AVER WDM1  1240 BOD     1 ENGL AGGR REPL
RCHRES  11 NUTRX  DNUST  1 1          AVER WDM1  1217 DNO3    1 ENGL AGGR REPL
RCHRES  11 NUTRX  DNUST  2 1          AVER WDM1  1218 DNH3    1 ENGL AGGR REPL
RCHRES  11 NUTRX  DNUST  4 1          AVER WDM1  1219 DPO4    1 ENGL AGGR REPL
RCHRES  11 PLANK  PHYCLA 1 1          AVER WDM1  1249 CHLA    1 ENGL AGGR REPL
RCHRES  11 PLANK  PKST3  4 1          AVER WDM1  1237 ORGN    1 ENGL AGGR REPL
RCHRES  11 PLANK  PKST3  5 1          AVER WDM1  1102 ORGP    1 ENGL AGGR REPL
RCHRES  11 PLANK  PKST3  1 1          AVER WDM1  1613 DETN    1 ENGL AGGR REPL
RCHRES  11 PLANK  PKST3  2 1          AVER WDM1  1614 DETP    1 ENGL AGGR REPL
RCHRES  11 PLANK  PKST3  3 1          AVER WDM1  1615 DETC    1 ENGL AGGR REPL
RCHRES  11 SEDTRN SSED   4 1          AVER WDM1  1141 TSS     1 ENGL AGGR REPL
RCHRES  12 HYDR   RO     1 1          AVER WDM1  2012 RO      1 METR AGGR REPL
RCHRES  12 OXRX   DOX    1 1          AVER WDM1  3012 DO      1 ENGL AGGR REPL
RCHRES  12 OXRX   DOX    1 1          MIN  WDM1  4012 DO      1 ENGL AGGR REPL
*** In the following COPY statements
*** multiplier of 1.008 converts from ac*in/hr to cfs
*** MULTIPLIER OF 907 CONVERTS FROM TONS TO KG
*** multiplier of 0.454 CONVERTS FROM LBS TO KG
*** output flows and loads from sub-basin 1
COPY     1 OUTPUT MEAN   1 1   0.02855     WDM1  9006 PERO    1 METR AGGR REPL
COPY     1 OUTPUT MEAN   2 1       907     WDM1  9000 TSS     1 ENGL AGGR REPL
COPY     1 OUTPUT MEAN   3 1     0.454     WDM1  9002 NH3N    1 ENGL AGGR REPL
COPY     1 OUTPUT MEAN   4 1     0.454     WDM1  9003 NO3N    1 ENGL AGGR REPL
COPY     1 OUTPUT MEAN   5 1     0.454     WDM1  9004 PO4P    1 ENGL AGGR REPL
COPY     1 OUTPUT MEAN   6 1     0.454     WDM1  9005 BOD     1 ENGL AGGR REPL
COPY     1 OUTPUT MEAN   7 1     0.454     WDM1  9001 DO      1 ENGL AGGR REPL
***output flows and loads from sub-basin 2
COPY     2 OUTPUT MEAN   1 1   0.02855     WDM1  9016 PERO    1 METR AGGR REPL
COPY     2 OUTPUT MEAN   2 1       907     WDM1  9010 TSS     1 ENGL AGGR REPL
COPY     2 OUTPUT MEAN   3 1     0.454     WDM1  9012 NH3N    1 ENGL AGGR REPL
COPY     2 OUTPUT MEAN   4 1     0.454     WDM1  9013 NO3N    1 ENGL AGGR REPL
COPY     2 OUTPUT MEAN   5 1     0.454     WDM1  9014 PO4P    1 ENGL AGGR REPL
COPY     2 OUTPUT MEAN   6 1     0.454     WDM1  9015 BOD     1 ENGL AGGR REPL
COPY     2 OUTPUT MEAN   7 1     0.454     WDM1  9011 DO      1 ENGL AGGR REPL
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***output flows and loads from sub-basin 3
COPY      3 OUTPUT MEAN   1 1   0.02855     WDM1  9026 PERO   1 METR AGGR REPL
COPY      3 OUTPUT MEAN   2 1       907     WDM1  9020 TSS    1 ENGL AGGR REPL
COPY      3 OUTPUT MEAN   3 1     0.454     WDM1  9022 NH3N   1 ENGL AGGR REPL
COPY      3 OUTPUT MEAN   4 1     0.454     WDM1  9023 NO3N   1 ENGL AGGR REPL
COPY      3 OUTPUT MEAN   5 1     0.454     WDM1  9024 PO4P   1 ENGL AGGR REPL
COPY      3 OUTPUT MEAN   6 1     0.454     WDM1  9025 BOD    1 ENGL AGGR REPL
COPY      3 OUTPUT MEAN   7 1     0.454     WDM1  9021 DO     1 ENGL AGGR REPL
***output flows and loads from sub-basin 4
COPY      4 OUTPUT MEAN   1 1   0.02855     WDM1  9036 PERO   1 METR AGGR REPL
COPY      4 OUTPUT MEAN   2 1       907     WDM1  9030 TSS    1 ENGL AGGR REPL
COPY      4 OUTPUT MEAN   3 1     0.454     WDM1  9032 NH3N   1 ENGL AGGR REPL
COPY      4 OUTPUT MEAN   4 1     0.454     WDM1  9033 NO3N   1 ENGL AGGR REPL
COPY      4 OUTPUT MEAN   5 1     0.454     WDM1  9034 PO4P   1 ENGL AGGR REPL
COPY      4 OUTPUT MEAN   6 1     0.454     WDM1  9035 BOD    1 ENGL AGGR REPL
COPY      4 OUTPUT MEAN   7 1     0.454     WDM1  9031 DO     1 ENGL AGGR REPL
***output flows and loads from sub-basin 5
COPY      5 OUTPUT MEAN   1 1   0.02855     WDM1  9046 PERO   1 METR AGGR REPL
COPY      5 OUTPUT MEAN   2 1       907     WDM1  9040 TSS    1 ENGL AGGR REPL
COPY      5 OUTPUT MEAN   3 1     0.454     WDM1  9042 NH3N   1 ENGL AGGR REPL
COPY      5 OUTPUT MEAN   4 1     0.454     WDM1  9043 NO3N   1 ENGL AGGR REPL
COPY      5 OUTPUT MEAN   5 1     0.454     WDM1  9044 PO4P   1 ENGL AGGR REPL
COPY      5 OUTPUT MEAN   6 1     0.454     WDM1  9045 BOD    1 ENGL AGGR REPL
COPY      5 OUTPUT MEAN   7 1     0.454     WDM1  9041 DO     1 ENGL AGGR REPL
***output flows and loads from sub-basin 6
COPY      6 OUTPUT MEAN   1 1   0.02855     WDM1  9056 PERO   1 METR AGGR REPL
COPY      6 OUTPUT MEAN   2 1       907     WDM1  9050 TSS    1 ENGL AGGR REPL
COPY      6 OUTPUT MEAN   3 1     0.454     WDM1  9052 NH3N   1 ENGL AGGR REPL
COPY      6 OUTPUT MEAN   4 1     0.454     WDM1  9053 NO3N   1 ENGL AGGR REPL
COPY      6 OUTPUT MEAN   5 1     0.454     WDM1  9054 PO4P   1 ENGL AGGR REPL
COPY      6 OUTPUT MEAN   6 1     0.454     WDM1  9055 BOD    1 ENGL AGGR REPL
COPY      6 OUTPUT MEAN   7 1     0.454     WDM1  9051 DO     1 ENGL AGGR REPL
***output flows and loads from sub-basin 7
COPY      7 OUTPUT MEAN   1 1   0.02855     WDM1  9066 PERO   1 METR AGGR REPL
COPY      7 OUTPUT MEAN   2 1       907     WDM1  9060 TSS    1 ENGL AGGR REPL
COPY      7 OUTPUT MEAN   3 1     0.454     WDM1  9062 NH3N   1 ENGL AGGR REPL
COPY      7 OUTPUT MEAN   4 1     0.454     WDM1  9063 NO3N   1 ENGL AGGR REPL
COPY      7 OUTPUT MEAN   5 1     0.454     WDM1  9064 PO4P   1 ENGL AGGR REPL
COPY      7 OUTPUT MEAN   6 1     0.454     WDM1  9065 BOD    1 ENGL AGGR REPL
COPY      7 OUTPUT MEAN   7 1     0.454     WDM1  9061 DO     1 ENGL AGGR REPL
***output flows and loads from sub-basin 8
COPY      8 OUTPUT MEAN   1 1   0.02855     WDM1  9076 PERO   1 METR AGGR REPL
COPY      8 OUTPUT MEAN   2 1       907     WDM1  9070 TSS    1 ENGL AGGR REPL
COPY      8 OUTPUT MEAN   3 1     0.454     WDM1  9072 NH3N   1 ENGL AGGR REPL
COPY      8 OUTPUT MEAN   4 1     0.454     WDM1  9073 NO3N   1 ENGL AGGR REPL
COPY      8 OUTPUT MEAN   5 1     0.454     WDM1  9074 PO4P   1 ENGL AGGR REPL
COPY      8 OUTPUT MEAN   6 1     0.454     WDM1  9075 BOD    1 ENGL AGGR REPL
COPY      8 OUTPUT MEAN   7 1     0.454     WDM1  9071 DO     1 ENGL AGGR REPL
***output flows and loads from sub-basin 9
COPY      9 OUTPUT MEAN   1 1   0.02855     WDM1  9086 PERO   1 METR AGGR REPL
COPY      9 OUTPUT MEAN   2 1       907     WDM1  9080 TSS    1 ENGL AGGR REPL
COPY      9 OUTPUT MEAN   3 1     0.454     WDM1  9082 NH3N   1 ENGL AGGR REPL
COPY      9 OUTPUT MEAN   4 1     0.454     WDM1  9083 NO3N   1 ENGL AGGR REPL
COPY      9 OUTPUT MEAN   5 1     0.454     WDM1  9084 PO4P   1 ENGL AGGR REPL
COPY      9 OUTPUT MEAN   6 1     0.454     WDM1  9085 BOD    1 ENGL AGGR REPL
COPY      9 OUTPUT MEAN   7 1     0.454     WDM1  9081 DO     1 ENGL AGGR REPL
***output flows and loads from sub-basin 10
COPY     10 OUTPUT MEAN   1 1   0.02855     WDM1  9096 PERO   1 METR AGGR REPL
COPY     10 OUTPUT MEAN   2 1       907     WDM1  9090 TSS    1 ENGL AGGR REPL
COPY     10 OUTPUT MEAN   3 1     0.454     WDM1  9092 NH3N   1 ENGL AGGR REPL
COPY     10 OUTPUT MEAN   4 1     0.454     WDM1  9093 NO3N   1 ENGL AGGR REPL
COPY     10 OUTPUT MEAN   5 1     0.454     WDM1  9094 PO4P   1 ENGL AGGR REPL
COPY     10 OUTPUT MEAN   6 1     0.454     WDM1  9095 BOD    1 ENGL AGGR REPL
```

```
COPY    10 OUTPUT MEAN   7 1     0.454     WDM1  9091 DO     1 ENGL AGGR REPL
***output flows and loads from sub-basin 11
COPY    11 OUTPUT MEAN   1 1   0.02855     WDM1  9106 PERO   1 METR AGGR REPL
COPY    11 OUTPUT MEAN   2 1       907     WDM1  9100 TSS    1 ENGL AGGR REPL
COPY    11 OUTPUT MEAN   3 1     0.454     WDM1  9102 NH3N   1 ENGL AGGR REPL
COPY    11 OUTPUT MEAN   4 1     0.454     WDM1  9103 NO3N   1 ENGL AGGR REPL
COPY    11 OUTPUT MEAN   5 1     0.454     WDM1  9104 PO4P   1 ENGL AGGR REPL
COPY    11 OUTPUT MEAN   6 1     0.454     WDM1  9105 BOD    1 ENGL AGGR REPL
COPY    11 OUTPUT MEAN   7 1     0.454     WDM1  9101 DO     1 ENGL AGGR REPL
***output flows and loads from sub-basin 12
COPY    12 OUTPUT MEAN   1 1   0.02855     WDM1  9116 PERO   1 METR AGGR REPL
COPY    12 OUTPUT MEAN   2 1       907     WDM1  9110 TSS    1 ENGL AGGR REPL
COPY    12 OUTPUT MEAN   3 1     0.454     WDM1  9112 NH3N   1 ENGL AGGR REPL
COPY    12 OUTPUT MEAN   4 1     0.454     WDM1  9113 NO3N   1 ENGL AGGR REPL
COPY    12 OUTPUT MEAN   5 1     0.454     WDM1  9114 PO4P   1 ENGL AGGR REPL
COPY    12 OUTPUT MEAN   6 1     0.454     WDM1  9115 BOD    1 ENGL AGGR REPL
COPY    12 OUTPUT MEAN   7 1     0.454     WDM1  9111 DO     1 ENGL AGGR REPL
END EXT TARGETS

MASS-LINK

  MASS-LINK        3
<-Volume-> <-Grp> <-Member-><--Mult-->     <-Target vols> <-Grp> <-Member->  ***
<Name>            <Name> x x<-factor->     <Name>                <Name> x x  ***
RCHRES     ROFLOW                          RCHRES         INFLOW
  END MASS-LINK    3

  MASS-LINK        4
<-Volume-> <-Grp> <-Member-><--Mult-->     <-Target vols> <-Grp> <-Member->  ***
<Name>            <Name> x x<-factor->     <Name>                <Name> x x  ***
PERLND     PWATER PERO                     COPY           INPUT  MEAN   1
PERLND     SEDMNT SOSED  1                 COPY           INPUT  MEAN   2
PERLND     PQUAL  POQUAL 1                 COPY           INPUT  MEAN   3
PERLND     PQUAL  POQUAL 2                 COPY           INPUT  MEAN   4
PERLND     PQUAL  POQUAL 3                 COPY           INPUT  MEAN   5
PERLND     PQUAL  POQUAL 4                 COPY           INPUT  MEAN   6
PERLND     PWTGAS PODOXM                   COPY           INPUT  MEAN   7
  END MASS-LINK    4

  MASS-LINK        5
<-Volume-> <-Grp> <-Member-><--Mult-->     <-Target vols> <-Grp> <-Member->  ***
<Name>            <Name> x x<-factor->     <Name>                <Name> x x  ***
IMPLND     IWATER SURO                     COPY           INPUT  MEAN   1
IMPLND     SOLIDS SOSLD  1                 COPY           INPUT  MEAN   2
IMPLND     IQUAL  SOQUAL 1                 COPY           INPUT  MEAN   3
IMPLND     IQUAL  SOQUAL 2                 COPY           INPUT  MEAN   4
IMPLND     IQUAL  SOQUAL 3                 COPY           INPUT  MEAN   5
IMPLND     IQUAL  SOQUAL 4                 COPY           INPUT  MEAN   6
IMPLND     IWTGAS SODOXM                   COPY           INPUT  MEAN   7
  END MASS-LINK    5

  MASS-LINK        1
<-Volume-> <-Grp> <-Member-><--Mult-->     <-Target vols> <-Grp> <-Member->  ***
<Name>            <Name> x x<-factor->     <Name>                <Name> x x  ***
IMPLND     IWATER SURO       0.0833333     RCHRES         INFLOW IVOL
IMPLND     SOLIDS SOSLD  1        0.05     RCHRES         INFLOW ISED   1
IMPLND     SOLIDS SOSLD  1        0.55     RCHRES         INFLOW ISED   2
IMPLND     SOLIDS SOSLD  1         0.4     RCHRES         INFLOW ISED   3
IMPLND     IWTGAS SODOXM                   RCHRES         INFLOW OXIF   1
IMPLND     IWTGAS SOHT                     RCHRES         INFLOW IHEAT
IMPLND     IWTGAS SOHT                     RCHRES         INFLOW IHEAT  1
IMPLND     IQUAL  SOQUAL 1                 RCHRES         INFLOW NUIF1  2
IMPLND     IQUAL  SOQUAL 2                 RCHRES         INFLOW NUIF1  1
```

```
IMPLND     IQUAL  SOQUAL 3                RCHRES         INFLOW NUIF1  4
IMPLND     IQUAL  SOQUAL 4                RCHRES         INFLOW OXIF   2
IMPLND     IQUAL  SOQUAL 4          0.1   RCHRES         INFLOW PKIF   3
IMPLND     IQUAL  SOQUAL 4        0.015   RCHRES         INFLOW PKIF   4
IMPLND     IQUAL  SOQUAL 4          0.5   RCHRES         INFLOW PKIF   5
  END MASS-LINK    1

  MASS-LINK        2
<-Volume-> <-Grp> <-Member-><--Mult-->    <-Target vols> <-Grp> <-Member->  ***
<Name>            <Name> x x<-factor->    <Name>                <Name> x x  ***
PERLND     PWATER PERO       0.0833333    RCHRES         INFLOW IVOL
PERLND     SEDMNT SOSED  1         0.05   RCHRES         INFLOW ISED   1
PERLND     SEDMNT SOSED  1         0.55   RCHRES         INFLOW ISED   2
PERLND     SEDMNT SOSED  1          0.4   RCHRES         INFLOW ISED   3
PERLND     PWTGAS PODOXM                  RCHRES         INFLOW OXIF   1
PERLND     PWTGAS POHT                    RCHRES         INFLOW IHEAT
PERLND     PWTGAS POHT                    RCHRES         INFLOW IHEAT  1
PERLND     PQUAL  POQUAL 1                RCHRES         INFLOW NUIF1  2
PERLND     PQUAL  POQUAL 2                RCHRES         INFLOW NUIF1  1
PERLND     PQUAL  POQUAL 3                RCHRES         INFLOW NUIF1  4
PERLND     PQUAL  POQUAL 4                RCHRES         INFLOW OXIF   2
PERLND     PQUAL  POQUAL 4          0.1   RCHRES         INFLOW PKIF   3
PERLND     PQUAL  POQUAL 4        0.015   RCHRES         INFLOW PKIF   4
PERLND     PQUAL  POQUAL 4          0.5   RCHRES         INFLOW PKIF   5
  END MASS-LINK    2
END MASS-LINK

END RUN
```

Appendix B Cow Bayou HSPF User Control Interface File

Note: The annotations that were added to this print version for clarity may prevent it from running. It may be necessary to strip out extra comment lines that begin with three asterisks.

```
RUN

GLOBAL
  UCI Created by Kirk Dean/Nabin Basnet for the Cow Bayou watershed
  START       2001/01/01 01:00  END    2013/01/31 23:00
  RUN INTERP OUTPT LEVELS   10   10
  RESUME     0 RUN     1                         UNITS    1
END GLOBAL

FILES
<FILE>  <UN#>***<----FILE NAME------------------------------------------------->
MESSU      24   cow_lt.ech
           91   cow_lt.out
WDM1       25   cow_out.wdm
WDM2       26   cow_meteorol.wdm
WDM3       27   cow_source.wdm
BINO       92   cow_lt.hbn
END FILES

OPN SEQUENCE
    INGRP              INDELT 01:00
      PERLND     101
      PERLND     102
      PERLND     103
      PERLND     104
      PERLND     105
      PERLND     106
      PERLND     107
      PERLND     108
      PERLND     109
      PERLND     110
      PERLND     111
      PERLND     112
      PERLND     113
      PERLND     114
      PERLND     115
      PERLND     116
      PERLND     117
      IMPLND     101
      IMPLND     102
      IMPLND     103
      IMPLND     104
      RCHRES       1
      RCHRES       2
      RCHRES       3
      RCHRES       4
      RCHRES       5
      RCHRES       6
      RCHRES       7
      RCHRES       8
      RCHRES       9
      RCHRES      10
      RCHRES      11
```

```
      RCHRES      13
      RCHRES      12
      RCHRES      14
      RCHRES      15
      RCHRES      16
      RCHRES      17
      RCHRES      18
      COPY         1
      COPY         2
      COPY         3
      COPY         4
      COPY         5
      COPY         6
      COPY         7
      COPY         8
      COPY         9
      COPY        10
      COPY        11
      COPY        12
      COPY        13
      COPY        14
      COPY        15
      COPY        16
      COPY        17
      COPY        18
    END INGRP
END OPN SEQUENCE

PERLND
  ACTIVITY
*** <PLS >               Active Sections                               ***
*** x -  x ATMP SNOW PWAT  SED  PST  PWG PQAL MSTL PEST NITR PHOS TRAC ***
  101  117    1    0    1    1    1    1    1    0    0    0    0    0
  END ACTIVITY

  PRINT-INFO
*** < PLS>                       Print-flags                           PIVL  PYR
*** x  - x ATMP SNOW PWAT  SED  PST  PWG PQAL MSTL PEST NITR PHOS TRAC
  101  117    4    4    4    4    4    4    4    4    4    4    4    4    1   12
  END PRINT-INFO

  BINARY-INFO
*** < PLS>               Binary Output Flags                           PIVL  PYR
*** x  - x ATMP SNOW PWAT  SED  PST  PWG PQAL MSTL PEST NITR PHOS TRAC
  101  117    4    4    4    4    4    4    4    4    4    4    4    4    1   12
  END BINARY-INFO

  GEN-INFO
***             Name                  Unit-systems   Printer BinaryOut
*** <PLS >                                t-series Engl Metr Engl Metr
*** x -  x                                 in  out
  101     Developed Open Space              1    1    0    0   92    0
  102     Developed Low Intens              1    1    0    0   92    0
  103     Developed Medium Int              1    1    0    0   92    0
  104     Developed High Inten              1    1    0    0   92    0
  105     Barren                            1    1    0    0   92    0
  106     Deciduous Forest                  1    1    0    0   92    0
  107     Evergreen Forest                  1    1    0    0   92    0
  108     Mixed Forest                      1    1    0    0   92    0
  109     Pasture/Hay                       1    1    0    0   92    0
  110     Cropland                          1    1    0    0   92    0
  111     Grassland/Herbaceous              1    1    0    0   92    0
  112     Shrub/Scrub                       1    1    0    0   92    0
```

```
  113     Open Water                          1    1    0    0   92    0
  114     Woody Wetlands                      1    1    0    0   92    0
  115     Herbaceous Wetlands                 1    1    0    0   92    0
  116     Septic Fields                       1    1    0    0   92    0
  117     Future Unused                       1    1    0    0   92    0
  END GEN-INFO

  ATEMP-DAT
*** <PLS >     ELDAT    AIRTEMP
*** x -  x      (ft)    (deg F)
  101  117       -6.        33.
  END ATEMP-DAT

  PWAT-PARM1
*** <PLS >                   Flags
*** x -  x CSNO RTOP UZFG  VCS  VUZ  VMN VIFW VIRC  VLE IFFC  HWT IRRG IFRD
  101  114    0    1    1    1    1    0    0    0    1    0    0    0    0
  115         0    2    1    1    0    0    0    0    1    0    1    0    0
  116  117    0    1    1    1    1    0    0    0    1    0    0    0    0
  END PWAT-PARM1

  PWAT-PARM2
*** < PLS>    FOREST      LZSN    INFILT      LSUR     SLSUR     KVARY     AGWRC
*** x  - x                (in)   (in/hr)      (ft)              (1/in)   (1/day)
***                        CAL       CAL                                     CAL
  101             0.       5.0      0.25      500.     0.002        5.      0.96
  102             0.       5.0      0.25      500.     0.002        5.      0.96
  103             0.       5.0      0.25      500.     0.002        5.      0.96
  104             0.       5.0      0.25      500.     0.002        5.      0.96
  105             0.       5.0      0.25      500.     0.002        5.      0.96
  106             0.       5.0      0.25      500.     0.002        5.      0.96
  107             0.       5.0      0.25      500.     0.002        5.      0.96
  108             0.       5.0      0.25      500.     0.002        5.      0.96
  109             0.       5.0      0.25      500.     0.002        5.      0.96
  110             0.       5.0      0.25      500.     0.003        5.      0.96
  111             0.       5.0      0.25      500.     0.002        5.      0.96
  112             0.       5.0      0.25      500.     0.002        5.      0.96
  113             0.       5.0      0.25      500.     0.001        5.      0.96
  114             0.       5.0      0.25      500.     0.002        5.      0.96
  115             0.       5.0      0.25      500.     0.001        5.      0.96
  116  117        0.       5.0      0.25      500.     0.002        5.      0.96
  END PWAT-PARM2

  PWAT-PARM3
*** < PLS>    PETMAX    PETMIN    INFEXP    INFILD    DEEPFR    BASETP    AGWETP
*** x  - x   (deg F)   (deg F)
  101  117       40.       35.       2.0       2.0      0.10      0.10      0.20
  END PWAT-PARM3

  PWAT-PARM4
*** <PLS >     CEPSC      UZSN      NSUR     INTFW       IRC     LZETP
*** x -  x      (in)      (in)                       (1/day)
  101           0.15       0.6       0.4       10.      0.75       0.5
  102           0.15       0.6       0.4       10.      0.75       0.5
  103           0.15       0.6       0.4       10.      0.75       0.5
  104           0.15       0.6       0.4       10.      0.75       0.5
  105           0.15       0.6       0.4       10.      0.75       0.5
  106           0.15       0.6       0.4       10.      0.75       0.5
  107           0.15       0.6       0.4       10.      0.75       0.5
  108           0.15       0.6       0.4       10.      0.75       0.5
  109           0.15       0.6       0.4       10.      0.75       0.5
  110           0.15       0.6       0.4       10.      0.75       0.5
  111           0.15       0.6       0.4       10.      0.75       0.5
```

```
  112          0.15       0.6       0.4       10.       0.75       0.5
  113          0.01       0.6       0.4       10.       0.75       0.5
  114  117     0.15       0.6       0.4       10.       0.75       0.5
  END PWAT-PARM4

  PWAT-PARM6
*** <PLS >     MELEV      BELV    GWDATM       PCW       PGW      UPGW
*** x -  x      (ft)      (ft)      (ft)
  101          53.0      37.3        0.      0.30      0.10      0.15
  102          53.0      37.3        0.      0.30      0.10      0.15
  103          53.0      37.3        0.      0.30      0.10      0.15
  104          51.3      37.3        0.      0.30      0.10      0.15
  105          45.6      37.3        0.      0.30      0.10      0.15
  106          41.9      37.3        0.      0.30      0.10      0.15
  107          45.8      37.3        0.      0.30      0.10      0.15
  108          43.5      37.3        0.      0.30      0.10      0.15
  109          53.0      37.3        0.      0.30      0.10      0.15
  110          53.0      37.3        0.      0.30      0.10      0.15
  111          53.0      37.3        0.      0.30      0.10      0.15
  112          53.0      37.3        0.      0.30      0.10      0.15
  113          41.1      37.3        0.      0.30      0.10      0.15
  114          39.4      37.3        0.      0.30      0.10      0.15
  115          44.0      37.3        0.      0.30      0.10      0.15
  116          53.0      37.3        0.      0.30      0.10      0.15
  117          50.0      37.3        0.      0.30      0.10      0.15
  END PWAT-PARM6

  PWAT-PARM7
*** < PLS>    STABNO      SRRC     SREXP     IFWSC     DELTA    UELFAC    LELFAC
*** x  - x               (/hr)                (in)      (in)
***                        CAL                 CAL       CAL
  101             0.       0.1        1.       0.5     0.002        4.       2.5
  102             0.       0.1        1.       0.5     0.002        4.       2.5
  103             0.       0.1        1.       0.5     0.002        4.       2.5
  104             0.       0.1        1.       0.5     0.002        4.       2.5
  105             0.       0.1        1.       0.5     0.002        4.       2.5
  106             0.       0.1        1.       0.5     0.002        4.       2.5
  107             0.       0.1        1.       0.5     0.002        4.       2.5
  108             0.       0.1        1.       0.5     0.002        4.       2.5
  109             0.       0.1        1.       0.5     0.002        4.       2.5
  110             0.       0.1        1.       0.5     0.002        4.       2.5
  111             0.       0.1        1.       0.5     0.002        4.       2.5
  112             0.       0.1        1.       0.5     0.002        4.       2.5
  113             0.       0.1        1.       0.5     0.002        4.       2.5
  114             0.       0.1        1.       0.5     0.002        4.       2.5
  115             0.       0.1        1.       0.5     0.002        4.       2.5
  116             0.       0.1        1.       0.5     0.002        4.       2.5
  117             0.       0.1        1.       0.5     0.002        4.       2.5
  END PWAT-PARM7

  PWAT-STATE1
*** < PLS>  PWATER state variables (in)
*** x  - x      CEPS      SURS       UZS      IFWS       LZS      AGWS      GWVS
  101  117      0.01      0.01       0.1       0.1        4.       2.5        0.
  END PWAT-STATE1

  MON-INTERCEP
*** <PLS >  Interception storage capacity at start of each month (in) CAL
*** x -  x  JAN  FEB  MAR  APR  MAY  JUN  JUL  AUG  SEP  OCT  NOV  DEC
  101      0.05 0.05 0.05 0.09 0.11 0.15 0.15 0.15 0.15 0.13 0.09 0.05
  102      0.05 0.05 0.05 0.09 0.11 0.15 0.15 0.15 0.15 0.13 0.09 0.05
  103      0.05 0.05 0.05 0.09 0.11 0.15 0.15 0.15 0.15 0.13 0.09 0.05
  104      0.05 0.05 0.05 0.09 0.11 0.15 0.15 0.15 0.15 0.13 0.09 0.05
```

```
  105      0.01 0.01 0.01 0.01 0.01 0.01 0.01 0.01 0.01 0.01 0.01 0.01
  106      0.03 0.03 0.05 0.18 0.26 0.28 0.28 0.28 0.28 0.25 0.18 0.03
  107      0.10 0.10 0.10 0.15 0.20 0.25 0.25 0.25 0.25 0.20 0.15 0.10
  108      0.05 0.05 0.07 0.16 0.23 0.26 0.26 0.26 0.26 0.22 0.16 0.05
  109      0.05 0.05 0.06 0.08 0.12 0.15 0.15 0.15 0.15 0.10 0.08 0.05
  110      0.01 0.01 0.04 0.08 0.12 0.15 0.15 0.15 0.15 0.05 0.01 0.01
  111      0.05 0.05 0.06 0.10 0.15 0.20 0.20 0.20 0.20 0.15 0.10 0.05
  112      0.03 0.03 0.06 0.12 0.22 0.22 0.22 0.22 0.18 0.16 0.12 0.05
  113      0.01 0.01 0.01 0.01 0.01 0.01 0.01 0.01 0.01 0.01 0.01 0.01
  114      0.05 0.05 0.07 0.16 0.20 0.22 0.22 0.22 0.22 0.20 0.16 0.05
  115      0.05 0.05 0.06 0.08 0.12 0.15 0.15 0.15 0.15 0.10 0.08 0.05
  116      0.05 0.05 0.05 0.09 0.11 0.15 0.15 0.15 0.15 0.13 0.09 0.05
  117      0.05 0.05 0.05 0.09 0.11 0.13 0.13 0.13 0.13 0.13 0.09 0.05
  END MON-INTERCEP

  MON-UZSN
*** <PLS >  Upper zone storage capacity at start of each month (in) CAL
*** x -  x  JAN  FEB  MAR  APR  MAY  JUN  JUL  AUG  SEP  OCT  NOV  DEC
  101  117  0.5  0.1  0.1  0.4  0.7  1.0  1.2  1.3  1.2  1.0  1.0  1.0
  END MON-UZSN

  MON-LZETPARM
*** <PLS >  Lower zone evapotranspiration param at start of each month CAL
*** x -  x  JAN  FEB  MAR  APR  MAY  JUN  JUL  AUG  SEP  OCT  NOV  DEC
  101  117  0.1 0.10 0.17 0.69 0.86 0.90 0.90 0.90 0.90 0.49 0.26  0.1
  END MON-LZETPARM

  SED-PARM1
*** <PLS >  Sediment parameters 1
*** x -  x  CRV VSIV SDOP
  101  117    1    0    1
  END SED-PARM1

  SED-PARM2
*** <PLS >      SMPF      KRER      JRER     AFFIX     COVER      NVSI
*** x -  x                                  (/day)           lb/ac-day
  101             1.      0.43        2.      0.01      0.88        1.
  102             1.      0.43        2.      0.01      0.88        1.
  103             1.      0.43        2.      0.01      0.88        1.
  104             1.      0.43        2.      0.01      0.88        1.
  105             1.      0.43        2.      0.01      0.88        1.
  106             1.      0.43        2.     0.002      0.88        2.
  107             1.      0.43        2.     0.002      0.88        2.
  108             1.      0.43        2.     0.002      0.88        2.
  109             1.      0.43        2.      0.01      0.88        1.
  110             1.      0.43        2.      0.01      0.88        2.
  111             1.      0.43        2.      0.01      0.88        1.
  112             1.      0.43        2.      0.01      0.88        1.
  113             1.      0.43        2.     0.002      0.88        0.
  114             1.      0.28        2.     0.002      0.88        2.
  115             1.      0.49        2.     0.002      0.88        1.
  116             1.      0.43        2.      0.01      0.88        1.
  117             1.      0.43        2.      0.01      0.88        1.
  END SED-PARM2

  SED-PARM3
*** <PLS >  Sediment parameter 3
*** x -  x      KSER      JSER      KGER      JGER
  101            0.5        2.        0.        2.
  102            0.5        2.      0.01        2.
  103           0.62        2.      0.07        2.
  104           0.84        2.     0.125        2.
  105             5.        2.      0.25        2.
```

```
  106          0.55       2.        0.        2.
  107          0.55       2.        0.        2.
  108          0.55       2.        0.        2.
  109           1.6       2.       0.3        2.
  110            5.      1.3        5.       1.3
  111           0.8       2.        0.        2.
  112           1.0       2.        0.        2.
  113            0.       2.        0.        2.
  114           0.5       2.        0.        2.
  115           0.5       2.        0.        2.
  116           0.5       2.      0.01        2.
  117           0.5       2.        0.        2.
  END SED-PARM3

  MON-COVER
*** <PLS >  Monthly values for erosion related cover
*** x -  x  JAN  FEB  MAR  APR  MAY  JUN  JUL  AUG  SEP  OCT  NOV  DEC
  101       0.9  0.9  0.9 0.91 0.93 0.93 0.93 0.93 0.93 0.91  0.9  0.9
  102       0.9  0.9  0.9 0.91 0.93 0.93 0.93 0.93 0.93 0.91  0.9  0.9
  103       0.9  0.9  0.9 0.91 0.93 0.93 0.93 0.93 0.93 0.91  0.9  0.9
  104       0.9  0.9  0.9 0.91 0.93 0.93 0.93 0.93 0.93 0.91  0.9  0.9
  105      0.01 0.01 0.01 0.01 0.01 0.01 0.01 0.01 0.01 0.01 0.01 0.01
  106       0.8  0.8  0.8 0.94 0.97 0.97 0.97 0.97 0.97 0.97 0.91 0.85
  107      0.97 0.97 0.97 0.97 0.97 0.97 0.97 0.97 0.97 0.97 0.97 0.97
  108      0.94 0.94 0.94 0.95 0.97 0.97 0.97 0.97 0.97 0.97 0.96 0.94
  109       0.9  0.9  0.9 0.91 0.92 0.93 0.92 0.91 0.90 0.90  0.9  0.9
  110       0.7  0.7  0.5  0.5  0.6 0.75  0.8  0.9  0.9  0.7  0.7  0.7
  111       0.9  0.9  0.9 0.91 0.92 0.93 0.94 0.94 0.93 0.92 0.91  0.9
  112       0.8  0.8  0.8 0.91 0.92 0.93 0.94 0.94 0.93 0.92 0.91 0.85
  113        1.   1.   1.   1.   1.   1.   1.   1.   1.   1.   1.   1.
  114      0.97 0.97 0.97 0.97 0.97 0.97 0.97 0.97 0.97 0.97 0.97 0.97
  115       0.9  0.9  0.9 0.91 0.92 0.93 0.94 0.94 0.93 0.92 0.91  0.9
  116       0.9  0.9  0.9 0.91 0.93 0.93 0.93 0.93 0.93 0.91  0.9  0.9
  117       0.9  0.9  0.9 0.91 0.93 0.93 0.93 0.93 0.93 0.91  0.9  0.9
  END MON-COVER

  SED-STOR
*** <PLS >  Detached sediment storage (tons/acre)
*** x -  x      DETS
  101           0.4
  102           0.4
  103           0.4
  104           0.4
  105           0.5
  106           0.1
  107           0.1
  108           0.1
  109           0.2
  110           0.5
  111           0.2
  112           0.1
  113            0.
  114           0.1
  115           0.1
  116           0.4
  117           0.4
  END SED-STOR

  PSTEMP-PARM1
*** <PLS >  Flags for section PSTEMP
*** x -  x SLTV ULTV LGTV TSOP
  101  117    0    0    0    1
  END PSTEMP-PARM1
```

```
  PSTEMP-PARM2
*** <PLS >      ASLT      BSLT     ULTP1     ULTP2     LGTP1     LGTP2
*** x -  x   (deg F)   (deg F)             (deg F)             (deg F)
  101  117       35.       0.4       40.       0.3       65.        0.
  END PSTEMP-PARM2

  MON-ASLT
*** <PLS >  Value of ASLT at start of each month (deg F)
*** x -  x  JAN  FEB  MAR  APR  MAY  JUN  JUL  AUG  SEP  OCT  NOV  DEC
  101  117  45.  45.  45.  48.  55.  65.  70.  77.  73.  68.  60.  50.
  END MON-ASLT

  MON-BSLT
*** <PLS >  Value of BSLT at start of each month (deg F/F)
*** x -  x  JAN  FEB  MAR  APR  MAY  JUN  JUL  AUG  SEP  OCT  NOV  DEC
  101  117 0.15 0.15 0.15 0.15 0.15 0.15 0.15 0.15 0.15 0.15 0.15 0.15
  END MON-BSLT

  MON-ULTP1
*** <PLS >  Value of ULTP1 at start of each month in deg F (TSOPFG=1)
*** x -  x  JAN  FEB  MAR  APR  MAY  JUN  JUL  AUG  SEP  OCT  NOV  DEC
  101  117  52.  52.  52.  56.  62.  70.  77.  77.  73.  68.  60.  54.
  END MON-ULTP1

  MON-ULTP2
*** <PLS >  Value of ULTP2 at start of each month in Deg F/F (TSOPFG=1)
*** x -  x  JAN  FEB  MAR  APR  MAY  JUN  JUL  AUG  SEP  OCT  NOV  DEC
  101  117 0.15 0.15 0.15 0.15 0.15 0.15 0.15 0.15 0.15 0.15 0.15 0.15
  END MON-ULTP2

  MON-LGTP1
*** <PLS >  Value of LGTP1 at start of each month in Deg F (TSOPFG=1)
*** x -  x  JAN  FEB  MAR  APR  MAY  JUN  JUL  AUG  SEP  OCT  NOV  DEC
  101  117  48.  48.  52.  58.  60.  63.  63.  64.  60.  55.  52.  48.
  END MON-LGTP1

  PSTEMP-TEMPS
*** <PLS >  Initial temperatures (deg F)
*** x -  x     AIRTC     SLTMP     ULTMP     LGTMP
  101  117       40.       45.       50.       69.
  END PSTEMP-TEMPS

  PWT-PARM1
*** <PLS >  Flags for section PWTGAS
*** x -  x  IDV  ICV  GDV  GVC
  101  117    0    0    0    0
  END PWT-PARM1

  PWT-PARM2
***         Second group of PWTGAS parms
*** <PLS >      ELEV     IDOXP     ICO2P     ADOXP     ACO2P
*** x -  x      (ft)    (mg/l)  (mg C/l)    (mg/l)  (mg C/l)
  101  117       25.       4.0      0.15       4.0      0.15
  END PWT-PARM2

  MON-IFWDOX
*** <PLS > Value at start of each month for interflow DO concentration (mg/l)
*** x -  x  JAN  FEB  MAR  APR  MAY  JUN  JUL  AUG  SEP  OCT  NOV  DEC
  101  117 12.7 12.7 11.2 9.70 7.40 6.60 6.20 6.20 7.00 8.40 9.40 11.6
  END MON-IFWDOX

  MON-GRNDDOX
```

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*** <PLS >Value at start of each month for groundwater DO concentration (mg/l)
*** x -  x  JAN  FEB  MAR  APR  MAY  JUN  JUL  AUG  SEP  OCT  NOV  DEC
  101  117 10.0 10.0 10.0 10.0 7.50 5.50 5.00 5.00 5.50 7.50  9.0 10.0
  END MON-GRNDDOX

  PWT-TEMPS
*** <PLS >    Initial water temperatures (deg F)
*** x -  x     SOTMP     IOTMP     AOTMP
  101  117       45.       50.       69.
  END PWT-TEMPS

  PWT-GASES
***                   Initial DO and CO2 concentrations
*** <PLS >     SODOX     SOCO2     IODOX     IOCO2     AODOX     AOCO2
*** x -  x    (mg/l)  (mg C/l)    (mg/l)   (mg C/l)   (mg/l)  (mg C/l)
  101  117       8.8      0.15       4.0      0.15       4.0      0.15
  END PWT-GASES

  NQUALS
*** <PLS >
*** x -  xNQUAL
  101  117    4
  END NQUALS

  PQL-AD-FLAGS
***                        Atmospheric Deposition Flags
*** < PLS>  QUAL1  QUAL2  QUAL3  QUAL4  QUAL5  QUAL6  QUAL7  QUAL8  QUAL9 QUAL10
*** x  - x <F><C> <F><C> <F><C> <F><C> <F><C> <F><C> <F><C> <F><C> <F><C> <F><C>
  101  117   0  0   0  0   0  0   0  0   0  0   0  0   0  0   0  0   0  0   0  0
  END PQL-AD-FLAGS

  QUAL-PROPS
*** <PLS >  Identifiers and Flags
*** x -  x    QUALID      QTID  QSD VPFW VPFS  QSO  VQO QIFW VIQC QAGW VAQC
  101  117NH3+NH4         LBS     0    0    0    1    0    1    0    1    0
  END QUAL-PROPS

  QUAL-INPUT
***         Storage on surface and nonseasonal parameters
***           SQO   POTFW   POTFS   ACQOP  SQOLIM   WSQOP    IOQC    AOQC
*** <PLS >  qty/ac qty/ton qty/ton    qty/  qty/ac   in/hr qty/ft3 qty/ft3
*** x -  x                         ac.day
  101          0.1      0.      0.  0.1520     0.3     1.2 1.6E-05 4.0E-06
  102          0.1      0.      0.  0.1530     0.3     1.2 1.6E-05 4.0E-06
  103          0.1      0.      0.  0.1540     0.3     1.2 1.6E-05 4.0E-06
  104          0.1      0.      0.  0.1550     0.3     1.2 1.6E-05 4.0E-06
  105         0.01      0.      0.   0.006    0.02     0.4 1.6E-05 4.0E-06
  106          0.1      0.      0.  0.0900     0.2     1.4 1.6E-05 4.0E-06
  107          0.1      0.      0.  0.0900     0.2     1.4 1.6E-05 4.0E-06
  108          0.1      0.      0.  0.0900     0.2     1.4 1.6E-05 4.0E-06
  109         0.01      0.      0.  0.0170    0.03     1.2 1.6E-05 4.0E-06
  110         0.01      0.      0.  0.0080    0.02     0.4 1.6E-05 4.0E-06
  111         0.01      0.      0.  0.0170    0.03     1.2 1.6E-05 4.0E-06
  112          0.1      0.      0.  0.0500     0.2     1.2 1.6E-05 4.0E-06
  113         0.01      0.      0.   0.001    0.01     0.4 1.6E-05 4.0E-06
  114          0.1      0.      0.  0.0900     0.2     1.4 1.6E-05 4.0E-06
  115         0.01      0.      0.  0.0170    0.03     1.4 1.6E-05 4.0E-06
  116          1.0      0.      0.  0.1530     2.0     1.2 1.6E-04 4.0E-05
  117          0.1      0.      0.  0.1530     0.3     1.2 1.6E-05 4.0E-06
  END QUAL-INPUT

  QUAL-PROPS
*** <PLS >  Identifiers and Flags
```

```
*** x -  x    QUALID      QTID  QSD VPFW VPFS  QSO  VQO QIFW VIQC QAGW VAQC
  101  117NO3             LBS     0    0    0    1    0    1    0    1    0
  END QUAL-PROPS

  QUAL-INPUT
***         Storage on surface and nonseasonal parameters
***            SQO   POTFW   POTFS   ACQOP  SQOLIM   WSQOP    IOQC    AOQC
*** <PLS >  qty/ac qty/ton qty/ton    qty/  qty/ac   in/hr qty/ft3 qty/ft3
*** x -  x                          ac.day
  101  117    0.04      0.      0.  0.0057    0.08     0.7 6.2E-06 6.2E-06
  END QUAL-INPUT

  QUAL-PROPS
*** <PLS >  Identifiers and Flags
*** x -  x    QUALID      QTID  QSD VPFW VPFS  QSO  VQO QIFW VIQC QAGW VAQC
  101  117ORTHO P         LBS     0    0    0    1    0    1    0    1    0
  END QUAL-PROPS

  QUAL-INPUT
***         Storage on surface and nonseasonal parameters
***            SQO   POTFW   POTFS   ACQOP  SQOLIM   WSQOP    IOQC    AOQC
*** <PLS >  qty/ac qty/ton qty/ton    qty/  qty/ac   in/hr qty/ft3 qty/ft3
*** x -  x                          ac.day
  101            0.2      0.      0.  0.0740     0.2     1.2 3.2E-06 1.0E-06
  102            0.2      0.      0.  0.0760     0.3     1.2 3.2E-06 1.0E-06
  103            0.2      0.      0.  0.0770     0.3     1.2 3.2E-06 1.0E-06
  104            0.2      0.      0.  0.0770     0.3     1.2 3.2E-06 1.0E-06
  105           0.01      0.      0.  0.0010     0.1     0.4 3.2E-06 1.0E-06
  106            0.1      0.      0.  0.0076     0.1     1.4 3.2E-06 1.0E-06
  107            0.1      0.      0.  0.0076     0.1     1.4 3.2E-06 1.0E-06
  108            0.1      0.      0.  0.0076     0.1     1.4 3.2E-06 1.0E-06
  109            0.1      0.      0.  0.0110     0.1     1.2 3.2E-06 1.0E-06
  110           0.01      0.      0.  0.0013     0.1     0.4 3.2E-06 1.0E-06
  111            0.1      0.      0.  0.0110     0.1     1.2 3.2E-06 1.0E-06
  112            0.1      0.      0.  0.0110     0.1     1.2 3.2E-06 1.0E-06
  113           0.01      0.      0.  0.0010     0.1     1.2 3.2E-06 1.0E-06
  114            0.1      0.      0.  0.0076     0.1     1.4 3.2E-06 1.0E-06
  115            0.1      0.      0.  0.0110     0.1     1.4 3.2E-06 1.0E-06
  116            2.0      0.      0.  0.0760     2.0     1.2 3.2E-05 1.0E-05
  117            0.1      0.      0.  0.0760     0.3     1.2 3.2E-06 1.0E-06
  END QUAL-INPUT

  QUAL-PROPS
*** <PLS >  Identifiers and Flags
*** x -  x    QUALID      QTID  QSD VPFW VPFS  QSO  VQO QIFW VIQC QAGW VAQC
  101  117BOD             LBS     0    0    0    1    0    1    0    1    0
  END QUAL-PROPS

  QUAL-INPUT
***         Storage on surface and nonseasonal parameters
***            SQO   POTFW   POTFS   ACQOP  SQOLIM   WSQOP    IOQC    AOQC
*** <PLS >  qty/ac qty/ton qty/ton    qty/  qty/ac   in/hr qty/ft3 qty/ft3
*** x -  x                          ac.day
  101             1.      0.      0.   0.614      3.     0.7 2.5E-04 6.2E-05
  102             1.      0.      0.   0.638      5.     0.7 2.5E-04 6.2E-05
  103             1.      0.      0.   0.654      5.     0.7 2.5E-04 6.2E-05
  104             1.      0.      0.   0.656      5.     0.5 2.5E-04 6.2E-05
  105            0.1      0.      0.   0.100      1.     0.5 2.5E-04 6.2E-05
  106             1.      0.      0.   0.406      5.     1.4 2.5E-04 6.2E-05
  107             1.      0.      0.   0.406      5.     1.4 2.5E-04 6.2E-05
  108             1.      0.      0.   0.406      5.     1.4 2.5E-04 6.2E-05
  109             1.      0.      0.   0.198      3.     0.7 2.5E-04 6.2E-05
  110             1.      0.      0.   0.100      5.     0.7 2.5E-04 6.2E-05
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  111          1.      0.      0.   0.300      3.      0.7 2.5E-04 6.2E-05
  112          1.      0.      0.   0.198      3.      0.7 2.5E-04 6.2E-05
  113         0.1      0.      0.   0.020     0.1      0.7 2.5E-04 6.2E-05
  114          1.      0.      0.   0.406      5.      1.4 2.5E-04 6.2E-05
  115          1.      0.      0.   0.198      3.      1.4 2.5E-04 6.2E-05
  116         10.      0.      0.   0.638     50.      0.7 2.5E-03 6.2E-04
  117          1.      0.      0.   0.638      5.      1.1 2.5E-04 6.2E-05
  END QUAL-INPUT

END PERLND

IMPLND
  ACTIVITY
*** <ILS >               Active Sections
*** x -  x ATMP SNOW IWAT  SLD  IWG IQAL
  101  104    1    0    1    1    1    1
  END ACTIVITY

  PRINT-INFO
*** <ILS > ******** Print-flags ******** PIVL  PYR
*** x -  x ATMP SNOW IWAT  SLD  IWG IQAL *********
  101  104    4    4    4    4    4    4    1   12
  END PRINT-INFO

  BINARY-INFO
*** <ILS > **** Binary-Output-flags **** PIVL  PYR
*** x -  x ATMP SNOW IWAT  SLD  IWG IQAL *********
  101  104    4    4    4    4    4    4    1   12
  END BINARY-INFO

  GEN-INFO
***             Name             Unit-systems   Printer BinaryOut
*** <ILS >                           t-series Engl Metr Engl Metr
*** x -  x                            in  out
  101     Developed Open Space         1    1    0    0   92    0
  102     Developed Low Intens         1    1    0    0   92    0
  103     Developed Medium Int         1    1    0    0   92    0
  104     Developed High Inten         1    1    0    0   92    0
  END GEN-INFO

  ATEMP-DAT
*** <ILS >     ELDAT    AIRTEMP
*** x -  x      (ft)    (deg F)
  101  104       -6.        33.
  END ATEMP-DAT

  IWAT-PARM1
*** <ILS >        Flags
*** x -  x CSNO RTOP  VRS  VNN RTLI
  101  104    0    1    0    0    0
  END IWAT-PARM1

  IWAT-PARM2
*** <ILS >      LSUR     SLSUR      NSUR     RETSC
*** x -  x      (ft)                          (in)
  101  104      100.    0.0028      0.07      0.07
  END IWAT-PARM2

  IWAT-PARM3
*** <ILS >    PETMAX    PETMIN
*** x -  x   (deg F)   (deg F)
  101  104       40.       35.
  END IWAT-PARM3
```

```
  IWAT-STATE1
*** <ILS >  IWATER state variables (inches)
*** x -  x      RETS      SURS
  101  104        0.        0.
  END IWAT-STATE1

  SLD-PARM1
*** <ILS >     Flags
*** x -  x VASD VRSD SDOP
  101  104    0    0    1
  END SLD-PARM1

  SLD-PARM2
***             KEIM      JEIM    ACCSDP    REMSDP
*** <ILS >                          tons/      /day
*** x -  x                         ac.day
  101  104       0.2        2.     0.010      0.01
  END SLD-PARM2

  SLD-STOR
*** <ILS >  Solids storage (tons/acre)
*** x -  x
  101  104      0.01
  END SLD-STOR

  IWT-PARM1
*** <ILS >  Flags for section IWTGAS
*** x -  x WTFV CSNO
  101  104    0    0
  END IWT-PARM1

  IWT-PARM2
***         Second group of IWTGAS parms
*** <ILS >      ELEV      AWTF      BWTF
*** x -  x      (ft)   (deg F) (deg F/F)
  101  104       20.       40.       0.3
  END IWT-PARM2

  MON-AWTF
*** <ILS >  Value of AWTF at start of each month (deg F)
*** x -  x  JAN  FEB  MAR  APR  MAY  JUN  JUL  AUG  SEP  OCT  NOV  DEC
  101  104 29.0 29.0 30.0 34.0 54.0 63.0 65.0 64.0 60.0 48.0 35.0 30.0
  END MON-AWTF

  MON-BWTF
*** <ILS >  Value of BWTF at start of each month (deg F/F)
*** x -  x  JAN  FEB  MAR  APR  MAY  JUN  JUL  AUG  SEP  OCT  NOV  DEC
  101  104  .55  .55  .65  .75  .90  1.1  1.2  1.1  1.0  .65  .65  .60
  END MON-BWTF

  NQUALS
*** <ILS >
*** x -  xNQUAL
  101  104    4
  END NQUALS

  IQL-AD-FLAGS
***                         Atmospheric Deposition Flags
*** < ILS>  QUAL1  QUAL2  QUAL3  QUAL4  QUAL5  QUAL6  QUAL7  QUAL8  QUAL9 QUAL10
*** x  - x <F><C> <F><C> <F><C> <F><C> <F><C> <F><C> <F><C> <F><C> <F><C> <F><C>
  101  104  -1  0  -1  0   0  0   0  0   0  0   0  0   0  0   0  0   0  0   0  0
  END IQL-AD-FLAGS
```

```
  QUAL-PROPS
*** <ILS >    Identifiers and Flags
*** x -  x      QUALID    QTID  QSD VPFW  QSO  VQO
  101  104NH3+NH4         LBS     0    0    1    0
  END QUAL-PROPS

  QUAL-INPUT
***         Storage on surface and nonseasonal parameters
***            SQO   POTFW   ACQOP  SQOLIM   WSQOP
*** <ILS >  qty/ac qty/ton    qty/  qty/ac   in/hr
*** x -  x                  ac.day
  101  104    0.05      0.   0.014     0.1     0.3
  END QUAL-INPUT

  QUAL-PROPS
*** <ILS >    Identifiers and Flags
*** x -  x      QUALID    QTID  QSD VPFW  QSO  VQO
  101  104NO3             LBS     0    0    1    0
  END QUAL-PROPS

  QUAL-INPUT
***         Storage on surface and nonseasonal parameters
***            SQO   POTFW   ACQOP  SQOLIM   WSQOP
*** <ILS >  qty/ac qty/ton    qty/  qty/ac   in/hr
*** x -  x                  ac.day
  101  104    0.05      0.   0.006     0.1     0.2
  END QUAL-INPUT

  QUAL-PROPS
*** <ILS >    Identifiers and Flags
*** x -  x      QUALID    QTID  QSD VPFW  QSO  VQO
  101  104ORTHO P         LBS     0    0    1    0
  END QUAL-PROPS

  QUAL-INPUT
***         Storage on surface and nonseasonal parameters
***            SQO   POTFW   ACQOP  SQOLIM   WSQOP
*** <ILS >  qty/ac qty/ton    qty/  qty/ac   in/hr
*** x -  x                  ac.day
  101  104    0.10      0.   0.010     0.2     0.3
  END QUAL-INPUT

  QUAL-PROPS
*** <ILS >    Identifiers and Flags
*** x -  x      QUALID    QTID  QSD VPFW  QSO  VQO
  101  104BOD             LBS     0    0    1    0
  END QUAL-PROPS

  QUAL-INPUT
***         Storage on surface and nonseasonal parameters
***            SQO   POTFW   ACQOP  SQOLIM   WSQOP
*** <ILS >  qty/ac qty/ton    qty/  qty/ac   in/hr
*** x -  x                  ac.day
  101  104      1.      0.    0.13      2.     0.3
  END QUAL-INPUT

END IMPLND

RCHRES
  ACTIVITY
*** RCHRES  Active sections
*** x -  x HYFG ADFG CNFG HTFG SDFG GQFG OXFG NUFG PKFG PHFG
```

```
    1   18    1    1    0    1    1    0    1    1    1    0
  END ACTIVITY

  PRINT-INFO
*** RCHRES  Printout level flags
*** x -  x HYDR ADCA CONS HEAT  SED  GQL OXRX NUTR PLNK PHCB PIVL  PYR
    1   18    4    4         4    4         4    4    4         1   12
  END PRINT-INFO

  BINARY-INFO
*** RCHRES  Binary Output level flags
*** x -  x HYDR ADCA CONS HEAT  SED  GQL OXRX NUTR PLNK PHCB PIVL  PYR
    1   18    4    4         4    4         4    4    4         1   12
  END BINARY-INFO

  GEN-INFO
***             Name        Nexits   Unit Systems   Printer
*** RCHRES                             t-series  Engl Metr LKFG
*** x -  x                               in  out
    1     CB7upper             1         1    1   91    0    0   92    0
    2     Dognash              1         1    1   91    0    0   92    0
    3     CB7lower             1         1    1   91    0    0   92    0
    4     CB6                  1         1    1   91    0    0   92    0
    5     TGupper              1         1    1   91    0    0   92    0
    6     TGmidI10             1         1    1   91    0    0   92    0
    7     CCupper              1         1    1   91    0    0   92    0
    8     CB5                  1         1    1   91    0    0   92    0
    9     CB4                  1         1    1   91    0    0   92    0
   10     CClower              1         1    1   91    0    0   92    0
   11     Sandy Creek          1         1    1   91    0    0   92    0
   12     CB3_5                1         1    1   91    0    0   92    0
   13     TGlower              1         1    1   91    0    0   92    0
   14     CB2_5                1         1    1   91    0    0   92    0
   15     CNB                  1         1    1   91    0    0   92    0
   16     CB2                  1         1    1   91    0    0   92    0
   17     CO3                  1         1    1   91    0    0   92    0
   18     CB0_5                1         1    1   91    0    0   92    0
  END GEN-INFO

  HYDR-PARM1
***        Flags for HYDR section
***RC HRES  VC A1 A2 A3  ODFVFG for each *** ODGTFG for each     FUNCT  for each
*** x  - x  FG FG FG FG  possible   exit *** possible   exit     possible   exit
    1   18   0  1  1  1    4  0  0  0  0       0  0  0  0  0       1  1  1  1  1
  END HYDR-PARM1

  HYDR-PARM2
*** RCHRES FTBW FTBU        LEN     DELTH     STCOR        KS      DB50
*** x -  x              (miles)      (ft)      (ft)                (in)
    1        0.   1.       9.04      29.5       3.2       0.5     0.008
    2        0.   2.       8.58       22.       3.2       0.5     0.008
    3        0.   3.       9.79      13.1       3.2       0.5     0.008
    4        0.   4.       7.08      13.8       3.2       0.5     0.008
    5        0.   5.       6.63       5.2       3.2       0.5     0.008
    6        0.   6.       5.01       9.2       3.2       0.5     0.008
    7        0.   7.       5.65      16.4       3.2       0.5     0.008
    8        0.   8.       4.94       2.3       3.2       0.5     0.007
    9        0.   9.       3.03       1.5       3.2       0.5     0.004
   10        0.  10.        3.7       4.9       3.2       0.5     0.007
   11        0.  11.       5.18      13.1       3.2       0.5     0.007
   12        0.  12.       3.48        2.       3.2       0.5     0.004
   13        0.  13.       5.87       8.8       3.2       0.5     0.004
   14        0.  14.       4.21        1.       3.2       0.5     0.005
```

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   15        0.  15.       4.6       5.6       3.2       0.5     0.007
   16        0.  16.      2.59       0.4       3.2       0.5     0.006
   17        0.  17.      3.02        2.       3.2       0.5     0.006
   18        0.  18.       3.2       0.2       3.2       0.5     0.003
  END HYDR-PARM2

  HYDR-INIT
***        Initial conditions for HYDR section
***RC HRES       VOL  CAT Initial value  of COLIND     initial  value  of OUTDGT
*** x  - x     ac-ft      for each possible   exit  for each possible exit,ft3
    1   18       10.       4.2  4.5  4.5  4.5  4.2       2.1  1.2  0.5  1.2  1.8
  END HYDR-INIT

  ADCALC-DATA
*** RCHRES  Data for section ADCALC
*** x -  x     CRRAT       VOL (ac-ft)
    1   18       1.7      100.
  END ADCALC-DATA

  HT-BED-FLAGS
*** RCHRES Bed Heat Conductance Flags
*** x -  x BDFG TGFG TSTP
    1   18    1    3   55
  END HT-BED-FLAGS

  HEAT-PARM
*** RCHRES      ELEV     ELDAT    CFSAEX    KATRAD     KCOND     KEVAP
*** x -  x      (ft)      (ft)
    1            10.       -6.       0.2      9.37      6.12      2.24
    2            10.       -6.       0.2      9.37      6.12      2.24
    3             6.      -10.       0.2      9.37      6.12      2.24
    4             4.      -12.       0.2      9.37      6.12      2.24
    5             6.      -10.       0.2      9.37      6.12      2.24
    6             4.      -12.       0.2      9.37      6.12      2.24
    7             4.      -12.       0.2      9.37      6.12      2.24
    8             1.      -15.       0.2      9.37      6.12      2.24
    9             0.      -16.       0.2      9.37      6.12      2.24
   10             0.      -16.       0.4      9.37      6.12      2.24
   11             0.      -16.       0.4      9.37      6.12      2.24
   12             0.      -16.       0.4      9.37      6.12      2.24
   13             0.      -16.       0.4      9.37      6.12      2.24
   14             0.      -16.       0.6      9.37      6.12      2.24
   15             0.      -16.       0.4      9.37      6.12      2.24
   16             0.      -16.      0.75      9.37      6.12      2.24
   17             0.      -16.      0.75      9.37      6.12      2.24
   18             0.      -16.      0.75      9.37      6.12      2.24
  END HEAT-PARM

  HT-BED-PARM
***       Bed Heat Conduction Parameters for Single and Two-layer Methods
*** RCHRES    MUDDEP     TGRND      KMUD     KGRND
*** x -  x      (ft)   (deg F)      (kcal/m2/C/hr)
    1   18       0.8       70.       20.       1.4
  END HT-BED-PARM

  MON-HT-TGRND
*** RCHRES  Monthly values of ground temperatures (deg F)
*** x -  x  TG1  TG2  TG3  TG4  TG5  TG6  TG7  TG8  TG9 TG10 TG11 TG12
    1   18  56.  55.  58.  63.  68.  74.  79.  82.  81.  75.  68.  60.
  END MON-HT-TGRND

  HEAT-INIT
*** RCHRES        TW    AIRTMP
```

```
*** x -  x    (deg F)    (deg F)
    1   18       48.        40.
  END HEAT-INIT

  SANDFG
*** RCHRES
*** x -  x SNDFG
    1   18    3
  END SANDFG

  SED-GENPARM
*** RCHRES    BEDWID    BEDWRN        POR
*** x -  x      (ft)      (ft)
    1            15.        6.        0.3
    2             9.        6.        0.3
    3            15.        6.        0.3
    4             9.        6.       0.27
    5             8.        6.        0.3
    6            15.        6.        0.3
    7             8.        6.        0.3
    8            40.        6.       0.28
    9            50.        6.       0.51
   10            20.        6.        0.3
   11            15.        6.        0.3
   12            60.        6.        0.4
   13            30.        6.        0.4
   14           240.        6.        0.6
   15            20.        6.        0.3
   16           220.        6.        0.5
   17           100.        6.        0.5
   18           300.        6.        0.6
  END SED-GENPARM

  SAND-PM
*** RCHRES         D         W        RHO     KSAND    EXPSND
*** x -  x      (in)  (in/sec)  (gm/cm3)
    1   18    0.0079      0.46       2.60       0.8       3.2
  END SAND-PM

  SILT-CLAY-PM
*** RCHRES         D         W        RHO     TAUCD     TAUCS         M
*** x -  x      (in)  (in/sec)     gm/cm3    lb/ft2    lb/ft2  lb/ft2.d
    1        0.00160     0.018       2.60     0.020     0.130      0.05
    2        0.00160     0.018       2.60     0.020     0.130      0.05
    3        0.00160     0.018       2.60     0.020     0.088      0.05
    4        0.00160     0.018       2.60     0.020     0.116      0.05
    5        0.00160     0.018       2.60     0.020     0.030      0.05
    6        0.00160     0.018       2.60     0.020     0.048      0.05
    7        0.00160     0.018       2.60     0.020     0.085      0.05
    8        0.00160     0.018       2.60     0.020     0.028      0.05
    9        0.00160     0.018       2.60     0.020     0.033      0.05
   10        0.00160     0.018       2.60     0.020     0.041      0.05
   11        0.00160     0.018       2.60     0.020     0.065      0.05
   12        0.00160     0.018       2.60     0.020     0.045      0.05
   13        0.00160     0.018       2.60     0.020     0.055      0.05
   14        0.00160     0.018       2.60     0.020     0.020      0.05
   15        0.00160     0.018       2.60     0.020     0.035      0.05
   16        0.00160     0.018       2.60     0.020     0.020      0.05
   17        0.00160     0.018       2.60     0.020     0.030      0.05
   18        0.00160     0.018       2.60     0.020     0.020      0.05
  END SILT-CLAY-PM

  SILT-CLAY-PM
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*** RCHRES         D         W       RHO     TAUCD     TAUCS         M
*** x -  x      (in)  (in/sec)    gm/cm3    lb/ft2    lb/ft2  lb/ft2.d
    1        0.00006   0.00005      2.60     0.015     0.100      0.05
    2        0.00006   0.00005      2.60     0.015     0.100      0.05
    3        0.00006   0.00005      2.60     0.015     0.065      0.05
    4        0.00006   0.00005      2.60     0.015     0.089      0.05
    5        0.00006   0.00005      2.60     0.015     0.018      0.05
    6        0.00006   0.00005      2.60     0.015     0.046      0.05
    7        0.00006   0.00005      2.60     0.015     0.070      0.05
    8        0.00006   0.00005      2.60     0.015     0.022      0.05
    9        0.00006   0.00005      2.60     0.015     0.026      0.05
   10        0.00006   0.00005      2.60     0.015     0.034      0.05
   11        0.00006   0.00005      2.60     0.015     0.035      0.05
   12        0.00006   0.00005      2.60     0.015     0.037      0.05
   13        0.00006   0.00005      2.60     0.015     0.044      0.05
   14        0.00006   0.00005      2.60     0.015     0.015      0.05
   15        0.00006   0.00005      2.60     0.015     0.016      0.05
   16        0.00006   0.00005      2.60     0.015     0.015      0.05
   17        0.00006   0.00005      2.60     0.015     0.015      0.05
   18        0.00006   0.00005      2.60     0.015     0.015      0.05
  END SILT-CLAY-PM

  SSED-INIT
*** RCHRES     Suspended sed concs (mg/l)
*** x -  x      Sand      Silt      Clay
    1   18        1.        5.        5.
  END SSED-INIT

  BED-INIT
*** RCHRES    BEDDEP  Initial bed composition
*** x -  x      (ft)      Sand      Silt      Clay
    1    5       1.5     0.880     0.050     0.070
    6    8       1.5     0.780     0.120     0.100
    9            1.5     0.520     0.120     0.360
   10            1.5     0.800     0.100     0.100
   11            1.5     0.800     0.100     0.100
   12            1.5     0.700     0.100     0.200
   13            1.5     0.700     0.100     0.200
   14            1.5     0.550     0.090     0.360
   15            1.5     0.700     0.100     0.200
   16   17       1.5     0.670     0.080     0.250
   18            1.5     0.500     0.170     0.330
  END BED-INIT

  BENTH-FLAG
*** RCHRES  Benthic release flag
*** x -  x BENF
    1   18    1
  END BENTH-FLAG

  OX-FLAGS
*** RCHRES Oxygen flags
*** x -  x REAM
    1   18    2
  END OX-FLAGS

  OX-GENPARM
*** RCHRES    KBOD20     TCBOD    KODSET    SUPSAT
*** x -  x       /hr                 ft/hr
    1   18     0.002     1.047     0.001        1.
  END OX-GENPARM

  OX-BENPARM
```

```
*** RCHRES     BENOD      TCBEN      EXPOD  BRBOD(1)  BRBOD(2)     EXPREL
*** x -  x  mg/m2.hr                        mg/m2.hr  mg/m2.hr
    1           150.     1.074       1.22       0.1       0.1       2.82
    2           150.     1.074       1.22       0.1       0.1       2.82
    3           150.     1.074       1.22       0.1       0.1       2.82
    4           150.     1.074       1.22       0.1       0.1       2.82
    5           150.     1.074       1.22       0.1       0.1       2.82
    6           150.     1.074       1.22       0.1       0.1       2.82
    7           150.     1.074       1.22       0.1       0.1       2.82
    8           150.     1.074       1.22       0.1       0.1       2.82
    9           150.     1.074       1.22       0.1       0.1       2.82
   10           150.     1.074       1.22       0.1       0.1       2.82
   11           150.     1.074       1.22       0.1       0.1       2.82
   12           150.     1.074       1.22       0.1       0.1       2.82
   13           150.     1.074       1.22       0.1       0.1       2.82
   14           150.     1.074       1.22       0.1       0.1       2.82
   15           150.     1.074       1.22       0.1       0.1       2.82
   16           150.     1.074       1.22       0.1       0.1       2.82
   17           150.     1.074       1.22       0.1       0.1       2.82
   18           150.     1.074       1.22       0.1       0.1       2.82
  END OX-BENPARM

  OX-TCGINV
*** RCHRES  Temperature correction coef
*** x -  x    TCGINV
    1   18     1.047
  END OX-TCGINV

  OX-REAPARM
*** RCHRES    TCGINV       REAK    EXPRED    EXPREV
*** x -  x                  /hr
    1   18     1.024        0.2    -1.673     0.969
  END OX-REAPARM

  OX-INIT
*** RCHRES       DOX        BOD     SATDO
*** x -  x      mg/l       mg/l      mg/l
    1   18        8.        3.5      13.5
  END OX-INIT

  NUT-FLAGS
*** RCHRES  Nutrient flags
*** x -  x  NH3  NO2  PO4  AMV  DEN ADNH ADPO PHFL
    1   18    1    0    1    0    1    0    1    2
  END NUT-FLAGS

  CONV-VAL1
*** RCHRES      CVBO     CVBPC     CVBPN    BPCNTC
*** x -  x     mg/mg  mols/mol  mols/mol
    1   18      1.63      106.       16.       49.
  END CONV-VAL1

  NUT-BENPARM
*** RCHRES  BRNIT(1)  BRNIT(2)  BRPO4(1)  BRPO4(2)     ANAER
*** x -  x  mg/m2.hr  mg/m2.hr  mg/m2.hr  mg/m2.hr      mg/l
    1   18        0.        0.        0.        0.       0.1
  END NUT-BENPARM

  NUT-NITDENIT
*** RCHRES    KTAM20    KNO220     TCNIT    KNO320     TCDEN    DENOXT
*** x -  x       /hr       /hr                 /hr                mg/l
    1   18      0.01     0.002      1.07      0.02      1.04        2.
  END NUT-NITDENIT
```

```
  NUT-ADSPARM
*** RCHRES       Partition coefficients for NH4 AND PO4  (ml/g)
*** x -  x  NH4-sand  NH4-silt  NH4-clay  PO4-sand  PO4-silt  PO4-clay
    1   18     1E-10     1E-10     1E-10     1E-10       0.1        1.
  END NUT-ADSPARM

  NUT-DINIT
*** RCHRES       NO3       TAM       NO2       PO4     PHVAL
*** x -  x      mg/l      mg/l      mg/l      mg/l
    1   18       0.1       0.1      0.01      0.05        7.
  END NUT-DINIT

  PLNK-FLAGS
*** RCHRES Plankton flags
*** x -  x PHYF ZOOF BALF SDLT AMRF DECF NSFG ZFOO  BNP
    1   18    1    0    1    0    0    1    1    2    0
  END PLNK-FLAGS

  PLNK-PARM1
***RC HRES    RATCLP    NONREF    LITSED     ALNPR      EXTB     MALGR    PARADF
*** x  - x                       l/mg.ft                  /ft       /hr
    1   18      0.68      0.25        0.      0.75       0.3     0.085        1.
  END PLNK-PARM1

  PLNK-PARM2
***RC HRES     CMMLT      CMMN     CMMNP      CMMP    TALGRH    TALGRL    TALGRM
*** x  - x    ly/min      mg/l      mg/l      mg/l     deg F     deg F     deg F
    1   18      0.01     0.025    0.0001     0.005       95.      -20.       86.
  END PLNK-PARM2

  PLNK-PARM3
*** RCHRES     ALR20      ALDH      ALDL     OXALD     NALDH     PALDH
*** x -  x       /hr       /hr       /hr       /hr      mg/l      mg/l
    1   18     0.005      0.02     0.001      0.03      0.01     0.002
  END PLNK-PARM3

  PHYTO-PARM
*** RCHRES      SEED    MXSTAY      OREF    CLALDH    PHYSET    REFSET
*** x -  x      mg/l      mg/l     ft3/s      ug/l     ft/hr     ft/hr
    1   18        1.        2.      100.       20.     0.005     0.010
  END PHYTO-PARM

  BENAL-PARM
***RC HRES      MBAL    CFBALR    CFBALG    MINBAL     CAMPR     FRAVL    NMAXFX
*** x  - x     mg/m2                         mg/m2      mg/l                mg/l
    1   18     2500.      0.35        1.    0.0001     0.001        0.       10.
  END BENAL-PARM

  PLNK-INIT
*** RCHRES     PHYTO       ZOO     BENAL       ORN       ORP       ORC
*** x -  x      mg/l     org/l     mg/m2      mg/l      mg/l      mg/l
    1   18       0.5      0.03     2500.       1.0       0.1       0.5
  END PLNK-INIT

END RCHRES

FTABLES

  FTABLE      1
 rows cols                           ***
   16    4
     depth      area    volume  outflow1 ***
```

```
       0.         0.         0.         0.
     0.2        10.         1.         0.
       1.        33.        23.         0.
       2.        43.        66.        24.
       3.        44.       110.        40.
       4.        46.       156.        56.
       5.        47.       203.       111.
       6.        48.       251.       184.
       8.        49.       350.       287.
      10.        55.       460.       419.
      12.        66.       590.       647.
      14.        82.       755.       896.
      16.       110.       975.      1245.
      18.       137.      1248.      1709.
      20.      4383.     10015.     14623.
      22.      7013.     24040.     37088.
  END FTABLE  1

  FTABLE      2
 rows cols                               ***
   16    4
     depth      area    volume  outflow1 ***
       0.         0.         0.         0.
     0.2        4.8       0.48         0.
       1.       15.6       11.1         0.
       2.       20.3       31.4        12.
       3.       20.8       52.2        20.
       4.       21.8        74.        28.
       5.       22.4        96.        56.
       6.       22.9       119.        92.
       8.       23.4       166.       144.
      10.        26.       218.       210.
      12.        31.       280.       324.
      14.        39.       358.       448.
      16.        52.       462.       623.
      18.        65.       592.       855.
      20.       520.      1632.      7312.
      22.      1040.      3712.     13135.
  END FTABLE  2

  FTABLE      3
 rows cols                               ***
   16    4
     depth      area    volume  outflow1 ***
       0.         0.         0.         0.
     0.2        11.        1.1         0.
       1.        36.       25.4         0.
       2.        46.        72.        24.
       3.        48.       119.        41.
       4.        50.       169.        57.
       5.        51.       220.       112.
       6.        52.       272.       184.
       8.        53.       379.       288.
      10.        59.       498.       420.
      12.        71.       640.       648.
      14.        89.       818.       898.
      16.       119.      1055.      1247.
      18.       148.      1352.      1711.
      20.      4747.     10845.     14625.
      22.      7595.     26035.     37090.
  END FTABLE  3

  FTABLE      4
```

```
 rows cols                              ***
   18    4
     depth      area    volume  outflow1 ***
        0.        0.        0.        0.
       0.2        8.      0.69       0.1
       0.4      10.6      2.92        1.
        1.      17.2      12.9       10.
        2.      27.5      42.9       40.
        3.      32.6       73.      100.
        4.      36.9     111.6      150.
        5.      41.2     150.2      210.
        6.      46.3      206.      310.
        8.      51.5      275.      500.
       10.      66.9      429.      700.
       12.       79.      515.      900.
       14.      103.      687.     1300.
       16.      112.      944.     2100.
       18.      124.     1201.     3000.
      19.5     5003.     4205.     8100.
       22.    10006.    23000.    45300.
       25.    40026.    98050.   198000.
  END FTABLE  4

  FTABLE      5
 rows cols                              ***
   12    4
     depth      area    volume  outflow1 ***
        0.        0.        0.        0.
       0.2       2.8       0.3      0.07
        1.       7.3       4.8        6.
        2.       8.2       13.      16.2
        3.        9.       22.       27.
        4.      11.3       33.       50.
        5.      24.8       58.      123.
        6.      28.1       86.      257.
        8.      43.9      174.      562.
       10.      84.4      343.     1236.
       12.      563.     1468.     5662.
       14.     1125.     3718.    15267.
  END FTABLE  5

  FTABLE      6
 rows cols                              ***
   12    4
     depth      area    volume  outflow1 ***
        0.        0.        0.        0.
       0.2        3.       0.3       0.1
        1.       7.9       5.2        9.
        2.       8.8       14.       23.
        3.       9.7      23.7       39.
        4.      12.1       36.       71.
        5.      26.7       63.      175.
        6.      30.4       93.      367.
        8.      47.4      188.      800.
       10.      91.1      370.     1770.
       12.      607.     1584.     8090.
       14.     1215.     4014.    21800.
  END FTABLE  6

  FTABLE      7
 rows cols                              ***
   14    4
     depth      area    volume  outflow1 ***
```

```
       0.        0.        0.        0.
      0.2       3.4      0.34        0.
      0.6       4.9      1.66        0.
       1.       8.9       4.1      0.01
       2.       9.9      12.7        1.
       3.       11.      22.7       20.
       4.       13.      34.2      69.7
       5.      15.1       48.      136.
       7.      19.2       84.      327.
       9.       24.      120.      536.
      10.      53.4      155.      767.
      12.     102.7      300.     1694.
      14.      685.     1100.     8010.
      16.     1370.     2600.    21727.
  END FTABLE  7

  FTABLE      8
 rows cols                               ***
  18    4
     depth      area    volume  outflow1 ***
       0.        0.        0.        0.
      0.2        3.       0.3        0.
      0.5        6.       1.5        0.
       1.       12.       5.5      0.05
       2.       15.      17.5        3.
       3.       24.       36.       20.
       4.       26.       56.      100.
       5.       29.      82.5      200.
       6.       32.      112.      336.
       8.       36.      180.      585.
      10.       47.      260.      950.
      12.       55.      350.     1440.
      14.       72.      470.     2130.
      16.       78.      600.     2960.
      18.       87.      760.     3980.
      20.     3490.     4500.    30000.
      22.     6980.    12000.   100000.
      25.    28000.    70000.   600000.
  END FTABLE  8

  FTABLE      9
 rows cols                               ***
  18    4
     depth      area    volume  outflow1 ***
       0.        0.        0.        0.
      0.2       3.7      0.37      0.12
      0.4       7.3      1.84       1.9
       1.      10.3        8.      15.5
       2.      11.8      19.8       52.
       3.      12.9      32.6       98.
       4.       14.       47.      165.
       5.      15.4       62.      236.
       6.      16.9       79.      322.
       8.      19.1      117.      542.
      10.       22.      161.      834.
      12.       34.      229.     1308.
      14.       44.      317.     1984.
      16.       48.      412.     2800.
      18.       53.      519.     3800.
      20.     2141.     4800.    37900.
      22.     4282.    13370.   112800.
      25.    17130.    64760.   600000.
  END FTABLE  9
```

```
  FTABLE     10
 rows cols                               ***
   14    4
     depth      area    volume  outflow1 ***
        0.        0.        0.        0.
       0.2       2.7      0.27      0.12
       0.6       3.9      1.82      2.43
        1.        7.       4.6      10.3
        2.       7.8      12.4      27.7
        3.       8.6       21.      46.9
        4.      10.2       31.     83.64
        5.      11.8       43.     163.4
        7.      15.1       73.      392.
        9.      18.8      111.      643.
       10.       42.      153.      920.
       12.      80.7      314.     2033.
       14.      538.     1391.     9613.
       16.     1076.     3543.    26073.
  END FTABLE 10

  FTABLE     11
 rows cols                               ***
   13    4
     depth      area    volume  outflow1 ***
        0.        0.        0.        0.
       0.5       3.1       0.5        0.
        1.       8.2       2.9        0.
        2.       9.1      10.2       0.5
        3.       10.      19.3        5.
        4.      11.9       30.       30.
        5.      13.8       42.      100.
        6.      17.6       57.      200.
        8.       22.       95.      380.
       10.       49.      165.      800.
       12.       94.      285.     1700.
       14.      628.     1000.     7000.
       16.     1256.     2600.    20000.
  END FTABLE 11

  FTABLE     13
 rows cols                               ***
   12    4
     depth      area    volume  outflow1 ***
        0.        0.        0.        0.
       0.5       3.6       0.8        0.
        1.      17.8        6.        0.
        2.       21.      21.5        1.
        3.       27.       44.       20.
        4.      28.5       69.       80.
        5.      29.9       97.      200.
        6.      31.3      127.      400.
        8.      55.5      220.      900.
       10.      107.      380.     1920.
       12.      712.     1300.     8200.
       14.     1423.     3000.    22000.
  END FTABLE 13

  FTABLE     12
 rows cols                               ***
   18    4
     depth      area    volume  outflow1 ***
        0.        0.        0.        0.
```

```
      0.2       4.2      0.42      0.12
       1.       8.4       7.2       12.
       2.      11.8       19.       44.
       3.      13.5      32.5       86.
       4.      14.8      47.2      123.
       5.       16.       63.      195.
       6.      17.7       81.      270.
       8.      19.4      120.      426.
      10.      21.9      164.      660.
      12.      25.3      214.      965.
      14.      33.7      282.     1400.
      16.       51.      383.     2100.
      18.       67.      518.     3100.
      20.      101.      720.     4600.
      22.     2459.     5639.    38800.
      25.     4918.    20394.   150000.
      30.    19674.   118760.   960000.
  END FTABLE 12

  FTABLE     14
 rows cols                               ***
   18    4
     depth      area    volume  outflow1 ***
       0.        0.        0.        0.
      0.2       15.      1.53      0.23
       1.       26.      21.9       20.
       2.       38.      60.2       75.
       3.       61.     121.5      175.
       4.       76.      198.      280.
       5.       92.      290.      480.
       6.      102.      392.      700.
       8.      122.      637.     1200.
      10.      153.      943.     2060.
      12.      179.     1300.     3180.
      14.      189.     1680.     4500.
      16.      204.     2090.     6200.
      18.      255.     2600.     8300.
      20.      510.     3620.    12600.
      22.     2975.     9600.    36000.
      25.     5950.    27400.   109000.
      30.    23800.   146400.   860000.
  END FTABLE 14

  FTABLE     15
 rows cols                               ***
   12    4
     depth      area    volume  outflow1 ***
       0.        0.        0.        0.
      0.5       2.8       0.5        0.
       1.      13.9       7.5      0.05
       2.      14.5       22.       39.
       3.      15.1       37.       66.
       4.      15.1       52.      112.
       5.      15.1       67.      205.
       6.      15.1       82.      354.
       8.      43.5      169.      789.
      10.      83.6      336.     1750.
      12.      558.     1452.     7800.
      14.     1115.     3682.    19800.
  END FTABLE 15

  FTABLE     16
 rows cols                               ***
```

```
  18    4
    depth      area    volume  outflow1 ***
       0.        0.        0.        0.
      0.2       9.4      0.94       0.1
       1.      15.7      13.5       31.
       2.      23.5       37.      114.
       3.      31.4       68.      244.
       4.      37.7      106.      372.
       5.      40.8      147.      608.
       6.       44.      191.      850.
       8.       47.      285.     1360.
      10.       50.      386.     2090.
      12.       53.      492.     2980.
      14.       56.      605.     4050.
      16.       63.      731.     5350.
      18.       69.      869.     6920.
      20.       94.     1057.     9090.
      22.     1830.     4718.    43580.
      25.     3660.    15700.   155000.
      30.    14640.    88900.   963000.
 END FTABLE 16

 FTABLE     17
rows cols                              ***
  18    4
    depth      area    volume  outflow1 ***
       0.        0.        0.        0.
      0.2       11.       1.1       0.1
       1.      18.3      15.7       28.
       2.      25.6      41.4       99.
       3.       33.      74.3      205.
       4.       40.      115.      310.
       5.       48.      162.      520.
       6.       55.      217.      750.
       8.       62.      342.     1260.
      10.       77.      495.     2070.
      12.       95.      686.     3200.
      14.      110.      905.     4700.
      16.      128.     1160.     6600.
      18.      183.     1530.     9400.
      20.      366.     2260.    15000.
      22.     2134.     6530.    47000.
      25.     4270.    19330.   147000.
      30.    17070.   105000.   875000.
 END FTABLE 17

 FTABLE     18
rows cols                              ***
  18    4
    depth      area    volume  outflow1 ***
       0.        0.        0.        0.
      0.2      11.6       1.2       0.1
       1.      19.4      16.7       28.
       2.      29.1      45.8      103.
       3.      46.5      92.3      240.
       4.      58.2      151.      384.
       5.      69.8      220.      665.
       6.      77.6      298.      968.
       8.      93.1      484.     1680.
      10.      101.      686.     2700.
      12.      109.      903.     4000.
      14.      116.     1140.     5500.
      16.      136.     1410.     7500.
```

```
       18.      194.     1800.    10400.
       20.      388.     2570.    16100.
       22.     2260.     7090.    47700.
       25.     4523.    20660.   149000.
       30.    18090.   111111.   877000.
  END FTABLE 18
END FTABLES

COPY
  TIMESERIES
  Copy-opn***
*** x -  x  NPT  NMN
    1   18    0    7
  END TIMESERIES

END COPY

EXT SOURCES
<-Volume-> <Member> SsysSgap<--Mult-->Tran <-Target vols> <-Grp> <-Member-> ***
<Name>   x <Name> x tem strg<-factor->strg <Name>   x   x        <Name> x x ***
*** Met Seg EVADALE
WDM2    35 PREC     ENGL              SAME PERLND 101 117 EXTNL  PREC
WDM2    36 ATEM     ENGL              SAME PERLND 101 117 EXTNL  GATMP
WDM2    39 DEWP     ENGL              SAME PERLND 101 117 EXTNL  DTMPG
WDM2    38 WIND     ENGL              SAME PERLND 101 117 EXTNL  WINMOV
WDM2    40 SOLR     ENGL              SAME PERLND 101 117 EXTNL  SOLRAD
WDM2    42 PEVT     ENGL              SAME PERLND 101 117 EXTNL  PETINP
*** Met Seg EVADALE
WDM2    35 PREC     ENGL              SAME IMPLND 101 104 EXTNL  PREC
WDM2    36 ATEM     ENGL              SAME IMPLND 101 104 EXTNL  GATMP
WDM2    39 DEWP     ENGL              SAME IMPLND 101 104 EXTNL  DTMPG
WDM2    38 WIND     ENGL              SAME IMPLND 101 104 EXTNL  WINMOV
WDM2    40 SOLR     ENGL              SAME IMPLND 101 104 EXTNL  SOLRAD
WDM2    42 PEVT     ENGL              SAME IMPLND 101 104 EXTNL  PETINP
*** Met Seg BPT
WDM2    35 PREC     ENGL              SAME RCHRES   1  18 EXTNL  PREC
WDM2    36 ATEM     ENGL              SAME RCHRES   1  18 EXTNL  GATMP
WDM2    39 DEWP     ENGL              SAME RCHRES   1  18 EXTNL  DEWTMP
WDM2    38 WIND     ENGL              SAME RCHRES   1  18 EXTNL  WIND
WDM2    40 SOLR     ENGL              SAME RCHRES   1  18 EXTNL  SOLRAD
WDM2    41 CLOU     ENGL              SAME RCHRES   1  18 EXTNL  CLOUD
WDM2    43 EVAP     ENGL              SAME RCHRES   1  18 EXTNL  POTEV

WDM3  8111 BOD      ENGL          47.9DIV  RCHRES   1     INFLOW OXIF   2
WDM3  8112 TSS      ENGL          47.9DIV  RCHRES   1     INFLOW ISED   2
WDM3  8114 DNH3     ENGL          47.9DIV  RCHRES   1     INFLOW NUIF1  2
WDM3  8115 DPO4     ENGL          47.9DIV  RCHRES   1     INFLOW NUIF1  4
WDM3  7001 FLOW     ENGL          0.13DIV  RCHRES   1     INFLOW IVOL
WDM3  7002 BOD      ENGL          8.36DIV  RCHRES   1     INFLOW OXIF   2
WDM3  7003 DNH3     ENGL          3.08DIV  RCHRES   1     INFLOW NUIF1  2
WDM3  7004 ORGN     ENGL          5.12DIV  RCHRES   1     INFLOW PKIF   3
WDM3  7005 DO       ENGL          5.42DIV  RCHRES   1     INFLOW OXIF   1
WDM3  8111 BOD      ENGL          14.6DIV  RCHRES   2     INFLOW OXIF   2
WDM3  8112 TSS      ENGL          14.6DIV  RCHRES   2     INFLOW ISED   2
WDM3  8114 DNH3     ENGL          14.6DIV  RCHRES   2     INFLOW NUIF1  2
WDM3  8115 DPO4     ENGL          14.6DIV  RCHRES   2     INFLOW NUIF1  4
WDM3  7001 FLOW     ENGL          0.00DIV  RCHRES   2     INFLOW IVOL
WDM3  7002 BOD      ENGL          0.00DIV  RCHRES   2     INFLOW OXIF   2
WDM3  7003 DNH3     ENGL          0.00DIV  RCHRES   2     INFLOW NUIF1  2
WDM3  7004 ORGN     ENGL          0.00DIV  RCHRES   2     INFLOW PKIF   3
WDM3  7005 DO       ENGL          0.00DIV  RCHRES   2     INFLOW OXIF   1
WDM3  8111 BOD      ENGL           9.4DIV  RCHRES   3     INFLOW OXIF   2
WDM3  8112 TSS      ENGL           9.4DIV  RCHRES   3     INFLOW ISED   2
```

```
WDM3  8114 DNH3     ENGL            9.4DIV  RCHRES   3     INFLOW NUIF1  2
WDM3  8115 DPO4     ENGL            9.4DIV  RCHRES   3     INFLOW NUIF1  4
WDM3  7001 FLOW     ENGL          0.000DIV  RCHRES   3     INFLOW IVOL
WDM3  7002 BOD      ENGL            0.0DIV  RCHRES   3     INFLOW OXIF   2
WDM3  7003 DNH3     ENGL            0.0DIV  RCHRES   3     INFLOW NUIF1  2
WDM3  7004 ORGN     ENGL            0.0DIV  RCHRES   3     INFLOW PKIF   3
WDM3  7005 DO       ENGL            0.0DIV  RCHRES   3     INFLOW OXIF   1
WDM3  8111 BOD      ENGL           48.6DIV  RCHRES   4     INFLOW OXIF   2
WDM3  8112 TSS      ENGL           48.6DIV  RCHRES   4     INFLOW ISED   2
WDM3  8114 DNH3     ENGL           48.6DIV  RCHRES   4     INFLOW NUIF1  2
WDM3  8115 DPO4     ENGL           48.6DIV  RCHRES   4     INFLOW NUIF1  4
WDM3  7001 FLOW     ENGL          0.000DIV  RCHRES   4     INFLOW IVOL
WDM3  7002 BOD      ENGL            0.0DIV  RCHRES   4     INFLOW OXIF   2
WDM3  7003 DNH3     ENGL            0.0DIV  RCHRES   4     INFLOW NUIF1  2
WDM3  7004 ORGN     ENGL            0.0DIV  RCHRES   4     INFLOW PKIF   3
WDM3  7005 DO       ENGL            0.0DIV  RCHRES   4     INFLOW OXIF   1
WDM3  8111 BOD      ENGL           28.7DIV  RCHRES   5     INFLOW OXIF   2
WDM3  8112 TSS      ENGL           28.7DIV  RCHRES   5     INFLOW ISED   2
WDM3  8114 DNH3     ENGL           28.7DIV  RCHRES   5     INFLOW NUIF1  2
WDM3  8115 DPO4     ENGL           28.7DIV  RCHRES   5     INFLOW NUIF1  4
WDM3  7001 FLOW     ENGL          0.000DIV  RCHRES   5     INFLOW IVOL
WDM3  7002 BOD      ENGL            0.0DIV  RCHRES   5     INFLOW OXIF   2
WDM3  7003 DNH3     ENGL            0.0DIV  RCHRES   5     INFLOW NUIF1  2
WDM3  7004 ORGN     ENGL            0.0DIV  RCHRES   5     INFLOW PKIF   3
WDM3  7005 DO       ENGL            0.0DIV  RCHRES   5     INFLOW OXIF   1
WDM3  8111 BOD      ENGL           90.0DIV  RCHRES   6     INFLOW OXIF   2
WDM3  8112 TSS      ENGL           90.0DIV  RCHRES   6     INFLOW ISED   2
WDM3  8114 DNH3     ENGL           90.0DIV  RCHRES   6     INFLOW NUIF1  2
WDM3  8115 DPO4     ENGL           90.0DIV  RCHRES   6     INFLOW NUIF1  4
WDM3  7001 FLOW     ENGL          0.000DIV  RCHRES   6     INFLOW IVOL
WDM3  7002 BOD      ENGL            0.0DIV  RCHRES   6     INFLOW OXIF   2
WDM3  7003 DNH3     ENGL            0.0DIV  RCHRES   6     INFLOW NUIF1  2
WDM3  7004 ORGN     ENGL            0.0DIV  RCHRES   6     INFLOW PKIF   3
WDM3  7005 DO       ENGL            0.0DIV  RCHRES   6     INFLOW OXIF   1
WDM3  8111 BOD      ENGL           54.6DIV  RCHRES   7     INFLOW OXIF   2
WDM3  8112 TSS      ENGL           54.6DIV  RCHRES   7     INFLOW ISED   2
WDM3  8114 DNH3     ENGL           54.6DIV  RCHRES   7     INFLOW NUIF1  2
WDM3  8115 DPO4     ENGL           54.6DIV  RCHRES   7     INFLOW NUIF1  4
WDM3  7001 FLOW     ENGL          0.000DIV  RCHRES   7     INFLOW IVOL
WDM3  7002 BOD      ENGL            0.0DIV  RCHRES   7     INFLOW OXIF   2
WDM3  7003 DNH3     ENGL            0.0DIV  RCHRES   7     INFLOW NUIF1  2
WDM3  7004 ORGN     ENGL            0.0DIV  RCHRES   7     INFLOW PKIF   3
WDM3  7005 DO       ENGL            0.0DIV  RCHRES   7     INFLOW OXIF   1
WDM3  8111 BOD      ENGL           68.7DIV  RCHRES   8     INFLOW OXIF   2
WDM3  8112 TSS      ENGL           68.7DIV  RCHRES   8     INFLOW ISED   2
WDM3  8114 DNH3     ENGL           68.7DIV  RCHRES   8     INFLOW NUIF1  2
WDM3  8115 DPO4     ENGL           68.7DIV  RCHRES   8     INFLOW NUIF1  4
WDM3  7001 FLOW     ENGL          0.000DIV  RCHRES   8     INFLOW IVOL
WDM3  7002 BOD      ENGL            0.0DIV  RCHRES   8     INFLOW OXIF   2
WDM3  7003 DNH3     ENGL            0.0DIV  RCHRES   8     INFLOW NUIF1  2
WDM3  7004 ORGN     ENGL            0.0DIV  RCHRES   8     INFLOW PKIF   3
WDM3  7005 DO       ENGL            0.0DIV  RCHRES   8     INFLOW OXIF   1
WDM3  8111 BOD      ENGL           14.1DIV  RCHRES   9     INFLOW OXIF   2
WDM3  8112 TSS      ENGL           14.1DIV  RCHRES   9     INFLOW ISED   2
WDM3  8114 DNH3     ENGL           14.1DIV  RCHRES   9     INFLOW NUIF1  2
WDM3  8115 DPO4     ENGL           14.1DIV  RCHRES   9     INFLOW NUIF1  4
WDM3  7001 FLOW     ENGL          0.000DIV  RCHRES   9     INFLOW IVOL
WDM3  7002 BOD      ENGL            0.0DIV  RCHRES   9     INFLOW OXIF   2
WDM3  7003 DNH3     ENGL            0.0DIV  RCHRES   9     INFLOW NUIF1  2
WDM3  7004 ORGN     ENGL            0.0DIV  RCHRES   9     INFLOW PKIF   3
WDM3  7005 DO       ENGL            0.0DIV  RCHRES   9     INFLOW OXIF   1
WDM3  8111 BOD      ENGL            8.1DIV  RCHRES  10     INFLOW OXIF   2
WDM3  8112 TSS      ENGL            8.1DIV  RCHRES  10     INFLOW ISED   2
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WDM3  8114 DNH3     ENGL           8.1DIV  RCHRES  10     INFLOW NUIF1  2
WDM3  8115 DPO4     ENGL           8.1DIV  RCHRES  10     INFLOW NUIF1  4
WDM3  7001 FLOW     ENGL         0.000DIV  RCHRES  10     INFLOW IVOL
WDM3  7002 BOD      ENGL           0.0DIV  RCHRES  10     INFLOW OXIF   2
WDM3  7003 DNH3     ENGL           0.0DIV  RCHRES  10     INFLOW NUIF1  2
WDM3  7004 ORGN     ENGL           0.0DIV  RCHRES  10     INFLOW PKIF   3
WDM3  7005 DO       ENGL           0.0DIV  RCHRES  10     INFLOW OXIF   1
WDM3  8111 BOD      ENGL           4.4DIV  RCHRES  11     INFLOW OXIF   2
WDM3  8112 TSS      ENGL           4.4DIV  RCHRES  11     INFLOW ISED   2
WDM3  8114 DNH3     ENGL           4.4DIV  RCHRES  11     INFLOW NUIF1  2
WDM3  8115 DPO4     ENGL           4.4DIV  RCHRES  11     INFLOW NUIF1  4
WDM3  7001 FLOW     ENGL          0.20DIV  RCHRES  11     INFLOW IVOL
WDM3  7002 BOD      ENGL         14.28DIV  RCHRES  11     INFLOW OXIF   2
WDM3  7003 DNH3     ENGL          1.70DIV  RCHRES  11     INFLOW NUIF1  2
WDM3  7004 ORGN     ENGL          1.39DIV  RCHRES  11     INFLOW PKIF   3
WDM3  7005 DO       ENGL          3.40DIV  RCHRES  11     INFLOW OXIF   1
WDM3  8111 BOD      ENGL           2.7DIV  RCHRES  12     INFLOW OXIF   2
WDM3  8112 TSS      ENGL           2.7DIV  RCHRES  12     INFLOW ISED   2
WDM3  8114 DNH3     ENGL           2.7DIV  RCHRES  12     INFLOW NUIF1  2
WDM3  8115 DPO4     ENGL           2.7DIV  RCHRES  12     INFLOW NUIF1  4
WDM3  7001 FLOW     ENGL         0.000DIV  RCHRES  12     INFLOW IVOL
WDM3  7002 BOD      ENGL           0.0DIV  RCHRES  12     INFLOW OXIF   2
WDM3  7003 DNH3     ENGL           0.0DIV  RCHRES  12     INFLOW NUIF1  2
WDM3  7004 ORGN     ENGL           0.0DIV  RCHRES  12     INFLOW PKIF   3
WDM3  7005 DO       ENGL           0.0DIV  RCHRES  12     INFLOW OXIF   1
WDM3  8111 BOD      ENGL          48.9DIV  RCHRES  13     INFLOW OXIF   2
WDM3  8112 TSS      ENGL          48.9DIV  RCHRES  13     INFLOW ISED   2
WDM3  8114 DNH3     ENGL          48.9DIV  RCHRES  13     INFLOW NUIF1  2
WDM3  8115 DPO4     ENGL          48.9DIV  RCHRES  13     INFLOW NUIF1  4
WDM3  7001 FLOW     ENGL         0.000DIV  RCHRES  13     INFLOW IVOL
WDM3  7002 BOD      ENGL           0.0DIV  RCHRES  13     INFLOW OXIF   2
WDM3  7003 DNH3     ENGL           0.0DIV  RCHRES  13     INFLOW NUIF1  2
WDM3  7004 ORGN     ENGL           0.0DIV  RCHRES  13     INFLOW PKIF   3
WDM3  7005 DO       ENGL           0.0DIV  RCHRES  13     INFLOW OXIF   1
WDM3  8111 BOD      ENGL           3.7DIV  RCHRES  14     INFLOW OXIF   2
WDM3  8112 TSS      ENGL           3.7DIV  RCHRES  14     INFLOW ISED   2
WDM3  8114 DNH3     ENGL           3.7DIV  RCHRES  14     INFLOW NUIF1  2
WDM3  8115 DPO4     ENGL           3.7DIV  RCHRES  14     INFLOW NUIF1  4
WDM3  7001 FLOW     ENGL         0.000DIV  RCHRES  14     INFLOW IVOL
WDM3  7002 BOD      ENGL           0.0DIV  RCHRES  14     INFLOW OXIF   2
WDM3  7003 DNH3     ENGL           0.0DIV  RCHRES  14     INFLOW NUIF1  2
WDM3  7004 ORGN     ENGL           0.0DIV  RCHRES  14     INFLOW PKIF   3
WDM3  7005 DO       ENGL           0.0DIV  RCHRES  14     INFLOW OXIF   1
WDM3  8111 BOD      ENGL          18.9DIV  RCHRES  15     INFLOW OXIF   2
WDM3  8112 TSS      ENGL          18.9DIV  RCHRES  15     INFLOW ISED   2
WDM3  8114 DNH3     ENGL          18.9DIV  RCHRES  15     INFLOW NUIF1  2
WDM3  8115 DPO4     ENGL          18.9DIV  RCHRES  15     INFLOW NUIF1  4
WDM3  7001 FLOW     ENGL         0.000DIV  RCHRES  15     INFLOW IVOL
WDM3  7002 BOD      ENGL           0.0DIV  RCHRES  15     INFLOW OXIF   2
WDM3  7003 DNH3     ENGL           0.0DIV  RCHRES  15     INFLOW NUIF1  2
WDM3  7004 ORGN     ENGL           0.0DIV  RCHRES  15     INFLOW PKIF   3
WDM3  7005 DO       ENGL           0.0DIV  RCHRES  15     INFLOW OXIF   1
WDM3  8111 BOD      ENGL          27.2DIV  RCHRES  16     INFLOW OXIF   2
WDM3  8112 TSS      ENGL          27.2DIV  RCHRES  16     INFLOW ISED   2
WDM3  8114 DNH3     ENGL          27.2DIV  RCHRES  16     INFLOW NUIF1  2
WDM3  8115 DPO4     ENGL          27.2DIV  RCHRES  16     INFLOW NUIF1  4
WDM3  7001 FLOW     ENGL         0.000DIV  RCHRES  16     INFLOW IVOL
WDM3  7002 BOD      ENGL           0.0DIV  RCHRES  16     INFLOW OXIF   2
WDM3  7003 DNH3     ENGL           0.0DIV  RCHRES  16     INFLOW NUIF1  2
WDM3  7004 ORGN     ENGL           0.0DIV  RCHRES  16     INFLOW PKIF   3
WDM3  7005 DO       ENGL           0.0DIV  RCHRES  16     INFLOW OXIF   1
WDM3  8111 BOD      ENGL          10.3DIV  RCHRES  17     INFLOW OXIF   2
WDM3  8112 TSS      ENGL          10.3DIV  RCHRES  17     INFLOW ISED   2
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WDM3  8114 DNH3     ENGL          10.3DIV  RCHRES  17     INFLOW NUIF1  2
WDM3  8115 DPO4     ENGL          10.3DIV  RCHRES  17     INFLOW NUIF1  4
WDM3  7001 FLOW     ENGL         0.000DIV  RCHRES  17     INFLOW IVOL
WDM3  7002 BOD      ENGL           0.0DIV  RCHRES  17     INFLOW OXIF   2
WDM3  7003 DNH3     ENGL           0.0DIV  RCHRES  17     INFLOW NUIF1  2
WDM3  7004 ORGN     ENGL           0.0DIV  RCHRES  17     INFLOW PKIF   3
WDM3  7005 DO       ENGL           0.0DIV  RCHRES  17     INFLOW OXIF   1
WDM3  8111 BOD      ENGL           3.5DIV  RCHRES  18     INFLOW OXIF   2
WDM3  8112 TSS      ENGL           3.5DIV  RCHRES  18     INFLOW ISED   2
WDM3  8114 DNH3     ENGL           3.5DIV  RCHRES  18     INFLOW NUIF1  2
WDM3  8115 DPO4     ENGL           3.5DIV  RCHRES  18     INFLOW NUIF1  4
WDM3  7001 FLOW     ENGL         0.000DIV  RCHRES  18     INFLOW IVOL
WDM3  7002 BOD      ENGL           0.0DIV  RCHRES  18     INFLOW OXIF   2
WDM3  7003 DNH3     ENGL           0.0DIV  RCHRES  18     INFLOW NUIF1  2
WDM3  7004 ORGN     ENGL           0.0DIV  RCHRES  18     INFLOW PKIF   3
WDM3  7005 DO       ENGL           0.0DIV  RCHRES  18     INFLOW OXIF   1
*** 6205 and 6206 are atmospheric deposition loads of NH3-N and NO3-N
WDM3  7306 NO3N     ENGL              DIV  PERLND 101     EXTNL  PQADFX 2 1
WDM3  7305 NH3N     ENGL              DIV  PERLND 101     EXTNL  PQADFX 1 1
WDM3  7306 NO3N     ENGL              DIV  PERLND 102     EXTNL  PQADFX 2 1
WDM3  7305 NH3N     ENGL              DIV  PERLND 102     EXTNL  PQADFX 1 1
WDM3  7306 NO3N     ENGL              DIV  PERLND 103     EXTNL  PQADFX 2 1
WDM3  7305 NH3N     ENGL              DIV  PERLND 103     EXTNL  PQADFX 1 1
WDM3  7306 NO3N     ENGL              DIV  PERLND 104     EXTNL  PQADFX 2 1
WDM3  7305 NH3N     ENGL              DIV  PERLND 104     EXTNL  PQADFX 1 1
WDM3  7306 NO3N     ENGL              DIV  PERLND 105     EXTNL  PQADFX 2 1
WDM3  7305 NH3N     ENGL              DIV  PERLND 105     EXTNL  PQADFX 1 1
WDM3  7306 NO3N     ENGL              DIV  PERLND 106     EXTNL  PQADFX 2 1
WDM3  7305 NH3N     ENGL              DIV  PERLND 106     EXTNL  PQADFX 1 1
WDM3  7306 NO3N     ENGL              DIV  PERLND 107     EXTNL  PQADFX 2 1
WDM3  7305 NH3N     ENGL              DIV  PERLND 107     EXTNL  PQADFX 1 1
WDM3  7306 NO3N     ENGL              DIV  PERLND 108     EXTNL  PQADFX 2 1
WDM3  7305 NH3N     ENGL              DIV  PERLND 108     EXTNL  PQADFX 1 1
WDM3  7306 NO3N     ENGL              DIV  PERLND 109     EXTNL  PQADFX 2 1
WDM3  7305 NH3N     ENGL              DIV  PERLND 109     EXTNL  PQADFX 1 1
WDM3  7306 NO3N     ENGL              DIV  PERLND 110     EXTNL  PQADFX 2 1
WDM3  7305 NH3N     ENGL              DIV  PERLND 110     EXTNL  PQADFX 1 1
WDM3  7306 NO3N     ENGL              DIV  PERLND 111     EXTNL  PQADFX 2 1
WDM3  7305 NH3N     ENGL              DIV  PERLND 111     EXTNL  PQADFX 1 1
WDM3  7306 NO3N     ENGL              DIV  PERLND 112     EXTNL  PQADFX 2 1
WDM3  7305 NH3N     ENGL              DIV  PERLND 112     EXTNL  PQADFX 1 1
WDM3  7306 NO3N     ENGL              DIV  PERLND 113     EXTNL  PQADFX 2 1
WDM3  7305 NH3N     ENGL              DIV  PERLND 113     EXTNL  PQADFX 1 1
WDM3  7306 NO3N     ENGL              DIV  PERLND 114     EXTNL  PQADFX 2 1
WDM3  7305 NH3N     ENGL              DIV  PERLND 114     EXTNL  PQADFX 1 1
WDM3  7306 NO3N     ENGL              DIV  PERLND 115     EXTNL  PQADFX 2 1
WDM3  7305 NH3N     ENGL              DIV  PERLND 115     EXTNL  PQADFX 1 1
WDM3  7306 NO3N     ENGL              DIV  PERLND 116     EXTNL  PQADFX 2 1
WDM3  7305 NH3N     ENGL              DIV  PERLND 116     EXTNL  PQADFX 1 1
WDM3  7306 NO3N     ENGL              DIV  PERLND 117     EXTNL  PQADFX 2 1
WDM3  7305 NH3N     ENGL              DIV  PERLND 117     EXTNL  PQADFX 1 1
WDM3  7306 NO3N     ENGL              DIV  IMPLND 101     EXTNL  IQADFX 2 1
WDM3  7305 NH3N     ENGL              DIV  IMPLND 101     EXTNL  IQADFX 1 1
WDM3  7306 NO3N     ENGL              DIV  IMPLND 102     EXTNL  IQADFX 2 1
WDM3  7305 NH3N     ENGL              DIV  IMPLND 102     EXTNL  IQADFX 1 1
WDM3  7306 NO3N     ENGL              DIV  IMPLND 103     EXTNL  IQADFX 2 1
WDM3  7305 NH3N     ENGL              DIV  IMPLND 103     EXTNL  IQADFX 1 1
WDM3  7306 NO3N     ENGL              DIV  IMPLND 104     EXTNL  IQADFX 2 1
WDM3  7305 NH3N     ENGL              DIV  IMPLND 104     EXTNL  IQADFX 1 1
***FAILING OSSF LOADS TO PERLND 116
*** 0.9 multiplier is fraction of failing septic effluent to PERLND 116 surface
WDM3  8111 BOD      ENGL           0.9DIV  PERLND 116     EXTNL  SLIQO  4
WDM3  8112 TSS      ENGL           0.9DIV  PERLND 116     EXTNL  SLSED  1
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WDM3  8113 FLOW     ENGL           0.9DIV  PERLND 116     EXTNL  SURLI  1
WDM3  8114 DNH3     ENGL           0.9DIV  PERLND 116     EXTNL  SLIQO  1
WDM3  8115 DPO4     ENGL           0.9DIV  PERLND 116     EXTNL  SLIQO  3
END EXT SOURCES

SCHEMATIC
<-Volume->                  <--Area-->     <-Volume->  <ML#> ***       <sb>
<Name>   x                  <-factor->     <Name>   x        ***        x x
PERLND 101                         894     RCHRES   1      2
PERLND 102                         373     RCHRES   1      2
PERLND 103                          71     RCHRES   1      2
PERLND 104                           6     RCHRES   1      2
PERLND 105                          16     RCHRES   1      2
PERLND 106                           0     RCHRES   1      2
PERLND 107                        3107     RCHRES   1      2
PERLND 108                        1845     RCHRES   1      2
PERLND 109                        1663     RCHRES   1      2
PERLND 110                         271     RCHRES   1      2
PERLND 111                        1866     RCHRES   1      2
PERLND 112                        1858     RCHRES   1      2
PERLND 113                           8     RCHRES   1      2
PERLND 114                        5260     RCHRES   1      2
PERLND 115                          62     RCHRES   1      2
PERLND 116                          48     RCHRES   1      2
PERLND 117                           0     RCHRES   1      2
IMPLND 101                         110     RCHRES   1      1
IMPLND 102                         180     RCHRES   1      1
IMPLND 103                         115     RCHRES   1      1
IMPLND 104                          48     RCHRES   1      1
PERLND 101                         419     RCHRES   2      2
PERLND 102                          89     RCHRES   2      2
PERLND 103                           0     RCHRES   2      2
PERLND 104                           0     RCHRES   2      2
PERLND 105                           0     RCHRES   2      2
PERLND 106                           0     RCHRES   2      2
PERLND 107                        2702     RCHRES   2      2
PERLND 108                        1251     RCHRES   2      2
PERLND 109                         344     RCHRES   2      2
PERLND 110                          17     RCHRES   2      2
PERLND 111                        1252     RCHRES   2      2
PERLND 112                        1499     RCHRES   2      2
PERLND 113                           6     RCHRES   2      2
PERLND 114                        5553     RCHRES   2      2
PERLND 115                         145     RCHRES   2      2
PERLND 116                          15     RCHRES   2      2
PERLND 117                           0     RCHRES   2      2
IMPLND 101                          52     RCHRES   2      1
IMPLND 102                          44     RCHRES   2      1
IMPLND 103                           1     RCHRES   2      1
IMPLND 104                           0     RCHRES   2      1
PERLND 101                         195     RCHRES   3      2
PERLND 102                          22     RCHRES   3      2
PERLND 103                           3     RCHRES   3      2
PERLND 104                           0     RCHRES   3      2
PERLND 105                           0     RCHRES   3      2
PERLND 106                           0     RCHRES   3      2
PERLND 107                        2173     RCHRES   3      2
PERLND 108                         556     RCHRES   3      2
PERLND 109                         173     RCHRES   3      2
PERLND 110                          16     RCHRES   3      2
PERLND 111                        1045     RCHRES   3      2
PERLND 112                         550     RCHRES   3      2
PERLND 113                           1     RCHRES   3      2
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PERLND 114                      5181     RCHRES   3      2
PERLND 115                        68     RCHRES   3      2
PERLND 116                         9     RCHRES   3      2
PERLND 117                         0     RCHRES   3      2
IMPLND 101                        24     RCHRES   3      1
IMPLND 102                        14     RCHRES   3      1
IMPLND 103                         6     RCHRES   3      1
IMPLND 104                         0     RCHRES   3      1
RCHRES   1                               RCHRES   3      3
PERLND 101                       709     RCHRES   4      5
PERLND 102                       166     RCHRES   4      5
PERLND 103                         2     RCHRES   4      5
PERLND 104                         0     RCHRES   4      5
PERLND 105                         3     RCHRES   4      5
PERLND 106                         3     RCHRES   4      5
PERLND 107                      1679     RCHRES   4      5
PERLND 108                      1521     RCHRES   4      5
PERLND 109                       297     RCHRES   4      5
PERLND 110                        76     RCHRES   4      5
PERLND 111                       785     RCHRES   4      5
PERLND 112                       405     RCHRES   4      5
PERLND 113                         8     RCHRES   4      5
PERLND 114                      6371     RCHRES   4      5
PERLND 115                       227     RCHRES   4      5
PERLND 116                        49     RCHRES   4      5
PERLND 117                         0     RCHRES   4      5
IMPLND 101                        88     RCHRES   4      4
IMPLND 102                        92     RCHRES   4      4
IMPLND 103                         4     RCHRES   4      4
IMPLND 104                         2     RCHRES   4      4
RCHRES   2                               RCHRES   4      3
RCHRES   3                               RCHRES   4      3
PERLND 101                       370     RCHRES   5      7
PERLND 102                        40     RCHRES   5      7
PERLND 103                         7     RCHRES   5      7
PERLND 104                         0     RCHRES   5      7
PERLND 105                         3     RCHRES   5      7
PERLND 106                         6     RCHRES   5      7
PERLND 107                      1503     RCHRES   5      7
PERLND 108                      1054     RCHRES   5      7
PERLND 109                        61     RCHRES   5      7
PERLND 110                         7     RCHRES   5      7
PERLND 111                       807     RCHRES   5      7
PERLND 112                      1085     RCHRES   5      7
PERLND 113                         0     RCHRES   5      7
PERLND 114                      3501     RCHRES   5      7
PERLND 115                        41     RCHRES   5      7
PERLND 116                        29     RCHRES   5      7
PERLND 117                         0     RCHRES   5      7
IMPLND 101                        46     RCHRES   5      6
IMPLND 102                        29     RCHRES   5      6
IMPLND 103                        11     RCHRES   5      6
IMPLND 104                         0     RCHRES   5      6
PERLND 101                       755     RCHRES   6      7
PERLND 102                       250     RCHRES   6      7
PERLND 103                        43     RCHRES   6      7
PERLND 104                         6     RCHRES   6      7
PERLND 105                         2     RCHRES   6      7
PERLND 106                         0     RCHRES   6      7
PERLND 107                       228     RCHRES   6      7
PERLND 108                      1130     RCHRES   6      7
PERLND 109                        71     RCHRES   6      7
PERLND 110                        33     RCHRES   6      7
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PERLND 111                          403     RCHRES   6       7
PERLND 112                          222     RCHRES   6       7
PERLND 113                            8     RCHRES   6       7
PERLND 114                         1453     RCHRES   6       7
PERLND 115                            9     RCHRES   6       7
PERLND 116                           90     RCHRES   6       7
PERLND 117                            0     RCHRES   6       7
IMPLND 101                           93     RCHRES   6       6
IMPLND 102                          146     RCHRES   6       6
IMPLND 103                           70     RCHRES   6       6
IMPLND 104                           51     RCHRES   6       6
RCHRES   5                                  RCHRES   6       3
PERLND 101                          634     RCHRES   7       9
PERLND 102                          232     RCHRES   7       9
PERLND 103                           28     RCHRES   7       9
PERLND 104                            2     RCHRES   7       9
PERLND 105                            4     RCHRES   7       9
PERLND 106                            0     RCHRES   7       9
PERLND 107                          557     RCHRES   7       9
PERLND 108                         1072     RCHRES   7       9
PERLND 109                         1982     RCHRES   7       9
PERLND 110                           43     RCHRES   7       9
PERLND 111                          455     RCHRES   7       9
PERLND 112                          602     RCHRES   7       9
PERLND 113                           17     RCHRES   7       9
PERLND 114                         2212     RCHRES   7       9
PERLND 115                          133     RCHRES   7       9
PERLND 116                           55     RCHRES   7       9
PERLND 117                            0     RCHRES   7       9
IMPLND 101                           78     RCHRES   7       8
IMPLND 102                          123     RCHRES   7       8
IMPLND 103                           46     RCHRES   7       8
IMPLND 104                           13     RCHRES   7       8
PERLND 101                          781     RCHRES   8      11
PERLND 102                          202     RCHRES   8      11
PERLND 103                           14     RCHRES   8      11
PERLND 104                            0     RCHRES   8      11
PERLND 105                            3     RCHRES   8      11
PERLND 106                           44     RCHRES   8      11
PERLND 107                         1785     RCHRES   8      11
PERLND 108                         3009     RCHRES   8      11
PERLND 109                          512     RCHRES   8      11
PERLND 110                           46     RCHRES   8      11
PERLND 111                          689     RCHRES   8      11
PERLND 112                          935     RCHRES   8      11
PERLND 113                           46     RCHRES   8      11
PERLND 114                         3202     RCHRES   8      11
PERLND 115                          164     RCHRES   8      11
PERLND 116                           69     RCHRES   8      11
PERLND 117                            0     RCHRES   8      11
IMPLND 101                           97     RCHRES   8      10
IMPLND 102                          116     RCHRES   8      10
IMPLND 103                           24     RCHRES   8      10
IMPLND 104                            2     RCHRES   8      10
RCHRES   4                                  RCHRES   8       3
PERLND 101                          151     RCHRES   9      13
PERLND 102                           83     RCHRES   9      13
PERLND 103                           23     RCHRES   9      13
PERLND 104                            0     RCHRES   9      13
PERLND 105                            0     RCHRES   9      13
PERLND 106                            0     RCHRES   9      13
PERLND 107                          161     RCHRES   9      13
PERLND 108                          271     RCHRES   9      13
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PERLND 109                         347     RCHRES   9      13
PERLND 110                          17     RCHRES   9      13
PERLND 111                          77     RCHRES   9      13
PERLND 112                         133     RCHRES   9      13
PERLND 113                           0     RCHRES   9      13
PERLND 114                        1491     RCHRES   9      13
PERLND 115                          46     RCHRES   9      13
PERLND 116                          14     RCHRES   9      13
PERLND 117                           0     RCHRES   9      13
IMPLND 101                          19     RCHRES   9      12
IMPLND 102                          42     RCHRES   9      12
IMPLND 103                          37     RCHRES   9      12
IMPLND 104                           1     RCHRES   9      12
RCHRES   8                                 RCHRES   9       3
PERLND 101                          33     RCHRES  10       9
PERLND 102                          68     RCHRES  10       9
PERLND 103                           6     RCHRES  10       9
PERLND 104                           0     RCHRES  10       9
PERLND 105                           0     RCHRES  10       9
PERLND 106                          12     RCHRES  10       9
PERLND 107                         224     RCHRES  10       9
PERLND 108                          36     RCHRES  10       9
PERLND 109                         172     RCHRES  10       9
PERLND 110                          10     RCHRES  10       9
PERLND 111                          30     RCHRES  10       9
PERLND 112                           9     RCHRES  10       9
PERLND 113                           0     RCHRES  10       9
PERLND 114                        1484     RCHRES  10       9
PERLND 115                          21     RCHRES  10       9
PERLND 116                           8     RCHRES  10       9
PERLND 117                           0     RCHRES  10       9
IMPLND 101                           4     RCHRES  10       8
IMPLND 102                          33     RCHRES  10       8
IMPLND 103                          10     RCHRES  10       8
IMPLND 104                           0     RCHRES  10       8
RCHRES   7                                 RCHRES  10       3
PERLND 101                        1036     RCHRES  11      15
PERLND 102                         647     RCHRES  11      15
PERLND 103                          76     RCHRES  11      15
PERLND 104                           8     RCHRES  11      15
PERLND 105                           0     RCHRES  11      15
PERLND 106                           0     RCHRES  11      15
PERLND 107                         151     RCHRES  11      15
PERLND 108                         254     RCHRES  11      15
PERLND 109                         964     RCHRES  11      15
PERLND 110                          86     RCHRES  11      15
PERLND 111                         210     RCHRES  11      15
PERLND 112                         192     RCHRES  11      15
PERLND 113                          39     RCHRES  11      15
PERLND 114                        1198     RCHRES  11      15
PERLND 115                         178     RCHRES  11      15
PERLND 116                           4     RCHRES  11      15
PERLND 117                           0     RCHRES  11      15
IMPLND 101                         128     RCHRES  11      14
IMPLND 102                         279     RCHRES  11      14
IMPLND 103                         124     RCHRES  11      14
IMPLND 104                          67     RCHRES  11      14
PERLND 101                         303     RCHRES  12      17
PERLND 102                         140     RCHRES  12      17
PERLND 103                           5     RCHRES  12      17
PERLND 104                           2     RCHRES  12      17
PERLND 105                           4     RCHRES  12      17
PERLND 106                          18     RCHRES  12      17
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PERLND 107                         30     RCHRES  12      17
PERLND 108                        125     RCHRES  12      17
PERLND 109                        179     RCHRES  12      17
PERLND 110                         34     RCHRES  12      17
PERLND 111                        139     RCHRES  12      17
PERLND 112                        255     RCHRES  12      17
PERLND 113                         19     RCHRES  12      17
PERLND 114                       1535     RCHRES  12      17
PERLND 115                         80     RCHRES  12      17
PERLND 116                          3     RCHRES  12      17
PERLND 117                          0     RCHRES  12      17
IMPLND 101                         37     RCHRES  12      16
IMPLND 102                         61     RCHRES  12      16
IMPLND 103                          8     RCHRES  12      16
IMPLND 104                         16     RCHRES  12      16
RCHRES   9                                RCHRES  12       3
RCHRES  13                                RCHRES  12       3
PERLND 101                        506     RCHRES  13       7
PERLND 102                        287     RCHRES  13       7
PERLND 103                         60     RCHRES  13       7
PERLND 104                          6     RCHRES  13       7
PERLND 105                          6     RCHRES  13       7
PERLND 106                          2     RCHRES  13       7
PERLND 107                       1148     RCHRES  13       7
PERLND 108                       1017     RCHRES  13       7
PERLND 109                       1276     RCHRES  13       7
PERLND 110                        630     RCHRES  13       7
PERLND 111                        220     RCHRES  13       7
PERLND 112                        250     RCHRES  13       7
PERLND 113                         12     RCHRES  13       7
PERLND 114                       2748     RCHRES  13       7
PERLND 115                         38     RCHRES  13       7
PERLND 116                         49     RCHRES  13       7
PERLND 117                          0     RCHRES  13       7
IMPLND 101                         62     RCHRES  13       6
IMPLND 102                        144     RCHRES  13       6
IMPLND 103                         97     RCHRES  13       6
IMPLND 104                         51     RCHRES  13       6
RCHRES   6                                RCHRES  13       3
PERLND 101                        309     RCHRES  14      19
PERLND 102                        392     RCHRES  14      19
PERLND 103                         17     RCHRES  14      19
PERLND 104                          2     RCHRES  14      19
PERLND 105                          4     RCHRES  14      19
PERLND 106                          0     RCHRES  14      19
PERLND 107                         66     RCHRES  14      19
PERLND 108                        299     RCHRES  14      19
PERLND 109                        133     RCHRES  14      19
PERLND 110                         11     RCHRES  14      19
PERLND 111                         98     RCHRES  14      19
PERLND 112                         48     RCHRES  14      19
PERLND 113                        168     RCHRES  14      19
PERLND 114                        833     RCHRES  14      19
PERLND 115                        380     RCHRES  14      19
PERLND 116                          4     RCHRES  14      19
PERLND 117                          0     RCHRES  14      19
IMPLND 101                         38     RCHRES  14      18
IMPLND 102                        170     RCHRES  14      18
IMPLND 103                         27     RCHRES  14      18
IMPLND 104                         14     RCHRES  14      18
RCHRES  10                                RCHRES  14       3
RCHRES  11                                RCHRES  14       3
RCHRES  12                                RCHRES  14       3
```

```
PERLND 101                          1050     RCHRES  15      21
PERLND 102                           538     RCHRES  15      21
PERLND 103                            58     RCHRES  15      21
PERLND 104                             4     RCHRES  15      21
PERLND 105                             0     RCHRES  15      21
PERLND 106                             6     RCHRES  15      21
PERLND 107                           193     RCHRES  15      21
PERLND 108                           206     RCHRES  15      21
PERLND 109                          1141     RCHRES  15      21
PERLND 110                           105     RCHRES  15      21
PERLND 111                            50     RCHRES  15      21
PERLND 112                            12     RCHRES  15      21
PERLND 113                            40     RCHRES  15      21
PERLND 114                           124     RCHRES  15      21
PERLND 115                            35     RCHRES  15      21
PERLND 116                            19     RCHRES  15      21
PERLND 117                             0     RCHRES  15      21
IMPLND 101                           130     RCHRES  15      20
IMPLND 102                           239     RCHRES  15      20
IMPLND 103                            95     RCHRES  15      20
IMPLND 104                            29     RCHRES  15      20
PERLND 101                           633     RCHRES  16      23
PERLND 102                           595     RCHRES  16      23
PERLND 103                            55     RCHRES  16      23
PERLND 104                             7     RCHRES  16      23
PERLND 105                            23     RCHRES  16      23
PERLND 106                             2     RCHRES  16      23
PERLND 107                            10     RCHRES  16      23
PERLND 108                            75     RCHRES  16      23
PERLND 109                           820     RCHRES  16      23
PERLND 110                            76     RCHRES  16      23
PERLND 111                            24     RCHRES  16      23
PERLND 112                            81     RCHRES  16      23
PERLND 113                           230     RCHRES  16      23
PERLND 114                           643     RCHRES  16      23
PERLND 115                           215     RCHRES  16      23
PERLND 116                            27     RCHRES  16      23
PERLND 117                             0     RCHRES  16      23
IMPLND 101                            78     RCHRES  16      22
IMPLND 102                           267     RCHRES  16      22
IMPLND 103                            89     RCHRES  16      22
IMPLND 104                            61     RCHRES  16      22
RCHRES  14                                   RCHRES  16       3
PERLND 101                           362     RCHRES  17      25
PERLND 102                           317     RCHRES  17      25
PERLND 103                           107     RCHRES  17      25
PERLND 104                            50     RCHRES  17      25
PERLND 105                             3     RCHRES  17      25
PERLND 106                             6     RCHRES  17      25
PERLND 107                            42     RCHRES  17      25
PERLND 108                           155     RCHRES  17      25
PERLND 109                           878     RCHRES  17      25
PERLND 110                           101     RCHRES  17      25
PERLND 111                            82     RCHRES  17      25
PERLND 112                            23     RCHRES  17      25
PERLND 113                           165     RCHRES  17      25
PERLND 114                           397     RCHRES  17      25
PERLND 115                           583     RCHRES  17      25
PERLND 116                            10     RCHRES  17      25
PERLND 117                             0     RCHRES  17      25
IMPLND 101                            45     RCHRES  17      24
IMPLND 102                           140     RCHRES  17      24
IMPLND 103                           174     RCHRES  17      24
```

```
IMPLND 104                       409     RCHRES  17      24
RCHRES  15                               RCHRES  17       3
PERLND 101                        49     RCHRES  18      25
PERLND 102                        74     RCHRES  18      25
PERLND 103                         7     RCHRES  18      25
PERLND 104                         1     RCHRES  18      25
PERLND 105                         0     RCHRES  18      25
PERLND 106                         0     RCHRES  18      25
PERLND 107                         0     RCHRES  18      25
PERLND 108                         4     RCHRES  18      25
PERLND 109                       740     RCHRES  18      25
PERLND 110                         0     RCHRES  18      25
PERLND 111                         2     RCHRES  18      25
PERLND 112                        65     RCHRES  18      25
PERLND 113                       238     RCHRES  18      25
PERLND 114                        68     RCHRES  18      25
PERLND 115                       994     RCHRES  18      25
PERLND 116                         4     RCHRES  18      25
PERLND 117                         0     RCHRES  18      25
IMPLND 101                         6     RCHRES  18      24
IMPLND 102                        33     RCHRES  18      24
IMPLND 103                        11     RCHRES  18      24
IMPLND 104                         6     RCHRES  18      24
RCHRES  16                               RCHRES  18       3
RCHRES  17                               RCHRES  18       3
PERLND 101                       894     COPY     1      27
PERLND 102                       373     COPY     1      27
PERLND 103                        71     COPY     1      27
PERLND 104                         6     COPY     1      27
PERLND 105                        16     COPY     1      27
PERLND 106                         0     COPY     1      27
PERLND 107                      3107     COPY     1      27
PERLND 108                      1845     COPY     1      27
PERLND 109                      1663     COPY     1      27
PERLND 110                       271     COPY     1      27
PERLND 111                      1866     COPY     1      27
PERLND 112                      1858     COPY     1      27
PERLND 113                         8     COPY     1      27
PERLND 114                      5260     COPY     1      27
PERLND 115                        62     COPY     1      27
PERLND 116                        48     COPY     1      27
PERLND 117                         0     COPY     1      27
IMPLND 101                       110     COPY     1      26
IMPLND 102                       180     COPY     1      26
IMPLND 103                       115     COPY     1      26
IMPLND 104                        48     COPY     1      26
PERLND 101                       419     COPY     2      27
PERLND 102                        89     COPY     2      27
PERLND 103                         0     COPY     2      27
PERLND 104                         0     COPY     2      27
PERLND 105                         0     COPY     2      27
PERLND 106                         0     COPY     2      27
PERLND 107                      2702     COPY     2      27
PERLND 108                      1251     COPY     2      27
PERLND 109                       344     COPY     2      27
PERLND 110                        17     COPY     2      27
PERLND 111                      1252     COPY     2      27
PERLND 112                      1499     COPY     2      27
PERLND 113                         6     COPY     2      27
PERLND 114                      5553     COPY     2      27
PERLND 115                       145     COPY     2      27
PERLND 116                        15     COPY     2      27
PERLND 117                         0     COPY     2      27
```

IMPLND 101	52	COPY	2	26
IMPLND 102	44	COPY	2	26
IMPLND 103	1	COPY	2	26
IMPLND 104	0	COPY	2	26
PERLND 101	195	COPY	3	27
PERLND 102	22	COPY	3	27
PERLND 103	3	COPY	3	27
PERLND 104	0	COPY	3	27
PERLND 105	0	COPY	3	27
PERLND 106	0	COPY	3	27
PERLND 107	2173	COPY	3	27
PERLND 108	556	COPY	3	27
PERLND 109	173	COPY	3	27
PERLND 110	16	COPY	3	27
PERLND 111	1045	COPY	3	27
PERLND 112	550	COPY	3	27
PERLND 113	1	COPY	3	27
PERLND 114	5181	COPY	3	27
PERLND 115	68	COPY	3	27
PERLND 116	9	COPY	3	27
PERLND 117	0	COPY	3	27
IMPLND 101	24	COPY	3	26
IMPLND 102	14	COPY	3	26
IMPLND 103	6	COPY	3	26
IMPLND 104	0	COPY	3	26
PERLND 101	709	COPY	4	29
PERLND 102	166	COPY	4	29
PERLND 103	2	COPY	4	29
PERLND 104	0	COPY	4	29
PERLND 105	3	COPY	4	29
PERLND 106	3	COPY	4	29
PERLND 107	1679	COPY	4	29
PERLND 108	1521	COPY	4	29
PERLND 109	297	COPY	4	29
PERLND 110	76	COPY	4	29
PERLND 111	785	COPY	4	29
PERLND 112	405	COPY	4	29
PERLND 113	8	COPY	4	29
PERLND 114	6371	COPY	4	29
PERLND 115	227	COPY	4	29
PERLND 116	49	COPY	4	29
PERLND 117	0	COPY	4	29
IMPLND 101	88	COPY	4	28
IMPLND 102	92	COPY	4	28
IMPLND 103	4	COPY	4	28
IMPLND 104	2	COPY	4	28
PERLND 101	370	COPY	5	31
PERLND 102	40	COPY	5	31
PERLND 103	7	COPY	5	31
PERLND 104	0	COPY	5	31
PERLND 105	3	COPY	5	31
PERLND 106	6	COPY	5	31
PERLND 107	1503	COPY	5	31
PERLND 108	1054	COPY	5	31
PERLND 109	61	COPY	5	31
PERLND 110	7	COPY	5	31
PERLND 111	807	COPY	5	31
PERLND 112	1085	COPY	5	31
PERLND 113	0	COPY	5	31
PERLND 114	3501	COPY	5	31
PERLND 115	41	COPY	5	31
PERLND 116	29	COPY	5	31
PERLND 117	0	COPY	5	31

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IMPLND 101                   46      COPY     5      30
IMPLND 102                   29      COPY     5      30
IMPLND 103                   11      COPY     5      30
IMPLND 104                    0      COPY     5      30
PERLND 101                  755      COPY     6      31
PERLND 102                  250      COPY     6      31
PERLND 103                   43      COPY     6      31
PERLND 104                    6      COPY     6      31
PERLND 105                    2      COPY     6      31
PERLND 106                    0      COPY     6      31
PERLND 107                  228      COPY     6      31
PERLND 108                 1130      COPY     6      31
PERLND 109                   71      COPY     6      31
PERLND 110                   33      COPY     6      31
PERLND 111                  403      COPY     6      31
PERLND 112                  222      COPY     6      31
PERLND 113                    8      COPY     6      31
PERLND 114                 1453      COPY     6      31
PERLND 115                    9      COPY     6      31
PERLND 116                   90      COPY     6      31
PERLND 117                    0      COPY     6      31
IMPLND 101                   93      COPY     6      30
IMPLND 102                  146      COPY     6      30
IMPLND 103                   70      COPY     6      30
IMPLND 104                   51      COPY     6      30
PERLND 101                  634      COPY     7      33
PERLND 102                  232      COPY     7      33
PERLND 103                   28      COPY     7      33
PERLND 104                    2      COPY     7      33
PERLND 105                    4      COPY     7      33
PERLND 106                    0      COPY     7      33
PERLND 107                  557      COPY     7      33
PERLND 108                 1072      COPY     7      33
PERLND 109                 1982      COPY     7      33
PERLND 110                   43      COPY     7      33
PERLND 111                  455      COPY     7      33
PERLND 112                  602      COPY     7      33
PERLND 113                   17      COPY     7      33
PERLND 114                 2212      COPY     7      33
PERLND 115                  133      COPY     7      33
PERLND 116                   55      COPY     7      33
PERLND 117                    0      COPY     7      33
IMPLND 101                   78      COPY     7      32
IMPLND 102                  123      COPY     7      32
IMPLND 103                   46      COPY     7      32
IMPLND 104                   13      COPY     7      32
PERLND 101                  781      COPY     8      35
PERLND 102                  202      COPY     8      35
PERLND 103                   14      COPY     8      35
PERLND 104                    0      COPY     8      35
PERLND 105                    3      COPY     8      35
PERLND 106                   44      COPY     8      35
PERLND 107                 1785      COPY     8      35
PERLND 108                 3009      COPY     8      35
PERLND 109                  512      COPY     8      35
PERLND 110                   46      COPY     8      35
PERLND 111                  689      COPY     8      35
PERLND 112                  935      COPY     8      35
PERLND 113                   46      COPY     8      35
PERLND 114                 3202      COPY     8      35
PERLND 115                  164      COPY     8      35
PERLND 116                   69      COPY     8      35
PERLND 117                    0      COPY     8      35
```

IMPLND 101	97	COPY	8	34
IMPLND 102	116	COPY	8	34
IMPLND 103	24	COPY	8	34
IMPLND 104	2	COPY	8	34
PERLND 101	151	COPY	9	37
PERLND 102	83	COPY	9	37
PERLND 103	23	COPY	9	37
PERLND 104	0	COPY	9	37
PERLND 105	0	COPY	9	37
PERLND 106	0	COPY	9	37
PERLND 107	161	COPY	9	37
PERLND 108	271	COPY	9	37
PERLND 109	347	COPY	9	37
PERLND 110	17	COPY	9	37
PERLND 111	77	COPY	9	37
PERLND 112	133	COPY	9	37
PERLND 113	0	COPY	9	37
PERLND 114	1491	COPY	9	37
PERLND 115	46	COPY	9	37
PERLND 116	14	COPY	9	37
PERLND 117	0	COPY	9	37
IMPLND 101	19	COPY	9	36
IMPLND 102	42	COPY	9	36
IMPLND 103	37	COPY	9	36
IMPLND 104	1	COPY	9	36
PERLND 101	33	COPY	10	33
PERLND 102	68	COPY	10	33
PERLND 103	6	COPY	10	33
PERLND 104	0	COPY	10	33
PERLND 105	0	COPY	10	33
PERLND 106	12	COPY	10	33
PERLND 107	224	COPY	10	33
PERLND 108	36	COPY	10	33
PERLND 109	172	COPY	10	33
PERLND 110	10	COPY	10	33
PERLND 111	30	COPY	10	33
PERLND 112	9	COPY	10	33
PERLND 113	0	COPY	10	33
PERLND 114	1484	COPY	10	33
PERLND 115	21	COPY	10	33
PERLND 116	8	COPY	10	33
PERLND 117	0	COPY	10	33
IMPLND 101	4	COPY	10	32
IMPLND 102	33	COPY	10	32
IMPLND 103	10	COPY	10	32
IMPLND 104	0	COPY	10	32
PERLND 101	1036	COPY	11	39
PERLND 102	647	COPY	11	39
PERLND 103	76	COPY	11	39
PERLND 104	8	COPY	11	39
PERLND 105	0	COPY	11	39
PERLND 106	0	COPY	11	39
PERLND 107	151	COPY	11	39
PERLND 108	254	COPY	11	39
PERLND 109	964	COPY	11	39
PERLND 110	86	COPY	11	39
PERLND 111	210	COPY	11	39
PERLND 112	192	COPY	11	39
PERLND 113	39	COPY	11	39
PERLND 114	1198	COPY	11	39
PERLND 115	178	COPY	11	39
PERLND 116	4	COPY	11	39
PERLND 117	0	COPY	11	39

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IMPLND 101                          128      COPY    11      38
IMPLND 102                          279      COPY    11      38
IMPLND 103                          124      COPY    11      38
IMPLND 104                           67      COPY    11      38
PERLND 101                          303      COPY    12      41
PERLND 102                          140      COPY    12      41
PERLND 103                            5      COPY    12      41
PERLND 104                            2      COPY    12      41
PERLND 105                            4      COPY    12      41
PERLND 106                           18      COPY    12      41
PERLND 107                           30      COPY    12      41
PERLND 108                          125      COPY    12      41
PERLND 109                          179      COPY    12      41
PERLND 110                           34      COPY    12      41
PERLND 111                          139      COPY    12      41
PERLND 112                          255      COPY    12      41
PERLND 113                           19      COPY    12      41
PERLND 114                         1535      COPY    12      41
PERLND 115                           80      COPY    12      41
PERLND 116                            3      COPY    12      41
PERLND 117                            0      COPY    12      41
IMPLND 101                           37      COPY    12      40
IMPLND 102                           61      COPY    12      40
IMPLND 103                            8      COPY    12      40
IMPLND 104                           16      COPY    12      40
PERLND 101                          506      COPY    13      31
PERLND 102                          287      COPY    13      31
PERLND 103                           60      COPY    13      31
PERLND 104                            6      COPY    13      31
PERLND 105                            6      COPY    13      31
PERLND 106                            2      COPY    13      31
PERLND 107                         1148      COPY    13      31
PERLND 108                         1017      COPY    13      31
PERLND 109                         1276      COPY    13      31
PERLND 110                          630      COPY    13      31
PERLND 111                          220      COPY    13      31
PERLND 112                          250      COPY    13      31
PERLND 113                           12      COPY    13      31
PERLND 114                         2748      COPY    13      31
PERLND 115                           38      COPY    13      31
PERLND 116                           49      COPY    13      31
PERLND 117                            0      COPY    13      31
IMPLND 101                           62      COPY    13      30
IMPLND 102                          144      COPY    13      30
IMPLND 103                           97      COPY    13      30
IMPLND 104                           51      COPY    13      30
PERLND 101                          309      COPY    14      43
PERLND 102                          392      COPY    14      43
PERLND 103                           17      COPY    14      43
PERLND 104                            2      COPY    14      43
PERLND 105                            4      COPY    14      43
PERLND 106                            0      COPY    14      43
PERLND 107                           66      COPY    14      43
PERLND 108                          299      COPY    14      43
PERLND 109                          133      COPY    14      43
PERLND 110                           11      COPY    14      43
PERLND 111                           98      COPY    14      43
PERLND 112                           48      COPY    14      43
PERLND 113                          168      COPY    14      43
PERLND 114                          833      COPY    14      43
PERLND 115                          380      COPY    14      43
PERLND 116                            4      COPY    14      43
PERLND 117                            0      COPY    14      43
```

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IMPLND 101                        38     COPY    14      42
IMPLND 102                       170     COPY    14      42
IMPLND 103                        27     COPY    14      42
IMPLND 104                        14     COPY    14      42
PERLND 101                      1050     COPY    15      45
PERLND 102                       538     COPY    15      45
PERLND 103                        58     COPY    15      45
PERLND 104                         4     COPY    15      45
PERLND 105                         0     COPY    15      45
PERLND 106                         6     COPY    15      45
PERLND 107                       193     COPY    15      45
PERLND 108                       206     COPY    15      45
PERLND 109                      1141     COPY    15      45
PERLND 110                       105     COPY    15      45
PERLND 111                        50     COPY    15      45
PERLND 112                        12     COPY    15      45
PERLND 113                        40     COPY    15      45
PERLND 114                       124     COPY    15      45
PERLND 115                        35     COPY    15      45
PERLND 116                        19     COPY    15      45
PERLND 117                         0     COPY    15      45
IMPLND 101                       130     COPY    15      44
IMPLND 102                       239     COPY    15      44
IMPLND 103                        95     COPY    15      44
IMPLND 104                        29     COPY    15      44
PERLND 101                       633     COPY    16      47
PERLND 102                       595     COPY    16      47
PERLND 103                        55     COPY    16      47
PERLND 104                         7     COPY    16      47
PERLND 105                        23     COPY    16      47
PERLND 106                         2     COPY    16      47
PERLND 107                        10     COPY    16      47
PERLND 108                        75     COPY    16      47
PERLND 109                       820     COPY    16      47
PERLND 110                        76     COPY    16      47
PERLND 111                        24     COPY    16      47
PERLND 112                        81     COPY    16      47
PERLND 113                       230     COPY    16      47
PERLND 114                       643     COPY    16      47
PERLND 115                       215     COPY    16      47
PERLND 116                        27     COPY    16      47
PERLND 117                         0     COPY    16      47
IMPLND 101                        78     COPY    16      46
IMPLND 102                       267     COPY    16      46
IMPLND 103                        89     COPY    16      46
IMPLND 104                        61     COPY    16      46
PERLND 101                       362     COPY    17      49
PERLND 102                       317     COPY    17      49
PERLND 103                       107     COPY    17      49
PERLND 104                        50     COPY    17      49
PERLND 105                         3     COPY    17      49
PERLND 106                         6     COPY    17      49
PERLND 107                        42     COPY    17      49
PERLND 108                       155     COPY    17      49
PERLND 109                       878     COPY    17      49
PERLND 110                       101     COPY    17      49
PERLND 111                        82     COPY    17      49
PERLND 112                        23     COPY    17      49
PERLND 113                       165     COPY    17      49
PERLND 114                       397     COPY    17      49
PERLND 115                       583     COPY    17      49
PERLND 116                        10     COPY    17      49
PERLND 117                         0     COPY    17      49
```

```
IMPLND 101                        45      COPY    17     48
IMPLND 102                       140      COPY    17     48
IMPLND 103                       174      COPY    17     48
IMPLND 104                       409      COPY    17     48
PERLND 101                        49      COPY    18     49
PERLND 102                        74      COPY    18     49
PERLND 103                         7      COPY    18     49
PERLND 104                         1      COPY    18     49
PERLND 105                         0      COPY    18     49
PERLND 106                         0      COPY    18     49
PERLND 107                         0      COPY    18     49
PERLND 108                         4      COPY    18     49
PERLND 109                       740      COPY    18     49
PERLND 110                         0      COPY    18     49
PERLND 111                         2      COPY    18     49
PERLND 112                        65      COPY    18     49
PERLND 113                       238      COPY    18     49
PERLND 114                        68      COPY    18     49
PERLND 115                       994      COPY    18     49
PERLND 116                         4      COPY    18     49
PERLND 117                         0      COPY    18     49
IMPLND 101                         6      COPY    18     48
IMPLND 102                        33      COPY    18     48
IMPLND 103                        11      COPY    18     48
IMPLND 104                         6      COPY    18     48
END SCHEMATIC

EXT TARGETS
<-Volume-> <-Grp> <-Member-><--Mult-->Tran <-Volume-> <Member> Tsys Aggr Amd ***
<Name>   x        <Name> x x<-factor->strg <Name>   x <Name>qf  tem strg strg***
RCHRES   1 HYDR   RO      1 1          AVER WDM1  1315 RO     1 METR AGGR REPL
RCHRES   1 OXRX   DOX     1 1          AVER WDM1  3001 DO     1 ENGL AGGR REPL
RCHRES   1 OXRX   DOX     1 1          MIN  WDM1  4001 DO     1 ENGL AGGR REPL
RCHRES   2 HYDR   RO      1 1          AVER WDM1  1339 RO     1 METR AGGR REPL
RCHRES   2 OXRX   DOX     1 1          AVER WDM1  3002 DO     1 ENGL AGGR REPL
RCHRES   2 OXRX   DOX     1 1          MIN  WDM1  4002 DO     1 ENGL AGGR REPL
RCHRES   3 HYDR   RO      1 1          AVER WDM1  1363 RO     1 METR AGGR REPL
RCHRES   3 OXRX   DOX     1 1          AVER WDM1  3003 DO     1 ENGL AGGR REPL
RCHRES   3 OXRX   DOX     1 1          MIN  WDM1  4003 DO     1 ENGL AGGR REPL
RCHRES   4 HYDR   RO      1 1          AVER WDM1  1387 RO     1 METR AGGR REPL
RCHRES   4 OXRX   DOX     1 1          AVER WDM1  3004 DO     1 ENGL AGGR REPL
RCHRES   4 OXRX   DOX     1 1          MIN  WDM1  4004 DO     1 ENGL AGGR REPL
RCHRES   5 HYDR   RO      1 1          AVER WDM1  1411 RO     1 METR AGGR REPL
RCHRES   5 OXRX   DOX     1 1          AVER WDM1  3005 DO     1 ENGL AGGR REPL
RCHRES   5 OXRX   DOX     1 1          MIN  WDM1  4005 DO     1 ENGL AGGR REPL
RCHRES   6 HYDR   RO      1 1          AVER WDM1  1219 RO     1 METR AGGR REPL
RCHRES   6 OXRX   DOX     1 1          AVER WDM1  3006 DO     1 ENGL AGGR REPL
RCHRES   6 OXRX   DOX     1 1          MIN  WDM1  4006 DO     1 ENGL AGGR REPL
RCHRES   7 HYDR   RO      1 1          AVER WDM1  1003 RO     1 METR AGGR REPL
RCHRES   7 OXRX   DOX     1 1          AVER WDM1  3007 DO     1 ENGL AGGR REPL
RCHRES   7 OXRX   DOX     1 1          MIN  WDM1  4007 DO     1 ENGL AGGR REPL
RCHRES   7 SEDTRN SSED    4 1          AVER WDM1  1021 TSS    1 ENGL AGGR REPL
RCHRES   7 SEDTRN SSED    1 1          AVER WDM1  1505 SAND   1 ENGL AGGR REPL
RCHRES   7 SEDTRN SSED    2 1          AVER WDM1  1506 SILT   1 ENGL AGGR REPL
RCHRES   7 SEDTRN SSED    3 1          AVER WDM1  1507 CLAY   1 ENGL AGGR REPL
RCHRES   7 OXRX   BOD     1 1          AVER WDM1  1627 BOD    1 ENGL AGGR REPL
RCHRES   7 NUTRX  DNUST   2 1          AVER WDM1  1440 DNH3   1 ENGL AGGR REPL
RCHRES   7 NUTRX  DNUST   1 1          AVER WDM1  1439 DNO3   1 ENGL AGGR REPL
RCHRES   7 NUTRX  DNUST   4 1          AVER WDM1  1441 DPO4   1 ENGL AGGR REPL
RCHRES   7 PLANK  PHYCLA  1 1          AVER WDM1  1433 CHLA   1 ENGL AGGR REPL
RCHRES   7 PLANK  PKST3   4 1          AVER WDM1  1460 ORGN   1 ENGL AGGR REPL
RCHRES   7 PLANK  PKST3   5 1          AVER WDM1  1461 ORGP   1 ENGL AGGR REPL
RCHRES   7 PLANK  PKST3   1 1          AVER WDM1  1457 DETN   1 ENGL AGGR REPL
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RCHRES   7 PLANK  PKST3  2 1          AVER WDM1  1458 DETP   1 ENGL AGGR REPL
RCHRES   7 PLANK  PKST3  3 1          AVER WDM1  1459 DETC   1 ENGL AGGR REPL
RCHRES   8 HYDR   RO     1 1          AVER WDM1  1027 RO     1 METR AGGR REPL
RCHRES   8 OXRX   DOX    1 1          AVER WDM1  3008 DO     1 ENGL AGGR REPL
RCHRES   8 OXRX   DOX    1 1          MIN  WDM1  4008 DO     1 ENGL AGGR REPL
RCHRES   8 SEDTRN SSED   4 1          AVER WDM1  1045 TSS    1 ENGL AGGR REPL
RCHRES   8 SEDTRN SSED   1 1          AVER WDM1  1508 SAND   1 ENGL AGGR REPL
RCHRES   8 SEDTRN SSED   2 1          AVER WDM1  1509 SILT   1 ENGL AGGR REPL
RCHRES   8 SEDTRN SSED   3 1          AVER WDM1  1510 CLAY   1 ENGL AGGR REPL
RCHRES   8 OXRX   BOD    1 1          AVER WDM1  1628 BOD    1 ENGL AGGR REPL
RCHRES   8 NUTRX  DNUST  2 1          AVER WDM1  1443 DNH3   1 ENGL AGGR REPL
RCHRES   8 NUTRX  DNUST  1 1          AVER WDM1  1442 DNO3   1 ENGL AGGR REPL
RCHRES   8 NUTRX  DNUST  4 1          AVER WDM1  1444 DPO4   1 ENGL AGGR REPL
RCHRES   8 PLANK  PHYCLA 1 1          AVER WDM1  1434 CHLA   1 ENGL AGGR REPL
RCHRES   8 PLANK  PKST3  4 1          AVER WDM1  1465 ORGN   1 ENGL AGGR REPL
RCHRES   8 PLANK  PKST3  5 1          AVER WDM1  1466 ORGP   1 ENGL AGGR REPL
RCHRES   8 PLANK  PKST3  1 1          AVER WDM1  1462 DETN   1 ENGL AGGR REPL
RCHRES   8 PLANK  PKST3  2 1          AVER WDM1  1463 DETP   1 ENGL AGGR REPL
RCHRES   8 PLANK  PKST3  3 1          AVER WDM1  1464 DETC   1 ENGL AGGR REPL
RCHRES   9 HYDR   RO     1 1          AVER WDM1  1243 RO     1 METR AGGR REPL
RCHRES  10 HYDR   RO     1 1          AVER WDM1  1051 RO     1 METR AGGR REPL
RCHRES  10 OXRX   DOX    1 1          AVER WDM1  3010 DO     1 ENGL AGGR REPL
RCHRES  10 OXRX   DOX    1 1          MIN  WDM1  4010 DO     1 ENGL AGGR REPL
RCHRES  11 HYDR   RO     1 1          AVER WDM1  1075 RO     1 METR AGGR REPL
RCHRES  11 OXRX   DOX    1 1          AVER WDM1  3011 DO     1 ENGL AGGR REPL
RCHRES  11 OXRX   DOX    1 1          MIN  WDM1  4011 DO     1 ENGL AGGR REPL
RCHRES  11 SEDTRN SSED   4 1          AVER WDM1  1093 TSS    1 ENGL AGGR REPL
RCHRES  11 SEDTRN SSED   1 1          AVER WDM1  1511 SAND   1 ENGL AGGR REPL
RCHRES  11 SEDTRN SSED   2 1          AVER WDM1  1512 SILT   1 ENGL AGGR REPL
RCHRES  11 SEDTRN SSED   3 1          AVER WDM1  1513 CLAY   1 ENGL AGGR REPL
RCHRES  11 OXRX   BOD    1 1          AVER WDM1  1631 BOD    1 ENGL AGGR REPL
RCHRES  11 NUTRX  DNUST  2 1          AVER WDM1  1449 DNH3   1 ENGL AGGR REPL
RCHRES  11 NUTRX  DNUST  1 1          AVER WDM1  1448 DNO3   1 ENGL AGGR REPL
RCHRES  11 NUTRX  DNUST  4 1          AVER WDM1  1450 DPO4   1 ENGL AGGR REPL
RCHRES  11 PLANK  PHYCLA 1 1          AVER WDM1  1436 CHLA   1 ENGL AGGR REPL
RCHRES  11 PLANK  PKST3  4 1          AVER WDM1  1475 ORGN   1 ENGL AGGR REPL
RCHRES  11 PLANK  PKST3  5 1          AVER WDM1  1476 ORGP   1 ENGL AGGR REPL
RCHRES  11 PLANK  PKST3  1 1          AVER WDM1  1472 DETN   1 ENGL AGGR REPL
RCHRES  11 PLANK  PKST3  2 1          AVER WDM1  1473 DETP   1 ENGL AGGR REPL
RCHRES  11 PLANK  PKST3  3 1          AVER WDM1  1474 DETC   1 ENGL AGGR REPL
RCHRES  13 HYDR   RO     1 1          AVER WDM1  1099 RO     1 METR AGGR REPL
RCHRES  13 OXRX   DOX    1 1          AVER WDM1  3013 DO     1 ENGL AGGR REPL
RCHRES  13 OXRX   DOX    1 1          MIN  WDM1  4013 DO     1 ENGL AGGR REPL
RCHRES  13 SEDTRN SSED   4 1          AVER WDM1  1117 TSS    1 ENGL AGGR REPL
RCHRES  13 SEDTRN SSED   1 1          AVER WDM1  1514 SAND   1 ENGL AGGR REPL
RCHRES  13 SEDTRN SSED   2 1          AVER WDM1  1515 SILT   1 ENGL AGGR REPL
RCHRES  13 SEDTRN SSED   3 1          AVER WDM1  1516 CLAY   1 ENGL AGGR REPL
RCHRES  13 OXRX   BOD    1 1          AVER WDM1  1633 BOD    1 ENGL AGGR REPL
RCHRES  13 NUTRX  DNUST  2 1          AVER WDM1  1452 DNH3   1 ENGL AGGR REPL
RCHRES  13 NUTRX  DNUST  1 1          AVER WDM1  1451 DNO3   1 ENGL AGGR REPL
RCHRES  13 NUTRX  DNUST  4 1          AVER WDM1  1453 DPO4   1 ENGL AGGR REPL
RCHRES  13 PLANK  PHYCLA 1 1          AVER WDM1  1437 CHLA   1 ENGL AGGR REPL
RCHRES  13 PLANK  PKST3  4 1          AVER WDM1  1480 ORGN   1 ENGL AGGR REPL
RCHRES  13 PLANK  PKST3  5 1          AVER WDM1  1481 ORGP   1 ENGL AGGR REPL
RCHRES  13 PLANK  PKST3  1 1          AVER WDM1  1477 DETN   1 ENGL AGGR REPL
RCHRES  13 PLANK  PKST3  2 1          AVER WDM1  1478 DETP   1 ENGL AGGR REPL
RCHRES  13 PLANK  PKST3  3 1          AVER WDM1  1479 DETC   1 ENGL AGGR REPL
RCHRES  12 HYDR   RO     1 1          AVER WDM1  1267 RO     1 METR AGGR REPL
RCHRES  14 HYDR   RO     1 1          AVER WDM1  1291 RO     1 METR AGGR REPL
RCHRES  14 HTRCH  TW     1 1          AVER WDM1  1296 TW     1 METR AGGR REPL
RCHRES  15 HYDR   RO     1 1          AVER WDM1  1123 RO     1 METR AGGR REPL
RCHRES  15 OXRX   DOX    1 1          AVER WDM1  3015 DO     1 ENGL AGGR REPL
RCHRES  15 OXRX   DOX    1 1          MIN  WDM1  4015 DO     1 ENGL AGGR REPL
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RCHRES  15 SEDTRN SSED   4 1         AVER WDM1  1141 TSS    1 ENGL AGGR REPL
RCHRES  15 SEDTRN SSED   1 1         AVER WDM1  1517 SAND   1 ENGL AGGR REPL
RCHRES  15 SEDTRN SSED   2 1         AVER WDM1  1518 SILT   1 ENGL AGGR REPL
RCHRES  15 SEDTRN SSED   3 1         AVER WDM1  1519 CLAY   1 ENGL AGGR REPL
RCHRES  15 OXRX   BOD    1 1         AVER WDM1  1635 BOD    1 ENGL AGGR REPL
RCHRES  15 NUTRX  DNUST  2 1         AVER WDM1  1455 DNH3   1 ENGL AGGR REPL
RCHRES  15 NUTRX  DNUST  1 1         AVER WDM1  1454 DNO3   1 ENGL AGGR REPL
RCHRES  15 NUTRX  DNUST  4 1         AVER WDM1  1456 DPO4   1 ENGL AGGR REPL
RCHRES  15 PLANK  PHYCLA 1 1         AVER WDM1  1438 CHLA   1 ENGL AGGR REPL
RCHRES  15 PLANK  PKST3  4 1         AVER WDM1  1485 ORGN   1 ENGL AGGR REPL
RCHRES  15 PLANK  PKST3  5 1         AVER WDM1  1486 ORGP   1 ENGL AGGR REPL
RCHRES  15 PLANK  PKST3  1 1         AVER WDM1  1482 DETN   1 ENGL AGGR REPL
RCHRES  15 PLANK  PKST3  2 1         AVER WDM1  1483 DETP   1 ENGL AGGR REPL
RCHRES  15 PLANK  PKST3  3 1         AVER WDM1  1484 DETC   1 ENGL AGGR REPL
RCHRES  16 HYDR   RO     1 1         AVER WDM1  1147 RO     1 METR AGGR REPL
RCHRES  17 HYDR   RO     1 1         AVER WDM1  1171 RO     1 METR AGGR REPL
RCHRES  18 HYDR   RO     1 1         AVER WDM1  1195 RO     1 METR AGGR REPL
COPY     1 OUTPUT MEAN   1 1  0.02855     WDM1  9006 PERO   1 METR AGGR REPL
COPY     1 OUTPUT MEAN   2 1      907     WDM1  9000 TSS    1 ENGL AGGR REPL
COPY     1 OUTPUT MEAN   3 1    0.454     WDM1  9002 NH3N   1 ENGL AGGR REPL
COPY     1 OUTPUT MEAN   4 1    0.454     WDM1  9003 NO3N   1 ENGL AGGR REPL
COPY     1 OUTPUT MEAN   5 1    0.454     WDM1  9004 PO4P   1 ENGL AGGR REPL
COPY     1 OUTPUT MEAN   6 1    0.454     WDM1  9005 BOD    1 ENGL AGGR REPL
COPY     1 OUTPUT MEAN   7 1    0.454     WDM1  9001 DO     1 ENGL AGGR REPL
COPY     2 OUTPUT MEAN   1 1  0.02855     WDM1  9016 PERO   1 METR AGGR REPL
COPY     2 OUTPUT MEAN   2 1      907     WDM1  9010 TSS    1 ENGL AGGR REPL
COPY     2 OUTPUT MEAN   3 1    0.454     WDM1  9012 NH3N   1 ENGL AGGR REPL
COPY     2 OUTPUT MEAN   4 1    0.454     WDM1  9013 NO3N   1 ENGL AGGR REPL
COPY     2 OUTPUT MEAN   5 1    0.454     WDM1  9014 PO4P   1 ENGL AGGR REPL
COPY     2 OUTPUT MEAN   6 1    0.454     WDM1  9015 BOD    1 ENGL AGGR REPL
COPY     2 OUTPUT MEAN   7 1    0.454     WDM1  9011 DO     1 ENGL AGGR REPL
COPY     3 OUTPUT MEAN   1 1  0.02855     WDM1  9026 PERO   1 METR AGGR REPL
COPY     3 OUTPUT MEAN   2 1      907     WDM1  9020 TSS    1 ENGL AGGR REPL
COPY     3 OUTPUT MEAN   3 1    0.454     WDM1  9022 NH3N   1 ENGL AGGR REPL
COPY     3 OUTPUT MEAN   4 1    0.454     WDM1  9023 NO3N   1 ENGL AGGR REPL
COPY     3 OUTPUT MEAN   5 1    0.454     WDM1  9024 PO4P   1 ENGL AGGR REPL
COPY     3 OUTPUT MEAN   6 1    0.454     WDM1  9025 BOD    1 ENGL AGGR REPL
COPY     3 OUTPUT MEAN   7 1    0.454     WDM1  9021 DO     1 ENGL AGGR REPL
COPY     4 OUTPUT MEAN   1 1  0.02855     WDM1  9036 PERO   1 METR AGGR REPL
COPY     4 OUTPUT MEAN   2 1      907     WDM1  9030 TSS    1 ENGL AGGR REPL
COPY     4 OUTPUT MEAN   3 1    0.454     WDM1  9032 NH3N   1 ENGL AGGR REPL
COPY     4 OUTPUT MEAN   4 1    0.454     WDM1  9033 NO3N   1 ENGL AGGR REPL
COPY     4 OUTPUT MEAN   5 1    0.454     WDM1  9034 PO4P   1 ENGL AGGR REPL
COPY     4 OUTPUT MEAN   6 1    0.454     WDM1  9035 BOD    1 ENGL AGGR REPL
COPY     4 OUTPUT MEAN   7 1    0.454     WDM1  9031 DO     1 ENGL AGGR REPL
COPY     5 OUTPUT MEAN   1 1  0.02855     WDM1  9046 PERO   1 METR AGGR REPL
COPY     5 OUTPUT MEAN   2 1      907     WDM1  9040 TSS    1 ENGL AGGR REPL
COPY     5 OUTPUT MEAN   3 1    0.454     WDM1  9042 NH3N   1 ENGL AGGR REPL
COPY     5 OUTPUT MEAN   4 1    0.454     WDM1  9043 NO3N   1 ENGL AGGR REPL
COPY     5 OUTPUT MEAN   5 1    0.454     WDM1  9044 PO4P   1 ENGL AGGR REPL
COPY     5 OUTPUT MEAN   6 1    0.454     WDM1  9045 BOD    1 ENGL AGGR REPL
COPY     5 OUTPUT MEAN   7 1    0.454     WDM1  9041 DO     1 ENGL AGGR REPL
COPY     6 OUTPUT MEAN   1 1  0.02855     WDM1  9056 PERO   1 METR AGGR REPL
COPY     6 OUTPUT MEAN   2 1      907     WDM1  9050 TSS    1 ENGL AGGR REPL
COPY     6 OUTPUT MEAN   3 1    0.454     WDM1  9052 NH3N   1 ENGL AGGR REPL
COPY     6 OUTPUT MEAN   4 1    0.454     WDM1  9053 NO3N   1 ENGL AGGR REPL
COPY     6 OUTPUT MEAN   5 1    0.454     WDM1  9054 PO4P   1 ENGL AGGR REPL
COPY     6 OUTPUT MEAN   6 1    0.454     WDM1  9055 BOD    1 ENGL AGGR REPL
COPY     6 OUTPUT MEAN   7 1    0.454     WDM1  9051 DO     1 ENGL AGGR REPL
COPY     7 OUTPUT MEAN   1 1  0.02855     WDM1  9066 PERO   1 METR AGGR REPL
COPY     7 OUTPUT MEAN   2 1      907     WDM1  9060 TSS    1 ENGL AGGR REPL
COPY     7 OUTPUT MEAN   3 1    0.454     WDM1  9062 NH3N   1 ENGL AGGR REPL
COPY     7 OUTPUT MEAN   4 1    0.454     WDM1  9063 NO3N   1 ENGL AGGR REPL
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COPY      7 OUTPUT MEAN   5 1     0.454     WDM1  9064 PO4P   1 ENGL AGGR REPL
COPY      7 OUTPUT MEAN   6 1     0.454     WDM1  9065 BOD    1 ENGL AGGR REPL
COPY      7 OUTPUT MEAN   7 1     0.454     WDM1  9061 DO     1 ENGL AGGR REPL
COPY      8 OUTPUT MEAN   1 1   0.02855     WDM1  9076 PERO   1 METR AGGR REPL
COPY      8 OUTPUT MEAN   2 1       907     WDM1  9070 TSS    1 ENGL AGGR REPL
COPY      8 OUTPUT MEAN   3 1     0.454     WDM1  9072 NH3N   1 ENGL AGGR REPL
COPY      8 OUTPUT MEAN   4 1     0.454     WDM1  9073 NO3N   1 ENGL AGGR REPL
COPY      8 OUTPUT MEAN   5 1     0.454     WDM1  9074 PO4P   1 ENGL AGGR REPL
COPY      8 OUTPUT MEAN   6 1     0.454     WDM1  9075 BOD    1 ENGL AGGR REPL
COPY      8 OUTPUT MEAN   7 1     0.454     WDM1  9071 DO     1 ENGL AGGR REPL
COPY      9 OUTPUT MEAN   1 1   0.02855     WDM1  9086 PERO   1 METR AGGR REPL
COPY      9 OUTPUT MEAN   2 1       907     WDM1  9080 TSS    1 ENGL AGGR REPL
COPY      9 OUTPUT MEAN   3 1     0.454     WDM1  9082 NH3N   1 ENGL AGGR REPL
COPY      9 OUTPUT MEAN   4 1     0.454     WDM1  9083 NO3N   1 ENGL AGGR REPL
COPY      9 OUTPUT MEAN   5 1     0.454     WDM1  9084 PO4P   1 ENGL AGGR REPL
COPY      9 OUTPUT MEAN   6 1     0.454     WDM1  9085 BOD    1 ENGL AGGR REPL
COPY      9 OUTPUT MEAN   7 1     0.454     WDM1  9081 DO     1 ENGL AGGR REPL
COPY     10 OUTPUT MEAN   1 1   0.02855     WDM1  9096 PERO   1 METR AGGR REPL
COPY     10 OUTPUT MEAN   2 1       907     WDM1  9090 TSS    1 ENGL AGGR REPL
COPY     10 OUTPUT MEAN   3 1     0.454     WDM1  9092 NH3N   1 ENGL AGGR REPL
COPY     10 OUTPUT MEAN   4 1     0.454     WDM1  9093 NO3N   1 ENGL AGGR REPL
COPY     10 OUTPUT MEAN   5 1     0.454     WDM1  9094 PO4P   1 ENGL AGGR REPL
COPY     10 OUTPUT MEAN   6 1     0.454     WDM1  9095 BOD    1 ENGL AGGR REPL
COPY     10 OUTPUT MEAN   7 1     0.454     WDM1  9091 DO     1 ENGL AGGR REPL
COPY     11 OUTPUT MEAN   1 1   0.02855     WDM1  9106 PERO   1 METR AGGR REPL
COPY     11 OUTPUT MEAN   2 1       907     WDM1  9100 TSS    1 ENGL AGGR REPL
COPY     11 OUTPUT MEAN   3 1     0.454     WDM1  9102 NH3N   1 ENGL AGGR REPL
COPY     11 OUTPUT MEAN   4 1     0.454     WDM1  9103 NO3N   1 ENGL AGGR REPL
COPY     11 OUTPUT MEAN   5 1     0.454     WDM1  9104 PO4P   1 ENGL AGGR REPL
COPY     11 OUTPUT MEAN   6 1     0.454     WDM1  9105 BOD    1 ENGL AGGR REPL
COPY     11 OUTPUT MEAN   7 1     0.454     WDM1  9101 DO     1 ENGL AGGR REPL
COPY     12 OUTPUT MEAN   1 1   0.02855     WDM1  9116 PERO   1 METR AGGR REPL
COPY     12 OUTPUT MEAN   2 1       907     WDM1  9110 TSS    1 ENGL AGGR REPL
COPY     12 OUTPUT MEAN   3 1     0.454     WDM1  9112 NH3N   1 ENGL AGGR REPL
COPY     12 OUTPUT MEAN   4 1     0.454     WDM1  9113 NO3N   1 ENGL AGGR REPL
COPY     12 OUTPUT MEAN   5 1     0.454     WDM1  9114 PO4P   1 ENGL AGGR REPL
COPY     12 OUTPUT MEAN   6 1     0.454     WDM1  9115 BOD    1 ENGL AGGR REPL
COPY     12 OUTPUT MEAN   7 1     0.454     WDM1  9111 DO     1 ENGL AGGR REPL
COPY     13 OUTPUT MEAN   1 1   0.02855     WDM1  9126 PERO   1 METR AGGR REPL
COPY     13 OUTPUT MEAN   2 1       907     WDM1  9120 TSS    1 ENGL AGGR REPL
COPY     13 OUTPUT MEAN   3 1     0.454     WDM1  9122 NH3N   1 ENGL AGGR REPL
COPY     13 OUTPUT MEAN   4 1     0.454     WDM1  9123 NO3N   1 ENGL AGGR REPL
COPY     13 OUTPUT MEAN   5 1     0.454     WDM1  9124 PO4P   1 ENGL AGGR REPL
COPY     13 OUTPUT MEAN   6 1     0.454     WDM1  9125 BOD    1 ENGL AGGR REPL
COPY     13 OUTPUT MEAN   7 1     0.454     WDM1  9121 DO     1 ENGL AGGR REPL
COPY     14 OUTPUT MEAN   1 1   0.02855     WDM1  9136 PERO   1 METR AGGR REPL
COPY     14 OUTPUT MEAN   2 1       907     WDM1  9130 TSS    1 ENGL AGGR REPL
COPY     14 OUTPUT MEAN   3 1     0.454     WDM1  9132 NH3N   1 ENGL AGGR REPL
COPY     14 OUTPUT MEAN   4 1     0.454     WDM1  9133 NO3N   1 ENGL AGGR REPL
COPY     14 OUTPUT MEAN   5 1     0.454     WDM1  9134 PO4P   1 ENGL AGGR REPL
COPY     14 OUTPUT MEAN   6 1     0.454     WDM1  9135 BOD    1 ENGL AGGR REPL
COPY     14 OUTPUT MEAN   7 1     0.454     WDM1  9131 DO     1 ENGL AGGR REPL
COPY     15 OUTPUT MEAN   1 1   0.02855     WDM1  9146 PERO   1 METR AGGR REPL
COPY     15 OUTPUT MEAN   2 1       907     WDM1  9140 TSS    1 ENGL AGGR REPL
COPY     15 OUTPUT MEAN   3 1     0.454     WDM1  9142 NH3N   1 ENGL AGGR REPL
COPY     15 OUTPUT MEAN   4 1     0.454     WDM1  9143 NO3N   1 ENGL AGGR REPL
COPY     15 OUTPUT MEAN   5 1     0.454     WDM1  9144 PO4P   1 ENGL AGGR REPL
COPY     15 OUTPUT MEAN   6 1     0.454     WDM1  9145 BOD    1 ENGL AGGR REPL
COPY     15 OUTPUT MEAN   7 1     0.454     WDM1  9141 DO     1 ENGL AGGR REPL
COPY     16 OUTPUT MEAN   1 1   0.02855     WDM1  9156 PERO   1 METR AGGR REPL
COPY     16 OUTPUT MEAN   2 1       907     WDM1  9150 TSS    1 ENGL AGGR REPL
COPY     16 OUTPUT MEAN   3 1     0.454     WDM1  9152 NH3N   1 ENGL AGGR REPL
COPY     16 OUTPUT MEAN   4 1     0.454     WDM1  9153 NO3N   1 ENGL AGGR REPL
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COPY    16 OUTPUT MEAN   5 1      0.454      WDM1  9154 PO4P   1 ENGL AGGR REPL
COPY    16 OUTPUT MEAN   6 1      0.454      WDM1  9155 BOD    1 ENGL AGGR REPL
COPY    16 OUTPUT MEAN   7 1      0.454      WDM1  9151 DO     1 ENGL AGGR REPL
COPY    17 OUTPUT MEAN   1 1    0.02855      WDM1  9166 PERO   1 METR AGGR REPL
COPY    17 OUTPUT MEAN   2 1        907      WDM1  9160 TSS    1 ENGL AGGR REPL
COPY    17 OUTPUT MEAN   3 1      0.454      WDM1  9162 NH3N   1 ENGL AGGR REPL
COPY    17 OUTPUT MEAN   4 1      0.454      WDM1  9163 NO3N   1 ENGL AGGR REPL
COPY    17 OUTPUT MEAN   5 1      0.454      WDM1  9164 PO4P   1 ENGL AGGR REPL
COPY    17 OUTPUT MEAN   6 1      0.454      WDM1  9165 BOD    1 ENGL AGGR REPL
COPY    17 OUTPUT MEAN   7 1      0.454      WDM1  9161 DO     1 ENGL AGGR REPL
COPY    18 OUTPUT MEAN   1 1    0.02855      WDM1  9176 PERO   1 METR AGGR REPL
COPY    18 OUTPUT MEAN   2 1        907      WDM1  9170 TSS    1 ENGL AGGR REPL
COPY    18 OUTPUT MEAN   3 1      0.454      WDM1  9172 NH3N   1 ENGL AGGR REPL
COPY    18 OUTPUT MEAN   4 1      0.454      WDM1  9173 NO3N   1 ENGL AGGR REPL
COPY    18 OUTPUT MEAN   5 1      0.454      WDM1  9174 PO4P   1 ENGL AGGR REPL
COPY    18 OUTPUT MEAN   6 1      0.454      WDM1  9175 BOD    1 ENGL AGGR REPL
COPY    18 OUTPUT MEAN   7 1      0.454      WDM1  9171 DO     1 ENGL AGGR REPL
END EXT TARGETS

MASS-LINK

  MASS-LINK        3
<-Volume-> <-Grp> <-Member-><--Mult-->     <-Target vols> <-Grp> <-Member->  ***
<Name>            <Name> x x<-factor->     <Name>                <Name> x x  ***
RCHRES     ROFLOW                          RCHRES         INFLOW
  END MASS-LINK    3

  MASS-LINK        2
<-Volume-> <-Grp> <-Member-><--Mult-->     <-Target vols> <-Grp> <-Member->  ***
<Name>            <Name> x x<-factor->     <Name>                <Name> x x  ***
PERLND     PWATER PERO       0.0833333     RCHRES         INFLOW IVOL
PERLND     PWTGAS POHT                     RCHRES         INFLOW IHEAT
PERLND     PQUAL  POQUAL 1        1.00     RCHRES         INFLOW NUIF1  2
PERLND     PQUAL  POQUAL 2                 RCHRES         INFLOW NUIF1  1
PERLND     PQUAL  POQUAL 3                 RCHRES         INFLOW NUIF1  4
PERLND     PQUAL  POQUAL 4        1.00     RCHRES         INFLOW OXIF   2
PERLND     PQUAL  POQUAL 4       0.100     RCHRES         INFLOW PKIF   3
PERLND     PQUAL  POQUAL 4       0.015     RCHRES         INFLOW PKIF   4
PERLND     PQUAL  POQUAL 4         0.5     RCHRES         INFLOW PKIF   5
PERLND     SEDMNT SOSED  1        0.05     RCHRES         INFLOW ISED   1
PERLND     SEDMNT SOSED  1        0.55     RCHRES         INFLOW ISED   2
PERLND     SEDMNT SOSED  1         0.4     RCHRES         INFLOW ISED   3
PERLND     PWTGAS PODOXM                   RCHRES         INFLOW OXIF   1
PERLND     PWTGAS POHT                     RCHRES         INFLOW IHEAT  1
  END MASS-LINK    2

  MASS-LINK        1
<-Volume-> <-Grp> <-Member-><--Mult-->     <-Target vols> <-Grp> <-Member->  ***
<Name>            <Name> x x<-factor->     <Name>                <Name> x x  ***
IMPLND     IWATER SURO       0.0833333     RCHRES         INFLOW IVOL
IMPLND     IWTGAS SOHT                     RCHRES         INFLOW IHEAT
IMPLND     IQUAL  SOQUAL 1        1.00     RCHRES         INFLOW NUIF1  2
IMPLND     IQUAL  SOQUAL 2                 RCHRES         INFLOW NUIF1  1
IMPLND     IQUAL  SOQUAL 3                 RCHRES         INFLOW NUIF1  4
IMPLND     IQUAL  SOQUAL 4        1.00     RCHRES         INFLOW OXIF   2
IMPLND     IQUAL  SOQUAL 4       0.100     RCHRES         INFLOW PKIF   3
IMPLND     IQUAL  SOQUAL 4       0.015     RCHRES         INFLOW PKIF   4
IMPLND     IQUAL  SOQUAL 4         0.5     RCHRES         INFLOW PKIF   5
IMPLND     SOLIDS SOSLD  1        0.05     RCHRES         INFLOW ISED   1
IMPLND     SOLIDS SOSLD  1        0.55     RCHRES         INFLOW ISED   2
IMPLND     SOLIDS SOSLD  1         0.4     RCHRES         INFLOW ISED   3
IMPLND     IWTGAS SODOXM                   RCHRES         INFLOW OXIF   1
IMPLND     IWTGAS SOHT                     RCHRES         INFLOW IHEAT  1
```

```
  END MASS-LINK    1

  MASS-LINK       27
<-Volume-> <-Grp> <-Member-><--Mult-->     <-Target vols> <-Grp> <-Member->  ***
<Name>            <Name> x x<-factor->     <Name>                <Name> x x  ***
PERLND     PWATER PERO                     COPY           INPUT  MEAN   1
PERLND     SEDMNT SOSED  1                 COPY           INPUT  MEAN   2
PERLND     PQUAL  POQUAL 1        1.00     COPY           INPUT  MEAN   3
PERLND     PQUAL  POQUAL 2                 COPY           INPUT  MEAN   4
PERLND     PQUAL  POQUAL 3                 COPY           INPUT  MEAN   5
PERLND     PQUAL  POQUAL 4        1.00     COPY           INPUT  MEAN   6
PERLND     PWTGAS PODOXM                   COPY           INPUT  MEAN   7
  END MASS-LINK   27

  MASS-LINK       26
<-Volume-> <-Grp> <-Member-><--Mult-->     <-Target vols> <-Grp> <-Member->  ***
<Name>            <Name> x x<-factor->     <Name>                <Name> x x  ***
IMPLND     IWATER SURO                     COPY           INPUT  MEAN   1
IMPLND     SOLIDS SOSLD  1                 COPY           INPUT  MEAN   2
IMPLND     IQUAL  SOQUAL 1        1.00     COPY           INPUT  MEAN   3
IMPLND     IQUAL  SOQUAL 2                 COPY           INPUT  MEAN   4
IMPLND     IQUAL  SOQUAL 3                 COPY           INPUT  MEAN   5
IMPLND     IQUAL  SOQUAL 4        1.00     COPY           INPUT  MEAN   6
IMPLND     IWTGAS SODOXM                   COPY           INPUT  MEAN   7
  END MASS-LINK   26

  MASS-LINK        5
<-Volume-> <-Grp> <-Member-><--Mult-->     <-Target vols> <-Grp> <-Member->  ***
<Name>            <Name> x x<-factor->     <Name>                <Name> x x  ***
PERLND     PWATER PERO       0.0833333     RCHRES         INFLOW IVOL
PERLND     PWTGAS POHT                     RCHRES         INFLOW IHEAT
PERLND     PQUAL  POQUAL 1        1.00     RCHRES         INFLOW NUIF1  2
PERLND     PQUAL  POQUAL 2                 RCHRES         INFLOW NUIF1  1
PERLND     PQUAL  POQUAL 3                 RCHRES         INFLOW NUIF1  4
PERLND     PQUAL  POQUAL 4        1.00     RCHRES         INFLOW OXIF   2
PERLND     PQUAL  POQUAL 4       0.100     RCHRES         INFLOW PKIF   3
PERLND     PQUAL  POQUAL 4       0.015     RCHRES         INFLOW PKIF   4
PERLND     PQUAL  POQUAL 4         0.5     RCHRES         INFLOW PKIF   5
PERLND     SEDMNT SOSED  1        0.05     RCHRES         INFLOW ISED   1
PERLND     SEDMNT SOSED  1        0.55     RCHRES         INFLOW ISED   2
PERLND     SEDMNT SOSED  1         0.4     RCHRES         INFLOW ISED   3
PERLND     PWTGAS PODOXM                   RCHRES         INFLOW OXIF   1
PERLND     PWTGAS POHT                     RCHRES         INFLOW IHEAT  1
  END MASS-LINK    5

  MASS-LINK        4
<-Volume-> <-Grp> <-Member-><--Mult-->     <-Target vols> <-Grp> <-Member->  ***
<Name>            <Name> x x<-factor->     <Name>                <Name> x x  ***
IMPLND     IWATER SURO       0.0833333     RCHRES         INFLOW IVOL
IMPLND     IWTGAS SOHT                     RCHRES         INFLOW IHEAT
IMPLND     IQUAL  SOQUAL 1        1.00     RCHRES         INFLOW NUIF1  2
IMPLND     IQUAL  SOQUAL 2                 RCHRES         INFLOW NUIF1  1
IMPLND     IQUAL  SOQUAL 3                 RCHRES         INFLOW NUIF1  4
IMPLND     IQUAL  SOQUAL 4        1.00     RCHRES         INFLOW OXIF   2
IMPLND     IQUAL  SOQUAL 4       0.100     RCHRES         INFLOW PKIF   3
IMPLND     IQUAL  SOQUAL 4       0.015     RCHRES         INFLOW PKIF   4
IMPLND     IQUAL  SOQUAL 4         0.5     RCHRES         INFLOW PKIF   5
IMPLND     SOLIDS SOSLD  1        0.05     RCHRES         INFLOW ISED   1
IMPLND     SOLIDS SOSLD  1        0.55     RCHRES         INFLOW ISED   2
IMPLND     SOLIDS SOSLD  1         0.4     RCHRES         INFLOW ISED   3
IMPLND     IWTGAS SODOXM                   RCHRES         INFLOW OXIF   1
IMPLND     IWTGAS SOHT                     RCHRES         INFLOW IHEAT  1
  END MASS-LINK    4
```

```
  MASS-LINK       29
<-Volume-> <-Grp> <-Member-><--Mult-->     <-Target vols> <-Grp> <-Member->  ***
<Name>            <Name> x x<-factor->     <Name>                <Name> x x  ***
PERLND     PWATER PERO                     COPY           INPUT  MEAN   1
PERLND     SEDMNT SOSED  1                 COPY           INPUT  MEAN   2
PERLND     PQUAL  POQUAL 1        1.00     COPY           INPUT  MEAN   3
PERLND     PQUAL  POQUAL 2                 COPY           INPUT  MEAN   4
PERLND     PQUAL  POQUAL 3                 COPY           INPUT  MEAN   5
PERLND     PQUAL  POQUAL 4        1.00     COPY           INPUT  MEAN   6
PERLND     PWTGAS PODOXM                   COPY           INPUT  MEAN   7
  END MASS-LINK   29

  MASS-LINK       28
<-Volume-> <-Grp> <-Member-><--Mult-->     <-Target vols> <-Grp> <-Member->  ***
<Name>            <Name> x x<-factor->     <Name>                <Name> x x  ***
IMPLND     IWATER SURO                     COPY           INPUT  MEAN   1
IMPLND     SOLIDS SOSLD  1                 COPY           INPUT  MEAN   2
IMPLND     IQUAL  SOQUAL 1        1.00     COPY           INPUT  MEAN   3
IMPLND     IQUAL  SOQUAL 2                 COPY           INPUT  MEAN   4
IMPLND     IQUAL  SOQUAL 3                 COPY           INPUT  MEAN   5
IMPLND     IQUAL  SOQUAL 4        1.00     COPY           INPUT  MEAN   6
IMPLND     IWTGAS SODOXM                   COPY           INPUT  MEAN   7
  END MASS-LINK   28

  MASS-LINK        7
<-Volume-> <-Grp> <-Member-><--Mult-->     <-Target vols> <-Grp> <-Member->  ***
<Name>            <Name> x x<-factor->     <Name>                <Name> x x  ***
PERLND     PWATER PERO       0.0833333     RCHRES         INFLOW IVOL
PERLND     PWTGAS POHT                     RCHRES         INFLOW IHEAT
PERLND     PQUAL  POQUAL 1        1.00     RCHRES         INFLOW NUIF1  2
PERLND     PQUAL  POQUAL 2                 RCHRES         INFLOW NUIF1  1
PERLND     PQUAL  POQUAL 3                 RCHRES         INFLOW NUIF1  4
PERLND     PQUAL  POQUAL 4        1.00     RCHRES         INFLOW OXIF   2
PERLND     PQUAL  POQUAL 4       0.100     RCHRES         INFLOW PKIF   3
PERLND     PQUAL  POQUAL 4       0.015     RCHRES         INFLOW PKIF   4
PERLND     PQUAL  POQUAL 4         0.5     RCHRES         INFLOW PKIF   5
PERLND     SEDMNT SOSED  1        0.05     RCHRES         INFLOW ISED   1
PERLND     SEDMNT SOSED  1        0.55     RCHRES         INFLOW ISED   2
PERLND     SEDMNT SOSED  1         0.4     RCHRES         INFLOW ISED   3
PERLND     PWTGAS PODOXM                   RCHRES         INFLOW OXIF   1
PERLND     PWTGAS POHT                     RCHRES         INFLOW IHEAT  1
  END MASS-LINK    7

  MASS-LINK        6
<-Volume-> <-Grp> <-Member-><--Mult-->     <-Target vols> <-Grp> <-Member->  ***
<Name>            <Name> x x<-factor->     <Name>                <Name> x x  ***
IMPLND     IWATER SURO       0.0833333     RCHRES         INFLOW IVOL
IMPLND     IWTGAS SOHT                     RCHRES         INFLOW IHEAT
IMPLND     IQUAL  SOQUAL 1        1.00     RCHRES         INFLOW NUIF1  2
IMPLND     IQUAL  SOQUAL 2                 RCHRES         INFLOW NUIF1  1
IMPLND     IQUAL  SOQUAL 3                 RCHRES         INFLOW NUIF1  4
IMPLND     IQUAL  SOQUAL 4        1.00     RCHRES         INFLOW OXIF   2
IMPLND     IQUAL  SOQUAL 4       0.100     RCHRES         INFLOW PKIF   3
IMPLND     IQUAL  SOQUAL 4       0.015     RCHRES         INFLOW PKIF   4
IMPLND     IQUAL  SOQUAL 4         0.5     RCHRES         INFLOW PKIF   5
IMPLND     SOLIDS SOSLD  1        0.05     RCHRES         INFLOW ISED   1
IMPLND     SOLIDS SOSLD  1        0.55     RCHRES         INFLOW ISED   2
IMPLND     SOLIDS SOSLD  1         0.4     RCHRES         INFLOW ISED   3
IMPLND     IWTGAS SODOXM                   RCHRES         INFLOW OXIF   1
IMPLND     IWTGAS SOHT                     RCHRES         INFLOW IHEAT  1
  END MASS-LINK    6
```

```
  MASS-LINK       31
<-Volume-> <-Grp> <-Member-><--Mult-->     <-Target vols> <-Grp> <-Member->  ***
<Name>            <Name> x x<-factor->     <Name>                <Name> x x  ***
PERLND     PWATER PERO                     COPY           INPUT  MEAN   1
PERLND     SEDMNT SOSED  1                 COPY           INPUT  MEAN   2
PERLND     PQUAL  POQUAL 1        1.00     COPY           INPUT  MEAN   3
PERLND     PQUAL  POQUAL 2                 COPY           INPUT  MEAN   4
PERLND     PQUAL  POQUAL 3                 COPY           INPUT  MEAN   5
PERLND     PQUAL  POQUAL 4        1.00     COPY           INPUT  MEAN   6
PERLND     PWTGAS PODOXM                   COPY           INPUT  MEAN   7
  END MASS-LINK   31

  MASS-LINK       30
<-Volume-> <-Grp> <-Member-><--Mult-->     <-Target vols> <-Grp> <-Member->  ***
<Name>            <Name> x x<-factor->     <Name>                <Name> x x  ***
IMPLND     IWATER SURO                     COPY           INPUT  MEAN   1
IMPLND     SOLIDS SOSLD  1                 COPY           INPUT  MEAN   2
IMPLND     IQUAL  SOQUAL 1        1.00     COPY           INPUT  MEAN   3
IMPLND     IQUAL  SOQUAL 2                 COPY           INPUT  MEAN   4
IMPLND     IQUAL  SOQUAL 3                 COPY           INPUT  MEAN   5
IMPLND     IQUAL  SOQUAL 4        1.00     COPY           INPUT  MEAN   6
IMPLND     IWTGAS SODOXM                   COPY           INPUT  MEAN   7
  END MASS-LINK   30

  MASS-LINK        9
<-Volume-> <-Grp> <-Member-><--Mult-->     <-Target vols> <-Grp> <-Member->  ***
<Name>            <Name> x x<-factor->     <Name>                <Name> x x  ***
PERLND     PWATER PERO       0.0833333     RCHRES         INFLOW IVOL
PERLND     PWTGAS POHT                     RCHRES         INFLOW IHEAT
PERLND     PQUAL  POQUAL 1        1.00     RCHRES         INFLOW NUIF1  2
PERLND     PQUAL  POQUAL 2                 RCHRES         INFLOW NUIF1  1
PERLND     PQUAL  POQUAL 3                 RCHRES         INFLOW NUIF1  4
PERLND     PQUAL  POQUAL 4        1.00     RCHRES         INFLOW OXIF   2
PERLND     PQUAL  POQUAL 4       0.100     RCHRES         INFLOW PKIF   3
PERLND     PQUAL  POQUAL 4       0.015     RCHRES         INFLOW PKIF   4
PERLND     PQUAL  POQUAL 4         0.5     RCHRES         INFLOW PKIF   5
PERLND     SEDMNT SOSED  1        0.05     RCHRES         INFLOW ISED   1
PERLND     SEDMNT SOSED  1        0.55     RCHRES         INFLOW ISED   2
PERLND     SEDMNT SOSED  1         0.4     RCHRES         INFLOW ISED   3
PERLND     PWTGAS PODOXM                   RCHRES         INFLOW OXIF   1
PERLND     PWTGAS POHT                     RCHRES         INFLOW IHEAT  1
  END MASS-LINK    9

  MASS-LINK        8
<-Volume-> <-Grp> <-Member-><--Mult-->     <-Target vols> <-Grp> <-Member->  ***
<Name>            <Name> x x<-factor->     <Name>                <Name> x x  ***
IMPLND     IWATER SURO       0.0833333     RCHRES         INFLOW IVOL
IMPLND     IWTGAS SOHT                     RCHRES         INFLOW IHEAT
IMPLND     IQUAL  SOQUAL 1        1.00     RCHRES         INFLOW NUIF1  2
IMPLND     IQUAL  SOQUAL 2                 RCHRES         INFLOW NUIF1  1
IMPLND     IQUAL  SOQUAL 3                 RCHRES         INFLOW NUIF1  4
IMPLND     IQUAL  SOQUAL 4        1.00     RCHRES         INFLOW OXIF   2
IMPLND     IQUAL  SOQUAL 4       0.100     RCHRES         INFLOW PKIF   3
IMPLND     IQUAL  SOQUAL 4       0.015     RCHRES         INFLOW PKIF   4
IMPLND     IQUAL  SOQUAL 4         0.5     RCHRES         INFLOW PKIF   5
IMPLND     SOLIDS SOSLD  1        0.05     RCHRES         INFLOW ISED   1
IMPLND     SOLIDS SOSLD  1        0.55     RCHRES         INFLOW ISED   2
IMPLND     SOLIDS SOSLD  1         0.4     RCHRES         INFLOW ISED   3
IMPLND     IWTGAS SODOXM                   RCHRES         INFLOW OXIF   1
IMPLND     IWTGAS SOHT                     RCHRES         INFLOW IHEAT  1
  END MASS-LINK    8

  MASS-LINK       33
```

```
<-Volume-> <-Grp> <-Member-><--Mult-->     <-Target vols> <-Grp> <-Member->  ***
<Name>            <Name> x x<-factor->     <Name>                <Name> x x  ***
PERLND     PWATER PERO                     COPY           INPUT  MEAN   1
PERLND     SEDMNT SOSED  1                 COPY           INPUT  MEAN   2
PERLND     PQUAL  POQUAL 1        1.00     COPY           INPUT  MEAN   3
PERLND     PQUAL  POQUAL 2                 COPY           INPUT  MEAN   4
PERLND     PQUAL  POQUAL 3                 COPY           INPUT  MEAN   5
PERLND     PQUAL  POQUAL 4        1.00     COPY           INPUT  MEAN   6
PERLND     PWTGAS PODOXM                   COPY           INPUT  MEAN   7
  END MASS-LINK   33

  MASS-LINK       32
<-Volume-> <-Grp> <-Member-><--Mult-->     <-Target vols> <-Grp> <-Member->  ***
<Name>            <Name> x x<-factor->     <Name>                <Name> x x  ***
IMPLND     IWATER SURO                     COPY           INPUT  MEAN   1
IMPLND     SOLIDS SOSLD  1                 COPY           INPUT  MEAN   2
IMPLND     IQUAL  SOQUAL 1        1.00     COPY           INPUT  MEAN   3
IMPLND     IQUAL  SOQUAL 2                 COPY           INPUT  MEAN   4
IMPLND     IQUAL  SOQUAL 3                 COPY           INPUT  MEAN   5
IMPLND     IQUAL  SOQUAL 4        1.00     COPY           INPUT  MEAN   6
IMPLND     IWTGAS SODOXM                   COPY           INPUT  MEAN   7
  END MASS-LINK   32

  MASS-LINK       11
<-Volume-> <-Grp> <-Member-><--Mult-->     <-Target vols> <-Grp> <-Member->  ***
<Name>            <Name> x x<-factor->     <Name>                <Name> x x  ***
PERLND     PWATER PERO       0.0833333     RCHRES         INFLOW IVOL
PERLND     PWTGAS POHT                     RCHRES         INFLOW IHEAT
PERLND     PQUAL  POQUAL 1        1.00     RCHRES         INFLOW NUIF1  2
PERLND     PQUAL  POQUAL 2                 RCHRES         INFLOW NUIF1  1
PERLND     PQUAL  POQUAL 3                 RCHRES         INFLOW NUIF1  4
PERLND     PQUAL  POQUAL 4        1.00     RCHRES         INFLOW OXIF   2
PERLND     PQUAL  POQUAL 4       0.100     RCHRES         INFLOW PKIF   3
PERLND     PQUAL  POQUAL 4       0.015     RCHRES         INFLOW PKIF   4
PERLND     PQUAL  POQUAL 4         0.5     RCHRES         INFLOW PKIF   5
PERLND     SEDMNT SOSED  1        0.05     RCHRES         INFLOW ISED   1
PERLND     SEDMNT SOSED  1        0.55     RCHRES         INFLOW ISED   2
PERLND     SEDMNT SOSED  1         0.4     RCHRES         INFLOW ISED   3
PERLND     PWTGAS PODOXM                   RCHRES         INFLOW OXIF   1
PERLND     PWTGAS POHT                     RCHRES         INFLOW IHEAT  1
  END MASS-LINK   11

  MASS-LINK       10
<-Volume-> <-Grp> <-Member-><--Mult-->     <-Target vols> <-Grp> <-Member->  ***
<Name>            <Name> x x<-factor->     <Name>                <Name> x x  ***
IMPLND     IWATER SURO       0.0833333     RCHRES         INFLOW IVOL
IMPLND     IWTGAS SOHT                     RCHRES         INFLOW IHEAT
IMPLND     IQUAL  SOQUAL 1        1.00     RCHRES         INFLOW NUIF1  2
IMPLND     IQUAL  SOQUAL 2                 RCHRES         INFLOW NUIF1  1
IMPLND     IQUAL  SOQUAL 3                 RCHRES         INFLOW NUIF1  4
IMPLND     IQUAL  SOQUAL 4        1.00     RCHRES         INFLOW OXIF   2
IMPLND     IQUAL  SOQUAL 4       0.100     RCHRES         INFLOW PKIF   3
IMPLND     IQUAL  SOQUAL 4       0.015     RCHRES         INFLOW PKIF   4
IMPLND     IQUAL  SOQUAL 4         0.5     RCHRES         INFLOW PKIF   5
IMPLND     SOLIDS SOSLD  1        0.05     RCHRES         INFLOW ISED   1
IMPLND     SOLIDS SOSLD  1        0.55     RCHRES         INFLOW ISED   2
IMPLND     SOLIDS SOSLD  1         0.4     RCHRES         INFLOW ISED   3
IMPLND     IWTGAS SODOXM                   RCHRES         INFLOW OXIF   1
IMPLND     IWTGAS SOHT                     RCHRES         INFLOW IHEAT  1
  END MASS-LINK   10

  MASS-LINK       35
<-Volume-> <-Grp> <-Member-><--Mult-->     <-Target vols> <-Grp> <-Member->  ***
```

```
<Name>            <Name> x x<-factor->     <Name>                <Name> x x  ***
PERLND     PWATER PERO                     COPY            INPUT  MEAN   1
PERLND     SEDMNT SOSED  1                 COPY            INPUT  MEAN   2
PERLND     PQUAL  POQUAL 1        1.00     COPY            INPUT  MEAN   3
PERLND     PQUAL  POQUAL 2                 COPY            INPUT  MEAN   4
PERLND     PQUAL  POQUAL 3                 COPY            INPUT  MEAN   5
PERLND     PQUAL  POQUAL 4        1.00     COPY            INPUT  MEAN   6
PERLND     PWTGAS PODOXM                   COPY            INPUT  MEAN   7
  END MASS-LINK   35

  MASS-LINK       34
<-Volume-> <-Grp> <-Member-><--Mult-->     <-Target vols> <-Grp> <-Member->  ***
<Name>            <Name> x x<-factor->     <Name>                <Name> x x  ***
IMPLND     IWATER SURO                     COPY            INPUT  MEAN   1
IMPLND     SOLIDS SOSLD  1                 COPY            INPUT  MEAN   2
IMPLND     IQUAL  SOQUAL 1        1.00     COPY            INPUT  MEAN   3
IMPLND     IQUAL  SOQUAL 2                 COPY            INPUT  MEAN   4
IMPLND     IQUAL  SOQUAL 3                 COPY            INPUT  MEAN   5
IMPLND     IQUAL  SOQUAL 4        1.00     COPY            INPUT  MEAN   6
IMPLND     IWTGAS SODOXM                   COPY            INPUT  MEAN   7
  END MASS-LINK   34

  MASS-LINK       13
<-Volume-> <-Grp> <-Member-><--Mult-->     <-Target vols> <-Grp> <-Member->  ***
<Name>            <Name> x x<-factor->     <Name>                <Name> x x  ***
PERLND     PWATER PERO       0.0833333     RCHRES          INFLOW IVOL
PERLND     PWTGAS POHT                     RCHRES          INFLOW IHEAT
PERLND     PQUAL  POQUAL 1        1.00     RCHRES          INFLOW NUIF1  2
PERLND     PQUAL  POQUAL 2                 RCHRES          INFLOW NUIF1  1
PERLND     PQUAL  POQUAL 3                 RCHRES          INFLOW NUIF1  4
PERLND     PQUAL  POQUAL 4        1.00     RCHRES          INFLOW OXIF   2
PERLND     PQUAL  POQUAL 4       0.100     RCHRES          INFLOW PKIF   3
PERLND     PQUAL  POQUAL 4       0.015     RCHRES          INFLOW PKIF   4
PERLND     PQUAL  POQUAL 4         0.5     RCHRES          INFLOW PKIF   5
PERLND     SEDMNT SOSED  1        0.05     RCHRES          INFLOW ISED   1
PERLND     SEDMNT SOSED  1        0.55     RCHRES          INFLOW ISED   2
PERLND     SEDMNT SOSED  1         0.4     RCHRES          INFLOW ISED   3
PERLND     PWTGAS PODOXM                   RCHRES          INFLOW OXIF   1
PERLND     PWTGAS POHT                     RCHRES          INFLOW IHEAT  1
  END MASS-LINK   13

  MASS-LINK       12
<-Volume-> <-Grp> <-Member-><--Mult-->     <-Target vols> <-Grp> <-Member->  ***
<Name>            <Name> x x<-factor->     <Name>                <Name> x x  ***
IMPLND     IWATER SURO       0.0833333     RCHRES          INFLOW IVOL
IMPLND     IWTGAS SOHT                     RCHRES          INFLOW IHEAT
IMPLND     IQUAL  SOQUAL 1        1.00     RCHRES          INFLOW NUIF1  2
IMPLND     IQUAL  SOQUAL 2                 RCHRES          INFLOW NUIF1  1
IMPLND     IQUAL  SOQUAL 3                 RCHRES          INFLOW NUIF1  4
IMPLND     IQUAL  SOQUAL 4        1.00     RCHRES          INFLOW OXIF   2
IMPLND     IQUAL  SOQUAL 4       0.100     RCHRES          INFLOW PKIF   3
IMPLND     IQUAL  SOQUAL 4       0.015     RCHRES          INFLOW PKIF   4
IMPLND     IQUAL  SOQUAL 4         0.5     RCHRES          INFLOW PKIF   5
IMPLND     SOLIDS SOSLD  1        0.05     RCHRES          INFLOW ISED   1
IMPLND     SOLIDS SOSLD  1        0.55     RCHRES          INFLOW ISED   2
IMPLND     SOLIDS SOSLD  1         0.4     RCHRES          INFLOW ISED   3
IMPLND     IWTGAS SODOXM                   RCHRES          INFLOW OXIF   1
IMPLND     IWTGAS SOHT                     RCHRES          INFLOW IHEAT  1
  END MASS-LINK   12

  MASS-LINK       37
<-Volume-> <-Grp> <-Member-><--Mult-->     <-Target vols> <-Grp> <-Member->  ***
<Name>            <Name> x x<-factor->     <Name>                <Name> x x  ***
```

```
PERLND     PWATER PERO                     COPY           INPUT  MEAN   1
PERLND     SEDMNT SOSED  1                 COPY           INPUT  MEAN   2
PERLND     PQUAL  POQUAL 1        1.00     COPY           INPUT  MEAN   3
PERLND     PQUAL  POQUAL 2                 COPY           INPUT  MEAN   4
PERLND     PQUAL  POQUAL 3                 COPY           INPUT  MEAN   5
PERLND     PQUAL  POQUAL 4        1.00     COPY           INPUT  MEAN   6
PERLND     PWTGAS PODOXM                   COPY           INPUT  MEAN   7
  END MASS-LINK   37

  MASS-LINK       36
<-Volume-> <-Grp> <-Member-><--Mult-->     <-Target vols> <-Grp> <-Member->  ***
<Name>            <Name> x x<-factor->     <Name>                <Name> x x  ***
IMPLND     IWATER SURO                     COPY           INPUT  MEAN   1
IMPLND     SOLIDS SOSLD  1                 COPY           INPUT  MEAN   2
IMPLND     IQUAL  SOQUAL 1        1.00     COPY           INPUT  MEAN   3
IMPLND     IQUAL  SOQUAL 2                 COPY           INPUT  MEAN   4
IMPLND     IQUAL  SOQUAL 3                 COPY           INPUT  MEAN   5
IMPLND     IQUAL  SOQUAL 4        1.00     COPY           INPUT  MEAN   6
IMPLND     IWTGAS SODOXM                   COPY           INPUT  MEAN   7
  END MASS-LINK   36

  MASS-LINK       15
<-Volume-> <-Grp> <-Member-><--Mult-->     <-Target vols> <-Grp> <-Member->  ***
<Name>            <Name> x x<-factor->     <Name>                <Name> x x  ***
PERLND     PWATER PERO       0.0833333     RCHRES         INFLOW IVOL
PERLND     PWTGAS POHT                     RCHRES         INFLOW IHEAT
PERLND     PQUAL  POQUAL 1        1.00     RCHRES         INFLOW NUIF1  2
PERLND     PQUAL  POQUAL 2                 RCHRES         INFLOW NUIF1  1
PERLND     PQUAL  POQUAL 3                 RCHRES         INFLOW NUIF1  4
PERLND     PQUAL  POQUAL 4        1.00     RCHRES         INFLOW OXIF   2
PERLND     PQUAL  POQUAL 4       0.100     RCHRES         INFLOW PKIF   3
PERLND     PQUAL  POQUAL 4       0.015     RCHRES         INFLOW PKIF   4
PERLND     PQUAL  POQUAL 4         0.5     RCHRES         INFLOW PKIF   5
PERLND     SEDMNT SOSED  1        0.05     RCHRES         INFLOW ISED   1
PERLND     SEDMNT SOSED  1        0.55     RCHRES         INFLOW ISED   2
PERLND     SEDMNT SOSED  1         0.4     RCHRES         INFLOW ISED   3
PERLND     PWTGAS PODOXM                   RCHRES         INFLOW OXIF   1
PERLND     PWTGAS POHT                     RCHRES         INFLOW IHEAT  1
  END MASS-LINK   15

  MASS-LINK       14
<-Volume-> <-Grp> <-Member-><--Mult-->     <-Target vols> <-Grp> <-Member->  ***
<Name>            <Name> x x<-factor->     <Name>                <Name> x x  ***
IMPLND     IWATER SURO       0.0833333     RCHRES         INFLOW IVOL
IMPLND     IWTGAS SOHT                     RCHRES         INFLOW IHEAT
IMPLND     IQUAL  SOQUAL 1        1.00     RCHRES         INFLOW NUIF1  2
IMPLND     IQUAL  SOQUAL 2                 RCHRES         INFLOW NUIF1  1
IMPLND     IQUAL  SOQUAL 3                 RCHRES         INFLOW NUIF1  4
IMPLND     IQUAL  SOQUAL 4        1.00     RCHRES         INFLOW OXIF   2
IMPLND     IQUAL  SOQUAL 4       0.100     RCHRES         INFLOW PKIF   3
IMPLND     IQUAL  SOQUAL 4       0.015     RCHRES         INFLOW PKIF   4
IMPLND     IQUAL  SOQUAL 4         0.5     RCHRES         INFLOW PKIF   5
IMPLND     SOLIDS SOSLD  1        0.05     RCHRES         INFLOW ISED   1
IMPLND     SOLIDS SOSLD  1        0.55     RCHRES         INFLOW ISED   2
IMPLND     SOLIDS SOSLD  1         0.4     RCHRES         INFLOW ISED   3
IMPLND     IWTGAS SODOXM                   RCHRES         INFLOW OXIF   1
IMPLND     IWTGAS SOHT                     RCHRES         INFLOW IHEAT  1
  END MASS-LINK   14

  MASS-LINK       39
<-Volume-> <-Grp> <-Member-><--Mult-->     <-Target vols> <-Grp> <-Member->  ***
<Name>            <Name> x x<-factor->     <Name>                <Name> x x  ***
PERLND     PWATER PERO                     COPY           INPUT  MEAN   1
```

```
PERLND     SEDMNT SOSED  1                    COPY           INPUT  MEAN   2
PERLND     PQUAL  POQUAL 1        1.00        COPY           INPUT  MEAN   3
PERLND     PQUAL  POQUAL 2                    COPY           INPUT  MEAN   4
PERLND     PQUAL  POQUAL 3                    COPY           INPUT  MEAN   5
PERLND     PQUAL  POQUAL 4        1.00        COPY           INPUT  MEAN   6
PERLND     PWTGAS PODOXM                      COPY           INPUT  MEAN   7
  END MASS-LINK   39

  MASS-LINK       38
<-Volume-> <-Grp> <-Member-><--Mult-->     <-Target vols> <-Grp> <-Member->  ***
<Name>            <Name> x x<-factor->     <Name>                <Name> x x  ***
IMPLND     IWATER SURO                        COPY           INPUT  MEAN   1
IMPLND     SOLIDS SOSLD  1                    COPY           INPUT  MEAN   2
IMPLND     IQUAL  SOQUAL 1        1.00        COPY           INPUT  MEAN   3
IMPLND     IQUAL  SOQUAL 2                    COPY           INPUT  MEAN   4
IMPLND     IQUAL  SOQUAL 3                    COPY           INPUT  MEAN   5
IMPLND     IQUAL  SOQUAL 4        1.00        COPY           INPUT  MEAN   6
IMPLND     IWTGAS SODOXM                      COPY           INPUT  MEAN   7
  END MASS-LINK   38

  MASS-LINK       17
<-Volume-> <-Grp> <-Member-><--Mult-->     <-Target vols> <-Grp> <-Member->  ***
<Name>            <Name> x x<-factor->     <Name>                <Name> x x  ***
PERLND     PWATER PERO       0.0833333        RCHRES         INFLOW IVOL
PERLND     PWTGAS POHT                        RCHRES         INFLOW IHEAT
PERLND     PQUAL  POQUAL 1        1.00        RCHRES         INFLOW NUIF1  2
PERLND     PQUAL  POQUAL 2                    RCHRES         INFLOW NUIF1  1
PERLND     PQUAL  POQUAL 3                    RCHRES         INFLOW NUIF1  4
PERLND     PQUAL  POQUAL 4        1.00        RCHRES         INFLOW OXIF   2
PERLND     PQUAL  POQUAL 4       0.100        RCHRES         INFLOW PKIF   3
PERLND     PQUAL  POQUAL 4       0.015        RCHRES         INFLOW PKIF   4
PERLND     PQUAL  POQUAL 4         0.5        RCHRES         INFLOW PKIF   5
PERLND     SEDMNT SOSED  1        0.05        RCHRES         INFLOW ISED   1
PERLND     SEDMNT SOSED  1        0.55        RCHRES         INFLOW ISED   2
PERLND     SEDMNT SOSED  1         0.4        RCHRES         INFLOW ISED   3
PERLND     PWTGAS PODOXM                      RCHRES         INFLOW OXIF   1
PERLND     PWTGAS POHT                        RCHRES         INFLOW IHEAT  1
  END MASS-LINK   17

  MASS-LINK       16
<-Volume-> <-Grp> <-Member-><--Mult-->     <-Target vols> <-Grp> <-Member->  ***
<Name>            <Name> x x<-factor->     <Name>                <Name> x x  ***
IMPLND     IWATER SURO       0.0833333        RCHRES         INFLOW IVOL
IMPLND     IWTGAS SOHT                        RCHRES         INFLOW IHEAT
IMPLND     IQUAL  SOQUAL 1        1.00        RCHRES         INFLOW NUIF1  2
IMPLND     IQUAL  SOQUAL 2                    RCHRES         INFLOW NUIF1  1
IMPLND     IQUAL  SOQUAL 3                    RCHRES         INFLOW NUIF1  4
IMPLND     IQUAL  SOQUAL 4        1.00        RCHRES         INFLOW OXIF   2
IMPLND     IQUAL  SOQUAL 4       0.100        RCHRES         INFLOW PKIF   3
IMPLND     IQUAL  SOQUAL 4       0.015        RCHRES         INFLOW PKIF   4
IMPLND     IQUAL  SOQUAL 4         0.5        RCHRES         INFLOW PKIF   5
IMPLND     SOLIDS SOSLD  1        0.05        RCHRES         INFLOW ISED   1
IMPLND     SOLIDS SOSLD  1        0.55        RCHRES         INFLOW ISED   2
IMPLND     SOLIDS SOSLD  1         0.4        RCHRES         INFLOW ISED   3
IMPLND     IWTGAS SODOXM                      RCHRES         INFLOW OXIF   1
IMPLND     IWTGAS SOHT                        RCHRES         INFLOW IHEAT  1
  END MASS-LINK   16

  MASS-LINK       41
<-Volume-> <-Grp> <-Member-><--Mult-->     <-Target vols> <-Grp> <-Member->  ***
<Name>            <Name> x x<-factor->     <Name>                <Name> x x  ***
PERLND     PWATER PERO                        COPY           INPUT  MEAN   1
PERLND     SEDMNT SOSED  1                    COPY           INPUT  MEAN   2
```

```
PERLND     PQUAL  POQUAL 1        1.00     COPY           INPUT  MEAN   3
PERLND     PQUAL  POQUAL 2                 COPY           INPUT  MEAN   4
PERLND     PQUAL  POQUAL 3                 COPY           INPUT  MEAN   5
PERLND     PQUAL  POQUAL 4        1.00     COPY           INPUT  MEAN   6
PERLND     PWTGAS PODOXM                   COPY           INPUT  MEAN   7
  END MASS-LINK   41

  MASS-LINK       40
<-Volume-> <-Grp> <-Member-><--Mult-->     <-Target vols> <-Grp> <-Member->  ***
<Name>            <Name> x x<-factor->     <Name>                <Name> x x  ***
IMPLND     IWATER SURO                     COPY           INPUT  MEAN   1
IMPLND     SOLIDS SOSLD  1                 COPY           INPUT  MEAN   2
IMPLND     IQUAL  SOQUAL 1        1.00     COPY           INPUT  MEAN   3
IMPLND     IQUAL  SOQUAL 2                 COPY           INPUT  MEAN   4
IMPLND     IQUAL  SOQUAL 3                 COPY           INPUT  MEAN   5
IMPLND     IQUAL  SOQUAL 4        1.00     COPY           INPUT  MEAN   6
IMPLND     IWTGAS SODOXM                   COPY           INPUT  MEAN   7
  END MASS-LINK   40

  MASS-LINK       19
<-Volume-> <-Grp> <-Member-><--Mult-->     <-Target vols> <-Grp> <-Member->  ***
<Name>            <Name> x x<-factor->     <Name>                <Name> x x  ***
PERLND     PWATER PERO       0.0833333     RCHRES         INFLOW IVOL
PERLND     PWTGAS POHT                     RCHRES         INFLOW IHEAT
PERLND     PQUAL  POQUAL 1        1.00     RCHRES         INFLOW NUIF1  2
PERLND     PQUAL  POQUAL 2                 RCHRES         INFLOW NUIF1  1
PERLND     PQUAL  POQUAL 3                 RCHRES         INFLOW NUIF1  4
PERLND     PQUAL  POQUAL 4        1.00     RCHRES         INFLOW OXIF   2
PERLND     PQUAL  POQUAL 4       0.100     RCHRES         INFLOW PKIF   3
PERLND     PQUAL  POQUAL 4       0.015     RCHRES         INFLOW PKIF   4
PERLND     PQUAL  POQUAL 4         0.5     RCHRES         INFLOW PKIF   5
PERLND     SEDMNT SOSED  1        0.05     RCHRES         INFLOW ISED   1
PERLND     SEDMNT SOSED  1        0.55     RCHRES         INFLOW ISED   2
PERLND     SEDMNT SOSED  1         0.4     RCHRES         INFLOW ISED   3
PERLND     PWTGAS PODOXM                   RCHRES         INFLOW OXIF   1
PERLND     PWTGAS POHT                     RCHRES         INFLOW IHEAT  1
  END MASS-LINK   19

  MASS-LINK       18
<-Volume-> <-Grp> <-Member-><--Mult-->     <-Target vols> <-Grp> <-Member->  ***
<Name>            <Name> x x<-factor->     <Name>                <Name> x x  ***
IMPLND     IWATER SURO       0.0833333     RCHRES         INFLOW IVOL
IMPLND     IWTGAS SOHT                     RCHRES         INFLOW IHEAT
IMPLND     IQUAL  SOQUAL 1        1.00     RCHRES         INFLOW NUIF1  2
IMPLND     IQUAL  SOQUAL 2                 RCHRES         INFLOW NUIF1  1
IMPLND     IQUAL  SOQUAL 3                 RCHRES         INFLOW NUIF1  4
IMPLND     IQUAL  SOQUAL 4        1.00     RCHRES         INFLOW OXIF   2
IMPLND     IQUAL  SOQUAL 4       0.100     RCHRES         INFLOW PKIF   3
IMPLND     IQUAL  SOQUAL 4       0.015     RCHRES         INFLOW PKIF   4
IMPLND     IQUAL  SOQUAL 4         0.5     RCHRES         INFLOW PKIF   5
IMPLND     SOLIDS SOSLD  1        0.05     RCHRES         INFLOW ISED   1
IMPLND     SOLIDS SOSLD  1        0.55     RCHRES         INFLOW ISED   2
IMPLND     SOLIDS SOSLD  1         0.4     RCHRES         INFLOW ISED   3
IMPLND     IWTGAS SODOXM                   RCHRES         INFLOW OXIF   1
IMPLND     IWTGAS SOHT                     RCHRES         INFLOW IHEAT  1
  END MASS-LINK   18

  MASS-LINK       43
<-Volume-> <-Grp> <-Member-><--Mult-->     <-Target vols> <-Grp> <-Member->  ***
<Name>            <Name> x x<-factor->     <Name>                <Name> x x  ***
PERLND     PWATER PERO                     COPY           INPUT  MEAN   1
PERLND     SEDMNT SOSED  1                 COPY           INPUT  MEAN   2
PERLND     PQUAL  POQUAL 1        1.00     COPY           INPUT  MEAN   3
```

```
PERLND     PQUAL  POQUAL 2                 COPY           INPUT  MEAN   4
PERLND     PQUAL  POQUAL 3                 COPY           INPUT  MEAN   5
PERLND     PQUAL  POQUAL 4        1.00     COPY           INPUT  MEAN   6
PERLND     PWTGAS PODOXM                   COPY           INPUT  MEAN   7
  END MASS-LINK   43

  MASS-LINK       42
<-Volume-> <-Grp> <-Member-><--Mult-->     <-Target vols> <-Grp> <-Member->  ***
<Name>            <Name> x x<-factor->     <Name>                <Name> x x  ***
IMPLND     IWATER SURO                     COPY           INPUT  MEAN   1
IMPLND     SOLIDS SOSLD  1                 COPY           INPUT  MEAN   2
IMPLND     IQUAL  SOQUAL 1        1.00     COPY           INPUT  MEAN   3
IMPLND     IQUAL  SOQUAL 2                 COPY           INPUT  MEAN   4
IMPLND     IQUAL  SOQUAL 3                 COPY           INPUT  MEAN   5
IMPLND     IQUAL  SOQUAL 4        1.00     COPY           INPUT  MEAN   6
IMPLND     IWTGAS SODOXM                   COPY           INPUT  MEAN   7
  END MASS-LINK   42

  MASS-LINK       21
<-Volume-> <-Grp> <-Member-><--Mult-->     <-Target vols> <-Grp> <-Member->  ***
<Name>            <Name> x x<-factor->     <Name>                <Name> x x  ***
PERLND     PWATER PERO       0.0833333     RCHRES         INFLOW IVOL
PERLND     PWTGAS POHT                     RCHRES         INFLOW IHEAT
PERLND     PQUAL  POQUAL 1        1.00     RCHRES         INFLOW NUIF1  2
PERLND     PQUAL  POQUAL 2                 RCHRES         INFLOW NUIF1  1
PERLND     PQUAL  POQUAL 3                 RCHRES         INFLOW NUIF1  4
PERLND     PQUAL  POQUAL 4        1.00     RCHRES         INFLOW OXIF   2
PERLND     PQUAL  POQUAL 4       0.100     RCHRES         INFLOW PKIF   3
PERLND     PQUAL  POQUAL 4       0.015     RCHRES         INFLOW PKIF   4
PERLND     PQUAL  POQUAL 4         0.5     RCHRES         INFLOW PKIF   5
PERLND     SEDMNT SOSED  1        0.05     RCHRES         INFLOW ISED   1
PERLND     SEDMNT SOSED  1        0.55     RCHRES         INFLOW ISED   2
PERLND     SEDMNT SOSED  1         0.4     RCHRES         INFLOW ISED   3
PERLND     PWTGAS PODOXM                   RCHRES         INFLOW OXIF   1
PERLND     PWTGAS POHT                     RCHRES         INFLOW IHEAT  1
  END MASS-LINK   21

  MASS-LINK       20
<-Volume-> <-Grp> <-Member-><--Mult-->     <-Target vols> <-Grp> <-Member->  ***
<Name>            <Name> x x<-factor->     <Name>                <Name> x x  ***
IMPLND     IWATER SURO       0.0833333     RCHRES         INFLOW IVOL
IMPLND     IWTGAS SOHT                     RCHRES         INFLOW IHEAT
IMPLND     IQUAL  SOQUAL 1        1.00     RCHRES         INFLOW NUIF1  2
IMPLND     IQUAL  SOQUAL 2                 RCHRES         INFLOW NUIF1  1
IMPLND     IQUAL  SOQUAL 3                 RCHRES         INFLOW NUIF1  4
IMPLND     IQUAL  SOQUAL 4        1.00     RCHRES         INFLOW OXIF   2
IMPLND     IQUAL  SOQUAL 4       0.100     RCHRES         INFLOW PKIF   3
IMPLND     IQUAL  SOQUAL 4       0.015     RCHRES         INFLOW PKIF   4
IMPLND     IQUAL  SOQUAL 4         0.5     RCHRES         INFLOW PKIF   5
IMPLND     SOLIDS SOSLD  1        0.05     RCHRES         INFLOW ISED   1
IMPLND     SOLIDS SOSLD  1        0.55     RCHRES         INFLOW ISED   2
IMPLND     SOLIDS SOSLD  1         0.4     RCHRES         INFLOW ISED   3
IMPLND     IWTGAS SODOXM                   RCHRES         INFLOW OXIF   1
IMPLND     IWTGAS SOHT                     RCHRES         INFLOW IHEAT  1
  END MASS-LINK   20

  MASS-LINK       45
<-Volume-> <-Grp> <-Member-><--Mult-->     <-Target vols> <-Grp> <-Member->  ***
<Name>            <Name> x x<-factor->     <Name>                <Name> x x  ***
PERLND     PWATER PERO                     COPY           INPUT  MEAN   1
PERLND     SEDMNT SOSED  1                 COPY           INPUT  MEAN   2
PERLND     PQUAL  POQUAL 1        1.00     COPY           INPUT  MEAN   3
PERLND     PQUAL  POQUAL 2                 COPY           INPUT  MEAN   4
```

```
PERLND     PQUAL  POQUAL 3                 COPY           INPUT  MEAN   5
PERLND     PQUAL  POQUAL 4        1.00     COPY           INPUT  MEAN   6
PERLND     PWTGAS PODOXM                   COPY           INPUT  MEAN   7
  END MASS-LINK   45

  MASS-LINK       44
<-Volume-> <-Grp> <-Member-><--Mult-->     <-Target vols> <-Grp> <-Member->  ***
<Name>            <Name> x x<-factor->     <Name>                <Name> x x  ***
IMPLND     IWATER SURO                     COPY           INPUT  MEAN   1
IMPLND     SOLIDS SOSLD  1                 COPY           INPUT  MEAN   2
IMPLND     IQUAL  SOQUAL 1        1.00     COPY           INPUT  MEAN   3
IMPLND     IQUAL  SOQUAL 2                 COPY           INPUT  MEAN   4
IMPLND     IQUAL  SOQUAL 3                 COPY           INPUT  MEAN   5
IMPLND     IQUAL  SOQUAL 4        1.00     COPY           INPUT  MEAN   6
IMPLND     IWTGAS SODOXM                   COPY           INPUT  MEAN   7
  END MASS-LINK   44

  MASS-LINK       23
<-Volume-> <-Grp> <-Member-><--Mult-->     <-Target vols> <-Grp> <-Member->  ***
<Name>            <Name> x x<-factor->     <Name>                <Name> x x  ***
PERLND     PWATER PERO       0.0833333     RCHRES         INFLOW IVOL
PERLND     PWTGAS POHT                     RCHRES         INFLOW IHEAT
PERLND     PQUAL  POQUAL 1        1.00     RCHRES         INFLOW NUIF1  2
PERLND     PQUAL  POQUAL 2                 RCHRES         INFLOW NUIF1  1
PERLND     PQUAL  POQUAL 3                 RCHRES         INFLOW NUIF1  4
PERLND     PQUAL  POQUAL 4        1.00     RCHRES         INFLOW OXIF   2
PERLND     PQUAL  POQUAL 4       0.100     RCHRES         INFLOW PKIF   3
PERLND     PQUAL  POQUAL 4       0.015     RCHRES         INFLOW PKIF   4
PERLND     PQUAL  POQUAL 4         0.5     RCHRES         INFLOW PKIF   5
PERLND     SEDMNT SOSED  1        0.05     RCHRES         INFLOW ISED   1
PERLND     SEDMNT SOSED  1        0.55     RCHRES         INFLOW ISED   2
PERLND     SEDMNT SOSED  1         0.4     RCHRES         INFLOW ISED   3
PERLND     PWTGAS PODOXM                   RCHRES         INFLOW OXIF   1
PERLND     PWTGAS POHT                     RCHRES         INFLOW IHEAT  1
  END MASS-LINK   23

  MASS-LINK       22
<-Volume-> <-Grp> <-Member-><--Mult-->     <-Target vols> <-Grp> <-Member->  ***
<Name>            <Name> x x<-factor->     <Name>                <Name> x x  ***
IMPLND     IWATER SURO       0.0833333     RCHRES         INFLOW IVOL
IMPLND     IWTGAS SOHT                     RCHRES         INFLOW IHEAT
IMPLND     IQUAL  SOQUAL 1        1.00     RCHRES         INFLOW NUIF1  2
IMPLND     IQUAL  SOQUAL 2                 RCHRES         INFLOW NUIF1  1
IMPLND     IQUAL  SOQUAL 3                 RCHRES         INFLOW NUIF1  4
IMPLND     IQUAL  SOQUAL 4        1.00     RCHRES         INFLOW OXIF   2
IMPLND     IQUAL  SOQUAL 4       0.100     RCHRES         INFLOW PKIF   3
IMPLND     IQUAL  SOQUAL 4       0.015     RCHRES         INFLOW PKIF   4
IMPLND     IQUAL  SOQUAL 4         0.5     RCHRES         INFLOW PKIF   5
IMPLND     SOLIDS SOSLD  1        0.05     RCHRES         INFLOW ISED   1
IMPLND     SOLIDS SOSLD  1        0.55     RCHRES         INFLOW ISED   2
IMPLND     SOLIDS SOSLD  1         0.4     RCHRES         INFLOW ISED   3
IMPLND     IWTGAS SODOXM                   RCHRES         INFLOW OXIF   1
IMPLND     IWTGAS SOHT                     RCHRES         INFLOW IHEAT  1
  END MASS-LINK   22

  MASS-LINK       47
<-Volume-> <-Grp> <-Member-><--Mult-->     <-Target vols> <-Grp> <-Member->  ***
<Name>            <Name> x x<-factor->     <Name>                <Name> x x  ***
PERLND     PWATER PERO                     COPY           INPUT  MEAN   1
PERLND     SEDMNT SOSED  1                 COPY           INPUT  MEAN   2
PERLND     PQUAL  POQUAL 1        1.00     COPY           INPUT  MEAN   3
PERLND     PQUAL  POQUAL 2                 COPY           INPUT  MEAN   4
PERLND     PQUAL  POQUAL 3                 COPY           INPUT  MEAN   5
```

```
PERLND     PQUAL  POQUAL 4        1.00     COPY           INPUT  MEAN   6
PERLND     PWTGAS PODOXM                   COPY           INPUT  MEAN   7
  END MASS-LINK   47

  MASS-LINK       46
<-Volume-> <-Grp> <-Member-><--Mult-->     <-Target vols> <-Grp> <-Member->  ***
<Name>            <Name> x x<-factor->     <Name>                <Name> x x  ***
IMPLND     IWATER SURO                     COPY           INPUT  MEAN   1
IMPLND     SOLIDS SOSLD  1                 COPY           INPUT  MEAN   2
IMPLND     IQUAL  SOQUAL 1        1.00     COPY           INPUT  MEAN   3
IMPLND     IQUAL  SOQUAL 2                 COPY           INPUT  MEAN   4
IMPLND     IQUAL  SOQUAL 3                 COPY           INPUT  MEAN   5
IMPLND     IQUAL  SOQUAL 4        1.00     COPY           INPUT  MEAN   6
IMPLND     IWTGAS SODOXM                   COPY           INPUT  MEAN   7
  END MASS-LINK   46

  MASS-LINK       25
<-Volume-> <-Grp> <-Member-><--Mult-->     <-Target vols> <-Grp> <-Member->  ***
<Name>            <Name> x x<-factor->     <Name>                <Name> x x  ***
PERLND     PWATER PERO       0.0833333     RCHRES         INFLOW IVOL
PERLND     PWTGAS POHT                     RCHRES         INFLOW IHEAT
PERLND     PQUAL  POQUAL 1        1.00     RCHRES         INFLOW NUIF1  2
PERLND     PQUAL  POQUAL 2                 RCHRES         INFLOW NUIF1  1
PERLND     PQUAL  POQUAL 3                 RCHRES         INFLOW NUIF1  4
PERLND     PQUAL  POQUAL 4        1.00     RCHRES         INFLOW OXIF   2
PERLND     PQUAL  POQUAL 4       0.100     RCHRES         INFLOW PKIF   3
PERLND     PQUAL  POQUAL 4       0.015     RCHRES         INFLOW PKIF   4
PERLND     PQUAL  POQUAL 4         0.5     RCHRES         INFLOW PKIF   5
PERLND     SEDMNT SOSED  1        0.05     RCHRES         INFLOW ISED   1
PERLND     SEDMNT SOSED  1        0.55     RCHRES         INFLOW ISED   2
PERLND     SEDMNT SOSED  1         0.4     RCHRES         INFLOW ISED   3
PERLND     PWTGAS PODOXM                   RCHRES         INFLOW OXIF   1
PERLND     PWTGAS POHT                     RCHRES         INFLOW IHEAT  1
  END MASS-LINK   25

  MASS-LINK       24
<-Volume-> <-Grp> <-Member-><--Mult-->     <-Target vols> <-Grp> <-Member->  ***
<Name>            <Name> x x<-factor->     <Name>                <Name> x x  ***
IMPLND     IWATER SURO       0.0833333     RCHRES         INFLOW IVOL
IMPLND     IWTGAS SOHT                     RCHRES         INFLOW IHEAT
IMPLND     IQUAL  SOQUAL 1        1.00     RCHRES         INFLOW NUIF1  2
IMPLND     IQUAL  SOQUAL 2                 RCHRES         INFLOW NUIF1  1
IMPLND     IQUAL  SOQUAL 3                 RCHRES         INFLOW NUIF1  4
IMPLND     IQUAL  SOQUAL 4        1.00     RCHRES         INFLOW OXIF   2
IMPLND     IQUAL  SOQUAL 4       0.100     RCHRES         INFLOW PKIF   3
IMPLND     IQUAL  SOQUAL 4       0.015     RCHRES         INFLOW PKIF   4
IMPLND     IQUAL  SOQUAL 4         0.5     RCHRES         INFLOW PKIF   5
IMPLND     SOLIDS SOSLD  1        0.05     RCHRES         INFLOW ISED   1
IMPLND     SOLIDS SOSLD  1        0.55     RCHRES         INFLOW ISED   2
IMPLND     SOLIDS SOSLD  1         0.4     RCHRES         INFLOW ISED   3
IMPLND     IWTGAS SODOXM                   RCHRES         INFLOW OXIF   1
IMPLND     IWTGAS SOHT                     RCHRES         INFLOW IHEAT  1
  END MASS-LINK   24

  MASS-LINK       49
<-Volume-> <-Grp> <-Member-><--Mult-->     <-Target vols> <-Grp> <-Member->  ***
<Name>            <Name> x x<-factor->     <Name>                <Name> x x  ***
PERLND     PWATER PERO                     COPY           INPUT  MEAN   1
PERLND     SEDMNT SOSED  1                 COPY           INPUT  MEAN   2
PERLND     PQUAL  POQUAL 1        1.00     COPY           INPUT  MEAN   3
PERLND     PQUAL  POQUAL 2                 COPY           INPUT  MEAN   4
PERLND     PQUAL  POQUAL 3                 COPY           INPUT  MEAN   5
PERLND     PQUAL  POQUAL 4        1.00     COPY           INPUT  MEAN   6
```

```
PERLND     PWTGAS PODOXM                       COPY           INPUT  MEAN   7
  END MASS-LINK   49

  MASS-LINK       48
<-Volume-> <-Grp> <-Member-><--Mult-->     <-Target vols> <-Grp> <-Member->  ***
<Name>            <Name> x x<-factor->     <Name>                <Name> x x  ***
IMPLND     IWATER SURO                     COPY           INPUT  MEAN   1
IMPLND     SOLIDS SOSLD  1                 COPY           INPUT  MEAN   2
IMPLND     IQUAL  SOQUAL 1        1.00     COPY           INPUT  MEAN   3
IMPLND     IQUAL  SOQUAL 2                 COPY           INPUT  MEAN   4
IMPLND     IQUAL  SOQUAL 3                 COPY           INPUT  MEAN   5
IMPLND     IQUAL  SOQUAL 4        1.00     COPY           INPUT  MEAN   6
IMPLND     IWTGAS SODOXM                   COPY           INPUT  MEAN   7
  END MASS-LINK   48
END MASS-LINK

END RUN
```

Appendix C Adams Bayou RMA2 Geometry and Boundary Condition Files

```
T1  Adams Bayou Model B Long Term Run GFGEN input file
T2  Geometry input file
T3
SI  1
$L  3
GE     1     1     2     3     0     0     0     0     0     1    0.0
GE     2     3     4     5     0     0     0     0     0     1    0.0
GE     3     5     6     7     0     0     0     0     0     1    0.0
GE     4     7     8     9     0     0     0     0     0     1    0.0
GE     5     9    10    11     0     0     0     0     0     1    0.0
GE     6    11    12    13     0     0     0     0     0     1    0.0
GE     7    13    14    15     0     0     0     0     0     1    0.0
GE    57    15    16    17     0     0     0     0     0   901    0.0
GE     8    16    18    19     0     0     0     0     0     1    0.0
GE     9    19    20    21     0     0     0     0     0     1    0.0
GE    10    21    22    23     0     0     0     0     0     1    0.0
GE    11    23    24    25     0     0     0     0     0     1    0.0
GE    12    25    26    27     0     0     0     0     0     1    0.0
GE    13    17    28    29     0     0     0     0     0     1    0.0
GE    14    29    30    31     0     0     0     0     0     1    0.0
GE    15    31    32    33     0     0     0     0     0     1    0.0
GE    16    33    34    35     0     0     0     0     0     1    0.0
GE    17    35    36    37     0     0     0     0     0     1    0.0
GE    18    37    38    39     0     0     0     0     0     1    0.0
GE    58    39    40    41     0     0     0     0     0   901    0.0
GE    59    41    44    45     0     0     0     0     0     2    0.0
GE    60    45    46    47     0     0     0     0     0     2    0.0
GE    61    47    48    49     0     0     0     0     0     3    0.0
GE    62    49    50    51     0     0     0     0     0     3    0.0
GE    63    51    52    53     0     0     0     0     0     3    0.0
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GE    22    59    60    61     0     0     0     0     0     1    0.0
GE    65    61    62    63     0     0     0     0     0   901    0.0
GE    23    62    64    65     0     0     0     0     0     1    0.0
GE    66    63    66    67     0     0     0     0     0     1    0.0
GE    67    67    68    69     0     0     0     0     0     3    0.0
GE    68    69    70    71     0     0     0     0     0     3    0.0
GE    69    71    72    73     0     0     0     0     0     3    0.0
GE    24    65    74    75     0     0     0     0     0     1    0.0
GE    25    75    76    77     0     0     0     0     0     1    0.0
GE    26    77    78    79     0     0     0     0     0     1    0.0
GE    27    79    80    81     0     0     0     0     0     1    0.0
GE    28    81    82    83     0     0     0     0     0     1    0.0
GE    29    83    84    85     0     0     0     0     0     1    0.0
GE    30    85    86    87     0     0     0     0     0     1    0.0
GE    31    87    88    89     0     0     0     0     0     1    0.0
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GE    34    93    94    95     0     0     0     0     0     2    0.0
GE    35    95    96    97     0     0     0     0     0     2    0.0
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GE    37   100   102   103     0     0     0     0     0     2    0.0
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GE    40   111   112   113      0      0      0      0      0      2    0.0
GE    41   113   114   115      0      0      0      0      0      2    0.0
GE    42   115   116   117      0      0      0      0      0      2    0.0
GE    43   117   118   119      0      0      0      0      0      2    0.0
GE    44   119   120   121      0      0      0      0      0      2    0.0
GE    45   121   122   123      0      0      0      0      0      2    0.0
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GE    76   139   140   141      0      0      0      0      0      3    0.0
GE    51   135   142   143      0      0      0      0      0      2    0.0
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GE    55   149   150   151      0      0      0      0      0      3    0.0
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GNN      1          2101191.16           7340222.73                    -15
GNN      2          2101336.81           7340379.97                    -15
GNN      3          2101482.46           7340537.22                    -15
GNN      4          2101628.11           7340694.46                    -15
GNN      5          2101773.76           7340851.71                    -15
GNN      6          2101919.40           7341008.96                    -15
GNN      7          2102065.05           7341166.20                    -15
GNN      8          2102210.70           7341323.45                    -15
GNN      9          2102356.35           7341480.69                    -15
GNN     10          2102502.00           7341637.94                    -15
GNN     11          2102647.65           7341795.19                    -15
GNN     12          2102793.29           7341952.43                    -15
GNN     13          2102938.94           7342109.68                    -15
GNN     14          2103084.59           7342266.93                    -15
GNN     15          2103230.24           7342424.17                    -15
GNN     16          2103230.24           7342424.17                    -15
GNN     17          2103230.24           7342424.17                   -5.5
GNN     18          2103375.89           7342581.42                    -15
GNN     19          2103521.54           7342738.66                    -15
GNN     20          2103667.18           7342895.91                    -15
GNN     21          2103812.83           7343053.16                    -15
GNN     22          2103958.48           7343210.40                    -15
GNN     23          2104104.13           7343367.65                    -15
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GNN     25          2104395.42           7343682.14                    -15
GNN     26          2104541.07           7343839.39                    -15
GNN     27          2104686.72           7343996.63                    -15
GNN     28          2103108.87           7342573.92                   -4.7
GNN     29          2102987.50           7342723.67                   -4.7
GNN     30          2102866.13           7342873.42                   -4.7
GNN     31          2102744.75           7343023.17                   -4.7
GNN     32          2102623.38           7343172.92                   -4.7
GNN     33          2102502.01           7343322.67                   -4.7
GNN     34          2102380.64           7343472.42                   -4.7
GNN     35          2102259.27           7343622.17                   -4.7
GNN     36          2102033.74           7343728.18                   -4.7
GNN     37          2101808.21           7343834.20                   -4.7
GNN     38          2101582.67           7343940.22                   -4.7
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GNN	39	2101357.14	7344046.23	-4.6
GNN	40	2101357.14	7344046.23	-4.6
GNN	41	2101357.14	7344046.23	-2.4
GNN	42	2101244.00	7344159.00	-4.6
GNN	43	2101191.00	7344305.00	-4.6
GNN	44	2101196.17	7344102.69	-2.4
GNN	45	2101035.20	7344159.15	-2.3
GNN	46	2100874.23	7344215.61	-2.2
GNN	47	2100713.26	7344272.07	-2.1
GNN	48	2100552.29	7344328.53	-2
GNN	49	2100391.32	7344384.99	-1.9
GNN	50	2100230.35	7344441.45	-1.8
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GNN	53	2099747.44	7344610.83	-1.5
GNN	54	2099586.47	7344667.29	-1.4
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GNN	64	2101752.60	7345215.02	-4.2
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GNN	67	2101427.15	7345255.73	-1.7
GNN	68	2101312.17	7345335.84	-1.6
GNN	69	2101197.20	7345415.95	-1.5
GNN	70	2101082.22	7345496.06	-1.4
GNN	71	2100967.25	7345576.17	-1.3
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GNN	81	2101565.97	7346397.27	-4.1
GNN	82	2101469.51	7346522.74	-4.1
GNN	83	2101373.06	7346648.20	-4.1
GNN	84	2101276.61	7346773.67	-4
GNN	85	2101180.15	7346899.13	-3.5
GNN	86	2101131.16	7347037.51	-3.5
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GNN	98	2099859.92	7348276.44	-3.6
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GNN	122	2098907.19		7350482.89		-3.5	
GNN	123	2098720.59		7350589.88		-3.4	
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GNN	138	2096840.12		7352025.32		-1.5	
GNN	139	2096710.88		7352218.48		-1.4	
GNN	140	2096581.65		7352411.64		-1.3	
GNN	141	2096452.42		7352604.79		-1.3	
GNN	142	2096640.61		7351575.82		-2.1	
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GNN	147	2095549.79		7352231.54		-1.6	
GNN	148	2095326.02		7352384.64		-1.5	
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GNN	151	2094654.70		7352843.94		-1.35	
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GWN	2	43	5	5	0	0	0
GWN	3	43	5	5	0	0	0
GWN	4	43	5	5	0	0	0
GWN	5	43	5	5	0	0	0
GWN	6	43	5	5	0	0	0
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GWN	9	43	5	5	0	0	0
GWN	10	43	5	5	0	0	0
GWN	11	43	5	5	0	0	0

GWN	12	43	5	5	0	0	0
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GWN	14	43	5	5	0	0	0
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GWN	19	43	5	5	0	0	0
GWN	20	43	5	5	0	0	0
GWN	21	43	5	5	0	0	0
GWN	22	43	5	5	0	0	0
GWN	23	43	5	5	0	0	0
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GWN	25	43	5	5	0	0	0
GWN	26	43	5	5	0	0	0
GWN	27	43	5	5	0	0	0
GWN	28	43	5	5	0	0	0
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GWN	30	43	5	5	200	-3	200
GWN	31	43	5	5	200	-2	200
GWN	32	43	5	5	200	-2	200
GWN	33	43	5	5	200	-2	200
GWN	34	35	5	5	100	-2	100
GWN	35	35	5	5	100	-2	100
GWN	36	35	5	5	100	-2	100
GWN	37	30	5	5	100	-2	100
GWN	38	30	5	5	200	-2	200
GWN	39	24	3.9	5.6	200	-2	200
GWN	40	24	3.9	5.6	100	-2	100
GWN	41	6.3	1	1	25	-2.4	25
GWN	42	18	3	3	100	-2	100
GWN	43	18	3	3	100	-2	100
GWN	44	6.3	1	1	25	-2.4	25
GWN	45	6.3	1	1	25	-2.3	25
GWN	46	6.3	1	1	10	-2	5
GWN	47	6.3	0.9	0.9	10	-2	5
GWN	48	6.3	0.8	0.8	0	0	0
GWN	49	6.3	0.7	0.7	0	0	0
GWN	50	6.3	0.6	0.6	0	0	0
GWN	51	6.3	0.5	0.5	0	0	0
GWN	52	6	0.5	0.5	25	-1	25
GWN	53	5.8	0.5	0.5	0	0	0
GWN	54	5.5	0.5	0.5	0	0	0
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GWN	56	18	3	3	50	-2	25
GWN	57	18	3	3	50	-2	25
GWN	58	18	3	3	50	-2	25
GWN	59	18	3	3	50	-2	25
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GWN	61	18	3	3	50	-2	25
GWN	62	18	3	3	50	-2	30
GWN	63	8	5.9	5.9	20	-2	10
GWN	64	12	2.5	2.5	50	-2	30
GWN	65	12	2.5	2.5	200	-2	100
GWN	66	8	5.9	5.9	20	-2	10
GWN	67	8	5.9	5.9	20	-2	10
GWN	68	6.6	0.9	0.9	20	-1.6	0.9
GWN	69	6.6	0.8	0.8	20	-1.5	0.8
GWN	70	6.6	0.7	0.7	20	-1.4	0.7
GWN	71	6.6	0.6	0.6	20	-1.3	0.6
GWN	72	6.6	0.5	0.5	20	-1.3	0.5
GWN	73	6.6	0.5	0.5	40	-1.3	30
GWN	74	10	2.8	2.8	200	-2	100

GWN	75	10	2.8	2.8	200	-2	100
GWN	76	10	2.8	2.8	100	-2	50
GWN	77	10	2.8	2.8	100	-2	50
GWN	78	10	2.8	2.8	100	-2	50
GWN	79	12	3	3	100	-2	50
GWN	80	15	7.7	6.3	100	-2	50
GWN	81	15	7.7	6.3	100	-2	50
GWN	82	15	7.7	6.3	100	-2	50
GWN	83	10	4	4	100	-2	50
GWN	84	10	4	4	100	-2	50
GWN	85	10	4	4	100	-2	50
GWN	86	10	5	5	50	-2	25
GWN	87	10	8	8	50	-2	25
GWN	88	5	19.7	5.9	0	0	0
GWN	89	5	19.7	5.9	0	0	0
GWN	90	5	5	5	50	-2	25
GWN	91	5	5	5	50	-2	25
GWN	92	5	5	5	50	-2	25
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GWN	98	5	5	5	10	-2	5
GWN	99	5	5	5	10	-2	5
GWN	100	5	5	5	100	-2	50
GWN	101	5	1	1	5	-1	5
GWN	102	5	4	4	100	-2	50
GWN	103	5	3.6	3.6	100	-2	50
GWN	104	5	0.7	0.7	5	-1	5
GWN	105	5	0.5	0.5	5	-1	5
GWN	106	5	0.5	0.5	10	-1	10
GWN	107	5	0.5	0.5	40	-1.3	30
GWN	108	5	3.6	3.6	100	-2	50
GWN	109	5	3.6	3.6	100	-2	50
GWN	110	5	3.6	3.6	200	-2	100
GWN	111	5	3.6	3.6	200	-2	100
GWN	112	4	5.7	8.5	200	-2	100
GWN	113	4	5.7	8.5	100	-2	50
GWN	114	5	5	5	100	-2	50
GWN	115	5	5	5	100	-2	50
GWN	116	5	2.6	2.6	20	-2	10
GWN	117	5	2.6	2.6	10	-1	10
GWN	118	5	2.6	2.6	10	-1	10
GWN	119	5	2.6	3	10	-1	10
GWN	120	9.8	2.2	3.4	10	-1	10
GWN	121	9.8	2.2	3.4	50	-1	50
GWN	122	5	2.6	2.6	50	-1	50
GWN	123	5	2.6	2.6	10	-1	10
GWN	124	8	2.6	2.6	0	0	0
GWN	125	9.1	2.2	2.2	0	0	0
GWN	126	9.1	2.2	2.2	0	0	0
GWN	127	9.1	2.2	2.2	0	0	0
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GWN	131	11.3	2.4	1.1	0	0	0
GWN	132	11.3	2.4	1.1	0	0	0
GWN	133	2	1.4	1.4	10	-1	10
GWN	134	8.5	2	2	10	-1	10
GWN	135	8.5	2	2	10	-1	10
GWN	136	2	1.4	1.4	5	-1	5
GWN	137	2	1.4	1.4	5	-1	5

GWN	138	2	1.1	1.1	0	0	0
GWN	139	2	0.9	0.9	5	-0.5	5
GWN	140	2	0.7	0.7	0	0	0
GWN	141	2	0.5	0.5	10	-1	10
GWN	142	8.5	2	2	10	-1	10
GWN	143	8.5	2	2	45	-1.5	30
GWN	144	8	2	2	5	-1	5
GWN	145	8	2	2	5	-1	5
GWN	146	8	2	2	5	-1	5
GWN	147	8	2	2	5	-1	5
GWN	148	8	2	2	5	-1	5
GWN	149	8	2	2	5	-1	5
GWN	150	8	2	2	5	-1	5
GWN	151	8	2	2	5	-1	5
GWN	152	6	2	2	5	-1	5
GWN	153	4	2	2	52	-1.3	40

Below is the first day of the Adams Bayou RMA2 boundary condition file.

```
T1  Adams Bayou Long Term Run "B"
T2  Jan 1, 2002 - Jan 1,  2013 at 30 minute (0.5 hour) time step
T3  Fully Permitted PS Flows
$M  1
$L  0 0 1 1 0 1 0 0 0 0
SI  1
DE  0.084  0.183  5
EX  1     5000.00     5000.00
EY  1     5000.00     5000.00
EX  2     5000.00     5000.00
EY  2     5000.00     5000.00
EX  3     5000.00     5000.00
EY  3     5000.00     5000.00
EX  4     5000.00     5000.00
EY  4     5000.00     5000.00
FT  20
IC  0.105  0.3  0.08
RDT 1  1  0.060  2  0.060  1E-14  0  0
RDT 2  1  0.090  2  0.110  1E-14  0  0
RDT 3  1  0.090  2  0.110  1E-14  0  0
CO RSC  10000   0   0
TI  15  15  0.01  0.01
TR   0   0  0  0
TS  -1   0     0
TZ  0.5  96431 192863  0  0
CO  BAN cards are boundary flow azimuths in radians from x-axis
BAN   1  4.0
BAN  27  4.0
BAN  55  5.9
BAN  73  5.7
BAN 107  1.1
BAN 141  5.3
BAN 153  5.7
CO   initial boundary flows in cms
CO   BQE 28 is Orange County WCID #2 self-reported flows
CO   BQE 36 is City of Pinehurst self-reported flows
CO   City of Orange wet weather outfall would be added at element 28 boundary
CO   BCN cards are water elevations at downstream boundary in meters amsl
BQE 36    0.00004483
BQE 28    0.00008984
BQN 141   0.02572400
BQE 15    0.00004752
BQN 153   0.16487000
```

```
BQE 31    0.00007528
BQE 41    0.00003794
BQE 47    0.00005878
BQE 50    0.00004001
BQE 51    0.00004236
BQN 55    0.01708300
BQE 72    0.00003016
BQN 73    0.00910950
BQE 74    0.00003331
BQN 27    464.000000
BCN  1  00200  0  0  0.105
END  Simulation at time =  0.0
BCN  1  00200  0  0  0.105
END  Simulation at time =  0.5
BQN 141   0.02567800
BQE 15    0.00004687
BQN 153   0.16765000
BQE 31    0.00007421
BQE 41    0.00003740
BQE 47    0.00005796
BQE 50    0.00003945
BQE 51    0.00004248
BQN 55    0.01711200
BQE 72    0.00003052
BQN 73    0.00925050
BQE 74    0.00003286
BCN  1  00200  0  0  0.102
END  Simulation at time =  1.0
BCN  1  00200  0  0  0.101
END  Simulation at time =  1.5
BQN 141   0.02561800
BQE 15    0.00004623
BQN 153   0.16965000
BQE 31    0.00007316
BQE 41    0.00003687
BQE 47    0.00005714
BQE 50    0.00003891
BQE 51    0.00004256
BQN 55    0.01712700
BQE 72    0.00003073
BQN 73    0.00936530
BQE 74    0.00003241
BCN  1  00200  0  0  0.091
END  Simulation at time =  2.0
BCN  1  00200  0  0  0.085
END  Simulation at time =  2.5
BQN 141   0.02554700
BQE 15    0.00004560
BQN 153   0.17101000
BQE 31    0.00007213
BQE 41    0.00003635
BQE 47    0.00005634
BQE 50    0.00003837
BQE 51    0.00004260
BQN 55    0.01712700
BQE 72    0.00003083
BQN 73    0.00945660
BQE 74    0.00003196
BCN  1  00200  0  0  0.081
END  Simulation at time =  3.0
BCN  1  00200  0  0  0.086
END  Simulation at time =  3.5
BQN 141   0.02546300
```

```
BQE 15    0.00004498
BQN 153   0.17181000
BQE 31    0.00007110
BQE 41    0.00003583
BQE 47    0.00005555
BQE 50    0.00003784
BQE 51    0.00004261
BQN 55    0.01711400
BQE 72    0.00003084
BQN 73    0.00952660
BQE 74    0.00003153
BCN  1  00200  0  0  0.075
END  Simulation at time =  4.0
BCN  1  00200  0  0  0.08
END  Simulation at time =  4.5
BQN 141   0.02536900
BQE 15    0.00004437
BQN 153   0.17215000
BQE 31    0.00007010
BQE 41    0.00003533
BQE 47    0.00005477
BQE 50    0.00003731
BQE 51    0.00004258
BQN 55    0.01709000
BQE 72    0.00003076
BQN 73    0.00957740
BQE 74    0.00003110
BCN  1  00200  0  0  0.066
END  Simulation at time =  5.0
BCN  1  00200  0  0  0.056
END  Simulation at time =  5.5
BQN 141   0.02521300
BQE 15    0.00004159
BQN 153   0.17088000
BQE 31    0.00006585
BQE 41    0.00003313
BQE 47    0.00005139
BQE 50    0.00003504
BQE 51    0.00004243
BQN 55    0.01700600
BQE 72    0.00003036
BQN 73    0.00956620
BQE 74    0.00002918
BCN  1  00200  0  0  0.044
END  Simulation at time =  6.0
BCN  1  00200  0  0  0.032
END  Simulation at time =  6.5
BQN 141   0.02419300
BQE 15    0.00000638
BQN 153   0.14894000
BQE 31    0.00000933
BQE 41    0.00000379
BQE 47    0.00000607
BQE 50    0.00000471
BQE 51    0.00004054
BQN 55    0.01612200
BQE 72    0.00002542
BQN 73    0.00876330
BQE 74    0.00000385
BCN  1  00200  0  0  0.014
END  Simulation at time =  7.0
BCN  1  00200  0  0  0.004
END  Simulation at time =  7.5
```

```
BQN 141   0.02318500
BQE 15    0.00000265
BQN 153   0.12861000
BQE 31    0.00000627
BQE 41    0.00000325
BQE 47    0.00000527
BQE 50    0.00000402
BQE 51    0.00003850
BQN 55    0.01522500
BQE 72    0.00002120
BQN 73    0.00794300
BQE 74    0.00000359
BCN  1  00200  0  0  -0.024
END  Simulation at time =  8.0
BCN  1  00200  0  0  -0.061
END  Simulation at time =  8.5
BQN 141   0.02221200
BQE 15    0.00000262
BQN 153   0.11081000
BQE 31    0.00000618
BQE 41    0.00000321
BQE 47    0.00000517
BQE 50    0.00000388
BQE 51    0.00003655
BQN 55    0.01435000
BQE 72    0.00001766
BQN 73    0.00716700
BQE 74    0.00000345
BCN  1  00200  0  0  -0.082
END  Simulation at time =  9.0
BCN  1  00200  0  0  -0.118
END  Simulation at time =  9.5
BQN 141   0.02128100
BQE 15    0.00000259
BQN 153   0.09554500
BQE 31    0.00000611
BQE 41    0.00000318
BQE 47    0.00000511
BQE 50    0.00000384
BQE 51    0.00003470
BQN 55    0.01352200
BQE 72    0.00001473
BQN 73    0.00645910
BQE 74    0.00000341
BCN  1  00200  0  0  -0.145
END  Simulation at time =  10.0
BCN  1  00200  0  0  -0.162
END  Simulation at time =  10.5
BQN 141   0.02039200
BQE 15    0.00000256
BQN 153   0.08488900
BQE 31    0.00000603
BQE 41    0.00000314
BQE 47    0.00000505
BQE 50    0.00000379
BQE 51    0.00003294
BQN 55    0.01273700
BQE 72    0.00001232
BQN 73    0.00581340
BQE 74    0.00000336
BCN  1  00200  0  0  -0.191
END  Simulation at time =  11.0
BCN  1  00200  0  0  -0.222
```

```
END  Simulation at time =  11.5
BQN 141   0.01954200
BQE 15    0.00000253
BQN 153   0.08455600
BQE 31    0.00000596
BQE 41    0.00000310
BQE 47    0.00000499
BQE 50    0.00000374
BQE 51    0.00003128
BQN 55    0.01199500
BQE 72    0.00001033
BQN 73    0.00522420
BQE 74    0.00000332
BCN  1  00200  0  0  -0.256
END  Simulation at time =  12.0
BCN  1  00200  0  0  -0.284
END  Simulation at time =  12.5
BQN 141   0.01872900
BQE 15    0.00000250
BQN 153   0.08422300
BQE 31    0.00000589
BQE 41    0.00000306
BQE 47    0.00000492
BQE 50    0.00000369
BQE 51    0.00002972
BQN 55    0.01129200
BQE 72    0.00000869
BQN 73    0.00468660
BQE 74    0.00000328
BCN  1  00200  0  0  -0.295
END  Simulation at time =  13.0
BCN  1  00200  0  0  -0.297
END  Simulation at time =  13.5
BQN 141   0.01796100
BQE 15    0.00000247
BQN 153   0.08390100
BQE 31    0.00000584
BQE 41    0.00000303
BQE 47    0.00000491
BQE 50    0.00000373
BQE 51    0.00002825
BQN 55    0.01065100
BQE 72    0.00000740
BQN 73    0.00422380
BQE 74    0.00000334
BCN  1  00200  0  0  -0.317
END  Simulation at time =  14.0
BCN  1  00200  0  0  -0.316
END  Simulation at time =  14.5
BQN 141   0.01724800
BQE 15    0.00000310
BQN 153   0.08360500
BQE 31    0.00000631
BQE 41    0.00000308
BQE 47    0.00000504
BQE 50    0.00000396
BQE 51    0.00002694
BQN 55    0.01009900
BQE 72    0.00000648
BQN 73    0.00386090
BQE 74    0.00000351
BCN  1  00200  0  0  -0.353
END  Simulation at time =  15.0
```

```
BCN  1  00200  0  0  -0.31
END  Simulation at time =  15.5
BQN 141   0.01711900
BQE 15    0.00002510
BQN 153   0.08370100
BQE 31    0.00004299
BQE 41    0.00002151
BQE 47    0.00003341
BQE 50    0.00002304
BQE 51    0.00002693
BQN 55    0.01009400
BQE 72    0.00000861
BQN 73    0.00406750
BQE 74    0.00001914
BCN  1  00200  0  0  -0.305
END  Simulation at time =  16.0
BCN  1  00200  0  0  -0.276
END  Simulation at time =  16.5
BQN 141   0.01703600
BQE 15    0.00002687
BQN 153   0.08382400
BQE 31    0.00004556
BQE 41    0.00002285
BQE 47    0.00003549
BQE 50    0.00002444
BQE 51    0.00002700
BQN 55    0.01012900
BQE 72    0.00001058
BQN 73    0.00429150
BQE 74    0.00002034
BCN  1  00200  0  0  -0.258
END  Simulation at time =  17.0
BCN  1  00200  0  0  -0.241
END  Simulation at time =  17.5
BQN 141   0.01694700
BQE 15    0.00002651
BQN 153   0.08394100
BQE 31    0.00004492
BQE 41    0.00002253
BQE 47    0.00003500
BQE 50    0.00002411
BQE 51    0.00002704
BQN 55    0.01015300
BQE 72    0.00001216
BQN 73    0.00448720
BQE 74    0.00002007
BCN  1  00200  0  0  -0.221
END  Simulation at time =  18.0
BCN  1  00200  0  0  -0.171
END  Simulation at time =  18.5
BQN 141   0.01685400
BQE 15    0.00002615
BQN 153   0.08405000
BQE 31    0.00004429
BQE 41    0.00002221
BQE 47    0.00003452
BQE 50    0.00002378
BQE 51    0.00002705
BQN 55    0.01016800
BQE 72    0.00001341
BQN 73    0.00465740
BQE 74    0.00001981
BCN  1  00200  0  0  -0.133
```

```
END  Simulation at time =  19.0
BCN  1  00200  0  0  -0.098
END  Simulation at time =  19.5
BQN 141   0.01675600
BQE 15    0.00002580
BQN 153   0.08415300
BQE 31    0.00004367
BQE 41    0.00002190
BQE 47    0.00003404
BQE 50    0.00002346
BQE 51    0.00002705
BQN 55    0.01017400
BQE 72    0.00001439
BQN 73    0.00480430
BQE 74    0.00001955
BCN  1  00200  0  0  -0.061
END  Simulation at time =  20.0
BCN  1  00200  0  0  -0.032
END  Simulation at time =  20.5
BQN 141   0.01665300
BQE 15    0.00002544
BQN 153   0.08425000
BQE 31    0.00004306
BQE 41    0.00002159
BQE 47    0.00003357
BQE 50    0.00002314
BQE 51    0.00002703
BQN 55    0.01017300
BQE 72    0.00001515
BQN 73    0.00493030
BQE 74    0.00001929
BCN  1  00200  0  0  -0.001
END  Simulation at time =  21.0
BCN  1  00200  0  0  0.027
END  Simulation at time =  21.5
BQN 141   0.01654600
BQE 15    0.00002509
BQN 153   0.08434000
BQE 31    0.00004245
BQE 41    0.00002129
BQE 47    0.00003310
BQE 50    0.00002283
BQE 51    0.00002699
BQN 55    0.01016400
BQE 72    0.00001573
BQN 73    0.00503730
BQE 74    0.00001903
BCN  1  00200  0  0  0.027
END  Simulation at time =  22.0
BCN  1  00200  0  0  0.001
END  Simulation at time =  22.5
BQN 141   0.01643500
BQE 15    0.00002475
BQN 153   0.08442300
BQE 31    0.00004186
BQE 41    0.00002099
BQE 47    0.00003264
BQE 50    0.00002252
BQE 51    0.00002693
BQN 55    0.01014700
BQE 72    0.00001616
BQN 73    0.00512700
BQE 74    0.00001878
```

```
BCN  1  00200  0  0  -0.01
END  Simulation at time =  23.0
BCN  1  00200  0  0  -0.008
END  Simulation at time =  23.5
BQN 141   0.01630600
BQE 15    0.00002382
BQN 153   0.08449100
BQE 31    0.00004031
BQE 41    0.00002022
BQE 47    0.00003145
BQE 50    0.00002171
BQE 51    0.00002682
BQN 55    0.01011300
BQE 72    0.00001640
BQN 73    0.00518880
BQE 74    0.00001810
BQN 27    456.000000
BCN  1  00200  0  0  0.031
END  Simulation at time =  24.0
STOP
```

Note: The model printout was stopped here, after one day, due to space considerations.

Appendix D Cow Bayou RMA2 Geometry and Boundary Condition Files

```
T1  Cow Bayou Model B Long Term Run GFGEN input file
T2  geometry input file
T3
SI  1
$L  3
GE     1     1     2     3     0     0     0     0     0     1    0.0
GE     2     3     4     5     0     0     0     0     0     1    0.0
GE     3     5     6     7     0     0     0     0     0   901    0.0
GE     4     6     8     9     0     0     0     0     0     1    0.0
GE     5     9    10    11     0     0     0     0     0     1    0.0
GE     6    11    12    13     0     0     0     0     0   901    0.0
GE     7    12    14    15     0     0     0     0     0     1    0.0
GE     8     7    16    17     0     0     0     0     0     1    0.0
GE     9    13    18    19     0     0     0     0     0     2    0.0
GE    10    19    20    21     0     0     0     0     0     2    0.0
GE    11    21    22    23     0     0     0     0     0     2    0.0
GE    12    23    24    25     0     0     0     0     0     2    0.0
GE    13    25    26    27     0     0     0     0     0     2    0.0
GE    14    27    28    29     0     0     0     0     0     2    0.0
GE    15    29    30    31     0     0     0     0     0     2    0.0
GE    16    31    32    33     0     0     0     0     0     2    0.0
GE    17    17    33    34     0     0     0     0     0   901    0.0
GE    18    34    35    36     0     0     0     0     0     1    0.0
GE    19    36    37    38     0     0     0     0     0     1    0.0
GE    20    38    39    40     0     0     0     0     0     1    0.0
GE    21   160    41    42     0     0     0     0     0     1    0.0
GE    22    42    43    44     0     0     0     0     0     1    0.0
GE    23    44    45    46     0     0     0     0     0   901    0.0
GE    24    45    47    48     0     0     0     0     0     1    0.0
GE    25    48    49    50     0     0     0     0     0   901    0.0
GE    26    46    51    52     0     0     0     0     0     2    0.0
GE    27    52    53    54     0     0     0     0     0     2    0.0
GE    28    54    55    56     0     0     0     0     0   901    0.0
GE    29    55    57    58     0     0     0     0     0     2    0.0
GE    30    58    59    50     0     0     0     0     0     2    0.0
GE    31    56    60    61     0     0     0     0     0     2    0.0
GE    32    61    62    63     0     0     0     0     0     3    0.0
GE    33    63    64    65     0     0     0     0     0     3    0.0
GE    34    65    66    67     0     0     0     0     0     4    0.0
GE    35    67    68    69     0     0     0     0     0     4    0.0
GE    36    69    70    71     0     0     0     0     0     4    0.0
GE    37    49    72    73     0     0     0     0     0     1    0.0
GE    38    73    74    75     0     0     0     0     0     1    0.0
GE    39    75    76    77     0     0     0     0     0     1    0.0
GE    40    77    78    79     0     0     0     0     0     1    0.0
GE    41    79    80    81     0     0     0     0     0     1    0.0
GE    42    81    82    83     0     0     0     0     0     1    0.0
GE    43    83    84    85     0     0     0     0     0     1    0.0
GE    44    85    86    87     0     0     0     0     0     2    0.0
GE    45    87    88    89     0     0     0     0     0     2    0.0
GE    46    89    90    91     0     0     0     0     0   901    0.0
GE    47    90    92    93     0     0     0     0     0     3    0.0
GE    48    91    94    95     0     0     0     0     0     4    0.0
GE    49    95    96    97     0     0     0     0     0     4    0.0
GE    50    97    98    99     0     0     0     0     0     4    0.0
GE    51    93   100   101     0     0     0     0     0     3    0.0
```

```
GE     52   101   102   103     0     0     0     0     0     3    0.0
GE     53   103   104   105     0     0     0     0     0   901    0.0
GE     54   104   106   107     0     0     0     0     0     3    0.0
GE     55   105   108   109     0     0     0     0     0     4    0.0
GE     56   109   110   111     0     0     0     0     0     4    0.0
GE     57   111   112   113     0     0     0     0     0     4    0.0
GE     58   113   114   115     0     0     0     0     0     4    0.0
GE     59   115   116   117     0     0     0     0     0     4    0.0
GE     60   107   118   119     0     0     0     0     0     2    0.0
GE     61   119   120   121     0     0     0     0     0     2    0.0
GE     62   121   122   123     0     0     0     0     0     2    0.0
GE     63   123   124   125     0     0     0     0     0     2    0.0
GE     64   125   126   127     0     0     0     0     0     2    0.0
GE     65   127   128   129     0     0     0     0     0     2    0.0
GE     66   129   130   131     0     0     0     0     0   901    0.0
GE     67   130   132   133     0     0     0     0     0     2    0.0
GE     68   131   134   135     0     0     0     0     0     4    0.0
GE     69   135   136   137     0     0     0     0     0     4    0.0
GE     70   137   138   139     0     0     0     0     0     4    0.0
GE     71   139   140   141     0     0     0     0     0     4    0.0
GE     72   141   142   143     0     0     0     0     0     4    0.0
GE     73   143   144   145     0     0     0     0     0     4    0.0
GE     74   133   146   147     0     0     0     0     0     2    0.0
GE     75   147   148   149     0     0     0     0     0     2    0.0
GE     76   149   150   151     0     0     0     0     0     2    0.0
GE     77   151   152   153     0     0     0     0     0     2    0.0
GE     78   153   154   155     0     0     0     0     0     2    0.0
GE     79   155   156   157     0     0     0     0     0     2    0.0
GE     80   157   158   159     0     0     0     0     0     2    0.0
GE     81    40   160   161     0     0     0     0     0   901    0.0
GE     82   161   162   163     0     0     0     0     0     4    0.0
GE     83   163   164   165     0     0     0     0     0     4    0.0
GNN     1          2100046.90         7338324.40                -15.00
GNN     2          2100299.70         7338436.60                -15.00
GNN     3          2100552.40         7338548.90                -15.00
GNN     4          2100805.20         7338661.10                -15.00
GNN     5          2101057.90         7338773.40                -15.00
GNN     6          2101057.90         7338773.40                -15.00
GNN     7          2101057.90         7338773.40                 -5.00
GNN     8          2101277.30         7338921.60                -15.00
GNN     9          2101496.60         7339069.90                -15.00
GNN    10          2101716.00         7339218.20                -15.00
GNN    11          2101935.30         7339366.50                -15.00
GNN    12          2101935.30         7339366.50                -15.00
GNN    13          2101935.30         7339366.50                 -3.60
GNN    14          2102188.10         7339478.50                -15.00
GNN    15          2102440.80         7339591.00                -15.00
GNN    16          2100735.50         7339139.60                 -4.85
GNN    17          2100413.00         7339505.80                 -4.70
GNN    18          2101827.20         7339601.00                 -3.60
GNN    19          2101719.00         7339836.00                 -3.60
GNN    20          2101448.00         7339846.00                 -3.60
GNN    21          2101225.00         7339697.00                 -3.60
GNN    22          2100980.00         7339590.00                 -3.60
GNN    23          2100731.00         7339491.00                 -3.60
GNN    24          2100788.00         7339753.00                 -3.60
GNN    25          2100755.00         7340018.00                 -3.60
GNN    26          2100788.00         7340283.00                 -3.60
GNN    27          2100652.00         7340512.00                 -3.60
GNN    28          2100390.00         7340452.00                 -3.60
GNN    29          2100171.00         7340297.00                 -3.60
GNN    30          2100290.00         7340058.00                 -3.60
GNN    31          2100513.00         7339909.00                 -3.60
```

GNN	32	2100625.00	7339667.00	-3.60
GNN	33	2100413.00	7339505.80	-3.60
GNN	34	2100413.00	7339505.80	-4.70
GNN	35	2100167.00	7339821.00	-4.70
GNN	36	2099921.00	7340136.00	-4.70
GNN	37	2099575.00	7340336.00	-4.75
GNN	38	2099189.00	7340440.00	-4.80
GNN	39	2098949.50	7340491.40	-4.90
GNN	40	2098710.00	7340542.90	-5.00
GNN	41	2098165.50	7340646.90	-5.10
GNN	42	2097621.00	7340751.00	-5.20
GNN	43	2097227.00	7340820.00	-5.25
GNN	44	2096833.00	7340889.00	-5.30
GNN	45	2096833.00	7340889.00	-5.00
GNN	46	2096833.00	7340889.00	-2.20
GNN	47	2096439.00	7340958.00	-4.90
GNN	48	2096045.00	7341027.00	-4.80
GNN	49	2096045.00	7341027.00	-4.80
GNN	50	2096045.00	7341027.00	-2.20
GNN	51	2096930.00	7341097.50	-2.20
GNN	52	2097027.00	7341306.00	-2.20
GNN	53	2096838.50	7341438.00	-2.20
GNN	54	2096680.00	7341571.80	-2.20
GNN	55	2096680.00	7341571.80	-2.20
GNN	56	2096680.00	7341571.80	-2.20
GNN	57	2096426.00	7341517.00	-2.20
GNN	58	2096202.00	7341464.00	-2.20
GNN	59	2096123.50	7341245.50	-2.20
GNN	60	2096475.00	7341720.00	-2.15
GNN	61	2096300.00	7341870.00	-2.10
GNN	62	2096300.00	7342100.00	-2.05
GNN	63	2096152.00	7342276.00	-2.00
GNN	64	2096092.00	7342498.00	-1.90
GNN	65	2096052.00	7342725.00	-1.80
GNN	66	2095955.00	7342933.00	-1.70
GNN	67	2095858.00	7343141.00	-1.60
GNN	68	2095695.00	7343304.00	-1.50
GNN	69	2095487.00	7343207.00	-1.40
GNN	70	2095257.00	7343207.00	-1.30
GNN	71	2095049.00	7343110.00	-1.20
GNN	72	2095662.00	7341144.00	-4.70
GNN	73	2095279.00	7341261.00	-4.60
GNN	74	2094896.00	7341378.00	-4.60
GNN	75	2094513.00	7341495.00	-4.60
GNN	76	2094083.60	7341645.10	-4.50
GNN	77	2093774.00	7341801.00	-4.40
GNN	78	2093491.00	7342084.00	-4.35
GNN	79	2093262.00	7342412.00	-4.30
GNN	80	2093033.00	7342740.00	-4.25
GNN	81	2092804.00	7343068.00	-4.20
GNN	82	2092579.00	7343399.00	-4.20
GNN	83	2092354.00	7343730.00	-4.20
GNN	84	2092129.00	7344061.00	-4.20
GNN	85	2091929.00	7344407.00	-4.20
GNN	86	2091894.00	7344805.00	-4.70
GNN	87	2091859.00	7345203.00	-5.20
GNN	88	2091928.00	7345597.00	-4.70
GNN	89	2092128.00	7345943.00	-4.20
GNN	90	2092128.00	7345943.00	-4.00
GNN	91	2092128.00	7345943.00	-1.80
GNN	92	2091845.00	7346226.00	-3.90
GNN	93	2091645.00	7345880.00	-3.80
GNN	94	2092253.00	7346160.00	-1.70

GNN	95	2092480.00	7346266.00	-1.60
GNN	96	2092657.00	7346443.00	-1.50
GNN	97	2092782.00	7346660.00	-1.40
GNN	98	2092907.00	7346877.00	-1.30
GNN	99	2092907.00	7347127.00	-1.20
GNN	100	2091476.00	7346243.00	-3.70
GNN	101	2091307.00	7345880.00	-3.60
GNN	102	2090944.00	7346049.00	-3.55
GNN	103	2090647.70	7346224.50	-3.50
GNN	104	2090647.70	7346224.50	-3.50
GNN	105	2090647.70	7346224.50	-2.00
GNN	106	2090216.00	7346277.80	-3.40
GNN	107	2089830.00	7346174.00	-3.30
GNN	108	2090685.00	7346672.00	-1.90
GNN	109	2090685.00	7347072.00	-1.80
GNN	110	2090581.00	7347458.00	-1.70
GNN	111	2090412.00	7347821.00	-1.60
GNN	112	2090026.00	7347925.00	-1.55
GNN	113	2089743.00	7348208.00	-1.50
GNN	114	2090000.00	7348514.00	-1.45
GNN	115	2090169.00	7348877.00	-1.40
GNN	116	2090273.00	7349263.00	-1.35
GNN	117	2090104.00	7349626.00	-1.30
GNN	118	2089639.10	7345951.70	-3.20
GNN	119	2089147.00	7345891.00	-3.10
GNN	120	2089078.00	7346285.00	-3.00
GNN	121	2088678.00	7346285.00	-2.90
GNN	122	2088395.00	7346568.00	-2.80
GNN	123	2088195.00	7346914.00	-2.70
GNN	124	2087832.00	7347083.00	-2.60
GNN	125	2088032.00	7347429.00	-2.50
GNN	126	2088032.00	7347779.00	-2.40
GNN	127	2087831.00	7348066.00	-2.30
GNN	128	2087496.00	7347964.00	-2.25
GNN	129	2087147.00	7347994.80	-2.20
GNN	130	2087147.00	7347994.80	-2.20
GNN	131	2087147.00	7347994.80	-1.80
GNN	132	2086830.00	7348143.00	-2.15
GNN	133	2086583.00	7348390.00	-2.10
GNN	134	2086879.00	7347770.00	-1.70
GNN	135	2086576.00	7347595.00	-1.60
GNN	136	2086241.00	7347493.00	-1.55
GNN	137	2085896.00	7347432.00	-1.50
GNN	138	2085567.00	7347312.00	-1.45
GNN	139	2085250.00	7347164.00	-1.40
GNN	140	2084963.00	7346962.00	-1.35
GNN	141	2084618.00	7346901.00	-1.30
GNN	142	2084283.00	7346799.00	-1.30
GNN	143	2083948.00	7346697.00	-1.30
GNN	144	2083603.00	7346636.00	-1.30
GNN	145	2083286.00	7346784.00	-1.30
GNN	146	2086685.00	7348725.00	-2.00
GNN	147	2086624.00	7349070.00	-1.90
GNN	148	2086608.30	7349424.70	-1.85
GNN	149	2086592.60	7349779.60	-1.80
GNN	150	2086281.30	7349734.20	-1.75
GNN	151	2085970.00	7349689.00	-1.70
GNN	152	2085625.00	7349750.00	-1.60
GNN	153	2085357.00	7349975.00	-1.50
GNN	154	2085089.00	7350200.00	-1.40
GNN	155	2084888.00	7350487.00	-1.30
GNN	156	2084641.00	7350734.00	-1.30
GNN	157	2084440.00	7351021.00	-1.30

GNN	158	2084239.00	7351308.00	-1.30			
GNN	159	2084038.00	7351595.00	-1.30			
GNN	160	2098710.00	7340542.90	-5.00			
GNN	161	2098710.00	7340542.90	-1.30			
GNN	162	2098710.00	7340942.90	-1.25			
GNN	163	2098710.00	7341342.90	-1.20			
GNN	164	2098710.00	7341742.90	-1.15			
GNN	165	2098710.00	7342142.90	-1.10			
GWN	1	100	7.5	7.5	120	-10	12
GWN	2	100	7.5	7.5	120	-10	12
GWN	3	100	7.5	7.5	120	-10	12
GWN	4	100	7.5	7.5	120	-10	12
GWN	5	100	7.5	7.5	120	-10	12
GWN	6	100	7.5	7.5	120	-10	12
GWN	7	25	5.5	10	50	-2	50
GWN	8	100	7.5	7.5	120	-10	12
GWN	9	100	7.5	7.5	120	-10	12
GWN	10	100	7.5	7.5	120	-10	12
GWN	11	100	7.5	7.5	120	-10	12
GWN	12	100	7.5	7.5	120	-10	12
GWN	13	25	1.2	5.1	100	-3.6	50
GWN	14	100	7.5	7.5	120	-10	12
GWN	15	100	7.5	7.5	120	-10	12
GWN	16	25	5.5	10	50	-2	50
GWN	17	25	5.5	10	50	-2	50
GWN	18	25	1.2	5.1	100	-2	50
GWN	19	25	1.2	5.1	100	-2	50
GWN	20	25	1.2	5.1	100	-2	50
GWN	21	25	1.2	5.1	50	-2	50
GWN	22	25	1.2	5.1	50	-2	50
GWN	23	25	1.2	5.1	50	-2	50
GWN	24	25	1.2	5.1	50	-2	50
GWN	25	25	1.2	5.1	50	-2	50
GWN	26	25	1.2	5.1	50	-2	50
GWN	27	25	1.2	5.1	200	-2	50
GWN	28	25	1.2	5.1	50	-2	50
GWN	29	25	1.2	5.1	50	-2	50
GWN	30	25	1.2	5.1	100	-2	50
GWN	31	25	1.2	5.1	50	-2	50
GWN	32	25	1.2	5.1	50	-2	50
GWN	33	25	1.2	5.1	50	-2	50
GWN	34	25	5.5	10	50	-2	50
GWN	35	25	5.5	10	50	-2	50
GWN	36	25	5.5	10	200	-3.6	60
GWN	37	25	5.5	10	200	-3.6	60
GWN	38	25	5.5	10	200	-3.6	60
GWN	39	25	5.5	10	200	-3.6	60
GWN	40	25	5.5	10	200	-3.6	60
GWN	41	26	5.25	9.35	200	-3.6	60
GWN	42	27	5	8.7	200	-3.6	60
GWN	43	27	5	8.7	200	-3.6	60
GWN	44	27	5	8.7	200	-3.6	60
GWN	45	27	5	8.7	200	-3.6	200
GWN	46	11	9.1	7.3	20	-2	10
GWN	47	31	5.25	6.85	200	-3.6	200
GWN	48	35	5.5	5	200	-3.6	200
GWN	49	35	4	5	200	-3.6	200
GWN	50	11	9.1	7.3	20	-2	10
GWN	51	11	9.1	7.3	30	-2	15
GWN	52	11	9.1	7.3	30	-2	15
GWN	53	11	9.1	7.3	10	-1	10
GWN	54	11	9.1	7.3	60	-2	30
GWN	55	11	9.1	7.3	60	-2	30

GWN	56	10	1.5	1.5	50	-2	25
GWN	57	11	9.1	7.3	60	-2	30
GWN	58	11	9.1	7.3	30	-2	30
GWN	59	11	9.1	7.3	10	-1	10
GWN	60	10	1.5	1.5	50	-2	100
GWN	61	10	1.5	1.5	50	-2	100
GWN	62	10	1.5	1.5	20	-1.5	30
GWN	63	10	1.5	1.5	20	-1.5	30
GWN	64	10	1.5	1.5	20	-1.5	30
GWN	65	10	1.5	1.5	20	-1.5	30
GWN	66	8	1.5	1.5	30	-1.5	45
GWN	67	6	1.5	1.5	30	-1.5	45
GWN	68	5.5	1.5	1.5	30	-1.5	45
GWN	69	5	1.5	1.5	30	-1.5	45
GWN	70	5	1.25	1.25	30	-1.4	45
GWN	71	5	1	1	130	-1.3	100
GWN	72	35	3	5	200	-3	200
GWN	73	35	2	5	200	-3	200
GWN	74	35	1.55	4.3	200	-3	200
GWN	75	35	1	4	200	-3	200
GWN	76	35	2	4	200	-3	200
GWN	77	35	3	4	200	-3	200
GWN	78	35	5	5	200	-3	200
GWN	79	35	7	6	200	-3	200
GWN	80	35	9	7	200	-3	200
GWN	81	35	11	8	200	-3	200
GWN	82	35	11	8	200	-3	200
GWN	83	35	11	8	200	-3	200
GWN	84	33	7	6	200	-3	200
GWN	85	31	5	4	200	-3	200
GWN	86	23	4	3.8	30	-3	10
GWN	87	15	3	3.6	0	0	0
GWN	88	15	4	4.3	0	0	0
GWN	89	15	5	5	0	0	0
GWN	90	12	3	3	10	-2	5
GWN	91	6	1	1	0	0	0
GWN	92	12	3	3	10	-2	5
GWN	93	12	3	3	10	-2	5
GWN	94	5.7	1	1	0	0	0
GWN	95	5.4	1	1	0	0	0
GWN	96	5.1	1	1	0	0	0
GWN	97	4.7	1	1	0	0	0
GWN	98	4.4	1	1	0	0	0
GWN	99	4.1	1	1	20	-1	20
GWN	100	12	3	3	10	-2	5
GWN	101	12	3	3	10	-2	5
GWN	102	12	2.4	2.6	10	-2	5
GWN	103	12	1.8	2.2	10	-2	5
GWN	104	12	1.8	2.2	10	-2	5
GWN	105	2	0.5	1	0	0	0
GWN	106	12	1.8	2.2	40	-2	20
GWN	107	12	1.8	2.2	40	-2	20
GWN	108	1.9	0.5	1	0	0	0
GWN	109	1.8	0.5	1	0	0	0
GWN	110	1.7	0.5	1	0	0	0
GWN	111	1.6	0.5	1	0	0	0
GWN	112	1.5	0.5	1	0	0	0
GWN	113	1.4	0.5	1	0	0	0
GWN	114	1.3	0.5	1	0	0	0
GWN	115	1.2	0.5	1	0	0	0
GWN	116	1.1	0.5	1	0	0	0
GWN	117	1	0.5	1	20	-1	20
GWN	118	12	1.8	2.2	40	-2	20

```
GWN   119        12       1.8       2.2       40       -2       20
GWN   120        12       1.8       2.2       40       -2       20
GWN   121        12       1.8       2.2       20       -2       10
GWN   122        12       1.8       2.2       10       -2        5
GWN   123        12       1.8       2.2       10       -2        5
GWN   124        12       1.8       2.2       10       -2        5
GWN   125        12       1.8       2.2       10       -1       10
GWN   126        12       1.8       2.2       10       -1       10
GWN   127        12       1.8       2.2       10       -1       10
GWN   128        12       1.8       2.2        0        0        0
GWN   129        12       1.8       2.2        0        0        0
GWN   130       8.8       1.5         2        0        0        0
GWN   131      10.5       0.5         1        0        0        0
GWN   132       8.8       1.5         2        0        0        0
GWN   133       8.8       1.5         2        0        0        0
GWN   134      10.5       0.5         1        0        0        0
GWN   135      10.5       0.5         1        0        0        0
GWN   136      10.5       0.5         1        0        0        0
GWN   137      10.5       0.5         1        0        0        0
GWN   138        10       0.5         1        0        0        0
GWN   139       9.5       0.5         1        0        0        0
GWN   140       8.5       0.5         1        0        0        0
GWN   141       7.5       0.5         1        0        0        0
GWN   142       6.5       0.5         1        0        0        0
GWN   143       5.5       0.5         1        0        0        0
GWN   144       4.5       0.5         1        0        0        0
GWN   145       3.5       0.5         1       80     -1.3       80
GWN   146       8.4      1.75         2       10       -1       10
GWN   147         8         2         2        0        0        0
GWN   148         7         2         2        5       -1        5
GWN   149         7         2         2        0        0        0
GWN   150       6.5         2         2       20       -1       20
GWN   151         6         2         2       20       -1       20
GWN   152       5.5         2         2       20       -1       20
GWN   153         5         2         2       20       -1       20
GWN   154         3         4       2.5       20       -1       20
GWN   155         1         6         3       20       -1       20
GWN   156         1         6         3       20       -1       20
GWN   157         1         6         3       20       -1       20
GWN   158         1         6         3       20       -1       20
GWN   159         1         6         3       80     -1.3       80
GWN   160        25       5.5        10      200     -3.6       60
GWN   161        13         1         1        0        0        0
GWN   162         9       1.5       1.5        0        0        0
GWN   163       4.8       1.9       1.9        0        0        0
GWN   164       4.0       1.9       1.9        0        0        0
GWN   165       3.8       1.9       1.9       10     -1.1       10
```

Below is the first day of the Cow Bayou RMA2 boundary condition file.

```
T1  Cow Bayou Long Term Run B
T2  Jan 1, 2002 - Jan 1, 2013 at 30 min (0.5 hr) time step
T3  Fully Permitted PS Flows
$M  1
$L  0 0 1 1 0 0 0 0 0 0
SI  1
DE  0.084  0.183  5
EX  1     5000.00     5000.00
EY  1     5000.00     5000.00
EX  2     5000.00     5000.00
EY  2     5000.00     5000.00
EX  3     5000.00     5000.00
```

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EY  3     5000.00     5000.00
EX  4     5000.00     5000.00
EY  4     5000.00     5000.00
FT  20
IC  0.105  0.3  0.08
RDT 1  1  0.030  2  0.040  1E-14  0  0
RDT 2  1  0.040  2  0.045  1E-14  0  0
RDT 3  1  0.045  2  0.050  1E-14  0  0
RDT 4  1  0.060  2  0.070  1E-14  0  0
CO RSC  10000   0   0
TI  25  15  0.0001  0.01
TR   0  0  0  0
TS  -1 0 0
TZ  0.5  96431.5 192864  0  0
CO  BAN cards are boundary flow azimuths in radians from x-axis
BAN 1  3.58
BAN 15  3.58
BAN  71  0.46
BAN  99  4.71
BAN 117 5.12
BAN 145  5.85
BAN 159 5.32
BAN 165 4.71
CO   initial boundary flows in cms
CO  BQE 14 is Honeywell WQ0000670-000 self-reported flows
CO  BQE 19 is Lanxess WQ0001167-000 self-reported flows
CO   BQE 21 is Firestone WQ0000454-000 self-reported flows
CO   BQE 36 is City of Bridge City WQ0013691-001 self-reported flows
CO   BQE 37 is Gulflander Partners Group WQ0013488-001 self-reported flows
CO   BQE 38 is City of Bridge City WQ0010051-001 self-reported flows
CO   BQE 44 is Orangefield WSC WQ0014772-001 self-reported flows
CO   BQE 50 is Sabine River Authority WQ0012134-001 self-reported flows
CO   BQE 78 is TXDOT WQ0011457-001 self-reported flows
CO   BQE 79 is PCS Development Group WQ0011916-001 self-reported flows
CO   BQE 83 includes Chevron WQ0000359-000 and Printpack ...
CO      WQ0002858-000 self-reported flows
BQE 14    0.00002448
BQE 19    0.00020373
BQE 21    0.00002821
BQE 36    0.00000190
BQE 37    0.00000055
BQE 38    0.00005148
BQE 44    0.00000085
BQE 50    0.00000007
BQE 78    0.00000025
BQE 79    0.00000064
BQE 83    0.00005397
BQN 117   0.342150
BQN 145   0.910430
BQN 159   3.332000
BQE 18    0.000116
BQE 22    0.000175
BQE 39    0.000193
BQE 43    0.000147
BQE 58    0.000110
BQE 62    0.000155
BQN 71    0.156670
BQE 75    0.000169
BQN 99    0.227490
BQN  15    464.00000000
BCN  1  00200  0  0  0.105
END  Simulation at time =  0.0
BCN  1  00200  0  0  0.105
```

```
END  Simulation at time =  0.5
BQN 117   0.341210
BQN 145   0.907130
BQN 159   3.307000
BQE 18    0.000114
BQE 22    0.000171
BQE 39    0.000189
BQE 43    0.000144
BQE 58    0.000108
BQE 62    0.000152
BQN 71    0.155310
BQE 75    0.000165
BQN 99    0.226020
BCN  1  00200  0  0  0.102
END  Simulation at time =  1.0
BCN  1  00200  0  0  0.101
END  Simulation at time =  1.5
BQN 117   0.339440
BQN 145   0.903110
BQN 159   3.281000
BQE 18    0.000112
BQE 22    0.000168
BQE 39    0.000185
BQE 43    0.000141
BQE 58    0.000106
BQE 62    0.000149
BQN 71    0.153630
BQE 75    0.000162
BQN 99    0.224060
BCN  1  00200  0  0  0.091
END  Simulation at time =  2.0
BCN  1  00200  0  0  0.085
END  Simulation at time =  2.5
BQN 117   0.336970
BQN 145   0.898430
BQN 159   3.254400
BQE 18    0.000110
BQE 22    0.000164
BQE 39    0.000181
BQE 43    0.000138
BQE 58    0.000104
BQE 62    0.000146
BQN 71    0.151690
BQE 75    0.000159
BQN 99    0.221710
BCN  1  00200  0  0  0.081
END  Simulation at time =  3.0
BCN  1  00200  0  0  0.086
END  Simulation at time =  3.5
BQN 117   0.333930
BQN 145   0.893160
BQN 159   3.227500
BQE 18    0.000107
BQE 22    0.000161
BQE 39    0.000178
BQE 43    0.000135
BQE 58    0.000102
BQE 62    0.000143
BQN 71    0.149570
BQE 75    0.000156
BQN 99    0.219060
BCN  1  00200  0  0  0.075
END  Simulation at time =  4.0
```

```
BCN  1  00200  0  0  0.08
END  Simulation at time =  4.5
BQN 117   0.330430
BQN 145   0.887320
BQN 159   3.200400
BQE 18    0.000105
BQE 22    0.000158
BQE 39    0.000174
BQE 43    0.000133
BQE 58    0.000100
BQE 62    0.000140
BQN 71    0.147320
BQE 75    0.000152
BQN 99    0.216170
BCN  1  00200  0  0  0.066
END  Simulation at time =  5.0
BCN  1  00200  0  0  0.056
END  Simulation at time =  5.5
BQN 117   0.325820
BQN 145   0.879970
BQN 159   3.171100
BQE 18    0.000101
BQE 22    0.000152
BQE 39    0.000168
BQE 43    0.000128
BQE 58    0.000096
BQE 62    0.000135
BQN 71    0.144500
BQE 75    0.000147
BQN 99    0.212550
BCN  1  00200  0  0  0.044
END  Simulation at time =  6.0
BCN  1  00200  0  0  0.032
END  Simulation at time =  6.5
BQN 117   0.306920
BQN 145   0.853280
BQN 159   3.101300
BQE 18    0.000066
BQE 22    0.000100
BQE 39    0.000112
BQE 43    0.000084
BQE 58    0.000063
BQE 62    0.000090
BQN 71    0.132810
BQE 75    0.000097
BQN 99    0.198050
BCN  1  00200  0  0  0.014
END  Simulation at time =  7.0
BCN  1  00200  0  0  0.004
END  Simulation at time =  7.5
BQN 117   0.280070
BQN 145   0.815500
BQN 159   3.010300
BQE 18    0.000039
BQE 22    0.000062
BQE 39    0.000070
BQE 43    0.000052
BQE 58    0.000041
BQE 62    0.000055
BQN 71    0.116630
BQE 75    0.000062
BQN 99    0.177660
BCN  1  00200  0  0  -0.024
```

```
END  Simulation at time =  8.0
BCN  1  00200  0  0  -0.061
END  Simulation at time =  8.5
BQN 117   0.256740
BQN 145   0.780360
BQN 159   2.928000
BQE 18    0.000038
BQE 22    0.000060
BQE 39    0.000067
BQE 43    0.000051
BQE 58    0.000040
BQE 62    0.000054
BQN 71    0.103250
BQE 75    0.000061
BQN 99    0.160510
BCN  1  00200  0  0  -0.082
END  Simulation at time =  9.0
BCN  1  00200  0  0  -0.118
END  Simulation at time =  9.5
BQN 117   0.236590
BQN 145   0.748070
BQN 159   2.853700
BQE 18    0.000037
BQE 22    0.000059
BQE 39    0.000067
BQE 43    0.000050
BQE 58    0.000040
BQE 62    0.000054
BQN 71    0.092412
BQE 75    0.000060
BQN 99    0.146230
BCN  1  00200  0  0  -0.145
END  Simulation at time =  10.0
BCN  1  00200  0  0  -0.162
END  Simulation at time =  10.5
BQN 117   0.219160
BQN 145   0.718170
BQN 159   2.784000
BQE 18    0.000037
BQE 22    0.000058
BQE 39    0.000066
BQE 43    0.000050
BQE 58    0.000039
BQE 62    0.000053
BQN 71    0.083611
BQE 75    0.000059
BQN 99    0.139940
BCN  1  00200  0  0  -0.191
END  Simulation at time =  11.0
BCN  1  00200  0  0  -0.222
END  Simulation at time =  11.5
BQN 117   0.204060
BQN 145   0.690260
BQN 159   2.719900
BQE 18    0.000036
BQE 22    0.000058
BQE 39    0.000065
BQE 43    0.000049
BQE 58    0.000039
BQE 62    0.000052
BQN 71    0.076440
BQE 75    0.000058
BQN 99    0.137450
```

```
BCN  1  00200  0  0  -0.256
END  Simulation at time =  12.0
BCN  1  00200  0  0  -0.284
END  Simulation at time =  12.5
BQN 117   0.190950
BQN 145   0.664060
BQN 159   2.661800
BQE 18    0.000036
BQE 22    0.000057
BQE 39    0.000064
BQE 43    0.000048
BQE 58    0.000038
BQE 62    0.000052
BQN 71    0.070576
BQE 75    0.000058
BQN 99    0.135020
BCN  1  00200  0  0  -0.295
END  Simulation at time =  13.0
BCN  1  00200  0  0  -0.297
END  Simulation at time =  13.5
BQN 117   0.179700
BQN 145   0.639780
BQN 159   2.609300
BQE 18    0.000036
BQE 22    0.000056
BQE 39    0.000064
BQE 43    0.000048
BQE 58    0.000038
BQE 62    0.000051
BQN 71    0.065976
BQE 75    0.000057
BQN 99    0.132680
BCN  1  00200  0  0  -0.317
END  Simulation at time =  14.0
BCN  1  00200  0  0  -0.316
END  Simulation at time =  14.5
BQN 117   0.173700
BQN 145   0.622320
BQN 159   2.572000
BQE 18    0.000044
BQE 22    0.000069
BQE 39    0.000078
BQE 43    0.000058
BQE 58    0.000045
BQE 62    0.000062
BQN 71    0.064776
BQE 75    0.000069
BQN 99    0.131090
BCN  1  00200  0  0  -0.353
END  Simulation at time =  15.0
BCN  1  00200  0  0  -0.31
END  Simulation at time =  15.5
BQN 117   0.181570
BQN 145   0.622910
BQN 159   2.575600
BQE 18    0.000076
BQE 22    0.000115
BQE 39    0.000128
BQE 43    0.000097
BQE 58    0.000073
BQE 62    0.000103
BQN 71    0.072099
BQE 75    0.000112
```

```
BQN 99    0.131860
BCN  1  00200  0  0  -0.305
END  Simulation at time =  16.0
BCN  1  00200  0  0  -0.276
END  Simulation at time =  16.5
BQN 117   0.188380
BQN 145   0.622630
BQN 159   2.576400
BQE 18    0.000076
BQE 22    0.000115
BQE 39    0.000128
BQE 43    0.000097
BQE 58    0.000074
BQE 62    0.000103
BQN 71    0.078016
BQE 75    0.000112
BQN 99    0.132610
BCN  1  00200  0  0  -0.258
END  Simulation at time =  17.0
BCN  1  00200  0  0  -0.241
END  Simulation at time =  17.5
BQN 117   0.193560
BQN 145   0.620830
BQN 159   2.572600
BQE 18    0.000074
BQE 22    0.000113
BQE 39    0.000125
BQE 43    0.000095
BQE 58    0.000072
BQE 62    0.000101
BQN 71    0.082362
BQE 75    0.000110
BQN 99    0.133220
BCN  1  00200  0  0  -0.221
END  Simulation at time =  18.0
BCN  1  00200  0  0  -0.171
END  Simulation at time =  18.5
BQN 117   0.197360
BQN 145   0.617870
BQN 159   2.565200
BQE 18    0.000073
BQE 22    0.000111
BQE 39    0.000123
BQE 43    0.000093
BQE 58    0.000071
BQE 62    0.000099
BQN 71    0.085457
BQE 75    0.000108
BQN 99    0.133700
BCN  1  00200  0  0  -0.133
END  Simulation at time =  19.0
BCN  1  00200  0  0  -0.098
END  Simulation at time =  19.5
BQN 117   0.200000
BQN 145   0.614030
BQN 159   2.554700
BQE 18    0.000072
BQE 22    0.000109
BQE 39    0.000120
BQE 43    0.000091
BQE 58    0.000069
BQE 62    0.000097
BQN 71    0.087561
```

```
BQE 75    0.000106
BQN 99    0.134050
BCN  1  00200  0  0  -0.061
END  Simulation at time =  20.0
BCN  1  00200  0  0  -0.032
END  Simulation at time =  20.5
BQN 117   0.201670
BQN 145   0.609510
BQN 159   2.541800
BQE 18    0.000070
BQE 22    0.000106
BQE 39    0.000118
BQE 43    0.000090
BQE 58    0.000068
BQE 62    0.000095
BQN 71    0.088880
BQE 75    0.000104
BQN 99    0.134290
BCN  1  00200  0  0  -0.001
END  Simulation at time =  21.0
BCN  1  00200  0  0  0.027
END  Simulation at time =  21.5
BQN 117   0.202510
BQN 145   0.604480
BQN 159   2.526800
BQE 18    0.000069
BQE 22    0.000104
BQE 39    0.000116
BQE 43    0.000088
BQE 58    0.000067
BQE 62    0.000093
BQN 71    0.089579
BQE 75    0.000102
BQN 99    0.134410
BCN  1  00200  0  0  0.027
END  Simulation at time =  22.0
BCN  1  00200  0  0  0.001
END  Simulation at time =  22.5
BQN 117   0.202660
BQN 145   0.599050
BQN 159   2.510200
BQE 18    0.000068
BQE 22    0.000102
BQE 39    0.000114
BQE 43    0.000086
BQE 58    0.000066
BQE 62    0.000091
BQN 71    0.089789
BQE 75    0.000100
BQN 99    0.134440
BCN  1  00200  0  0  -0.01
END  Simulation at time =  23.0
BCN  1  00200  0  0  -0.008
END  Simulation at time =  23.5
BQN 117   0.201840
BQN 145   0.592780
BQN 159   2.490900
BQE 18    0.000065
BQE 22    0.000099
BQE 39    0.000110
BQE 43    0.000083
BQE 58    0.000063
BQE 62    0.000088
```

```
BQN 71    0.089371
BQE 75    0.000097
BQN 99    0.134290
BQN  15    456.00000000
BCN  1  00200  0  0  0.031
END  Simulation at time =  24.0
STOP
```

Note: The model printout was stopped here, after one day, due to space considerations.The complete model input would occupy many hundreds of pages.

Appendix E Goodness-of-fit for the Adams Bayou RMA2 Hydrodynamic Model

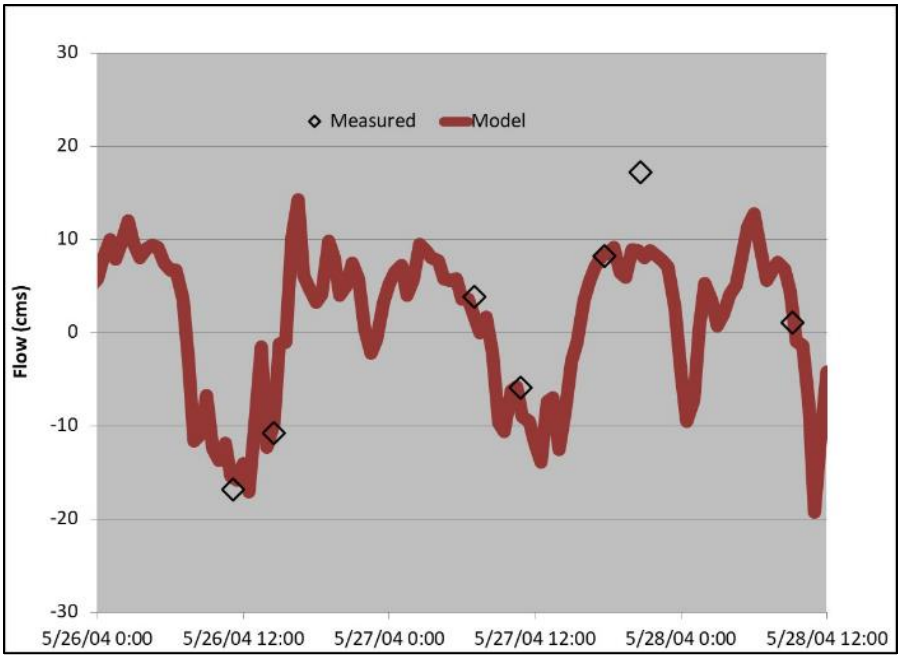

Figure E-1 Flow calibration at station AB2

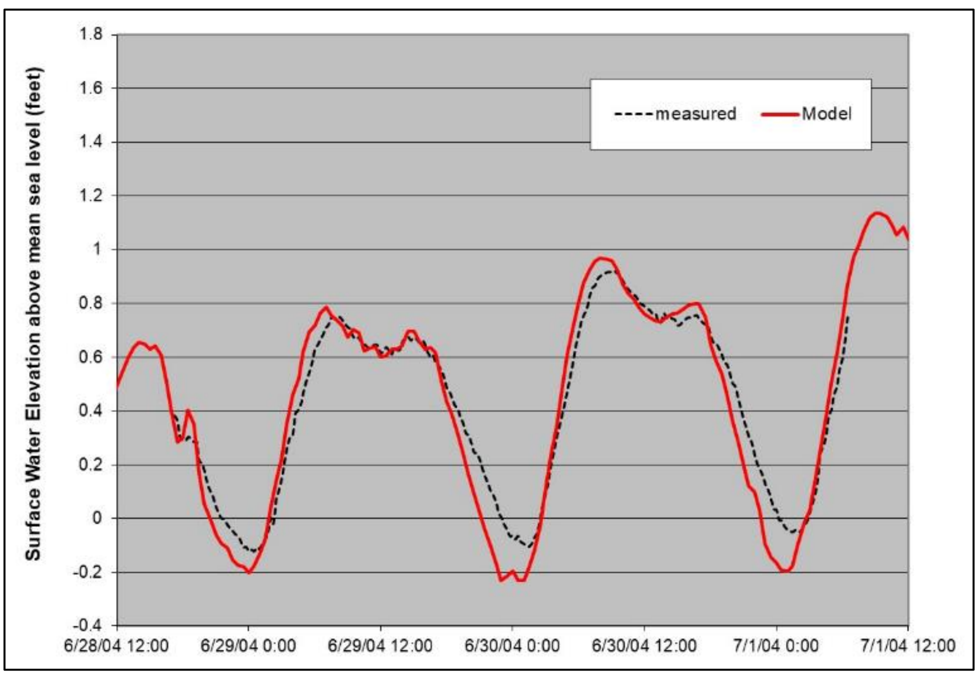

Figure E-2 Water level validation at station AB2

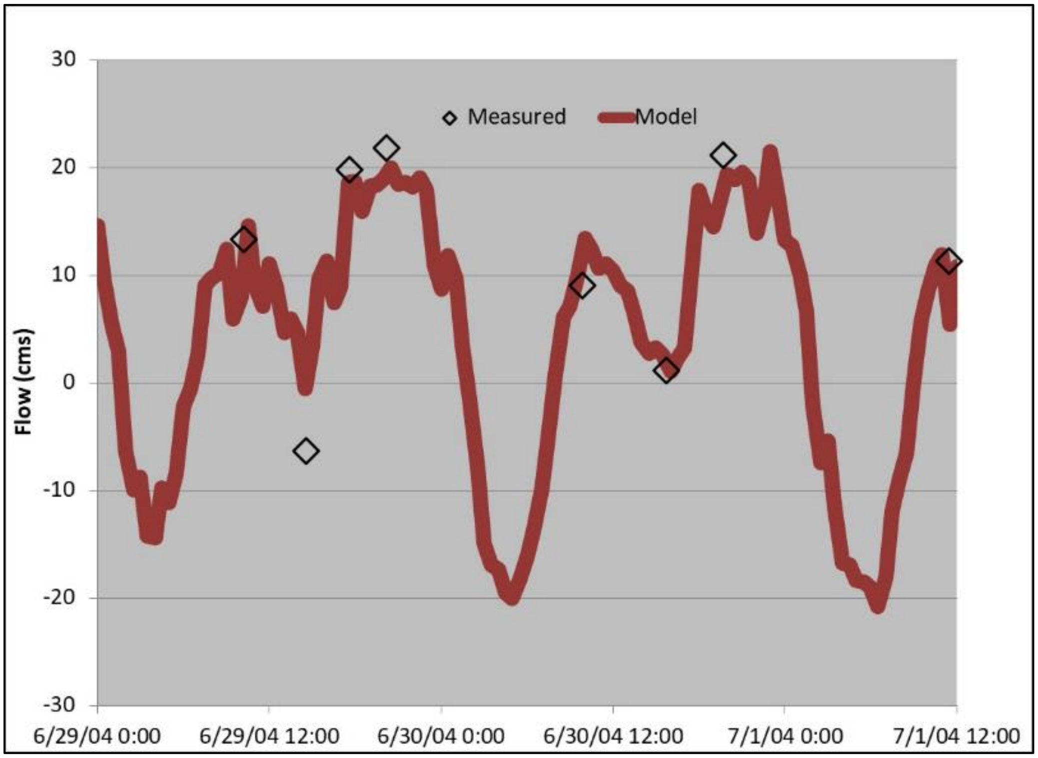

Figure E-3 Flow validation at station AB2

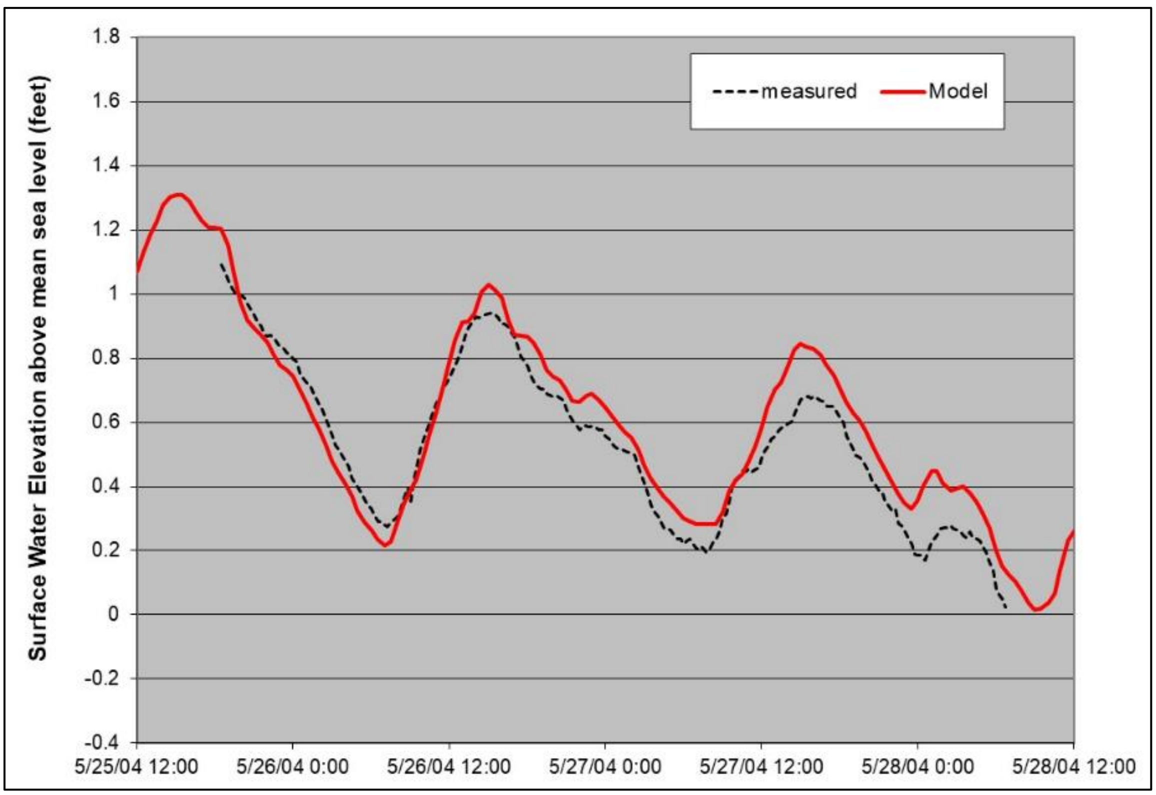

Figure E-4 Water level calibration at station AB3

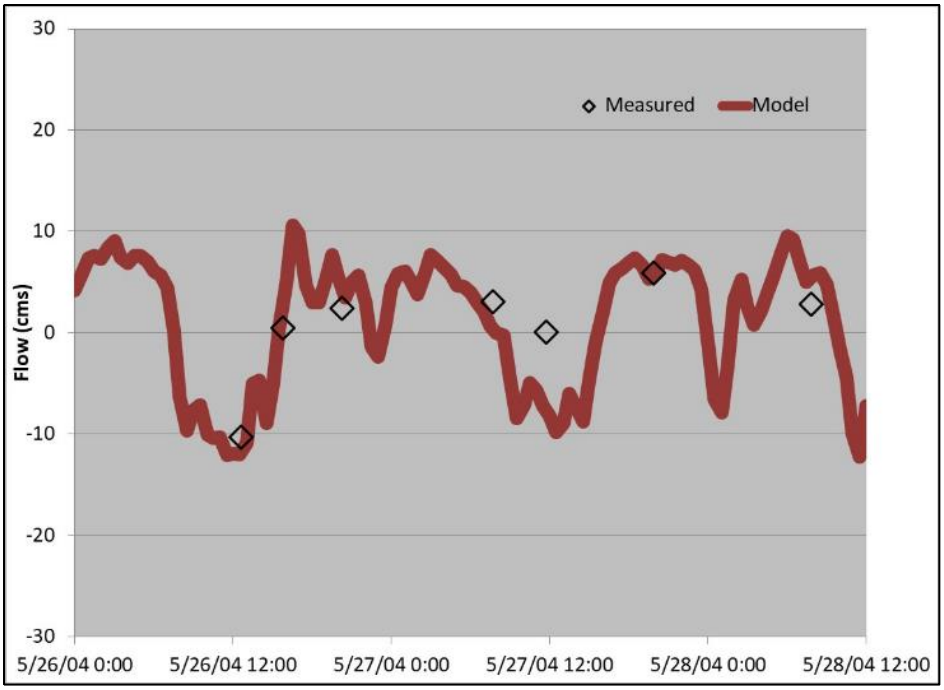

Figure E-5 Flow calibration at station AB3

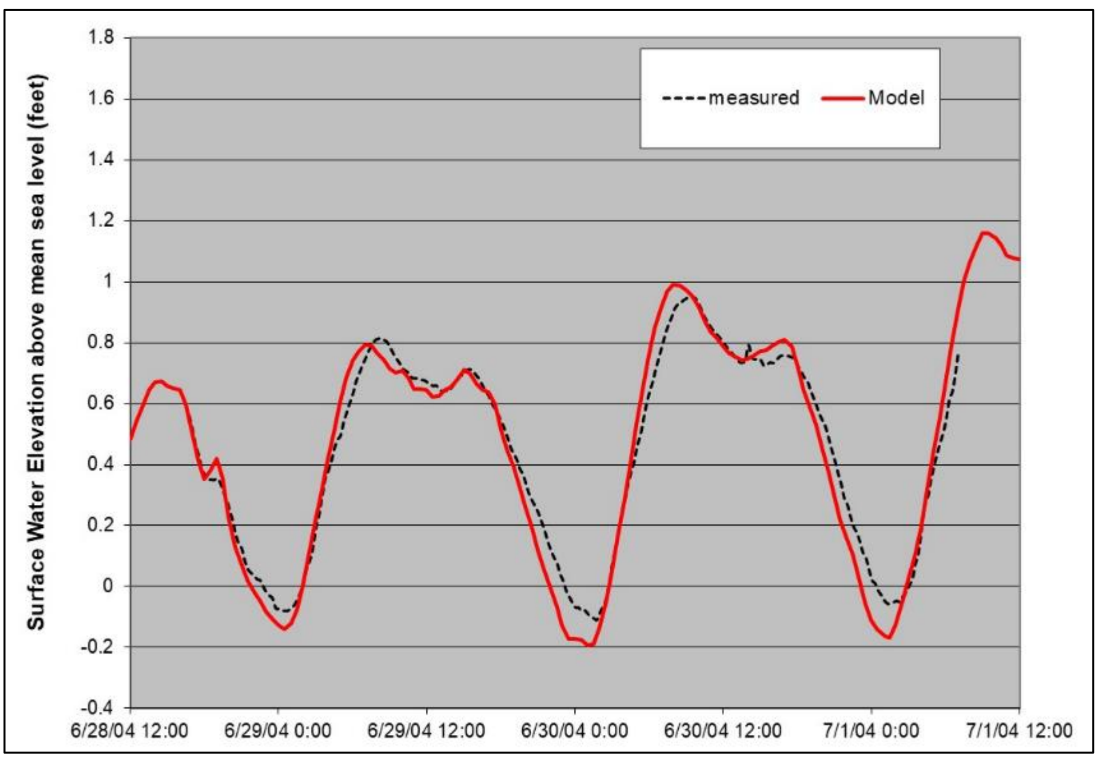

Figure E-6 Water level validation at station AB3

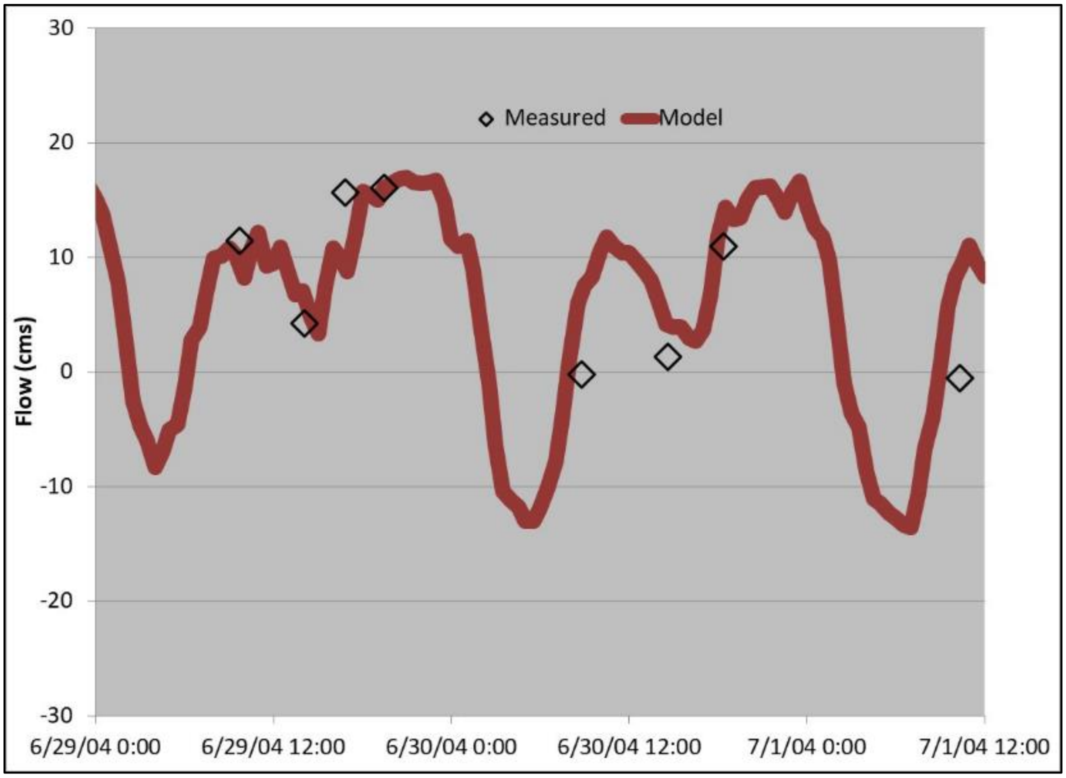

Figure E-7 Flow validation at station AB3

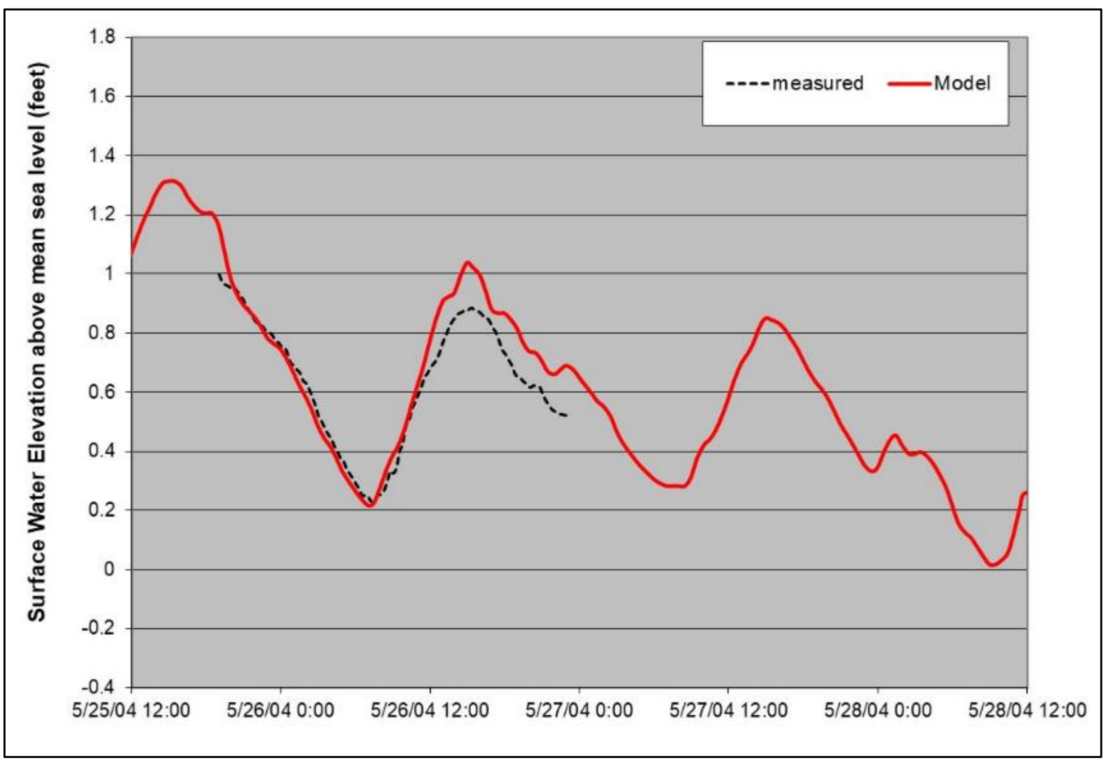

Figure E-8 Water level calibration at station AB4

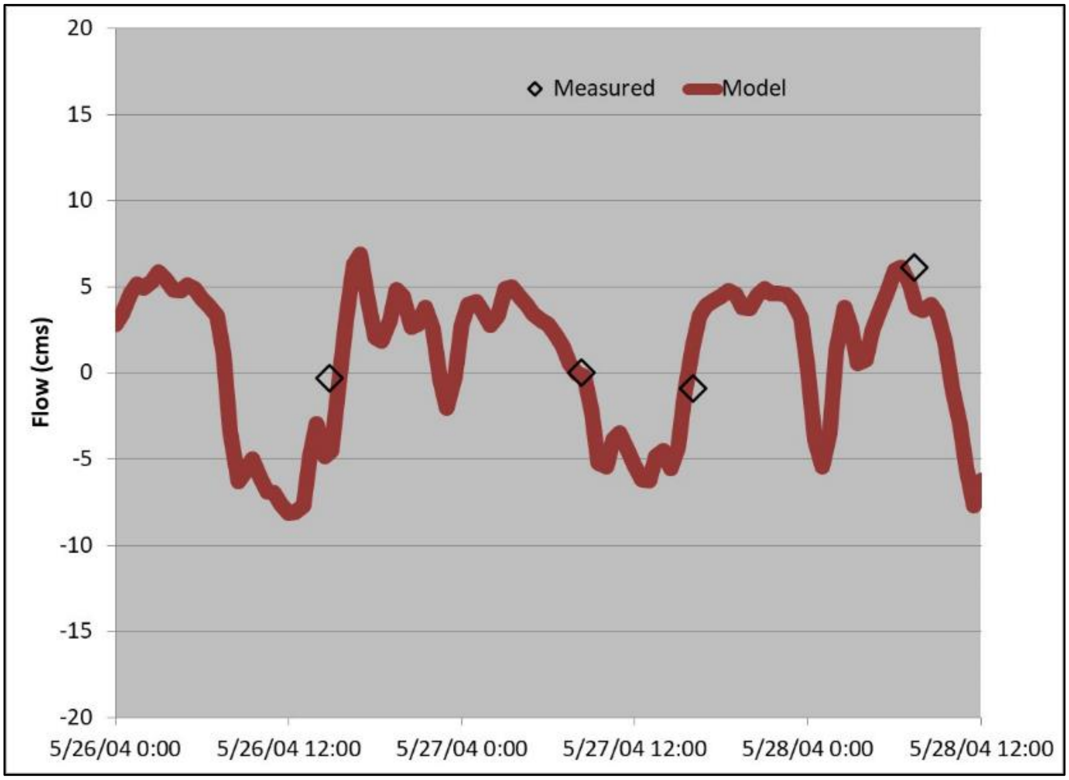

Figure E-9 Flow calibration at station AB4

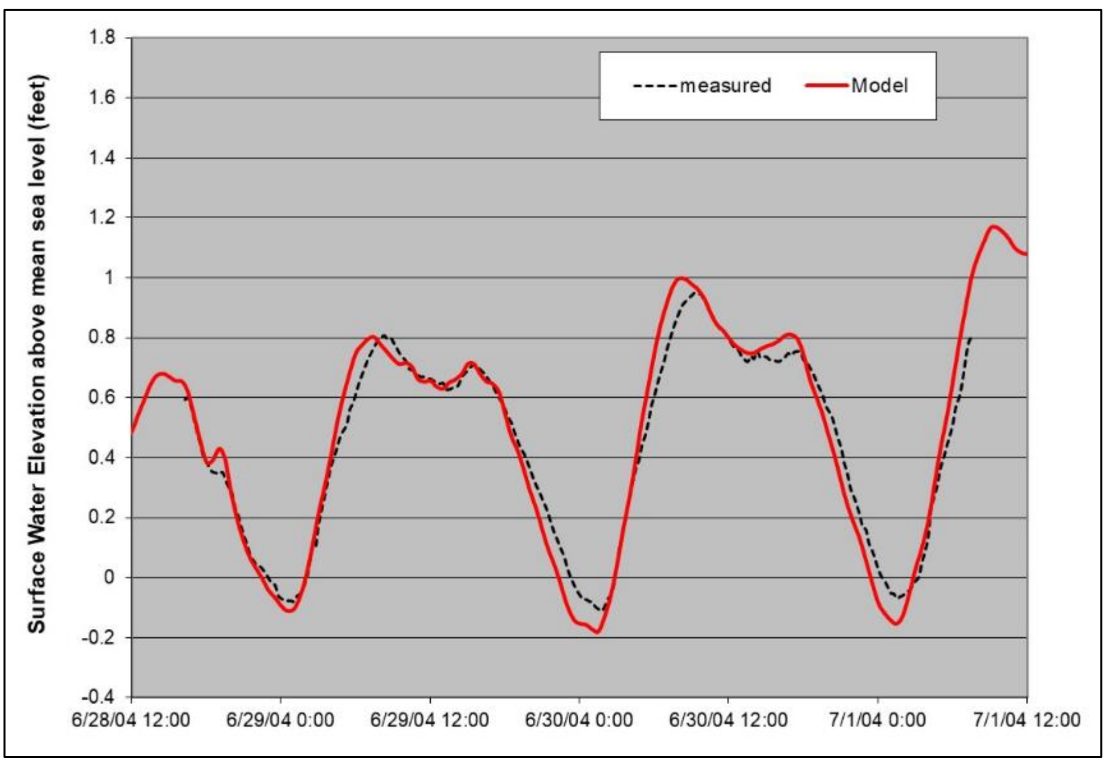

Figure E-10 Water level validation at station AB4

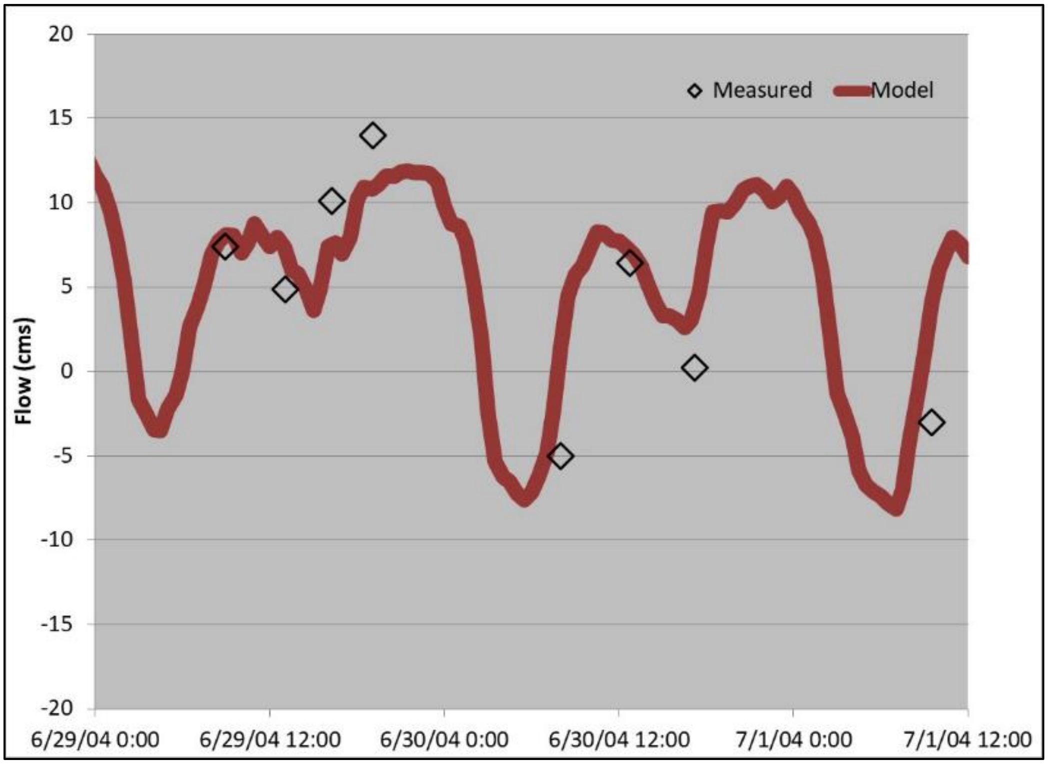

Figure E-11 Flow validation at station AB4

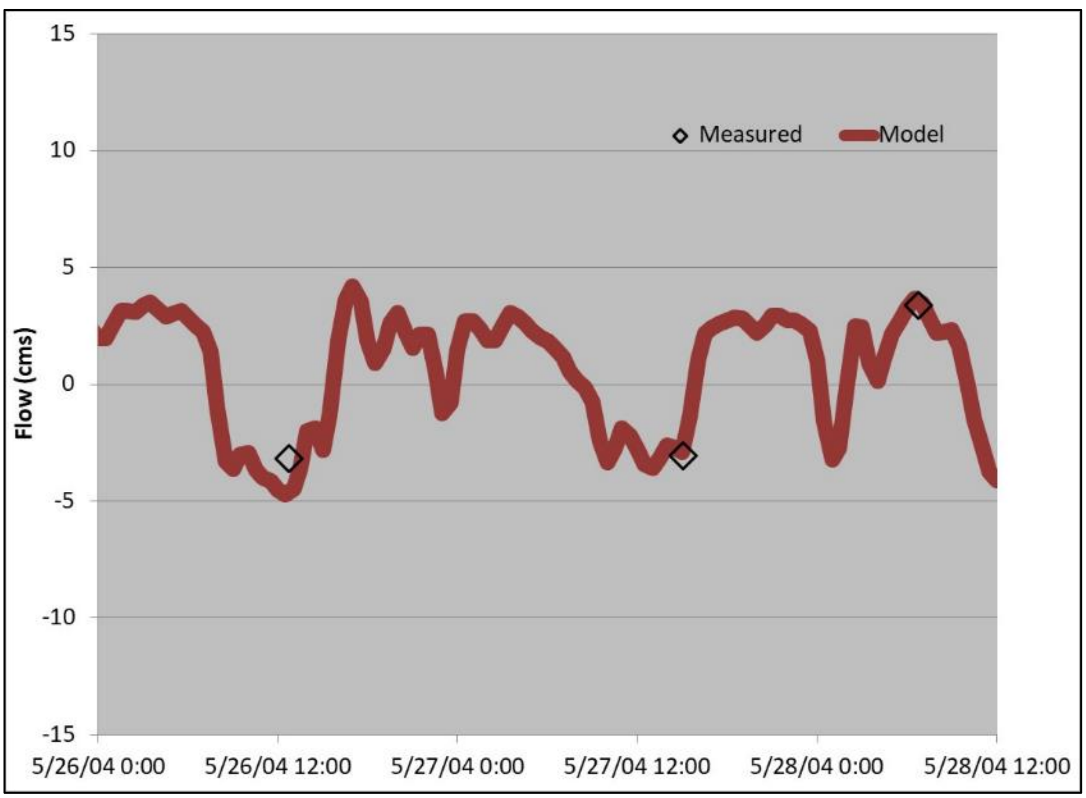

Figure E-12 Flow calibration at station AB5

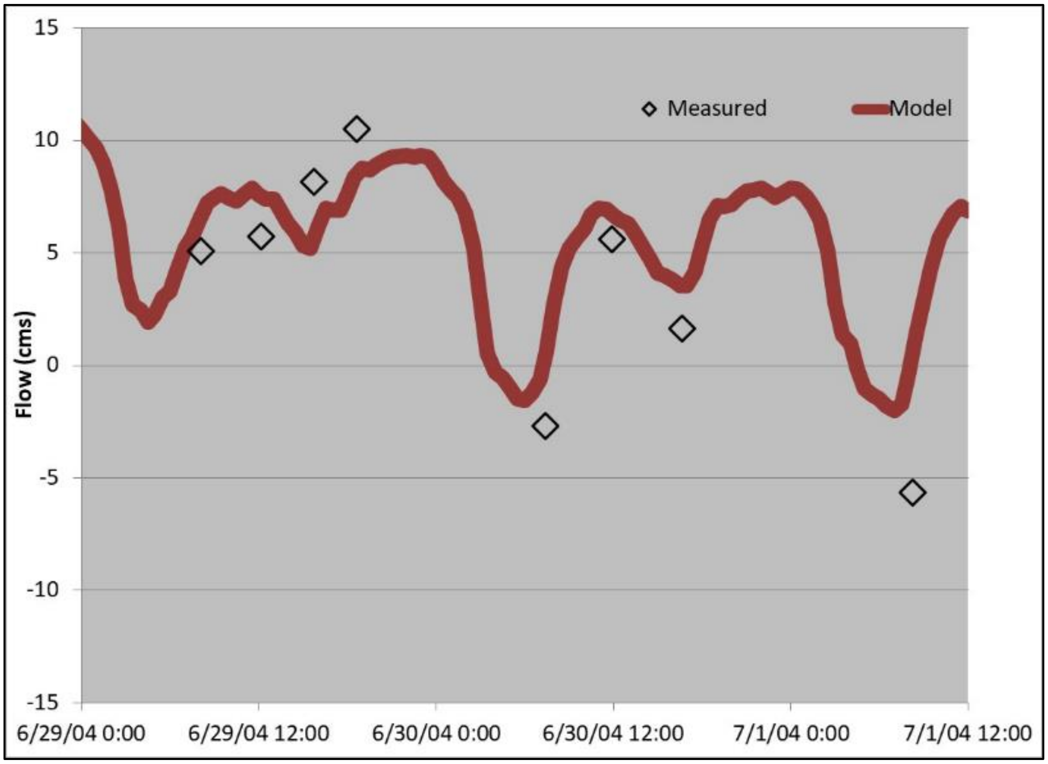

Figure E-13 Flow validation at station AB5

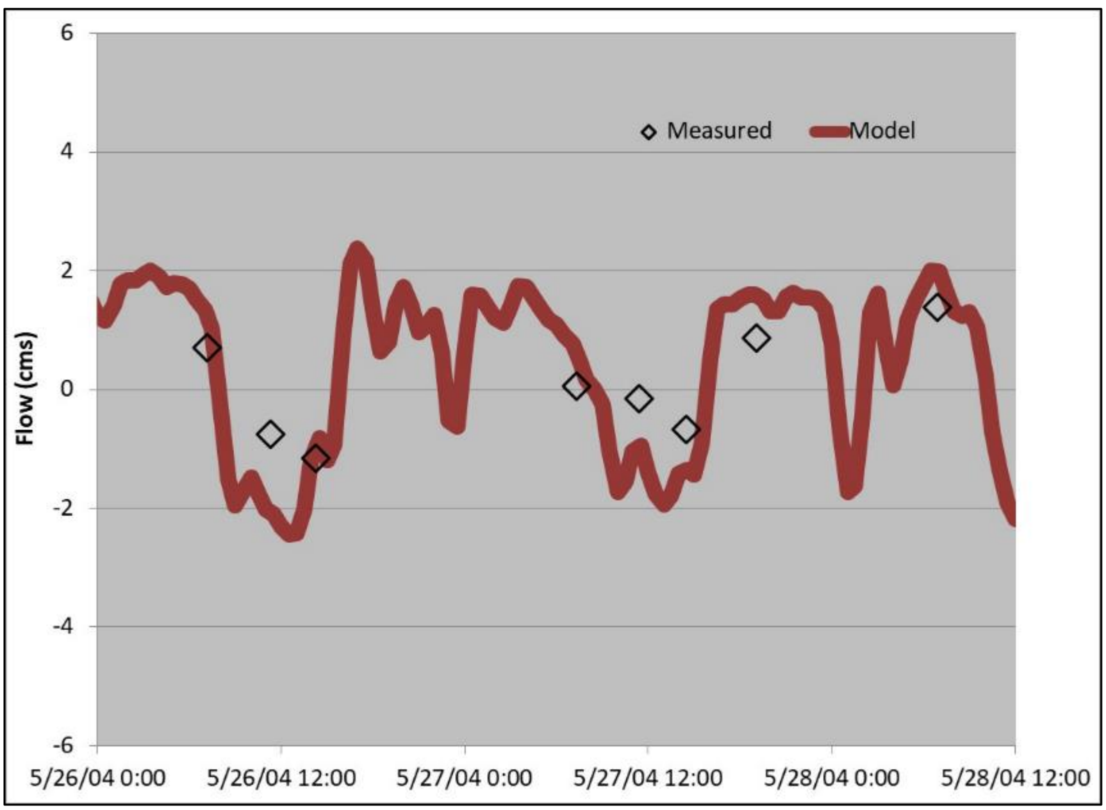

Figure E-14 Flow calibration at station AB6

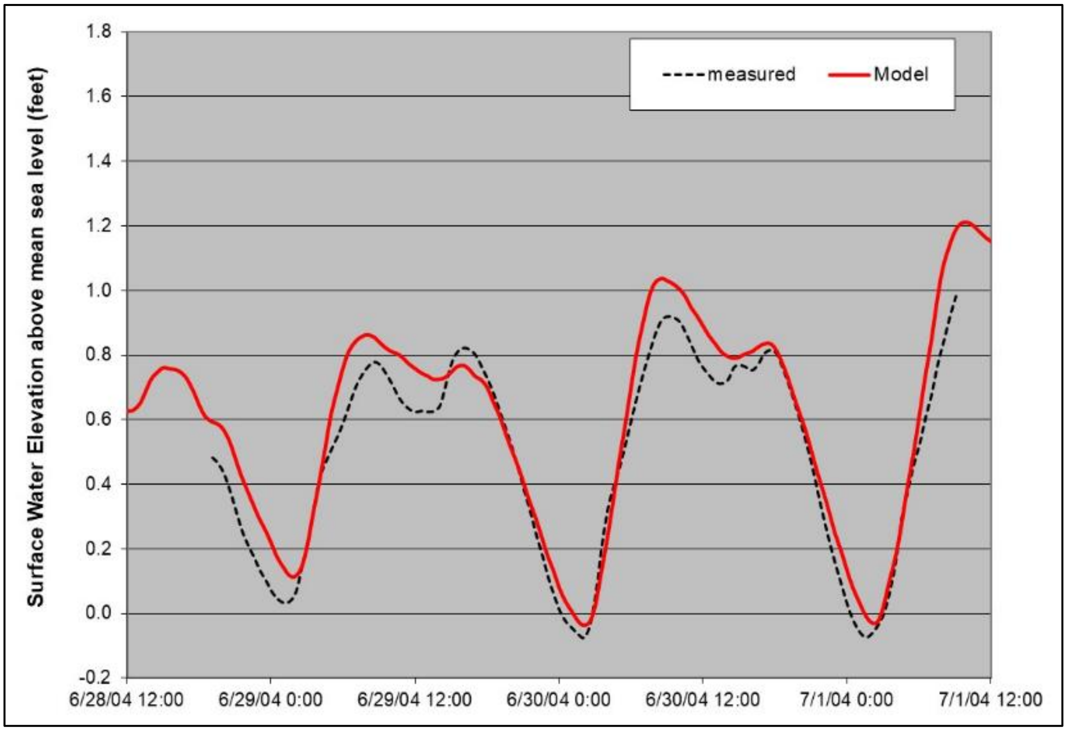

Figure E-15 Water level validation at station AB6

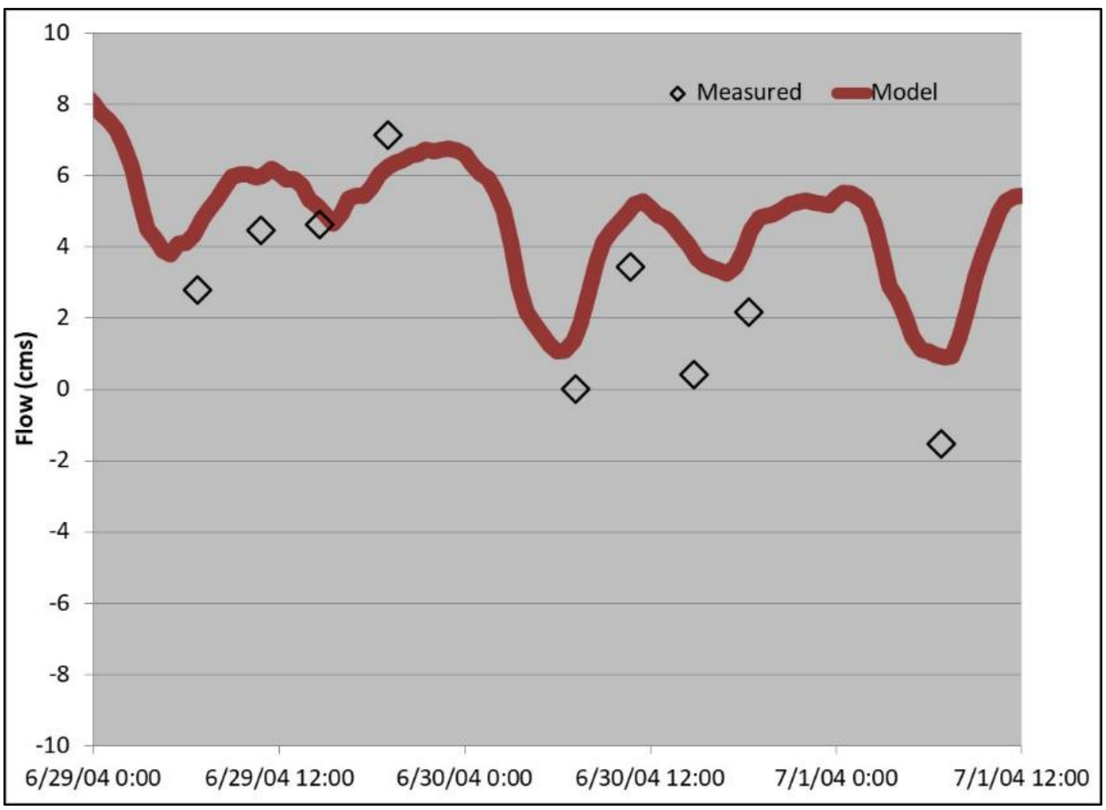

Figure E-16 Flow validation at station AB6

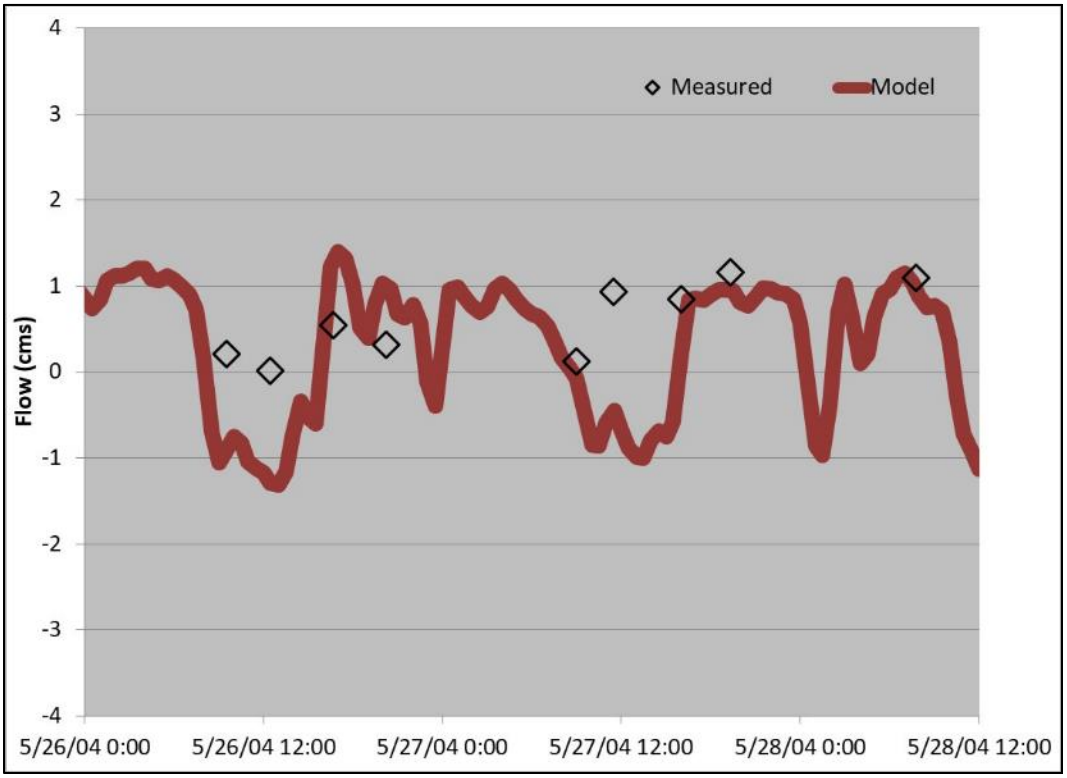

Figure E-17 Flow calibration at station AB7

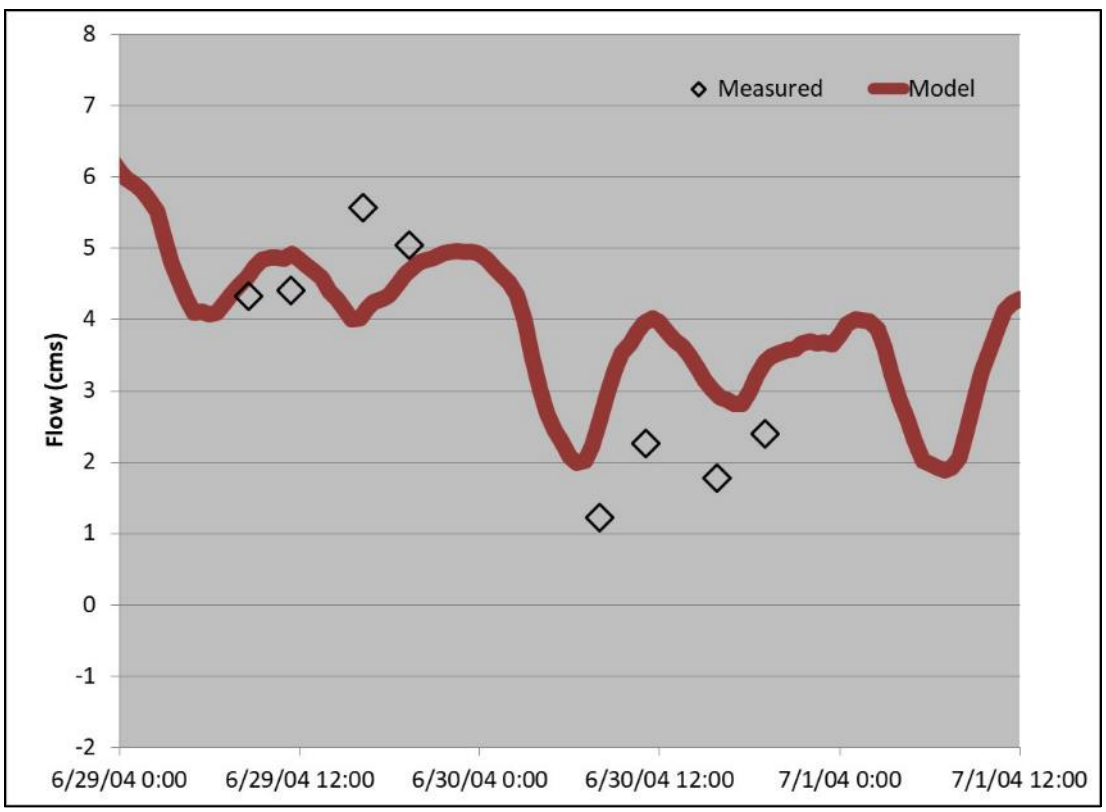

Figure E-18 Flow validation at station AB7

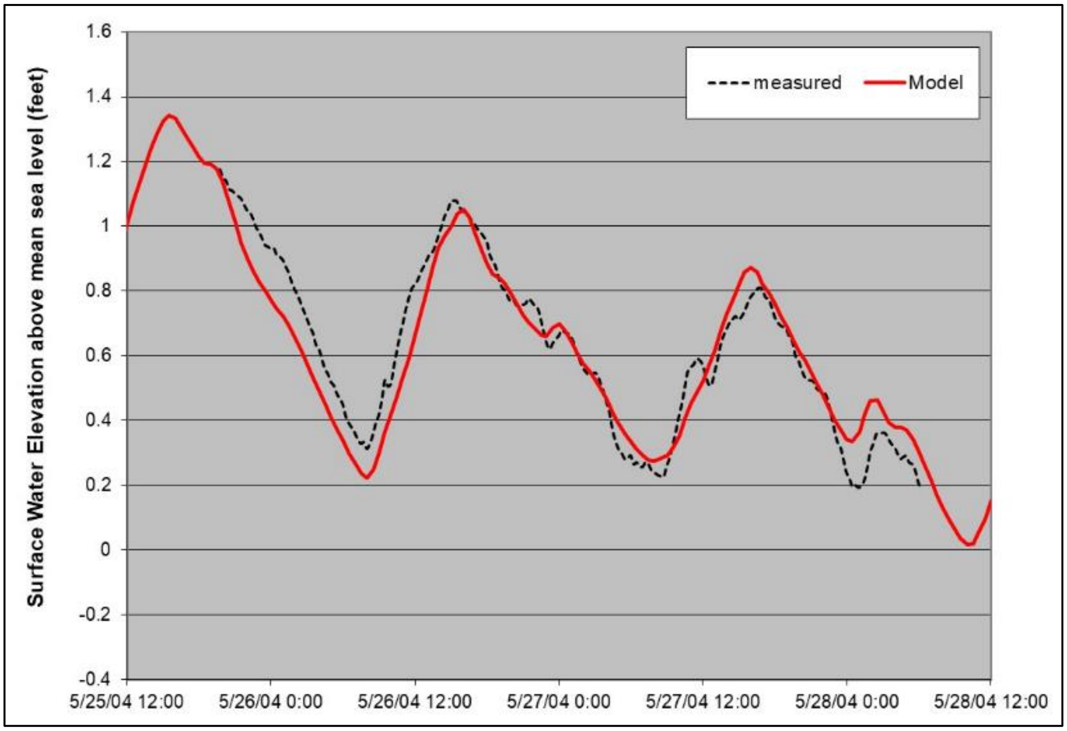

Figure E-19 Water level calibration at station AB8

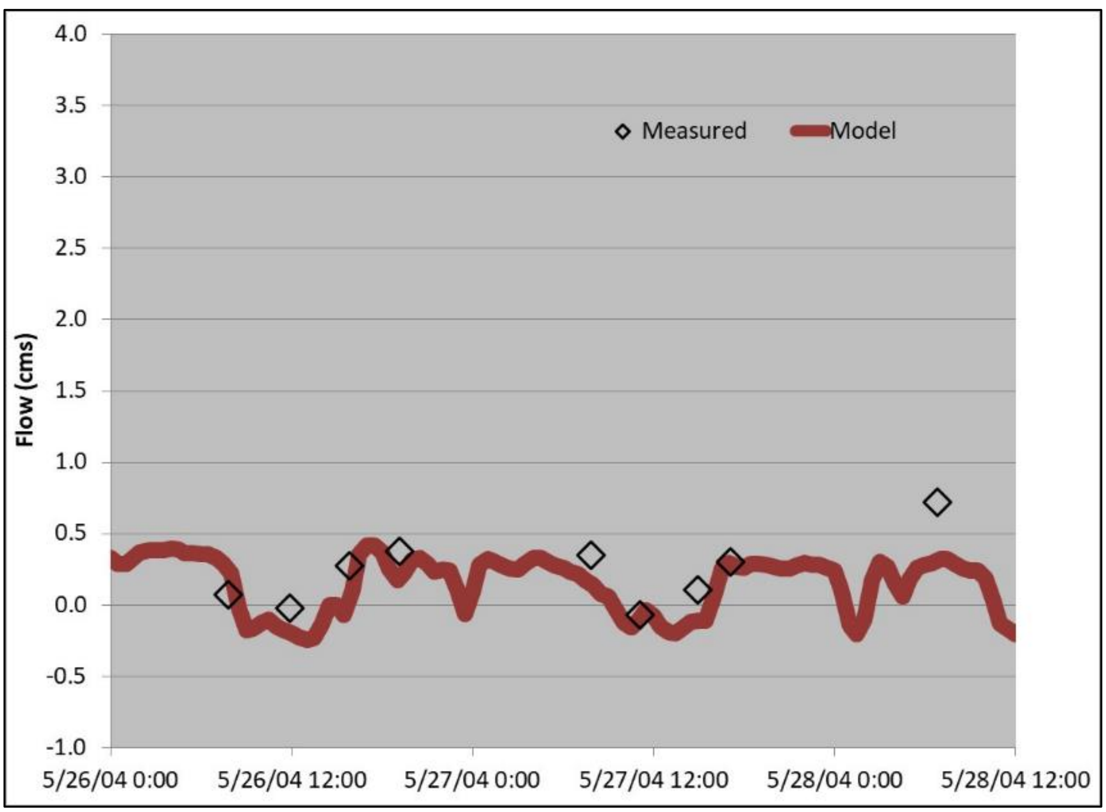

Figure E-20 Flow calibration at station AB8

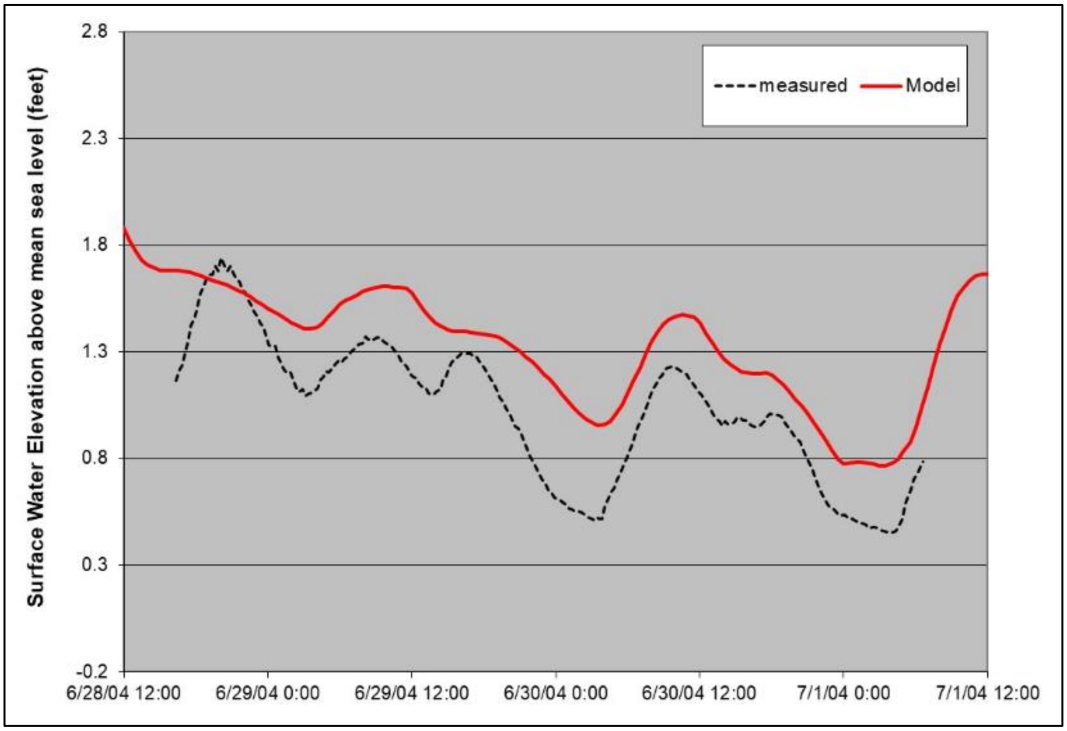

Figure E-21 Water level validation at station AB8

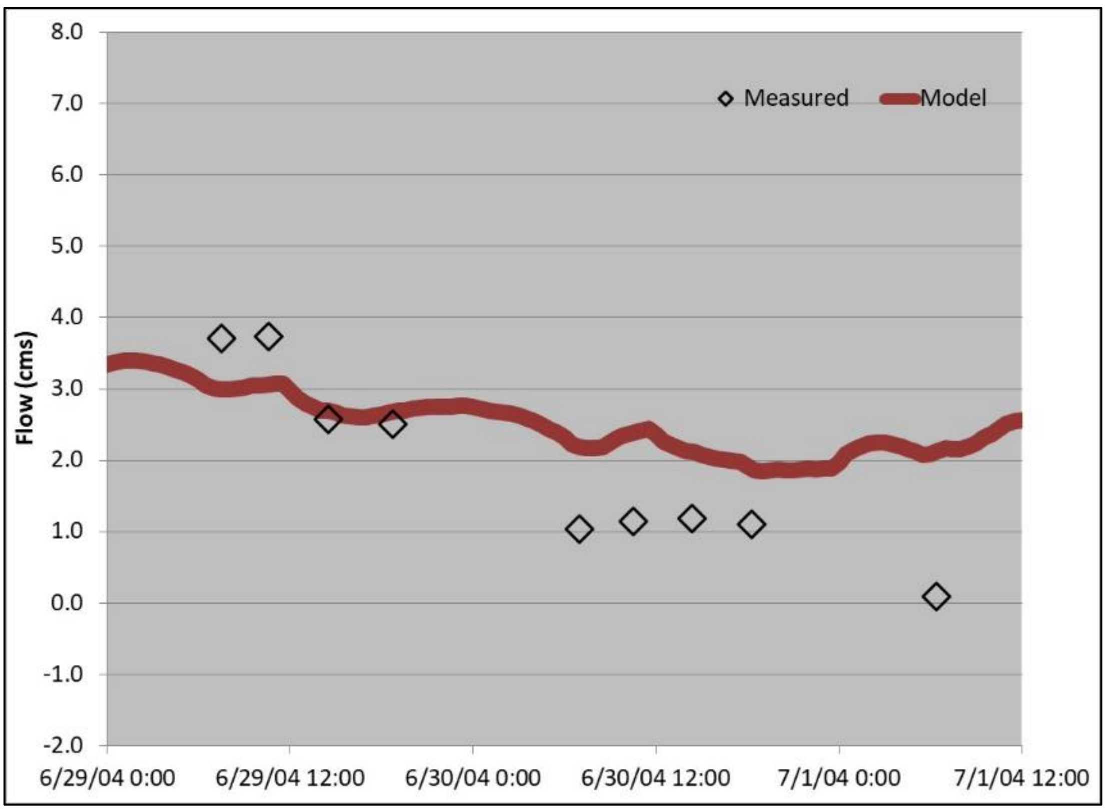

Figure E-22 Flow validation at station AB8

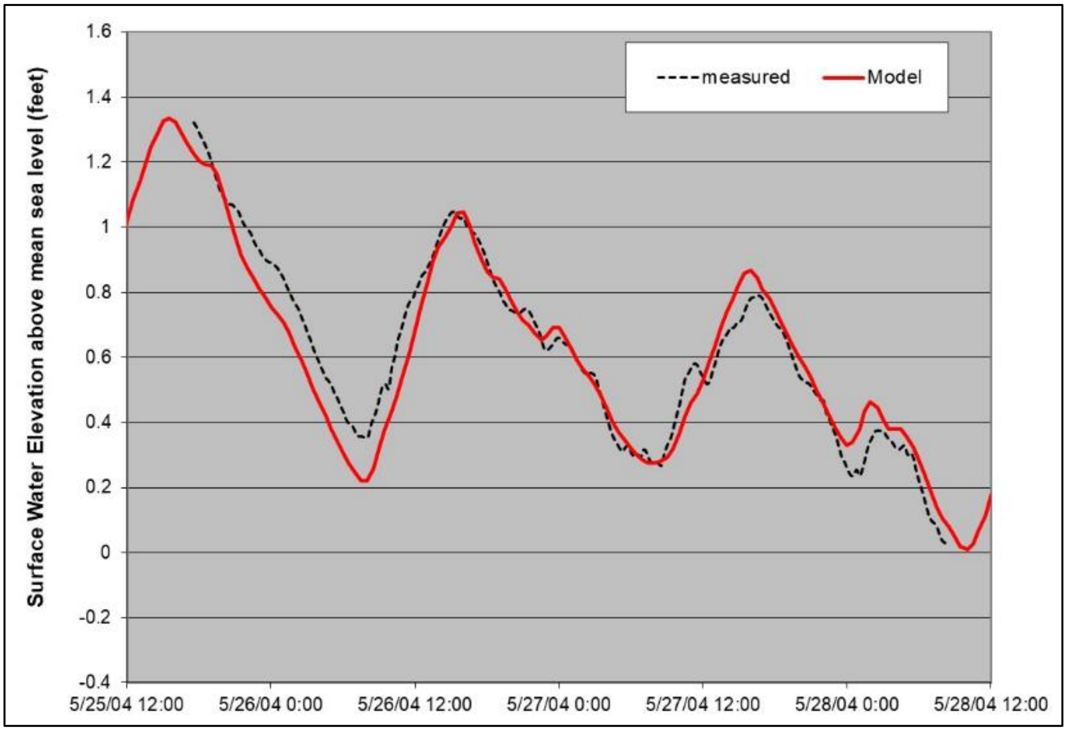

Figure E-23 Water level calibration at station GG (Gum Gully)

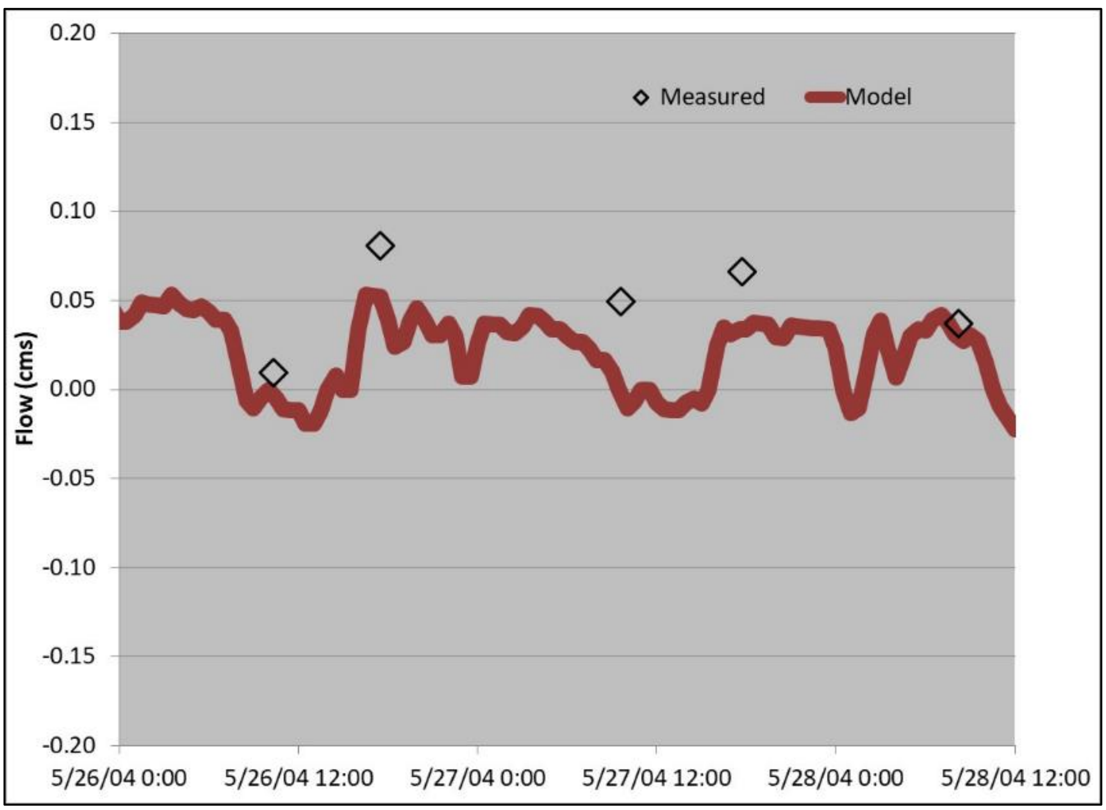

Figure E-24 Flow calibration at station GG (Gum Gully)

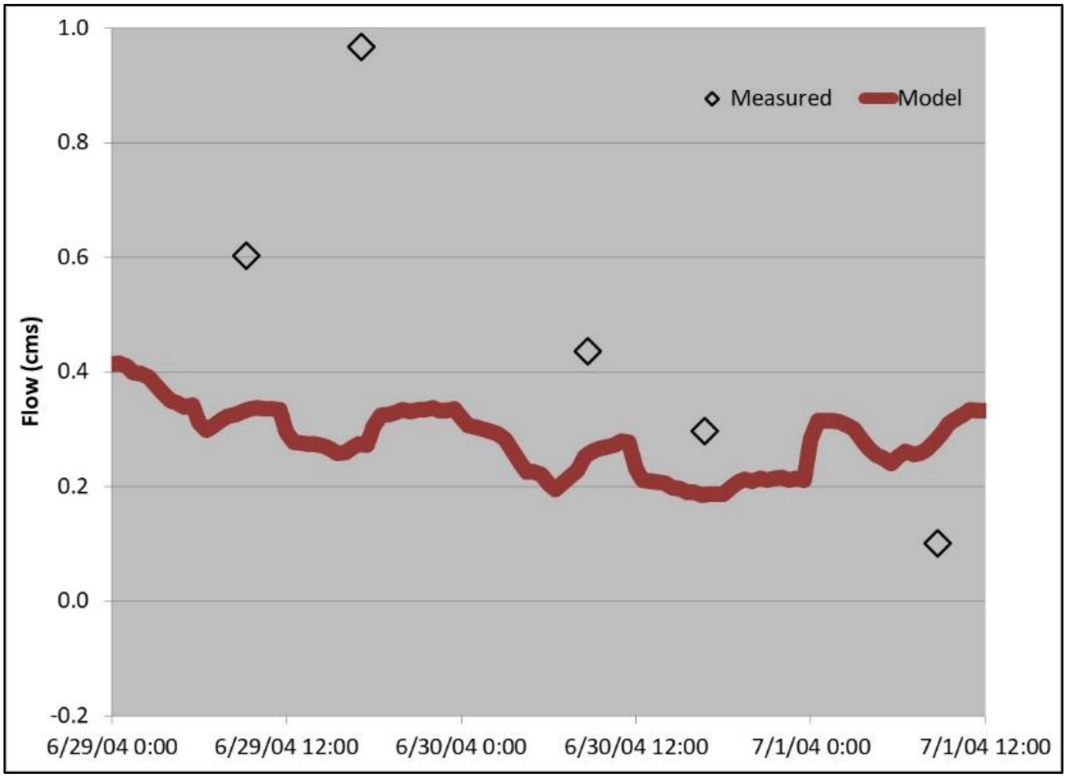

Figure E-25 Flow validation at station GG (Gum Gully)

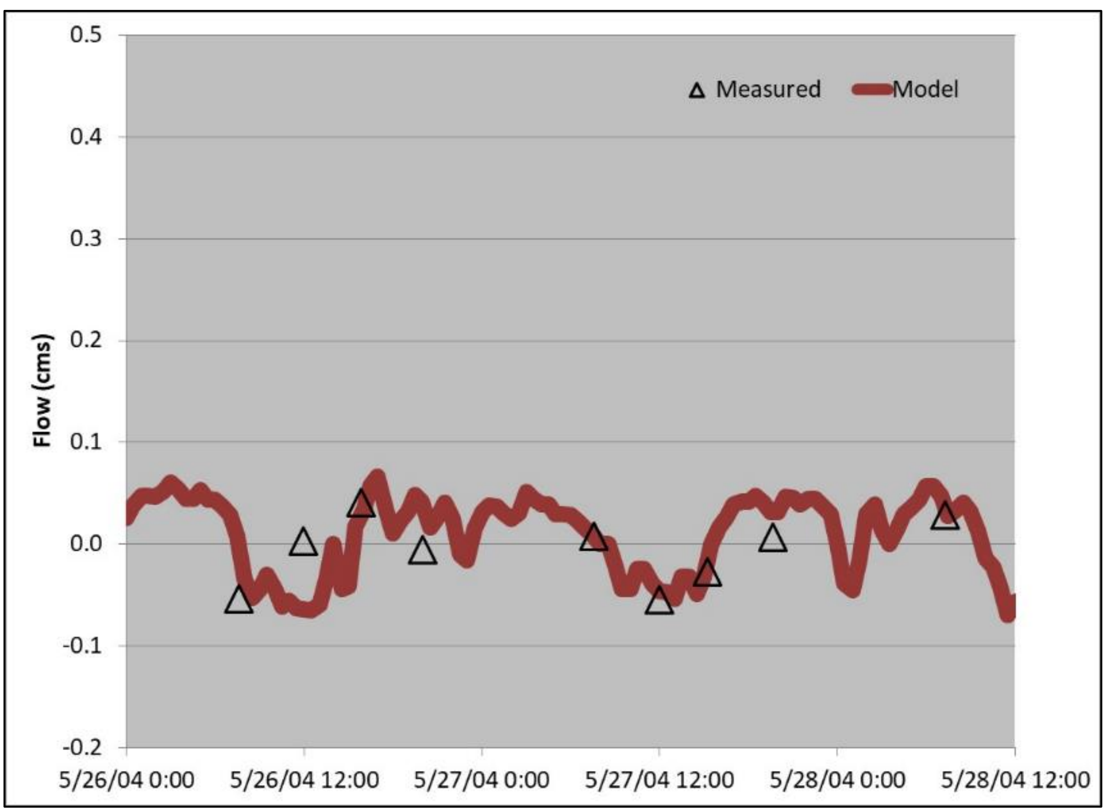

Figure E-26 Flow calibration at station HG (Hudson Gully)

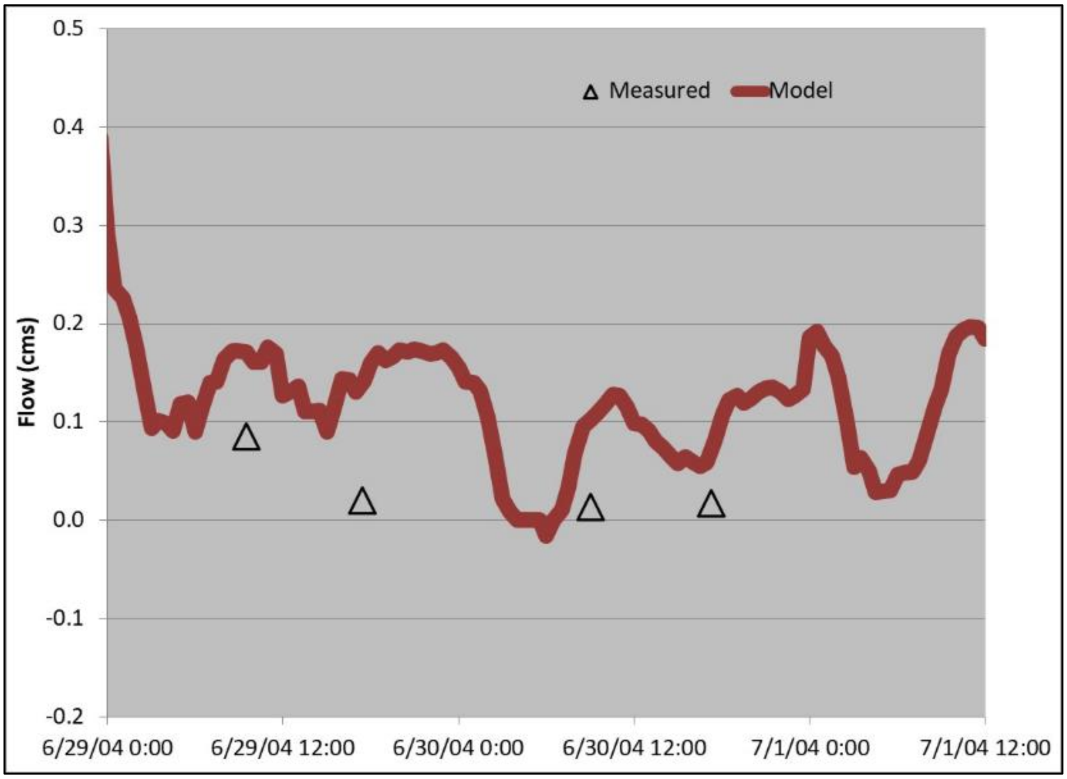

Figure E-27 Flow validation at station HG (Hudson Gully)

Appendix F Goodness-of-fit for the Cow Bayou RMA2 Hydrodynamic Model

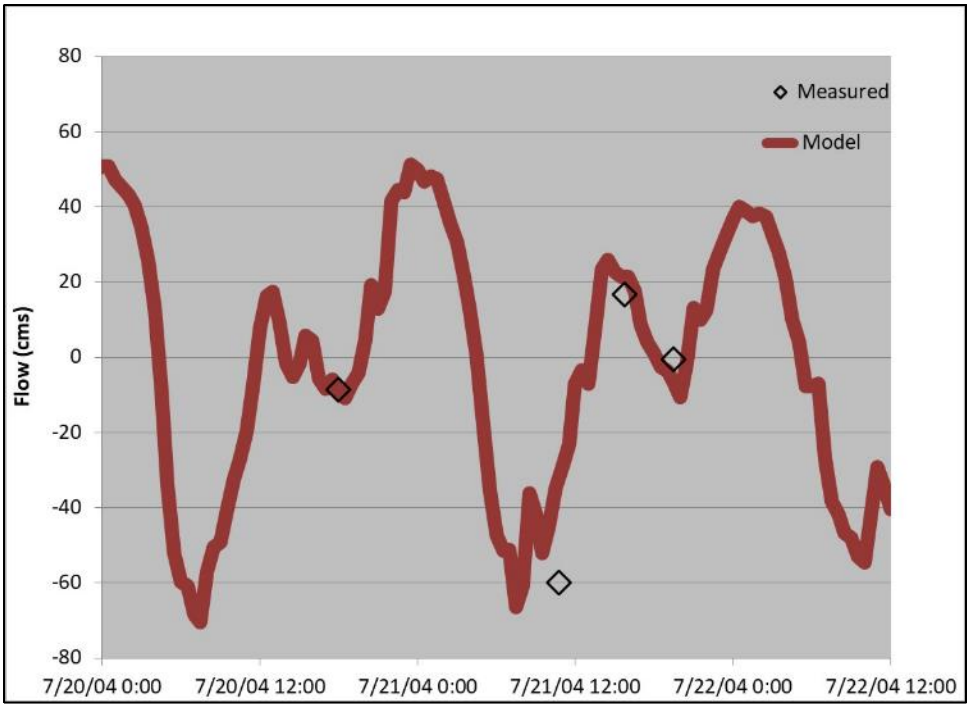

Figure F-1 Flow calibration at Station CB0.5

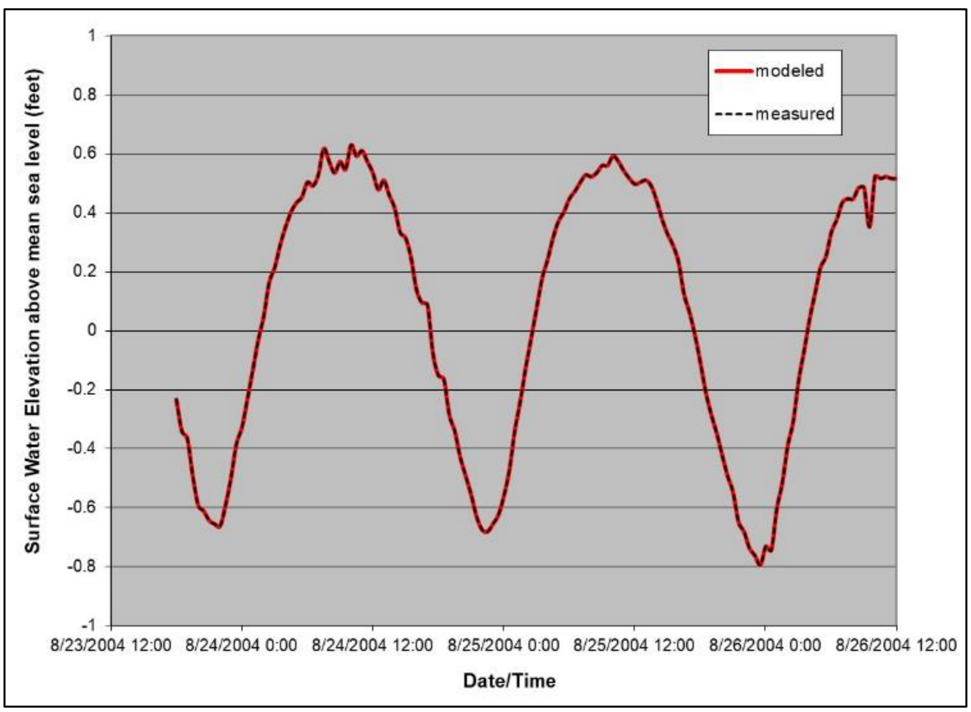

Figure F-2 Water level validation at Station CB0.5

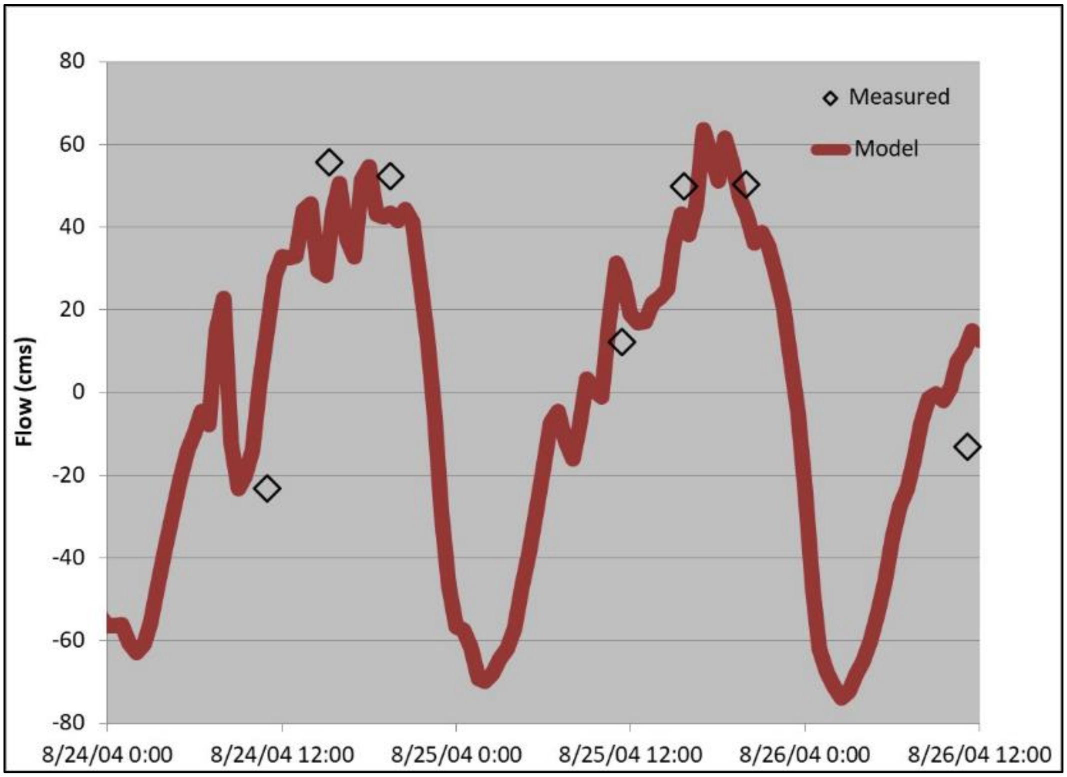

Figure F-3 Flow validation at Station CB0.5

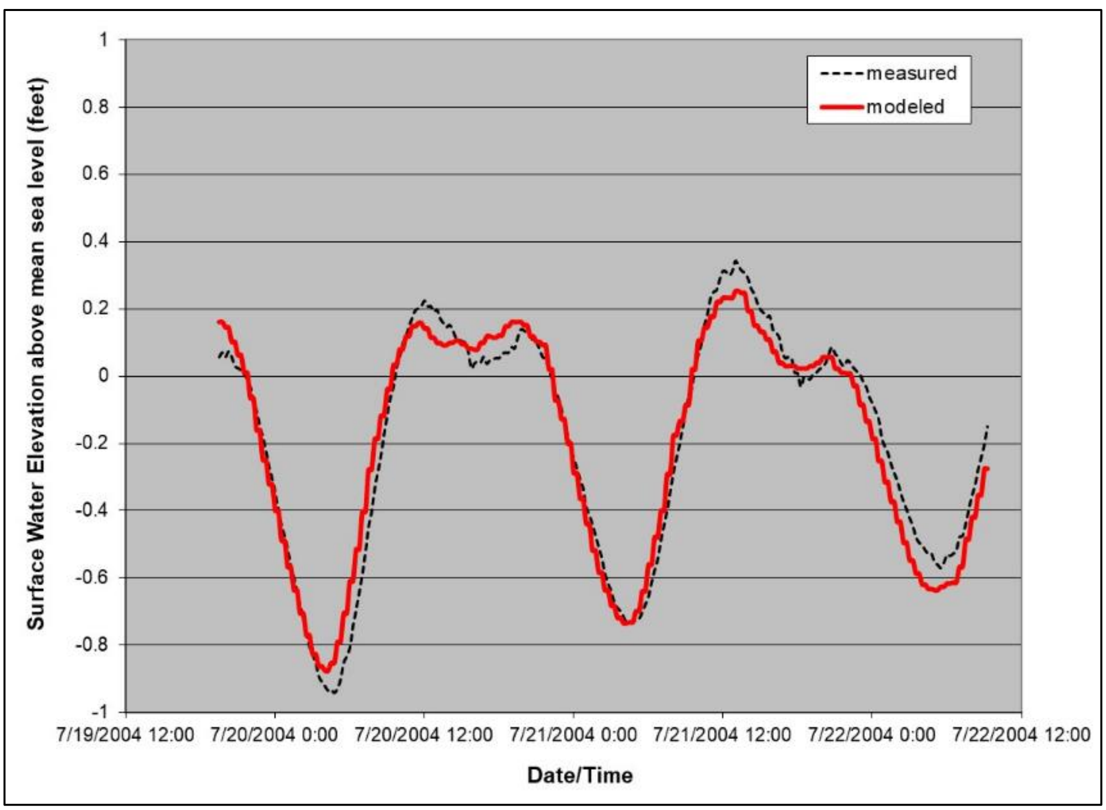

Figure F-4 Water level calibration at Station CB1

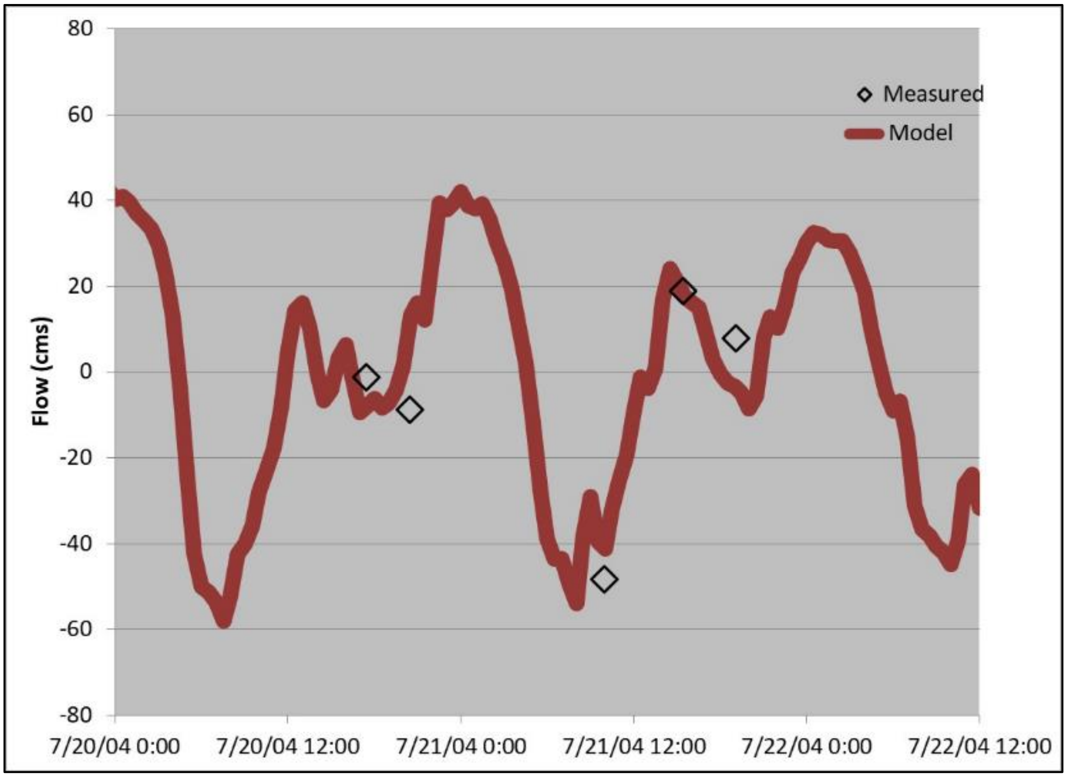

Figure F-5 Flow calibration at station CB1

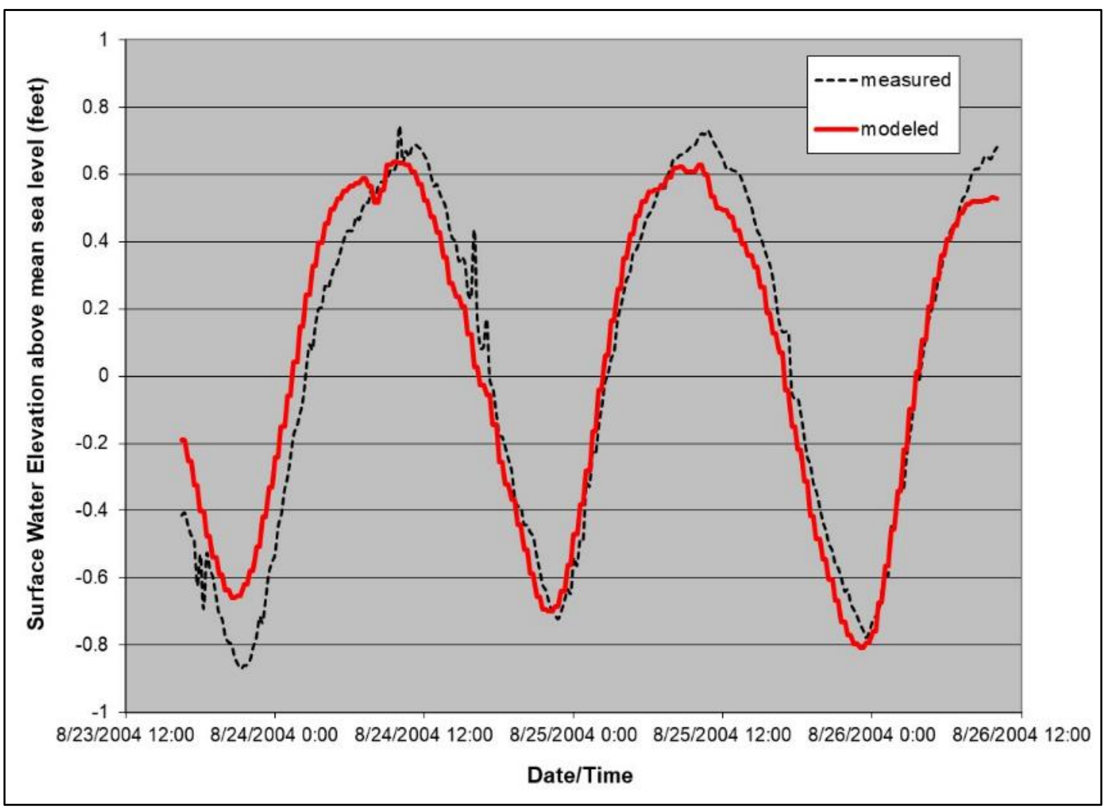

Figure F-6 Water level Validation at station CB1

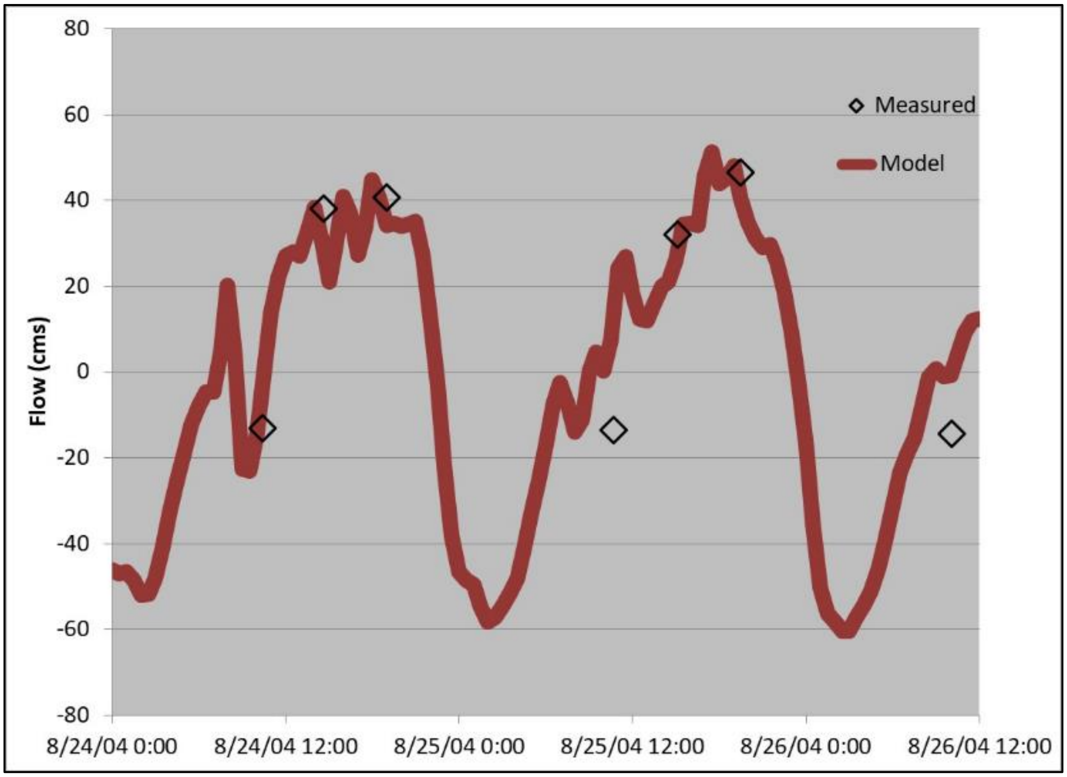

Figure F-7 Flow validation at station CB1

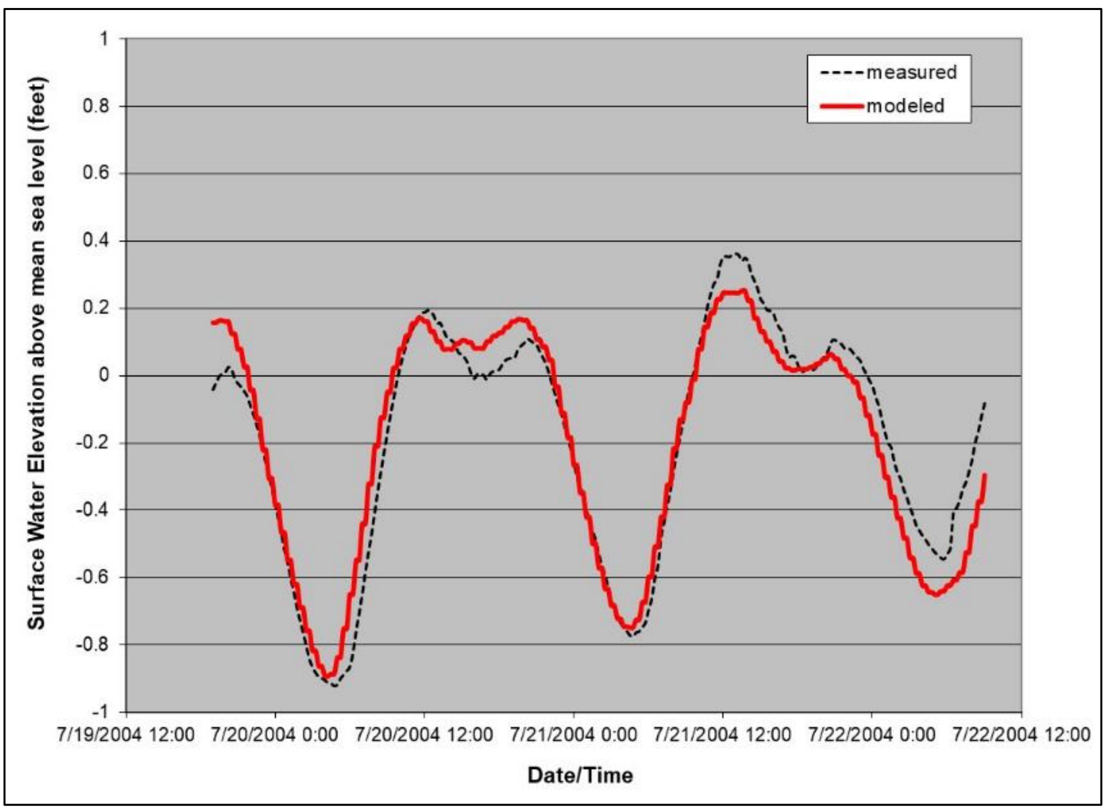

Figure F-8 Water level calibration at station CB2

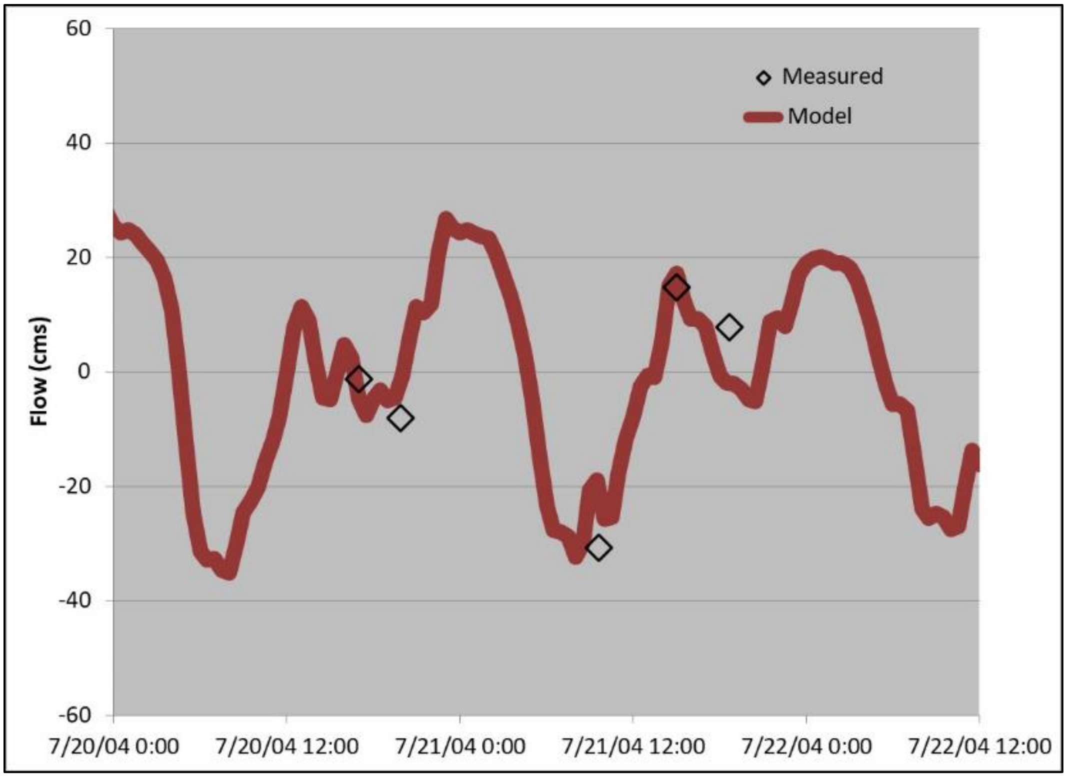

Figure F-9 Flow calibration at station CB2

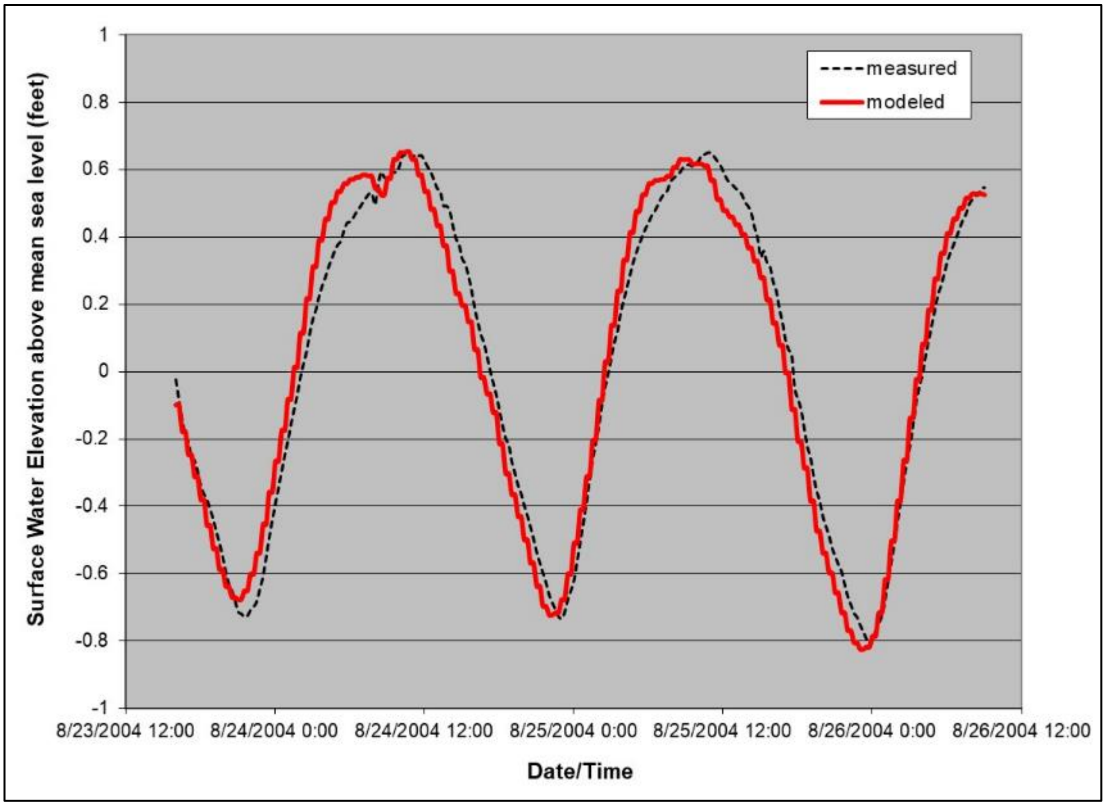

Figure F-10 Water level validation at station CB2

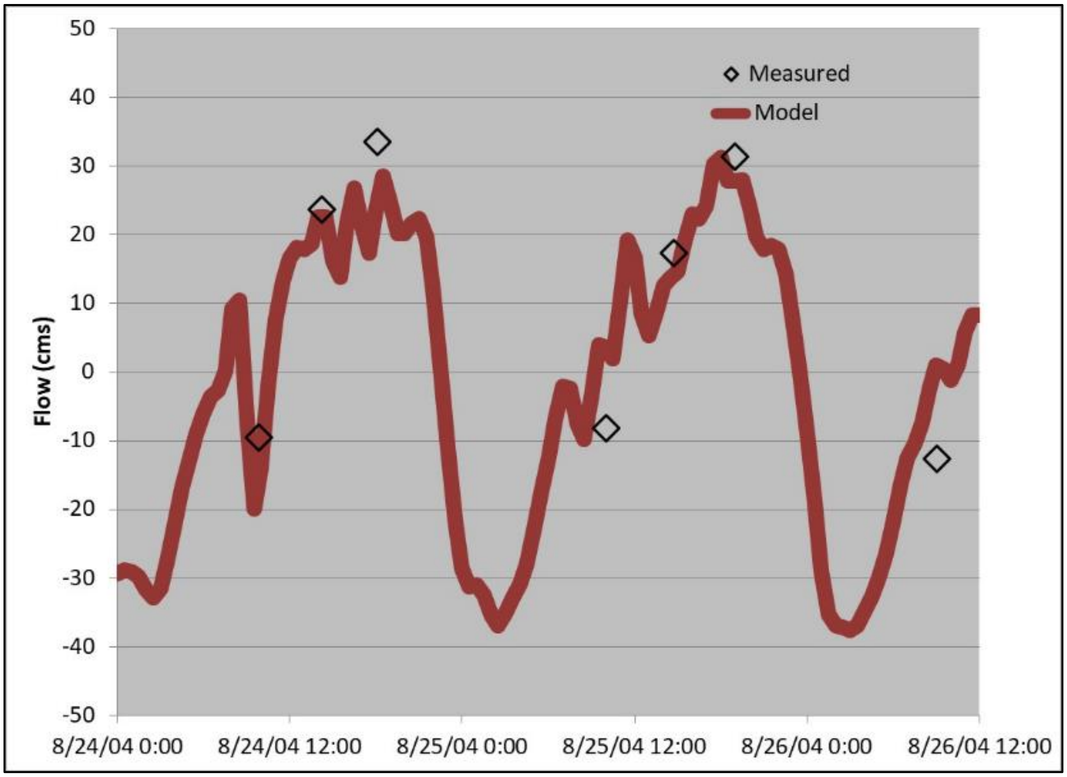

Figure F-11 Flow validation at station CB2

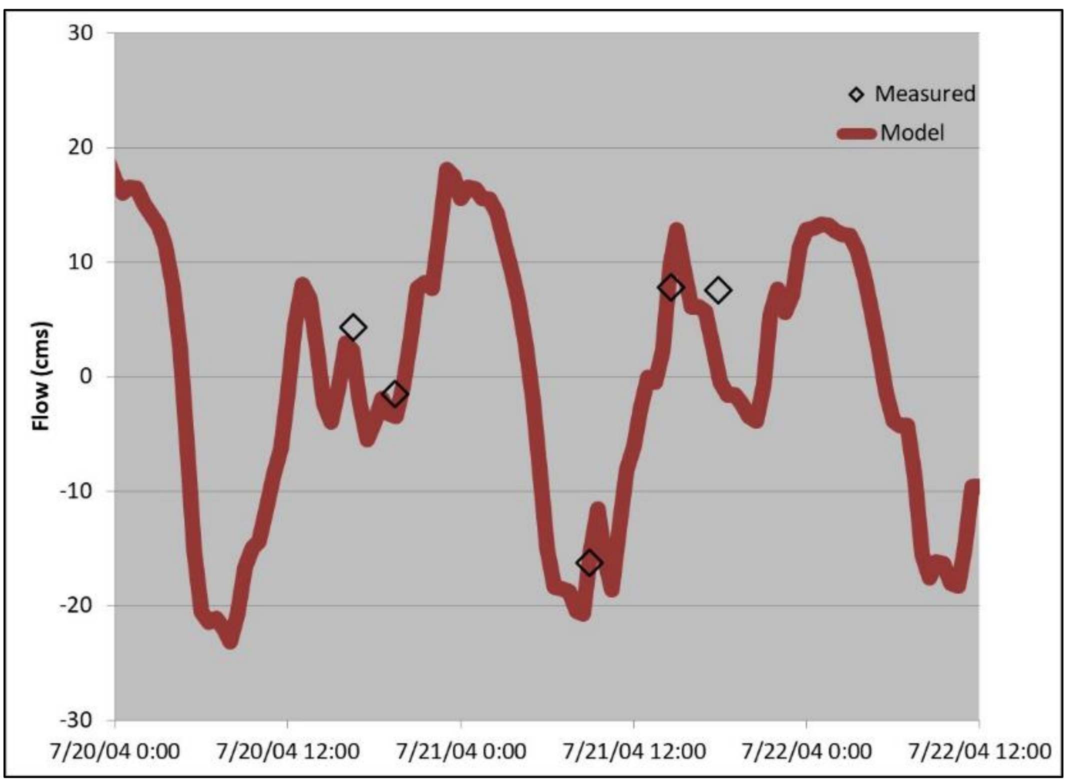

Figure F-12 Flow calibration at station CB2.5

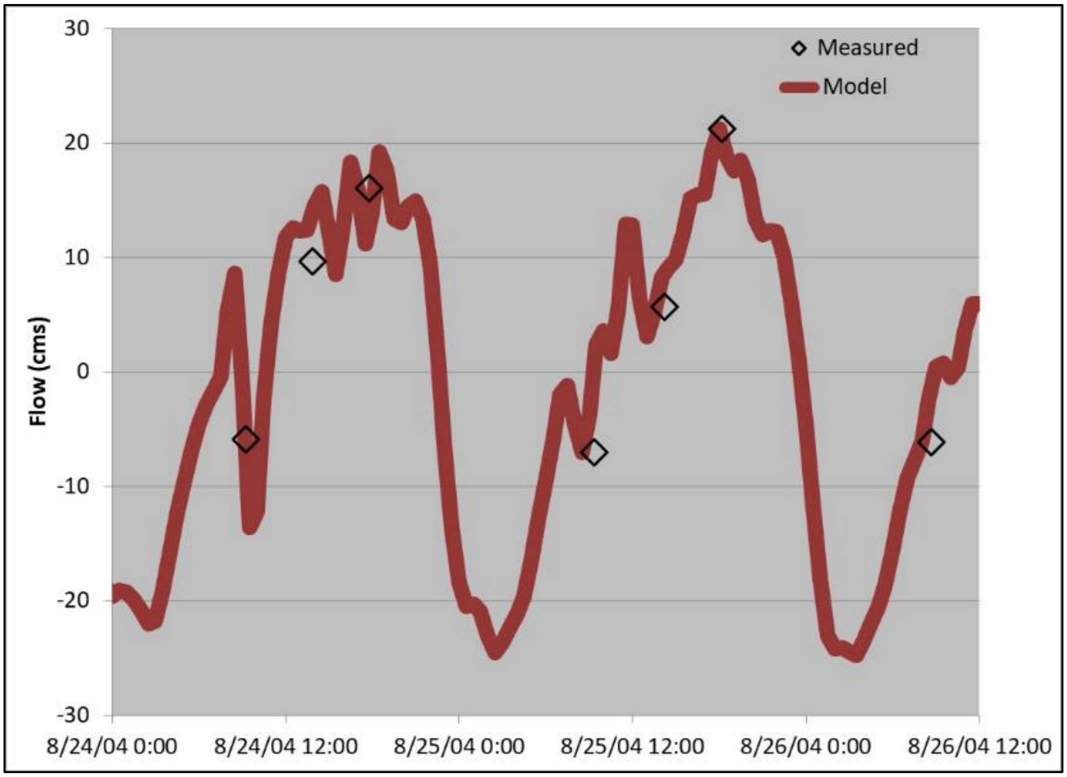

Figure F-13 Flow validation at station CB2.5

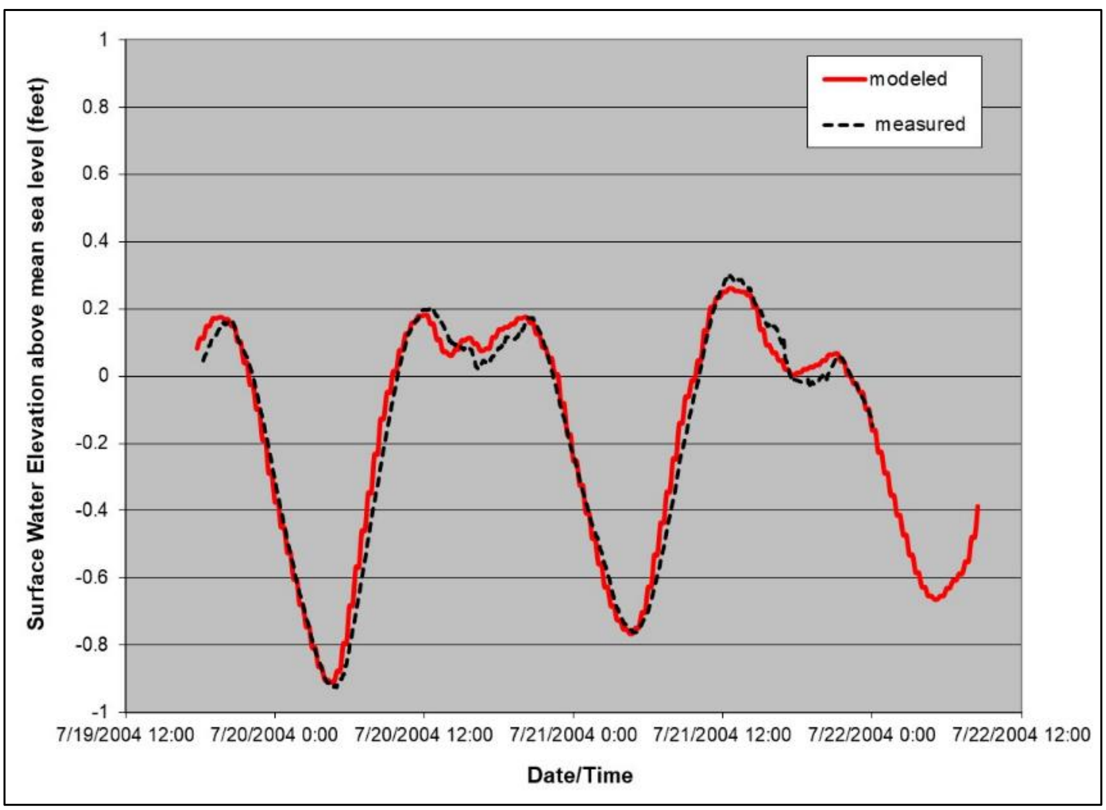

Figure F-14 Water level calibration at station CB3

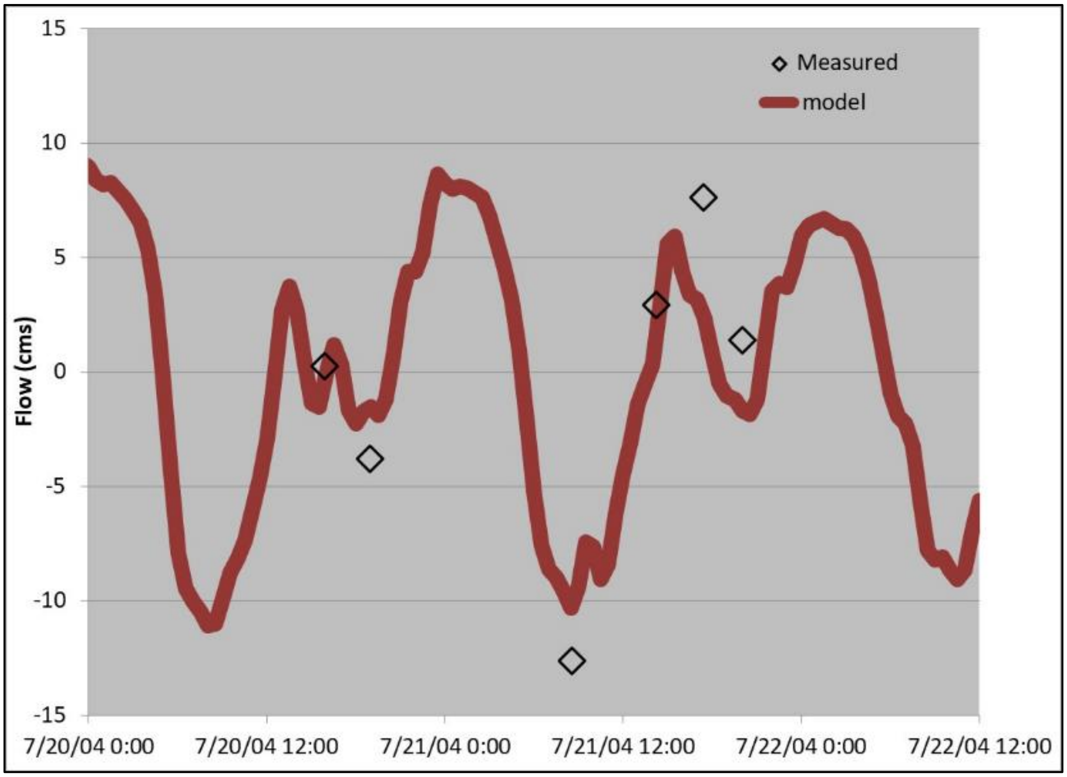

Figure F-15 Flow calibration at station CB3

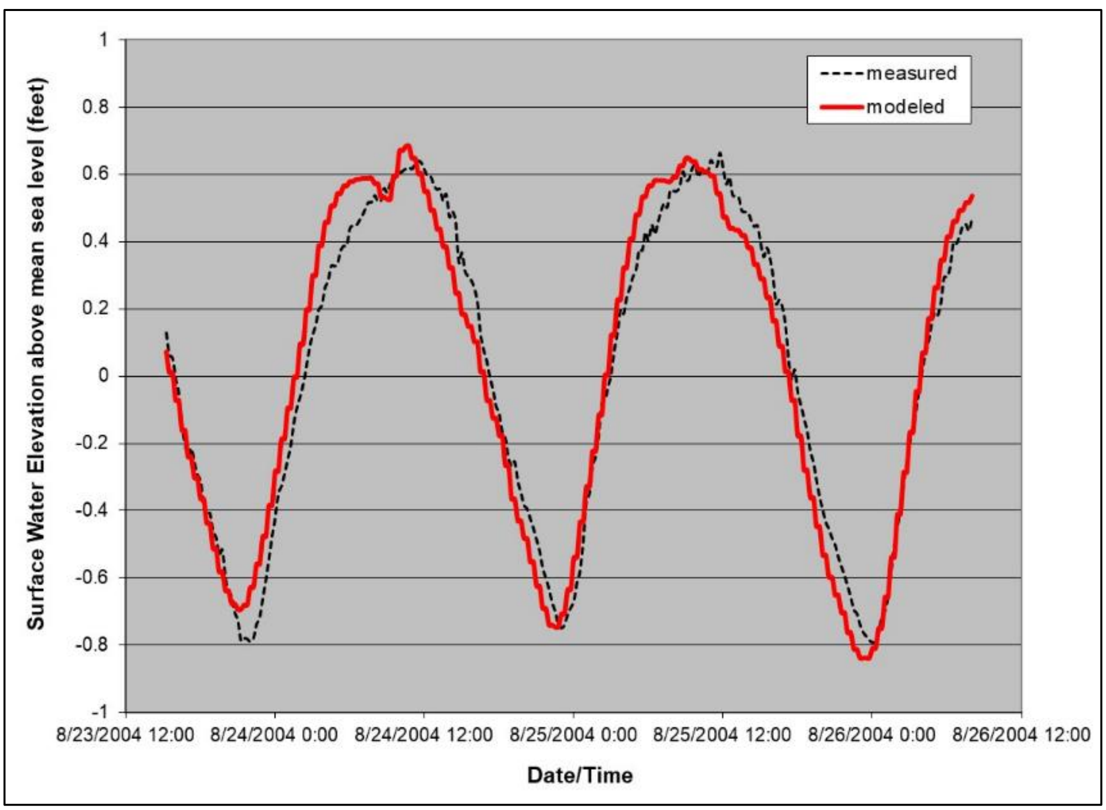

Figure F-16 Water level validation at station CB3

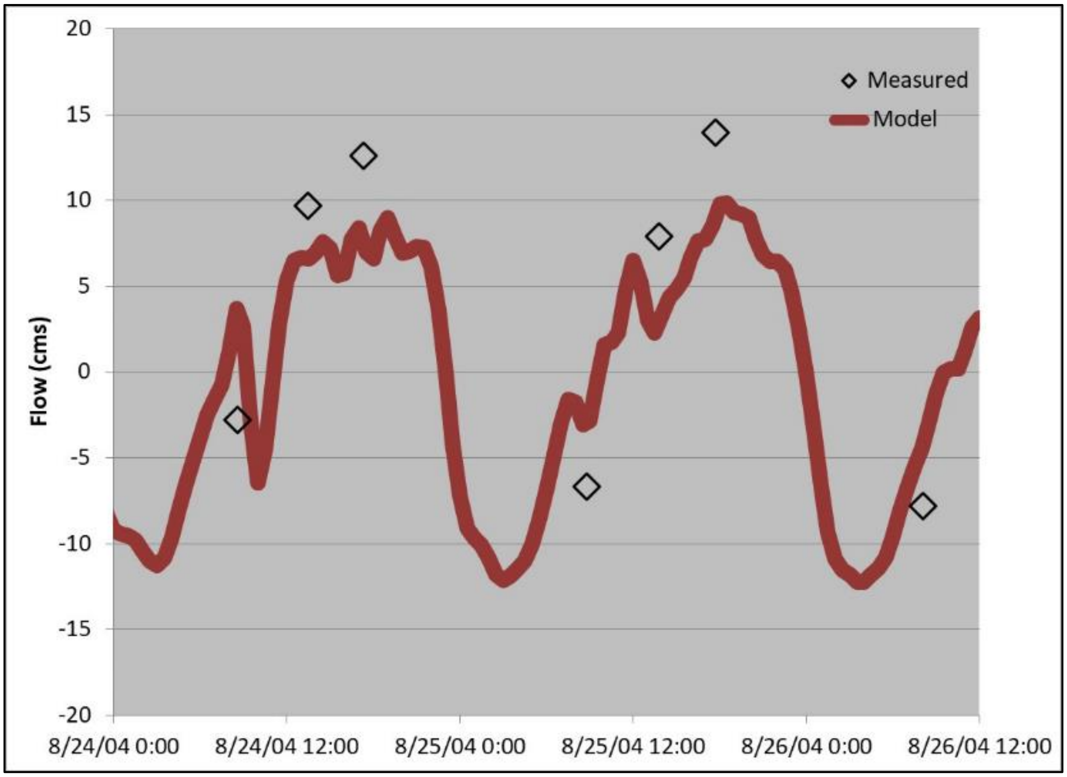

Figure F-17 Flow validation at station CB3

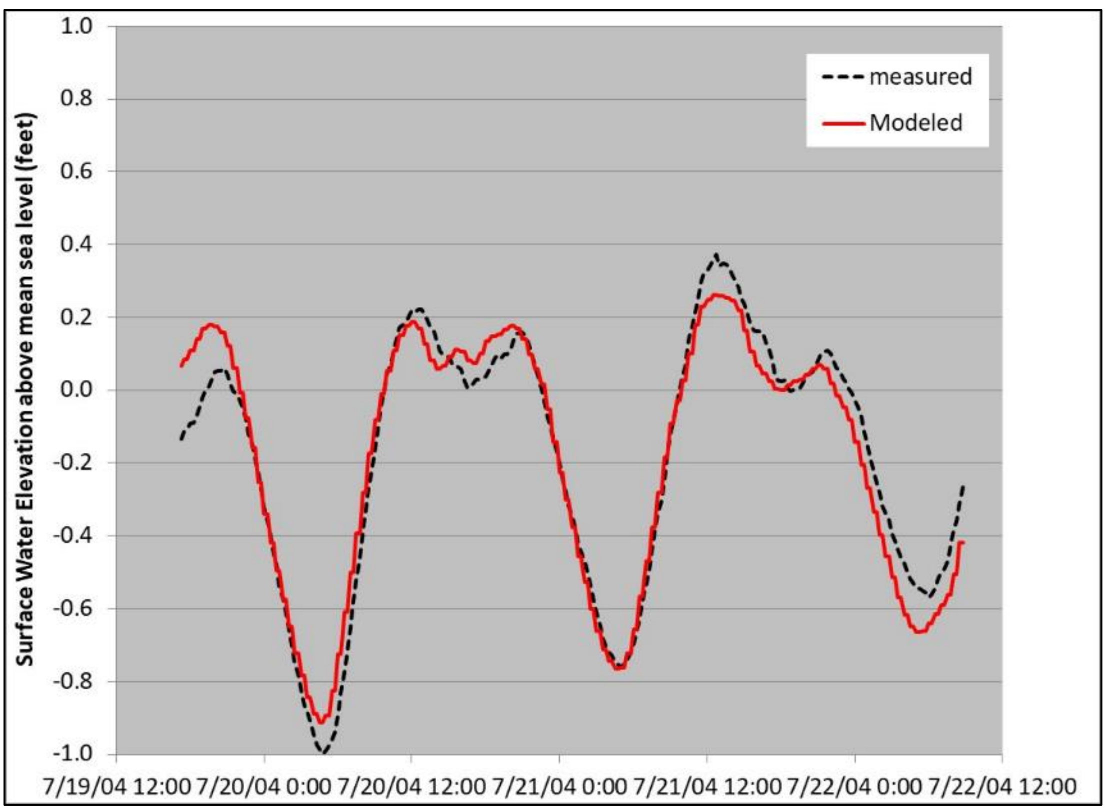

Figure F-18 Water level calibration at station CB3.5

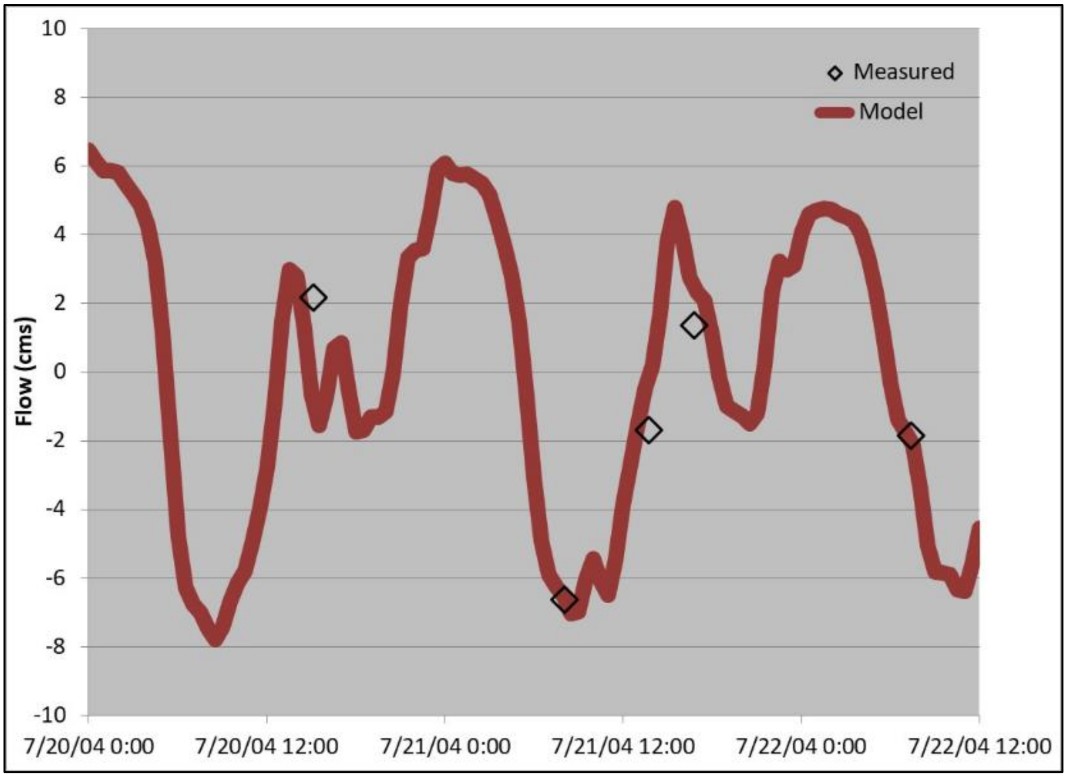

Figure F-19 Flow calibration at station CB3.5

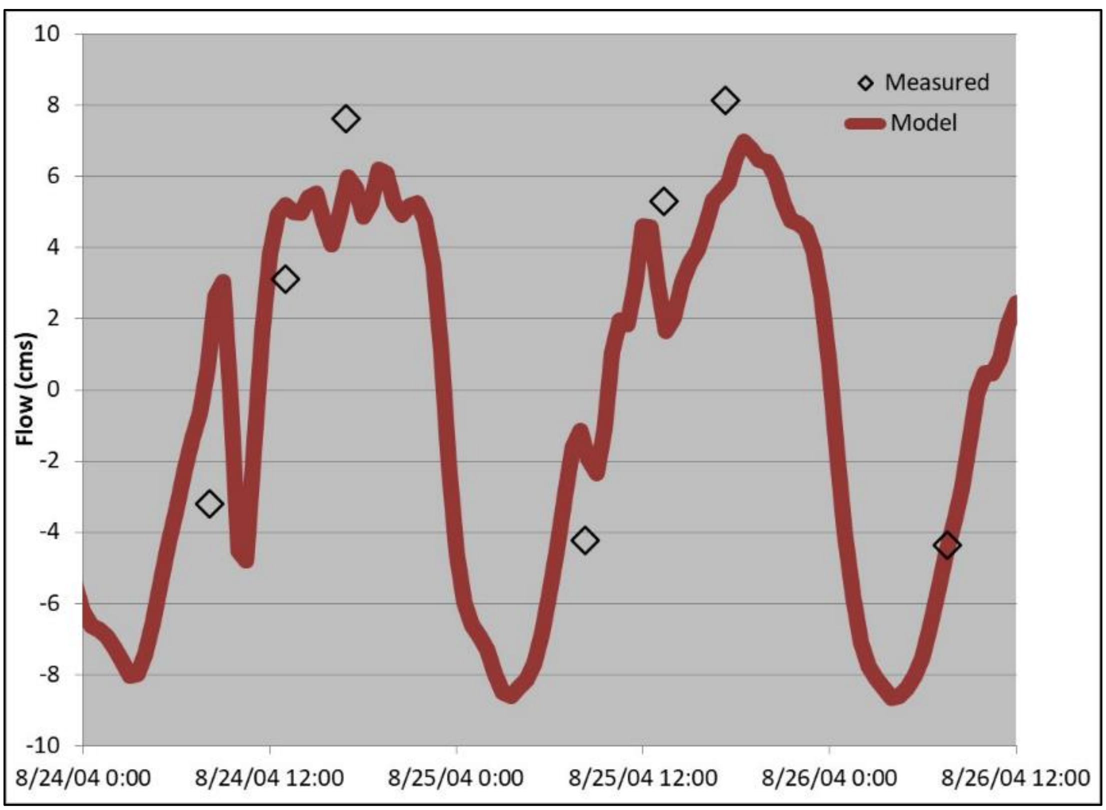

Figure F-20 Flow validation at station CB3.5

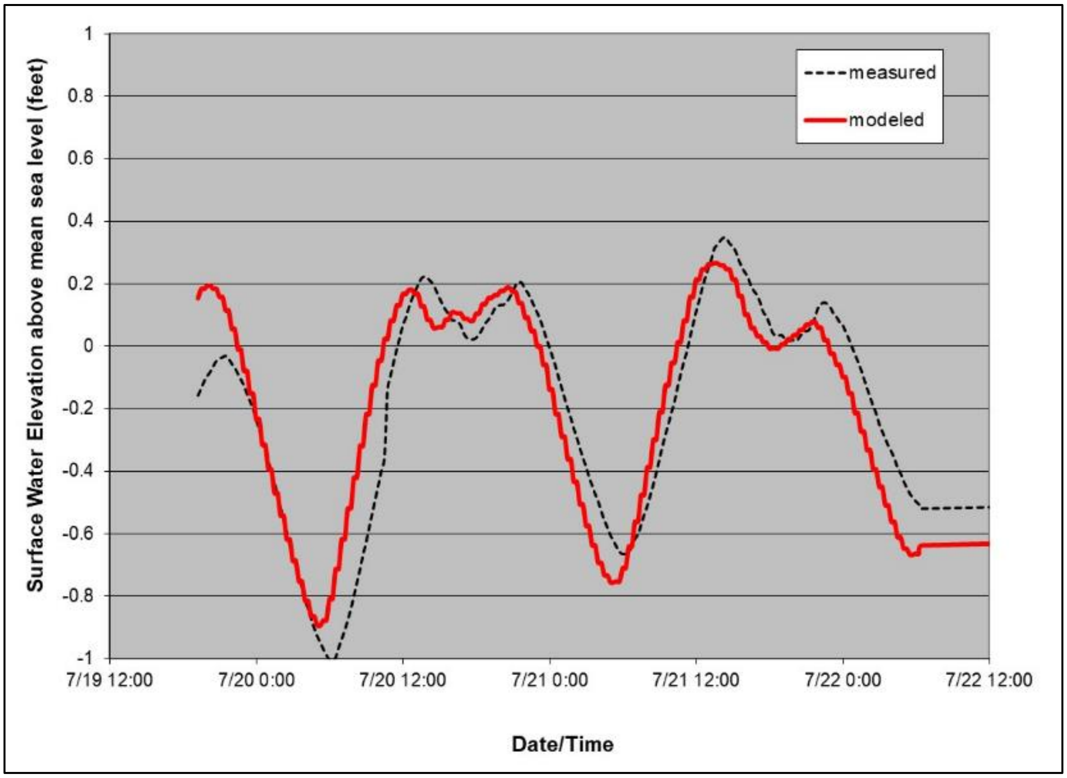

Figure F-21 Water level calibration at station CB4

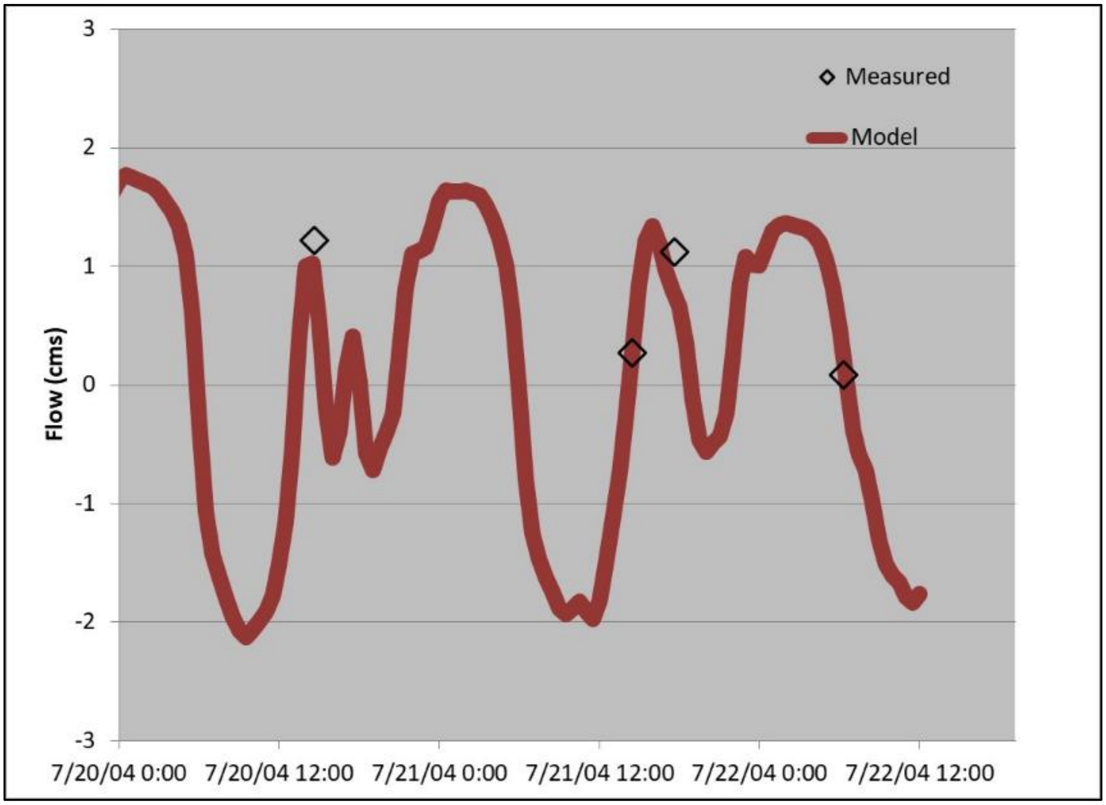

Figure F-22 Flow calibration at station CB4

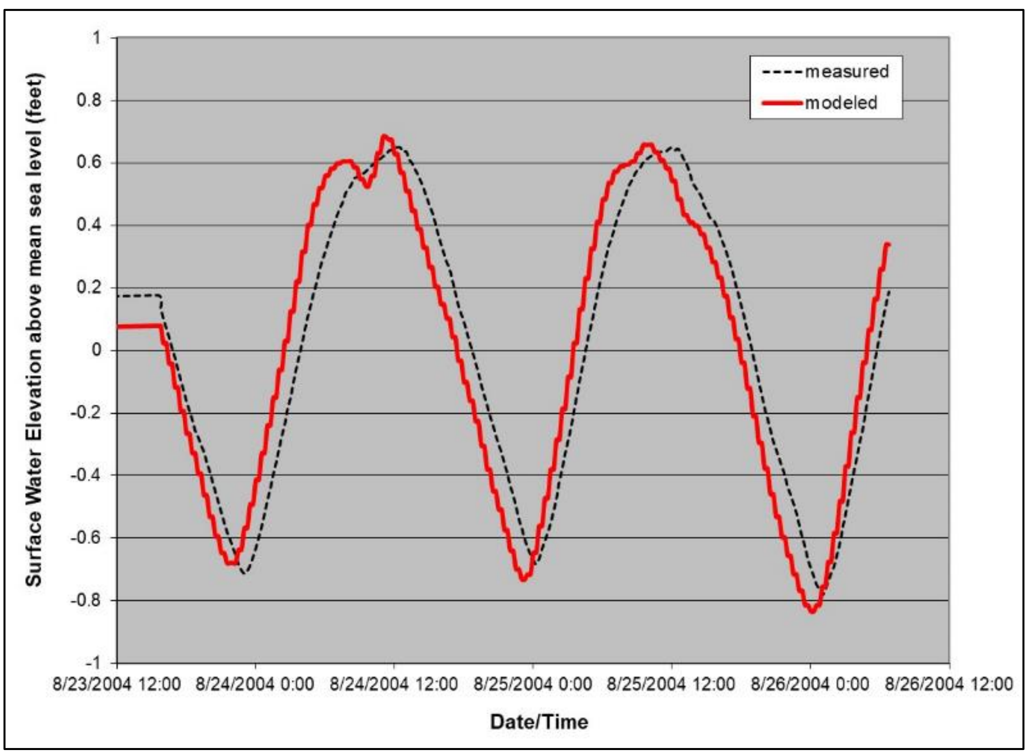

Figure F-23 Water level validation at station CB4

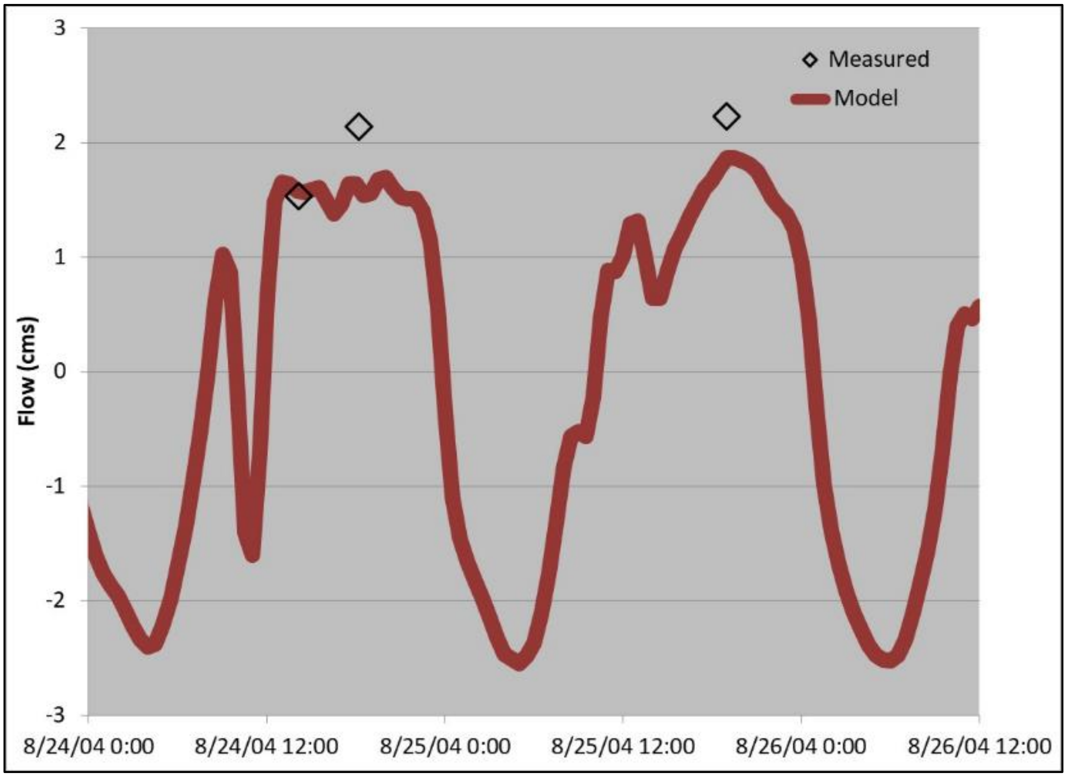

Figure F-24 Flow validation at station CB4

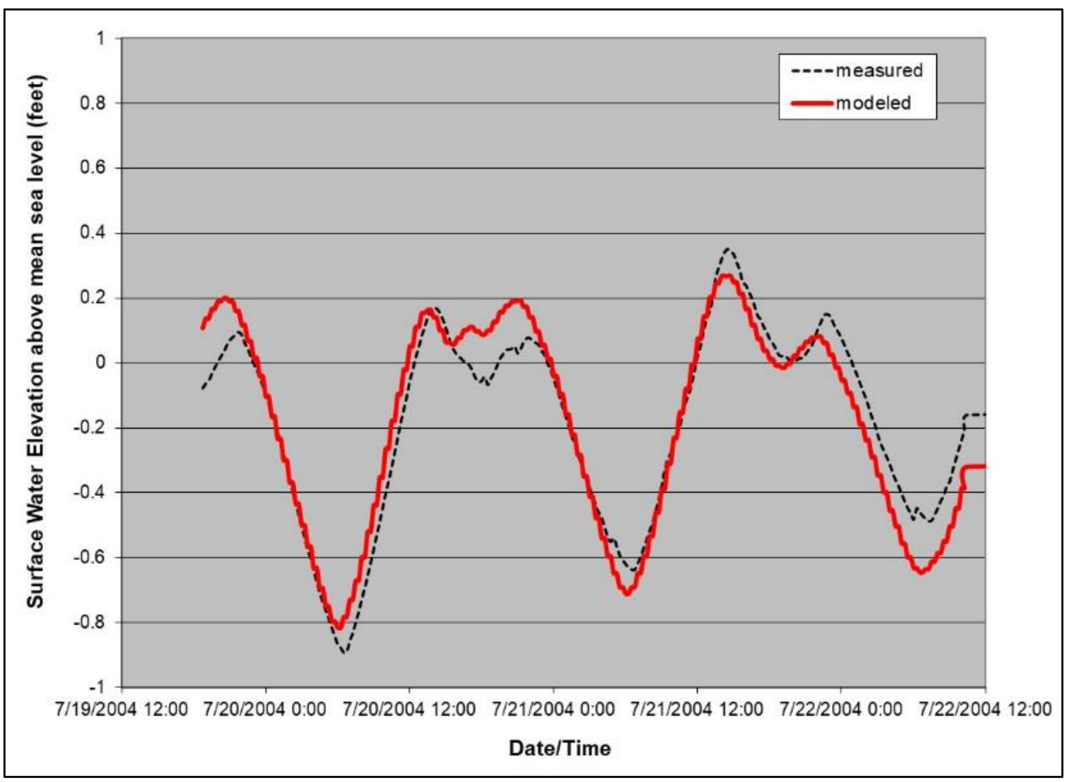

Figure F-25 Water level calibration at station CB5

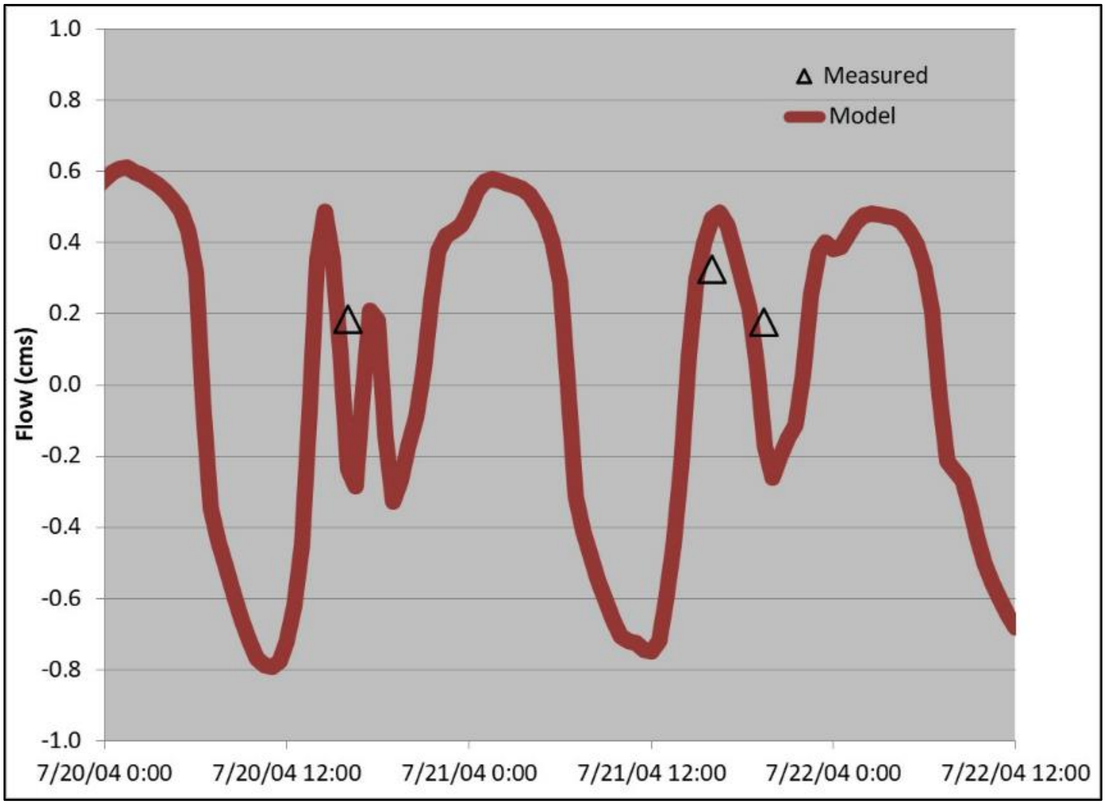

Figure F-26 Flow calibration at station CB5

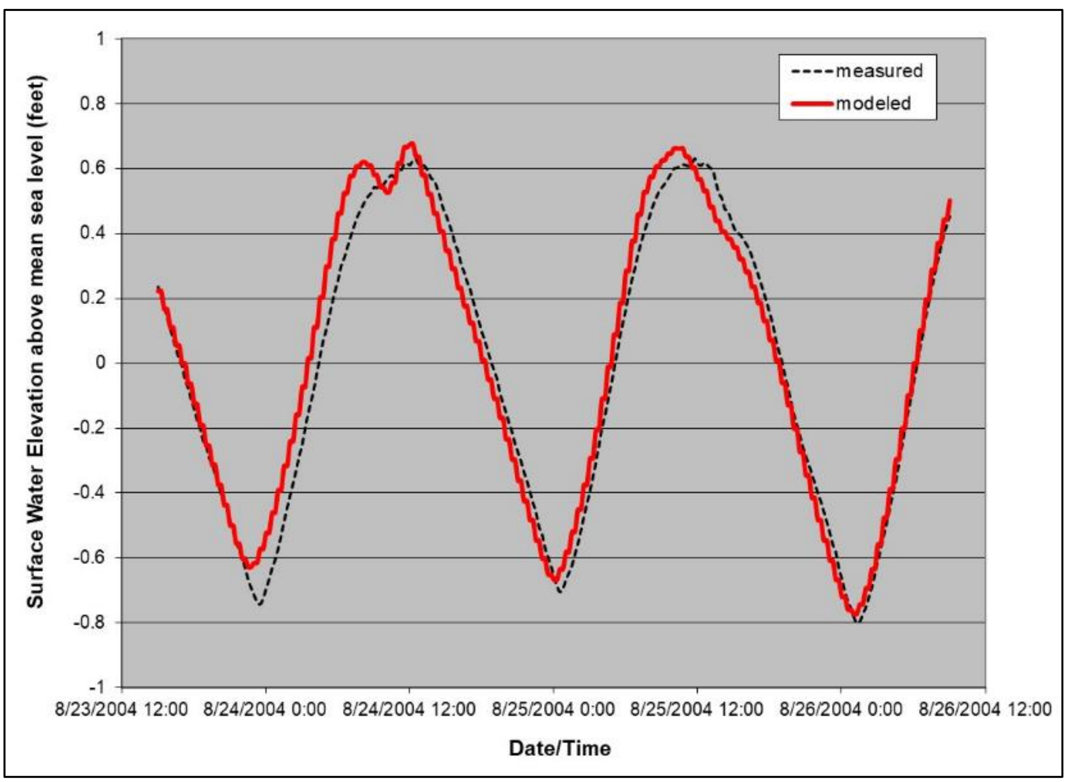

Figure F-27 Water level validation at station CB5

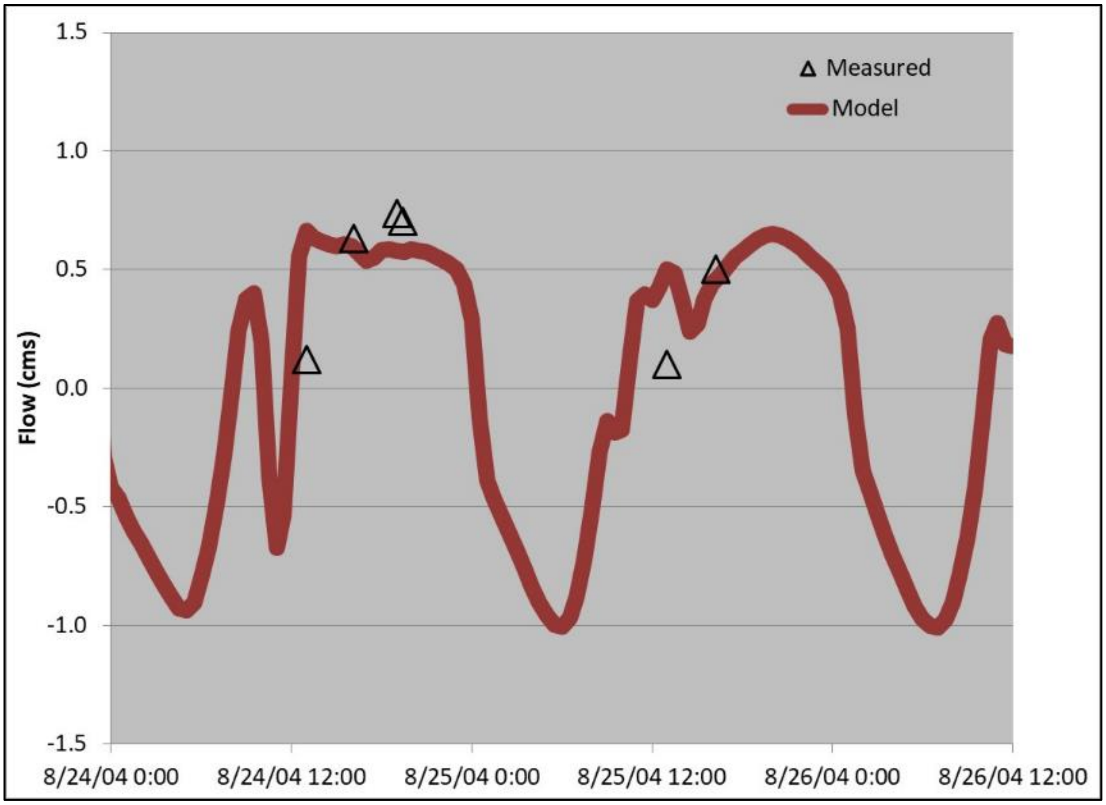

Figure F-28 Flow validation at station CB5

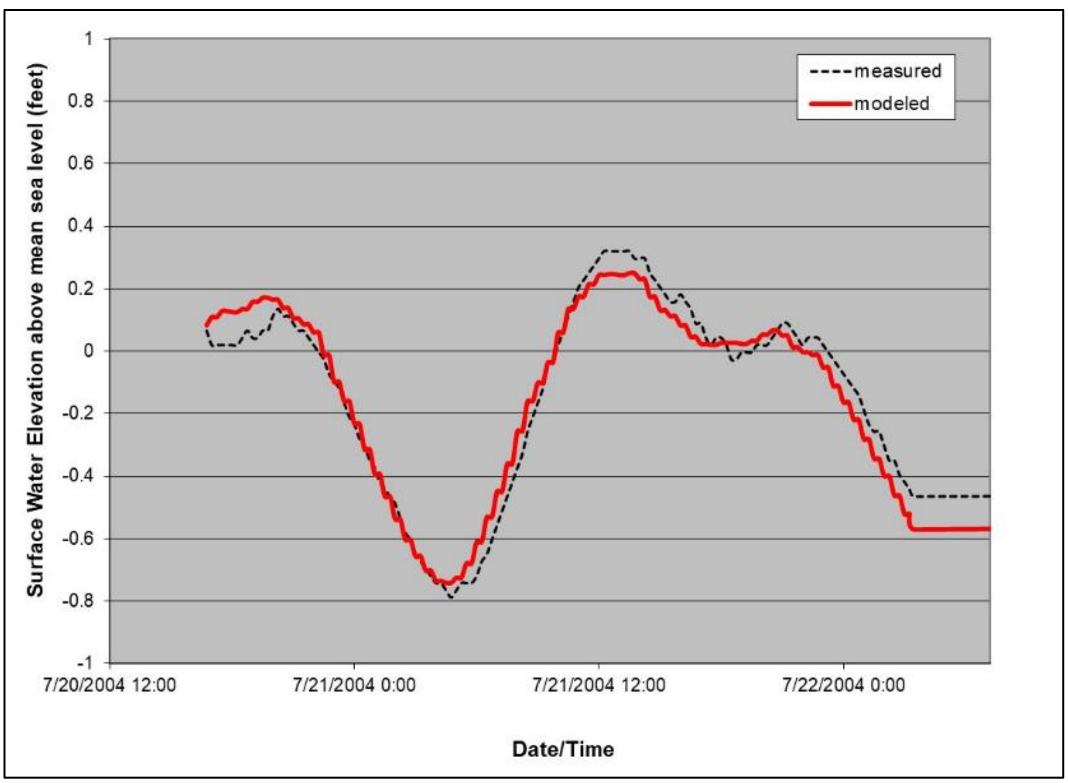

Figure F-29 Water level calibration at station CNB (Coon Bayou)

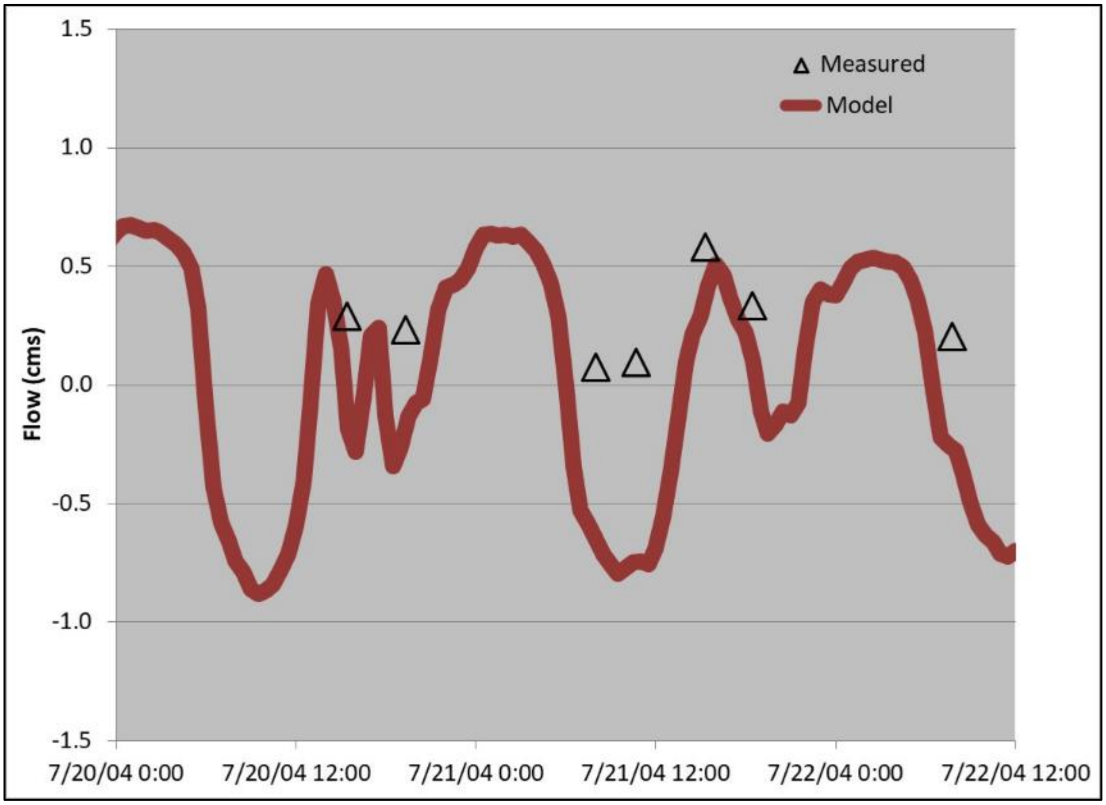

Figure F-30 Flow calibration at station CNB (Coon Bayou)

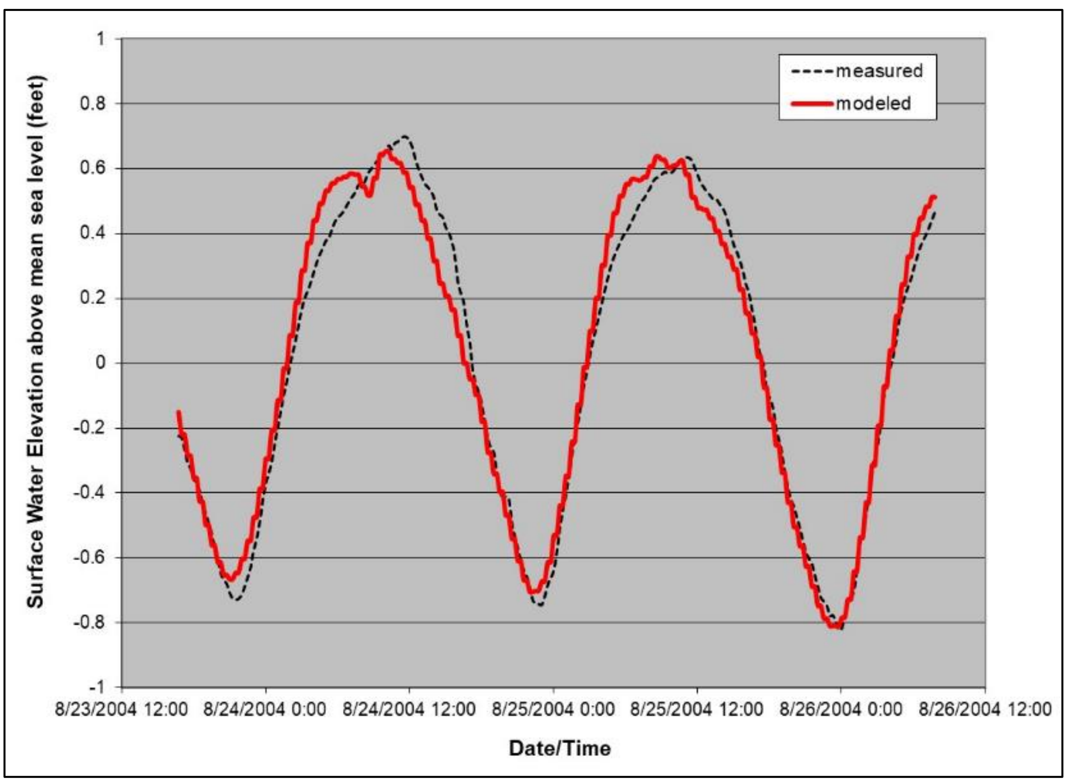

Figure F-31 Water level validation at station CNB (Coon Bayou)

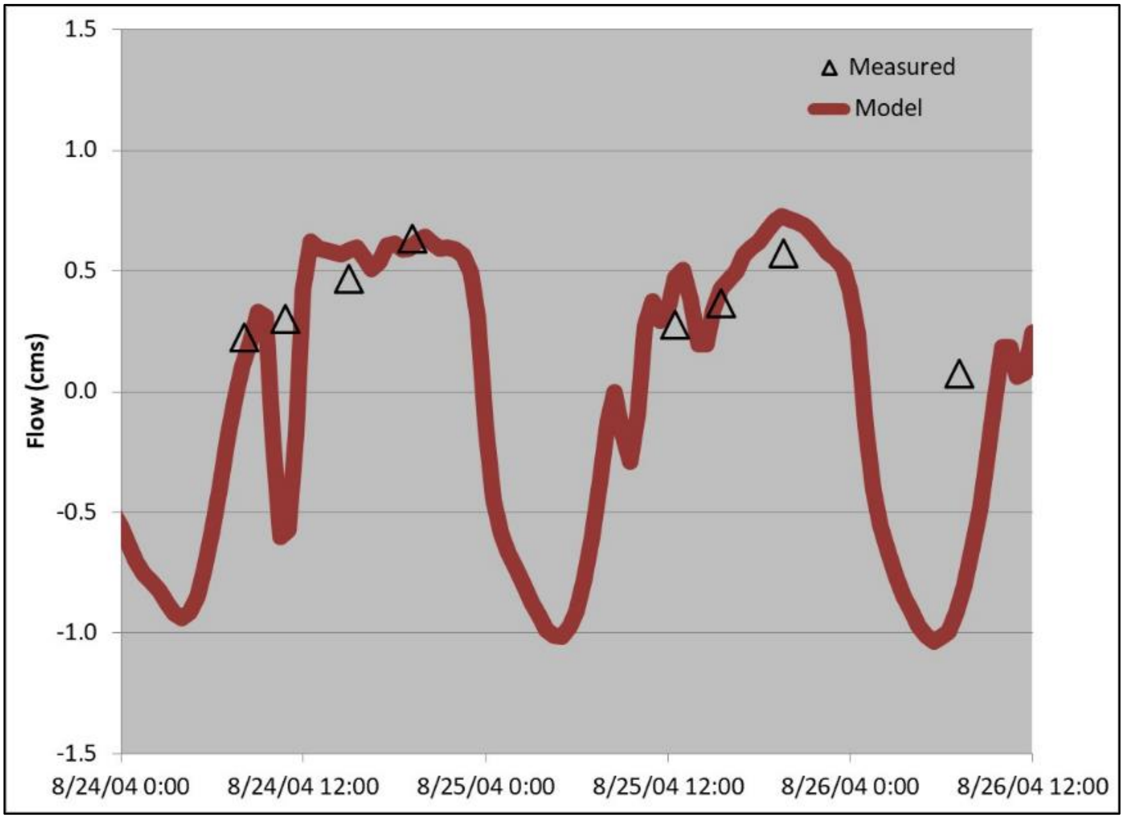

Figure F-32 Flow validation at station CNB (Coon Bayou)

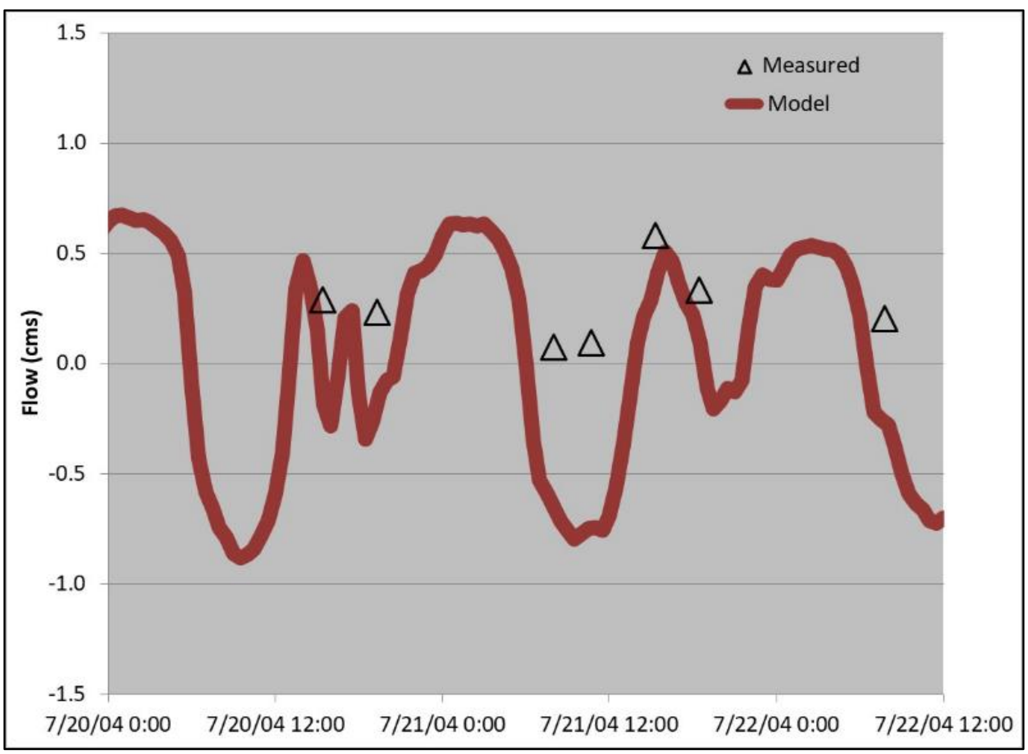

Figure F-33 Flow calibration at station TG2 (Terry Gully)

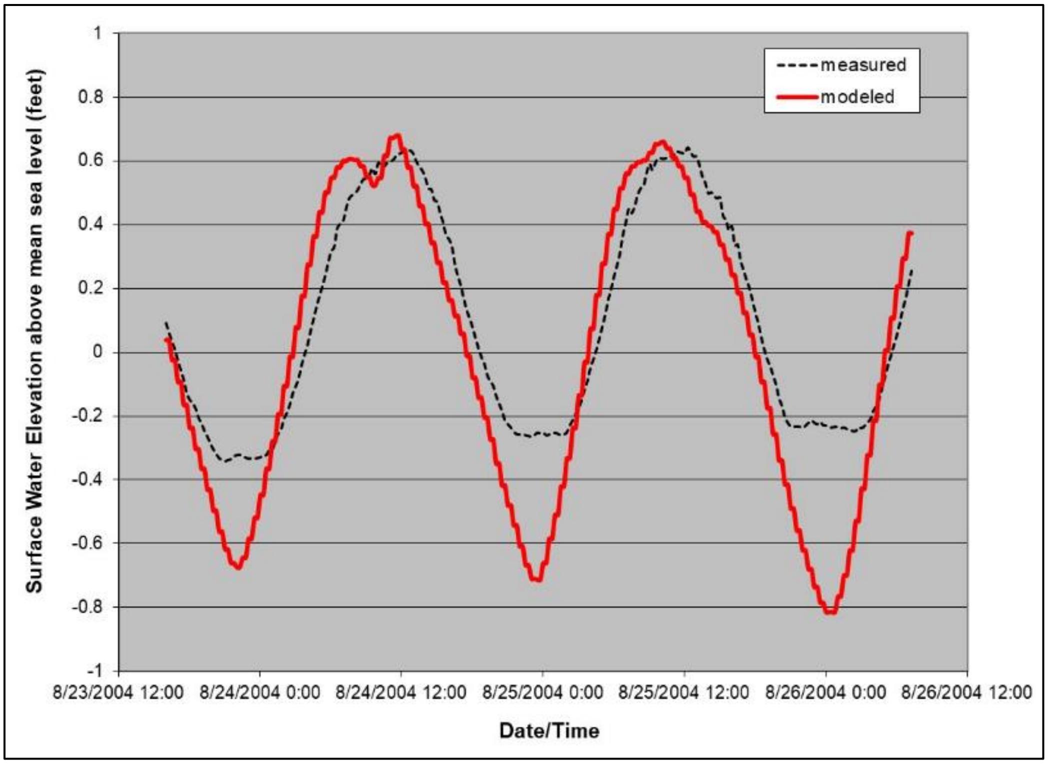

Figure F-34 Water level validation at station TG2 (Terry Gully)

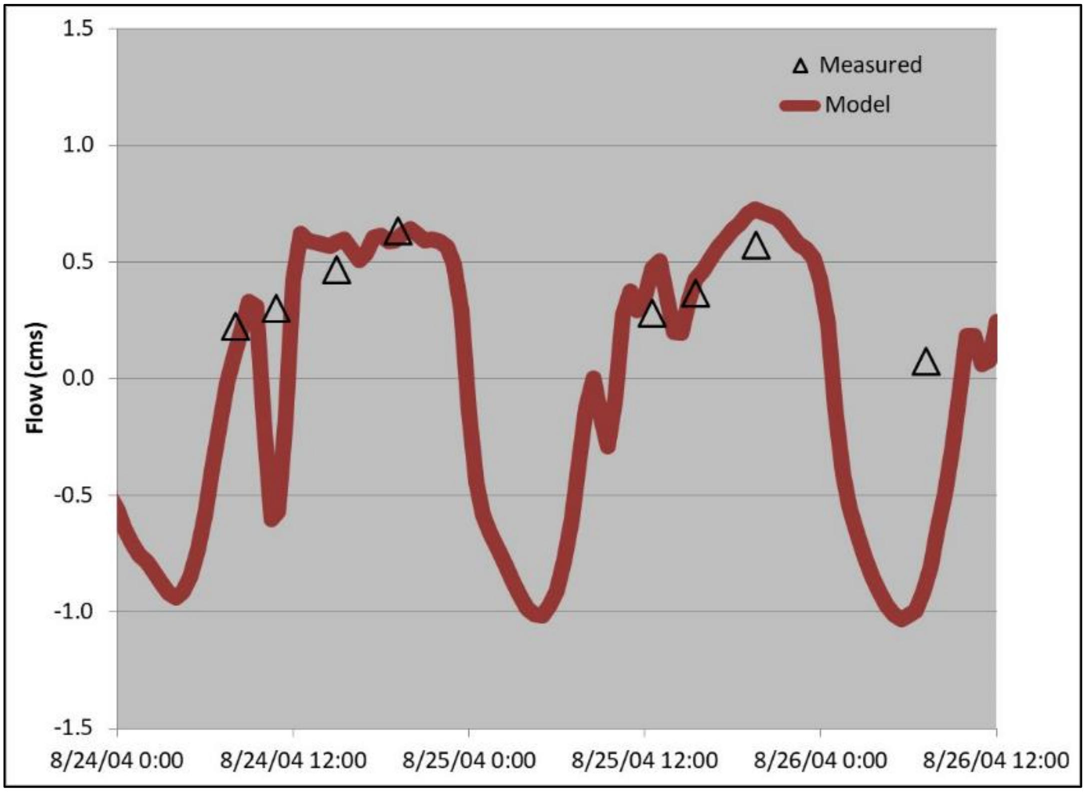

Figure F-35 Flow validation at station TG (Terry Gully)

Appendix G Goodness-of-fit for the Adams Bayou WASP Model

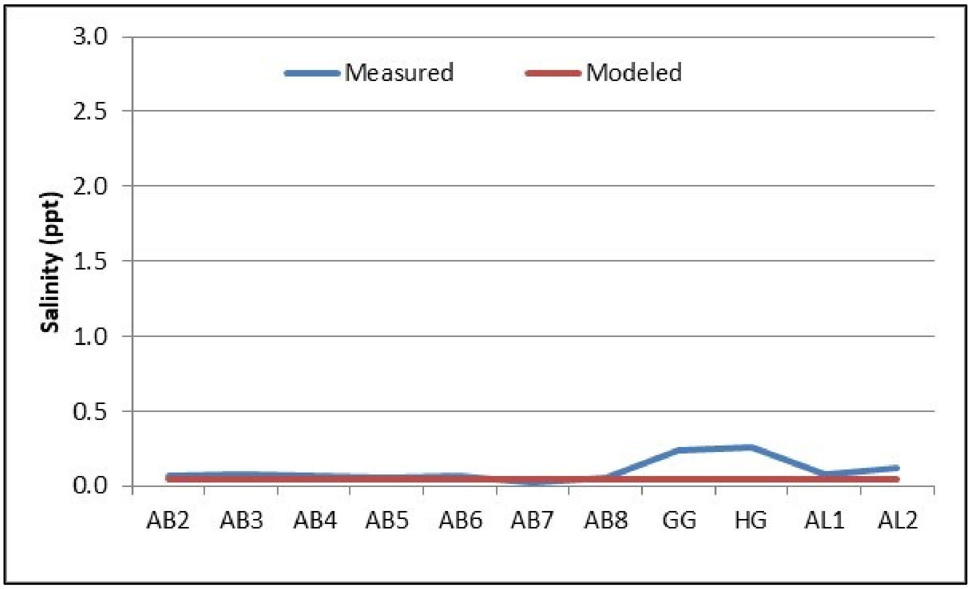

Figure G-1. Calibration of salinity in the Adams Bayou WASP model

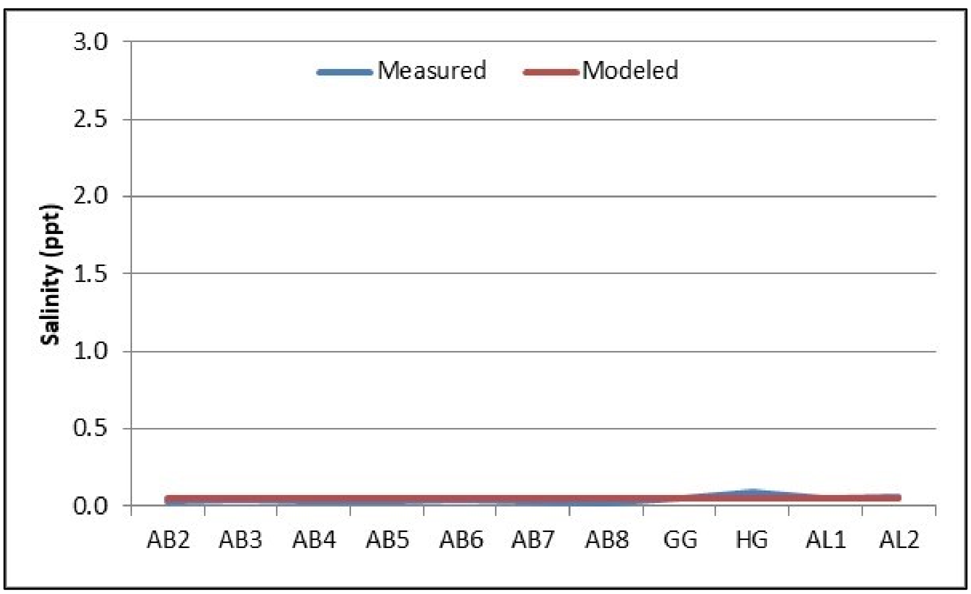

Figure G-2. Validation of salinity in the Adams Bayou WASP model

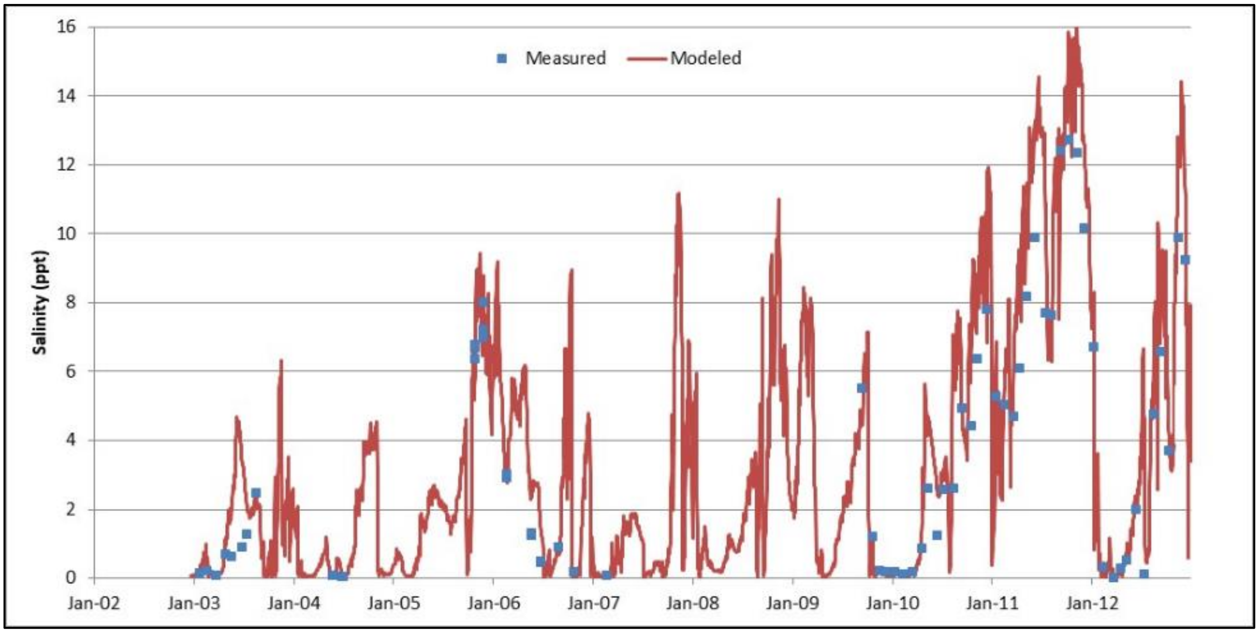

Figure G-3 Long-term validation of salinity calibration at Adams Bayou station AB2

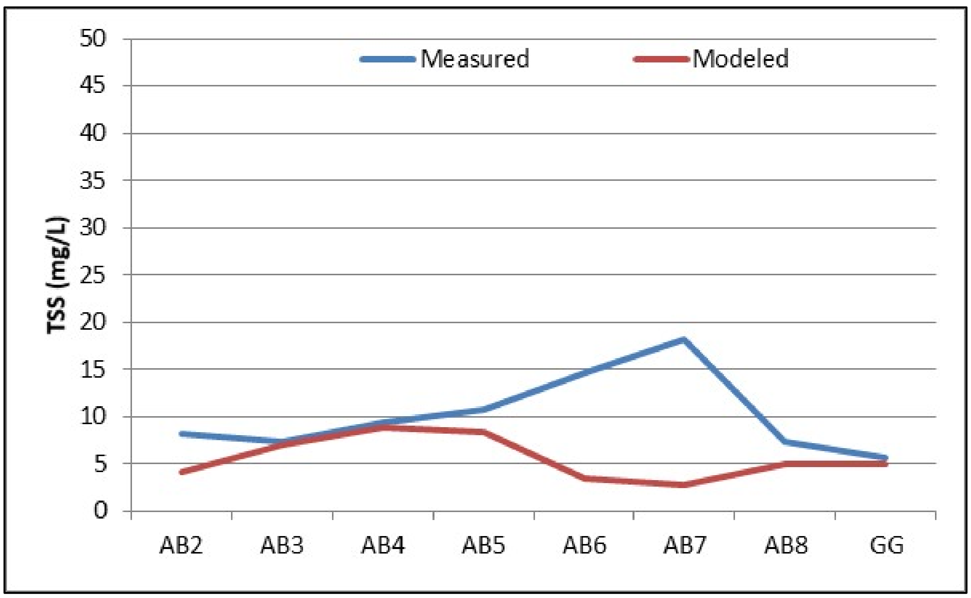

Figure G-4 Calibration of TSS in the Adams Bayou WASP model

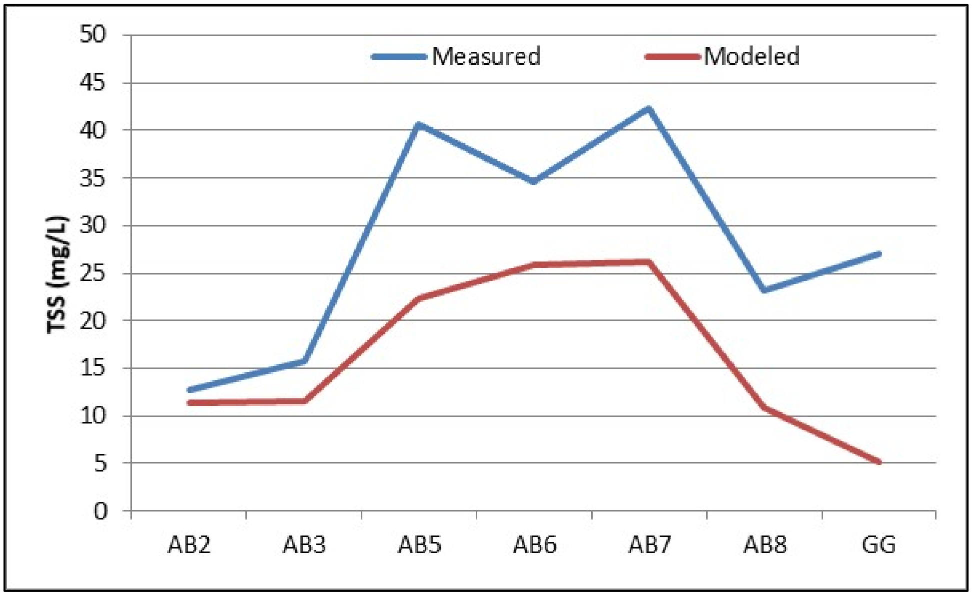

Figure G-5 Validation of TSS in the Adams Bayou WASP model

Figure G-6 Calibration of ultimate cBOD in the Adams Bayou WASP model

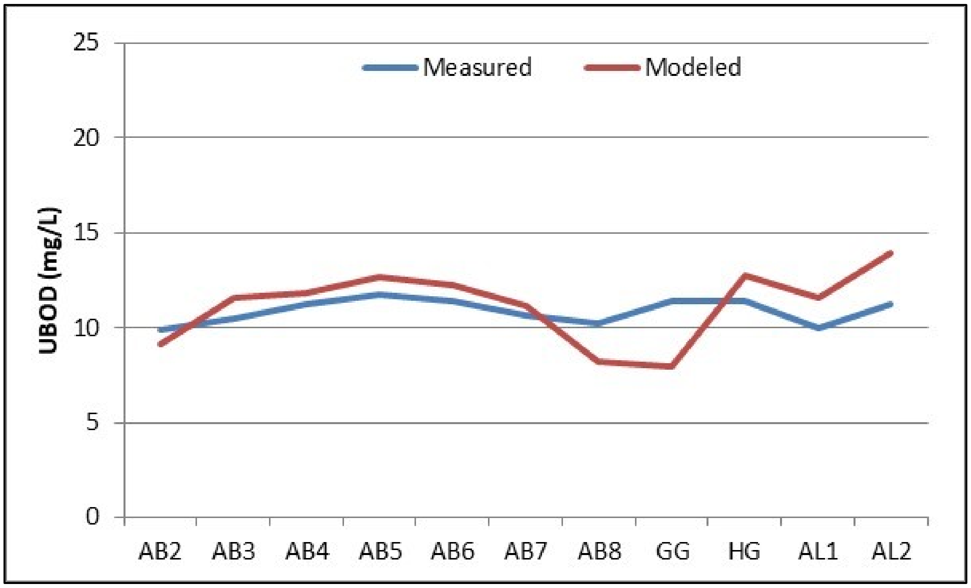

Figure G-7 Validation of ultimate cBOD in the Adams Bayou WASP model

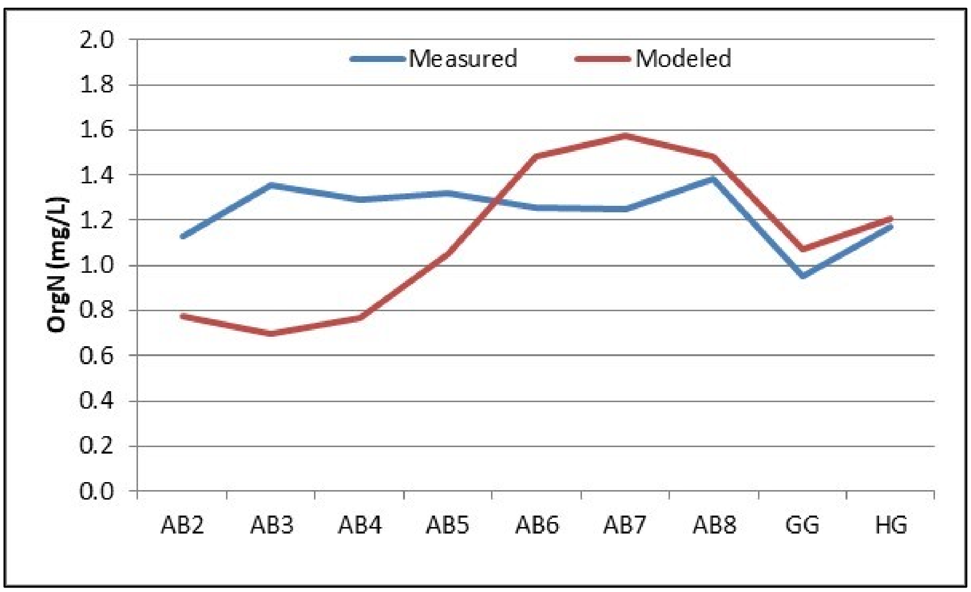

Figure G-8 Calibration of OrgN in the Adams Bayou WASP model

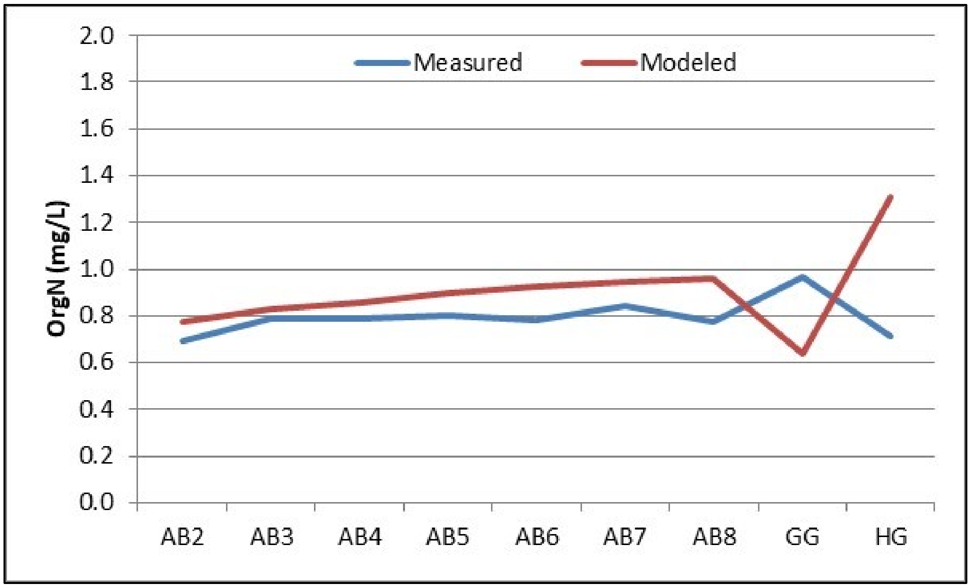

Figure G-9 Validation of OrgN in the Adams Bayou WASP model

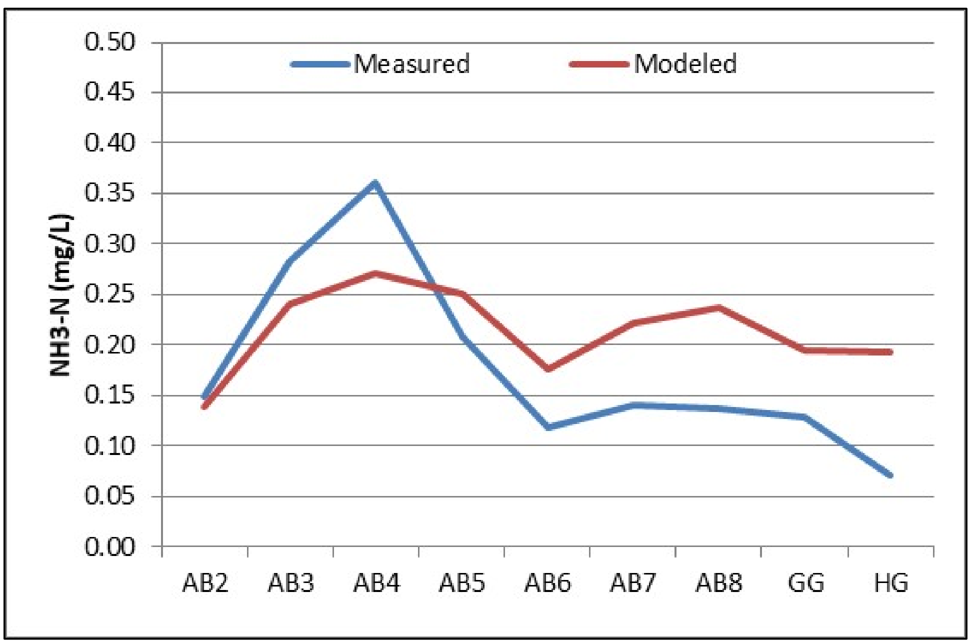

Figure G-10 Calibration of NH_3N in the Adams Bayou WASP model

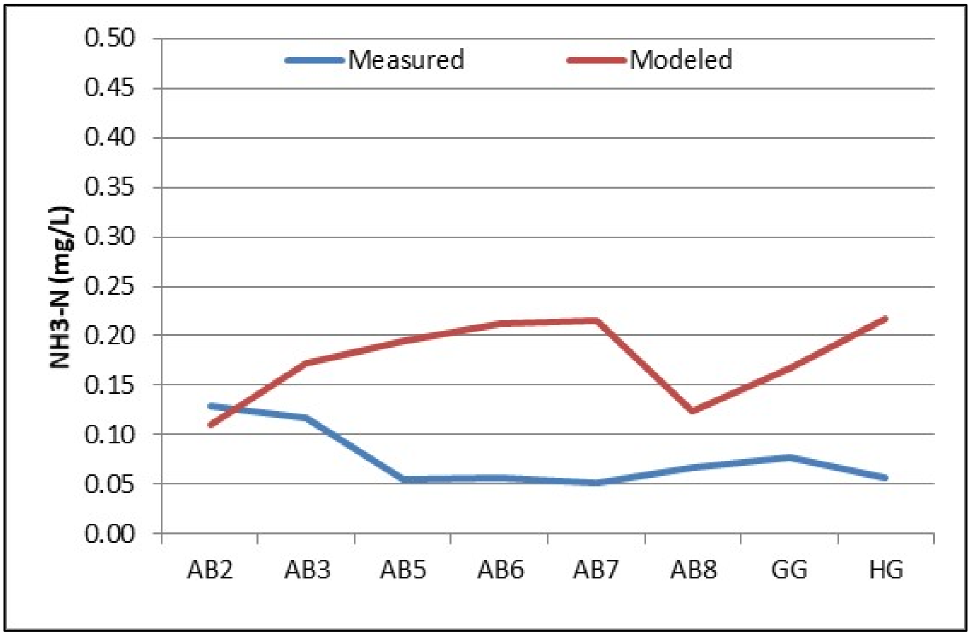

Figure G-11 Validation of NH_3N in the Adams Bayou WASP model

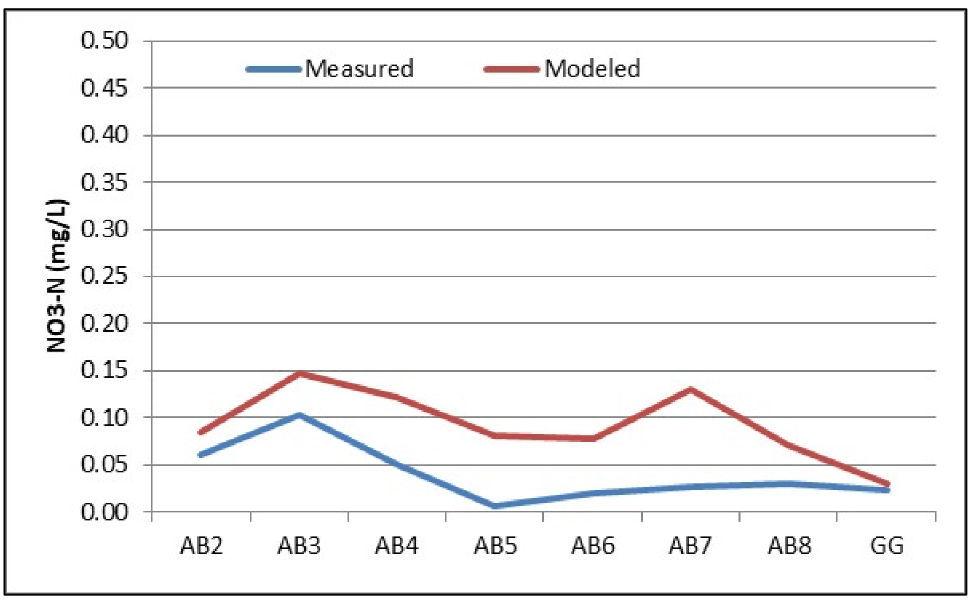

Figure G-12 Calibration of NO_3N in the Adams Bayou WASP model

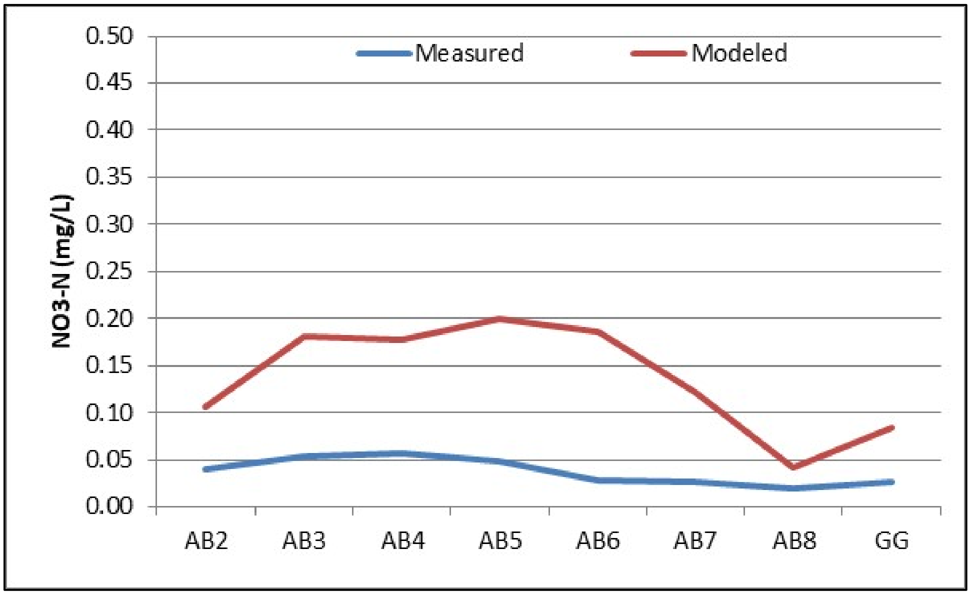

Figure G-13 Validation of NO_3N in the Adams Bayou WASP model

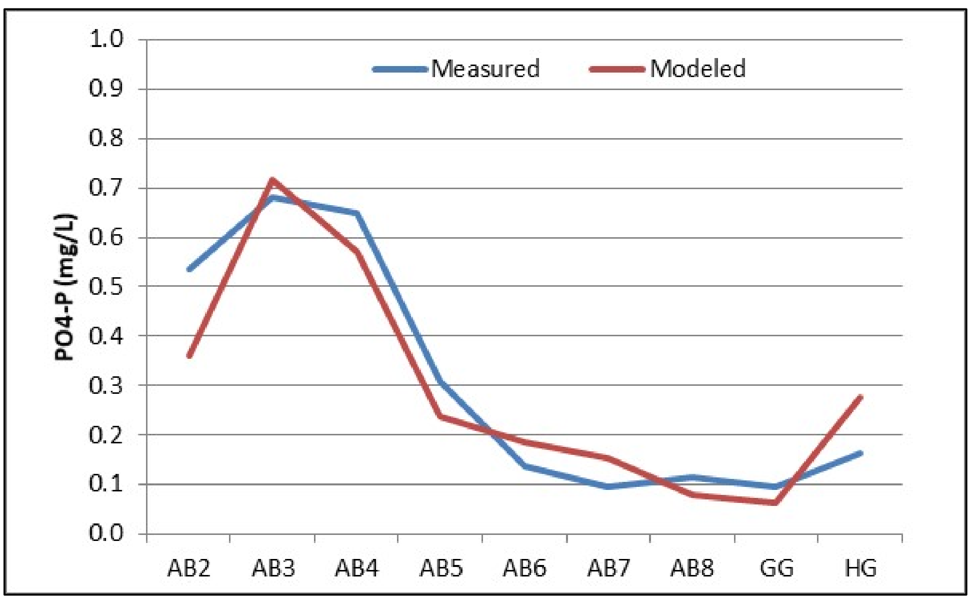

Figure G-14 Calibration of PO_4P in the Adams Bayou WASP model

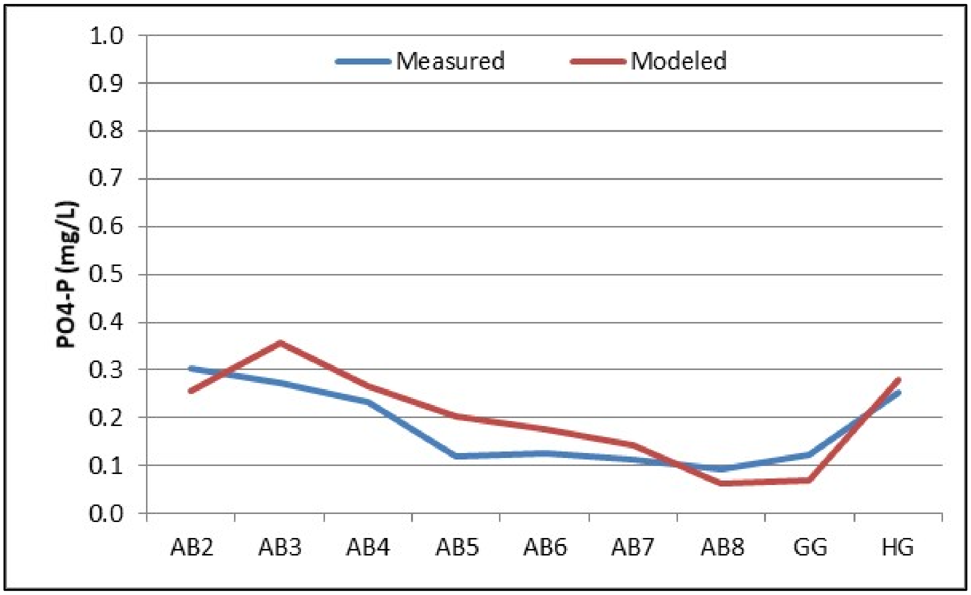

Figure G-15 Validation of PO_4P in the Adams Bayou WASP model

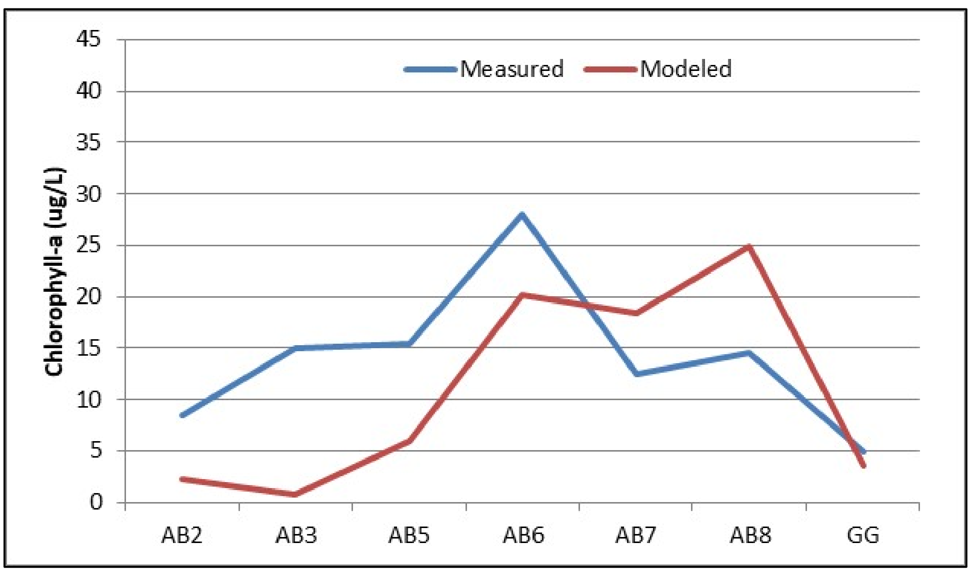

Figure G-16 Calibration of Chlorophyll-a in the Adams Bayou WASP model

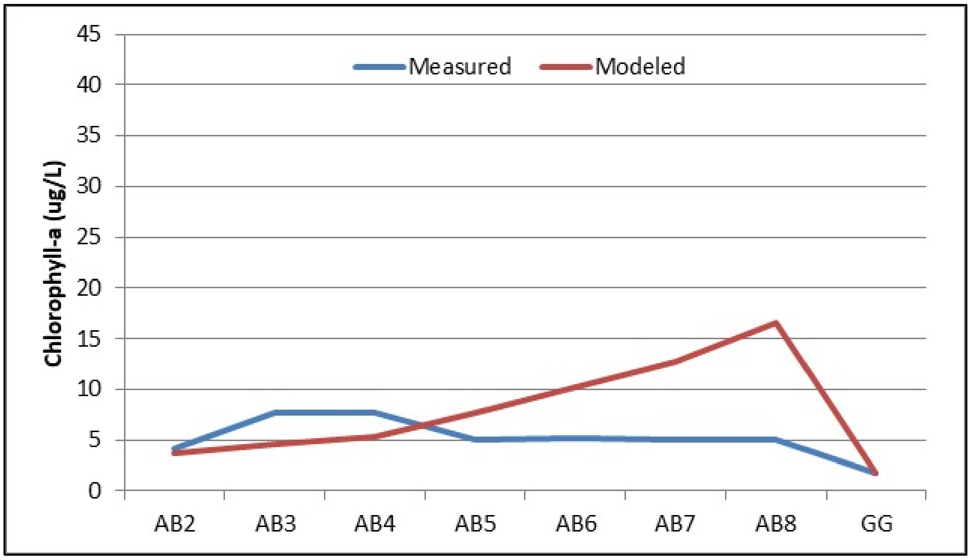

Figure G-17 Validation of Chlorophyll-a in the Adams Bayou WASP model

Appendix H Goodness-of-fit for the Cow Bayou WASP Model

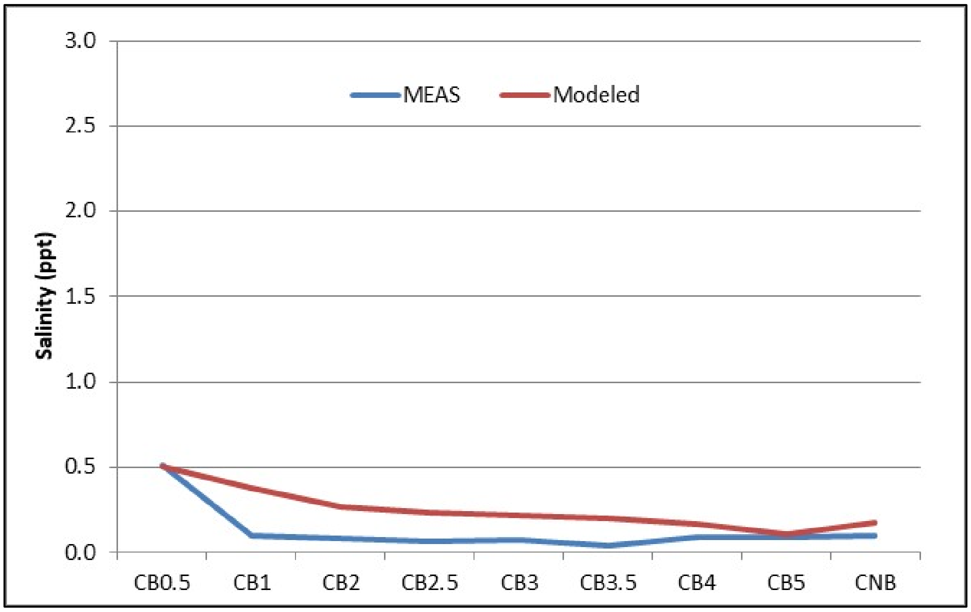

Figure H-1   Calibration of salinity in the Cow Bayou WASP model

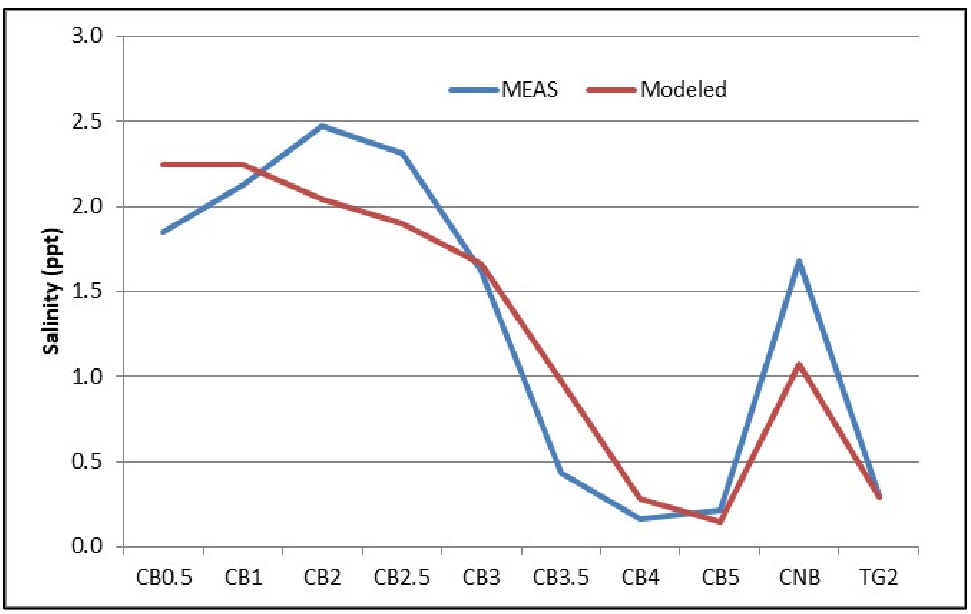

Figure H-2   Validation of salinity in the Cow Bayou WASP model

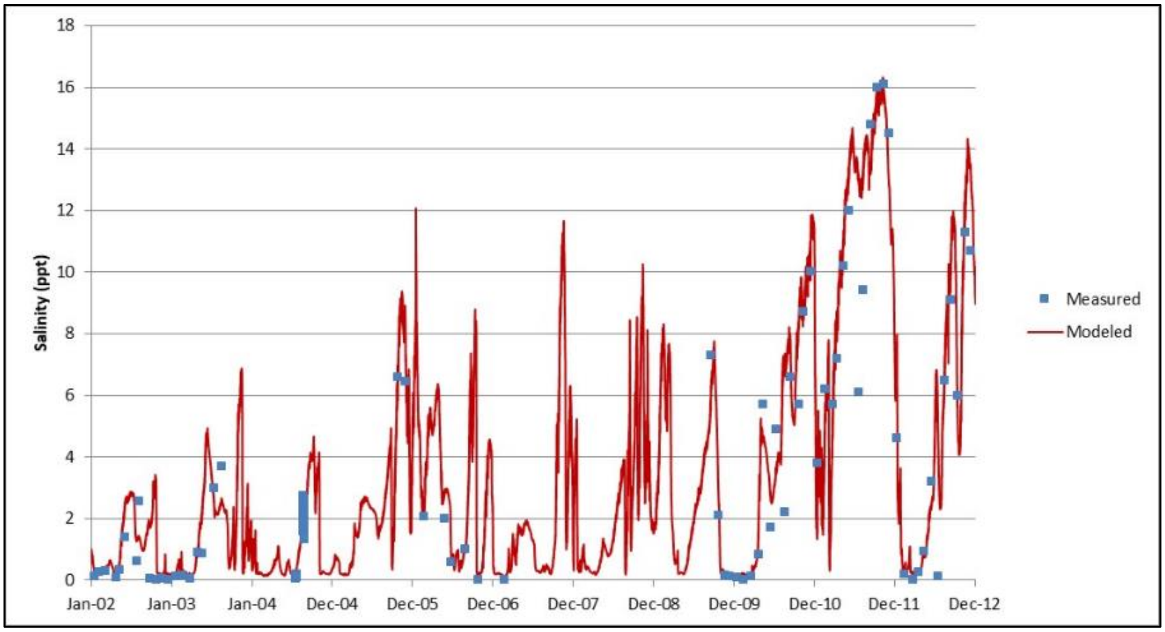

Figure H-3 Long-term validation of salinity calibration at Cow Bayou station CB1

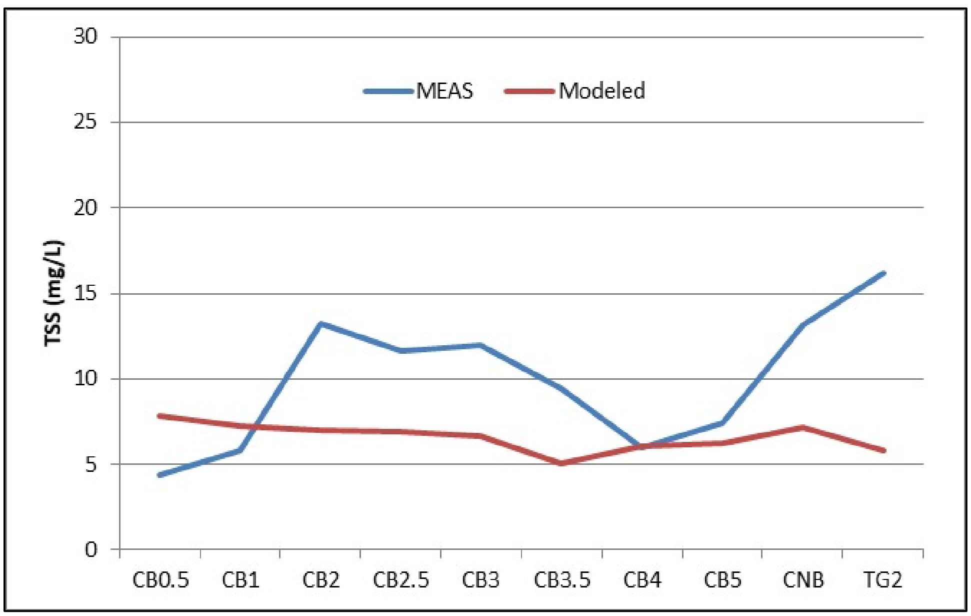

Figure H-4 Calibration of salinity in the Cow Bayou WASP model

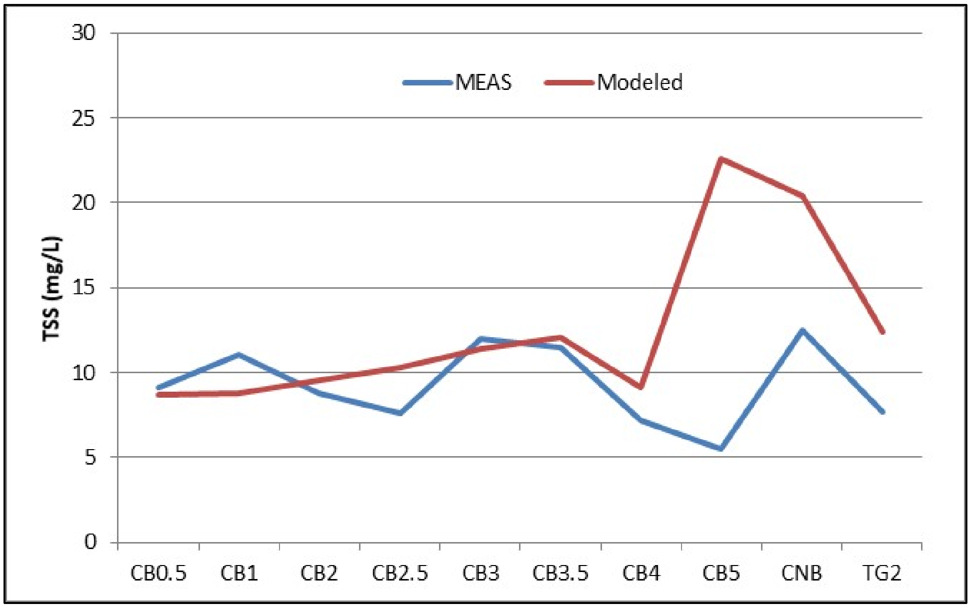

Figure H-5 Validation of TSS in the Cow Bayou WASP model

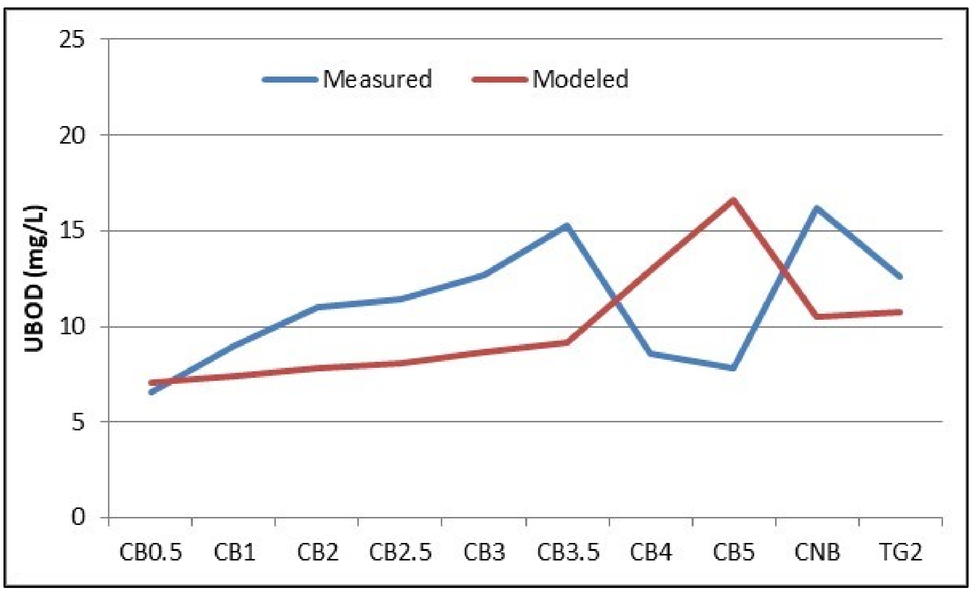

Figure H-6 Calibration of ultimate cBOD in the Cow Bayou WASP model

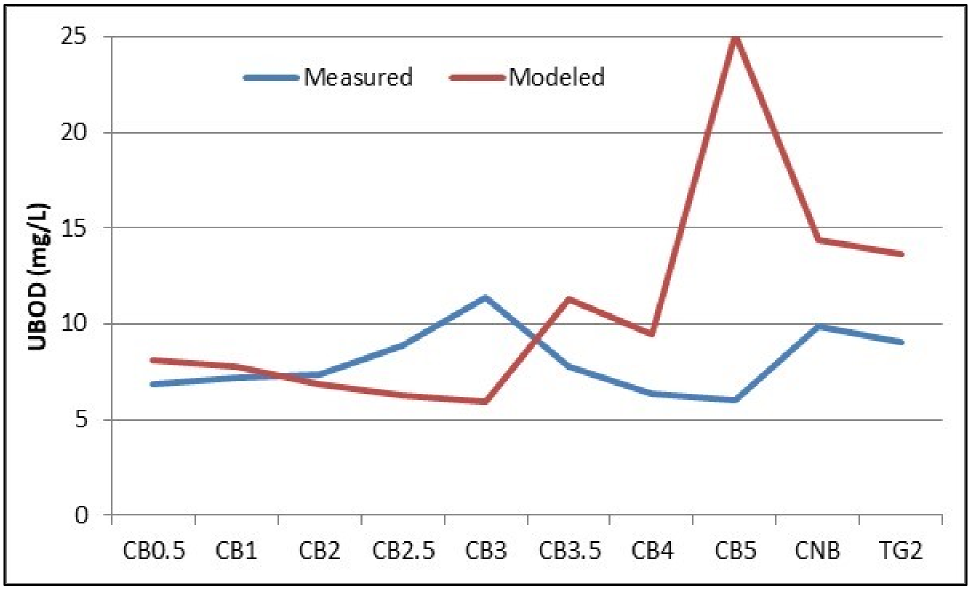

Figure H-7 Validation of ultimate cBOD in the Cow Bayou WASP model

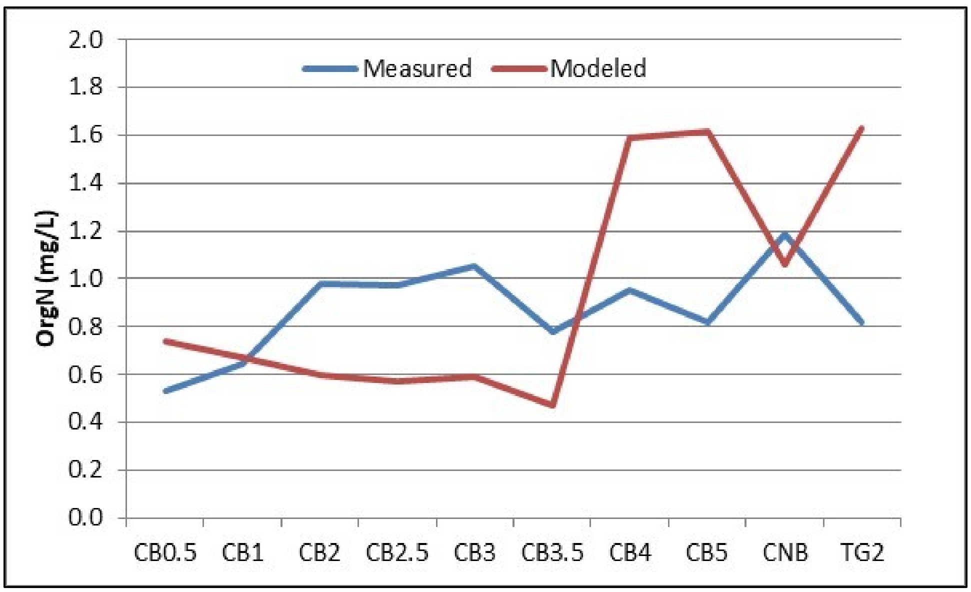

Figure H-8 Calibration of OrgN in the Cow Bayou WASP model

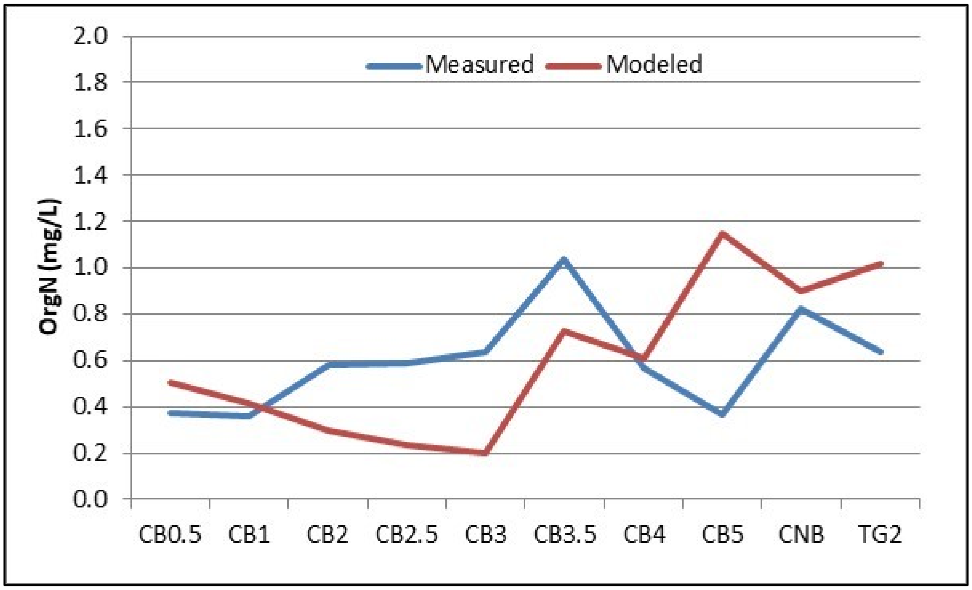

Figure H-9 Validation of OrgN in the Cow Bayou WASP model

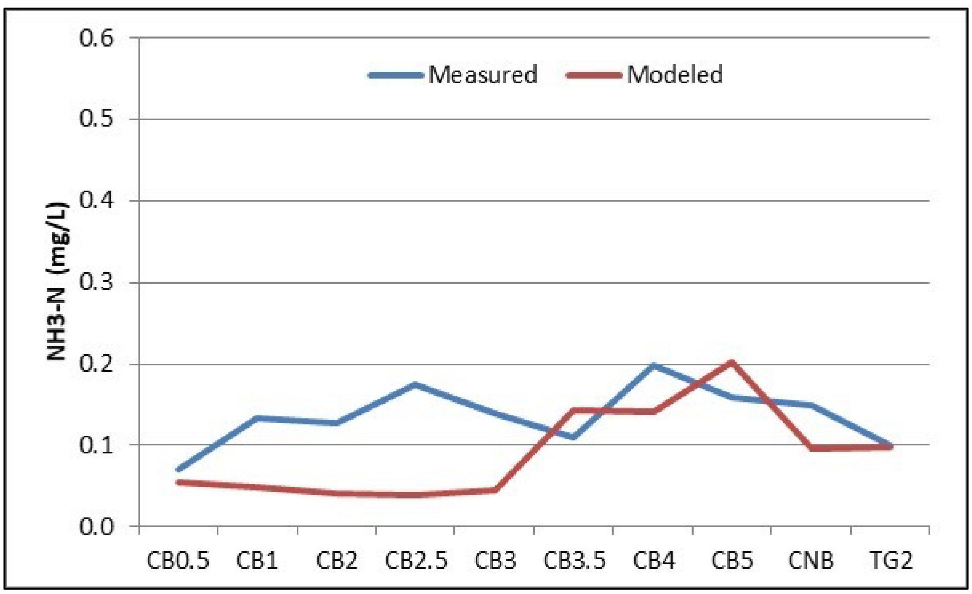

Figure H-10 Calibration of NH_3N in the Cow Bayou WASP model

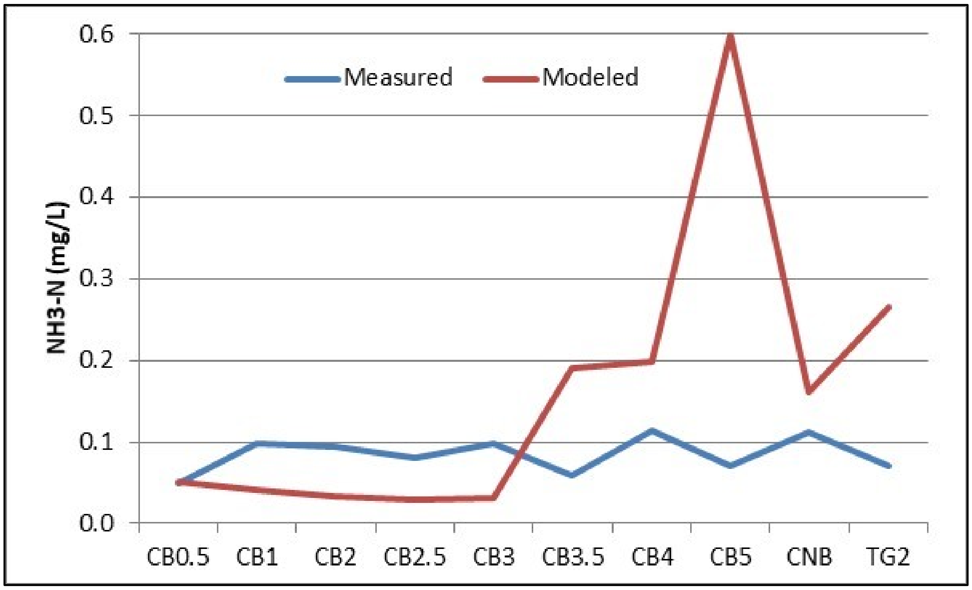

Figure H-11 Validation of NH_3N in the Cow Bayou WASP model

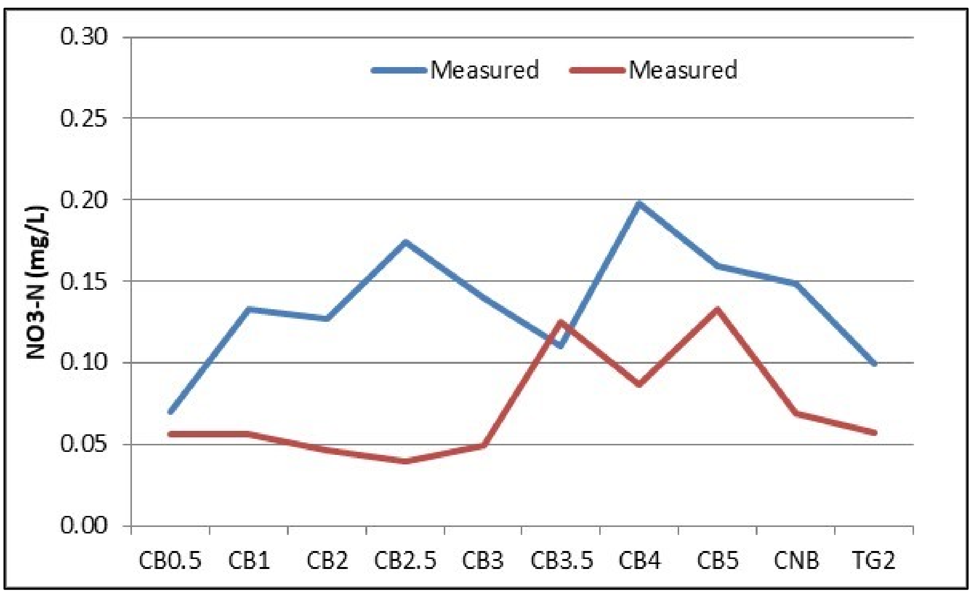

Figure H-12 Calibration of NO_3N in the Cow Bayou WASP model

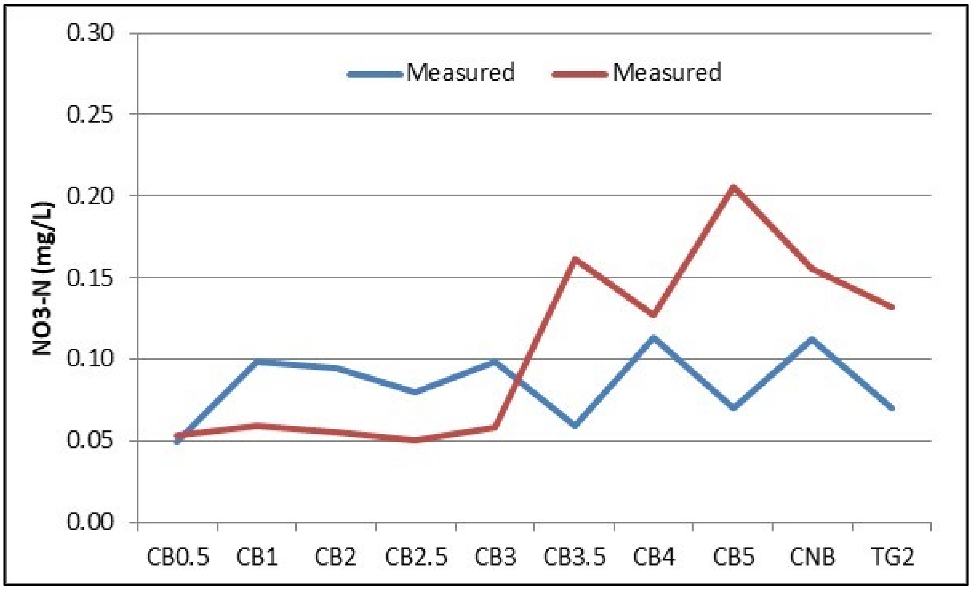

Figure H-13 Validation of NO_3N in the Cow Bayou WASP model

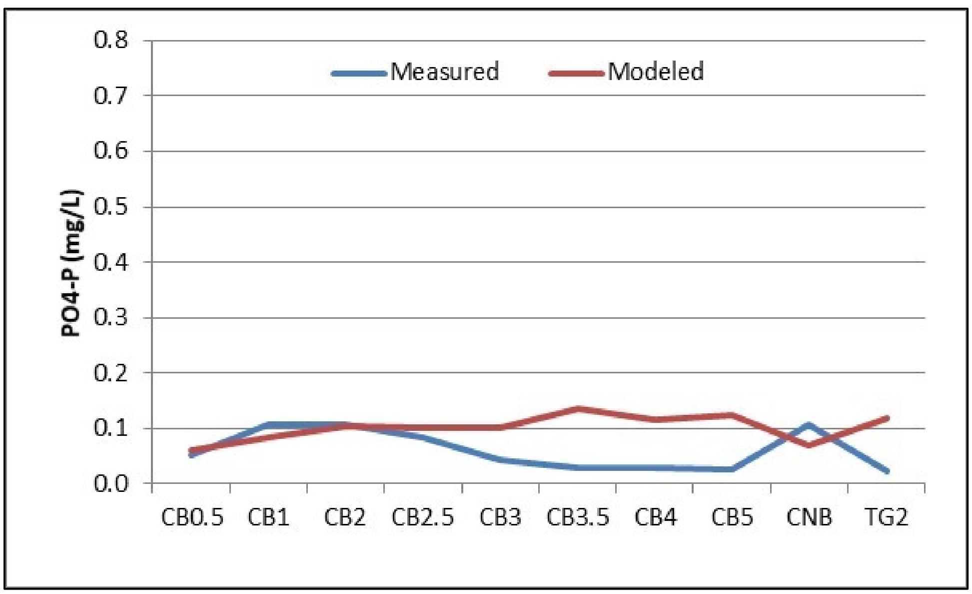

Figure H-14 Calibration of PO_4P in the Cow Bayou WASP model

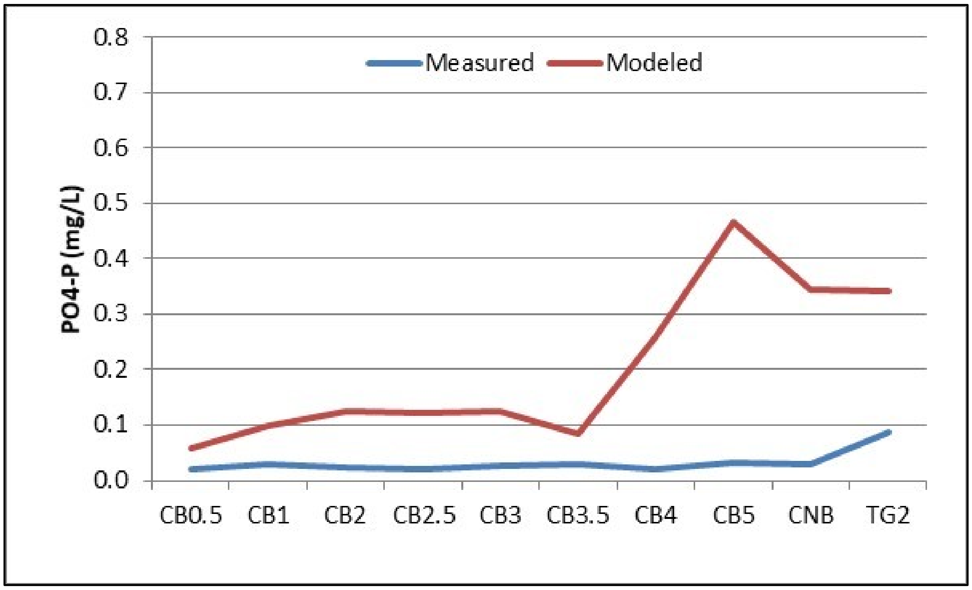

Figure H-15 Validation of PO_4P in the Cow Bayou WASP model

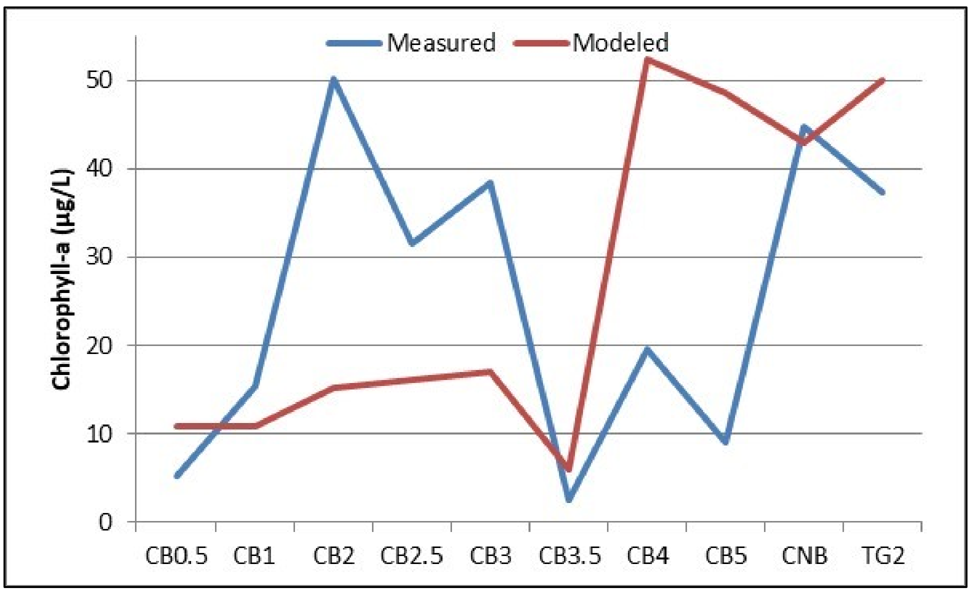

Figure H-16 Calibration of Chlorophyll-a in the Cow Bayou WASP model

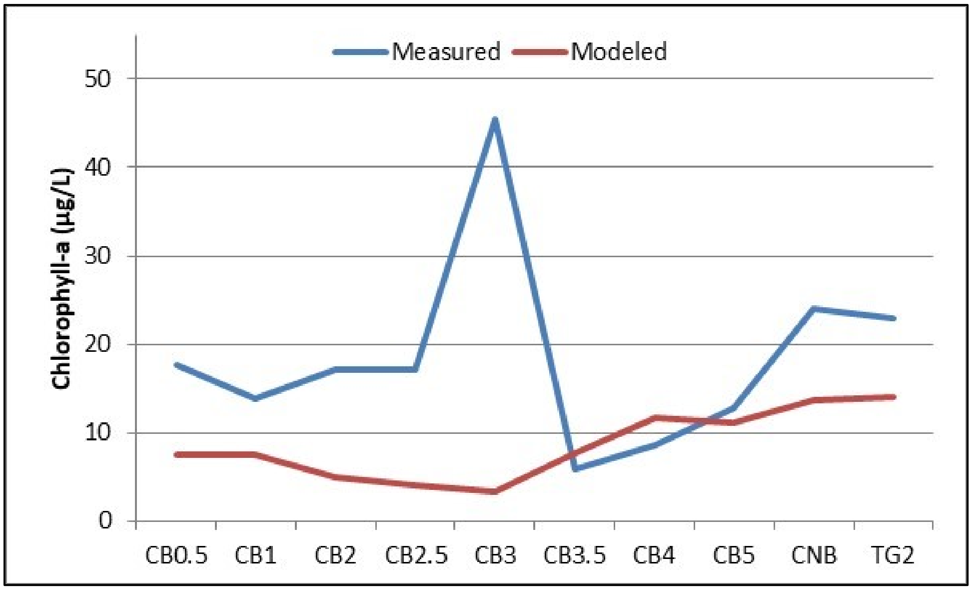

Figure H-17 Validation of Chlorophyll-a in the Cow Bayou WASP model