Central Platte River Model (OPSTUDY8)

Technical Documentation and Users Guide

Platte River EIS Office
Lakewood, Colorado

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CHAPTER ONE

BACKGROUND

1.1 OBJECTIVES OF THE MODEL

The Central Platte River OPSTUDY Model (CPR Model) was developed by the U.S. Bureau of Reclamation (USBR) and the U.S. Fish and Wildlife Service (FWS) as a tool for evaluating management alternatives affecting flows in the central Platte River in Nebraska. The model provides an accounting of water in the river system beginning around Lewellen, Nebraska (on the North Platte River) and Julesburg, Colorado (on the South Platte River), continuing downstream to Duncan, Nebraska. The modeled region therefore includes the entire "Big Bend" reach of the Platte River, which is the focal area of an endangered and threatened species recovery effort in central Nebraska.

The CPR Model allows for the assessment of a wide variety of water management scenarios at monthly time steps. The model simulates river conditions based on inflows to, outflows from, and demands on the river system. For example, various strategies for the storage and release of water by reservoirs, recharge to and return flow from alluvial aquifers, and the use, conservation, and routing of irrigation waters diverted from the Platte River system may be assessed with this model. The CPR Model allows alternatives to be compared in terms of estimated river flows, power generation, irrigation diversions, reservoir storage and release, return flows, losses associated with evaporation and seepage, and other measures.

The primary purpose for developing the Central Platte River Model was to create a standardized tool to assess and compare the likely ability of various water management alternatives to help achieve the objective of meeting or reducing shortages to FWS-defined "target flows" in the central Platte River. A detailed discussion of this objective, including desired target flows in the Platte River, is included in the Environmental Impact Study addressing the first 13 years of a Recovery Implementation Program (Program) to benefit four threatened and endangered species and their habitat in and along the Platte River in Nebraska (DOI, 2006).

1.2 OBJECTIVES AND ORGANIZATION OF THIS DOCUMENTATION

This document provides a detailed description of the Central Platte River Model. The intent of this document is to assist users in operating the model and interpreting model results. Ideally, this document will answer most user questions about the model, help users replicate and evaluate EIS model runs, and assist users in simulating new river management scenarios.

The organization of this document is as follows: This chapter provides general background information about the model and the modeling effort. **Chapter 2** describes the conceptual design and operation of the model. **Chapter 3** describes in detail how various existing/historic features of the Central Platte River system are represented in the model. **Chapter 4** describes in detail how various proposed or potential new features of the central Platte River system are represented in the model. **Chapter 5** describes how to run the model, including a description of input file formats, various Platte River water management alternatives evaluated for the Environmental Impact Statement (EIS) analysis, and a description of the output files, tables, and graphs. **References**, **Appendices**, and a **Glossary** are included at the end of this report.

In this document, model routines and subroutines are identified in CAPITALIZED ARIAL FONT. The names of variables used in the model code are identified using *CAPITALIZED ITALICS*. In Chapter 5, input and output file text is identified using 10-point courier font.

1.3 DEVELOPMENT HISTORY

The "OPSTUDY" programming framework upon which the Central Platte River Model was built was originally developed by Fred J. Otradovsky of the U.S. Bureau of Reclamation Kansas-Nebraska Projects Office in Grand Island, Nebraska (Otradovsky, 1986). The generic version of the program is described as "a utility program developed to assist the hydrologist who does his own programming, in coding monthly water operation studies of the bookkeeping type." OPSTUDY simplifies the development of water accounting models by providing a pre-built I/O framework, and by performing monthly and annual accounting calculations and summaries. Modelers using the OPSTUDY framework must write the core subroutines that perform the detailed water accounting operations specific to the system being modeled. These accounting procedures are written exclusively in Fortran.

Water accounting procedures specific to the Central Platte River Model were originally developed in the early 1980s by various individuals at the USBR, in particular Fred Otradovsky. Subsequent modifications and revisions to the model were made by various individuals, including Mark Killgore (contracted consultant), Mark Butler (FWS, Lakewood), and Duane Stroup (USBR, Lakewood). These revisions include the addition of new model elements for alternatives analysis, adjustments to various accounting procedures, addition of extensive documentation to the model code, and development of more user-friendly interfaces to the model through the use of Excel spreadsheets and macros.

The CPR Model has undergone many revisions over its many years of use. Versions are numbered based on the date of the last revision to the model.

1.4 MODEL MAINTENANCE

The current CPR Model for the central Platte River is maintained by the Great Plains Regional Office in Billings, Montana (406-247-7755). Questions about the model should be directed to that office.

1.5 GENERAL APPLICATIONS AND LIMITATIONS OF THE MODEL

The Central Platte River Model is a water accounting model for tracking gains, losses, diversions from and accretions to the central Platte River system. Its intended use is for comparing the effects of various management alternatives at a monthly time step, based on historic system operations, anticipated future operations, and historic river, canal, and reservoir records. Model comparison are made by simulating the effects of the proposed alternative(s) on stream flows and diversions in the central Platte River system assuming that the hydrologic and climatologic conditions occurring in 1947 through 1994 were replicated for the modeled scenario.

The CPR model, in its current form, is *not* designed to:

- Forecast flows or river operations for any specific period in the future; nor
- Function as a detailed water rights model.

1.6 CALIBRATION AND VALIDATION OF THE MODEL

Calibration and validation of the CPR Model was performed by comparing monthly time-step model output to an historical period of record. The time period of 1975 through 1994 was chosen to minimize the number of major new water resources development activity or changes in management procedures which have occurred in the Platte River basin upstream of Grand Island, Nebraska, during the calibration and validation period. This twenty-year period was further broken down into a 1985-1994 calibration period and a 1975-1984 validation period. A detailed discussion of the calibration/validation assumptions, procedures, and results are provided in a report generated by the Platte River EIS Office (2002).

1.7 SYSTEM REQUIREMENTS FOR THE MODEL

1.7.1 Hardware requirements

This model has been tested and verified to run on the following operating systems: Microsoft Windows 95, Microsoft Windows 98, Microsoft Windows ME (Millennium Edition), Microsoft Windows NT 4.0, and Microsoft Windows XP [1].

The model works best on Pentium II or faster class computers[2] with a screen resolution of at least 1024x768 and 256 colors. The model works best on systems with at least 128 MB of RAM. The model requires at least 2 GB of free space for the installation of the model, the input files used to analyze all EIS alternatives, and other supporting spreadsheets. Additional space is required to save the output from new model runs (approximately 200 MB per model run).

[1] Windows 95, Windows 98, Windows ME, Windows NT, Windows XP, Excel 97, Excel 2000 and VisualBasic are trademarks of the Microsoft Corporation. In this report, any use of trade, product, of firm names is for descriptive purposes only and does not imply endorsement by the U.S. Government.

[2] Pentium II and Pentium III are trademarks of the Intel Corporation.

1.7.2 Software requirements

Microsoft Excel 97 or a more recent version of Microsoft Excel must be loaded for all alternatives analysis. SDF View version 1.2 must be loaded if the analyses include a Tamarack Plan component (see Section 4.13). The SDF View software may be acquired free-of-charge from the following Web site: http://nile.lance.colostate.edu/projects/sdfview.

If the code for the CPR Model is to be modified and re-compiled, a compatible Fortran compiler is required. OPSTUDY is written in formatted Fortran77 code. We have used Visual Fortran[3] for purposes of compiling and linking the code, however many other Fortran compilers are likely to work as well.

1.7.3 Subdirectory structure

The **\Input** directory is the location where one or more main input files (see Section 2.7) are held. When the CPR Model is run, it expects to find the appropriately-formatted main input file in this subdirectory.

The **\Opcode** directory contains the raw Fortran code for the CPR model. This includes the code for the main routine, **opstudy.for**, as well as the code for various subroutines within the **compute.for**, **initcom.for**, **daily.for**, **pulse.for**, **WriteToTables.for**, and **oputil2.for** files. This directory also holds the "include" files that the Fortran compiler looks for at compile time (**dicton.inc**, **compute.inc**, **compute2.inc**, and **opstudy.inc**), and other configuration files for the Fortran compiler. The compiler for the CPR OPSTUDY Model expects to find these files in this directory.

The **\Output** directory is intended to hold various saved output files from various CPR Model runs. Each model run generates a variety of "raw" output files (see Section 5.5), and this is traditionally where these output files have been saved using a different subdirectory under \Output for each modeled alternative.

The **\SDFView** directory contains, under its \Program subdirectory, the SDF View software (see Section 4.13), and under its \Examples subdirectory, various sample input files in the format required for use with SDF View. The CPR Model expects the executable SDF View software to be located under the \SDFview\Program directory if CPR Model runs including the Tamarack project are invoked.

The **\Splatte** directory contains various Excel spreadsheets generated by the South Platte River model (Hydrosphere, 2001), representing model output under various South Platte River management scenarios. The key table within these spreadsheets, in terms of required input for the CPR Model, is the table with the heading "OPSTUDY Model HDATA Input".

[3] DIGITAL Visual Fortran is a product of Compaq, Hewitt-Packard, Digital Equipment Corporation, and the Microsoft Corporation.

The **Tools** directory contains tools for simplifying user interaction with the CPR Model. This includes the cortex.xls spreadsheet user interface (see Section 5.1) and input hydrology data (HDATA) stored in spreadsheet form for conversion to *.inh files for model runs (see Section 5.3.2). This directory also includes tools which greatly simplify the interpretation and graphing of model output (see Section 5.6). One spreadsheet (**CentralPlatteSchematic.xls**) in this directory provides a schematic representation of the central Platte River system, and is reproduced in this report as Figure 2.1.

CHAPTER TWO

CONCEPTUAL DESIGN OF THE MODEL

2.1 PHYSICAL SYSTEM REPRESENTATION

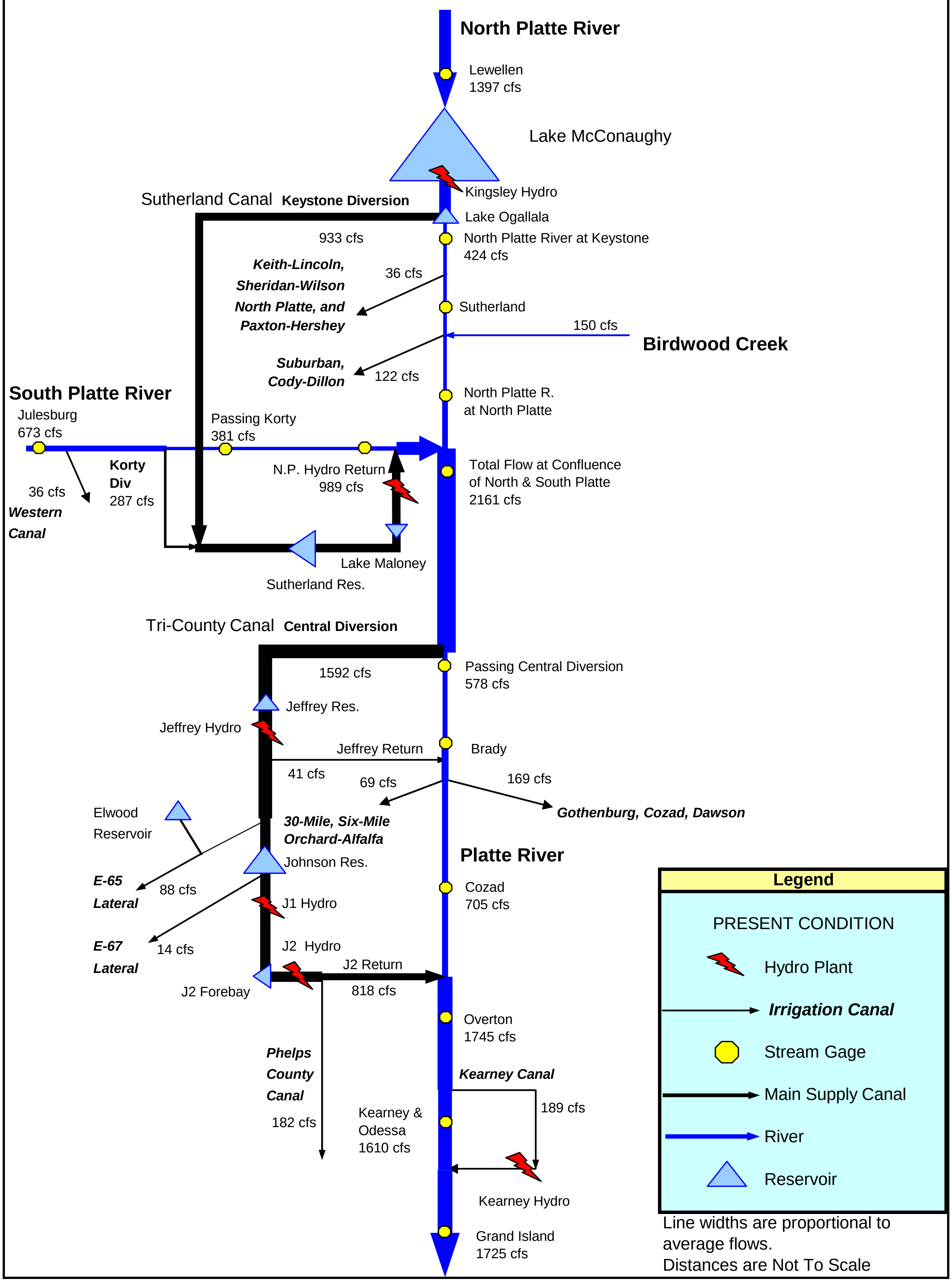
The Central Platte River Model is a mass-balance water accounting model that may be thought of as a linked system of vectors and nodes. In this context, vectors represent one-way avenues of water transport (such as river channels and diversion canals), and nodes represent critical points or features within the flow system (such as reservoirs, points of diversion, and flow gauging locations).

Flow in the central Platte River has been heavily modified by dams, diversions, and changes in consumptive uses and return flows along various reaches of the river system. Any model used to evaluate management alternatives must therefore represent the key controllable features as discrete model elements. A schematic vector-and-node representation of the central Platte River system is illustrated in Figure 2.1. As indicated by the figure, the model's representation of the system begins near the lower end of the South Platte river (near Julesburg, Colorado) and the North Platte River above Lake McConaughy (near Lewellen, Nebraska), and continues through central Nebraska as far as Duncan, Nebraska. Along the way, the model includes elements representing Lake McConaughy, the Sutherland Canal system, the Tri-County Canal system, and the Kearney Canal system, in addition to other major features.

2.2 BOUNDARY CONDITIONS

Among the external boundary conditions established for all CPR Model runs are three points of inflow into the system (the South Platte River, North Platte River, and Birdwood Creek), gains (or losses) for stream reaches between nodes, and irrigation demands within stream reaches. A corresponding time-series of monthly estimated values are provided by a "hydrologic input file" (see Section 2.7). Inflow, gain, and demand features of the model are discussed below.

Figure 2.1 Central Platte Schematic Displaying Average Annual Flow



2.2.1 Inflow from South Platte and North Platte Rivers, and Birdwood Creek

Stream flow in the South Platte River at Julesburg, Colorado, and in the North Platte River at Lewellen, Nebraska, are provided as a monthly time-series of values generated outside the CPR Model. Normally, streamflow in the North Platte River at Lewellen is generated as output from the North Platte River model (USBR, 1997). Flows at Julesburg are generated as output from the South Platte River model (Hydrosphere, 2001). The North and South Platte models operate independently from the CPR Model, except in the sense that they provide these inflow estimates.

Birdwood Creek enters the North Platte River approximately 10 miles upstream of North Platte, Nebraska. The flow contributions of Birdwood Creek are provided as a time series of historic Birdwood Creek flows (see Section 3.5).

2.2.2 Gains by River Reach

"Gains" by river reach refer to net accretions to (or losses from) streamflow along that segment, representing a net inflow of groundwater and/or surface water to the stream (or outflow and diversion from the stream). Gains may be the result of natural hydrology, return flows from irrigation activities, discharge from sewage treatment plants, and/or other sources. Losses may be the result of diversions, evapotranspiration, and/or stream recharge to groundwater adjacent to the stream ("seepage").

In the CPR Model, estimated stream gains are provided for each month of the simulated period for specific river reaches between established gage stations. (Only the aggregate gains/losses along each reach are quantified; no attempt has been made to attribute these to particular causes).

A total of ten reaches have been defined for the purpose of estimating stream gains/losses in the model; these are listed in Table 2.1. As indicated in the table, two reaches are defined for the South Platte basin, two for the North Platte basin, and six along the main stem of the Platte River.

Table 2.1 CPR Model stream reaches defined for river gains and losses.

Stream Reach	**River**
Keystone, NE to Sutherland, NE	North Platte
Sutherland, NE to North Platte, NE	North Platte
Julesburg, CO to Paxton, NE	South Platte
Paxton, NE to North Platte, NE	South Platte
North Platte, NE to Brady, NE	Platte
Brady, NE to Cozad, NE	Platte
Cozad, NE to Overton, NE	Platte
Overton, NE to Odessa, NE	Platte

Odessa, NE to Grand Island, NE	Platte
Grand Island, NE to Duncan, NE	Platte

In general terms, stream gains were estimated by performing a monthly mass-balance analysis of historic (1940-1994) gauged streamflow along each reach, and statistically adjusting these flows to represent “present conditions” in the basin. Details of the stream reach flow gains estimation procedure for the remaining reaches are provided in a document prepared by the USBR (1999). A description of the stream reach modeling elements in the CPR Model is provided in Section 3.11 of this report.

2.2.3 Irrigation Demand by River Reach

Estimated irrigation demands are provided to the model along six river reaches. Four of these reaches are associated with multiple diversion canals, and two are associated with one canal each, as listed in Table 2.2.

Table 2.2 CPR Model irrigation demand reaches, and associated canals

Reach	Canals included
Keystone to Sutherland river reach	Keith-Lincoln, Sheridan-Wilson, North Platte, Paxton-Hershey
Sutherland to N. Platte river reach	Suburban, Cody-Dillon
Brady to Cozad river reach	Gothenburg, 30-Mile, Six-Mile, Cozad, Orchard-Alfalfa, Dawson
Tri-County system	E-65 Lateral, E-67 Lateral, Phelps County
Julesburg to Paxton river reach	Western
Overton to Grand Island river reach	Kearney Canal

Irrigation demands for these reaches are based on an analysis of historic water usage along these canal systems. The time series of irrigation demands along each of these reaches was developed by the USBR 1982. The irrigation demands for the Tri-County Canal were adjusted to represent Present Condition during the CPR Model development for the EIS.

2.3 TIME STEPS

The Central Platte River Model operates on a monthly time-step. Thus, most of the input and output files values are *monthly means or totals* or *annual summaries* of monthly values. The CPR Model is set up to operate and report on monthly data by *calendar year* (January through December), not by water year (October through September).

2.4 GENERAL MODEL ASSUMPTIONS

As with all hydrologic models, a number of simplifying assumptions are built into the Central Platte River Model. These include:

(1) **1947-1994 climatology in the Platte River basin is reasonably representative of historic and future river basin conditions**. This model simulates effects of changes in water management on the Platte River system by replicating 1947 through 1994 hydrology for the modeled scenario. Because the model is intended as a *comparative* tool (that is, to compare "with and without" or "before and after" conditions), this period is considered acceptable, whether or not it is highly representative of future conditions. Nevertheless, use of this model does presume that future climatology in the watershed will not differ radically from the range of conditions existing from 1947 to 1994. Because this 48-year period includes a good sampling of unusually dry years (e.g., the mid-1950s) as well as unusually wet years (e.g., the mid-1980s), the climatological basis of this model is presumed to be reasonable for the intended purposes.

(2) **Many variables describing the Platte River system are "fixed" values which do not change significantly over the modeled period**. This model incorporates a large number of fixed values and relationships into its calculations. For example, the CPR Model assumes that the monthly unit-area rate of evaporation from Lake McConaughy reservoir is the same from one year to the next. In fact, evaporation rates (as well as other "fixed" relationships embedded in the model) vary somewhat from year to year depending upon weather conditions and other variables. However, in most or all cases, the variations over time are probably small relative to the other uncertainties and variabilities that are inherent in the system and in the simulation.

(3) **Flows within a single time step (i.e., one month) are in equilibrium**. This assumption potentially introduces some error if the longest travel time between nodes in the system is greater than one month. However, water released from Lake McConaughy (near the "top" of the Central Platte system) will typically reach Grand Island (near the "bottom" of the system) in about seven days, well within the monthly time step of the model. In addition, the existence of multiple reservoirs in the system minimizes potential errors associated with delayed surface and subsurface flows.

(4) **Operational decisions affecting the central Platte River system can be reasonably forecast based on operational history and proposed operating criteria, along with known flow and storage conditions**. By necessity, the CPR Model must make assumptions about operational decisions relating to various controllable features of the system, such as releases from Lake McConaughy (see Section 3.1) and diversions to canal systems (*e.g.*, diversions to the Sutherland Canal at Keystone; see Section 3.2). Generally, the operational rules imposed by the model are based on historic operations and/or proposed operational criteria, which in turn are largely determined by flow and storage conditions at various points in the system. Calibration and validation analyses of the model (see Section 1.6) confirm that the CPR Model's operational rules reasonably simulate historic operations, except under extraordinary conditions such as changes in operations for system maintenance and repair.

Many additional model assumptions are specific to the individual features represented in the model. These assumptions are addressed when these individual features are discussed, in

Chapter 3 ("Representation of Existing System Elements") and Chapter 4 ("Representation of Proposed System Elements").

2.5 DEFINITION OF THE "PRESENT CONDITION"

A "Present Condition" or "Reference Condition" modeling scenario was defined for purposes of comparing the results of various model runs against a standardized baseline. The "Present Condition" scenario is intended to reflect present-day operating criteria and demands on the Central Platte River system, applied as if those same conditions had existed throughout the 1947-1994 modeling period. For example, although the Gerald Gentleman power generation facility was not completed until the 1980's, the Present Condition scenario accounts for water in the river system as if this facility had existed throughout the 48-year period. In addition, the Present Condition scenario assumes that the NPPD and CNPPID facilities on the river system are relicensed on the same terms as their past licenses.

Ideally, July 1, 1997 is considered the "baseline date" for Present Condition. However, because many river system facilities and operations are implemented gradually over a long period of time, it may be more realistic to think of the "baseline date" as being the general time frame of the mid- to late-1990s.

Changes that occurred below Lake McConaughy during the 1947-1994 modeling period that are included as "Present Condition" features in the CPR Model are described in the Draft EIS hydrologic analysis.

2.6 MODEL STRUCTURE

The main Fortran program that is executed when the Central Platte River model is run is called OPSTUDY8. As implied by the name, OPSTUDY8 is a revision of earlier CPR Models (OPSTUDY4, OPSTUDY5, etc.). This main program initializes many of the arrays and model parameters necessary to the model, and then loops through every month of every year of the modeled period, summing the results and creating a number of output files. Along the way, OPSTUDY8 calls various Fortran subroutines which perform specific tasks. From a Platte River system modeling standpoint, the most essential of these subroutines is called COMPUTE, which performs water accounting computations unique to the central Platte River system.

A conceptual flow chart for the OPSTUDY8 program is shown in Figure 2.2. This figure illustrates the general sequence of steps performed by the model, and identifies the name and the purpose of the principal subroutines. Note that a number of different output files are written every time the model is run, and that the content and format of these output files is generally defined within the various "write" subroutines (WRITE1FLOW, WRITE2TAB, etc.) called by OPSTUDY8. The conceptual flow of the all-important COMPUTE subroutine is described in

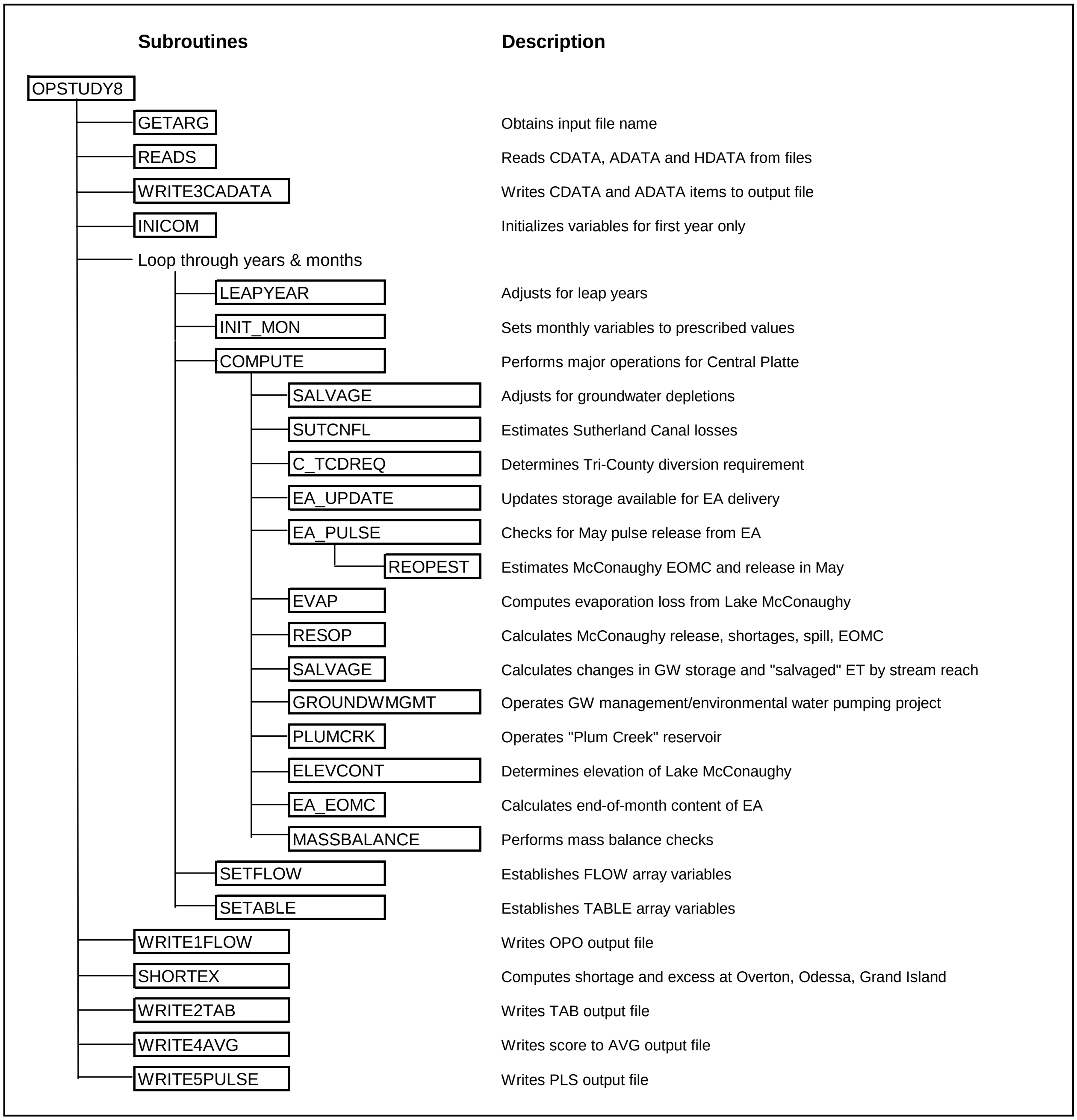


Figure 2.2 Conceptual flow chart for OPSTUDY8 and the subroutines it calls.

Section 2.9 of this document. Further details describing the representation of various central Platte River system elements within this overall modeling framework are provided in Chapters 3 and 4.

Input files required to set up and run the model are discussed briefly below, and described in greater detail in Section 5.2. The output files generated by the model also are summarized below, and described in detail in Section 5.5. All input and output files from OPSTUDY8 are in ASCII text-file format. To simplify their manipulation and interpretation, a number of Excel spreadsheets and macros have been developed to serve as pre- and post-processors for model input and output. These tools are discussed in Sections 5.3 and 5.6.

2.7 INPUT FILES

Two types of files are required at run-time to execute the Central Platte River Model. These are known as the **main input file** (.inp suffix), and the **hydrologic data file** (.inh suffix). These files specify fixed model parameters, parameters that vary on a monthly basis, and monthly hydrologic conditions during the 1947-1994 period. A general description of these files is provided below; a more complete description is provided in Section 5.3 of this document.

Input data provided to the CPR Model are referred to categorically as *ADATA*, *CDATA* and *HDATA* values. **CDATA** variables consist of up to 150 settings establishing the configuration of the alternative being modeled (for example: switches to turn various model options "on" and "off"), and values quantifying specific system characteristics (for example: the capacity of a proposed re-regulating reservoir). **ADATA** values consist of monthly parameters that are presumed to be fixed from one year to the next (for example: monthly unit-area rates of evaporation from Lake McConaughy). **HDATA** values consist of a time series of monthly hydrologic data, such as the 1947-1994 "reconstructed" monthly inflows from the South Platte and North Platte Rivers at Julesburg and at Lewellen. A listing and description of all CDATA, ADATA, and HDATA input variables is included as Appendix A to this document.

The **main input file** (*.inp) is an ASCII text file specifying the name of the input hydrologic data file, and identifying the specific elements to be included in a particular model run. This file also initializes many state variables, and sets acceptable ranges for values representing various components of the accounting model (CDATA values). In addition, this file provides monthly ADATA arrays of values. Information provided by the main input file includes:

- The name of the hydrologic data file to use (see below);
- The years to be modeled (e.g., 1947 through 1994);
- Flags which turn various model components "on" or "off";
- Values to initialize various state variables;
- Minimum and maximum bounds for the model (*e.g.*, minimum and maximum allowable diversion amounts, and minimum and maximum reservoir storage volumes);
- Mean monthly parameter values (*e.g.*, monthly mean lake evaporation rates; mean canal losses);
- "Group" and "line" numbers specifying the information to be written to output files; and
- Summary output table titles and on/off flags.

The **hydrologic data file** (*.inh) is an ASCII file providing monthly time series of hydrologic values ("HDATA") for the period of interest (e.g., January 1947 to December 1994), as required to run the model for the configuration specified by the main input file. These monthly (and annual total) hydrologic data values, which are expressed in units of acre-feet per month, may include:

- North Platte River at Lewellen flows;
- South Platte River at Julesburg flows;
- Birdwood Creek near Hershey historic discharge;
- Historic gains/losses by river reach;
- Irrigation demand by canal system;
- Deliveries from the Lake McConaughy Environmental Account (if any);
- South Platte re-regulation additions/losses (if any);
- Historic canal diversions;
- Lake McConaughy seepage and bank storage;
- Sutherland and Johnson system storage; and
- Colorado conservation water additions/losses (if any).

2.8 OUTPUT FILES

Each run of the OPSTUDY model generates output in the form of various "raw" text files. (Tools have been developed to simplify conversion of these text files into Excel spreadsheets for subsequent analysis and plotting, as will be discussed later). Output files are placed in the \Output directory. They may include files with the following extensions:

.TAB A large number of raw data tables generated by OPSTUDY, such as McConaughy reservoir end-of-month content, elevation, and outflow; end-of-month content at other reservoirs; monthly quantity of water diverted at various locations, etc.

.AVG Minimum/maximum/mean summary tables derived from the .TAB file.

.TXT Same as .TAB files, but in a modified format that is easy to import into a spreadsheet such as Microsoft Excel.

.PLS Short-duration near-bankfull flow calculations (created only if the modeled alternative considers short-duration near-bankfull flows).

.OPO *All* model output, grouped by year.

.PLT Data as formatted for plotting purposes by the original (pre-Platte River study) OPSTUDY routines.

.OST Platte River Project-customized output, formatted to simplify plot generation in Excel.

.GAG Similar to .OST file, except that the results are specific to 14 stream gages along the central Platte. Data expressed in cubic feet per second (cfs).

.GI Customized tables of data extracted from .TAB files. (Note that an explanation of the file parameters and arguments is included at the bottom of this file).

.DAY Daily flows for nineteen locations in the central Platte system and daily storage in the Johnson Lake flow attenuation plan and daily storage in the Central Platte Re-regulatory Reservoir.

.PUL Same data as the .DAY files with the addition of short-duration near-bankfull flow components at each flow location. The short-duration near-bankfull flow components are broken down by source of the flow.

A more detailed description of the content and format of these raw output files (as well as the tools available for converting these files and viewing the results in Excel format) is provided in Section 5.4 of this document.

2.9 CONCEPTUAL FLOW OF THE COMPUTE MODULE

OPSTUDY makes a call to the COMPUTE subroutine each time it steps to another month in the time series. The COMPUTE module is written to simulate the features and operational rules that are specific to the central Platte River system. The general computational steps executed by COMPUTE are described here. The model's representation of individual system elements is described in detail in Chapters 3 and 4.

The CPR Model computations performed by the COMPUTE subroutine can be conceptualized as occurring in three phases:

Phase I. Variables are initialized, and COMPUTE generates a starting estimate for the amount of water Lake McConaughy must release to meet downstream demands. (This estimate is based, generally speaking, on historic demands for water from all of the central Platte system elements downstream from Lake McConaughy).

Phase II. The McConaughy release estimated in Phase I is routed downstream, and the demands exercised upon this water are determined. If shortages are encountered at any point in the Platte River system, the program loops back and re-estimates (increases) the release required from McConaughy to make up for these shortages in the current month. These program loop-backs are repeated as often as necessary to satisfy shortages, or until the water available to meet these shortages is exhausted.

Phase III. Using values from the final Phase II iteration, final computations are made and a general cleanup is performed. At this point, the "true" release volume from Lake McConaughy has been determined, as well as the flow volumes, routing, and consumption of water at each of the downstream nodes. All that remains to be calculated in Phase III is the hydropower generation, which is based on the final dam release and flow volumes. Daily flows are also calculated during this phase of the simulation.

A more detailed, step-by-step description of these three phases follows.

2.9.1 Phase I: Computation of Demands on Lake McConaughy

In the COMPUTE.FOR code, "Phase I" calculations occur in the steps labeled 1 through 55. These steps perform the following operations:

1. **Initialize variables**. (Step 1). This includes settings defined by the input files (such as the starting content of Lake McConaughy), and those set within the COMPUTE routine (such as the spill from Lake McConaughy). Settings for the initialized values are discussed in Section 5.3.
2. **Estimate operational release at Lake McConaughy**. (Steps 2 and 3). Operational releases from the reservoir in each month are based on the hydrologic condition of the reservoir, as described in Section 3.1.
3. **Estimate demands along the North Platte River**. (Steps 4 through 7). In this step, demands on McConaughy storage are estimated from operations along the North Platte between Lake McConaughy and the confluence with the South Platte River. (The principal demands along this stretch of the river are associated with the Keystone Diversion and Sutherland Canal System – see Section 3.2).
4. **Estimate demands along the South Platte River** (Steps 8 through 23). The principal demands along the South Platte between Julesburg and the confluence with the North Platte River are associated with the Western Canal (see Section 3.3) and the Korty Canal (see Section 3.4).
5. **Estimate diversion demands for the Central District Tri-County Canal on the central Platte River** (Steps 24 through 27). The Tri-County Canal system diversion is located on the central Platte River just below the confluence of the North and South Platte Rivers. Representation of the Tri-County Canal system is described in Section 3.6.
6. **Estimate demands on the central Platte River below Brady**. (Steps 28 through 34). In this step, irrigation canal demands are estimated between Brady and Cozad, with adjustments, if necessary, for such features as "Colorado Conservation Water" (Section 4.5).
7. **Determine flows at various points in the central Platte River system** (Steps 35 through 47). In these steps, flows are estimated at various points along the central Platte River (such as instream flow at Overton) and the associated canal system (such as the Jeffrey Hydro return). Also, some additional adjustments are made for central Platte demands (such as irrigation demands along the Kearney Canal) and additions to flow (such as from the North Dry Creek groundwater pumping project).
8. **Estimate demands to meet environmental/wildlife flow targets** (Steps 49 through 52). Estimated instream flow at Overton, Nebraska, is compared against target flows (see Section 4.2). If appropriate, the additional releases required to meet targets are added to the demand on McConaughy.
9. **Make additional adjustments**. (Steps 53 through 55). COMPUTE makes further adjustments for canal losses and EA pulse flow releases (see Section 4.3).

By the end of all Phase I calculations, values for Lake McConaughy's monthly release, shortage, spill, and end-of-month content have been estimated. These estimates are modified in Phase II of the COMPUTE subroutine.

2.9.2 Phase II – Routing of Flows and Accounting for Demands

In Phase II, estimated releases from Phase I are routed through the Platte River system, and demands are re-calculated. Releases from McConaughy are adjusted with each loop through Phase II, and the COMPUTE program continues to loop as many times as necessary to either satisfy calculated shortages for the current month, or exhaust available water to meet these shortages. Phase II steps are labeled as number 57 through 101. They include the following:

1. **Add Wyoming EA and Colorado EA water to McConaughy** (Step 57). For the first loop through Phase II only, COMPUTE adds water provided by Wyoming and Colorado to the Environmental Account at Lake McConaughy (see discussion in Section 4.1).
2. **Compute Lake McConaughy release, shortage, spill and new end-of-month content.** (Steps 58 through 63).
3. **Re-compute demands along the North Platte River**. (Steps 64 through 71).
4. **Re-compute demands along the South Platte River** (Steps 72 through 76).
5. **Re-compute demands associated with the Central District Tri-County Canal on the central Platte River** (Steps 77 through 88).
6. **Re-compute demands on the central Platte River below Brady**. (Steps 89 through 95). This includes wildlife release demands.
7. **Re-compute flows at various points in the central Platte River system** (Steps 96 through 99).
8. **Make adjustments (if appropriate) for Groundwater Management Project, Power Interference Project, and Central Platte Re-Regulating Reservoir Project.** (Steps 100 through 101). Each of these projects (if included in this particular model run) may add to Platte River flows. Representation of these three projects in the Central Platte River Model is described in Sections 4.7, 4.8, and 4.10.

At the end of Phase II calculations, final downstream demands on Lake McConaughy have been determined (as opposed to the initial release estimates from Phase I).

2.9.3 Phase III – Final computations and setup for Next Month's Calculations

In Phase III, COMPUTE performs various summary calculations, final calculations, and setup calculations to initialize conditions for the next month's analysis in the model. These steps include the following:

1. **Compute hydro-electric power generation** (Step 102). The amount of power generated by the Sutherland North Platte, Jeffrey, Johnson, and Kingsley hydropower plants are calculated. (See Section 3.10)**.**
2. **Update McConaughy conditions.** (Steps 103 and 104). The surface acreage, elevation, and Environmental Account storage volume of McConaughy are updated.
3. **Perform mass-balance checks** (Step 105). The subroutine MASSBALANCE performs a mass-balance check for streamflow at Duncan, content at Lake McConaughy, and content at the Central Platte Re-Regulating Reservoir.
4. **Determine end-of-month-contents at various reservoirs** (Step 106). End-of-month contents are calculated for McConaughy, Elwood, Sutherland, and Johnson Lakes.

5. **Compute the daily flows and Update peak and pulse flow variables** (Step 107). COMPUTE calls the subroutine DAILY to compute daily flows for the month, distributes pulse flow volumes, operates the Central Platte Re-regulating Reservoir, and operates the Johnson Lake flow attenuation plan. COMPUTE also tracks the peak flow and pulse flow releases (if any) for the current year.

2.10 SCORING OF ALTERNATIVES

For the purpose of the Platte River Recovery Program, various river management alternatives are evaluated and compared, in part, by determining the extent to which they will contribute toward reductions in shortages to target flows in the central Platte River. For this reason, a post-processor assigns a "score" to the CPR Model output. This score expresses the total amount (in thousands of acre-feet) by which the modeled scenario reduces the estimated shortage to target flows at Grand Island, Nebraska relative to the estimated "Present Condition" shortage to target flows on an average annual basis. For example, a score of 50.0 indicates that the modeled scenario reduces the annual average estimated shortage to target flows at Grand Island by 50,000 acre-feet. The higher the score, the more desirable the modeled scenario from the perspective of providing improved flow conditions for the target species of the central Platte River.

An additional distinction is made within the model between the "**raw score**" and the "**adjusted score**". The latter refers to the score after various adjustments have been made based on specific aspects of the proposed management action. For example, because the proposed North Dry Creek groundwater pumping project (see Section 4.8) is located midway through the Big Bend reach (rather than above the reach), its contribution to the final score is reduced by 50%; conversely, the Central Platte Re-regulating Reservoir (see Section 4.5) would have added value because of its ability to regulate flows on a daily rather than monthly basis.

To obtain the "raw" score, monthly flow volumes in acre-feet simulated for the Present Condition and any alternatives are sorted from the highest flow volume to the lowest flow volume for each month. The sorted flow volumes are compared to the flow volumes calculated from the FWS flow recommendations. If the simulated flow volume is less than the flow volumes calculated from the FWS flow recommendations, the difference is the shortage to target flows. The sum of these differences is the total shortage to target flows for the simulation. The shortage to target flows for an alternative minus the shortage to target flows for Present Condition is the "raw" score.

Adjustments are made to the "raw" score to obtain the score for the alternative. These adjustments include reducing the score for water delivered via the North Dry Creek Kearney cutoff, increasing the score for the Dawson and Gothenburg recharge project, increasing the score for water released from the Central Platte Re-regulatory Reservoir, increasing the score for water released from Lake McConaughy for short-duration near-bankfull flow events, increasing the score for water not diverted at the Tri-County Canal headgate during short-duration near-bankfull flow events, and increasing the score for other Program flows.

The North Dry Creek Kearney cutoff enters the Platte River approximately in the middle of the critical reach of the Platte River (Lexington to Chapman). Therefore, any flows provided by the

North Dry Creek Kearney cutoff are given one-half credit because the flows only flow through approximately half of the critical reach. This is calculated by dividing the flows provided by the North Dry Creek Kearney cutoff by two.

The Dawson and Gothenburg recharge project was not simulated for the FEIS. Instead, the project was given full credit for the flows estimated in the Boyle report. This increases the score by 2 (2,000 kaf).

The Central Platte Re-regulatory Reservoir is operated using the daily flows calculated by the OPSTUDY model. The daily flows are calculated and the Central Platte Re-regulatory Reservoir is operated after the monthly flow calculations have been performed. The model then reports water stored and released in/from the reservoir. The net value (release minus storage) is the amount that shortages to FWS flow recommendations were reduced. This represents an improvement towards meeting the FWS flow recommendations in excess to the "raw" score that was calculated. This is the amount that the Central Platte Re-regulatory Reservoir is contributing to reductions to shortages.

Water released from Lake McConaughy for short-duration near-bankfull flow events is not included in the "raw" score calculation. The FWS has stated that any water released from Lake McConaughy for short-duration near-bankfull flow events will be credited towards score. Therefore, water released from Lake McConaughy for short-duration near-bankfull flow events is added to the "raw" score.

Water not diverted at the Tri-County Canal headgate during short-duration near-bankfull flow events is treated the same as water released from Lake McConaughy for short-duration near-bankfull flow events. This is water that CNPPID could divert, but does not in order to increase the amount of water that reaches Overton during short-duration near-bankfull flow events. Other changes to system operations such as using Johnson Reservoir to increase short-duration near-bankfull flow events are also part of the adjusted score.

Other Program flows are Program contributions (releases) greater than the flows under Present Condition and are above dry FWS flow recommendation, are less than the FWS average and wet flow recommendations. The purpose of this addition to score was to not penalize the Program because the EA operator released water to satisfy the wet or average flow recommendation during a dry year or what turned out to be a dry year.

These adjustments to the score are presented in a table on the 'Alt EA' tab/sheet of the Score4794.xls spreadsheet.

CHAPTER THREE

REPRESENTATION OF HISTORIC SYSTEM ELEMENTS

This section describes how historic or "existing" components of the Central Platte system (as opposed to hypothetical or proposed future components) are represented within the OPSTUDY accounting model.

3.1 LAKE MCCONAUGHY AND KINGSLEY HYDROELECTRIC DAM

Lake McConaughy, which is impounded behind Kingsley Dam in Nebraska, is the largest reservoir on the North Platte River, and the largest reservoir in the Central Platte River Model. Construction of Kingsley Dam began in 1938 and was completed in 1941 by the Central Nebraska Public Power and Irrigation District (CNPPID) as part of a massive irrigation and power generation project. At full storage, the dam contains as much as 1,743,100 acre-feet of water covering approximately 31,000 acres. The lake is 21 miles long, about 3-1/2 miles wide for a considerable distance from the dam, and approximately 140 feet deep near the dam. A structure called the "Morning Glory Spillway" allows release of water from the reservoir if it is at a level greater than 1427.4 feet MSL. In the 1980s, a single-turbine hydroelectric power generation facility was constructed at Kingsley Dam with a nominal power generation capacity of 50 megawatts. Water for this turbine is provided from the reservoir through a 19-foot-diameter penstock.

Lake Ogallala, immediately below Kingsley Dam, was created by the removal of earth for construction of the dam and the construction of the diversion structure which directs water into the Sutherland Canal. The primary purpose of Sutherland Canal is to divert cooling water to the Gerald Gentleman power generation station and to provide water for hydroelectric power generation at the North Platte hydroelectric plant. Lake Ogallala occupies about 500 surface acres and inundates about 1-1/2 miles of North Platte River channel. It currently serves as a reregulation facility for discharges from Lake McConaughy.

Lake McConaughy and the Kingsley Hydroelectric Dam are major features of the Central Platte River Model, not only because of their importance for regional water and energy supplies, but also because of their potential to store runoff suitable for later instream releases to the Central Platte River. Specifically, an "Environmental Account" (EA) has been established at Lake McConaughy for the purpose of storing water earmarked for later release for instream flow augmentation to benefit of listed species habitat conditions.

Representation of Lake McConaughy and Kingsley Dam in the Central Platte River Model includes variables for tracking the monthly state of the reservoir, electrical power generation at Kingsley Dam, operational releases from Lake McConaughy, spills from the reservoir, evaporative losses from the reservoir, and releases from the Howell-Bunger valve (through which released water bypasses the hydroelectric generator).

OPSTUDY variables associated with Lake McConaughy and Kingsley Dam (units are in acre-feet, unless otherwise noted)	
CONMAX	Maximum content for Lake McConaughy.
EAEVAP	Evaporation from the Environmental Account at Lake McConaughy.
EOMC	End-of-month content in Lake McConaughy.
EOMLST	End-of-month content for the previous month.
HYOUT	Flow through the Kingsley Dam turbine.
MACDMD	Total demand on Lake McConaughy storage.
MACELEV	Water surface elevation at McConaughy Lake (feet MSL).
MACGEN	Kingsley hydropower generation (kilomegawatt-hours).
MACHEAD	Head at the dam (in feet) between the surface of the tailwater and the McConaughy Lake surface (MACELEV – 3125.0).
MACOUT	Total outflow from McConaughy, including release and spill.
MACREL	Operational releases from Lake McConaughy.
MNGSPL	Spilled volume from the Morning Glory Spillway.
REVAP	Evaporative losses from Lake McConaughy.
RSEEP	Reservoir seepage.
SPILL	Spill releases from Lake McConaughy.

OPSTUDY variables associated with the Howell-Bunger release valve (units are acre-feet unless otherwise noted)	
HWJPER	Proportion of July-Sept Howell-Bunger release allocated to July.
HWAPER	Proportion of July-Sept Howell-Bunger release allocated to August.
HWSPER	Proportion of July-Sept Howell-Bunger release allocated to September.
HWLBUNGR(12)	Array of monthly releases from the Howell-Bunger valve.
HWLCONS	Y-intercept value for lake elevation/valve release linear relationship.
HWLOUT	Howell-Bunger release volume.
HWLSLOP	Slope value for lake elevation/valve release linear relationship (dimensionless).

3.1.1 Lake McConaughy Operational Releases

"Operational releases" from Lake McConaughy refer to discretionary releases made from the lake for various purposes, including power generation, canal maintenance, and meeting downstream irrigation demands. The operational plan at Lake McConaughy involves maximizing storage for irrigation purposes while also maximizing releases for hydropower generation from the available water supply. Thus, potentially conflicting objectives are weighed to reach an operational release decision. OPSTUDY simulates this decision-making by using release rules based on historical release practices, though it should be noted that human operators are not restrained by these rules in making actual operational release decisions. Operational releases are calculated for Lake McConaughy only if the operational rules flag (*CONHYDR*) is turned on (*i.e.*, set equal to 1). This flag is set as CDATA item #3.

OPSTUDY estimates monthly operational releases based on storage conditions in the reservoir (for October through March calculations), and also based on projected April-through-July inflows to the reservoir (for April though September calculations). The projected April-through-July inflow is derived from North Platte River discharge at Lewellen over these four months (*FOURINF*). Storage contents in McConaughy Reservoir at the end of September and the end of March are tracked by the variables *EOMSEPT* and *EOMMAR*, respectively.

Five possible hydrologic conditions of the lake are recognized by OPSTUDY for the purpose of determining operational releases: "very high", "high", "normal" (also referred to as "transitional"), "low", and "very low". Different release rules are established for each of these conditions, to reflect various reservoir management imperatives and downstream demands. The definition of these five hydrologic conditions at Lake McConaughy is as follows:

Table 3.1 Calculation of McConaughy monthly "Hydrologic Condition".

Hydrologic Condition	October through March	April through Sept
Very High (Condition = 1)	EOMSEPT > FALLVH	(EOMMAR + FOURINF) > SPRINGVH
High (Condition = 2)	EOMSEPT > FALLHI	(EOMMAR + FOURINF) > SPRINGHI
Normal (Condition = 3)	EOMSEPT > FALLNO	(EOMMAR + FOURINF) > SPRINGNO
Low (Condition = 4)	EOMSEPT > FALLLO	(EOMMAR + FOURINF) > SPRINGLO
Very Low (Condition = 5)	EOMSEPT > FALLVL	(EOMMAR + FOURINF) > SPRINGVL
Very Low (Condition = 5)	EOMSEPT <= FALLVL	(EOMMAR + FOURINF) <= SPRINGVL

Winter Releases

In OPSTUDY, the amount of water released during the non-irrigation season (October through March) depends on the end-of-September content of Lake McConaughy. The comparison volumes for October through March (*FALLVH, FALLHI*, etc.) are defined in the input file by CDATA values #23 through #27. April through September comparison volumes (*SPRINGVH*, etc.) are defined by CDATA values #28 through #32. For model runs, these values were set as follows:

	EIS Alternatives	Reference Condition
FALLVH	1,400,000 acre-feet	1,600,000 acre-feet
FALLHI	1,300,000 acre-feet	1,450,000 acre-feet
FALLNO	1,000,000 acre-feet	1,200,000 acre-feet
FALLLO	800,000 acre-feet	900,000 acre-feet
FALLVL	500,000 acre-feet	600,000 acre-feet
SPRINGVH	2,000,000 acre-feet	2,800,000 acre-feet
SPRINGHI	1,600,000 acre-feet	1,950,000 acre-feet
SPRINGNO	1,200,000 acre-feet	1,700,000 acre-feet
SPRINGLO	1,000,000 acre-feet	1,400,000 acre-feet
SPRINGVL	800,000 acre-feet	1,000,000 acre-feet

The storage-condition levels for the reference condition differ from those for the EIS alternatives in order to produce roughly the same release from Lake McConaughy, thus allowing power production to remain roughly the same during the winter (when power is more valuable due to market conditions). These values are based on a calibration of the model against historic releases from Lake McConaughy.

Summer Releases

Modeled releases from Lake McConaughy to satisfy downstream demands during the summer are based on a number of factors, including:

- Demands downstream of Lake McConaughy;
- Gains (or losses) downstream of Lake McConaughy;
- South Platte flows;
- Releases from downstream reservoirs, and
- The month of the year.

The operating criteria for June-through-September releases are heuristics that vary from month to month and were determined through a combination of regression analysis and model calibration. These hueristics are detailed by Stroup (2004).

3.1.2 Lake McConaughy Evaporative Losses

Evaporative losses from the surface of Lake McConaughy are calculated by the subroutine EVAP, which assigns a monthly evaporation estimate to the variable *REVAP*. EVAP first estimates a new end-of-month reservoir content assuming no evaporation loss. It then determines the average reservoir content for the month (*i.e.*, the mean of the beginning- and the end-of-the-month storage values), and computes the mean reservoir surface area using a reservoir area-capacity curve. The area-capacity curve is an exponential curve of the form:

$$(3.1) \quad \text{Area} = \text{CA} * \text{Capacity}^{\text{CB}}$$

where:

Area is the water surface area in thousands of acres;
Capacity is the reservoir storage in thousands of acre-feet; and
CA and ***CB*** are empirically-derived multiplier and exponent values, respectively.

In the case of Lake McConaughy, the *CA* and *CB* values are provided to the model via CDATA values 13 and 14, respectively. The values used for Lake McConaughy in all OPSTUDY alternatives analyses are 0.43237 for *CA*, and 0.58035 for *CB*. These values were derived by FWS by fitting curves to data in a detailed reservoir elevation/volume/surface area table created October 1, 1989 (this table, in turn, was derived from a capacity table dated March 1, 1987).

Evaporation loss for the month is calculated as the mean reservoir area times the net lake evaporation rate. The process is repeated once by subtracting the first estimate of evaporation from the original estimate of the end-of-month reservoir content to compute a new end-of-month content, a new average content for the month, and a new evaporation loss. The estimated evaporation loss derived from this second iteration is retained for the model simulation.

The net monthly unit-area lake evaporation rate at Lake McConaughy is based on estimates determined during Platte River Memorandum of Agreement negotiations, as follows (units are feet per month):

JAN	FEB	MAR	APR	MAY	JUN	JUL	AUG	SEP	OCT	NOV	DEC
0.058	0.078	0.119	0.168	0.182	0.237	0.426	0.408	0.254	0.195	0.106	0.05

3.1.3 Lake McConaughy Surface Elevation

The elevation of Lake McConaughy's surface is calculated by the subroutine ELEVCONT, which assigns the estimated elevation (as feet above mean sea level) to the variable *MACELEV*. ELEVCONT estimates the elevation based on the use of an elevation-content table developed for Lake McConaughy by CNPPID. This table consists of 29 paired values between 3131.0 and 3270.0 feet MSL elevation and 100 and 1,900,600 acre-feet of corresponding reservoir content. ELEVCONT uses linear interpolation to estimate elevation values between these calibration points.

3.1.4 Lake McConaughy End-of-Month Content

The end-of-the-month content of Lake McConaughy is estimated by the subroutine RESOP. The end-of-month content value is a simple mass-balance calculation, as follows:

(3.2) EOMC = PEOMC + INFL – REVP – SEEP - DEMAND

where:

EOMC is the end-of-month content;
PEOMC is the previous end-of-month content;
INFL is inflow for the month;
REVP is reservoir evaporation for the month;
SEEP is reservoir seepage/bank storage for the month; and
DEMAND is demand on the reservoir.

In OPSTUDY, **reservoir seepage/bank storage** at McConaughy is represented by the variable *RSEEP*, whose values are provided by HDATA item #26. Monthly estimates of seepage/bank storage for Lake McConaughy in HDATA were developed by the U.S. Department of the Interior, based on a mass-balance evaluation of historic lake inflows and outflows. Specifically, this quantity was calculated as:

(3.3) SEEP = Outflow - Inflow + Change in storage + Evaporation

"Seepage" or accretion into Lake McConaughy corresponds to a positive value for the month, and "bank storage" corresponds to a negative value (i.e., water moves out of the lake into adjacent groundwater storage). In reality, SEEP also includes any measurement errors inherent in the mass-balance equation, such as errors in streamflow measurement. For Central Platte River Model runs, SEEP values for the years 1947-1994 were determined through an analysis referred to as "Central Platte Hydrology Run 5", or CPH5. In that analysis, records of the U.S. Geological Survey and the Nebraska Department of Water Resources provided historic inflow and outflow data for the McConaughy calculations.

Evaporative losses from the lake have already been discussed above. The **demand on the reservoir** is calculated iteratively within the COMPUTE subroutine by summing the cumulative downstream demands from other components of the model, as discussed in the rest of this section.

3.1.5 Lake McConaughy Spills, Releases, and Shortages

Estimated spill, release, and shortage at Lake McConaughy is also estimated by the subroutine RESOP. The term "spill", as used here, refers to any release from Lake McConaughy in excess of the operational release and other releases required to meet downstream demands. Normally, a "spill" is made to manage water levels in Lake McConaughy. There are two kinds of "spill" from the lake: (1) spill from the hydroelectric turbines, and (2) unutilized spill from the Morning Glory spillway. RESOP does not distinguish between these two kinds of spill, but treats them as a single aggregate spill value. "Release" refers to *any* releases that are made for downstream purposes (as opposed to spills made to manage levels in the reservoir). "Shortage" refers to cases in which the end-of-month content of the reservoir is less than the amount of Environmental Account water that is hidden in dead storage to prevent its diversion for other uses.

If the *EOMC* from Equation (3.2) is greater than the maximum allowed reservoir end-of-month content (*CONMAX*) for that month, then:

- Spill is calculated as the *EOMC* minus *CONMAX*;
- *EOMC* is set to the maximum allowed reservoir content;
- Release is equal to the total reservoir demand; and
- Lake shortage is set to zero.

If the EOMC from Equation (3.2) is less than the amount of water stored in the Environmental Account (EA), then:

- Spill is zero;
- Shortage is the amount of water in the EA account minus the *EOMC*;
- Release is equal to the total demand on the reservoir minus the shortage;
- If no water is available for release, then EA water is added to the *EOMC* to address the reservoir shortage;
- If *EOMC* is zero, then the EA account is set to zero.

Otherwise,

- Spill is zero;
- Shortage is zero; and
- Release is equal to the total demand on the reservoir.

Monthly groundwater inflow to Lake McConaughy is estimated to be 3,600 acre-feet per month (CNPPID/NPPD, 1988).

The maximum end-of-month content in Lake McConaughy (*CONMAX* values, in units of thousands of acre-feet) is summarized in Table 3.2. The original design capacity of the reservoir was 1,948,000 acre-feet. Prior to 1974, CNPPID considered 1,916,500 (elevation 3269.0 MSL) to be "full" (CNPPID, 1989). However, following damage occurring at Kingsley Dam during a May 1, 1972 windstorm, consultants recommended reducing the elevation of the lake during high-risk periods for major windstorms (March 1 to May 15, and October 1 to December 31). On this basis, the maximum content of McConaughy was reduced to 1,743,000 acre-feet, and the monthly maximums were established in consultation with FERC as shown in Table 3.2.

Table 3.2. Maximum EOMC in Lake McConaughy (thousands of acre-feet)

JAN	FEB	MAR	APR	MAY	JUN	JUL	AUG	SEPT	OCT	NOV	DEC
1743.1	1668.6	1594.1	1609.1	1743.1	1743.1	1743.1	1743.1	1668.6	1594.1	1594.1	1594.1

3.2 KEYSTONE DIVERSION AND SUTHERLAND CANAL SYSTEM

Keystone Dam is a major diversion facility located just below Kingsley Dam. It directs cooling waters toward the Gerald Gentleman Station power plant via the Sutherland Canal system, and it also supplies the hydraulic head for the North Platte Hydropower Plant. Keystone Dam was originally constructed in 1934-35, and extensively remodeled in 1982 as part of the Kingsley hydropower facility development. The North Platte Hydropower Plant was established in 1934-1936.

Keystone Dam sends the majority of the North Platte River water through the Sutherland Supply Canal; flows in the North Platte River channel are greater than canal flows only during times of high releases from Kingsley Dam. The capacity of the Sutherland Canal is approximately 2,000 cfs. Several facilities are associated with the Sutherland Canal and are operated in coordination with one another. These include the Sutherland Reservoir, Maloney Reservoir, and the Korty Canal.

Gerald Gentleman Station, located near Sutherland, is Nebraska's largest power generating plant. It is operated by the Nebraska Public Power District (NPPD) and consists of two coal-fired generating units. Together, these units have the capability to generate 1,365 megawatts of power. Cooling water for the Gerald Gentleman power generation plant is drawn from the 3,000-acre Sutherland Reservoir and/or the inlet canal to this reservoir.

The North Platte Hydropower Plant, located near North Platte, Nebraska, has a hydropower generating capacity of 24 megawatts. The hydropower plant is fed by a two-mile-long power canal that conveys water from 1,650-acre Lake Maloney regulating reservoir. Water passing through the hydropower plant returns to the South Platte River, near North Platte, Nebraska, via the North Platte return.

OPSTUDY variables associated with the Keystone/Sutherland system (units are acre-feet, unless otherwise noted)	
HISKEY	Historic Keystone diversion.
KEYSDMD	Keystone storage demand (sum of the on-stream demand below Keystone plus the Sutherland Canal demand at Keystone).
KTKYMIN	Flow required below the point where the Korty diversion joins the Keystone diversion in the Sutherland Canal.
SCCAP	Sutherland Canal capacity.
SCDV	Sutherland Canal diversion.
SCMIN	Minimum flow in Sutherland Canal below Keystone diversion, in cfs (required primarily for maintenance of the siphon under the South Platte River).
SRCHNG	Change in storage in Sutherland Reservoir.
SREOMC	Sutherland Reservoir (previous) end-of-month content.
SRTARG	Sutherland Reservoir target end-of-month content.
SSDMD	Sutherland System demand.
SSDMDOLD	Sutherland System demand in previous iteration.
SSINCRS	Increase in the Sutherland canal flow to bring the flow up to the Minimum canal flow requirement set in the input file.
SSLOSS	Intercept of the loss function for the Sutherland Canal system.
SSLOSS1	Sutherland Canal loss.
SSLOSSM	The maximum potential loss in the Sutherland System assuming the North Platte Hydro is at capacity and the change in Sutherland Reservoir content SRCHNG.
SSLOSSLP	The slope of the loss function for the Sutherland canal system.
SUTHDMD	Irrigation demand for the Sutherland-North Platte irrigation canals.
SUTHVHREL	Discretional Sutherland diversions under “very high” reservoir conditions.
SUTHHIREL	Discretional Sutherland diversions under “high” reservoir conditions.
SUTHNOREL	Discretional Sutherland diversions under “normal” reservoir conditions.
SUTHLOREL	Discretional Sutherland diversions under “low” reservoir conditions.
SUTHLVREL	Discretional Sutherland diversions under “very low” reservoir conditions.

Setting Sutherland Canal Flows

Flow in the Sutherland Canal is modeled in COMPUTE by (1) meeting minimum flow requirements for the Sutherland Canal; (2) meeting additional demand required at the Sutherland Reservoir; (3) meeting additional demand required by the irrigation canals below the system; and (4) adding additional discretional water (if any) released from storage at Lake McConaughy because of high storage levels. The model also compensates for Sutherland Canal losses.

With regard to **minimum flows**: a certain level of minimum flow is required to maintain the Paxton Siphon under the South Platte River. Monthly minimum flow values are set in the input file by the *SCMIN* value or by ADATA value array #15. For most modeled scenarios, the minimum flows for all months were set to 0 cfs. The minimum Sutherland Canal flow is set to *SCMIN* if the storage in Lake McConaughy (*EOMLST*) is above the level set for minimum Sutherland Canal flows (*SCMAC* or CDATA value #54). *SCMIN* will be the maximum of the minimum flow required below Keystone (*SCMIN* or ADATA value #15) and any combined

Keystone diversion plus Korty diversion minimum flow (*KTKYMIN*) not satisfied by the Korty diversion (*KTKYMIN - KORTYAV* /*CFS*). The minimum flow in the Sutherland Canal is controlled by Lake McConaughy Operational Releases (section 3.1.1) and the values contained in the Cooperative Agreement (section 4.1).

The cooling needs of Gerald Gentleman station must be met by maintaining adequate water levels at **Sutherland Reservoir**. The model determines this demand by calculating the deficiency (if any) between the target end-of-month content for Sutherland Reservoir (as specified in the input file by HDATA array #27), and the previous end-of-month content of the reservoir.

Canal diversions are satisfied (if so specified by a flag in the model) by raising the Sutherland Canal system demand to match historic diversion quantities at Keystone. This is done only if the Sutherland demand is not already at the requisite level, and only if there is sufficient content in Lake McConaughy, that is: a volume greater than that specified by the *LOHISTRIG* variable in the code. Historic diversions at Keystone are defined by HDATA array item #23.

Discretional operational diversions at Keystone (*SSDMD*) are set based on conditions at Lake McConaughy. Specifically, conditions at McConaughy are classified into one of five categories ("very high", "high", "normal", "low" or "very low") based on lake content and (in certain months) expected inflow to the lake (this information is stored in the *CONDITION* variable; see the *McConaughy Operational Releases* discussion under Section 3.1.1). The Sutherland system demand is then raised to the historic amount defined for that flow condition (*SUTHVHREL*, *SUTHHIREL*, *SUTHNOREL*, *SUTHLOREL*, *SUTHVLREL*, or *SUTHELREL*, respectively), if the demand does not already meet or exceed that level.

Finally, **Sutherland canal losses** are estimated by the SUTCNFL subroutine. Sutherland canal losses are calculated as a linear function of flow in the Sutherland Canal, as follows:

(3.4) Estimated loss = (SSLOSSLP * SCDV) + SSLOSS

where:

SSLOSS is the "fixed" loss (y-intercept) for the linear flow/loss function;
SSLOSSLP is the slope of the linear flow/loss function; and
SSDV is the Sutherland Canal diversion at Keystone.

For the OPSTUDY model, the values of *SSLOSS* and *SSLOSSLP*, which vary by month, are set in the input file as ADATA value arrays #20 and #21. These monthly values were calculataed during the FERC relicensing process. Losses are actually estimated in two iterations. Values from the first iteration ("Phase I") are recalculated in the second iteration ("Phase II"). For all of the OPSTUDY modeled alternatives, the following values were used for calculating flow/loss relationships:

Table 3.3. Sutherland Canal Loss Function Intercept and Slope Values

Sutherland System Loss Function Intercept (KAF/MO)

JAN	FEB	MAR	APR	MAY	JUN	JUL	AUG	SEPT	OCT	NOV	DEC
11.184	7.509	9.639	9.06	14.337	16.836	-5.436	-6.104	6.449	13.102	12.037	11.218

Sutherland Canal Loss Function Slope (dimensionless)

JAN	FEB	MAR	APR	MAY	JUN	JUL	AUG	SEPT	OCT	NOV	DEC
0.01552	0.05502	0.05129	0.05349	0.00109	0.0504	0.25248	0.21665	0.08707	0.01181	0.00632	0.02544

The SUTCNFL subroutine also verifies that the Sutherland canal diversions do not exceed the capacity of the Sutherland canal. If the capacity of the canal is exceeded (*i.e.*, if *SCDV* is greater than *SCCAP*), then the "flow available at the Korty diversion" (*KORTYAV*) is reduced by the amount that the diversion exceeds capacity, and the diversion is set equal to capacity.

Adjustments are also made to the Sutherland Canal diversions to reflect requirements imposed by implementation of the "Nebraska Plan" Environmental Account. These adjustments are described in Section 4.1 of this report.

3.3 WESTERN CANAL DIVERSION

The Western Canal is located in Nebraska, and it diverts South Platte River water shortly downstream from the Colorado/Nebraska state line, providing this water for irrigation uses in the South Platte River valley. Return flows from the Western Canal (if any) enter the South Platte River downstream from the point of diversion prior to the Korty Canal diversion.

OPSTUDY variables associated with the Western Canal.
(Units in acre-feet, unless otherwise noted)

IRRGREDWC	Western Canal irrigation reduction flag (1.0=no conservation, <1.0 equals conservation).
WCDM	Western Canal demand.
WCDV	Western Canal diversion.
WCIRSAV	Western Canal irrigation savings.
WCSHORT	Western Canal shortage (demand minum diversion).

The demand for Western Canal water is determined on the basis of historic Western Canal irrigation demands, as provided by HDATA array item #16. The Western Canal diversion (*WCDV*) is equal to the demand (*WCDM*), unless South Platte River flow at Julesburg is insufficient to meet demand, in which case it is set to the South Platte River flow. If irrigation savings from water conservation practices are taking place along the Western Canal system (*i.e.*, if the *IRRGREDWC* flag is on), then conservation savings (*WCIRSAV*) are also calculated so that this water may quantified and "protected" from further diversions within the OPSTUDY model.

3.4 KORTY CANAL DIVERSION

The Korty Canal diversion is located on the South Platte River six miles west of Paxton, Nebraska. The canal capacity is approximately 1,100 cfs. The canal was constructed in 1945-1946. This canal joins the Keystone Diversion/Sutherland Canal system after 7.4 miles, at a point approximately 10 miles upstream from Sutherland Reservoir and the Gerald Gentleman station. There are no diversions or agricultural uses of water along the Korty Canal before it meets the Keystone Diversion/Sutherland Canal system.

OPSTUDY variables associated with the Korty Canal
(units in acre-feet, unless otherwise noted)

KCCAP	Korty Canal capacity.
KCDV	Korty Canal diversion.
KORTY	South Platte River flow at Korty.
KORTYAV	Flow available at Korty.
KTEF	Korty Diversion efficiency (a measure of how much flow in the South Platte River at Korty can be diverted into the Korty Canal). Scale of 0.0 (0 percent efficiency) to 1.0 (100 percent efficiency).
KTEFFLG	Flag (1.0 or 0.0) to calculate a diversion efficiency (KTEF) ; values other than zero for KTEFFLG result in the use of the constant percent efficiency value specified in the input file (CDATA item #56).
KTPROT	Flag (1.0 or 0.0) to "protect" Colorado Conservation water (*CONSCO*) from diversion past the Korty canal. (1 to protect, 0 to not protect).

In OPSTUDY, a "diversion efficiency" (*KTEF*) is first determined at Korty, to identify the proportion of flow in the South Platte River that can be diverted into Korty Canal. If the *KTEFFLG* value in the input file (CDATA value #55) is set equal to 0.0 then the monthly diversion efficiencies are calculated as described below; any other *KTEFFLG* value results in the use of a constant value specified in the input file (CDATA value #56). Diversion efficiency calculations triggered by a *KTEFFLG* value of 0.0 are as follows: if the flow in the South Platte at Korty is less than or equal to 14,400 acre-feet per month, then KTEF is set to 1.0 (100%). Otherwise, *KTEF* is set using these formulas:

$$\text{(3.5a)} \quad KTEF = (0.7112 * KORTY - 0.0024*KORTY**2) / KORTY$$

$$\text{(3.5b)} \quad KTEF = (0.4375*KORTY+7.5) / KORTY$$

where *KORTY* is the physical flow in the South Platte River at Korty in acre-feet per month. Equation 3.5a is for monthly flow volumes between 14,400 acre-feet and 40,000 acre-feet per month. Equation 3.5b is for all other flows. This diversion efficiency formula is based on the analysis of historic monthly flows and diversions at Korty from 1970 to 1994, from which three lines approximating the bounds of the flow/diversion relationship were estimated; see Figure 3.1.

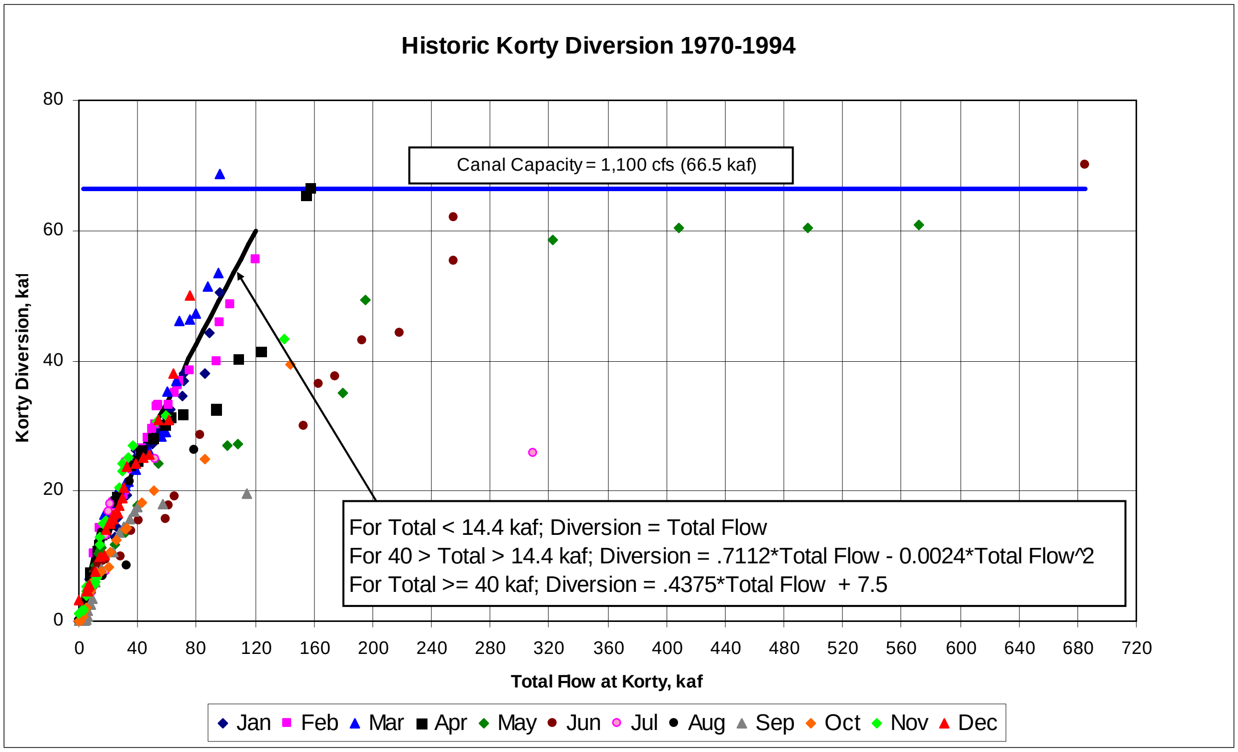


Figure 3.1 Historic monthly flows and diversions at Korty from 1970 to 1994, and approximated flow-diversion relationships.

The amount of water diverted into Korty Canal cannot exceed the remaining capacity of the Sutherland Canal. In the OPSTUDY model, the remaining capacity of the Sutherland Canal is calculated by determining the amount of additional flow which will fill the Sutherland Canal system, and subtracting from this the amount of flow already provided by the Keystone diversion.

The model assumes the Sutherland Canal prefers water from the Keystone diversion because it has less sediment and requires less canal maintenance. This is only if the water is being released from Lake McConaughy for other purposes. The model takes full advantage of diversions at Korty for producing power at the North Platte Hydropower plant.

The water diverted at Korty and the water diverted at Keystone are then summed to track the total Sutherland Canal diversion (*SCDV*).

3.5 BIRDWOOD CREEK

Birdwood Creek enters the North Platte River approximately 10 miles upstream of North Platte, Nebraska. The flow contribution of Birdwood Creek is provided as an external boundary condition to the model, based on historic Birdwood Creek flows as quantified by HDATA array item #3. In the real world, a portion of Birdwood Creek flows may be diverted to Birdwood Canal for irrigation purposes. In OPSTUDY, any such diversions to Birdwood Canal are reflected by reduced historic flows measured at the Birdwood Creek gage, which is below the

Birdwood Canal diversion. Thus, Birdwood Canal demands are not explicitly modeled. Any return flows from water usage along the Birdwood Canal would be reflected in the model as North Platte River gains between Sutherland and North Platte (see Section 2.2.2).

3.6 TRI-COUNTY (CENTRAL DISTRICT) CANAL DIVERSIONS

The CNPPID Diversion Dam at Maxwell, Nebraska, sends the majority of Platte River water through the Tri-County canal. Normally, canal flows are greater than flows in the Platte River channel except during times of high river flow. This supply canal is divided into two sections: (1) the “Jeffrey Section”, which runs from the canal headgate (mile 0.0) to the Jeffrey Return to the Platte River (mile 26.9), and (2) the “Johnson Section”, which runs from the Jeffrey Return to the Johnson Return to the Platte River at mile 75.5. The canal has a capacity of approximately 2,250 cfs, the Jeffrey Return has a capacity of 1,000 cfs, and the Johnson-2 Return (J-2 Return) has a capacity of approximately 2,000 cfs.

Among the features associated with the Tri-County Canal system are (from upstream to downstream) Jeffrey Lake, Midway Lakes, Gallagher Lake, Central Platte Re-Regulating Reservoir, Elwood Reservoir, and Johnson Reservoir. This supply canal furnishes water for four hydroelectric generating plants with an aggregate nominal generating capacity of 104 megawatts. In addition, it provides cooling water for the Canaday Steam Electric Station, which is gas and/or oil fired and has a 108 megawatt capacity. A significant portion of the water diverted through the Tri-County Canal is returned to the Platte River channel on the south side of Jeffery Island (known as the “Johnson-2” or “J-2” Return channel), a few miles upstream of the Overton Bridge. The Tri-County Canal also furnishes irrigation water to three irrigation laterals (E65, E67, and Phelps County Canal) owned by the Central District that service approximately 120,000 acres in three Nebraska counties (Gosper, Phelps, and Kearney).

In the OPSTUDY model, the Tri-County canal demand requirement is set by calculating the demand and comparing it to any minimum flow requirements for canal maintenance or Nebraska Plan limits. Demand is determined by computing (1) change in storage at Elwood Reservoir; (2) change in storage at Johnson Lake Reservoir; (3) losses in the Tri-County Canal; (4) irrigation demand along the Tri-County Canal system; and (5) the discretional operation diversion at the Tri-County Canal, which is based on the hydrologic condition of McConaughy Reservoir.

For each of five conditions based on Lake McConaughy storage and inflow (“very high”, “high”, “normal”, “low”, or “very low”), different OPSTUDY assumptions are made for modeling Lake McConaughy releases and Tri-County Canal diversions, as described in Appendix D.

OPSTUDY variables associated with the Tri-County Canal System (units are acre-feet, unless otherwise noted)	
ERCHNG	Elwood Reservoir change in storage.
EREOMC	Elwood Reservoir end-of-month content.
ERLOSS	Elwood Reservoir loss.
ERTARG	Elwood Reservoir end-of-month target content.
HIS3CO	Historic Tri-County diversion values (array of (years * 12) values)
JFAVA	Flow available for return through the Jeffrey Hydro Return.
JFRCAP	Jeffrey Hydro Return capacity.
JFRHR	Jeffrey Hydro Return.
HIS3CO	Historic Tri-County canal diversion.
JLCHNG	Johnson Reservoir change in storage.
JLEOMC	Johnson Reservoir end-of-month content.
JLTARG	Johnson Reservoir target content.
TCCAP	Tri-County Canal capacity.
TCDMD	Tri-County Canal demand.
TCDREQ	Tri-County Canal diversion requirement.
TCIDM	Tri-County Canal irrigation demand.
TCIRSAV	Reduction in Tri-County irrigation demand due to conservation.
TCLMAX	Tri-County Canal maximum loss when canal is flowing full.
TCLOSS	Intercept of the Tri-County Canal loss function.
TCLOSS1	Tri-County Canal loss (KAF/month).
TCLOSSLP	Slope of the Tri-County Canal loss function (dimensionless).
TCMDIV	Minimum Tri-County Canal diversion.
TRIVHREL	Tri-County Canal diversion under very high conditions.
TRIHIREL	Tri-County Canal diversion under high conditions.
TRINOREL	Tri-County Canal diversion under normal conditions.
TRILOREL	Tri-County Canal diversion under low conditions.
TRIVLREL	Tri-County Canal diversion under very low conditions

The **minimum diversion requirement** for the Tri-County canal (*TCMDV*) is defined in the input file by CDATA value #41 – although this value may be reset by the state EA code. The minimum diversion requirement for this canal, as defined by CNPPID, is 0 cfs.

The **change in storage at Elwood Reservoir** is calculated as the Elwood Reservoir target end-of-month content (*ERTARG*) minus the previous end-of-month content in Elwood Reservoir (*EREOMC*). Similarly, the **change in storage at Johnson Lake Reservoir** is calculated as the Johnson Lake target end-of-month content (*JLTARG*) minus the previous end-of-month content in Johnson Lake (*JLEOMC*). The target values for the end-of-month content of Elwood Reservoir are set in the input file by HDATA array #25 (target values used for all modeling runs are shown in Table 3.4). The Johnson Lake end-of-month targets could be set by HDATA array #28.

Table 3.4. Elwood Reservoir Target End-of-Month Content and Monthly Losses

Elwood Reservoir Target End-of-Month Conent (KAF)											
JAN	FEB	MAR	APR	MAY	JUN	JUL	AUG	SEPT	OCT	NOV	DEC
13.3	12.5	20.5	28.9	35.5	36.2	24,8	15.4	17.9	16.5	15.1	14.2
Elwood Reservoir Loss (KAF/MO)											
JAN	FEB	MAR	APR	MAY	JUN	JUL	AUG	SEPT	OCT	NOV	DEC
0.9	0.8	1.4	3.7	4.1	4.6	1.9	1.5	1.1	1.3	1.2	1.1

Losses in the Tri-County Canal system are determined for three different sections referred to as the upper, middle and lower canal, and then summed. For the upper canal section (diversion dam to the Jeffrey powerhouse) and the lower canal section (Johnson Lake to the J-2 return), losses are based on the average monthly canal losses from 1971 to 1994, as shown in Table 3.5. These values are provided to the model as ADATA array items #25 and #29, respectively.

Table 3.5. Average monthly losses for the upper and lower Tri-County canal sections.

Upper Central Canal Average Loss (KAF) 1971-1991											
JAN	FEB	MAR	APR	MAY	JUN	JUL	AUG	SEPT	OCT	NOV	DEC
7.595	6.515	6.430	6.240	6.780	7.075	8.730	8.155	5.460	5.570	5.400	7.190
Lower Central Canal Average Loss (KAF) 1971-1991											
JAN	FEB	MAR	APR	MAY	JUN	JUL	AUG	SEPT	OCT	NOV	DEC
0.410	0.675	1.100	1.295	1.205	1.365	1.370	1.270	1.520	1.115	0.445	0.335

Losses from the central canal section (Jeffrey powerhouse to Johnson Lake) are determined based on the actual flow in the canal, using the following formula derived from data provided by CNPPID (1991; 1993):

$$\text{Loss} = (\text{TCLOSSLP} * \text{Canal flow}) + \text{TCLOSS} \quad (3.6)$$

where:

TCLOSS is the intercept of the Tri-County Canal loss function; and
TCLOSSLP is the slope of the Tri-County Canal loss function.

For the OPSTUDY model, the values of *TCLOSS* and *TCLOSSLP*, which vary by month, are set in the input file as ADATA value arrays #26 and #27. These monthly values were determined by Mark Kilgour during the FERC relicensing process. For all of the OPSTUDY modeled alternatives, the following values were used:

Table 3.6. Intercept and slope values for the Tri-County Middle Canal loss estimation function.

Central District Middle Canal Constant Loss Term (KAF/MO)

JAN	FEB	MAR	APR	MAY	JUN	JUL	AUG	SEPT	OCT	NOV	DEC
3.858	3.517	7.74	10.097	9.676	13.136	7.764	16.622	13.618	10.168	9.323	7.548

Central Canal Loss Function Slope (dimensionless)

JAN	FEB	MAR	APR	MAY	JUN	JUL	AUG	SEPT	OCT	NOV	DEC
0.11399	0.11256	0.06417	0.04318	0.06225	0.05034	0.15987	0.09098	0.07705	0.07811	0.06785	0.07805

Loss in the central reach of the canal is estimated as follows: First, a *maximum* loss is determined by inserting the canal capacity flow (*TCCAP*) into Equation 3.6. Then, the actual loss is estimated on the basis of estimated flow in the canal, which is the same as the demand on the canal at North Platte (*TCDMD*). *TCDMD* is the sum of the irrigation demand (*TCIDM*), plus the Elwood Reservoir loss (*ERLOSS*), plus the change in storage at Johnson Lake (*JLCHNG*), plus the estimated canal loss (*TCLOSS1*). In the first iteration, *TCLOSS1* is set to zero in order to come up with an initial estimate of *TCDMD*. A first estimate of *TCLOSS1* is then generated by inserting *TCDMD* into Equation 3.6. Five iterations of *TCLOSS1* and *TCDMD* estimates are then made to account for the fact that any water added to the canal flow to account for losses would itself be subject to losses. Finally, checks are made to ensure that *TCLOSS1* never exceeds the maximum potential loss (*TCLMAX*), and that *TCDMD* never exceeds the maximum canal capacity.

Irrigation demand along the Tri-County canal system (*TCIDM*) is estimated within the subroutine C_TCDREQ. This subroutine calculates the diversion requirement based on the type of year (very wet, wet, etc.) and whether the state Environmental Account is being operated. C_TCDREQ performs its calculations in the following manner:

(1) The demand is set to the historic diversion amount;
(2) The demand is brought up to the minimum canal requirement set in the Nebraska Plan, if needed for this model simulation. (The requirement is 800 cfs in all cases except for “very low condition” years, in which case the requirement is 700 cfs);
(3) For months October through April, the minimum Tri-County diversion requirement (*TCDREQ*) is determined based on the type of year, as follows (values are in cfs units):

Hydrologic Condition	Oct	Nov	Dec	Jan	Feb	Mar	Apr
Very Wet	1600	1300	1000	1000	1200	1400	1400
Wet	1200	1100	1000	1000	1120	1240	1240
Normal	1000	975	950	950	1025	1100	1100
Dry	900	875	850	850	905	960	960
Very Dry	700	700	700	700	700	700	700

(4) If increasing *TCDREQ* creates flows in excess of what would have occurred with conservation savings (see Section 4.10), this subroutine cuts back *TCDREQ* by the difference between the increase in Tri-County diversion required and the conservation savings to compensate for reduced irrigation.

Later, in the COMPUTE subroutine, the *TCDREQ* value may be reviewed one more time. If the *HISTORIC* flag has been set in the input file (CDATA item #1), and the previous end-of-September Lake McConaughy content (*EOMSEPT*) is greater than the trigger content (*LOHISTRIG*, a variable set in the input file as CDATA item #2), *TCDREQ* is reset as the maximum of the historic Tri-County canal diversion (*HIS3CO*) and diversion requirement calculated previously (*TCDREQ*) limited to the canal capacity (*TCCAP*). *HIS3CO* is an array of historic values for all months over the period modeled; these are HDATA item #24 values.

The **discretional operation diversion at the Tri-County Canal** is based on the hydrologic condition at McConaughy. (This information is stored in the *CONDITION* variable; see the *McConaughy Operational Releases* discussion under Section 3.1.1). The discretional operation diversion is set as the maximum of (1) the minimum required Tri-County Canal flow (*TCDREQ*) calculated above, and (2) the operational diversion defined as necessary for this month (ADATA arrays #97 through #101) under these hydrologic conditions, provided that the flag is set in the input file (ADATA arrays #82 through #86) specifying that operational diversions should be made for this month.

The minimum discretional operational diversion at the Tri-County Canal is set as follows for all modeled scenarios.

Condition	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec
VH	1600	2000	2000	2200	2200	2200	2200	2200	2000	2000	2000	1600
High	1400	1800	1800	2000	2000	2000	2000	2000	2000	1800	1800	1400
Nor	1200	1400	1400	1600	1600	1600	1600	1600	1600	1400	1400	1200
Low	800	900	900	900	900	900	900	900	900	900	900	800
VL	700	700	700	700	700	700	700	700	700	700	700	700
EL	300	300	300	300	300	300	300	300	300	300	300	300

Additionally, a check is performed in COMPUTE which verifies that the Tri-County diversion requirement (*TCDREQ*) meets the minimum Tri-County diversion (*TCMDIV*).

The **flow available for release through the Jeffrey Return** (*JFAVA*) equals the Tri-County diversion requirement (*TCDREQ*) minus the Tri-County demand (*TCDMD*), not to exceed the Jeffrey Return capacity (*JFRCAP*), and not to be less than zero. (Note: if any Colorado Conservation water (*CONSCO*) is present at the Tri-County diversion, it will not become part of the Jeffrey available return flow (*JFAVA*) because it is not included in either *TCDREQ* or *TCDMD*. The capacity of the Jeffery Return is 1,000 cfs as defined in ADATA item #28.

3.7 KEARNEY CANAL (C45, C52, C95)

NPPD's Kearney Canal diverts water from the Platte River for irrigation and electrical power generation. The canal begins near Elm Creek, Nebraska, and returns flow to the Platte River near Kearney. The 16-mile-long canal was built in the 1880s, and the Kearney Dam and hydroelectric power station were established in 1889. The hydroelectric dam, which was refurbished by NPPD in 1996, has a capacity of 1.485 megawatts. The canal has a capacity of approximately 325 cfs.

OPSTUDY variables associated with the Kearney Canal system (units in acre-feet unless otherwise noted)	
KRCAP	Kearney Canal capacity.
KRDV	Kearney Canal diversion (flow).
KRHDM	Kearney Canal hydro demand.
KRHRTN	Kearney Canal return.
KRIDM	Kearney Canal irrigation demand.
KRLOSS	Kearney Canal loss.
KRSDMD	Kearney Canal storage demand.

The **Kearney Canal storage demand** (*KRSDMD*) is calculated as the Kearney Canal irrigation demand (*KRIDM*) plus the Kearney Canal hydro demand (*KRHDM*) minus the available flow at Overton (*OVAVA*), not to be less than zero.

The **Kearney Canal irrigation demand** is defined by HDATA item #19. The Kearney Canal hydro demand is defined by ADATA item #68, which is multiplied by a factor to adjust for leap years.

The **Kearney Canal diversion** is set equal to the Platte River flow at Overton, up to the capacity of the canal (*KRCAP*). The Kearney Canal capacity is defined by ADATA item #65.

The **Kearney canal irrigation delivery** (*KRIDV*) is the lesser of the Kearney canal irrigation demand (*KRIDM*) and the difference between the Kearney canal diversion and the Kearney canal loss (*KRDV - KRLOSS*). The Kearney canal shortage (*KRSHORT*) is the difference between the Kearney canal irrigation demand (*KRIDM*) and the Kearney canal irrigation diversion (*KRIDV*), not to be less than zero. The Kearney Canal system loss is treated as a monthly constant, based on historic data provided by and defined by ADATA item #67, as follows:

Kearney Canal System Loss (KAF/MO)											
JAN	FEB	MAR	APR	MAY	JUN	JUL	AUG	SEPT	OCT	NOV	DEC
0.0	0.0	0.6	1.5	0.8	0.9	0.1	0.1	0.2	1.6	0.8	0.0

Finally, the **Kearney return** (*KRHRTN*) is the Kearney diversion (*KRDV*) minus the Kearney canal loss (*KRLOSS*) minus the Kearney irrigation demand (*KRIDM*), not to be less than zero.

3.8 ADDITIONAL IRRIGATION DEMANDS BY STREAM REACH

In addition to the irrigation demands already described above that are associated with the Western Canal, Kearney Canal, and Tri-County Canal systems, irrigation demands are represented in the model for three specific stream reaches: the North Platte River from Keystone to Sutherland, the North Platte River from Sutherland to North Platte; and the Platte River from Brady to Cozad.

Irrigation demands on the North Platte River from Keystone to Sutherland (*KSDM*) include irrigation from the Keith-Lincoln, Sheridan-Wilson, North Platte, and Paxton-Hershey Canals. These demands are based on historic water use (see Section 2.2.3). They are provided to OPSTUDY as HDATA item #14.

Irrigation demands on the North Platte River from Sutherland to North Platte (*SNPDM*) include irrigation from the Suburban and Cody-Dillon canals. These demands are based on historic water use (see Section 2.2.3). They are provided to OPSTUDY as HDATA item #15.

Irrigation demands on the Platte River from Brady to Cozad (*BCIDM*) include irrigation from the Gothenburg, 30-Mile, Six-Mile, Cozad, Orchard-Alfalfa, and Dawson Canals. These demands are based on historic water use (see Section 2.2.3). They are provided to OPSTUDY as HDATA item #18:

3.9 HYDROELECTRIC POWER GENERATION

Hydropower is generated at a number of facilities in the central Platte River region, including the Kingsley Dam, North Platte, Jeffrey, and Johnson power stations. The COMPUTE subroutine calculates the amount of power generated by these plants in run-time Phase III, when COMPUTE is performing final calculations. The power generated is determined from calculations made in the final Phase II iteration. Hydropower generated at the Kearney plant (up to 1.485 megawatts) is ignored because it is such a small amount relative to the other hydropower facilities.

OPSTUDY variables associated with Hydropower Generation
(all units in thousand megawatt-hours)

JFGEN	Jeffrey hydropower generation.
J2GEN	Johnson hydropower generation.
MACGEN	Kingsley (Lake McConaughy) hydropower generation.
SGEN	Sutherland/North Platte hydropower generation.
TCGEN	Total Central District hydropower generation (JFGEN+J2GEN).
TOTGEN	Total hydropower generation (TCGEN+MACGEN+SGEN).

The **Sutherland/North Platte power generation** (*SGEN*) in thousand megawatt-hours (KMwH) is calculated on the basis of the North Platte hydro return flows. The formula is:

$$(3.7) \qquad SGEN = (NPHR * 0.162) - 0.47$$

where **NPHR** is the North Platte hydro return in KAF/month. This formula was provided by CNPPID/NPPD (1988).

The **Jeffrey hydropower generation** (*JFGEN*) in KMwH is calculated on the basis of the total Tri-County diversion in KAF (*TCDV*) and the average Tri-County Canal loss above the Jeffrey hydro in KAF (*TCLOSSA*). The formula is:

(3.8) JFGEN = 0.092759 * (TCDV-TCLOSSA)

This formula was provided by documentation from the FERC relicensing process.

The **Johnson hydropower generation** (*J2GEN*) in KMwH depends on the flow through the Johnson hydropower plant (*J2DCH*), which in turn is calculated from the Tri-County irrigation diversion (*TCIDV*) and the Johnson-2 river return (*J2HR*). The formula is:

(3.9) J2GEN = J2DCH * 0.2105

where **J2DCH** is the sum of *J2HR* plus 63.1 percent of *TCIDV*. If the "groundwater management storage project" was activated for this particular model run (see Section 4.6), then the amount taken from the J2 return and sent down the canal for groundwater storage (*GWMSTORE*) needs to be added to J2DCH before Equation 3.9 is calculated.

The **total Central District hydropower generation** (*TCGEN*) is simply the sum of *JFGEN* and *J2GEN*.

Kingsley hydropower generation in megawatts for any given month (MACGEN), is determined using this formula:

if MACHEAD > 58.0, then:

(3.10) MACGEN = (HYOUT - HWLOUT + EAPKREL) * MACHEAD * 1.025* (0.87 / 1000.0)

else MACGEN = 0.0.

According to CNPPID/NPPD (1988), this is a "standard power equation" which assumes a plant efficiency of 87% and in which:

HYOUT is flow through the turbine in KAF/month;
HWLOUT is release from the Howell-Bunger valve, in KAF/month;
EAPKREL is the Environmental Account release, in KAF/month; and
MACHEAD is the hydraulic head on the Kingsley turbine, in feet.

The quantity (HYOUT - HWLOUT + EAPKREL) is the flow through the turbine. ***HYOUT*** is set equal to the outflow from Lake McConaughy (*MACOUT*), unless that flow is greater than the maximum outlet capacity of the hydropower plant (352 KAF/month). If *MACOUT* exceeds the outlet capacity, this implies that water must be moving through the Morning Glory Spillway. Therefore, OPSTUDY verifies that the average content of Lake McConaughy during the month (*AVECONT*) is at least at the elevation of the spillway (1427.4 feet MSL), reduces spill through the turbine (*TURSPL*) by the amount of water moving through the Morning Glory spillway (*MNGSPL*), and sets the flow through the turbine (*HYOUT*) to the maximum of 352 KAF.

Water released from the Howell-Bunger valve (***HWLOUT***) is water that does not flow through the Kingsley turbine. *HWLOUT* is set equal to the release from the Howell-Bunger valve as described in Section 3.1, limited to a value no greater than the total release from the dam.

Determination of ***EAPKREL*** is described under Environmental Pulse Releases (Section 4.3).

MACHEAD is calculated as the mean elevation of water in Lake McConaughy during the month minus the elevation of the turbine (3125 feet MSL, as specified by CNPPID/NPPD, 1988).

3.10 STREAM REACH GAINS AND LOSSES

Gains and losses occurring along the stream reaches between various Central Platte River Model nodes must be taken into account. Gains and losses for various stream reaches (expressed in KAF/month; see list of variables below) are provided to the model for each month of each year by HDATA arrays #4 through #13. These values are in turn based on an analysis of historic records for 1941-1994, as described in Section 2.2.2.

Estimated **ground water depletions** by stream reach are monitored within the model on a month-by-month basis. Any time the model calculates a negative streamflow value (demands temporarily exceeding flow), this negative quantity is raised to zero to represent a dry stream, and a corresponding amount is registered as a “ground water depletion” along that stream reach. In effect, this quantity represents ground water storage depleted in the vicinity of the river, and this quantity is “borrowed” from ground water storage along that stream reach. These calculations are performed by the SALVAGE subroutine. The purpose for computing ground water depletions is that the consequent decline in groundwater levels may result in reduced evapotranspiration (ET) from the channel and adjacent wet meadow areas. Before flow through this reach can again occur within the model, the groundwater storage depletion must be replaced with a volume of water equal to the unsatisfied demand, less the amount of ET “salvaged”. Using the variables listed in the box below, aggregate depletions are carried over from one month to the next.

Basically, gains and losses for each modeled stream reach are added (or subtracted) from streamflow in the model between the appropriate nodes as OPSTUDY works its way down through the central Platte River system.

OPSTUDY variables associated with stream reach gains and depletions (units in acre-feet per month)	
COGN	Cozad to Overton stream reach gain.
COGWDP	Cozad to Overton stream reach ground water depletion.
GIDGN	Grand Island to Duncan stream reach gain.
GIDGWDP	Grand Island to Duncan stream reach ground water depletion.
JPGN	Julesburg to Paxton stream reach gain.
JPGWDP	Julesburg to Paxton stream reach ground water depletion.
KSGN	Keystone to Sutherland stream reach gain.
KSGWDP	Keystone to Sutherland stream reach ground water depletion.
NPBGN	North Platte to Brady stream reach gain.
NPBGWDP	North Platte to Brady stream reach ground water depletion.
OGIGN	Odessa to Grand Island stream reach gain.
OGIGWDP	Odessa to Grand Island stream reach ground water depletion.
OOGN	Overton to Odessa stream reach gain.
OOGWDP	Overton to Odessa stream reach ground water depletion.
PNPGN	Paxton to North Platte stream reach gain.
PNPGWDP	Paxton to North Platte stream reach ground water depletion.
SNPGN	Sutherland to North Platte stream reach gain.
SNPGWDP	Sutherland to North Platte stream reach ground water depletion.

3.11 GAGE LOCATION FLOWS

3.11.1 Monthly Flows

The Central Platte River Model estimates monthly streamflow at various gage locations along the North Platte, South Platte, and main stem Platte Rivers. These locations, and variables representing streamflow at these locations, are summarized in the box below. Estimation of streamflow at these points is determined at various stages within the OPSTUDY model as a mass-balance calculation. These values are recorded as model output so that the effects of the modeled scenario on streamflows at these locations can be evaluated.

OPSTUDY variables used to track monthly streamflow at specific locations (units are AF/month)	
BRADY	Platte River flow at Brady.
COZAD	Platte River flow at Cozad.
DUNCAN	Platte River flow at Duncan.
JULES	South Platte River flow near Julesburg.
GRNDISLD	Platte River flow at Grand Island.
KEYSTN	North Platte River flow at Keystone.
LEWELN	North Platte River flow at Lewellen.
LOUISVL	Platte River flow at Louisville.
NPTOTAV	Total available flow at North Platte.
ODESSA	Platte River flow at Odessa.
OVERTON	Platte River flow at Overton.
PAXTON	Platte River flow at Paxton.

3.11.2 Daily Flows

Because the daily pattern of river flow within a month can be highly variable, mean-monthly flow rates cannot be used to accurately compute certain effects. A subroutine in the OPSTUDY Model produces daily flows from the OPSTUDY output. The subroutine uses the historic daily flows and the difference in average monthly flows in cfs to simulate the daily flows that would result with the analyzed alternative.

The OPSTUDY model calculates daily flows from monthly values. The daily flows are assumed to have the same pattern as the historic daily flows, but are adjusted up or down based on the monthly volumes. The OPSTUDY model compares simulated average monthly flow in cfs to average of the historic daily flows in cfs. If the simulated flow is more than the historic, the daily flows are increased by the difference (average monthly flow in cfs minus average of the historic daily flows in cfs). For example, if the historic mean monthly flow was 100 cfs and the mean monthly flow from the OPSTUDY model is 120 cfs, 20 cfs is added to each historic daily flow that occurred during that month. Increases to flows in canals are subject to the capacity of the canal (i.e. the model can not calculate a flow in the canal greater than the canal capacity). If the simulated flow is less than the historic, the daily flows are decreased by the difference (average of the historic daily flows in cfs minus average monthly flow in cfs). The subroutine does not allow flows to drop below zero nor exceed the capacity of facilities like the J2 canal return.

If the model would cause flows to be less than zero or greater than the maximum, the monthly flow volume calculated by the model is allocated such that days with the greatest capacity for flow change receive the most adjustments. For example, assume it is August and the historic average flow is 10 cfs with twenty days of no flow and the simulated average is 5 cfs. The twenty days of no flow cannot be reduced and the remaining eleven days need to be reduced by more than 5 cfs. The formula used is as follows:
(historic mean daily flow)/(sum of the historic mean daily flows for the month)*(simulated monthly flows).

The assumption for using this method to develop daily flows is that most actions taken by the Program will be for extended periods not day-to-day adjustments. For example, releases from the EA are set and are not adjusted with much frequency during the summer months.

The daily flow calculated are used to help assess the effects of the program on peak flows, which in turn was used in the analysis of channel maintenance and wet meadow maintenance.

OPSTUDY variables associated with daily peak streamflow at Overton

OVCFSMAYPK	May EA pulse release peak at Overton (cfs)
PEAKCFS	Peak daily flow at Overton (cfs)
PEAKYRCFS	Maximum daily peak within the water year (cfs)
PEAKYRJ	Month of year in which peak daily flow at Overton occurred (1-12)

CHAPTER FOUR

REPRESENTATION OF NEW/PROPOSED SYSTEM ELEMENTS

This section describes how proposed or possible new components of the Central Platte system (as opposed to existing, historic elements) are represented within the Central Platte River Model.

4.1 ENVIRONMENTAL ACCOUNT (EA) (blocks 49, 51, 94, 104 in compute.for; EA_UPDATE in initcom.f) [4]

The establishment of an "Environmental Account" (EA) at Lake McConaughy (and, potentially, at "other approved storage facilities") was proposed in the "Nebraska Plan" filed with the Federal Electric Regulatory Commission (FERC) by Nebraska Governor E. Benjamin Nelson on October 1, 1992, as a component of the licensing requirements associated with CNPPID activities on the Platte River. Under the cooperative Platte River Partnership program, the EA concept has been expanded to incorporate potential contributions from Wyoming and Colorado as well as Nebraska. The EA makes water available for instream flow releases from Lake McConaughy and allows the manager of the EA the flexibility to make releases that are most beneficial to the species of concern. In the *Platte River Cooperative Agreement* (Platte River Partnership, 1997), the EA is defined as "an annual account of water in Lake McConaughy, or other Approved Storage Facilities, available for release for environmental purposes during the October 1 to September 30 water year". The first operation of the EA occurred in the water year October 1999 to September 2000.

The rules under which the EA is to be operated are detailed in the *Cooperative Agreement*. Water is allocated to the EA on the first of October of each year. The allocation is based upon the combined total of the reservoir level as of the beginning of October and the expected inflows from that date through April 30 of the following year. Contributions to the account from CNPPID and NPPD are based on 10% of the "storable natural inflows" to Lake McConaughy from October through April, up to a 100 KAF annual limit, and a 200 KAF total limit. Contributions to the account from the state of Wyoming include contributions from the "Pathfinder Modification Project". Additional contributions to the account may be made by all three states.

For purposes of the OPSTUDY model, the expected inflow is based on a perfect knowledge of future flows provided by historic hydrologic data in the input hydrology file. Guidelines agreed upon in the *Cooperative Agreement* also specify that any time Lake McConaughy reaches regulatory capacity, the EA shall be set to 100 KAF, regardless of whether the EA was greater or less than this amount prior to reservoir filling. If water remains in the EA at the end of the water year, carryover is permitted to the subsequent water year, within the 200 KAF limit.

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[4] Following many of the system-element headings in this chapter, index numbers are provided that correspond to numbered blocks within the "Compute" subroutine of the Opstudy code (*compute.for*) and/or references are provided to other Opstudy code where that system element is simulated. These cross-references are not necessarily comprehensive, however they may help the reader locate important corresponding sections of the Opstudy code.

OPSTUDY variables associated with the Environmental Account (Units are KAF unless otherwise noted)	
ACCRUEPER	EA accrual percentage of Lewellen inflow.
CONSBOR	Conservation water available from USBR funds.
EACCRUE	EA percentage accrual (0.0 to 1.0).
EAADJUST	Used to track total adjustment to EOMCEA due to full conditions at McConaughy in current and previous month.
EABORROW	EA "borrowed" from Lake McConaughy.
EAEVAP	Evaporation from EA.
EAFUNC	Maximum release from EA.
EAEOMLSTMO	EA contents in previous month.
EAETO	EA excess-to-ownership (ETO) water.
EAJNT	Net EA water from Colorado at Julesburg.
EALARGE	Flag to turn "enlarged EA" on or off (1=enlarged EA; 0=no enlarged EA)
EALEW	EA wildlife water from above Lake McConaughy.
EAMINREL	EA minimum release.
EANETCW	EA net conserved water.
EAOWED	Outstanding balance of water to be paid back to the EA.
EAPAYBK	EA payback to McConaughy for "loaned" water.
EAPROTECT	
EARESERVE	EA to reserve between January and April (i.e., hold for May).
EASTART	EA starting content when model initialized.
EASUM	Sum of accruals to the EA account for the current year.
EOMCEA	End-of-month content for EA.
EOMCEATST	Calculated end-of-month content for comparison to actual value.
EOMLST	End-of-month content of EA from previous month.
GWMCRED	Amount credited to the EA from the groundwater management project.
HIDEEA	EA water "hidden" in dead storage for carry-over to the next month.
PRCNTEA	Array of percentages of last month's EOMC available for release from EA.
STATEEA	On/off flag to simulate Nebraska Plan Environmental Account at Lake McConaughy (1.0 = on; 0.0 = off).
SSLOSSINCEA	EA's share of the Sutherland system canal losses.
TCLOSSINCEA	EA's share of the Tri-County canal losses.
WLREL	Wildlife release.
WLSTR	Wildlife storage.
WYEAOWN	Wyoming EA ownership from which Nebraska EA account may borrow at McConaughy.

In "Phase II" of the COMPUTE subroutine, in which the CPR Model is determining demands on Lake McConaughy and routing flow through the main stem of the Platte River (see Section 2.9.2), the end-of-month EA storage value is updated for each monthly iteration using this equation:

(4.2) New EA end-of-month storage =
Previous month's EA storage
+ a percentage of the inflow at Lewellen
+ EA water from Wyoming at Lewellen
- EA evaporation, wildlife release, and EA pulse release
+ Nebraska conservation water
+ USBR conservation water
+ Excess-to-Ownership water
+ Power Interference water
+ Groundwater Management Project credit

The **previous month's EA storage** is stored by the variable *EOMLST*. For the first modeled month, *EOMLST* is set equal to the starting volume *EASTART*, which is initialized by the INICOM subroutine using the value provided by CDATA item #69.

The **percentage of the inflow at Lewellen** (*ACCRUPER*) is assigned the value of CDATA item #70. For all model runs which incorporate an EA, this value is 0.10, or 10% of the North Platte River flow at Lewellen for months October through April, as specified in the *Cooperative Agreement*.

The **EA water from Wyoming at Lewellen** (*EALEW*) is all of the water provided by Wyoming to the Environmental Account, including Pathfinder Modification water (described in Section 4.11) and other water sources. These quantities are determined by the North Platte Model and are passed to the CPR Model as monthly HDATA array values.

EA evaporation is calculated as that portion of the total evaporation from Lake McConaughy during the month that should be debited against the Environmental Account. Calculation of the evaporative loss at Lake McConaughy during any month is described in Section 3.1. The EA's portion of this evaporative loss is calculated in the COMPUTE subroutine as:

(4.3) EAEVAP = (((EAEOMLSTMO + EOMCEA) / 2.0) / AVECON) * (REVAP)

where:

EAEVAP is the total evaporative loss from the EA account in KAF;
EAEOMLSTMO is the end-of-month EA content from the previous month;
EOMCA is the end-of-month EA content for the current month;
AVECON is the average end-of-month content of Lake McConaughy; and
REVAP is the total evaporation from the reservoir for the month, in KAF.

Wildlife releases from the EA account are determined as described in Section 4.2, and **EA short-duration near-bankfull releases** are determined as described in Section 4.3. The **Nebraska conservation water** is provided by the variable *EANETCW*, as described in Section 4.10. The **USBR conservation water** is calculated as described in Section 4.11.

The proportion of the **excess-to-ownership water** creditable to the EA account is determined as described in Section 4.12. The **power interference water** is calculated as described in Section 4.8. The **Groundwater Management Project credit** is calculated as described in Section 4.6.

In Phase II of the COMPUTE subroutine, after all McConaughy demands have been determined and all flows have been routed (see Section 2.9.3), COMPUTE calls the EA_EOMC subroutine to calculate final changes to EA storage brought about by releases and evaporation from the EA account. EA_EOMC determines this by:

(1) determining the amount added to the EA (if any) from the groundwater management project;

(2) determining if the EA has an outstanding balance of water to pay back (*EAOWED*) from any loan of McConaughy Storage in May through July;

(3) adding wildlife water from above McConaughy (*EALEW*) to the EA;

(4) assessing the EA for its share of evaporation and seepage from Lake McConaughy and crediting it for any accrued inflow at the end of the month;

(5) tracking Central's conservation water accruing to the EA;

(6) tracking accruals to the EA resulting from the October to April inflows to Lake McConaughy;

(7) adding the EA accrual resulting from Lewellen inflow;

(8) verifying that Lake McConaughy storage is sufficient to allocate conservation water to the EA;

(9) adjusting (if necessary) for "enlarged EA" conditions (*EAFLAG* = 1.0).

Finally, EA_EOMC performs a mass-balance check between the calculated (*EOMCEATST*) versus actual (*EOMCEA*) Environmental Account content.

4.2 EA WILDLIFE RELEASE (51, 53)

The intent of the Environmental Account is to provide water that may be released for beneficial instream flows for species of concern along the Platte River. The EA Manager, in consultation with the EA Committee (EAC), makes the decisions on how much and when water will be released from the EA account to supply beneficial flows. The *Cooperative Agreement* (Platte River Partnership, 1997) further specifies that "in October of each year, in consultation with the EAC, the EA Manager shall establish flow targets and an annual operating plan for the EA based on predicted water supplies, the status of the species of concern and the goals set by the Governance Committee." It is expected that the EA Manager will take into account, among other information, instream flow targets and timing priorities developed by FWS for the central Platte River (Bowman, 1994; Bowman and Carlson, 1994). Operational rules for minimum, maximum, and average releases to be made from McConaughy (including the EA) during specific periods of the year are defined within the *Cooperative Agreement*, and are based on five possible hydrologic conditions (very wet, wet, transitional, dry, and very dry). These rules and conditions are summarized in Appendix C.

In the Central Platte River Model, two EA wildlife release quantities are tracked: (1) wildlife storage release (*WLSREL*), and wildlife storage demand (*WLSDMD*). The “release” term tracks the actual release from the Environmental Account made in the current month for wildlife management instream flow purposes; the “demand” term tracks the demand on the McConaughy reservoir for wildlife release purposes. Generally, the release is set to be equal to the demand, however if the EA account is not sufficient to meet minimum release needs (*EAMINREL*), then the release may be set to zero while some finite demand value is stored. In this case, the demand term retains a “claim” on any EA water which becomes available for a wildlife release.

Before *WLSREL* can be calculated, the instream flow targets at Grand Island and Overton must be determined in the COMPUTE subroutine. Targets are based on the current year hydrologic condition and corresponding look-up values for Grand Island and Overton, which are stored in data arrays. An index value of 1 to 6 representing wildlife storage conditions (*IDXWLSTR*) is set by comparing storage conditions in the EA with content levels in the reservoir. The threshold content levels are provided by ADATA items #39 through #44 from the input file, which allow up to six different threshold content values to be set for each month.

Target instream flows for each month are defined by ADATA items #51 through #53 for “wet”, “average” and “dry” years, respectively, and assigned to the variable array *TISFR*. COMPUTE determines the target instream flow requirement at Grand Island (*GIREQ*) based on the target flows (*TISFR*) specified for the storage conditions (*IDXWLSTR*). The target instream flow requirements are also calculated for Overton (*OVREQ*), but for practical purposes only Grand Island target flows are used to determine EA releases. (In fact, *OVREQ* is simply set to the same value as *GIREQ*). The FWS monthly recommendations for instream flows at Overton are provided by ADATA item #57, and for Grand Island by ADATA item #58. These monthly recommendations are assigned to the OPSTUDY array variables *OISFR* and *GISFR*, respectively.

Adjustments are made to *OVREQ* and *GIREQ* during the summer months to try to achieve a declining hydrograph from June through August, such that EA releases are not made in one month which exceed those of previous months. In real life, a rise in river stage at this time of year may inundate tern and plover nests which were established at a lower stage. COMPUTE makes the adjustments as follows:

(1) Check to ensure that the environmental release does not result in a total release rate from McConaughy in excess of *MACMAX_PULSE*, which is the maximum flow through the turbine penstock;
(2) If the previous month's flow was above 1200 cfs, then set the target to 1200 cfs;
(3) If the previous month's flow was between 1200 and 800 cfs, then set the target to that previous flow level;
(4) If the previous month's flow was between 400 and 800 cfs, then set the target to 800 cfs; and
(5) If the previous month's flow was less than 400, then don't adjust the flow target (i.e., let the input file settings set the target).

(In actuality, values are reduced slightly from 1200, 800, 400, etc. cfs to avoid conflicts with the input and calculated values of the targets. The small reduction in cfs does not affect river stage).

Once *OVREQ* is determined, the wildlife storage release is initially calculated by COMPUTE as the greater of the required flow at Overton (*OVREQ*) minus the available flow at Overton (*OVAVA*) and zero. *WLSREL* is later updated to be the greater of what was released for Overton target flow (the previous *WLSREL*) or what is needed from storage to meet Grand Island target (*GIDMD*). Wildlife storage demand (*WLSDMD*) is then set to the required release (*WLSREL*).

WLSREL becomes part of the calculation for the total demand on Lake McConaughy. The EA pulse release (*EAPKREL*), if any (see Section 4.3), is added into the total demand at this point.

OPSTUDY variables associated with the EA Wildlife Release
(Units are KAF unless otherwise noted)

FWSAVE	FWS instream flow targets for average conditions.
FWSDRY	FWS instream flow targets for dry conditions.
FWSWET	FWS instream flow targets for wet conditions.
GIDMD	Grand Island EA wildlife release demand.
GIREQ	Grand Island instream flow requirement.
IDXWLSTR	"Index" of wildlife storage. The value is based on storage and Environmental Account conditions at McConaughy, ranging from 1 (very wet conditions) to 6 (very dry conditions), and is used as an array index for other array variables.
OVREQ	Flow required at Overton to meet target wildlife flows.
TISFR	Target instream flow requirement (six-element array).
WLSDMD	Wildlife storage demand.
WLSREL	Wildlife storage release (release of water from the environmental account for Platte River wildlife purposes).
WLSTR	Six-element array of threshold storage values to help determine EA release volume.

4.3 EA PULSE FLOWS (52, 54)

EA "pulse flows" refer to Program-enhanced flows that the U.S. Fish and Wildlife Service recommends for the central Platte River with the objective (along with other flow recommendations) "to rehabilitate and maintain the structure and function, patterns and processes, and habitat of the central Platte River Valley ecosystem." (Bowman and Carlson, 1994). Ideally, the desired flows would be met by natural high flows in the Platte River without any human intervention. However, this is unlikely to occur in many years, and in these cases target pulse flows may be achieved through the release of water stored in the Environmental Account.

In the context of the CPR Model, "pulse flows" generated by the model correspond the "short-duration near-bankfull flows" proposed by U.S. Fish and Wildlife as appropriate for the recovery and maintenance of desirable channel habitat conditions for the target avian species. These would be flows of approximately one to three days duration of a magnitude approaching but not exceeding bankfull channel capacity through the Central Platte habitat area. Short-duration near-bankfull flows have been proposed on an annual or near-annual basis along with other measures to test the ability of the Program to scour vegetation encroaching on Program channel areas and to mobilize sand and build ephemeral sandbars to benefit the nesting target species.

Experimental releases and monitoring of short-duration near-bankfull pulses of water are simulated by the Central Platte River model in May. The model does not simulate short-duration near-bankfull releases in any other month.

OPSTUDY Variables Associated with Pulse Flow Releases

EAPCDAYS	Days of sustained (flat) pulse hydrograph, not including rising and falling limbs.
EAPCODE	Code value 1 through 9 explaining EA pulse release decision for this month (see Table 4.2)
EAPFLG	Flag to turn on short EA pulse release in May (1=Yes, 0=No).
EAPKREL	EA pulse flow release (KAF).
EAPFALL	Rate of fall on descending limb of pulse release hydrograph (cfs/day).
EARESERVE	EA KAF to reserve between January and April (hold for May).
EAPRISE	Rate of rise on ascending limb of pulse release hydrograph (cfs/day).
EAPTARG	Critical flow level at Overton above which EA pulse release should not be made (cfs total OCT-JUN).
EAPTARGLOW	Minimum allowed incremental increase in daily peak flow at Overton from EA pulse release (cfs).
EAPTARGMAX	EA pulse flow target maximum at Overton (cfs).
MACMAXPULSE	Maximum flow rate through Kingsley turbine penstock for an EA pulse (in cfs).
PULSELOAN	“Loan” from the EA account used for a pulse release (KAF).

In the Central Platte River Model, short-duration near-bankfull releases are attempted in May if the *EAPFLG* flag is set to 1 for the modeled scenario (CDATA item #95). If the flag is on, then a subroutine called EAPULSE is called. EAPULSE first determines the peak flow at Overton without an EA pulse release for May or June. If the May or June Overton predicted peak flow in cfs (including monthly EA release) is above a critical cfs rate of 6,500 cfs (*EAPTARG*), then no EA pulse release (*EAPKREL*) is made. EAPULSE also checks to see if the peak daily flow since last October 1 (*PEAKYR*) exceeds the critical rate (*EAPTARG*). (Determined from the daily flows for each month, see Section 3.11.2). If May *and* June are not above the critical cfs rate, and the maximum peak since the previous October never exceeded *EAPTARG* cfs, then EAPULSE schedules a release from the EA in May only for a short-duration near-bankfull flow measurable at Overton.

EAPULSE performs checks to ensure that short-duration near-bankfull releases do not violate various release limitations. These checks include:

(1) Check to ensure that the short-duration near-bankfull release does not result in a total release rate from McConaughy in excess of the maximum flow through the turbine penstock (*MACMAX_PULSE*) ;
(2) Check to ensure that the short-duration near-bankfull release does not result in an exceedence of the maximum permissible flow at Overton (*EAPTARGMAX*);

(3) Check to see that the flow *with* the short-duration near-bankfull exceeds the peak daily flow *without* a pulse by at least a defined 1,000 cfs threshold difference (*EAPTARGLOW*); and
(4) Verification that there is enough EA volume to make the target short-duration near-bankfull release.

(Later in the calling COMPUTE subroutine, a check is also made that no EA short-duration near-bankfull release is made if there is any spill from the Morning Glory Spillway at Kingsley Dam. These two events should not occur in the same month).

If it is determined that a short-duration near-bankfull release can be made, the first step in estimating a short-duration near-bankfull releases in the OPSTUDY model is the estimate the flow of the North Platte River at North Platte, the diversion at the Sutherland Canal, and the total release from Lake McConaughy. If the model estimates that Lake McConaughy is spilling, no short-duration near-bankfull release is made. Otherwise, the maximum amount that can be released for a short-duration near-bankfull event is the minimum of the remaining release capacity at Lake McConaughy (turbine capacity minus estimated release) and the sum of the remaining capacity in the Sutherland Canal and the North Platte River at North Platte. The estimated flow of the North Platte River at North Platte includes the estimated gains and losses (including diversions) between Keystone and North Platte. The remaining capacity in the North Platte River at North Platte is the capacity of the North Platte River at flood stage minus the estimated flow.

In order to augment the short-duration near-bankfull event:

1. Releases from Lake McConaughy are ramped up at a maxium rate of 700 cfs per day. 200 cfs per day for the Sutherland Canal and 500 cfs per day in the North Platte River. The Sutherland Canal is ramped up to achieve a maximum release from the Sutherland Canal of 1850 cfs.
2. No losses are estimated for the short-duration near-bankfull event, which is consistent with the rest of the OPSTUDY model.

If a short-duration near-bankfull release should not be made for any reason, then the EAPULSE subroutine bails out without making the release. The value assigned to variable *EAPCODE* indicates whether a short-duration near-bankfull release was made (value 8 or 9), or if not, why not (values 1 through 7). The significance of EAPCODE value 1 through 9 is described in Table 4.4. The *EAPCODE* values for each month in the model run are written to the .pls output file (see Section 5.4.4).

Table 4.4 EACPODE values 1 through 9 explaining EA Pulse release decision.

0	Initialized value (no pulse release decision yet made).
1	No pulse release because May flow exceeds target without release.
2	High South Platte June flow, so no EA pulse release in May.
3	McConaughy is expected to spill in June, and South Platte average flow is not low, so no release made in May.
4	A daily peak above the target already occurred earlier in the year, so no pulse release made.
5	Target can't be reached because of turbine flow limitations, so no pulse release made.
6	EA supply does not allow for the pulse release, so no pulse release made.
7	Pulse won't exceed this May's peak by at least 1000 cfs, thus pulse release not made because benefits would be marginal.
8	Pulse release made (without borrowing from EA account).
9	Pulse release made (with borrowing from EA account).

It is assumed that the EA short-duration near-bankfull releases (if any) are released over the course of just a few days in May. From the release volume and a the daily flows calculated by the model a peak daily flows during the EA short-duration near-bankfull flow release is estimated.

A short-duration near-bankfull release is estimated based on a synthetic hydrograph associated with the release. The shape of the hydrograph is determined by three variables: (1) *EAPRISE*, which defines the rate of daily increase in cfs associated with the arrival of the pulse; (2) *EAPFALL*, which defines the rate of daily decrease in cfs associated with the passing of the pulse; and (3) *EAPCDAYS*, which defines the duration of the "sustained" pulse (not including the rise and fall) in days. Values for these three variables are provided by CDATA items #99, #100, and #98, respectively. The pulse hydrograph is constructed by the EA_PULSE subroutine as follows:

The total Environmental Account water available for pulse release, in cfs (*EACFSAVA*), is determined as the square root of the following quantity:

$$(EAPCDAYS^2) - 2 * (1/EAPRISE - 1/EAPFALL)* (-1000.0 * EAKAFAVA/1.98347)$$

where:

EAPRISE, ***EAPFALL***, and ***EAPCDAYS*** are the variables described above; and
EAKAFAVA is the available volume of the EA account at McConaughy, in KAF.

Daily peak flows for each month (without pulse releases) were already described in Section 3.11.2. COMPUTE keeps track of the maximum daily peak within the water year (*PEAKYRCFS*) and also the month in which the maximum peak occurred (*PEAKYRJ*).

The total EA release in May is calculated by COMPUTE as the sum of the pulse release (if any) and the wildlife storage release (WLSREL). The EA pulse flow release calculated by the model is stored in the variable *EAPKREL*, in units of thousands of acre feet for that month.

The Louisville gage is the only gage in the model which shows the Pulse Flow volume as part of the "monthly" flow. The other gages and diversions, etc., do not show the pulse flow volume. The reason for this is to avoid mixing the "monthly" and "daily" data together.

Daily peak flow during a short-duration near-bankfull release are determined from the daily flows during a month. After the daily flows are calculated, several adjustments are made to the daily flows. The first of these adjustments are for the short-duration near-bankfull flow events. The water volume used for the short-duration near-bankfull flow events is calculated using monthly data in the OPSTUDY model, but the volume is distributed in the daily flow portion of the model. Several days prior to the day (May 1 or May 20) scheduled for the short-duration near-bankfull flow event, the OPSTUDY model begins ramping up the flows in the Sutherland Canal (200 cfs per day) and the North Platte River (500 cfs per day). The objective is to have maximum flows at the Sutherland Return and in the North Platte River at North Platte for at least two days and hopefully (depends on the volume available) for three days. After the short-duration near-bankfull flow event, the model ramps down flows in the Sutherland Canal (200 cfs per day) and the North Platte River (500 cfs per day).

Releases from Lake McConaughy, reduced diversions to the Korty Canal and the Tri-County Canal, and releases from the Sutherland, Jeffrey, and J2 Returns are routed down the North Platte, South Platte, and Platte Rivers by the daily flow section of the OPSTUDY model. There are no losses charged to these releases, returns, and non-diversions by the model. This is consistent with the rest of the OPSTUDY model which does not have dynamic losses.

The methodology for determining the short-duration near-bankfull flow on any day is similar to calculating the pulse release volume. The first step in estimating short-duration near-bankfull releases in the OPSTUDY model is the estimate the flow of the North Platte River at North Platte, the diversion at the Sutherland Canal, the total release from Lake McConaughy. The maximum amount that can be released for a short-duration near-bankfull event is the minimum of the remaining release capacity at Lake McConaughy (turbine capacity minus estimated release) and the sum of the remaining capacity in the Sutherland Canal and the North Platte River at North Platte. The estimated flow of the North Platte River at North Platte includes the estimated gains and losses (including diversions) between Keystone and North Platte. The remaining capacity in the North Platte River at North Platte is the capacity of the North Platte River at flood stage minus the estimated flow.

In order to augment the short-duration near-bankfull event:

1. Releases from Lake McConaughy are ramped up at a maximum rate of 700 cfs per day. 200 cfs per day for the Sutherland Canal and 500 cfs per day in the North Platte River. The Sutherland Canal is ramped up to achieve a maximum release from the Sutherland Canal of 1850 cfs.
2. Sutherland Canal does not divert at the Korty Diversion during short-duration near-bankfull event. More flow in the South Platte River and less of the Sutherland Canal return capacity being used by South Platte flows.
3. The Tri-County Canal does not divert as much as they could during the short-duration near-bankfull event. More flow in the Platte River and less of the Tri-County Canal return capacity being used by Platte River flows.

4. The water that is diverted by the Tri-County Canal is returned to the Platte River through the Jeffrey Return. This is water not needed for the structural integrity of the canal.
5. Water is not diverted to Elwood Reservoir during the short-duration near-bankfull event. This allows either more water to be returned via the Jeffrey Return of not diverted by the Tri-County Canal.
6. Water is not delivered to the E-65 lateral, the E-67 lateral, or the Phelps County Canal during the short-duration near-bankfull event. This allows either more water to be returned via the Jeffrey Return of not diverted by the Tri-County Canal.
7. 4,000 acre-feet of the water used to ramp-up the releases from Lake McConaughy is stored in the Tri-County Canal system (mostly Johnson Lake). This water is released at a rate of 2,000 cfs for two days to coincide with the peak of the short-duration near-bankfull event in the Platte River.
8. No losses are estimated for the short-duration near-bankfull event, which is consistent with the rest of the OPSTUDY model.

4.4 COLORADO CONSERVATION WATER

Augmented flows to the South Platte River at Julesburg resulting from reduced consumption of South Platte Basin water in Colorado are referred to as "Colorado conservation water". The amount of Colorado conservation water provided as flow in the South Platte River at Julesburg in each month is defined for the model by HDATA item #29. In the COMPUTE subroutine, Colorado conservation water (*CONSCO*) is always protected from diversion for irrigation. It may or may not be protected from diversion for power generation depending upon the settings of the *KTPROT* flag (for the Korty Canal) and the *TCPROT* flag (for the Central/Tri-County Canal). These two flags are set by CDATA values #89 and #90, respectively.

OPSTUDY variables associated with Colorado Conservation Water

CONSCO	Colorado conservation water at Julesburg (KAF/month).
CONSCOC	Colorado conservation water in the Central Canal (KAF/month).
CONSCOR	Colorado conservation water in the river passing Central Canal (KAF/month).
KTPROT	Flag to protect Colorado conservation water from diversion at Korty (1 = protect, 0 = don't protect).
TCPROTP	Flag to protect Colorado conservation water from diversion at Central (1 = protect, 0 = don't protect).

4.5 CENTRAL PLATTE REREGULATING RESERVOIR PROJECT (101; CPREREG subroutine)

The Central Platte Reregulating Reservoir Project is proposed as a relatively small (up to 5,000 acre-foot capacity) re-regulating reservoir whose purpose is to change the timing of water releases from the J2 Return to the Platte River. The intent of this reservoir is to store "excess" instream flows coming out of the J2 return so that they can be released later when instream flows are below targets. The Central Platte Reregulating Reservoir Project is operated using the daily flows calculated by the OPSTUDY model.

This reservoir most likely would be an off-channel storage facility located southeast of Cozad, Nebraska. The Central Platte Reregulating Reservoir Project is simulated in the CPR Model only if the *CPRR* flag is set to 1.0 (CDATA item #113). The months during which diversions are allowed to the reservoir are turned "on" (1.0) and "off" (0.0) using ADATA array #102, which sets the corresponding *CPRRALLOW* value within the OPSTUDY model. Various Central Platte Reregulating Reservoir Project variables, such as the capacity and the outlet rate of the reservoir, are set by CDATA items #114 through #121. This includes initialization of the content of the reservoir (*CPRREOMLST*, CDATA item #115) for the first month of the model run.

OPSTUDY variables associated with the Central Platte Re-regulating Reservoir Project
(All units KAF unless otherwise noted)

CPRRALLOW	Flag to indicate whether the Central Platte Re-Regulating Reservoir is allowed to store in this month (1=yes, 0=no).
CPRRCAP	Capacity of the Central Platte Re-Regulating Reservoir.
CPRRCFSIN	Inlet rate to Central Platte Re-Regulating Reservoir (cfs).
CPRRCFSOUT	Outlet rate from Central Platte Re-Regulating Reservoir (cfs).
CPRR	Flag to turn on Central Platte Re-Regulating Reservoir Project for simulation (1 = on, 0 = off).
CPRRDEAD	Dead pool volume of Central Platte Re-Regulating Reservoir.
CPRREOMLST	Content of Central Platte Re-Regulating Reservoir in previous month.
CPRREVAP	Evaporation from Central Platte Re-Regulating Reservoir.
CPRREXP	Exponential factor for Central Platte Re-Regulating Reservoir area/capacity curve (dimensionless).
CPRRFLAG	Flag to check whether Central Platte Re-Regulating Reservoir adjustments have already been made for the present month being processed (1=yes, 2=no).
CPRRKIN	Inflow to Central Platte Re-Regulating Reservoir.
CPRRKOUT	Outflow from Central Platte Re-Regulating Reservoir.
CPRRMULT	Multiplier factor for Central Platte Re-Regulating Reservoir area/capacity curve (dimensionless).
CPRRREL	Release from the Central Platte Re-Regulating Reservoir.
CPRRSEEP	Seepage from the Central Platte Re-Regulating Reservoir.
CPRRSPACE	Empty space available in the Central Platte Re-Regulating Reservoir.
CPRRSPILL	Spill from the Central Platte Re-Regulating Reservoir.
CPRRSPFAC	Central Platte Re-Regulating Reservoir monthly seepage factor (decimal percent).
CPRRSTOR	Maximum amount of instream flow available for storage.

Calculations associated with Central Platte Re-Regulating Reservoir accounting are performed by the subroutine PLUMCRK. If there is excess instream flow, this routine tries to store it in the Central Platte Re-Regulating Reservoir, up to the capacity of the reservoir (*CPRRCAP*). The maximum amount storable (*CPRRSTOR*) is limited by the amount of average excess at Overton (*OVEXCES)*, and at Grand Island (*GIEXCES*), the J2 return (*J2HR*), the empty reservoir space (*CPRRSPACE*), and the inflow rate (*CPRRKIN*). When there is excess instream flow, the content of the reservoir (*CPRREOMC*) is updated, and the J2 return flow is correspondingly reduced by the amount stored. Seepage, evaporation, and spill (if any) are then calculated for the reservoir.

Seepage from the Central Platte Re-Regulating Reservoir is computed as the mean of the beginning-of-the-month and the end-of-month content ((*CPRREOMLST* + *CPRREOM*) / 2) multiplied by the Central Platte Re-Regulating Reservoir monthly seepage factor (*CPRRSPFAC*). Note that seepage out of the reservoir is represented by a positive value. In the CPR Model, the monthly seepage factor is treated as a year-round constant (CDATA item #120) equal to 0.02 (i.e., 2% a month). This value is based on an estimated mean reservoir surface area of 200 acres, and an estimated monthly rate of seepage of 0.516 acre-feet per acre of surface area (Boyle Engineering Corporation, 1999a). This seepage is assumed to accrete to instream flow at Overton (*OVERTON*) in the same month that the seepage occurs.

As at McConaughy Reservoir, **evaporation** from the Central Platte Re-Regulating Reservoir is calculated by the EVAP subroutine, using the same area/capacity relationship described in Equation 2.1, with *A* set equal to *CPRRMULT* (CDATA item #118) and *B* set equal to *CPRREXP* (CDATA item #119). The CPR Model uses the empirical values of 0.12 and 0.32 for *CPRRMULT* and *CPRREXP*, respectively. These are based on a hypothetical content-area curve generated for this reservoir (Figure 4.1) in which the reservoir has a surface area of 200 acres when it is at its full capacity of approximately 5000 acre-feet (Boyle Engineering Corporation, 1999s). **Spill** from the reservoir is calculated as any end-of-month content (*CPRREOM*) in excess of the reservoir capacity (*CPRRCAP*).

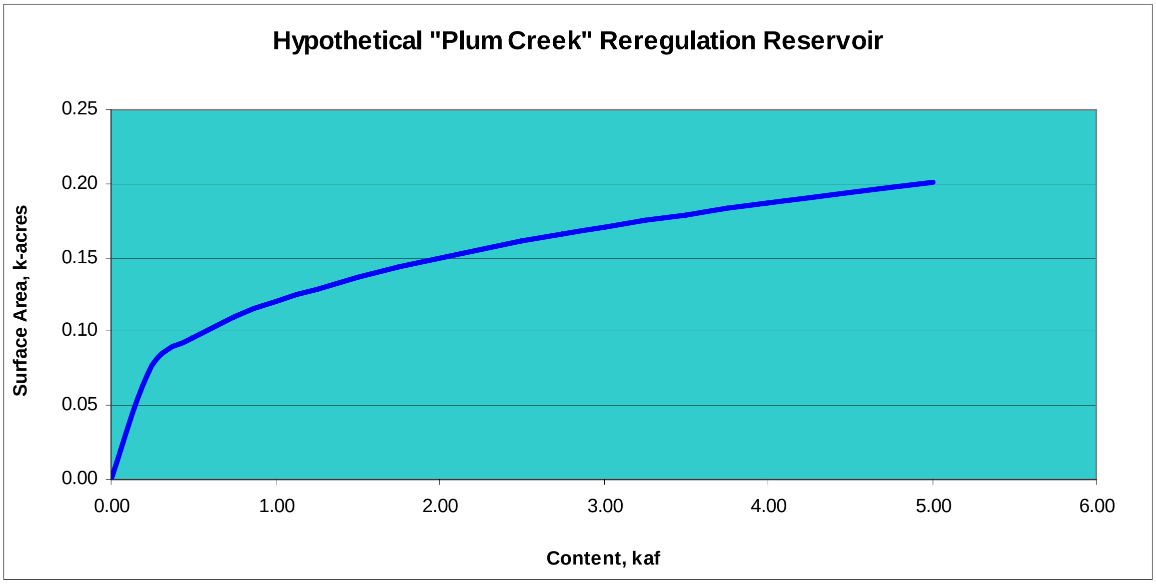


Figure 4.1 Hypothetical Content/Area Curve for Central Platte Re-Regulating Reservoir

A release is made from the Central Platte Re-Regulating Reservoir only if there is a flow shortage at Grand Island (*GISHORT*), which is defined as the difference between the FWS monthly flow recommendation at Grand Island (*GISFR*, see section 4.2) and the actual flow at Grand Island (*GRNDISL*). If such a shortage exists, a release is made up to the *GISHORT* volume, or the available supply in the reservoir (*CPRREOMC - CPRRDEAD*), whichever is limiting. The dead pool (*CPRRDEAD*) is considered to be unavailable water, and the model uses it to hold some water in reserve to pay for reservoir evaporation and seepage.

The inlet rate to (100 cfs) and outlet rate from (50 cfs) Central Platte Re-Regulating Reservoir are based on the general conceptual design of this reservoir.

In Central Platte River Model the Central Platte Re-Regulating Reservoir is not allowed to divert any of the EA short-duration near-bankfull releases that are made, because we don't want any operations at the Central Platte Re-Regulating Reservoir to reduce the size of that short-duration near-bankful. In addition to operations to regulate Platte River flows, the Central Platte Re-regulating Reservoir is used to augment flows during a short-duration near-bankfull event.

4.6 GROUNDWATER MANAGEMENT PROJECT (100B, GROUNDWMGMT, EA_EOMC)

The Ground Water Management Project diverts excess-to-target instream flows coming out of the J2 return and sends them down Central's irrigation canals to recharge groundwater areas. These areas of elevated groundwater are later pumped for irrigation use. The volume stored from October through April (up to the maximum amount managed) is allocated to the McConaughy Environmental Account beginning in May. This allocation is delivered evenly from May through September to avoid losing the entire supply as a result of Lake McConaughy filling and the EA having to be reset to 100 KAF. To operate the Project, the instream flow targets used are the average targets at Overton and Grand Island.

Calculations for Groundwater Management Project accounting are performed by the subroutine GROUNDWMGMT. (Of course, calculations are performed only if the option to include this project has been activated. This is done by setting the *GWMPROJ* variable within the OPSTUDY program to 1.0 (CDATA item #105)). The OPSTUDY calculations for the Groundwater Management Project are similar to the calculations used for the Central Platte Re-regulating Reservoir Project (Section 3.5): If there is excess-to-target instream flow during October through April, this subroutine tries to store the excess in the ground, up to the capacity limit (*GWMKTARG*). The maximum monthly amount storable (*GWMSTORE*) is limited by the amount of average excess at Overton (*OVEXCES*) and Grand Island (*GIEXCES*), the J2 return (*J2HR*), the available ground "storage space" (*GWMKTARG - GWMEOMC*), and the inflow rate (*GWMCAP*). The J2 return and Overton flow is reduced by the amount stored, and the total volume stored during October through April is tracked (*GWMCRED*).

For purposes of assigning a credit to the EA and for reducing Central's irrigation demands, the losses in the Keystone and Central systems that result in the net water stored are not included in the credit and subtracted from the demand.

From October through April, the total amount of water diverted to groundwater storage through the groundwater management project (*GWMCRED*) is calculated as follows:

New credit = Previous credit + GWMSTORE

In April, the groundwater credit is allocated by dividing it (in the subroutine INIT_MON) evenly by five months for irrigation use (*GWMPUMP*) during May through September. From May through September, the amount credited to each month is (*GWMCRED*) is added to the Environmental Account, where it becomes available for EA release (this step is performed within the subroutine EA_EOMC).

OPSTUDY variables associated with the Groundwater Management Project

GWMCAP	Monthly capacity that can go down the canals for storage in groundwater, kaf
GWMCRED	Amount of Groundwater Management Project water credited to the Environmental Account.
GWMEOMC	End-of-month content in Groundwater Management storage.
GWMFLAG	Flag to check whether Groundwater Management Project adjustments have already been made for the present month being processed (1=yes, 2=no).
GWMKTARG	Maximum end-of-month content in Groundwater Management storage.
GWMPROJ	Flag to turn on Groundwater Management Project (1 = on, 0 = off).
GWMPUMP	Amount removed from ground water storage for irrigation in May-Sep, KAF.
GWMSPACE	Available "storage" space (GWMKTARG-GWMEOMC), KAF.
GWMSTORE	Groundwater management project storage.

4.7 NORTH DRY CREEK GROUNDWATER PUMPING (47)

North Dry Creek enters the Platte River just west of Kearney, Nebraska, from the south side of the river. Its entrance point is below the Odessa stream gage. Pumping of high groundwater into North Dry Creek is proposed as a potential source of augmented flows to the Platte River for environmental purposes.

Monthly water potentially pumped from high groundwater areas into North Dry Creek for environmental purposes is provided to the model by ADATA array #46, and assigned to the variable *EANDRYCK*. If the North Dry Creek Groundwater alternative is being modeled (*NDRYCKFLG* = 1; this is set by CDATA item #107), then the COMPUTE subroutine computes the instream flow excess at Odessa and Grand Island. If both instream flows are being met (*i.e.*, the flow exceeds *GISFR*) then well pumping into North Dry Creek is not activated and the additional flow provided by the creek is zero (any "normal" flow is already included in the Odessa to Grand Island gain). If instream flows are not being met at either location, then the North Dry Creek wells are assumed to be pumping and the *EANDRYCK* amounts are added to the Platte River flow. If excess exists and the project will not pump during the month, then the variable *EANDRYCK* will be set to zero, otherwise, the program continues with the value set via the input file. The actual amount of water represented by *EANDRYCK* is eventually added to the flow in the river.

OPSTUDY variables associated with the North Dry Creek Groundwater Pumping Project

DRYCKFLG	Flag to turn the groundwater pumping option on (1.0) or off (0.0).
EANDRYCK	Monthly volume of water available for pumping into North Dry Creek for environmental purposes (KAF).

When a "score" (that is, estimated reduction in shortages to target flow) is calculated for the modeled Platte River management alternative, additional water provided by the North Dry Creek groundwater pumping activity (if any) is scored at *one-half* of the volume of introduced water This is because the project is located about halfway through the critical habitat stream reach, and thus only about half of the flow benefits would be realized (Boyle Engineering Corporation, 1999a, page 96). Note that this scoring adjustment to the North Dry Creek water is performed as a "post-processing" step the CPR Model output, and not within the CPR Model itself.

4.8 POWER INTERFERENCE PROJECT (100A)

The proposed "Power Interference Project" entails a monetary payment to a hydroelectric power generator sufficient to induce that generator to modify the release of water through the hydropower turbines. This might involve a change in the timing of such generation, or a bypass of the turbines in order to reduce target flow shortages at the critical habitat. The Power Interference Project would operate primarily at CNPPID's Kingsley Dam hydroelectric facility, the two Johnson hydros and Jeffrey hydro, in conjunction with the Lake McConaughy Environmental Account. NPPD's Sutherland System and North Platte Hydro facility would also be involved, as NPPD and CNPPID power generation operations are closely related.

Water in excess of that required for offsets to new depletions in Nebraska would be made available to the Program under this alternative. Currently, 1400 acre-feet per year are estimated to be made available in this manner (Boyle, 2000).

OPSTUDY variables associated with the Power Interference Project

PWRDIVISOR	Power interference divisor (potential/divisor = amount to EA).
PWRINTFR	Flag to turn on Power Interference alternative (1=yes, 0=no).
PWRXKAF	Power interference water available for the EA (KAF).

If the Power Interference is active (*PWRINTFR* = 1) then the power interference volume for the EA is estimated (*PWRXKAF*) based on instream flow excess-to-targets at Overton (*OVEXCES*), Grand Island excess (*GIEXCES*), Sutherland System excess (*PXSSDMD*), and Tri-County excess (*PXTCDMD*). The power interference volume is set to the minimum excess and is added to the EA content. Overton excesses are more predictable than excesses at Grand Island because of the shorter travel distance, but excess at Overton may be needed to meet negative gains between there and Grand Island. Therefore, the smaller of the estimated excess at Overton or Grand Island is used to limit the flow available from power interference.

The final power interference volume for the EA must also be greater than 1 KAF before it is "purchased". The power interference project has "first dibs" on instream flow excess-to-targets relative to the Groundwater Management project and any Central Platte Re-Regulating Reservoir which operates next and changes the J2 outflow.

4.9 PATHFINDER MODIFICATION PROJECT

Pathfinder Reservoir, which is located along the North Platte River in Wyoming about three miles below the Sweetwater River confluence and about 47 miles southwest of Casper, is operated by the U.S. Bureau of Reclamation under a 1904 water storage right. Because approximately 54 KAF of reservoir capacity has been lost to sedimentation since the reservoir was constructed, USBR proposes raising the level of the dam to recover this lost reservoir capacity. Of the 54,000 AF to be reclaimed, 34,000 AF would be committed to an environmental account for endangered species recovery purposes. The remaining 20,000 AF would provide municipal water to North Platte basin communities in Wyoming through contracts between the municipalities and the state of Wyoming.

Environmental water from the Pathfinder Modification Project and other Program projects in Wyoming are provided as an input dataset to the Central Platte River Model (HDATA array item #20), and is represented in the Central Platte River Model as a component of the inflow at Lewellen (*EALEW*). These data are normally generated from North Platte Model runs (USBR, 1997).

4.10 CENTRAL PLATTE RIVER IRRIGATION CONSERVATION/LEASING (Nebraska)

A reduction in the average annual diversion of surface water from the Platte River system in Nebraska is proposed by implementing such techniques as leasing of water from irrigation districts and individual farmers, and/or promoting conservation measures such as conservation cropping, deficit irrigation, fallowing, and on-farm irrigation changes. Most of these activities would likely occur within areas serviced by CNPPID. If *CONSERV* is set equal to 1.0 (CDATA item #72), then the CPR Model simulates the effect of these conservation and leasing activities on the Platte River system in Nebraska, including the transfer of this water to an environmental account at Lake McConaughy.

EANETCW (CDATA item #78) defines the total net conserved Nebraska water to add to the environmental account, as a sum of conservation/leasing savings from all irrigation canals. In the model, the net conserved water is added to the EA in October.   The model also reduces the demand on Lake McConaughy to reflect the proportion of conserved/leased water that is retained in the corresponding canal sections. Specifically, the demand is reduced by (1.0 - the “irrigation retaining factor”), where the irrigation retaining factor for each canal system is defined by CDATA items #73 through #79 (see Appendix A).

The irrigation retaining factors range from 0.94525 (for the Tri-County Canal) to 0.99449 (for the Keystone to Sutherland and Sutherland to North Platte canals). The various irrigation retaining factors were calculated by using the conservation savings estimated by Boyle Engineering (1999), and re-apportioning these savings from the stream reaches that Boyle describes to the reaches used within the CPR Model. Then the presumed reduced level of annual irrigation demands along each canal was compared to the historic average annual demand from the same canal to provide the irrigation retaining factor for each canal.

If the *CONSERV* flag is turned off, the irrigation retaining factors must be set equal to 1.0 (otherwise, the Central Platte River Model will return an error message and cease executing). Conversely, if the *CONSERV* flag is turned on, the factors must all be less than 1.0, as determined above.

OPSTUDY variables associated with irrigation conservation and leasing

CONS	Conservation saving for a month (KAF).
CONSERV	Flag to turn irrigation conservation/leasing flag on (1.0) or off (0.0).
EANETCW	Net conserved water to add to EA (KAF/year).
IRRGREDBC	Irrigation retaining factor, Brady to Cozad canals (percent).
IRRGREDKR	Irrigation retaining factor, Kearney Canal (percent).
IRRGREDKS	Irrigation retaining factor, Keystone/Sutherland Canal (percent).
IRRGREDSNP	Irrigation retaining factor, Sutherland to North Platte canals (percent).
IRRGREDTC	Irrigation retaining factor, Tri-County Canal (percent).
IRRGREDWC	Irrigation retaining factor, Western Canal (percent).
BCIRSAV	Reduction in Brady to Cozad canals irrigation demand (KAF).
KRIRSAV	Reduction in Kearney Canal irrigation demand (KAF).
KSIRSAV	Reduction in Keystone/Sutherland Canal irrigation demand (KAF).
SNPIRSAV	Reduction in Sutherland to North Platte canals irrigation demand (KAF).
TCIRSAV	Reduction in Tri-County Canal irrigation demand (KAF).
WCIRSAV	Reduction in Western Canal irrigation demand (KAF).

4.11 CONSERVATION WATER FROM USBR FUNDS

Of the CNPPID conservation activities described in Section 4.10, some have been or will be implemented with the aid of up to $500,000 in USBR funds applied to a variety of water conservation projects, such as ditch lining and pipeline improvements. These "USBR Funds" conservation savings are tracked separately within the model because they would be added to the Environmental Account at no extra cost to the Platte River Recovery Program.

Of the estimated 4,500 AF/year savings from CNPPID conservation activities, Boyle Engineering Corporation (2000) estimated that approximately 500 AF would be attributable to USBR Funds. Monthly conservation water to be added to the Environmental Account from USBR funds is provided by ADATA item #45, and in the model this is assigned to the variable ***CONSBOR*.** This water is added to the EA account at Lake McConaughy in the subroutine EA_UPDATE. In the model, the net conserved water is added to the EA in October.

4.12 EXCESS-TO-OWNERSHIP IN USBR NORTH PLATTE SYSTEM

"Excess-to-Ownership" or "ETO" water refers to North Platte River water in excess of USBR's right to store (for example, at Glendo Dam), and which therefore continues flowing through the North Platte River system. Monthly quantities of ETO water (*EAETO*) are provided to the Central Platte River Model by HDATA array item #22 in the input file.

The general practice of Nebraska and Wyoming, by implied agreement, has been to store this water such that 75% goes to Nebraska, and 25% to Wyoming. For the sake of the Central Platte River Model, a portion of this water (*EAETOPCT*) may be credited to the Environmental Account. This portion (if any) that is credited to the EA is therefore equal to *EAETO* * *EAETOPCT*. *EAETOPCT* is provided to the model as CDATA item #92. The value of this item has varied from one model simulation to another.

OPSTUDY variables associated with USBR Excess-to-Ownership Releases

EAETO	Excess to ownership that was not stored by USBR (KAF).
EAETOPCT	Percent of EAETO water to place in the EA (percent).

4.13 TAMARACK PLAN

The "Tamarack Plan" refers to a program proposed by the state of Colorado (and, to some extent, already implemented) to re-regulate flows in the lower South Platte River upstream from the Colorado/Nebraska state line. The intent of this project is to divert water from the South Platte River via ditches and alluvial aquifer wells into recharge basins in sandy upland areas during periods when flows exceed critical instream needs. By distributing the diverted water to properly-located recharge areas, this is expected to have the effect of maximizing return flows to the South Platte River during periods when instream flow augmentation is particularly desired (namely, April through September).

Any expansions to the existing Tamarack Project will likely be located along the south side of the South Platte River in the Tamarack Ranch State Wildlife Area (SWA) and the Pony Express SWA, about 40 miles upstream from the state line. As described by the *Cooperative Agreement* (Platte River Partnership, 1997):

> "The Tamarack Plan involves the use of participating existing and future wells and other water facilities in Colorado to reregulate flows that are in excess of legal rights to and physical demands for water in Colorado in a manner that is consistent with the flow-related goal of the Platte River Recovery Implementation Program. As a result of the geographic location of the Tamarack Plan near the state line, groundwater recharge that results from the Tamarack Plan is estimated to increase flows at the Julesburg gage during the period of April through September by an average of approximately 10,000 acre-feet over the flows that would otherwise occur during that period.
>
> ...

> The components of the Tamarack Plan will be developed within the 40 miles above the state line beginning at about the Tamarack Ranch State Wildlife Area ... near Crook, Colorado. These facilities will include wells located adjacent to the south Platte River that divert groundwater from the alluvial aquifer and canals that divert water from the South Platte River. Water that percolates into the groundwater alluvium from these facilities will return to the South Platte River at a later time."

Colorado's "Tamarack Plan" for re-regulating flows in the South Platte River is a component of the Central Platte River Model requiring its own separate modeling step. A separate modeling step is necessary because the proposed project requires an analysis of delayed return flow to the river from alluvial aquifers adjacent to the South Platte.

EIS analysis of return flows from the Tamarack Plan alternatives was supported by use of the "SDF View" program. SDF View is a software product of the Integrated Decision Support Group (IDSG) at Colorado State University (http://nile.lance.colostate.edu/projects/sdfview). SDF View uses the "SDF method" developed by the U.S. Geological Survey to quantify the rate, volume, and timing of depletive/accretive effects of pumping from or recharging to wells in unconfined alluvial river aquifers, such as those in the Tamarack project area.

By definition, SDF = a^2S/T, where a is the distance from the pumped well to the stream, S is the specific yield of the aquifer, and T is the aquifer transmissivity. SDF has the dimensions of time. For any aquifer that meets the assumptions of the SDF method (described below), it is equivalent to the time from the beginning of steady pumping from (or recharge to) the alluvial aquifer within which the volume of stream depletion (accretion) is 28 percent of the volume pumped (recharged). According to the *Cooperative Agreement* Tab 3A, the SDF values for potential canal systems and recharge basins in the lower South Platte River Basin in Colorado range from 60 days to 1500 days.

The assumptions underlying the SDF method, as listed below (Jenkins, 1968; Hotchkiss et al., 1999), are common to many analytical groundwater models:

- The alluvial aquifer is in perfect hydraulic connection with the stream;
- The aquifer is isotropic, homogeneous, and semi-infinite in areal extent, with a straight, fully-penetrating stream boundary and a horizontal, impervious base;
- Drawdown is considered to be negligible in comparison to the saturated thickness of the aquifer (*i.e.*, transmissivity does not change with pumping time);
- Water is released instantaneously from storage;
- The well (or recharge basin) is fully penetrating;
- The pumping rate (or recharge) is steady over the period of pumping (recharge);
- The water surface elevation in the stream is constant in space and time;
- The temperature of the stream is constant and equal to the temperature of the water in the aquifer;
- The residual effects of previous pumping are negligible.

While each of these assumptions may be violated to some extent at the Tamarack Project site, as they normally would be violated in any "real world" situation, the resulting effect on the SDF modeling results are presumed to be small relative to the unknowns inherent in the proposed management and operation of the Tamarack facilities, as well as uncertainties in future hydrologic conditions. Plans are to monitor the return flow characteristics of the project as it is implemented and, if necessary, modify project operations to ensure that they are meeting the intended return flow targets.

The simulated configuration of the Tamarack project for the CPR Model involves five recharge sites. These consist of five recharge basins located at varying distances from the river and fed by one ditch and/or multiple wells. The SDF values assigned to these five recharge sites, as provided by Jon Altenhofen of the Northern Colorado Water Conservancy District (2003), are as follows:

Recharge source	SDF
Ditch	300 days (not used for modeled scenarios)
Well set 1	480 days
Well set 2	270 days
Well set 3	120 days
Well set 4	Not used

In the CPR Model, these values are set within a spreadsheet that was constructed specifically to provide a framework for modeling the Tamarack project (Tamarack47_94.xls). Note that this project is therefore handled quite differently from others represented in the CPR Model. The description of the project is not based on ADATA or CDATA items (except for the *COEXCHNG* flag, see below). Rather, all modeling of the Tamarack Project is performed as a separate processing step, using spreadsheet macros and the SDF View software. The results are then incorporated into two HDATA array items (#2 and #21) which are passed to OPSTUDY8. These separate processing steps are described in Sections 5.1 and 5.3.3.

Three different kinds of Tamarack operations may be simulated in the CPR Model using options provided for the EIS study. The **first Tamarack configuration option** ("Code" in Tamarack_input4794.xls is set equal to 1) sizes the Tamarack operation based on its description in the *Cooperative Agreement* (Platte River Partnership, 1997) as subsequently modified in analyses provided on behalf of the State of Colorado (Altenhofen, 2003). This is intended to serve as Colorado's contribution to the Platte Recovery Program to offset historic depletions. The diversion capacities that are projected to be necessary to achieve the target average 10,000 acre-foot increase in flows at the Julesburg gage during the period of April through September are as summarized in Table 4.5 (these values were provided by Gerhart Koontz, of the USGS). These capacities account for an assumed loss of about 1% of the diverted water to evaporation.

Table 4.5 Assumed diversion capacity (AF) of Phase I Tamarack Project

Source	Nov	Dec	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Total
Ditches	0	0	0	0	0	0	0	0	0	0	0	0	0

Wells 1	7955	0	0	7425	8220	7955	8220	7955	8220	8220	7955	8220	80345
Wells 2	0	8220	0	0	0	0	0	0	0	0	0	0	8220
Wells 3	0	0	8220	0	0	0	0	0	0	0	0	0	8220
Wells 4	0	0	0	0	0	0	0	0	0	0	0	0	0
Total	7955	8220	8220	7425	8220	7955	8220	7955	8220	8220	7955	8220	96785

The **second Tamarack configuration option** for the CPR Model ("Code" set to 2) assumes an 80% enlargement in the capacity of the system over that described in the *Cooperative Agreement*. The corresponding diversions associated with this configuration are as summarized in Table 4.6.

Table 4.6 Diversion capacity (AF) of Phase III Tamarack Project, sized as 80% enlargement over Phase I

Source	**Nov**	**Dec**	**Jan**	**Feb**	**Mar**	**Apr**	**May**	**Jun**	**Jul**	**Aug**	**Sep**	**Oct**	**Total**
Ditches	0	0	0	0	0	0	0	0	0	0	0	0	0
Wells 1	14319	0	0	13365	14796	14319	14796	14319	14796	14796	14319	14796	144621
Wells 2	0	14796	0	0	0	0	0	0	0	0	0	0	14796
Wells 3	0	0	14796	0	0	0	0	0	0	0	0	0	14796
Wells 4	0	0	0	0	0	0	0	0	0	0	0	0	0
Total	14319	14796	14796	13365	14796	14319	14796	14319	14796	14796	14319	14796	174213

The **third Tamarack configuration option** ("Code" set to 3) represents a "super-sized" facility, in which the capacity is enlarged by 120% over the system described in the *Cooperative Agreement*. The diversion amounts associated with this option are as summarized in Table 4.7.

Table 4.7 Diversion capacity (AF) of "super-sized" Tamarack Project (120% enlargement over Phase I)

Source	**Nov**	**Dec**	**Jan**	**Feb**	**Mar**	**Apr**	**May**	**Jun**	**Jul**	**Aug**	**Sep**	**Oct**	**Total**
Ditches	0	0	0	0	0	0	0	0	0	0	0	0	0
Wells 1	17183	0	0	17183	17183	17183	17183	17183	17183	17183	17183	17183	171830
Wells 2	0	17183	0	0	0	0	0	0	0	0	0	0	17183
Wells 3	0	0	17183	0	0	0	0	0	0	0	0	0	17183
Wells 4	0	0	0	0	0	0	0	0	0	0	0	0	0
Total	17183	17183	17183	17183	17183	17183	17183	17183	17183	17183	17183	17183	206196

Although one of these three options (or the fourth option of *no* Tamarack project) was used for all EIS runs of the CPR Model, CPR Model users can modify these diversion volumes for other analyses. The procedures for doing so are described in Section 5.3.3 of this report.

Within the CPR Model, the quantity of Tamarack water available at Julesburg on a monthly basis is provided by HDATA item #21 in the hydrologic input file, and the adjusted historic inflows to the model at Julesburg are provided by HDATA item #2. Initially, item #21 values are provided by Hydrosphere modeling of the South Platte River, and item #2 values are all set to zero in the input hydrology file. Later, as mentioned above, HDATA item #2 and #21 values are adjusted (if the Tamarack Project is included in the modeled scenario) by the processing steps embedded in the Tamarack spreadsheet (Tamarack47_94.xls) and the SDF View software. These processing steps consider the capacity limitations defined above, and they determine the amount of flow available for diversion at the Tamarack site based on the projected flow at Grand Island (from the .GI output file, see Section 5.5), and the available excess flows at Grand Island. One percent of the water diverted to the Tamarack recharge basins is presumed to be lost to evapotranspiration; the remainder becomes return flow, whose accretive impact on South Platte River flows at Julesburg over the following months is simulated by SDF View. Values in the SDF View output file are the values used to adjust HDATA array values #2 and #21 for the subsequent OPSTUDY modeling.

Within OPSTUDY, the water released from the Tamarack project is assigned to the variable array *EAJUL*. Tamarack EA water at Julesburg may be exchanged for EA water at McConaughy within the model if the *COEXCHNG* flag (CDATA item #93) is set to 1.0. If this option is turned on, then the "net" Tamarack water which remains after any negative gains in the Julesburg-Paxton reach are satisfied is transferred to the Lake McConaughy EA account, and Tamarack EA "credits" associated with the South Platte River are set to zero.

OPSTUDY variables associated with the Tamarack Plan

COEXCHNG	Flag to exchange Tamarack EA water into McConaughy (1=yes, 0=no).
EAJNT	Net Tamarack EA water after negative gains in Julesburg-Paxton reach are satisfied (KAF).
EAJUL	Colorado Tamarack Environmental Account water at Julesburg (KAF).
EAJULLST	Portion of the Tamarack release used to satisfy any negative gains in the Julesburg-Paxton reach (KAF).

4.14 RIVERSIDE DRAINS

The "Riverside Drains" are drainage canals located in an area between Cozad and Overton, Nebraska, whose purpose is to drain very high groundwater from farmlands in areas adjacent to the Platte River. Water from the Riverside Drains is credited in the Central Platte River Model as water that returns to the Platte River.

Monthly Cozad-to-Overton inflow from the Riverside Drains is defined by ADATA item #47, and assigned to the variable *RIVRDRAIN*. *RIVRDRAIN* is then added to the Cozad-to-Overton stream reach gain (*COGN*) in COMPUTE. Stream reach adjustments resulting from the Cozad-

Overton Riverside Drains can be turned on/off in the model by setting *RIVRDFLAG* in the model to 1.0 (on) or 0.0 (off), as established by CDATA item #108.

The estimated monthly inflow from the Riverside Drains was derived from information provided by Glen Sanders of the Bureau of Reclamation.

OPSTUDY variables associated with the Riverside Drains	
RIVRDFLAG	Flag to turn option on (1.0) or off (0.0).
RIVRDRAIN	Monthly inflow from the Cozad-Overton riverside drains.

4.15 JOHNSON LAKE FLOW ATTENUATION PLAN

The final adjustment to daily flows is the adjustments that are made for the Johnson Lake flow attenuation plan (CNPPID, 2000). Under the plan up to 2,500 acre-feet may be stored in Johnson Lake to reduce ‘spikes’ in flow during the tern and plover nesting seasons. The flow attenuation is the minimum of the storage space available, the flow in the J2 return, and the difference between the desired flow and the flow in the Platte River at Overton.

CHAPTER FIVE

OPERATION OF THE MODEL (A USER'S GUIDE)

5.1 "CORTEX" INTERFACE

A single Excel spreadsheet interface has been developed for running the Central Platte River Model. This spreadsheet, which is called **cortex.xls**, establishes the links to other spreadsheets necessary to run the model, and it executes the model by invoking various macros. Cortex.xls is located under the \Tools directory.

To run the model, open the cortex.xls spreadsheet, allow the spreadsheet to enable the macros and establish the spreadsheet links, and then follow the remaining on-screen directions:

- Establish the correct path to the current OPSTUDY directory (if not already correct);
- Click the button labeled "Open Linked Spreadsheets" to begin running the model.

Assuming that all of the necessary spreadsheets are found by the macro, the macro will automatically open the required spreadsheets, and will display a new "Control Page" spreadsheet that walks the user through a number of individual modeling steps, as follows:

Step 1. Select the alternative for the model run (e.g., "Present Condition", "Proposed Program", etc).

Execute by pressing the "Step 1" button, and then select the desired alternative from the scrollable list (beginning at Cell A16), which in turn sets the correct "Alt #" number in the spreadsheet (Cell A12). The user then presses the "Return To Model Run" button to save the chosen alternative and return to the main Cortex spreadsheet.

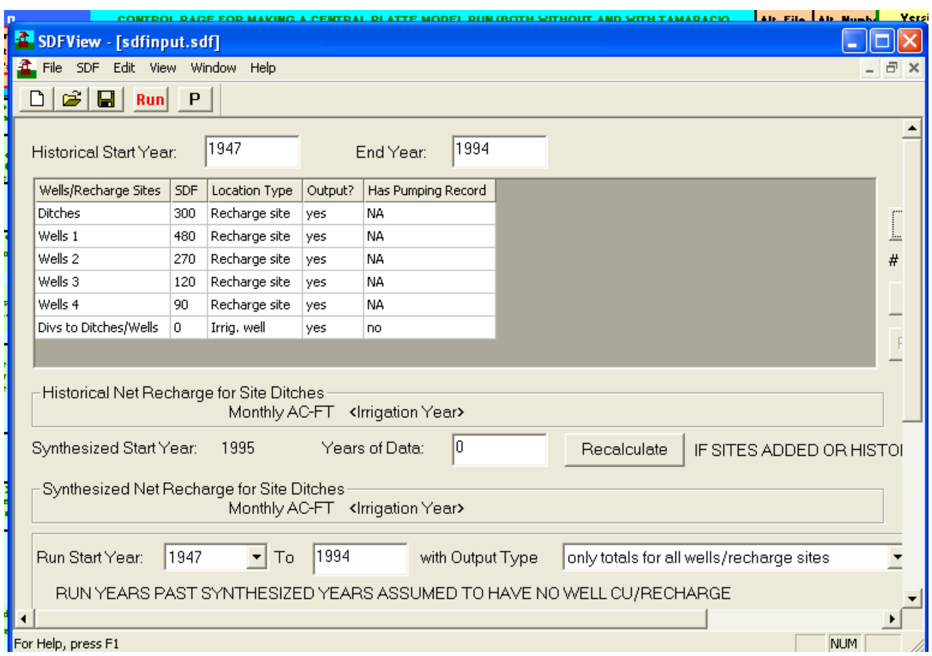
Step 2. Pressing the "Step 2" button sets off a macro which creates the input file for the OPSTUDY model using the input spreadsheets (Section 2.7). It also runs the OPSTUDY model on these input files. Note that the Tamarack Project component (if any) of the alternative being modeled is not incorporated at this point. This is because the impacts of Tamarack have to be modeled based on flows at Grand Island as simulated by the initial OPSTUDY model run. The effects of the Tamarack Project are simulated in a later modeling step (if appropriate) by using the SDF View streamflow depletion model on the [alternative].inh file.

When the Step 2 macro is run, all of the executable OPSTUDY Fortran routines are run on the input data. As a result, a DOS-type window is displayed, and when each "Fortran Pause" statement is encountered, the user is prompted for a carriage return before proceeding on to the next step. Hit carriage-return when these pauses occur.

OPSTUDY outputs the results as various files that are in a "raw" text file format (i.e., they are not Excel spreadsheets). These output files, which are described in Section 5.4, are placed under the \OUTPUT\[alternative] directory.

Step 3. If necessary (i.e., if the Tamarack Project is included in the alternative being modeled), this step is activated to assess the streamflow impacts of the proposed Tamarack project. The model accomplishes this by (1) creating an SDF View input file for the specified Tamarack project, and (2) running the SDF View model.[5] Click the button to run this step. Input to this model includes a .TAB file generated in Step 2 (e.g., NoTam5.tab), which provides modeled estimates of excess flows at Grand Island. The output from this step is saved to the file \tools\sdfoutput.out.

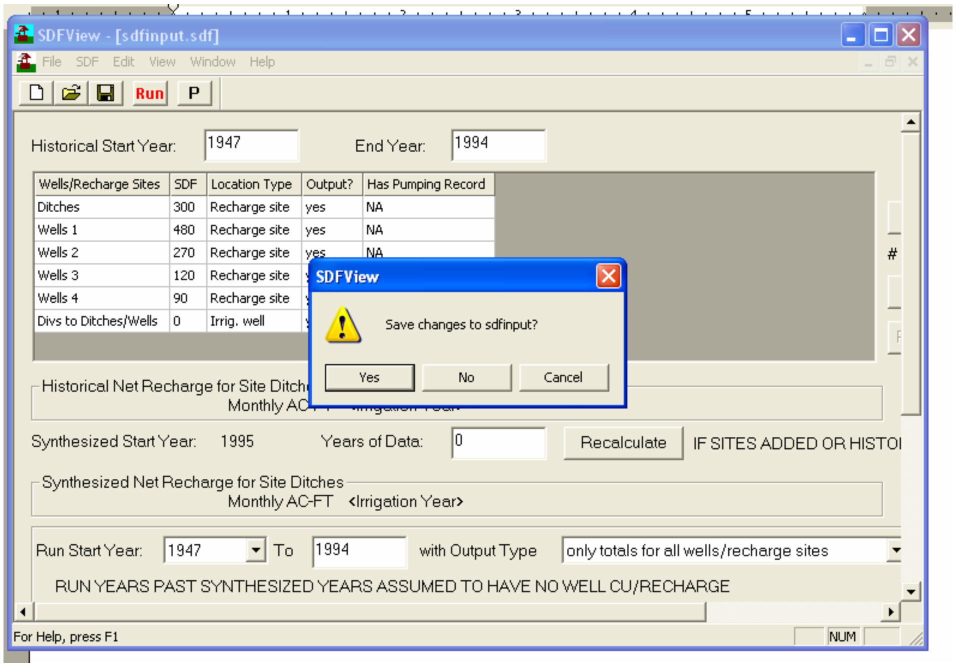
This step automatically builds the input file for SDF View, and invokes the SDF View interface, which pops up as a separate window. When this window pops up with the loaded "Start Year", "End Year", and ditch and well information, press the red "Run" button:



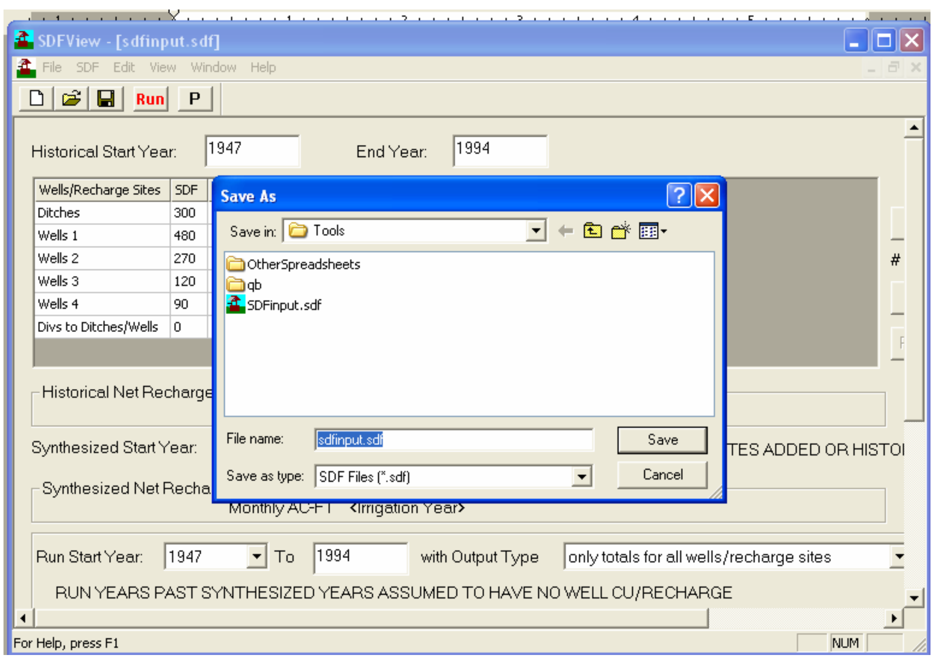
Another pop-up window will ask you if you wish to "Save changes to SDF Input".

[5] SDF View is a software product of the Integrated Decision Support Group at Colorado State University, used to determine stream depletion factors for pumping from or recharge to wells in unconfined alluvial river aquifers. For more details, see http://nile.lance.colostate.edu/projects/sdfview.

Answer Yes:

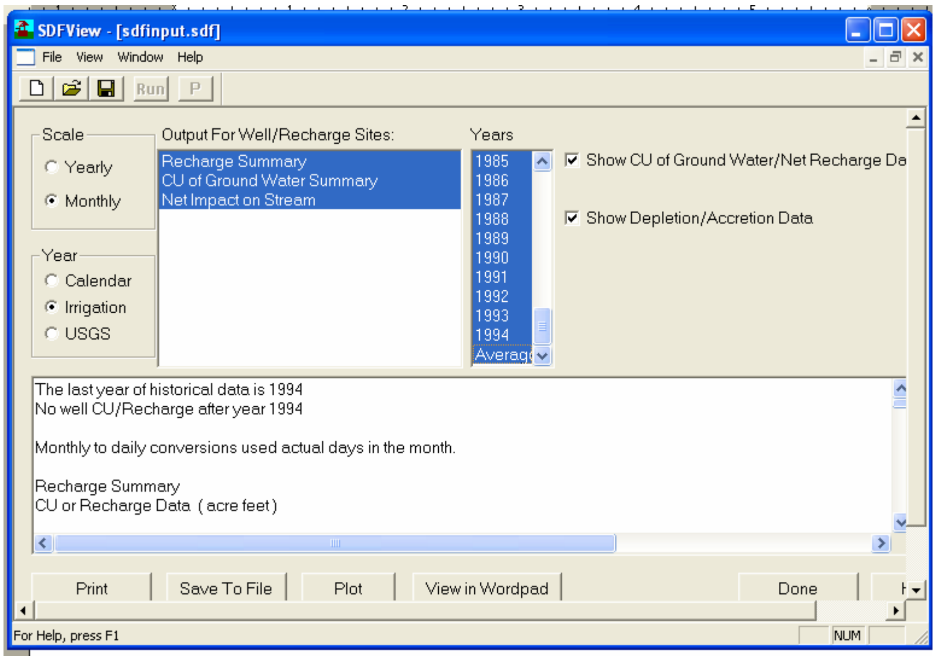


The file should be saved under the current working "Tools" subdirectory as the file "sdfinput.sdf" (this is normally the default input file name in the next popup window):

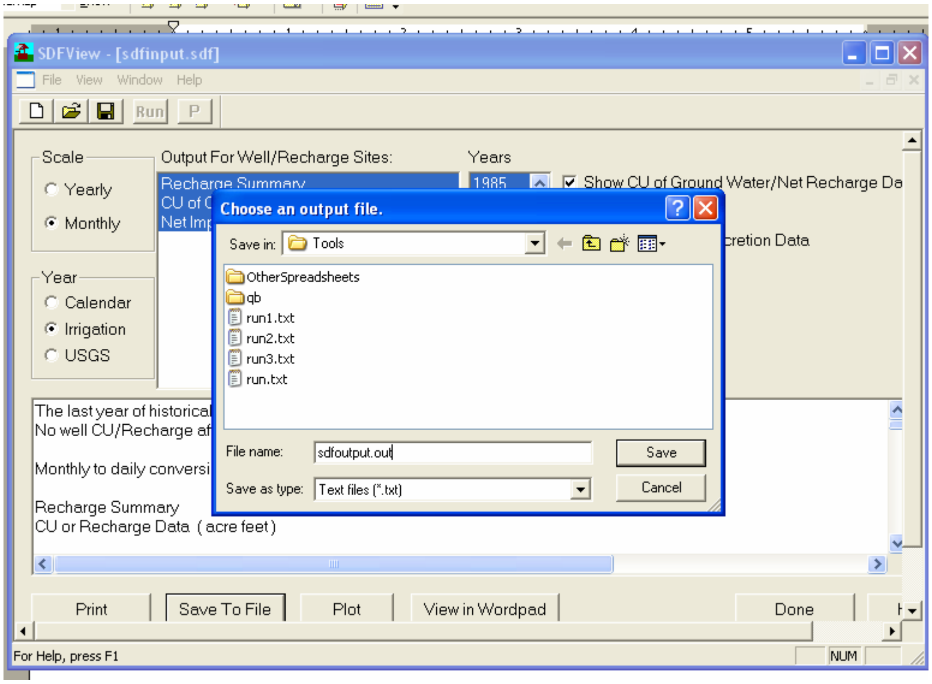


Press yes when prompted. Save over the existing file.

After SDF View runs, select all three of the kinds of output listed in the “Output for Well/Recharge Sites” window (namely, “Recharge Summary”, “CU of Ground Water Summary”, and “Net Impact on Stream”), and also highlight all of the years in the “Years” window (“1947" through “1994"), plus the “Average” year at the bottom of the list. Then press the button “Save to File” on the bottom of the popup window.



Save the output as the file name “sdfoutput.out” (you will have to type in this string). Also, as above, this file should be saved under the current working “Tools” directory. By default, this file is saved to the \Tools directory, as is necessary for the following model run steps.



After completing the above steps, press the "Done" button to close the Save-to-File window, and exit the SDF View window.

Step 4. This step generates a new input hydrology file (for example, LandHab.inh) for OPSTUDY which has been modified to include the Tamarack project impacts modeled in Step 3. (Again, this step is only relevant if the evaluated alternative includes a Tamarack component – i.e., if Step 3 was executed). In this step, the OPSTUDY model is run a second time with the revised input.

Step 5. At this step, the .TXT and .PLS files generated in Step 4 (or in Step 2) are imported into Excel format and saved as {pathname}\[alternative].xls, which serves as a sort of "hydrologic summary" for this alternative. This may require several minutes.

When the CPSummary.xls workbook is called up by this step, the execution may pause and the user may see a pop-up message indicating "This workbook contains one or more links that cannot be updated ... To open the workbook as-is, click Continue". This indicates that the spreadsheet can not find the Present Condition simulation output directory or that the CPSummary.xls spreadsheet in the Present Condition output directory. The user should click "Continue" to finish the operations of Step 5. Next, the user should return to Step 1 and select the Present Condition alternative and run the model with the Cortex.xls interface (Steps 1 through 6).

Upon successful execution of this Step 5, a new **score4794.xls** spreadsheet will be displayed just underneath the Cortex interface spreadsheet. This spreadsheet includes an updated "score" for the examined alternative, as well as other summary information. "Score" is an expression of the reduction in mean annual shortfalls to target flows under the examined alternative. This is the baseline shortage minus the modeled alternative shortage (in KAF units). The "**adjusted score**" refers to this score after various adjustments have been made based on specific factors or features of the central Platte system (for more details, see the discussion under Section 2.10).

Step 6. At this step, the daily flows generated by the model (and stored in the [alternative].DAY and [alternative].PUL files) are loaded into Excel for various hydrologic summaries and updates of the daily flow analysis spreadsheets. The files this step creates are saved to the appropriate Alternative subdirectory. This step may also require several minutes to run. As with Step 5, a pause in processing may occur when the CPSummary.xls worksheet is opened, and a popup window may appear indicating that "one or more links cannot be updated". If so, the user should click "Continue" to continue processing Step 6. Next, the user should return to Step 1 and select the Present Condition alternative and run the model with the Cortex.xls interface (Steps 1 through 6).

When Step 6 is completed, it returns the user to the Cortex interface, which is re-initialized to Step 1.

Note that at any of the above steps, the user can "backtrack" to a previous step (for example, return to Step 1 to select a new alternative for analysis). This can be done by simply selecting that step from the CORTEX menu.

5.2 OPSTUDY INPUT FILES AND FORMAT

As already discussed in Section 2.7, two types of run-time files are required to execute a particular run of the Central Platte River OPSTUDY Model. These are known as the **main input file** (.inp suffix), and the **hydrologic data file** (.inh suffix).

5.2.1 Main Input File

The **main input file** is an ASCII text file specifying the name of the input hydrologic data file, and identifying the specific features to be included in this particular model run. This file also initializes many state variables, and sets acceptable ranges for values representing various components of the accounting model ("CDATA" values). In addition, this file provides monthly "ADATA" value arrays, which consist of one value for each of the twelve months of the year.

OPSTUDY expects the main input files to be located under the \Opstudy\Input directory. A sample *.inp file is included as Appendix E to this document. The line-by-line format of the main input file is as follows. Each "line" is a line of ASCII text, separated by the standard ASCII line feed/carriage return marking the end of a line. The examples cited below correspond to the sample file in Appendix E, to aid in following the line-by-line descriptions.

Lines 1 and 2
Identification of the Model.

Example:

CENTRAL NEBRASKA OPSTUDY MODEL, PLATTE RIVER EIS OFFICE
PRESENT CONDITION OPERATION RULES STUDY 1947 - 1994

Line 3
Name of the input hydrology file (see Section 5.2.2).

Example:

Present.inh	Name of file containing HDATA

Lines 4 to 17
A list of input and output file descriptors, in this order (the OPSTUDY variables to which this information is assigned are identified in parentheses):
4. Name of study (ISTUDY),
5. First year (four digits) of study (ISTART),
6. Last year (four digits) of study (IEND),
7. Number of line group headings for output (NG),
8. Number of line headings for output (NL),
9. Number of summary tables for output (NT),
10. Number of CDATA elements (NC),
11. Number of ADATA elements (NA),
12. Number of HDATA elements (NH),
13. First year represented by HDATA (IFRST),
14. Number of years of HDATA (NYI),
15. Flag to write output in columns to the *.PLT file (IPLT), 1=yes, 0=no.
16. Whether to write info to screen and other debugging files (KDIS), 1=yes, 0=no.
17. Number of lines for header comments in output files (NCL),

Example lines 4-10:

PCOper	ISTUDY	Name of the study
1947	ISTART	First year of study (usually equal to IFRST)
1994	IEND	Last year of study (usually last year of available data.)
17	NG	Number of line group headings
123	NL	Number of line headings

175	NT	Number of Summary tables

Lines 18 to 28

Comments related to the modeled condition.

Example lines 18-22:

```
COMMENTS
' This is the EIS staff interpretation of the Present Condition Baseline.
' OPERATING RULES
'
' LEWELLEN REFERENCE INFLOWS
```

Lines 30 to 167

CDATA values, as described in Appendix A, preceded by 2 title lines. One CDATA value is provided per line. The actual number of CDATA items, and thus the number of lines, is actually defined in Line 10 of this input file. However, for all CPR Model runs, placeholders are provided for 150 potential CDATA values. Only the first space-delimited value in each line is read by the model. The remaining information on each line serves as documentation only. In the following example, this documentation consists of a CDATA descriptor, a description of the units of the value, the CDATA number, and the name of the variable in the model which is set to this value.

Example lines 30-39:

```
DATA      FLAG SETTINGS ALWAYS MEAN:  1=TRUE, 0=FALSE                      ----------  VARIABLE  -------
###-VALUE-----CENTRAL PLATTE RIVER OPSTUDY MODEL----PLATTE RIVER EIS OFFICE          unit/type   ###   name
   1  0.0     USE HISTORIC DIVERSION DEMAND ASSUMPTION AT KEYSTONE AND CENTRAL        FLAG        1  HISTORIC
   2  0.0     MAC TRIGGER FOR SUSPENDING HISTORIC DIVERSION ASSUMPTION                KAF         2  LOHISTRIG
   3  1.0     USE DISCRETIONARY OPERATIONAL HYDRO RELEASES                            FLAG        3  CONHYDR
   4  0.0     USE MCCONAUGHY MAXIMUM HISTORIC CONTENT LIMITS                          FLAG        4  CALIBRAT
   5  1.0     FLAG TO CALCULATE DAILY FLOWS                                           FLAG        5  DAYFLAG
   6  0.0     FLAG TO HAVE THE MODEL PRODUCE NEAR HISTORIC FLOW VALUES                FLAG        6  HISTFLAG
   7  0.0     NOT USED                                                                blank       7
   8  0.0     NOT USED                                                                blank       8
```

Lines 168 to 609

ADATA elements, as described in Appendix A, preceded by a title line. Each ADATA item consists of four lines, as follows:

Line 1 - ADATA item number 1 through 110.

Line 2 - ADATA item description (including units).

Line 3 - Identifiers for 12 months, JAN through DEC.

Line 4 - Corresponding January through December monthly ADATA values (up to six characters of precision are allowed).

Example, lines 168-180 describing the first four ADATA array values:

```
ADATA ITEMS
1
LAKE MCCONAUGHY - MAXIMUM END-OF-MONTH CONTENT (KAF)
JAN   FEB   MAR   APR   MAY   JUN   JUL   AUG   SEP   OCT   NOV   DEC
1594.11594.11594.11609.11743.11743.11743.11668.61594.11594.11594.11594.1

NET LAKE EVAPORATION (FT/MO)
JAN   FEB   MAR   APR   MAY   JUN   JUL   AUG   SEP   OCT   NOV   DEC
.058  .078  .119  .168  .182  .237  .426  .408  .254  .195  .106  .050
3
HOWELL-BUNGER STUFF (KAF)  JULY-SEP COMPUTED IN PROGRAM EACH YEAR
JAN   FEB   MAR   APR   MAY   JUN   JUL   AUG   SEP   OCT   NOV   DEC
0.35  0.00  0.00  0.11  2.50  9.70 9999. 9999. 9999.  10.8  2.35  0.01
4
```

Lines 185 to 308

These are line group headings and line headers for the (*.OPO) output file. The first line of each group contains the group heading, the group number, the number of lines in the group, the line header for the first line in the group, and whether to sum or average the data. The following lines have the line header for the remaining lines in the group, and whether to sum or average the data. This pattern is repeated for the number of groups in the (*.OPO) output file.

Example lines 185-227:

```
GROUP HEADER                                GRP LNS GRP_LN    LINE HEADER                 SUMLINE (0=SUM, 1=AVG)
LAKE MC CONAUGHY                              1 13   1      1 NORTH PLATTE R. AT LEWELLEN 0     CALC. 0=SUM, 1=AVG OF ANN. FLOW VALUES
                                                     2      2 RESERVOIR EVAPORATION       0                           0=SUM, 1=AVG
                                                     3      3 RES SEEPAGE AND BANKSTORAGE 0                           0=SUM, 1=AVG
                                                     4      4 RES DEMAND (INCL. EA PULSE) 0                           0=SUM, 1=AVG
                                                     5      5 TURBINE RELEASE (W/O PULSE) 0                           0=SUM, 1=AVG
                                                     6      6 TURBINE RELEASE (EA PULSE)  0                           0=SUM, 1=AVG
                                                     7      7 HOWELL BUNGER RELEASE       0                           0=SUM, 1=AVG
                                                     8      8 RESERVOIR SPILL, TURBINE    0                           0=SUM, 1=AVG
                                                     9      9 RESERVOIR SPILL, M.GLORY    0                           0=SUM, 1=AVG
                                                    10     10 TOTAL RESERVOIR SPILL       0                           0=SUM, 1=AVG
                                                    11     11 END-OF-MONTH CONTENT        1                           0=SUM, 1=AVG
                                                    12     12 TOT RES OUTFLOW (W/O PULSE) 0                           0=SUM, 1=AVG
                                                    13     13 SUTHERLAND CANAL DIVERSION  0                           0=SUM, 1=AVG
N. PLATTE R. - KEYSTONE TO SUTHERLAND         2  8     1   14 NORTH PLATTE R. NR KEYSTONE 0                           0=SUM, 1=AVG
                                                       2   16 IRRIGATION DEMAND           0                           0=SUM, 1=AVG
                                                       3   17 IRRIGATION DIVERSION        0                           0=SUM, 1=AVG
                                                       4   18 IRRIGATION SHORTAGE         0                           0=SUM, 1=AVG
                                                       5   19 SECTION GAIN                0                           0=SUM, 1=AVG
                                                       6   20 RIVER CHANNEL E.T. SALVAGE  0                           0=SUM, 1=AVG
                                                       7   21 CHANNEL G.W. STOR. CHANGE   0                           0=SUM, 1=AVG
                                                       8   22 N. PLATTE NEAR SUTHERLAND   0                           0=SUM, 1=AVG
```

Lines 309 to 659

Summary table headers, preceded by a title line, one header per line. These input data are listed in groups consisting of 2 lines for each summary table header. The first line is the table header and the second line is a flag identifying whether to calculate the sum (0), average (1), or maximum(2) under the given table header on an annual basis. The actual number of table header items, and thus the number of lines in this section, is actually defined in Line 9 of the input file. However, for all CPR Model runs, placeholders are provided for 145 table headers and 145 flags.

Example lines 433-449:

```
TABLE HEADERS
TABLE 1. LAKE MCCONAUGHY END-OF-MONTH CONTENT (KAF)
1                                    CALC. 0=SUM, 1=AVG, 2=MAX OF ANN. FLOW VALUES
TABLE 2. LAKE MCCONAUGHY END-OF-MONTH ELEVATION (FEET ABOVE MSL)
1                                                   0=SUM, 1=AVG, 2=MAX
TABLE 3. LAKE MCCONAUGHY TOTAL OUTFLOW (KAF)
0                                                   0=SUM, 1=AVG, 2=MAX
TABLE 4. KINGSLEY DAM SPILL THROUGH KINGSLEY HYDRO (KAF)
0                                                   0=SUM, 1=AVG, 2=MAX
TABLE 5. KINGSLEY DAM SPILL THROUGH KINGSLEY MORNING GLORY (KAF)
0                                                   0=SUM, 1=AVG, 2=MAX
TABLE 6. TOTAL KINGSLEY DAM SPILL (KAF)
0                                                   0=SUM, 1=AVG, 2=MAX
TABLE 7. TOTAL STORAGE DEMAND ON LAKE MCCONAUGHY(KAF)
0                                                   0=SUM, 1=AVG, 2=MAX
TABLE 8. HYDRO RELEASE (FOR OPERATIONAL RULES RUNS ONLY) (KAF)
1                                                   0=SUM, 1=AVG, 2=MAX
```

5.2.2 Hydrologic Data File

The **hydrologic data file** is an ASCII text file that provides a time series of monthly values ("HDATA") for various hydrologic parameters during the period of interest (e.g., January 1947 to December 1994), as required to run the model for the configuration specified by the main input file and in the cortex.xls spreadsheet. The hydrologic data file includes monthly inflows at Lewellen (North Platte River) and Julesburg (South Platte River), monthly gains by river reach, monthly irrigation demands and historic diversions, and other monthly estimates.

Although hydrologic data must be provided to OPSTUDY as a single text file in a specified format, tools have been developed which automate procedures for building the necessary file from multiple spreadsheets of data. If the Cortex spreadsheet interface is being used, the .inh file may be built for you from existing spreadsheets (see Section 5.3).

OPSTUDY expects the hydrologic data file to be located under the \Opstudy\Output\[alternative] directory. The format of the hydrologic data file is as follows:

- Data arrays must be provided for N HDATA items, where N is established by item #8 in line 2 of the input file. For the EIS modeling effort, the value of N was always 31, and therefore 31 HDATA arrays of values are always required.

- For each HDATA item, Y years of monthly hydrologic data are required, where Y is defined by item #10 in line 2 of the input file. For the EIS modeling effort, the value of Y is 48, representing the years 1947 to 1994 inclusive.

- For each year being modeled and for each HDATA item, space- or comma-delimited values for each of the twelve months of that year must be provided on a single line, beginning with January and ending with December. These values must be preceded by the year itself (e.g., 1947), making a total of 13 values for each year. (Numbers beyond the 13th value in a line are ignored by the OPSTUDY model. However, to simplify the interpretation of HDATA file data, annual totals have typically been included as a 14th value in each line). Thus, Y times 13 total values must be provided for each HDATA item (e.g.., 624 total values for 48 years of modeling).

- Monthly HDATA values are provided in a regular calendar year sequence, not as an October-through-September "water year" sequence.

- The first line of each HDATA array item is identified by the HDATA item number (e.g., "1") followed by a closing parenthesis and a description of the HDATA item.

  Example: The following are the first six lines of a hydrologic data file, showing monthly "Present Condition" inflows to the North Platte River at Lewellen for calendar years 1947 through 1951, in thousands of acre-feet. (i.e., in January 1947 the inflow was 83,600 acre-feet; in February 1947 79,400 acre-feet, etc.):

```
1)  NORTH PLATTE RIVER AT LEWELLEN REFERENCE INFLOWS:  PRESENT CONDITION  KAF     TOTAL
1947  83.6  79.4  94.8  90.5  54.6 385.0 283.3  41.8  83.7 121.8 117.9 116.5  1552.9
1948  89.5 103.8 103.6 106.2  55.2  95.6  78.6  62.0  89.6 118.4 109.7  87.7  1099.9
1949  58.6 105.3 131.0  98.5  96.9 151.0  81.6  56.8 102.7 125.1 106.1 101.5  1215.1
1950  88.2  95.8  92.7  79.8  57.7  41.4  62.5  72.9 123.6 132.7 111.8 108.2  1067.3
1951  84.8  85.6  87.3  82.1  63.8 105.2  88.4  58.9 168.7 127.5 121.6  91.0  1164.9
. . .
. . .
Etc. through 1994
```

5.3 TOOLS FOR BUILDING INPUT FILES

As described above, the input files for OPSTUDY model runs are ASCII text files in specific formats. The three Fortran "include" files do not normally require modifications from one model run to another, since the variable definitions will remain unchanged unless changes are made to the modeling code itself. However, the main input file and the hydrologic input file will vary from one alternatives analysis to another. Thus, if the necessary files do not already exist for a particular alternatives analysis, the user will need to create them. In addition, the user may wish to modify the modeled capacity of the ditch and/or wells associated with the Tamarack Plan project. The following discussion describes how the available tools simplify these modifications.

5.3.1 Main input file modification

The main input file is modified by simply using a standard text editor to change the necessary lines in the input file (for example, to change the settings for CDATA and ADATA values). No specific tools have been developed to streamline this process.

Modifying operations of the EA (not including short-duration near-bankfull releases)

The following list of variables contained in the Central Platte OPSTUDY Model determine how the environmental account (EA) in Lake McConaughy is operated. All of these variable are in the CDATA and ADATA sections of the OPSTUDY input (*.inp) file.

CDATA 67 is a flag that allows the user to activate an environmental account in Lake McConaughy. If the value is 1.0, there is an environmental account in Lake McConaughy. Otherwise, there is no environmental account in Lake McConaughy.

```
67 1.0        ENVIRONMENTAL ACCOUNT IN LAKE MCCONAUGHY IS ACTIVE
```

The starting capacity of the EA in Lake McConaughy is set with CDATA 69 and the amount (%) of the October through April inflows that are credited to the EA is set with CDATA 70. CDATA 71 is a flag that controls the content of the EA when Lake McConaughy fills. A value of 0 directs the model to make no adjustments to the EA content when Lake McConaughy fills. A value of 1 directs the model to set the EA content to 100,000 acre-feet when Lake McConaughy fills. A value of 2 directs the model to set the EA content to 100,000 acre-feet when Lake McConaughy fills only if the storage in the EA is greater than 100,000 acre-feet.

```
69 100.0      ENVIRONMENTAL ACCOUNT STARTING CAPACITY
70 0.10       LEWLLEN INFLOW TO EA ACCRUAL (%)
71 1.0        IF MAC FILLS SET EA CONTENT=100 KAF 1= ALWAYS 2= ONLY IF EA
              CONTENT>100 KAF
```

ADATA 35 allows the user to set a minimum end of month content for the EA. For example, setting the May value to 30 would cause the model to keep 30,000 acre-feet of water in the EA in May for use later in the year. Or, as shown below, to keep up to 50,000 acre-feet for the May-June pulse period.

```
35
   EA KAF to reserve (Min EA content)
   JAN   FEB   MAR   APR   MAY   JUN   JUL   AUG   SEP   OCT   NOV   DEC
   50.   50.   50.   50.    0.    0.    0.    0.    0.    0.    0.    0.
```

ADATA 36 also controls the amount of EA water (not held in reserve by ADATA 35) used during any month. A value of 1 indicates that all (100%) of the EA not held in reserve by

ADATA 35 can be used to augment flows during that month. A value of 0 turns the EA off for that month and no flow augmentation will occur.

```
 36
   PERCENT OF EA AVAILABLE IN JAN, FEB, MAR...DEC (0.0 TO 1.0) (ANY EA
'BORROW' MONTH SHOULD BE 1.0)
   JAN   FEB   MAR   APR   MAY   JUN   JUL   AUG   SEP   OCT   NOV   DEC
  1.00  1.00  1.00  1.00  1.00  1.00  1.00  1.00  1.00  1.00  1.00  1.00
```

ADATA 37 is also used to control releases from the EA. ADATA 37 is the minimum amount of water that will be released from the EA for each month. This variable was added to keep the model from trying to augment flows by releasing ridiculously small amounts of water (1 cfs for example).

```
 37
   MINIMUM EA RELEASE ALLOWED (I.E. NO EA RELEASES LESS THAN THIS), CFS
   JAN   FEB   MAR   APR   MAY   JUN   JUL   AUG   SEP   OCT   NOV   DEC
  400.   50.   50.   50.   50.   50.   50.   50.   50.  400.  400.  400.
```

ADATA 38 and 58 are additional variables that can be used to turn the EA on or off for any given month. ADATA 38 instructs the model to determine whether flows need to be augmented by checking flows at Overton and is usually turned off (all values = 0.). ADATA 58 is the same as ADATA 38 except it checks flows at Grand Island and is usually on (all values = 1.).

```
38
   FLAG TO MEET MINIMUM FLOW REQUIREMENT AT OVERTON  1=YES  0=NO
   JAN   FEB   MAR   APR   MAY   JUN   JUL   AUG   SEP   OCT   NOV   DEC
    0.    0.    0.    0.    0.    0.    0.    0.    0.    0.    0.    0.
58
   FLAG TO MEET MINIMUM FLOW REQUIREMENT AT GRAND ISLAND    1=YES  0=NO
   JAN   FEB   MAR   APR   MAY   JUN   JUL   AUG   SEP   OCT   NOV   DEC
    1.    1.    1.    1.    1.    1.    1.    1.    1.    1.    1.    1.
```

The following variables are grouped in sets of two because changes in the first affect the second. The first variable is the threshold volume contained in the EA and the second is the desired flow at Grand Island (and/or Overton if ADATA 38 =1.). The model checks the volume of water stored in the EA and if it is greater than the threshold volume the model will attempt to keep the flow in the river at the suggested monthly flow requirement. For example, if there is 100,000 acre-feet in the EA in January, the model will try to keep 1,000 cfs in the river with some qualifications: Either ADATA 58 or ADATA 38 must be 1, ADATA 35 must be less that 100, ADATA 36 cannot be 0, and release from the EA must be greater than the amount set in ADATA 37.

```
39
   EA THRESHOLD VOLUMES FOR INSTREAM FLOW RELEASES, LEVEL 1 (GREATEST), KAF
   JAN   FEB   MAR   APR   MAY   JUN   JUL   AUG   SEP   OCT   NOV   DEC
   90.   90.   90.   70.   70.   50.   30.   70.   20.   60.   60.   90.
51
   SUGGESTED MONTHLY FLOW REQUIREMENT  LEVEL 1, CFS
```

```
   JAN   FEB   MAR   APR   MAY   JUN   JUL   AUG   SEP   OCT   NOV   DEC
 1000. 2575. 2575. 2400. 2400. 2600.  800.  800.  800. 2400. 1700. 1000.
```

If the amount stored in the EA was not greater than the amount set in ADATA 39, the model will check if it is greater than the amount set in ADATA 40 and attempt to keep the river at the level set in ADATA 52.

```
40
   EA THRESHOLD VOLUMES FOR INSTREAM FLOW RELEASES, LEVEL 2 ( LEVEL 2 <= LEVEL
1, ETC.), KAF
   JAN   FEB   MAR   APR   MAY   JUN   JUL   AUG   SEP   OCT   NOV   DEC
   80.   80.   80.   50.   60.   10.   10.   60.   10.   10.   10.   80.
52
   SUGGESTED MONTHLY FLOW REQUIREMENT  LEVEL 2, CFS
   JAN   FEB   MAR   APR   MAY   JUN   JUL   AUG   SEP   OCT   NOV   DEC
 1000. 2575. 2575. 2400. 2000. 1700.  500.  500.  500. 1800. 1400. 1000.
```

If the amount stored in the EA was not greater than the amount set in ADATA 40, the model will check if it is greater than the amount set in ADATA 41 and attempt to keep the river at the level set in ADATA 53.

```
41
   EA THRESHOLD VOLUMES FOR INSTREAM FLOW RELEASES, LEVEL 3 , KAF
   JAN   FEB   MAR   APR   MAY   JUN   JUL   AUG   SEP   OCT   NOV   DEC
    0.    0.    0.    0.    0.    0.    0.    0.    0.    0.    0.    0.
53
   SUGGESTED MONTHLY FLOW REQUIREMENT  LEVEL 3, CFS
   JAN   FEB   MAR   APR   MAY   JUN   JUL   AUG   SEP   OCT   NOV   DEC
  600. 1725. 1725. 1700. 1100.  800.  500.  500.  500. 1300.  950.  600.
```

If the amount stored in the EA was not greater than the amount set in ADATA 41, the model will check if it is greater than the amount set in ADATA 42 and attempt to keep the river at the level set in ADATA 54.

```
42
   EA THRESHOLD VOLUMES FOR INSTREAM FLOW RELEASES, LEVEL 4 , KAF
   JAN   FEB   MAR   APR   MAY   JUN   JUL   AUG   SEP   OCT   NOV   DEC
    0.    0.    0.    0.    0.    0.    0.    0.    0.    0.    0.    0.
54
   SUGGESTED MONTHLY FLOW REQUIREMENT  LEVEL 4, CFS
   JAN   FEB   MAR   APR   MAY   JUN   JUL   AUG   SEP   OCT   NOV   DEC
   0.0   0.0   0.0   0.0   0.0   0.0   0.0   0.0   0.0   0.0   0.0   0.0
```

If the amount stored in the EA was not greater than the amount set in ADATA 42, the model will check if it is greater than the amount set in ADATA 43 and attempt to keep the river at the level set in ADATA 55.

```
43
   EA THRESHOLD VOLUMES FOR INSTREAM FLOW RELEASES, LEVEL 5 , KAF
   JAN   FEB   MAR   APR   MAY   JUN   JUL   AUG   SEP   OCT   NOV   DEC
    0.    0.    0.    0.    0.    0.    0.    0.    0.    0.    0.    0.
```

```
55
   SUGGESTED MONTHLY FLOW REQUIREMENT  LEVEL 5, CFS
   JAN   FEB   MAR   APR   MAY   JUN   JUL   AUG   SEP   OCT   NOV   DEC
   0.0   0.0   0.0   0.0   0.0   0.0   0.0   0.0   0.0   0.0   0.0   0.0
```

If the amount stored in the EA was not greater than the amount set in ADATA 43, the model will check if it is greater than the amount set in ADATA 44 and attempt to keep the river at the level set in ADATA 56.

```
44
   EA THRESHOLD VOLUMES FOR INSTREAM FLOW RELEASES, LEVEL 6 (LEAST), KAF
   JAN   FEB   MAR   APR   MAY   JUN   JUL   AUG   SEP   OCT   NOV   DEC
    0.    0.    0.    0.    0.    0.    0.    0.    0.    0.    0.    0.
56
   SUGGESTED MONTHLY FLOW REQUIREMENT  LEVEL 6, CFS
   JAN   FEB   MAR   APR   MAY   JUN   JUL   AUG   SEP   OCT   NOV   DEC
   0.0   0.0   0.0   0.0   0.0   0.0   0.0   0.0   0.0   0.0   0.0   0.0
```

Short-duration near-bankfull releases

The EA in Lake McConaughy can also be used to produce a short-duration near-bankfull flow event in the Spring. This is controlled by 10 variables in the CDATA section at the beginning of each OPSTUDY input (*.inp) file.

CDATA 95 is a flag that determines whether the model attempts to make a short-duration near-bankfull release each year.

```
 95 1.0        FLAG TO SELECT SHORT EA PULSE IN MAY, FLAG
```

CDATA 96 is a flag that makes short-duration near-bankfull releases the number 1 priority each year.

```
 96 0.0        FLAG TO GIVE PULSE FLOWS PRIORTIY, FLAG
```

CDATA 97 is the maximum flow rate in cfs through the Kingsley Dam turbine penstock.

```
 97 5700.      MAXIMUM CFS RATE THRU TURBINE PENSTOCK FOR EA PULSE, CFS
```

CDATA 98 is the target maximum short-duration near-bankfull in cfs to achieve at Overton. No short-duration near-bankfull will be made that will cause flows greater than this value.

```
 98 10000.     EA PULSE FLOW TARGET MAXIMUM AT OVERTON, CFS
```

CDATA 99 tells the model the duration in days for the short-duration near-bankfull release.

```
 99 3.0        DAYS OF SUSTAINED (FLAT) PULSE NOT INCL. RISE & FALL, DAYS
```

CDATA 100 and CDATA 101 are the ramp rates for increasing and decreasing the flow out of Lake McConaughy prior to a short-duration near-bankfull release.

```
100 700.       RAMP RATE UP IN CFS/DAY FOR RISING LIMB,  + VALUE, CFS/DAY
101 -700.      RAMP RATE DOWN IN CFS/DAY FOR FALLING LIMB, - VALUE, CFS/DAY
```

CDATA 102 is the short-duration near-bankfull target that the model attempts to meet on an annual basis.

```
102 6500.      PK DAILY DECISION FLOW LEVEL RE EA PULSE, CFS OCT-JUN, CFS
```

CDATA 103 is the amount below the short-duration near-bankfull target (CDATA 102) that a short-duration near-bankfull release will still be made. Subtract CDATA 103 from CDATA 102 to get the target minimum short-duration near-bankfull.

```
103 3000.      AMOUNT BELOW EAPTARG LEVEL TO PULSE ANYWAY IF EA CAN, CFS
```

CDATA 104 and 105 indicate when short-duration near-bankfull releases are to occur. Values of 0 and 5-53 are acceptable. A value of 0 tells the model to make the short-duration near-bankfull release two days after the highest flow at Julesburg Colorado on the South Platte River between April 5 and May 23. Values of 5-53 place the short-duration near-bankfull release on a specific day (where 1 corresponds to April 1; i.e. 5=April 5 and 53=May 23). There are two values to allow the model to switch between days most beneficial to terns versus beneficial to plovers.

```
104 26.        1ST DAY PULSE IS TO OCCUR, VALUE BTWN 5 & 53
               (5=APR 5, 53=MAY 23, 0=RANDOM)
105 45.        2ND DAY PULSE IS TO OCCUR, VALUE BTWN 5 & 53
               (5=APR 5, 53=MAY 23, 0=RANDOM)
```

North Platte River at North Platte capacity

CDATA 59 is a flag to consider the capacity in the North Platte River at North Platte when making EA releases. ADATA 4 is the capacity (flow at flood stage) of the North Platte River at North Platte. This ADATA is used to limit EA releases.

```
59 1.0        FLAG TO CONSIDER A CHOKE POINT AT NORTH PLATTE FOR EA OPERATIONS
```

```
4
   FLOW AT FLOOD STAGE IN THE NORTH PLATTE AT NORTH PLATTE, NE (CFS)
   JAN   FEB   MAR   APR   MAY   JUN   JUL   AUG   SEP   OCT   NOV   DEC
 3500. 3500. 3500. 3500. 3500. 3500. 3500. 3500. 3500. 3500. 3500. 3500.
```

Enlarged capacity of Lake McConaughy

CDATA 68 is a flag that allows the user to increase the capacity (relax the FERC storage limits) of Lake McConaughy and use the extra space to store water in an enlarged environmental account in Lake McConaughy. If the value is 1.0, there is an enlarged environmental account in Lake MConaughy. Otherwise, there is no enlarged environmental account in Lake MConaughy.

```
68 0.0       ENLARGED EA FLAG (RAISED MCCONAUGHY STORAGE LIMITS)
```

CDATA 68 is used in conjunction with ADATA 7, which sets the increased capacity of Lake McConaughy. The difference between ADATA 7 and ADATA 1 (LAKE MCCONAUGHY - MAXIMUM END-OF-MONTH CONTENT (KAF)) is the enlarged capacity of an EA in Lake McConaughy.

```
7
   INCREASED MAC CONTENT LIMITS
   JAN   FEB   MAR   APR   MAY   JUN   JUL   AUG   SEP   OCT   NOV   DEC
    0.    0.    0.    0.    0.    0.    0.    0.    0.    0.    0.    0.
```

Reduced irrigation demand

Reduced irrigation demand is controlled with CDATA 73 through 80. CDATA 73 is a flag that directs the model to reduce irrigation demands. CDATA 74 through 78 and 80 are the amounts of the Present Condition irrigation demands to retain. One minus the retaining factors is the amount of that irrigation demands are reduced. CDATA 79 is the volume of water to credit to the EA in October. If CDATA 79 is zero, the amount credited to the EA in October is calculated by the Model.

```
73 1.0       CONSERVATION/LEASING WATER FLAG
74 1.00000   IRRIG RETAINING FACTOR, % (KEY-SUTH CANALS CONSERVE/LEASING)
75 1.00000   IRRIG RETAINING FACTOR, % (SUTH-NP CANALS CONSERVE/LEASING)
76 0.93209   IRRIG RETAINING FACTOR, % (TC CANAL CONSERVE/LEASING)
77 0.99034   IRRIG RETAINING FACTOR, % (BRADY-COZAD CANALS CONSERVE/LEASING)
78 0.97718   IRRIG RETAINING FACTOR, % (KEARNEY CANAL CONSERVE/LEASING)
79 15.93     NET CONSERVED WATER ADDED TO EA, SUM OF ABOVE, OR CALC.
             BY MODEL IF 0.0
80 1.00000   IRRIG RETAINING FACTOR, % (WESTERN CANAL CONS/LEASE OF NATFLOW
```

Net controllable conserved water

ADATA 45 is the net controllable conserved water that is added to the EA in Lake McConaughy in October. This value includes water provided through Reclamation funds.

```
45
   NET CONTROLLABLE CONSERVED WATER ADDED TO EA, KAF
   JAN   FEB   MAR   APR   MAY   JUN   JUL   AUG   SEP   OCT   NOV   DEC
    0.    0.    0.    0.    0.    0.    0.    0.    0.    4.    0.    0.
```

Borrowing of water for environmental uses

CDATA 82, ADATA 48, HDATA 31 control water that is borrowed from Lake McConaughy and added to the EA. CDATA 82 and ADATA 48 are a flag that directs the model to allow borrowing of water from McConaughy. Water that is borrowed must be stored in Reclamation's system in Wyoming (HDATA 31) since borrowed water is restored to Lake McConaughy from deliveries to the EA from Wyoming later in the year.

```
82 0.0       ENABLE BORROW/PAYBACK, EA MAY BORROW FROM MAC (SEE A48)
```

```
48
   ALLOW EA TO BORROW FROM MAC IN MAY-JUL, PAY BACK BEFORE OCT WITH WY EA
DELIVERIES,(1=YES 0=NO)
   JAN   FEB   MAR   APR   MAY   JUN   JUL   AUG   SEP   OCT   NOV   DEC
    0.    0.    0.    0.    0.    0.    0.    0.    0.    0.    0.    0.
```

Power Interference

CDATA 83 is a flag that directs the model to calculate power interference. The volume of power interference that is stored in the EA is controlled by CDATA 84. One over CDATA 84 is the fraction of power interference to credit to the EA.

```
83 1.0       FLAG FOR POWER INTERFERENCE PROJECT
84 1.0       POWER INTERFERENCE DIVISOR (POTENTIAL/DIVISOR IS AMOUNT TO EA)
```

Colorado environmental contributions

CDATA 89, 90, and 93 are used to control how Colorado's environmental contributions are handled in the model. CDATA 89 and 90 protect Colorado's contributions from diversion and CDATA 93 exchanges Colorado's into Lake McConaughy (0.0=no, 1.0=yes). CDATA 91 protects all EA releases from diversion at the Tri-County diversion.

```
89 0.0       FLAG TO PROTECT CO CONSERVATION (CONSCO) WATER PAST KORTY DIV
90 0.0       FLAG TO PROTECT CONSCO WATER PAST CENTRAL DIVERSION
91 0.0       FLAG TO PROTECT EA RELEASES FROM DIVERSION AT CENTRAL
93 0.0       FLAG TO EXCHANGE TAMARACK EA WATER INTO MAC
```

Other EA contributions

CDATA 92 is used to place a percentage of ETO water that is not stored in Wyoming into the EA in Lake McConaughy. ETO that is not stored in Wyoming, but is instead allowed to flow into Nebraska is contained in HDATA 22.

```
92 0.0       PERCENT OF ETO WATER TO PLACE IN THE EA
```

CDATA 107, 108, 113 and ADATA 109 are used to direct the model in the operation of ground water conjunctive use. CDATA 107 is a flag that activates the project. CDATA 108 is the target volume for the project and CDATA 113 is a flag to store ground water conjunctive use water in the EA. ADATA 109 is the rate at which water can be stored in the conjunctive use aquifer.

```
107 1.0        FLAG TELLS WHETHER GW MANAGEMENT PROJECT IS ON
108 10.0       GW MGMT PROJ KAF TARGET (VOL TO STORE/PUMP EACH YEAR)
113 1.0        FLAG TO STORE WATER CONSERVATION AND GW MANAGEMENT IN EA

109
   GROUNDWATER MANAGEMENT SEEPAGE CAPACITY, KAF   (APPROXIMATELY 85 CFS)
   JAN   FEB   MAR   APR   MAY   JUN   JUL   AUG   SEP   OCT   NOV   DEC
  5.23  4.72  5.23  5.06  5.23  5.06  5.23  5.23  5.06  5.23  5.06  5.23
```

CDATA 111 and ADATA 46 control the North Dry Creek ground water pumping project. CDATA 111 is the control flag and ADATA 46 are the monthly volumes added to flows in the Platte River.

```
111 1.0        FLAG TO OPERATE N. DRY CREEK GW PUMPING PROJECT

46
   POTENTIAL EA WATER ADDED VIA N. DRY CREEK GROUNDWATER PUMPING PROJECT, KAF
   JAN   FEB   MAR   APR   MAY   JUN   JUL   AUG   SEP   OCT   NOV   DEC
    0.    0.    0.    0.   .50   .50   .50   .50   .50    0.    0.    0.
```

CDATA 112 and ADATA 47 control the riverside drains project. CDATA 112 is the control flag and ADATA 47 are the monthly volumes added to flows in the Platte River.

```
112 0.0        FLAG TO OPERATE RIVERSIDE DRAINS

47
   WATER ADDED VIA RIVERSIDE DRAINS (COZAD TO OVERTON REACH), KAF
   JAN   FEB   MAR   APR   MAY   JUN   JUL   AUG   SEP   OCT   NOV   DEC
   0.0   0.0   0.0   0.0   0.0   0.0   0.0   0.0   0.0   0.0   0.0   0.0
```

CDATA 115 through 125 and ADATA 108 control the Central Platte Re-regulatory Reservoir project. CDATA 115 and ADATA 108 are control flags, CDATA 116 is the starting content, CDATA 117 is the reservoir capacity, CDATA 118 is the inlet capacity, CDATA 119 is the dead (inactive) capacity of the reservoir, CDATA 120 and 121 are used to calculate reservoir area for a given capacity, CDATA 122 is the monthly reservoir seepage, CDATA 123 is the outlet capacity, CDATA 124 is a flag to use the reservoir to augment short-duration near-bankfull releases, and CDATA 25 is the capacity that is available for short-duration near-bankfull events. Daily flow targets for wet, dry, and average conditions are used in the operation of the Central Platte Re-regulatory Reservoir. These daily targets are contained in the file DayTargs.txt, which is read by the model. The daily flow targets may be modified using the DailyTargets.xls spreadsheet in the Opstudy\Input directory.

```
115 1.0        CP REREG RESERVOIR IS BEING OPERATED FLAG
116 0.820      CP REREG RES STARTING CONTENT
117 4.000      CP REREG RES CAPACITY
118 200.0      CP REREG RES INLET RATE
119 0.00       CP REREG RES DEAD POOL
120 0.120      CP REREG RES AREA/CAPACITY CURVE MULT.
```

```
121 0.320      CP REREG RES AREA/CAPACITY CURVE EXP.
122 0.02       CP REREG RES SEEPAGE FACTOR (DECIMAL PERCENT)
123 200.0      CP REREG RES OUTLET RATE
124 0.0        FLAG TO USE CP REREG RES TO AUGMENT PULSE FLOWS
125 3.436      CAPACITY OF CP REREG RES FOR PULSING PURPOSES
```

```
108
   CP REREG RESERVOIR ALLOWED TO STORE (USES AVERAGE TARGETS) 1=YES/0=NO
   JAN   FEB   MAR   APR   MAY   JUN   JUL   AUG   SEP   OCT   NOV   DEC
    1.    0.    0.    1.    0.    0.    1.    1.    1.    1.    1.    1.
```

CDATA 128 through 134 control the use of Johnson Lake to attenuate flows in the Platte River for tern and plover nesting. CDATA 128 is the control flag, CDATA 129 is the desired flow at Overton (maximum June 1 through August 15 flow), CDATA 130 is the capacity available in Johnson Lake, CDATA 131 is a flag to use Johnson Lake augment short-duration near-bankfull releases, CDATA 132 is the capacity in the Tri-County Canal system that is available for short-duration near-bankfull events, CDATA 133 is the capacity of the J2 return during a short-duration near-bankfull event, and CDATA 134 is the number of days to maintain the short duration pulse release from the Tri-County Canal system.

```
128 1.0        FLAG TO ATTENUATE SPIKE FLOWS WITH JOHNSON RESERVOIR
129 1700.0     MAXIMUM DESIRED FLOW AT OVERTON
130 2500.0     STORAGE AVAILBLE IN JOHNSON LAKE TO ATTENUATE SPIKE FLOWS
131 1.0        FLAG TO USE JOHNSON RESERVOIR TO AUGMENT PULSE FLOWS
132 4000.0     STORAGE AVAILBLE IN JOHNSON LAKE TO PULSE
133 2000.0     MAXIMUM CFS THAT PULSE CAN BE AUGMENTED
134 2.0        NUMBER OF DAYS TO PULSE OUT OF JOHNSON LAKE
```

CDATA 43, 47, and 48 control the other aspects of the Tri-County system during a short-duration near-bankfull event. CDATA 43 causes diversions at the Tri-County canal to be reduced during a short-duration near-bankfull event. CDATA 47 causes the model to not divert water to the E65 lateral, E67 lateral, and Phelps County Canal during a short-duration near-bankfull event. CDATA 48 causes the model to not store water in Elwood Reservoir during a short-duration near-bankfull event.

```
43 1.0        FLAG TO NOT DIVERT AT TRI-COUNTY DURING PULSE FLOWS
47 1.0        FLAG TO RELEASE IRRIGATION WATER TO AUGMENT THE PULSE
48 1.0        FLAG TO NOT DIVERT WATER TO ELWOOD RESERVOIR THUS
              AUGMENTING THE PULSE
```

CDATA 62 controls diversion at the Korty Canal during a short-duration near-bankfull event (0=no, 1=yes).

```
62 0.0        FLAG TO NOT DIVERT AT KORTY DURING PULSE FLOWS
```

5.3.2 Hydrologic input file modification

Modifications to the hydrologic input file from one modeled alternative to another can be substantial. To simplify the process of modifying hydrologic input files, macros have been incorporated into the cortex.xls spreadsheet that build the hydrologic file from several different

Excel spreadsheets to form a Central Platte River Model Decision Support System (DSS)

The DSS consists of eight spreadsheets (Cortex.xls, Gains_inh.xls, INHspawner.xls, Julesburg_inh.xls, Lewellen_inh.xls, McConaughy_inh.xls, Score4794.xls, and Tamarack_Input4794.xls). Data provided by the user for input to the model is contained in four of these spreadsheets (Gains_inh.xls, Julesburg_inh.xls, Lewellen_inh.xls, and McConaughy_inh.xls). The Cortex.xls and INHspawner.xls spreadsheets are used to select and manipulate the data in the Gains_inh.xls, Julesburg_inh.xls, Lewellen_inh.xls, and McConaughy_inh.xls spreadsheets. These Excel spreadsheets hold the necessary data for:

- North Platte River inflows at Lewellen;
- South Platte River inflows at Julesburg;
- Gains by stream reach (including Birdwood Creek inflows), irrigation demands by canal system, and historic diversions by stream reach;
- Seepage and bank storage at Lake McConaughy and other system reservoirs;
- Inflows from the Tamarack reregulation project on the South Platte River (if any).

Normally, the Excel spreadsheet of North Platte River inflows at Lewellen (Lewellen_inh.xls) is generated by the North Platte River model (USBR, 1997). The Excel spreadsheets of the South Platte River inflows at Julesburg (Julesburg_inh.xls) are typically based on output from the South Platte River model (Hydrosphere, 2001), manually cut and pasted into Julesburg_inh.xls, with any necessary modifications such as changing the units of the data. The “gains by stream reach” Excel spreadsheet is called “Gains_inh.xls”. The “seepage and bank storage” Excel spreadsheet is called “McConaughy_inh.xls”. The Tamarack data are normally created by SDF View. Cortex.xls expects these spreadsheets to be located under the \Opstudy\Tools directory.

When the Step 2 macro in the cortex.xls spreadsheet is executed, this executes a macro in the spreadsheet INHspawner.xls which creates the necessary hydrology input file from the above spreadsheets and places this under the \Opstudy\Output\[alternative] directory. (The features to be included in the chosen alternative are defined within cortex.xls, and the rules for building the input hydrology file are established by INHspawner.xls). As already described above, Step 2 also runs the OPSTUDY model on the input files.

The data sets that are contained in the four data spreadsheets (Gains_inh.xls, Julesburg_inh.xls, Lewellen_inh.xls, and McConaughy_inh.xls) are listed on eleven tabs/sheets in the Cortex.xls spreadsheet. The following figure shows the list of existing data sets contained in the McConaughy_inh.xls spreadsheet (listed on the McConaughy_inh tab of Cortex.xls). The Average column (column A) contains the average for the data set. The Element column (column B) contains the element number, which is used by the Cortex.xls and INHspawner.xls spreadsheets to develop the HDATA input file (*.inh) for the Central Platte River Model. The Description column (column C and higher) describes the data contained in each data set through the HDATA item number [**)] and the HDATA item title. The following figure shows that there are several blank data sets (Not used (blank)) available for new data.

McCONAUGHY_INH		Central District and NPPD related items are kept in this sheet.
Average	Element	Description
38.6	100	25) AVERAGE ELWOOD RESERVOIR STORAGE
-2.8	200	26) COMBINED SEEPAGE AND BANK STORAGE FOR LAKE MCCONAUGHY (HISTORIC FROM 1947-1994)
48.7	300	27) AVERAGE SUTHERLAND SYSTEM STORAGE
41.2	400	28) AVERAGE JOHNSON SYSTEM STORAGE
0.0	500	32) SUTHERLAND SYSTEM SEEPAGE AND EVAPORATION LOSS
0.0	600	33) TRI-COUNTY SYSTEM SEEPAGE AND EVAPORATION LOSS
0.0	700	Not used (blank)
7.4	800	25) HISTORIC ELWOOD RESERVOIR STORAGE
53.0	900	27) HISTORIC SUTHERLAND SYSTEM STORAGE
51.3	1000	28) HISTORIC JOHNSON SYSTEM STORAGE
15.3	1100	32) HISTORIC SUTHERLAND SYSTEM SEEPAGE AND EVAPORATION LOSS
22.0	1200	33) HISTORIC TRI-COUNTY SYSTEM SEEPAGE AND EVAPORATION LOSS
0.0	1300	Not used (blank)
0.0	1400	Not used (blank)
0.0	1500	Not used (blank)

Hdata number	Column in cortex tab of the Cortex.xls spreadsheet	Spreadsheet in which data sets are located	Tab where data sets are located within the spreadsheet	Description of the data sets	Tab in Cortex.xls where existing data sets are listed
1	G	Lewellen_inh.xls	Lewellen_Flows_Hdata	Flow in the North Platte River at Lewellen w/o EA flows	Lewellen_inh_Lewellen_Flow
2	H	Julesburg_inh.xls	HDATA	Flow in the South Platte River at Julesburg w/o EA flows	Julesburg_Inflows_List
3	I	Gains_inh.xls	Gains	Birdwood Creek inflows	Gains_inh_Gains
4	J	Gains_inh.xls	Gains	Keystone to Sutherland Gain/loss	Gains_inh_Gains
5	K	Gains_inh.xls	Gains	Sutherland to North Platte Gain/loss	Gains_inh_Gains
6	L	Gains_inh.xls	Gains	Julesburg to Paxton Gain/loss	Gains_inh_Gains
7	M	Gains_inh.xls	Gains	Paxton to North Platte Gain/loss	Gains_inh_Gains
8	N	Gains_inh.xls	Gains	North Platte to Brady Gain/loss	Gains_inh_Gains
9	O	Gains_inh.xls	Gains	Brady to Cozad Gain/loss	Gains_inh_Gains
10	P	Gains_inh.xls	Gains	Cozad to Overton Gain/loss	Gains_inh_Gains
11	Q	Gains_inh.xls	Gains	Overton to Odessa Gain/loss	Gains_inh_Gains
12	R	Gains_inh.xls	Gains	Odssea to Grand Island Gain/loss	Gains_inh_Gains
13	S	Gains_inh.xls	Gains	Grand Island to Duncan Gain/loss	Gains_inh_Gains
14	T	Gains_inh.xls	Diversions	Keystone to Sutherland Irrigation Demand	Gains_inh_Diversions
15	U	Gains_inh.xls	Diversions	Sutherland to North Platte Irrigation Demand	Gains_inh_Diversions
16	V	Gains_inh.xls	Diversions	Western Canal Irrigation Demand	Gains_inh_Diversions
17	W	Gains_inh.xls	Diversions	Tri-County Irrigation Demand	Gains_inh_Diversions
18	X	Gains_inh.xls	Diversions	Brady to Cozad Irrigation Demand	Gains_inh_Diversions
19	Y	Gains_inh.xls	Diversions	Kearney Irrigation Demand	Gains_inh_Diversions
20	Z	Lewellen_inh.xls	EA_Deliveries_Hdata	Deliveries to the EA in McConaughy from (Reclamation) sources above Lake McConaughy	Lewellen_inh_EA_Deliveries
21	AA	Julesburg_inh.xls	HDATA	Deliveries to the South Platte River from the Tamarack Project in Colorado above Julesburg	Julesburg_Tamarack_List
22	AB	Lewellen_inh.xls	ETO_Not_Stored_Hdata	ETO not stored in Wyoming and released for Environmental use in Nebraska	Lewellen_inh_ETO_Not_Stored
23	AC	Gains_inh.xls	Diversions	Historic Keystone Diversion	Gains_inh_OtherHDATA
24	AD	Gains_inh.xls	Diversions	Historic Tri-County Diversion	Gains_inh_OtherHDATA
25	AE	McConaughy_inh.xls	HDATA	Elwood Reservoir Target	McConaughy_inh
26	AF	McConaughy_inh.xls	HDATA	McConaughy bank storage and seepage	McConaughy_inh
27	AG	McConaughy_inh.xls	HDATA	Sutherland Reservoir Target	McConaughy_inh
28	AH	McConaughy_inh.xls	HDATA	Johnson Reservoir Target	McConaughy_inh
29	AI	Julesburg_inh.xls	HDATA	Other EA deliveries from Colorado above Julesburg	Julesburg_OtherColoradoWater
30	AJ	Gains_inh.xls	Gains	Duncan to Louisville Gain/loss	Gains_inh_Gains
31	AK	Lewellen_inh.xls	EA_Borrow_Hdata	EA available in Reclamation Reservoirs in Wyoming which can be borrowed from non-EA in McConaughy	Lewellen_inh_EA_Borrow
32	AL	McConaughy_inh.xls	HDATA	Sutherland System losses (SSLOSS1) calculated by the model if all values are 0	McConaughy_inh
33	AM	McConaughy_inh.xls	HDATA	Tri-County System losses (TCLOSS1) calculated by the model if all values are 0	McConaughy_inh
34	AN	Gains_inh.xls	Diversions	Korty Diversion	Gains_inh_OtherHDATA
35	AO	Gains_inh.xls	Gains	North Platte River at Keystone	Gains_inh_OtherHDATA
36	AP	Gains_inh.xls	Diversions	Kearney demand for producing hydro-power	Gains_inh_OtherHDATA
37	AQ	Gains_inh.xls	Gains	Jeffrey Hydro Return	Gains_inh_OtherHDATA
38	AR	Gains_inh.xls	Gains	Useable Brady to Cozad Gains	Gains_inh_OtherHDATA
39	AS	Gains_inh.xls	Gains	Useable North Platte to Brady Gains	Gains_inh_OtherHDATA
40	AT	Gains_inh.xls	Gains	Useable Julesburg to Paxton Gains	Gains_inh_OtherHDATA
1	AU	Gains_inh.xls	Gains	Adjustment to Lewellen flows for Nebraska or other future depletions	Gains_inh_Gains
2	AV	Gains_inh.xls	Gains	Adjustment to Julesburg flows for Nebraska or other future depletions	Gains_inh_Gains

The Central Platte River Model needs forty-two data sets to produce forty HDATA items for each simulation. The figure on the previous page (HDATA_Matrix tab of the Cortex.xls spreadsheet) shows the forty-two data sets that are needed for each model run. The first column is the HDATA item number. Notice that there are two data sets each for HDATA items 1 (Lewellen inflows) and 2 (Julesburg inflows). The first data sets are the flows provided by the North Platte and South Platte EIS models. The second data sets are adjustments to these flows for future depletions. The results (what is in the *.inh file) of the two data sets each for HDATA items 1 and 2 are just HDATA items 1 and 2.

The second column contains the column in the Cortex tab of the Cortex.xls spreadsheet where the Element number (previous figure) is used to direct the INHspawner.xls spreadsheet how to form the *.inh input file. The third and fourth columns are the spreadsheet and tab/sheet where the INHspawner.xls spreadsheet expects to find the data set. The fifth column is descriptions of the data contained in each data set. Except for the adjustments to Lewellen and Julesburg inflows, the descriptions are the same descriptions as the HDATA item. Therefore, the first 40 are descriptions for both the data set and the HDATA item. The sixth and final column is the tab of the Cortex.xls spreadsheet where the available data sets are listed.

McConaughy_inh.xls

The McConaughy_inh.xls spreadsheet contains the data sets for six HDATA items. The HDATA items are:
HDATA 25 – Elwood Reservoir Target;
HDATA 26 – McConaughy bank storage and seepage;
HDATA 27 – Sutherland Reservoir Target;
HDATA 28 – Johnson Reservoir Target;
HDATA 32 – Sutherland System losses (SSLOSS1) [calculated by the model if all values are 0]; and
HDATA 33 – Tri-County System losses (TCLOSS1) [calculated by the model if all values are 0].
There is one data set for HDATA 26 – McConaughy bank storage and seepage. This data set is historic values and is used for all model runs.

The remaining HDATA items have two data sets. One data set for each HDATA item is historic values and these data sets are used to recreate historic flows with the Central Platte River Model. The other data sets contain the data for all other model runs. The targets for Elwood Reservoir, Sutherland Reservoir, and Johnson Lake are the same for Present Conditions and all of the Alternatives. The losses for the Sutherland and Tri-County Canals are either calculated by the model (all values in the HDATA set equal to zero) or input by the user.

If the user wants to use data sets other than those provided for HDATA 25, 26, 27, 28, 32, and/or 33, the new data sets need to be on the HDATA tab of the McConaughy_inh.xls spreadsheet. Place the new monthly data (calendar year format for years 1947-1994) in one (or more) of the empty (Not used (blank)) data sets in the McConaughy_inh.xls spreadsheet. The spreadsheet is currently set up to calculate the annual average of the twelve monthly values. The spreadsheet also calculates the annual minimum, maximum and average for the forty-eight year period of record. Replace the HDATA title "(Not used (blank))" with the proper HDATA item number [**)] and a brief description of the data set. In the proper column (AE, AF, AG, AH, AL, or AM) and row on the Cortex tab of the Cortex.xls spreadsheet, the user places the element number of the new data set (or an existing data set).

Gains_inh.xls (including changes reflecting new depletions by reach)

The Gains_inh.xls spreadsheet contains most of the data sets required for the operation of the Central Platte River Model. The Gains_inh.xls spreadsheet contains the data sets for twenty-seven HDATA items plus the data sets that for adjustments to HDATA items 1 and 2. The data sets are contained on three tabs (Gains, Diversions, and OtherHDATA) of the Gains_inh.xls spreadsheet.

The Gains tab of the Gains_inh.xls spreadsheet contains the data sets for HDATA 3 through 13, HDATA 30, and the adjustments to HDATA items 1 and 2. HDATA 3 through 13 and HDATA 30 are the inflow from Birdwood Creek (HDATA 3), gains/losses in two reaches of the North Platte River (HDATA 4 and 5), gains/losses in two reaches of the South Platte River (HDATA 6 and 7), and gains/losses in seven reaches of the Platte River (HDATA 8 through 13 and HDATA 30). The Gains tab of the Gains_inh.xls spreadsheet contains data sets for Present Condition gains/losses, historic gains/losses, and Present Condition gains/losses adjusted for Nebraska and other future depletions. The tab also contains the adjustments to HDATA items 1 and 2 for future federal depletions.

Adjustments to Present Condition gains/losses adjusted for Nebraska and other future depletions are made on the GainsAdjuster tab of the Gains_inh.xls spreadsheet. Annual adjustments to flows for federal depletions at Lewellen on the North Platte, Julesburg on the South Platte, and Cozad to Overton reach gain/loss on the Platte River are made in cells A27 through A29. Monthly adjustments to flows for Nebraska's future depletions are made in cells D20 through E24. Adjustments for October through April are made in cells D20 through D24 and adjustments for May through September are made in cells E20 through E24. Any adjustments for federal depletions at Lewellen or Julesburg reduce the flows at these locations that are provided by the North Platte River EIS model and the South Platte River EIS model respectively.

The Diversions tab of the Gains_inh.xls spreadsheet contains irrigation demands used in the Central Platte River Model (HDATA 14 through 19). The tab contains data sets for Present Condition irrigation demands and historic irrigation demands. The historic irrigation demands are the historic diversions of the canals. The Present Condition irrigation demands are the historic diversions adjusted to Present Condition operations and water supplies.

The 'OtherHDATA' tab of the Gains_inh.xls spreadsheet contains data sets for HDATA 23, 24, and 34 through 40. The tab contains data sets for Present Condition and historic values. The historic values are used to recreate historic flows with the Central Platte River Model. Except for the Kearney Canal Diversion (HDATA 36), the Present Condition data sets are populated with values of zero and there are no Present Condition data sets for HDATA 38, 39, and 40. HDATA 38, 39, and 40 are the useable gains in the Brady-Cozad reach (HDATA 38), the North Platte to Brady reach (HDATA 39), and the Julesburg to Paxton reach (HDATA 40). HDATA 38, 39, and 40 are used to eliminate shortages caused by historic diversions greater than historic flows at end of the next upstream reach and are usually caused by very large reach gains.

If the user wants to use data sets other than those provided, the new data sets need to be on the 'Gains', 'Diversions', and/or 'OtherHDATA' tabs of the Gains_inh.xls spreadsheet. Place the new monthly data (calendar year format for years 1947-1994) in one (or more) of the empty "(Not used (blank))" data sets in the Gains_inh.xls spreadsheet. The spreadsheet is currently set up to calculate the annual total of the twelve monthly values. The spreadsheet also calculates the annual minimum, maximum and average for the forty-eight year period of record. Replace the HDATA title (Not used (blank)) with the proper HDATA item number [**)] and a brief description of the data set. In the proper column and row on the Cortex tab of the Cortex.xls spreadsheet, the user places the element number of the new data set (or an existing data set).

Julesburg_inh.xls

The Julesburg_inh.xls spreadsheet contains the output from the South Platte EIS model, which encompass data sets for three HDATA items. The HDATA items are:
HDATA 2 – Flow in the South Platte River at Julesburg w/o EA flows;
HDATA 21 – Deliveries to the South Platte River from the Tamarack Project in Colorado above Julesburg; and
HDATA 29 – Other EA deliveries from Colorado above Julesburg.

There are multiple data sets for HDATA 2 and HDATA 29. There is only one data set for HDATA 21 and all values in this data set are zero. HDATA 21 is only populated if Tamarack is included in an alternative and HDATA 21 created by the DSS using the Tamarack_Input4794.xls spreadsheet and the output from the SDF View model.

HDATA 2 and HDATA 29 are paired data sets. For every HDATA 2 data set there is (should be) a corresponding HDATA 29 dataset. The HDATA 2 data sets are on the 'Julesburg_Inflows' tab of the Julesburg_inh.xls spreadsheet. The HDATA 29 data sets are on the 'OtherColoradoWater' tab of the Julesburg_inh.xls spreadsheet. The element number for the HDATA 29 data sets are 4,000 greater than the HDATA 2 elements. Therefore, the element number for first HDATA 2 is 100 and for the first HDATA 29 is 4100.

On the Cortex tab of the Cortex.xls spreadsheet, change the element number in column H and the element number in column AI will be automatically updated. Column AA is never changed between model runs.

If the user wants to use data sets other than those provided for HDATA 2 and/or 29, the new data sets need to be on the Julesburg_Inflows and/or OtherColoradoWater tabs of the Julesburg_inh.xls spreadsheet. Place the new monthly data (calendar year format for years 1947-1994) in one (or more) of the empty (Not used (blank)) data sets in the Julesburg_inh.xls spreadsheet. The spreadsheet is currently set up to calculate the annual total of the twelve monthly values. The spreadsheet also calculates the annual minimum, maximum and average for the forty-eight year period of record. Replace the HDATA title (Not used (blank)) with the proper HDATA item number [**)] and a brief description of the data set. In the proper column (AI or AA) and row on the Cortex tab of the Cortex.xls spreadsheet, the user places the element number of the new data set (or an existing data set).

Lewellen_inh.xls

The Lewellen_inh.xls spreadsheet contains the output from the North Platte EIS model, which encompass data sets for four HDATA items. The HDATA items are HDATA 1 – Flow in the North Platte River at Lewellen w/o EA flows; HDATA 20 – Deliveries to the EA in McConaughy from (Reclamation) sources above Lake McConaughy; HDATA 22 – ETO not stored in Wyoming and released for Environmental use in Nebraska; and HDATA 31 – EA available in Reclamation Reservoirs in Wyoming which can be borrowed from non-EA in McConaughy.

There are multiple data sets for these HDATA items. All of the HDATA items are paired data sets. For every HDATA 1 data set there is (should be) a corresponding HDATA 20, HDATA 22, and HDATA 31 dataset. The HDATA 1 data sets are on the Lewellen_Flows_Hdata tab of the Lewellen_inh.xls spreadsheet. The HDATA 20 data sets are on the EA_Deliveries_Hdata tab of the Lewellen_inh.xls spreadsheet. The HDATA 22 data sets are on the EA_Borrow_Hdata tab of the Lewellen_inh.xls spreadsheet. The HDATA 31 data sets are on the ETO_Not_Stored_Hdata tab of the Lewellen_inh.xls spreadsheet. The element numbers for the HDATA 20 data sets are 4,000 greater than the HDATA 1 elements. The element numbers for the HDATA 22 data sets are 8,000 greater than the HDATA 1 elements. The element numbers for the HDATA 31 data sets are 12,000 greater than the HDATA 1 elements. Therefore, the element number for the first HDATA 1 is 100 and for the first HDATA 20 is 4100 and for the first HDATA 22 is 8100 and for the first HDATA 31 is 12100.

On the Cortex tab of the Cortex.xls spreadsheet, change the element number in column G and the element numbers in columns A, AB, and AK will be automatically updated.

If the user wants to use data sets other than those provided for HDATA 1 and/or 20 and/or 22 and/or 31, it is recommended that the North Platte EIS model be used to create the new HDATA data sets. However, if the user does not use the North Platte River EIS model, the new data sets provided by the user need to be on the Lewellen_Flows_Hdata, EA_Deliveries_Hdata, EA_Borrow_Hdata and/or ETO_Not_Stored_Hdata tabs of the Lewellen_inh.xls spreadsheet.

Place the new monthly data (calendar year format for years 1947-1994) in one (or more) of the empty (Not used (blank)) data sets in the Lewellen_inh.xls spreadsheet. The spreadsheet is currently set up to calculate the annual total of the twelve monthly values. The spreadsheet also calculates the annual minimum, maximum and average for the forty-eight year period of record. Replace the HDATA title (Not used (blank)) with the proper HDATA item number [**)] and a brief description of the data set. In the proper column (AI) and row on the Cortex tab of the Cortex.xls spreadsheet, the user places the element number of the new data set (or an existing data set).

5.3.3 Tamarack Plan modification

Configurations of the Tamarack Plan reregulating system that are not already represented by one of the three options used in the EIS analyses (see Section 4.13) may be modified by altering the values in the tables corresponding to codes 1, 2, 3, etc. for the Tamarack options in the spreadsheet "Tamarack_Input4794.xls", or alternatively by adding a new code value to the list of options operable from the cortex spreadsheet, linking this code to the correct range of cells in Tamarack_Input4794.xls, and adding the appropriate Tamarack configuration to the Tamarack spreadsheet.

The Cortex interface includes a step (Step 3) in which the output of the SDF View simulation of Tamarack Project effects on Platte River flows (see Section 4.13) is incorporated into the hydrology file for the current model run (HDATA items #2 and #21 are modified). Thus, user modifications to the Tamarack Plan do not require any direct manipulation of the hydrologic data file, nor of any ADATA or CDATA values in the main input file.

Tamarack operations are turned off by placing "None" in column D cells 25 through 50 on the "CORTEX" tab in the cortex.xls spreadsheet. This will cause the cortex spreadsheet to prompt the user to execute the macro for Step 5 instead of Step 3 after the execution of Step 2.

5.4 INITIALIZED MODEL STATE VARIABLES

When the CPR Model is run, a number of state variables are initialized to arbitrary values expressing the condition of the system when the model run begins (i.e., the condition of the system at the beginning of the first month of the first modeled year). These state variables include the starting content of as many as five reservoirs in the system (McConaughy, Elwood, Johnson, Sutherland, and the Central Platte Re-Regulating Reservoir), as well as the starting volume in the Environmental Account at McConaughy. All of these variables are initialized by setting their corresponding CDATA values in the main input file.

Table 5.1 CPR Model initialized condition state variables.

Initialized condition	CDATA item	OPSTUDY variable	Initialized value

Lake McConaughy starting content (KAF)	#10	EOMLST	1535.0
Elwood Reservoir starting content (KAF)	#42	EREOMC	15.3
Johnson Lake starting content (KAF)	#44	JLEOMC	39.6
Sutherland Reservoir starting content (KAF)	#58	SREOMC	45.0
Central Platte Re-regulating Reservoir starting content (KAF)	#114	CPRREOMLST	3,450
EA starting content (KAF)	#69	EASTART	100.0

The final column in Table 5.1 lists the settings of these CDATA values for all CPR Model runs performed as part of the Platte River EIS. The McConaughy starting content reflects the approximate historic average content on January 1. Sutherland, Elwood, and Johnson Reservoirs are generally fixed-level reservoirs, and thus their starting contents are set to these standardized levels. The starting content of the Environmental Account at Lake McConaughy is arbitrarily set to ½ of its maximum content of 200 KAF. Although each of these initialized settings are arbitrary values, the CPR Model results are not normally very sensitive to the initialized conditions after one or two years of model simulation.

In addition, the SPILL and MACREL variables for monthly spill and release from Lake McConaughy are initialized to zero at the beginning of the COMPUTE subroutine.

5.5 "RAW" OUTPUT FILES

Each run of the OPSTUDY model generates output results in the form of various "raw" text files. As described in Section 5.6, tools have been developed to simplify conversion of these text files into Excel spreadsheets for subsequent analysis and plotting. A description of the content of the raw text files follows. These output files are placed under the \Run directory.

.TAB files

Output files with the .TAB extension contain summary data tables generated by OPSTUDY. The number of tables to generate and the text headings to place on each of these tables are specified in the main input file. The .TAB file begins with several lines of information about the modeled scenario, including a time-stamp, for example:

```
STUDY NO. PC4794   Date: 01/10/2001    Time: 11:49 AM
                    CENTRAL PLATTE EIS OPSTUDY MODEL VERSION 2000.12.14

                       PRESENT CONDITION OPERATION STUDY 1947 - 1994
```

The number of header comment lines is defined by item number 12 in line two of the model input file. These header lines are followed by the data tables, which provide monthly and annual values for the entire modeling period the specified summary items. These tables also include summary figures listing the minimum, maximum, and mean values for each month of the modeled period. The following is sample .TAB output table listing modeled Lake McConaughy end-of-month content for years 1947-1994 (figures from the middle 42 years have been removed to shorten the length of this reproduced table):

TABLE 1. LAKE MCCONAUGHY END-OF-MONTH CONTENT (KAF)

YEAR	JAN	FEB	MAR	APR	MAY	JUN	JUL	AUG	SEP	OCT	NOV	DEC	TOTAL
1947	1559.7	1589.1	1594.1	1609.1	1580.3	1743.1	1743.1	1603.5	1575.8	1594.1	1594.1	1594.1	1615.0
1948	1645.2	1668.6	1594.1	1609.1	1537.9	1520.2	1424.3	1325.0	1295.0	1306.1	1375.3	1415.1	1476.3
1949	1435.1	1508.9	1577.3	1609.1	1604.5	1686.4	1642.9	1540.3	1547.8	1581.5	1594.0	1594.1	1576.8
...													
1992	1102.7	1147.2	1199.9	1222.4	1192.8	1192.3	1152.6	1069.1	1077.2	1123.5	1168.7	1197.4	1153.8
1993	1232.3	1273.8	1333.0	1376.6	1387.8	1388.2	1296.9	1273.4	1311.3	1358.3	1373.0	1384.0	1332.4
1994	1412.6	1438.1	1478.3	1502.9	1468.9	1395.6	1295.5	1160.7	1175.0	1219.8	1255.6	1280.2	1340.3
MINIMUM	957.1	1014.7	1068.7	1131.3	1192.8	1133.8	993.2	880.0	805.3	795.3	868.7	930.3	1045.2
AVERAGE	1385.7	1424.3	1440.8	1455.9	1482.0	1489.3	1380.6	1277.9	1266.4	1291.2	1323.1	1347.3	1380.4
MAXIMUM	1645.2	1668.6	1594.1	1609.1	1743.1	1743.1	1743.1	1743.1	1668.6	1594.1	1594.1	1594.1	1638.1

.AVG Files

The .AVG output files include the same minimum, maximum, and mean summary tables that are written to the .TAB file (e.g., the last three lines in the above sample .TAB output). The .AVG files do not include the monthly and annual data of the .TAB file, and thus are considerably shorter. The only information contained in the .AVG file that is not included in the corresponding .TAB file is a "reduction in flow shortage" summary, which has this format:

REDUCTION IN FLOW SHORTAGE AND EXCESS (KAF)
A + SCORE MEANS AN IMPROVEMENT IN SHORTAGE
A - EXCESS MEANS LESS EXCESS RELATIVE TO PC

YEAR	JAN	FEB	MAR	APR	MAY	JUN	JUL	AUG	SEP	OCT	NOV	DEC	TOTAL
SCORE	0.0	0.0	-0.1	0.0	0.0	0.2	0.0	0.0	0.0	-0.1	-0.1	0.0	-0.1
EXCESS	0.0	0.1	0.7	0.2	0.1	-0.6	-0.4	-0.7	0.1	-0.1	0.1	-0.3	-0.9

This table summarizes the change in monthly shortages to target flows of the modeled scenario, relative to the "Present Condition". These values are used to compute the "score" of the modeled scenario (see Section 2.10).

.TXT Files

The .TXT output files have the same informational content as the .TAB files. The only difference between the files is the format of the information. Numeric values in the TXT files are comma-delimited, and text strings in the TXT files are enclosed in quotes to make it easier to import the files into a spreadsheet like Excel. For example, the content of the TXT file corresponding to the TAB file example given above is:

```
"STUDY NO. PC4794      Date: 01/10/2001      Time: 11:49 AM"
 "CENTRAL PLATTE EIS OPSTUDY MODEL VERSION 2000.12.14                    "
 "PRESENT CONDITION OPERATION STUDY 1947 - 1994                    "

"TABLE 1. LAKE MCCONAUGHY END-OF-MONTH CONTENT (KAF)                    "

"YEAR"  "JAN"  "FEB"  "MAR"  "APR"  "MAY"  "JUN"  "JUL"  "AUG"  "SEP"  "OCT"  "NOV"  "DEC"  "TOTAL"
1947, 1559.7, 1589.1, 1594.1, 1609.1, 1580.3, 1743.1, 1743.1, 1603.5, 1575.8, 1594.1, 1594.1,  1594.1,  1615.0
1948, 1645.2, 1668.6, 1594.1, 1609.1, 1537.9, 1520.2, 1424.3, 1325.0, 1295.0, 1306.1, 1375.3,  1415.1, 1476.3
1949, 1435.1, 1508.9, 1577.3, 1609.1, 1604.5, 1686.4, 1642.9, 1540.3, 1547.8, 1581.5, 1594.0,  1594.1, 1576.8
...
1992, 1102.7, 1147.2, 1199.9, 1222.4, 1192.8, 1192.3, 1152.6, 1069.1, 1077.2, 1123.5, 1168.7,  1197.4, 1153.8
1993, 1232.3, 1273.8, 1333.0, 1376.6, 1387.8, 1388.2, 1296.9, 1273.4, 1311.3, 1358.3, 1373.0,  1384.0, 1332.4
1994, 1412.6, 1438.1, 1478.3, 1502.9, 1468.9, 1395.6, 1295.5, 1160.7, 1175.0, 1219.8, 1255.6,  1280.2, 1340.3

"MINIMUM",  957.1, 1014.7, 1068.7, 1131.3, 1192.8, 1133.8,  993.2,  880.0,  805.3,  795.3,   868.7,  930.3, 1045.2
"AVERAGE", 1385.7, 1424.3, 1440.8, 1455.9, 1482.0, 1489.3, 1380.6, 1277.9, 1266.4, 1291.2,  1323.1, 1347.3, 1380.4
"MAXIMUM", 1645.2, 1668.6, 1594.1, 1609.1, 1743.1, 1743.1, 1743.1, 1743.1, 1668.6, 1594.1,  1594.1, 1594.1, 1638.1
```

.PLS Files

The .PLS output files contain short-duration near-bankfull flow calculations for the modeled period if the modeled scenario included short-duration near-bankfull flow releases (see Section 4.3). If the short-duration near-bankfull flow releases are not part of the modeled scenario, a .PLS output file will be generated, but will contain no information.

The .PLS output file provides information about the short-duration near-bankfull flow occurring in each modeled year, including: short-duration near-bankfull flow code (see EAPCODE discussion in Section 4.3); month in which the peak occurs; estimated flows (in cfs) at various points in the system (e.g., South Platte at Julesburg) at the time the short-duration near-bankfull occurs; and Environmental Account release associated with the short-duration near-bankfull (if any). This output file also echoes back the settings that were used to model these particular short-duration near-bankfull releases (e.g., numbers of days to sustain short-duration near bankful, and allowed rate of short-duration near-bankfull hydrograph rise and fall), and summarizes how often the short-duration near-bankfull flow targets were achieved, along with the number of short-duration near-bankfull releases associated with each release “code” – that is: under what conditions did these short-duration near-bankfull occur (the possibilities are described under Table 4.2 in Section 4.3).

.OPO Files

The .OPO output files contain essentially all of the model data output, grouped by model feature and by year. The beginning of this file also echoes back the CDATA and ADATA settings as they existed for this particular model run. This output file therefore provides a rather comprehensive package of input and output from the model run.

The number of “groupings” of monthly output values for each year, the number line items in each of these groups, and the text descriptions accompanying these groups and line items are all specified in the model input file (see Section 5.2.1). A sample “grouping” of data would be various results falling under the theme of “Lake McConaughy”. Sample output included under the Lake McConaughy grouping for the first year in the .OPO file might appear as follows (this particular group consists of 13 line items, as specified by the input file):

```
1947                          JAN    FEB    MAR   APR    MAY    JUN    JUL    AUG    SEP    OCT
  NOV    DEC  TOTAL
                                                      (THOUSANDS OF ACRE-FEET)
       LAKE MC CONAUGHY
NORTH PLATTE R. AT LEWELLEN   83.6   79.4   94.8   90.5   54.6  385.0  283.3   41.8   83.7  121.8
 117.9  116.5 1552.9
RESERVOIR EVAPORATION          1.8    2.4    3.7    5.3    5.7    7.6   14.0   13.1    7.9    6.1
   3.3    1.6    72.4
RES SEEPAGE AND BANKSTORAGE    0.0    0.0    0.0    0.0    0.0    0.0    0.0    0.0    0.0    0.0
   0.0    0.0    0.0
RES DEMAND (INCL. EA PULSE)   57.1   47.6   62.2   50.0   77.7   40.6   87.6  168.3  103.5   82.1
  53.8   42.1   872.5
TURBINE RELEASE (W/O PULSE)   56.7   47.6   62.2   49.9   75.2   30.9   80.4  156.3   98.7   71.3
  51.4   42.1   822.7
TURBINE RELEASE (EA PULSE)     0.0    0.0    0.0    0.0    0.0    0.0    0.0    0.0    0.0    0.0
    0.0    0.0    0.0
HOWELL BUNGER RELEASE          0.3    0.0    0.0    0.1    2.5    9.7    7.2   12.0    4.8   10.8
   2.3    0.0    49.8
RESERVOIR SPILL, TURBINE       0.0    0.0   23.9   20.3    0.0  174.0  181.7    0.0    0.0   15.4
  60.8    72.8   548.9
RESERVOIR SPILL, M.GLORY       0.0    0.0    0.0    0.0    0.0    0.0    0.0    0.0    0.0    0.0
    0.0    0.0    0.0
TOTAL RESERVOIR SPILL          0.0    0.0   23.9   20.3    0.0  174.0  181.7    0.0    0.0   15.4
  60.8    72.8   548.9
END-OF-MONTH CONTENT        1559.7 1589.1 1594.1 1609.1 1580.3 1743.1 1743.1 1603.5 1575.8 1594.1
1594.1 1594.1 1615.0
TOT RES OUTFLOW (W/O PULSE)   57.1   47.6   86.1   70.2   77.7  214.6  269.3  168.3  103.5   97.5
  114.6  114.9  1421.4
SUTHERLAND CANAL DIVERSION    57.1   47.6   86.1   68.4   67.5  119.0  118.8  109.2   88.3
96.7   114.6   114.9  1088.2
```

The OPO file lists a series of other group and group line item monthly and annual output values for the first modeled year, and then repeats this output for every remaining year in the model run.

.PLT files

Data as formatted for plotting purposes by the original (pre-Platte River study) OPSTUDY routines.

.OST files

Output OST files contain output that has been custom-formatted for the Platte River Project to simplify the generation of plots using Excel. Monthly data are written out as space-delimited values, with the year and the month listed in columns 1 and 2 respectively, and the values for 25 OPSTUDY variables for that month written out to subsequent columns. These variables include simulated streamflow at various river locations (e.g., BRADY and GRNDISL), canal diversions (e.g., KEYDV and KCDV), and McConaughy Reservoir conditions (e.g., SPILL and EOMC). Output to the OST file for the first year of the model run looks something like this (19 variable columns have been dropped from this example):

```
YEAR  MO   LEWELN   MACDMD    SPILL ... OVERTON   GRNDISL CONDITION
1947   1     83.6     76.1      0.0       108.8     125.5         1
1947   2     79.4    102.0      0.0       135.1     141.0         1
1947   3     94.8    114.0      0.0       152.9     167.8         1
1947   4     90.5    119.0      0.0       154.6     165.3         1
1947   5     55.1    179.2      0.0       147.1     150.0         1
1947   6    321.7     67.8      0.0       166.2     207.2         1
1947   7    327.3    155.4      0.0       316.3     302.0         1
1947   8     72.7    228.0      0.0        77.4      60.5         1
1947   9     90.1    125.4      0.0        76.6      63.4         1
1947  10    117.4    118.9      0.0       118.7     104.1         1
1947  11    114.5     77.9      0.0       120.2     119.5         1
1947  12    113.8     53.8     35.7       120.2     119.5         1
```

.GAG files

GAG files are in the same format as OST files, but GAG files only report estimated flow (in cfs) for 15 stream and canal gaging locations (BIRDCFS, BRADYCFS, COZADCFS, etc.).

.GI files

GI output files consist of five tables based on monthly streamflow estimates at Grand Island, Nebraska. These tables are:

1. Total monthly Platte River discharge by month (column) for each year (row), in KAF units
2. The same monthly Platte River discharge values ordered as high to low values for each month (column), with the corresponding "percent exceeding" values as labels for each row (ranging from 1/n years to 100%).
3. Same as Table 1, but with values in cfs units.
4. Same as Table 2, but with values in cfs units.
5. Peak daily flow at Overton by month (column) for each year (row), in cfs units.

Each of these tables includes a summary of maximum, minimum, and mean values for each month during the modeled period.

.DAY files

Daily flows for nineteen locations in the central Platte system and daily storage in the Johnson Lake flow attenuation plan and daily storage in the Central Platte Re-regulatory Reservoir. Daily data are written out as space-delimited values, with the date listed in columns 1 and 2 respectively, and the values for 19 OPSTUDY variables for that month written out to subsequent columns. These variables include simulated streamflow at various river locations (e.g., BRADY and GRNDISL), canal diversions (e.g., KEYDV and KCDV), and returns (e.g., J2HR and JFHR). Output to the OST file for the first year of the model run looks something like this (19 variable columns have been dropped from this example):

```
                    GOVERNANCE COMMITTEE PROPOSED PROGRAM

                LOUIS     DUNC GRANDIS  ODDESA OVERTON
    1/ 1/1947   1946.     848.     638.   1986.   1374.
    1/ 2/1947   1864.     778.     698.   1336.   1334.
    1/ 3/1947   1874.     738.     779.   1336.   1304.
    1/ 4/1947   1892.     738.     949.   1336.   1234.
    1/ 5/1947   2154.     748.    1099.   1336.   1000.
    1/ 6/1947   2349.     798.    1409.   1322.   1184.
    1/ 7/1947   2548.     858.    1445.   1756.   1414.
    1/ 8/1947   2752.     925.    1509.   1826.   1414.
    1/ 9/1947   3165.     918.    1509.   1826.   1334.
    1/10/1947   3448.    1169.    1909.   1836.   1281.
    1/11/1947   3364.    1509.    2009.   1753.   1294.
    1/12/1947   3458.    1809.    1966.   1716.   1074.
    1/13/1947   3567.    2066.    2108.   1616.   1934.
    1/14/1947   4265.    2208.    2008.   2086.   1474.
    1/15/1947   4063.    2108.    1908.   1866.   1524.
    1/16/1947   4223.    1908.    2008.   2186.   1784.
    1/17/1947   4906.    1908.    1908.   2116.   1784.
    1/18/1947   5369.    2308.    1908.   1886.   1424.
    1/19/1947   5167.    2308.    2008.   1596.   1054.
    1/20/1947   5360.    2108.    2108.   1526.   1064.
```

.PUL files

Same data as the .DAY files with the addition of short-duration near-bankfull flow components at each flow location. The short-duration near-bankfull flow components are broken down by source of the flow.

5.6 TOOLS FOR EVALUATING AND GRAPHING OUTPUT

The output data files described in Section 5.5 are raw text files. A number of post-processing tools have been developed which streamline the evaluation, comparison, and graphing of model results. These tools are described in this section.

Potentially, a tremendous number of model output variables could be evaluated after each CPR Model run. However, among the most commonly-asked questions related to a particular modeling scenario are the following:

- What is the "score" of the modeled alternative (i.e., what is the "reduction in shortage to target flows" – see Section 2.10)
- How often do the pulse flows meet FWS targets, and for what reasons?
- How does the modeled scenario affect the monthly contents of Lake McConaughy?
- What is the state of the Environmental Account over the simulated period?
- What effects does the modeled scenario have on the magnitude, frequency, and timing of flows in the central Platte River?
- How often does streamflow fall to zero during the simulated period?

Among the tools provided with the Central Platte River Model to help answer these kinds of questions are the following Excel spreadsheets:

- Score4794.xls
- Comparedur-Cplatte.xls
- OPER12.xls
- CPSummary.xls
- CPSummary2.xls
- Daily_Flow_Comparison_Tools.xls
- DailyFlowAnalysis.xls
- DailyFlowExeedanceGraphs.xls
- DailyFlowsByBridgeSegment.xls
- MonthlyFlowGraphing.xls
- MonthlyValueComparison.xls
- OvertonPeakFlows.xls
- PulseFlowAnalysis.xls
- PulseFlowHistory.xls
- HistoricScore.xls
- Sdfoutput.xls
- CentralPlatteSchematic.xls

All of these spreadsheets are located under the \Opstudy\Tools directory. The analysis provided in each is summarized below.

5.6.1 Score4794

Score4794.xls is used to examine the "score" of the modeled alternative, examine the duration of EA releases, and summarize the nature of pulse flows. This spreadsheet is updated automatically whenever the model is run from the Cortex interface.

On the **Score** sheet, important "bottom-line" information is presented in the topmost table (A7:E14). This table identifies the raw and adjusted scores, and provides statistics on the average monthly EA accrual, balance, and release. Additional tables break down these annual totals by month.
The **Reference** sheet includes various tables summarizing the monthly reference conditions (Present Condition) for the modeled period.
The **Alternative** sheet includes the same tables for the modeled alternative.
The **Alternative EA** sheet summarizes Environmental Account statistics for all twelve months of the year, including EA contents, releases, and expenditures for pulse flows under the modeled alternatives. The **Ref EA** sheet provides the same summaries for the reference condition.
The **Tern&PloverNesting** sheet counts and summarizes the number of events in which tern and plover nests potentially could have been washed out by an increase in monthly flow.
The "**Graphs**" sheet provides month-by-month duration curves of simulated flow conditions at Grand Island relative to historic flows, present condition ("baseline") flows, and FWS instream flow recommendations. Companion bar graphs illustrate the extent (if any) to which EA releases aid in reducing shortages to target flows.

5.6.2 Comparedur_cplatte ("Durations" sheet button in Cortex)

Comparedur_cplatte is used to make side-by-side comparisons of various model output results (e.g., Lake McConaughy content at different times, or under different model scenarios). In order to make these comparisons, the user must first load three sets of model output as written to the corresponding [alternative].tab file, taken from either the same or different model runs. The **"Titles**" tab provides automated tools for loading the datasets and specifying the data to be analyzed, compared, and graphed. The comparison graphs and statistics are provided under the tabs "**Statistics**" and "**Differences**".

For detailed guidance on the use and interpretation of Comparedur-cplatte.xls, refer to the "**README**" tab in this spreadsheet file.

5.6.3 Oper12

The Oper12.xls spreadsheet and the macros it contains were developed for purposes of supporting a stepwise evaluation of twelve different CPR Model features and their individual and cumulative effects on model results, in particular the modeled content of Lake McConaughy. The results shown in the various Oper12 graphs reflect model behavior over the entire 1947-1994 period. The spreadsheet creates time-series graphs of values from two different model simulations. Values are graphed for Lake McConaughy, Sutherland Canal, Tri-County Canal, and river flows.

The “**Platte**” sheet graphs goodness-of-fit between historic and simulated “present conditions” flow at four Platte River locations (Brady, Cozad, Ovewrton, and Grand Island).

The “**Central**” sheet has graphs showing the goodness-of-fit between historic and simulated “present conditions” associated with operations of the CNPPID canal system. The graphs compare monthly values for measured vs. simulated Central diversions, Platte River flow passing the Central Diversion, Central canal losses, flows from the Jefferey Hydro return, and flows from the J-2 Hydro return.

The “**Confluence**” sheet graphs the goodness-of-fit between historic and simulated “present conditions” flow in the Platte River at the confluence of the North and the South Platte (including North Platte hydro return flows).

The “**Sutherland**” sheet has graphs showing the goodness-of-fit between historic and simulated “present conditions” associated with operations of the Sutherland Canal system. These graphs compare monthly values for measured and simulated diversions at Keystone, diversions at Korty, Sutherland Canal losses, and the North Platte Hydro return.

The “**McConaughy_NPR**” sheet has graphs showing the goodness-of-fit between historic and simulated “present conditions” associated with Lake McConaughy. These graphs compare monthly values for measured vs. simulated end-of-month contents at the lake, outflow from the lake, Sutherland Canal diversions at Keystone, and North Platte River flows at Keystone and at Sutherland.

The “**Regress**” sheet summarizes the goodness-of-fit regression statistics for the analysis of all of the above monthly historic records versus “present conditions” OPSTUDY model run estimates. This information is summarized in a table listing the correlation coefficient (R^2) and standard error for each historic vs. simulated variable comparison (e.g. Lake McConaughy end-of-month content).

5.6.4 CentralPlatteSchematic

The CentralPlatteSchematic.xls spreadsheet compares flow differences between two model runs and displays these differences in graphical format. The spreadsheet also displays a schematic of the central Platte system that is also a graphical representation of flows.

The "**schematic**" sheet displays a schematic of the central Platte (Figure 2.1 in this documents). The lines on the schematic are color coded to represent rivers and canals. The lines are also sized according the flow in the river or canal (thicker lines indicate higher flows). The flows represented by the schematic can be changed with a macro located in cells M3 and M4. The menu that appears when the macro is selected is shown in figure 5.6.1.

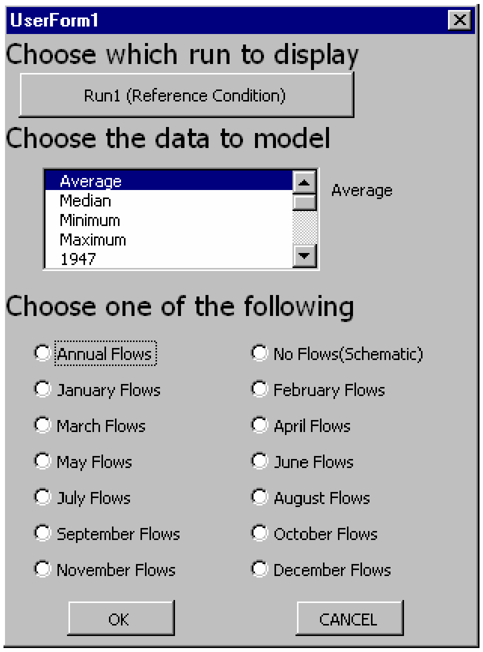


Figure 5.6.1 Central Platte Schematic Macro Menu

The button under the heading "Choose which run to display" toggles between the reference run and any alternative that is being examined. The list under "Choose the data to model" allows the user to choose between Average, Median, Minimum, Maximum, and annual flows to display on the schematic. The next section "Choose one of the following" is where the user selects either annual or monthly flows to display. The macro is executed by pressing the "OK" button and the macro is terminated without executing by pressing the "CANCEL" button.

The sheets "**JanSum, FebSum, MarSum, AprSum, MaySum, JunSum, JulSum, AugSum, SepSum, OctSum, NovSum, DecSum**", and "**AnnualSummary**" display the Average, Median, Minimum, Maximum, or annual flow data that was selected through the macro on the "schematic" sheet. The flow data at key gauge locations for both the reference and alternative model runs is displayed in both graphically and tabular format.

The sheet "**Compare**" compares the average values for each month and the annual total for each table produced by the model in the *.tab file. The comparison is the difference and the percent difference for each table.

The sheet "**Text**" collects words from the model output to form titles for the "schematic" sheet.

The sheets "**Reference**" and "**Alternative**" are the model output for the reference and the alternative model runs.

5.6.5 CPSummary

The CPSummary.xls spreadsheet collects and displays values from the model output in tabular and graphical format. Values for the alternative and the percent change from a reference run are displayed in the tables. In the graphs, the values for the alternative, the reference run, and the differences between the two are displayed.

The graphs and a few tables are shown on the "**Graphs**" sheet. The graphs include the end-of-September storage in Lake McConaughy, average monthly storage at Lake McConaughy, average monthly releases from Lake McConaughy, average monthly storage of off-channel reservoirs, and the average monthly flow at Grand Island compared to the daily flow targets. The tables on this sheet are summaries of:

- shortages to flow targets,
- months with no flow at Grand Island,
- pulse flow targets at Overton,
- storage in Lake McConaughy, and
- spills from lake McConaughy.

The "**Summary**" sheet contains eight summary tables. The tables are:

- shortages by river reach and/or canal,
- water conservation by reach and/or canal,
- irrigation demand by reach and/or canal,
- flows at key gage locations,
- environmental accruals by basin,
- interaction of the channel capacity at North Platte, NE with the operation of the Environmental Account in Lake McConaughy,
- diversions by major canals, and
- power generation.

The remaining sheets are information from the model output and are linked to the spreadsheet Tables.xls.

5.6.6 CPSummary2

The CPSummary2.xls spreadsheet collects and displays additional information regarding the effects of the modeled alternative on flows and flow periods of concern to the T&E species, such as 30-day pulse flows, 3-day pulse flows, low flows, and 50-percentile May flows.

5.6.7 CraneModelAnalysis

To improve river habitat for whooping cranes, the Recovery Program proposes to increase flows during the spring and fall periods of crane migration. The CraneModelAnalysis.xls spreadsheet models changes in habitat suitability resulting from hypothesized combinations of channel rehabilitation (widening and flattening) and changes in flow distributions and timing.

The combined effects of flow changes and channel reshaping on roost habitat were evaluated using the Whooping Crane Roost Habitat Model (WCRH Model). This model depicts the suitability of the channel roosting habitat in relation to river discharge based on habitat criteria that whooping crane experts believe are important: water depth and width, open channel width, and distance from disturbances. The WCRH Model is based on the concepts and principles of Physical Habitat Simulation Methodology (PHABSIM) (Bovee, 1982), and was developed by the Biology Workgroup of the Platte River Management Joint Study (PRMJS, 1990). Ziewitz (1992) published an earlier version of the model.

Use of the model in evaluating alternatives involves computing a flow/habitat relationship, assessing habitat suitability assuming no mechanical channel modifications, and assessing habitat suitability with mechanical channel modifications

Flow-Habitat Relationships: Four river sub-segments were defined for the sake of defining flow/habitat-suitability relationships: (1) the south channel of Jeffrey's Island, from the J-2 Hydropower Canal Return to the confluence with the north channel flow near the Overton Bridge; (2) Overton bridge to the Kearney Canal Diversion Dam near Elm Creek; (3) Kearney Diversion Dam to the Kearney Canal Return, east of Kearney, and; (4) Kearney Canal Return to Chapman. The habitat/flow relationship for each of these river reaches is in a post-processing spreadsheet included in the CPR Model. Each sub-segment is represented as a node in the CPR Model, and river flow can be simulated for each of these locations.

Assessing habitat suitability assuming no mechanical channel modifications: The habitat-versus-flow function is combined with the 48 years of modeled river flows to estimate habitat provided by each modeled alternative during the months of crane migration (April, October, and November). This is done for each of the four hydrologic segments and the results summed to determine the alternative's effect for the entire study area.

The 48 years are first run with existing water management operations of water projects to generate a 48-year dataset of habitat for "Present Condition." This is repeated with an alternative hydrology dataset representing changed water management operations, e.g., with the Governance Committee Alternative in place.

Assessing habitat suitability with mechanical channel modifications: Under certain modeled alternatives, reaches of narrow channel would be acquired and restored by leveling islands and modifying river banks to provide wide, open channels that are more suitable for crane use.

The resulting changes in channel shape would also change the geometry and hydraulics of the channel. To account for these changes, the model was mathematically modified by Dave Carlson of the Fish and Wildlife Service. Dave assumed that the Program would restore habitat at newly acquired sites to have wide channels that resemble sites that have greater whooping crane use. This results in a second, modified habitat/flow function.

The new habitat function is combined with the hydrology for an alternative using the same procedures explained above. The habitat evaluation that includes the effect of both channel shape changes and flow changes can then be compared with the effects of flow changes alone, and to the reference conditions.

<u>5.6.8 Daily_Flow_Comparison_Tool</u>

The Daily_Flow_Comparison_Tool.xls spreadsheet graphs twelve month of daily flow data for up to six of the 19 locations at which this is calculated by the CPR Model.   The six user-selected locations are graphed for both the reference condition and the alternative being analyzed. This allows daily flows form two model runs to be visually compared. Any twelve-month period can between January 1, 1948 and December 31, 1994 can be graphed.

<u>5.6.9 DailyFlowAnalysis.xls</u>

The DailyFlowAnalysis.xls spreadsheet analyzes the daily flows calculated by the CPR Model for any of the 19 flow locations and creates graphs and tables using these daily flow data. The daily flow characteristics of the modeled alternative are compared to the reference condition. The graphs and tables illustrate/compare such flow characteristics as annual flow volumes, annual peaks, annual minimum flows, flow magnitudes at different exceedence frequencies, etc.

<u>5.6.10 DailyFlowExeedanceGraphs.xls</u>

The DailyFlowExceedanceGraphs.xls spreadsheet creates daily flow magnitude vs. exceedance frequency curves for each month and annually for any of the 19 flow locations calculated by the CPR Model. Daily flows are sorted from highest to lowest in the “Data” sheet prior to graphing. The results for an alternative are compared to the daily flows for the reference condition run. In addition, mean daily flows are graphed separately for each of the 12 months for the entire modeled period illustrating both the modeled alternative and reference condition

<u>5.6.11 DailyFlowsByBridgeSegment.xls</u>

The DailyFlowsByBridgeSegment.xls spreadsheet calculates the daily flows for intermediate points between gage locations in the CPR Model. These intermediate flows are necessary for use in the Sed/Veg model developed by the U.S. Bureau of Reclamation (Murphy et al., 2006), which requires daily flow estimates for at least 17 specific Platte River transect locations to model daily effects on sediment transport, vegetative growth and demise, and channel morphology.

5.6.12 MonthlyFlowGraphing.xls

The MonthlyFlowGraphing.xls spreadsheet allows the user to view data from three model runs and two OPSTUDY model outputs. The outputs are graphed by month so all January values are shown on a single graph, all February values are on a single graph, etc. through all December values on a single graph. For example, Present Conditions plus two alternatives can be viewed by the spreadsheet. The user could select flow in the Platte River at Overton and Grand Island. The result would be twelve graphs (one for each month) with four to six lines (depends on the number of alternatives graphed) comparing monthly flows in the Platte River at Overton and Grand Island.

5.6.13 MonthlyValueComparison.xls

The MonthlyValueComparison.xls spreadsheet graphs the average monthly flow for the twelve months of the year depending on the hydrologic condition. The user has the ability to graph up to five flow locations. These are the South Platte River at North Platte, the North Platte River at North Platte, the Platte River at Cozad, the Platte River at Overton, and the Platte River at Grand Island. The user can graph either the Present Condition or an alternative or both for each of the five locations.

5.6.14 OvertonPeakFlows.xls

The OvertonPeakFlows.xls spreadsheet produces five graphs that compare daily flows (mean daily flows calculated by the OPSTUDY model) at Overton for two model runs (both model runs are depicted on each graph). The two model runs are Present Condition (Reference) and an alternative. The graphs produced are a flow-duration (exceedance) graph of annual peak daily flow; annual maximum peak daily flow with a ten year running average of the annual maximum peak daily flow; a flow-duration (exceedance) graph of May peak daily flow with that portion of the peak flow for the alternative provided from EA releases distinguihed from other flows; May maximum peak daily flow with a ten year running average of the May maximum peak daily flow; and a flow-duration (exceedance) graph of the February through June peak daily flow.

5.6.15 HistoricScore.xls

The HistoricScore.xls spreadsheet calculates the score of an alternative when the flows are compared to historic flows. The 400,000+ acre-feet of shortage that was calculated by the Fish and Wildlife Service (FWS) used the FWS flow recommendations and historic flows. The HistoricScore.xls spreadsheet recreates this analysis using both changes that have occurred between historic and Present Conditions and changes between historic and the alternative (expected conditions). The score calculates is a “raw” score without any of the adjustments that are made to get the score for the Program. In this respect, HistoricScore.xls underestimates the actual score of an alternative. HistoricScore.xls also graphs the monthly flow (cfs) flow-duration (exceedance) by month for historic, Present Condition, and expected condition (alternative) flows. The graphs also contain the FWS flow recommendations (including pulse flows).

5.6.16 Sdfoutput.xls

The sdfoutput.xls spreadsheet contains the output from the SDF View program. The output is in columns A through O and ends on row 311 (A1:O311). The output is summarized in a table in cels S1 to AF18 (S1:AF18). This summary is used in the Hydrology Appendix to show the effects of the Colorado's ground water recharge activities (commonly called the Tamarack Project) on flows at Julesburg.

5.6.17 PulseFlowAnalysis.xls

The PulseFlowAnalysis.xls spreadsheet calculates the average amount of EA water at Overton during a short-duration near-bankfull event. This value is higher than could be expected as losses are not included in the daily flow section of the OPSTUDY model.

5.6.18 PulseFlowHistory.xls

The PulseFlowHistory.xls spreadsheet contains the information from the *.pul file that is produced by the OPSTUDY model. The information is daily flows and short-duration near-bankfull flows for all locations for which daily flows are calculated.

5.7 COMMON RUN-TIME ERRORS & TROUBLESHOOTING

Problem: Pressing the "Open Linked Spreadsheets" button (Step 1) returns an error window with this message:

Run-time error '1004'
`C:\Opstudy\Tools\Gains_inh.xls` could not be found

Explanation: The macro invoked by this button cannot find the first Excel spreadsheet sought (Gains_inh.xls) under the expected directory. Most likely, the default path under which to search for the OPSTUDY directory has not been set to the correct path. In the above example, the OPSTUDY directory is presumed to be located directly under the C: drive. Instead, it may be necessary to specify something like "C:\Program Files\" in the corresponding spreadsheet cell above the "Open Linked Spreadsheets" button.

Problem: Pressing the Step 2 button returns an error window with this message:

Run-time error ‘53'
File not found

Explanation: The modeled alternative is being run as a ‘reference’ model run instead of being run against the reference as an ‘alternative’, or the corresponding .inp file has not been created.

Problem: Pressing the Step 5 button returns an error window with this message:

Run-time error ‘1004'
`sdfoutput.out` could not be found

Explanation: The file sdfoutput.out is supposed to be generated by Step 4, and placed under the \Tools directory. This message suggests that such a file was not generated and saved in Step 4. This is probably the result of not following the correct steps in Step 4, as described in Section 5.1.

Problem: Expected files cannot be found by the program.

Possible Explanation: Files are not located in the expected directories. For example, the files may be under a test directory called \OpcodeTest rather than \Opcode, where the program looks for them. See Section 1.6.3 for a discussion of where OPSTUDY expects to find specific files.

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GLOSSARY

Acre-foot

The volume of water equivalent to covering one acre one foot deep.
One acre-foot (AF) is equivalent to 43,560 cubic feet or 325,850 gallons.

Cooperative Agreement

An agreement signed by the Department of Interior and the states of Colorado, Nebraska, and Wyoming in July 1997 to pursue a basin-wide, cooperative effort to improve and maintain habitat for the target species that use the Platte River in Nebraska.

cfs

Cubic feet per second (ft^3/sec), a commonly-used unit for expressing the rate of flow in a stream, canal, or other conduit.

CNPPID

Central Nebraska Public Power and Irrigation District (also known as "Central").

EA

Environmental Account. This is an account of water stored in Lake McConaughy or other approved storage facilities which is available for release by U.S. Fish & Wildlife Service for environmental purposes.

EAC

Environmental Account Committee. This committee was established by the 1997 Cooperative Agreement "to work with and provide guidance to the EA Manager."

EIS (FEIS)

Environmental Impact Statement (Final Environmental Impact Statement).

EOMC

End-of-month content (e.g., in Lake McConaughy).

ETO

Excess-to-ownership account.

ET

Evapotranspiration.

FERC

Federal Energy Regulatory Commission.

FORTRAN

A high-level computer programming language originally developed for scientific and engineering computing applications. FORTRAN is a contraction of Formula Translator.

FWS

U.S. Fish and Wildlife Service.

IDSG

Integrated Decision Support Group (at Colorado State University).

KAF

Thousand acre-feet.

KMwH

Thousand megawatt-hours.

Mass Balance

Model conditions under which it is verified that no water is "created" or "destroyed" by the model. A mass-balance check in the CPR Model ensures that total inflow is equal to total outflow and losses (plus changes in storage, if any) for any modeled element or set of elements.

Megawatt

One million watts of electrical power.

MSL

Elevation relative to mean sea level.

Nebraska Plan

The State of Nebraska's plan for addressing future depletions to Platte River flows.

NPPD

Nebraska Public Power District

Pulse Flows

Elevated flows for periods of a few to 30 days recommended by the U.S. Fish & Wildlife Service for the Central Platte River habitat reach in February-March and in May-June. Together with other flows during these natural periods of elevated runoff, pulse flows are expected to serve multiple functions in helping to maintain and/or restore important ecosystem functions supportive of the target species.

Short-Duration Near-Bankfull Flows

Flows of approximately 1- to 3-days duration with magnitudes approaching but not exceeding bankfull channel capacity through the Central Platte River habitat reach. These flows, in the opinion of the U.S. Fish & Wildlife Service, ideally would occur on an annual or near-annual basis. Together with other land and water measures, these would be implemented as part of a Recovery Program to test their ability to scour and/or bury vegetation encroaching on Program channel areas, and to mobilize sand and build ephemeral sandbars which benefit nesting target species.

Stream Depletion Factor (SDF)

By definition, SDF is a^2S/T, where *a* is the distance from the pumped well to the stream, *S* is the specific yield of the aquifer, and *T* is the aquifer transmissivity. SDF has the dimensions of time. It is equivalent to the time from the beginning of steady pumping from (recharge to) an alluvial aquifer within which the volume of stream depletion (accretion) is 28 percent of the volume pumped (recharged). Stream depletion factors are used to estimate the rate, volume, and timing of stream depletions or accretions associated with well pumping or recharge in hydraulically connected alluvial aquifers.

SWA

State Wildlife Area.

Target flows

Minimum flow recommendations proposed by the U.S. Fish & Wildlife Service for the Central Platte River habitat reach. These targets are defined based on the time of year (e.g., February 1 through March 22), and on hydrologic conditions in the basin ("wet", "normal", or "dry").

USBR

U.S. Bureau of Reclamation.

Water year

Typically defined by the U.S. Geological Survey and most other water resource agencies as October 1 through September 30, and defined this way for this document. The water year is designated by the terminating calendar year, for example: "Water Year 1950" corresponds to October 1, 1949 through September 30, 1950.