NEBRASKA

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DEPT. OF NATURAL RESOURCES

Pete Ricketts, Governor

DATE: February 13, 2018

TO: Prospective Engineering Consultants

FROM: Jennifer J. Schellpeper, Division Supervisor for Water Planning, Nebraska Department of Natural Resources

SUBJECT: Request for Qualifications – DEVELOPMENT OF A PLATTE RIVER BASIN DECISION SUPPORT SYSTEM

On behalf of the State of Nebraska's *Department of Natural Resources – Water Planning Division (NeDNR),* we are requesting submissions of qualifications for engineering services for the development of a Platte River Basin decision support system. A detailed description of the preliminary work plan (scope of work) for the project is enclosed with this letter.

Engineering consultant firms will approach this project in any manner they see appropriate, provided they address the core requirements identified in the scope of work. Engineering consultant firms may team up as desired to cover all needed expertise, but the submission must come from a single firm.

The following shall be included in the submission:

A. Background and Qualifications (20 points):
- History of firm or firms.
- Size, organization and location of firm.

B. Approach to the Proposed Project (50 points):
- Proposed Project Team and Team Qualifications. Discuss the qualifications and scope of services to be provided by each team member.
    i. Sub-consultants proposed for the Project Team and their qualifications. Discuss the qualifications and scope of services to be provided by each team member for the sub-consultant.
    ii. Project management approach.
    iii. Quality Assurance/Quality Control approach.

C. Related Experience (30 points):
- Related project experience, specifically experience related to surface water permitting, operations of key water related diversions in the Platte River Basin, hydrologic and

Gordon W. "Jeff" Fassett, P.E., Director

Department of Natural Resources

301 Centennial Mall South
P.O. Box 94676
Lincoln, Nebraska 68509

OFFICE 402-471-2363
FAX 402-471-2900

dnr.nebraska.gov

hydraulic studies, modeling and available data to support the project, data integration and user interface development, Platte River Basin water operations and existing conditions, economic valuations of water, geographic information systems (GIS), and other information that may be necessary for project completion.

- Discuss your team's approach to working with NeDNR while satisfying the requirements of the project. The consultant(s), and sub-consultants, should provide references and be able to demonstrate that they successfully completed recent, similar projects on time and within budget.

D. Workload (10 points):

- Current and projected workload for the firm.
- Past, present and upcoming projects for agencies of the State of Nebraska.

E. Other Relevant Information (10 points):

- Include any other information about your firm, or about the project, that you feel is relevant to the project and the Selection Committee.
- Explain any other factors that make your consultant team uniquely qualified to provide professional services for this project

F. Submittal Requirements:

Seven copies of your submission will be required. No cost submittal is required, however hourly rates for all members of your project team should be made available with the submission. **To be eligible for work on this project the contracting firm must be on the current registered list of Consultants with Open Ended Contracts 2017-2021 maintained by the Department of Administrative Services (DAS)**. Please limit the text portion of your submittal to no more than 15 pages. Submissions will be accepted until 4:00 PM, Friday, March 16th, 2018 at the following location:

Jennifer J. Schellpeper, Water Planning Division Supervisor
Department of Natural Resources
301 Centennial Mall South, 4th floor
PO Box 94676,
Lincoln, NE 68509-4676

A selection committee will evaluate all responses. A minimum of two firms will be selected to be interviewed about their qualifications. Interviews will be conducted at the Department of Natural Resources on Thursday March 29th, 2018. Each selected firm will contacted to attend an interview at NeDNR offices in Lincoln, NE. Firms that are not selected for interviews will be informed in writing of the selection committee's decision.

All questions related to this request must be submitted in writing and directed to Jennifer Schellpeper (Jennifer.schellpeper@nebraska.gov) prior to March 9, 2018.

Enclosure

Task 4: Detailed Work Plan for

Platte River Basin Decision Support System

Oct. 31, 2017 DRAFT

Executive Summary

A decision support system (DSS) for the Platte River Basin will be constructed to provide management and administrative support for a variety of purposes, focusing initially on the use of excess flows for recharge benefits in the portion of the basin between Lake McConaughy and Duncan, but expanding to meet the needs of other objectives. The DSS will follow the standard structure of a DSS, including the use of data management and model management subsystems, and a user-friendly graphical user interface (GUI). All elements of the DSS will be developed with the purpose of supporting the decision-making efforts of water managers, rather than serving as a substitute for them, while encouraging DSS users to look “under the hood” at the model structure and analytical processes involved, rather than viewing the DSS as a black box. The DSS will be designed in a way that not only helps with decision-making efforts, but also enables those decisions to be implemented in the real world, providing concrete recommendations that can be put into practice given existing legal and institutional constraints.

The primary objectives identified for the DSS primarily involve water regulation and allocation, and involve modeling, forecasting, and economic evaluations. To achieve these objectives, a phased approach is proposed, consisting of a Phase I excess flow recharge analysis of new water supplies, a Phase II analysis of the transfer and modification of existing water supplies, and a Phase III involving continuous refinements, updates, and enhancements to the DSS structure. The DSS is also broken down into three geographic regions, including an Upper Platte portion upstream of Lake McConaughy (including the South Platte Basin), a Central Platte portion from Lake McConaughy to Duncan, and a Lower Platte Basin below Duncan (including the Loup and Elkhorn basins). This phased and modular approach will allow for the DSS to be developed incrementally, building on the experiences gained during previous steps and within other locations, and promoting constant improvements to the overall structure.

Seven “DSS Components” have been identified to serve as the foundation for the DSS structure, including a surface water routing and water right platform, a representation of groundwater impacts, an economic evaluation framework, a data management subsystem, a model management subsystem, an intuitive GUI, and elements to support decision implementation. These components will work together, using a 50-year time horizon, to determine actionable recommendations based on a user-defined set of evaluation criteria, supporting decision-making on both a local and basin-wide level.

Introduction and Background

In recent years the development of a decision support system for the Platte River Basin has been suggested – at least in part – as a way to meet several important water management objectives. For one, there is a desire to more fully utilize and integrate the many existing analytical procedures, models and tools created and/or used by NeDNR, and to better incorporate the results of those efforts in supporting actual decision-making processes. There is also an interest in looking beyond local or site-specific impacts and benefits associated with certain projects and actions, to instead consider how a region, or the Basin as a whole, might be affected.

A Platte River DSS could also be useful in helping to answer two general forms of questions that often arise during water planning discussions in the Basin: what should be done now, and what actions might be best for the future? The first question suggests the need for some form of real-time tool, capable of producing up-to-date analyses of present conditions and developing recommendations of immediate actions in response. The second question could require the development of scenario evaluations, where multiple arrays of hypothetical future conditions are used to derive alternatives that can be used to estimate the costs and benefits of actions over many years. Fortunately, decision support systems are well suited to address both forms of questions, and they need not be considered in isolation. In fact, a well-designed DSS will bridge the gap between these two approaches, offering options that address both immediate needs and future water management objectives together.

With these needs in mind, NeDNR staff worked with consultants to develop a list of key objectives for the Platte River DSS, spanning a variety of topics and management approaches. These objectives are described more thoroughly in later sections of this document, but are highlighted here as well:

- Excess Flow Recharge Analysis
- Water Administration
- Permit Evaluations
- Forecasting Tools
- Economic Impacts
- Groundwater Modeling
- Traceable Records of Water Operations
- Evaluating Allowable Water Use Development
- Support with Water Sustainability Fund Applications
- Flood Management

Many of these objectives were identified as being likely components of the first listed objective, the Excess Flow Recharge Analysis, and were considered as key objectives with respect to the first phase of DSS development, as described later. The last two bulleted objectives, concerning the Water Sustainability Fund project evaluation and flood management, were identified as lower in priority with respect to the initial phases of the project.

Several process improvements would be expected upon DSS completion. The DSS should provide quantitative and scientifically-based procedures to inform and support management decisions made by NeDNR staff as part of their administrative responsibilities. These processes should be reproducible, and straightforward enough to be replicated by outside groups and individuals with a basic technical level of expertise in water resources management. The DSS should also provide an ability to represent and estimate Basinwide benefits associated with alternative management actions.

To help govern the different relationships between the key tools and datasets used by the DSS, a basic structure is proposed involving seven "DSS Components", which function together under a classic DSS hierarchy. Surface water and groundwater tools, along with a basic economic analysis framework, would all work within a model management system, receiving input from and sending output to a data management system. The results of the model run would be organized and displayed via a user interface, which would in turn allow direct feedback from the DSS user. Together, these DSS Components would provide a streamlined and powerful tool for water managers to evaluate different management alternatives and options using a scientifically-based and replicable set of analytical processes.

The DSS would also be designed to integrate all of its elements in a way that would support actual decision-making processes, in a format that would suggest concrete management actions. By considering multiple scenarios, and weighing the costs and benefits associated with each, the DSS user would be presented with a detailed analysis of various potential actions which, in conjunction with established evaluation criteria, would provide scientifically sound and, in some cases, real-time, decision support. All of these features would be made easily accessible and understandable through an intuitive GUI, displaying all the key output and results needed to inform decision-making. These capabilities would be used to enhance, and not replace, the skills and capabilities of water managers, allowing them to make better-informed choices based on the best available and scientifically-based information.

Objectives of the DSS

In developing any DSS, one of the most important initial steps is to identify the functional requirements of the system itself[1]. NeDNR staff worked with a consultant over the course of several meetings/workshops to develop and refine a list of objectives that could be a part of a new DSS. Preliminary discussions were organized more as brainstorming sessions, while later meetings worked to prioritize and refine the initial list of objectives.

For the initial discussions, the list of objectives was not limited to any specific geographic subarea of the Platte River Basin or any predefined form of water management. However, it quickly became clear that most of the initial objectives identified by NeDNR staff did share certain common attributes. On a very general level, integrated water resources management can be separated into two broad forms of decision making: emergency water management, and water regulation and allocation. While some elements of flood management did come up, the vast majority of identified objectives fell into the water regulation and allocation category, as shown in the list of objectives below:

- **Water Administration** – a DSS could be used to help with day-to-day water administration, potentially linking with elements of the Platte Water Accounting Program (PWAP), and could consider impacts to instream flows and target flows.
- **Permit Evaluations** – this broad objective could include many processes under a DSS, including determining historic consumptive use, evaluating the amount of unappropriated water, and considering the impacts to water rights within geographic reaches affected by the new water right. Elements of the DSS could link with new tools being developed by NGPC for negative impact evaluations associated with new domestic permits, and could help with groundwater recharge permits in estimating well drawdowns and cones of depression. The net effect of storage and storage use permit combinations could also be considered.
- **Forecasting Tools** – predictive components could be used with many other processes, including excess flow analyses and permitting for recharge projects, developing hydrograph predictions, and in flood management efforts. Forecasting could also be used alongside other water administration components, to predict when recharge activities might be optimal.
- **Economic Impacts** – a DSS could be used to help determine the value of water when it is used for various purposes. While economic evaluations could include the use of cost/benefit ratios, lowest bidder concepts, and much more elaborate methods for

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[1] This document draws extensively from a report by SEPIC (Support to Enhance Privatization, Investment, and Competitiveness in the Water Sector of the Romanian Economy), titled "International Survey of Decision Support Systems for Integrated Water Management", Submitted to U.S. Agency for International Development/Romania, August 2004.

estimating project costs and benefits, NeDNR staff recommended that only “first tier” economic impact procedures be used for this initial effort.

- **Groundwater Modeling** – groundwater models including COHYST, the Western Water Use model (WWUM), and others could be integrated with a DSS, providing a more user-friendly interface to develop model input and evaluate model output. The DSS could also serve as a platform to connect groundwater models with other types of tools and models.
- **Traceable Records of Water Operations** – initially, it was suggested that the new DSS could be used to assist NeDNR with its current efforts in setting up a traceable record of when openings and closings occur during water administration. Later it was determined that NeDNR already has a good in-house process for this purpose – namely the Noticing Database. While a new DSS likely would not require the development of a new tool for this objective, the DSS could be linked to the existing NeDNR systems to inform the DSS and enhance its capabilities. It may also be possible to provide additional linkages between the DSS and other in-house NeDNR processes, perhaps via the WISKI data management system, to allow the DSS to provide more detailed and accurate records of water operations.

Besides mainly falling under the area of water regulation and allocation, these first objectives were also identified as necessary components for any evaluation of excess flow recharge potential. Early in the process of discussions, NeDNR indicated a desire to consider how a new DSS could be used to support ongoing efforts within the Department to evaluate potential recharge projects, taking advantage of excess flows during the off-season portion of the year and providing retimed accretions to benefit downstream flow needs such as instream flow requirements. As shown in the list above, most of the early identified objectives would be necessary elements for that type of excess flow recharge analysis. It is, however, important to note that this list of objectives is not solely relevant to the excess flow issue, since the objectives may be important to other conjunctive management projects and water management efforts.

Additional objectives were identified beyond those listed above. These objectives are listed separately here to differentiate them from the larger objective list, and could be developed as part of separate efforts outside of the primary DSS structure.

- **Evaluating Allowable Water Use Development** – In certain parts of the State, including portions of the Lower Platte River Basin, Natural Resources Districts are considering allowing additional water use development (mainly via groundwater irrigation wells) beyond currently restricted levels. A DSS could be used to help water managers to determine the allowable amount, location, and other specifications on future development using an objective set of criteria that could appeal to calls for equity and consistency in the process.
- **Support with Water Sustainability Fund Applications** – the Water Sustainability Fund application process includes a defined list of requirements and information needs that

must be provided by the applicant. A DSS could be constructed to seamlessly identify and organize information needs into a format that could be directly used in application responses. This could include projections as to the benefits the project may produce that would meet some of the goals and objectives established for the Water Sustainability Fund.

- **Flood Management** – while flood management falls more under the category of emergency water management, instead of water regulation and allocation, DSS platforms have been established to manage flooding conditions, and this could also be done in parts of the Platte River Basin. Flood management usually works under a shorter time step than other processes, and often requires more two-dimensional information than other areas. The flood management objective has been grouped under the list of objectives that are less applicable to the primary focus of this DSS, but it is possible that basic elements, such as simplified ratings curves to establish estimated flood stage under various flow regimes, could be incorporated as a part of the DSS development.

As mentioned earlier, the focus of DSS discussions quickly turned to the Excess Flow Recharge Analysis, specifically for the area below Lake McConaughy. While this continues to be the focus of the Platte DSS efforts, there is also an interest in expanding both the geographic area and the potential applications of the DSS once the initial development is completed. To meet this need, a **phased approach, involving multiple geographic scopes** is recommended, using the following process:

- **Phase I = Excess Flow Recharge Analysis**. This first phase would center on the identification and use of excess water supplies not currently needed to support existing water uses. Recharge activities through non-irrigation season canal diversions would be central to this phase.
- **Phase II = Transfers of Existing Water Supplies**. This second phase would focus on the movement and modification of existing water supplies between different locations, types, and uses. This may include conjunctive management projects and the use of innovative and non-traditional transfers.
- **Phase III = Integration and Maintenance**. This third phase would involve the continued integration of new and enhanced capabilities within the DSS, along with maintenance of the various DSS components and models to ensure they continue to operate as data inputs and process requirements change and evolve. The analytical tools that are part of the DSS would also increase in precision as the project proceeds. This phase may also consider some of the objectives identified earlier that do not factor into either of the previous phases, such as supporting Water Sustainability Fund applications or supporting flood management efforts. The timing of this phase may also match well with the Platte Program's potential time extension.

The three geographic regions under consideration are outlined here:

- **Central Platte** = McConaughy to Duncan reach
- **Upper Platte** = Upstream of McConaughy, and South Platte Basin
- **Lower Platte** = Below Duncan, including Loup and Elkhorn Basins

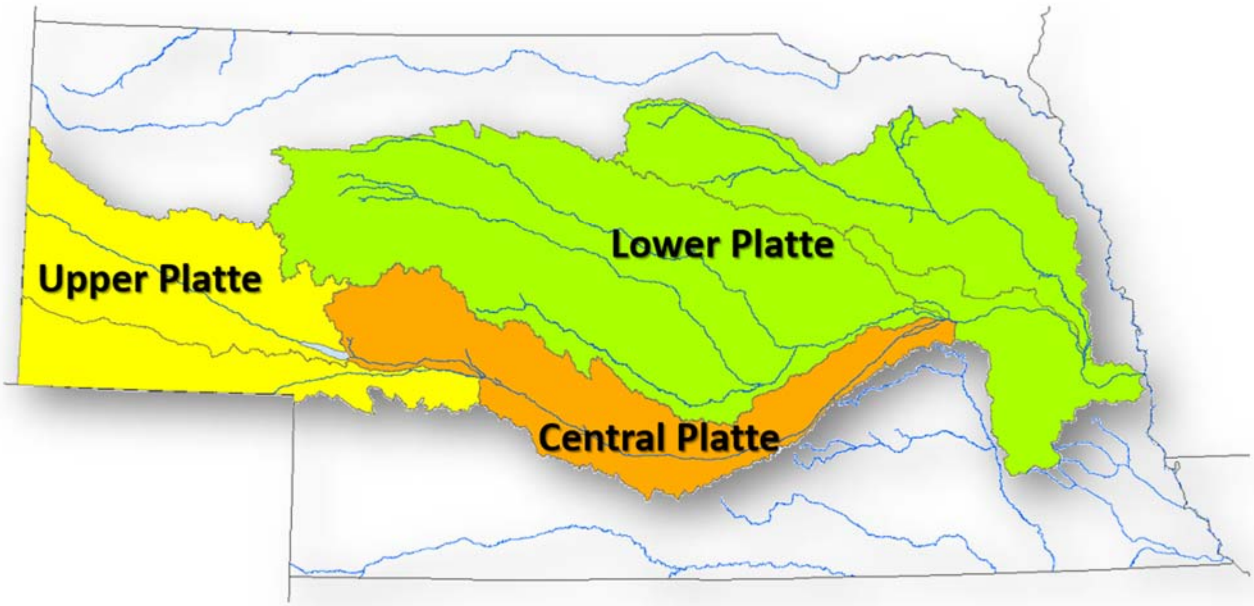

Figure 1: Geographic Regions for Platte DSS

A more complete explanation of the phased approach, and how the different geographic regions will be included, is contained in the Implementation Process section later in this document.

The objectives of the DSS help to determine what particular tools are needed to answer the types of questions that arise during the process of trying to meet those same objectives, but the general framework of a DSS is usually along the lines of the format shown in Figure 2. Data measurement, data processing, analysis (aka modeling), decision making, and decision implementation normally make up the framework for the cyclical processes that take place in a DSS.

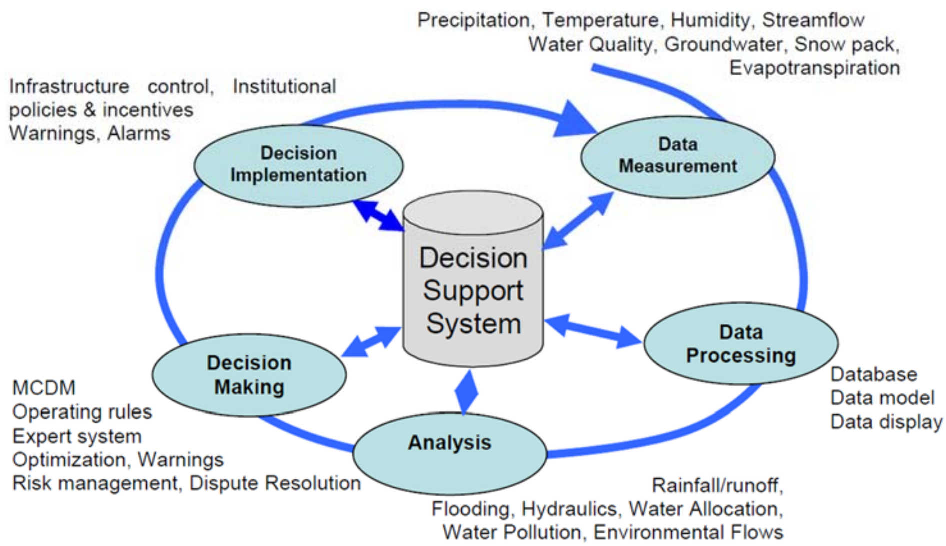

Figure 2: General Framework of a Water Resources Decision Support System (Source: SEPIC 2004)

What makes each water resources DSS unique is the choice of elements that comprise each of these steps, such as the lineup of models required to conduct the analysis efforts. These choices help define the linkages between the questions posed through the DSS and the information, datasets, and hydrologic tools and models employed to answer those questions. For Phase I, seven "DSS Components" have been identified to provide the necessary DSS linkages:

1. Surface Water Routing and Water Right Platform
2. Groundwater Impact Representation
3. Economic Framework
4. Data Management Subsystem
5. Model Management Subsystem
6. User Interface
7. Decision Implementation

These components, and the connections between them, are described in more detail in the Resources and Constraints section, but in general follow the basic flow of processes shown in Figure 2. For example, the first three DSS Components are tools that fall under the "Analysis" representation, the Data Management Subsystem is largely synonymous with the "Data Processing" representation, and the Model Management Subsystem involves the linkages of the "Analysis" tools and the other DSS elements. Together, these components will enable consideration of the primary list of objectives, as described earlier in this document.

Several decisions must be made as to the structure and capabilities of the DSS that will depend on the objectives and the overall purpose of the DSS. These features include the temporal scale, spatial scale, level of precision, and acceptable level of uncertainty:

- **Temporal scale** – for the types of water regulation and allocation problems associated with this DSS, a daily time step, aggregated to seasonal values when needed, should be appropriate. With respect to the overall time horizon, a 50-year time period should be sufficient to assess longer-term recharge benefits, and would be commensurate with other long-term planning horizons.
- **Spatial scale** – as discussed earlier, the initial focus for the Platte DSS is on the region from just downstream of Lake McConaughy to Duncan, Nebraska. Future DSS efforts will then move to the North Platte River Basin upstream of McConaughy (along with the South Platte Basin), and the Lower Platte below Duncan.
- **Level of precision** – for determining the needed level of precision, one of the primary factors with respect to the DSS will involve the canals that play a central role in the Phase I Excess Flow Recharge Analysis. Canal diversions along the Platte system are normally on the order of tens to a few hundred cfs, with total diverted quantities likely on the order of a few hundred to a few thousand acre-feet. Since recharge values will be a percentage of diversions, the DSS precision will probably need to be on the order of tens of cfs, or a few hundred acre-feet. For Phase II transfers, similar infrastructure would likely be involved, and comparable levels of precision should be adequate. Ideally, the DSS should have a scalable nature to allow for different levels of required precision depending on the quantity of diversions involved. For example, a higher level of precision will be needed for smaller-scale diversions than for the larger canals.
- **Acceptable level of uncertainty** – this DSS attribute will be driven by hydrologic variability, changes in water use practices and efficiencies, and by other factors. In practice, it likely will parallel level of precision, as discussed above. It may be beneficial to develop an "envelope" of allowable uncertainty in some instances during the use of the DSS to help guide the overall modeling and implementation efforts.

Resources and Constraints

This section describes some of the major resources that will be required to construct the DSS, and also explains how various elements will be connected to work together and provide useful information to the user. In addition, this section discusses various constraints and limitations that will be part of the makeup of the DSS, and how those factors relate to required levels of precision and allowable levels of uncertainty.

One of the first steps in developing a decision support system of any kind involves determining what existing tools are already available to meet the identified objectives, and what new tools may be required. One of two general approaches can then be used to construct a DSS (SEPIC 2004):

1. Stand-alone approach – under this approach, the DSS is developed from scratch, using a closely integrated set of modeling components with a unified data set, without directly using the resources from existing models.
2. Framework approach – in contrast, this approach uses existing tools and models, connected via an interface, where the DSS components pass outputs from one element as inputs into another in sequence, under a user-transparent system.

Under Task 2 of this project, a matrix of existing hydrologic tools, datasets, and models was compiled, and each entry was reviewed to determine its effectiveness in supporting the identified objectives. This matrix, included as Attachment A to this document, contains information on how and if each separate tool, dataset, or model could be used to support different parts of the DSS framework (referred to as "DSS Components" in this document), as described further in the following text. Based on the information compiled in this matrix, and on the long history of financial and resource investment that has been made by State and local groups in supporting the existing set of tools, it appears that there is already an extensive list of readily available tools to address all or most of the objectives defined in Phase I, and that a "framework approach", rather than starting from scratch, may be a more cost-efficient and scientifically justified approach for the overall DSS structure.

Required DSS Components

Certain features have been identified as necessary to fulfill the primary objectives of the Platte DSS. These "DSS Components" include seven primary features, outlined below. Following this section is a separate section titled "Recommended Additional Tools, Linkages, or Modifications to Existing Tools", which includes recommendations as to what tools and general approaches might work best for each of the seven DSS Components. Figure 3 shows the simplified connections between these components, as described further in the text that follows.

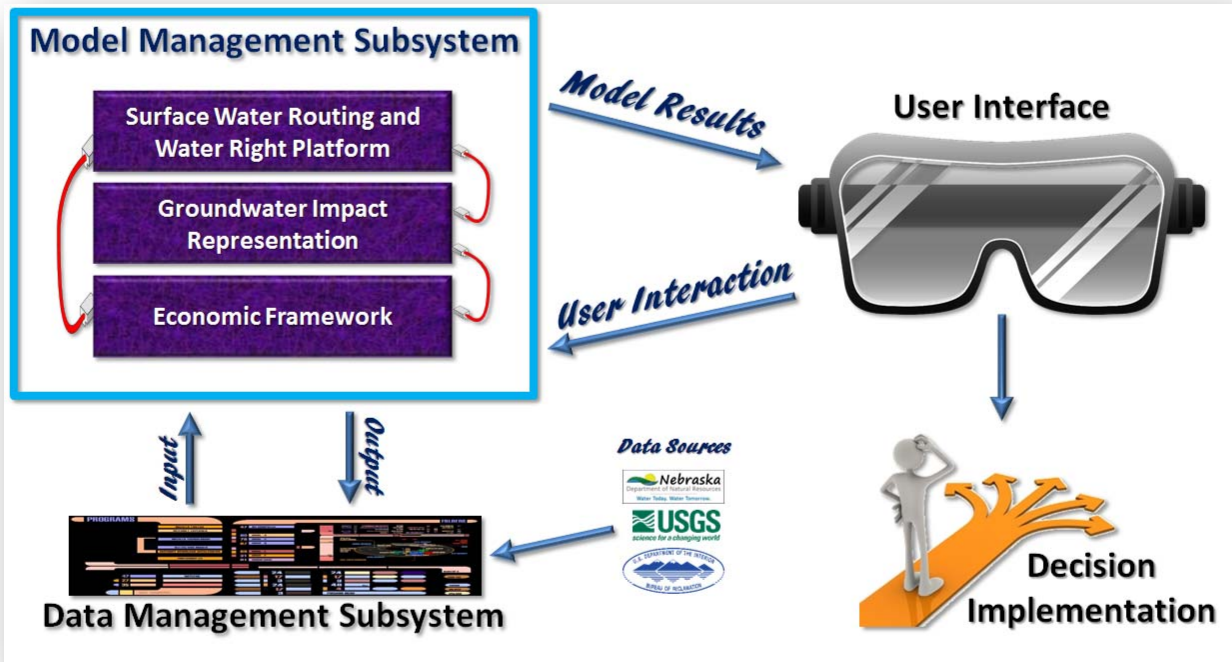

Figure 3: Interaction Between DSS Components

1. **Surface Water Routing and Water Right Platform**

   The Phase I Excess Flow Recharge Analysis involves evaluating existing irrigation canals within the central portion of the Platte River Basin, to determine the benefits over time of diverting non-irrigation season flows for delayed recharge to the river. Because this evaluation is focused on elements of the surface water system in this region, some form of surface water routing and water rights representation will be required. A surface water tool will also likely be required for certain forms of transfers under the Phase II efforts. This component will be used to estimate the availability of surface water at various locations, including at key canal diversions, along with any surface water diversions.

   The surface water routing model could take the form of a simple spreadsheet-based representation, such as what was developed to support current Excess Flow studies, or it could use elements of more sophisticated modeling packages, such as the COHYST Stella surface water model. Spatial representations of the surface water system could be created from scratch using platforms such as MODSIM, or any number of off-the-shelf modeling systems, depending on the desired complexity and capabilities of the model structure. In addition, some consideration of appropriative rights is probably necessary to account for potential changes in diversion – including changes for senior water right holders – resulting from altered surface water operations. Existing tools such as NeDNR's Platte Water Accounting Program (PWAP) may be helpful in establishing rules and constraints for the appropriative rights representation, particularly since NeDNR is currently working on modernizing the PWAP model code[2]. Surface water administration could also be simulated using spreadsheet-based approaches, enhancement of the existing COHYST Stella model, or through other modeling systems with built-in water rights representation (assuming those built-in features can accurately represent Nebraska water administration). NeDNR's Notice Tracking platform may also be useful in representing day-to-day water administration. Other sources, such as the two-week planning schedules prepared by CNPPID, may also be beneficial in simulating operational decision-making within the basin.

One particular issue related to the surface water component involves overland runoff, and the need for better quantification of its impacts. There is currently a shortfall in the amount of available data related to overland runoff, including runoff via drains and other surface water features. Because of this deficiency, the Platte DSS project will include a separate task under the development of the surface water routing model, involving a "discovery-phase" effort to better estimate and quantify overland runoff within the Platte Basin. This will culminate under Phase I efforts in the development of a list of recommended actions to address these data deficiencies, which may be implemented during subsequent phases of the Platte DSS project. While the implementation of these actions may fall outside of the direct purview of the DSS efforts, any results and findings from those future overland runoff investigations will be incorporated within the DSS components to improve the accuracy and precision of the various modeling platforms – particularly the surface water model.

In constructing the surface water platform, it would also be beneficial to include a forecasting component, to provide an additional factor for decision makers to weigh when considering management responses. A large number of hydro-climate forecasting tools are available, but a few have already been adapted for use in the Platte River Basin. These include the PRRIP Periodic Hydrologic Condition Designations and the PRRIP Dewberry Hydro-Climate Indices, along with the U.S. Bureau of Reclamation's April to July runoff forecasts. These tools could be incorporated into the Platte DSS to serve as additional resources for decision makers, and could even be used to derive 7-day hydrograph predictions at certain points along stream network, possibly using the methodology currently associated with baseflow recession curve analysis in conjunction with NeRain data sources.

[2] This modernization process involves updating of the model code only, and does not currently include any changes to the logic of the PWAP structure itself.

Key data for the surface water model will include streamflow records from NeDNR and USGS, canal diversions from NeDNR (including beginning and end dates for irrigation season and, if known, for recharge season), canal capacities, and perhaps some reservoir and canal data from CNPPID and NPPD. Historical administrative records from NeDNR may also help support the administrative rights representation if required.

2. **Groundwater Impact Representation**

Just as the surface water component will be critical for efforts under the Platte DSS, groundwater impact representation will also be essential to estimate the changes to baseflow resulting from modified canal operations, as well as the timing of those baseflow changes, and baseflow changes from alterations in groundwater pumping or any other management scenarios affecting aquifer conditions. The COHYST Groundwater Model is an existing model which spans the geographic range of the Central Platte region, along with portions of the Upper Platte and Lower Platte regions, as those areas are defined by this project. Similarly, the Western Water Use Groundwater Model (WWUM) and Upper Niobrara-White (UNW) Groundwater Model, along with the Central Nebraska (CNEB) Model, Big Blue Groundwater Model (BBM), and Lower Platte Missouri Tributaries Groundwater Models (LPMT), cover portions of the Upper Platte and Lower Platte regions, respectively. Together these models, as highlighted in Figure 3, represent the state-of-the-art groundwater tools currently being used by various agencies and organizations for a number of different programs and purposes in the Platte River Basin.

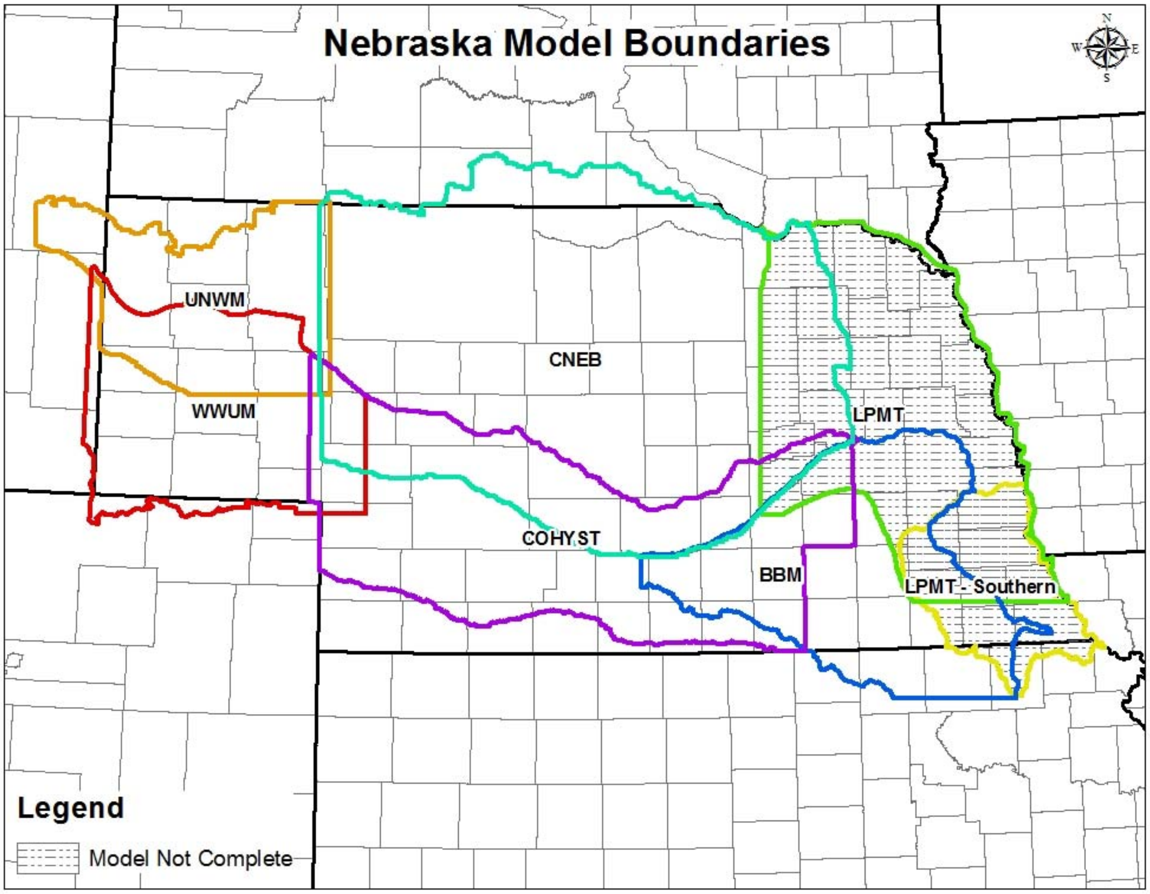

Figure 4: Nebraska Model Boundaries

For the Phase I Flow Recharge Analysis, as well as Phase II Water Transfer efforts, full utilization of these groundwater models may not be necessary, but the tools could be used to develop more basic response or unit functions to link the surface water and groundwater systems, as has been done in certain parts of the Platte River Basin to create SDF maps.

Key data for the groundwater models will include information on aquifer properties and recharge estimates. These data are already being used with the COHYST Groundwater Model as well as the other groundwater models in the basin, and should be, as a result, readily available. It should also be noted that the COHYST Watershed Model, which is a subset of the overall COHYST model, could also be used, in conjunction with the COHYST Groundwater Model as well as the COHYST Stella Surface Water Model, to provide information on the soil water balance as needed to determine impacts from modified surface water operations. Several of the other models in the basin similarly include soil water balance capabilities.

As with the surface water routing and water right platform, the groundwater models may also benefit by including a forecasting component, predicting future aquifer conditions based on past and current hydrological conditions. These forecasts could be linked with predicted weather patterns, surface water flows, canal diversions, recharge operations, and other factors.

3. Economic Framework

It is anticipated that some indication of the level of benefit associated with alternative management actions will be important in evaluating the results of Excess Flow Recharge Analysis. A wide variety of approaches are available for this purpose, spanning everything from complex optimization routines to simple lists of physical results. Whenever possible, monetary estimates will be helpful in determining the effectiveness of different management actions, but in some cases dollar estimates will not be available. Other quantitative estimates of benefits, or even qualitative descriptions of positive results from various actions, will also be valuable for these purposes.

One specific existing tool that could be useful for estimating economic impacts is the Water Optimizer program developed by UNL, for analyzing different water management strategies under limited water supplies. A "multi-field" version of Water Optimizer is also available which also allows for evaluation of water transfers and allocation distributions across multiple fields. Water Optimizer could be used to derive basic estimates as to the value of water at certain locations, and under various hydrologic conditions.

Several established economic methods are available for estimating benefits and values associated with in-stream environmental water supplies, which could be applicable to the Phase I efforts. These techniques include hedonic pricing, the Travel Cost Method, and contingent valuation[3]. More sophisticated quantitative economic models known as Input-Output models could also be helpful if there is interest in estimating the interdependencies across different regional economies resulting from changes in outputs of different goods – changes caused by altered access to water supplies. IMPLAN (Impact Analysis for Planning), REMI (Regional Economic Models, Inc.), and REDYN (Regional Dynamics Model) are examples of Input-Output models. Even more comprehensive methodologies such as hydro-economic models could also be employed, although these complex representations would likely be beyond what is necessary for Phase I purposes. Hydro-economic models such as the CALVIN model in California

[3] Examples and definitions of these economic techniques can be found in a variety of sources concerning non-market valuation methods, including the following reference: https://web.stanford.edu/~asahoo/ValuationMethods.pdf

represent hydrologic, engineering, environmental and economic components of water resource systems in a spatially distributed format.

While some of the established economic methods may be useful for evaluating different management options through the DSS, the nature of the Excess Flow Recharge Analysis and the available tools and data will require users to consider some factors that cannot be assigned a monetary value, and some that are difficult even to quantify. Despite these challenges, the DSS should not be blind to factors and benefits just because they do not easily equate to a dollar figure, particularly since some of these factors may be very important to Nebraska water users and water managers. For example, achieving fully appropriated conditions in an NRD may not easily translate to a dollars or dollar per acre-feet estimates, but the benefits to the NRD would be very real, nevertheless. Current activities and programs that are ongoing in the State of Nebraska related to water transfers and water banking (e.g. the CPNRD Water Bank and Water Transfer Program, the PRRIP-CNPPID 2016 Pilot Study, the CPNRD Groundwater Exchange, and the LLNRD Water Transfer Program and associated Water Bank) could provide information related to the value of water in certain situations where alternative economic methods are not applicable. Language within the interbasin transfer statutes could also help in framing economic benefits. Further discussion related to the Economic Framework DSS Component can be found in the section on performance metrics later in this document.

While flood management analysis was identified as an objective that should probably not be included within the Phase I tasks, it might be worthwhile to consider simple flood reduction benefits within the economic framework, perhaps by assigning a simple economic benefit for reductions in flood elevations at certain locations along the river – possibly using a basic lookup table. Existing PRRIP tools used for these purposes might be helpful in devising a simple relationship of that nature.

4. Data Management Subsystem

A DSS such as the one being developed for the Excess Flow Recharge Analysis will require careful management of all data and information, from the retrieval of the input data to export and reporting of model output. All data should be maintained in a single database, with well-defined metadata and a consistent format. Metadata should include information as to the specific site and/or source of information, along with the time of data retrieval and information on any modifications made to the original data set (i.e. data filling for missing data gaps). The structure of the dataset will need to be organized in a way that allows for easy access by the various DSS models, and in the correct format.

By establishing an organized and methodical data management subsystem, it will be much easier to determine the exact input data sources for any given model run, along with the associated output and model results. This will enable runs to be duplicated if necessary in the future to validate previous results, and will ensure consistency in the way that data flows through the DSS processes. Fortunately, the data needs for the Platte DSS will not likely require software or database systems more sophisticated than those that are readily available, and easily constructed. Much of this effort will likely instead be focused on determining the correct formats and procedures for moving data through the system, from retrieval to model output, and maintaining those procedures consistently throughout the various DSS modeling processes. Where possible, it may also be beneficial to take advantage of the formatting and data structure used in NeDNR's WISKI data management system, to allow for easy migration of data from NeDNR sources to the DSS data management subsystem.

5. Model Management Subsystem

Just as the DSS data will need to be carefully managed, the interaction between the different models within the DSS will also need to be skillfully integrated to allow the models to work in coordination. The model management subsystem is closely related to the data management system, but focuses more on how the models work together rather than on the data itself.

For Phases I and II of the Platte DSS, the primary role of the model management system will likely involve the connection between the groundwater and surface water models, as well as any connections with an appropriative water right representation if that component is separate from the surface water model. Depending on the types of models used for the groundwater and surface water representations, there may be issues related to the time steps used by the different components, along with potential differences in geographic extent and other factors. The model management subsystem will ensure that the individual models within the DSS will coordinate with each other, in conjunction with the data management subsystem, to produce accurate and reliable results.

6. User Interface

One of the key features of a contemporary DSS is the user interface, which serves multiple purposes and works as a connective tissue between the different components of the DSS and the user. A well-designed user interface will provide a user-friendly environment where the user can set input parameters, make other adjustments to the model processes (in some cases, as the models are running), and receive feedback and output from the model runs. A user interface should eliminate the need to perform complex procedures on a model-by-model basis, while streamlining the flow of data through the DSS components. Where possible, results should be displayed in simple graphs or figures, in a way that allows for quick implementation of required management actions.

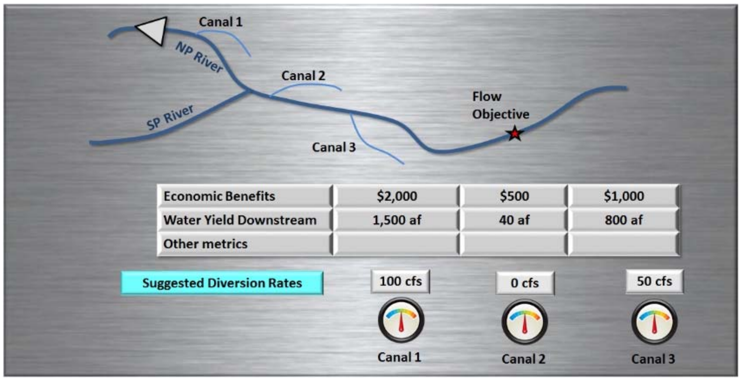

Figure 5: Example Conceptual User Interface

User interfaces, and particularly graphical user interfaces (GUIs), are standard on most off-the-shelf DSS packages today, and are also now easily created using modern programming languages. Some programs such as Stella allow for the creation of user interfaces that are directly connected to the higher-level object-oriented programming that is inherent in those models. The development of a good user interface will require significant feedback from the end user of the DSS to ensure that the information it displays is well-tailored to meet the ultimate needs and objectives of the user. While a well-structured user interface largely eliminates the need to "look under the hood" of the individual model components, an ideal interface will also encourage the user to do just that – by providing clear connections between the user interface elements and the underlying model structure. In this way, the user can take a closer look at the logic used to manage and generate model data and results, respectively, and better understand the way in which the physical and institutional processes are being represented by the model structure. This also helps prevent the DSS from being used as a "black box", by encouraging, rather than discouraging, critical thinking by the user with respect to the model elements and the logic behind them.

As part of the user interface, the DSS could also incorporate a Geographic Information Systems (GIS), to help relate model information spatially via points, lines, and polygons. GIS can be used to provide spatially-related information to the DSS models as model input, and can also be used within the models themselves by identifying geographic relationships between the different decision-making factors. A GIS can be loosely or tightly coupled with the other modeling components of the DSS, depending on the needs of the user. A GIS component may not be necessary for currently planned phases of the Platte DSS, but one readily-available tool that could be integrated with the DSS is the ArcHydro water resources data model, developed by Environmental Systems Research Institute, Inc. (Esri), in collaboration with the University of Texas at Austin. ArcHydro allows for easy exchange of data with independent models attached to ArcHdro using a dynamic linked library. Some off-the-shelf DSS packages include their own built-in GIS capabilities as well, and vary with respect to how tightly coupled those GIS components are with the other modeling tools.

7. **Decision Implementation**
   The basic framework of a generic water resources DSS shown in Figure 2 includes an additional element related to how the output, findings, and suggested responses from the DSS are put into action. Referred to as "Decision Implementation", this DSS component is not directly a part of any of the modeling or data management structure of the DSS, but instead involves how recommended actions from the DSS are carried out in the real world. Institutional policies, the constraints of physical infrastructure, and other real-world challenges must be navigated in order for a DSS to truly serve as an effective water resources management tool. This DSS component also involves the process of continually updating and testing the various tools over time, ensuring that the models and data structure are up to date, and that the processes under the DSS accurately represent the physical and institutional systems on which they are based.

   As the Platte DSS components are continually updated and improved, it will also be important to identify those areas where there are data gaps that limit the accuracy and efficiency of the various modeling routines. Emphasis should be placed on those gaps which have the greatest impact on the uncertainty associated with the different decision-making processes. For instance, there may be some parameters associated with surface water modeling that are not well documented or quantified, but which have little impact in terms of the overall surface water operations. In contrast, other parameters may have better estimates, but because of the sensitivity of surface water decisions to those particular parameters, may still lead to a high degree of uncertainty when there are data deficiencies – even if those deficiencies are small. The Platte DSS should include a structure to address these types of uncertainty by working to fill data gaps and other analytical shortfalls associated with those more sensitive parameters first, before addressing data gaps that have a lesser overall impact. An example of a process to address certain important data gaps is the overland runoff issue discussed in the surface water routing and water right platform section above.

Recommended Additional Tools, Linkages, or Modifications to Existing Tools

As described above, the Platte DSS is anticipated to require seven DSS Components: a surface water routing and water right platform, a groundwater impact representation, an economic framework, a data management subsystem, a model management subsystem, a user interface, and a decision implementation component. The preceding text included options for each of these components, including many existing tools already in use. This section includes recommendations as to where existing tools may be sufficient, and where either new tools or modifications to existing tools may be necessary. It also includes discussion as to the linkages between the different components that may strengthen the DSS capabilities.

With respect to the surface water routing and water right platform, it is likely that a hybrid of sorts could be developed, initially incorporating aspects of the COHYST Stella surface water model, and elements of PWAP to supplement the Stella tool with additional water rights representation as needed[4]. The existing Stella model uses a daily timestep, which is well-suited for representing water administrative actions. Since the existing Stella model includes nodes for each of the canal diversions within the Central Platte region, it should be straightforward to use the Stella model as the backbone for the Phase I Excess Flow Recharge Analysis for that area. It is likely that some elements of the existing Stella surface water model will not be necessary for this effort, and where possible the model could be modified to extract those elements and/or disable them. If it should later be determined, in consultation with NeDNR staff, that the Stella model is too complex for the needs of the Platte DSS, the Stella model could still be used to develop more basic response curves for the critical model nodes, which could then be incorporated into a more simplified spreadsheet representation of the surface water system. A similar approach could be used with surface water modeling in the Upper Platte region, using elements of the WWU surface water model. The Lower Platte region includes fewer surface water structures, and less associated surface water modeling support, and as a result may require the development of a new simple surface water representation as part of the Platte DSS efforts.

For representing groundwater impacts, full utilization of the COHYST Groundwater Model, and the other groundwater models that span the three geographic regions within the Platte DSS, may be unnecessary, as indicated earlier. Instead, the groundwater models, in conjunction with watershed models if needed and if available, could be used to develop simplified unit functions for groundwater impacts that could then be integrated with the surface water representation. Since the groundwater models usually operate on a monthly timestep, whereas surface water models often use daily values, aggregation of the surface water model data will be required if fully-developed groundwater models are used within the DSS.

In the case of the economic DSS component, adoption of one of the more formal and complex methods should not be necessary for Phase I needs, and probably will not be necessary for subsequent phases, unless special needs arise. It is likely to be more beneficial to the user if the DSS includes estimates of quantitative impacts in terms of reductions of target flow deficits, improvements to water supply reliability, and other key metrics. For some of these impacts, it may be possible to derive estimated monetary values using some of the publicly reported values under existing water transfer and banking operations in different parts of the Platte Basin. There may be a few impacts that are difficult to even quantify, but even these can be included –

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[4] The COHYST Stella Surface Water Model is currently being modified to provide new water rights capabilities, which – if incorporated in time for this effort – may remove the need for supplementing the model using PWAP or other tools and sources.

perhaps simply as tabular entries – within the DSS interface to allow for the user to consider those factors when weighing other benefits and impacts resulting from different management scenarios.

With respect to the data management subsystem, an organizational structure can be used to assist with data retrieval and indexing within a simple relational database, which can then be used to generate model input. Virtual basic and/or python scripts should be sufficient to move data between the database and the model structures, and to manage model output for reporting purposes. The database should also allow for archiving of model input, DSS settings, and output, and to allow for verification of earlier runs and easy access to those entries. Overall this step is not anticipated to be overly complex, and should require minimal resources to construct and manage.

The model management subsystem will largely mirror the data management subsystem, and should be relatively simple for the Platte DSS. If specific surface water models are adopted in some form, it should be straightforward to link the various DSS components within that modeling environment, supplemented with script language where needed. A daily timestep is anticipated, and only simulation routines should be required for the models at this point – no optimization is currently anticipated, although future efforts could consider optimization applications. Optimization, using an objective function and associated constraints, can more easily consider social value systems when dealing with water right allocations, but has certain disadvantages compared to simulation modeling as well.

For the user interface, Stella could again serve as the primary platform, as interface capabilities are built-in as part of the software. If additional display representations were desired outside of those available in Stella, a separate interface using Virtual Basic or other similar programming language could easily be used to create additional functionality. The emphasis of the user interface should be on creating a logical environment for decision makers (rather than tailoring to modelers and developers) which can be used to help formulate alternative scenarios and to interpret model results. The information in the interface should also be organized to directly support implementation actions by the users and decision makers. In the case of the Phase I Excess Flow Recharge Analysis, it would be useful to include some form of “real-time” feedback, providing recommendations as to when and how recharge activities would be optimal. Similar capabilities for the Phase II transfer work could also be helpful in determining real-time water management decisions.

With the “Decision Implementation” DSS Component, the processes of identifying and filling data gaps, refining input data and modeling methods, and other activities used to increase precision and accuracy, should all lead to informed, situation-based, decision-making as to what new tools or modifications to existing tools is necessary.

In summary, it is likely that existing tools and datasets will be sufficient for the majority of Phase I tasks, and only relatively minor additions and modifications would likely be required for the

Platte DSS. This would likely be true for future Phase II and Phase III tasks and components as well.

Implementation Process

This section includes information on how the DSS components and resulting output can be used to support the decisional objectives in a way that will have a real, practical benefits to decision makers. Issues related to the project phases and geographic scope, performance metrics used to evaluate model results, and ways to use those results to create productive actions are all discussed in the following text.

Project Phase Overview

The Platte River Basin Decision Support System will be constructed in a phased process, with separate "modules" for the different geographic regions in the basin. A summary of the three phases is included below:

- **Phase I = Excess Flow Recharge Analysis**. This first phase would center on the identification and use of excess water supplies not currently needed to support existing water uses. Recharge activities through non-irrigation season canal diversions would be central to this phase.
- **Phase II = Transfers of Existing Water Supplies**. This second phase would focus on the movement and modification of existing water supplies between different locations, types, and uses. This may include conjunctive management projects and the use of innovative and non-traditional transfers.
- **Phase III = Integration and Maintenance**. This third phase would involve the continued integration of new and enhanced capabilities within the DSS, along with maintenance of the various DSS components and models to ensure they continue to operate as data inputs and process requirements change and evolve. The analytical tools that are part of the DSS would also increase in precision as the project proceeds. This phase may also consider some of the objectives identified earlier that do not factor into either of the previous phases, such as supporting Water Sustainability Fund applications or supporting flood management efforts. The timing of this phase may also match well with the Platte Program's potential time extension.

Phase I: Excess Flow Recharge Analysis

While this workplan covers all three phases of the Platte DSS, Phase I is the focus of this document, and the various objectives and tasks associated with that effort will not be repeated here since they are described in more detail within the applicable sections. Phase I does, however, present certain challenges with respect to the implementation process, since several tasks under Phase I will need to be conducted simultaneously for all three geographic regions, as further described in the "Geographic Scopes" section below. This is because the various modeling platforms, particularly the surface water and groundwater representations, require certain information from the neighboring regions as input. For instance, recharge diversions from canals in the Central Platte region, as determined through the surface water representation for that area, will be dependent in part on canal operations and Lake McConaughy levels in the Upper Platte region. Because of these connections, the construction, calibration, and initial use of the surface and groundwater models will need to be concurrent – at least to some degree – during Phase I.

Phase I efforts will focus initially on the Central Platte region, with concurrent model development in the other two regions as described above. The modeling representations during Phase I in the Upper and Lower Platte regions will not necessarily need to be as extensive as within the Central Platte region initially, since the focus in these two regions during this time will be on providing the necessary information for the Central Platte models. After Phase I efforts within the Central Platte region are complete, the modeling components constructed for the Upper and Lower Platte regions can be refined to produced better results for the investigations focusing on the particular infrastructure and water management issues within their respective boundaries.

Phase II: Transfers of Existing Water Supplies

With respect to Phase II, Transfers of Existing Water Supplies, this subsequent phase will consider potential modifications to current water rights and will develop methods to help decision makers determine the best uses of water within the Platte Basin. These modifications could include transfers of location, changes in use (irrigation, domestic, etc.), and changes in appropriation type (natural-flow appropriation for direct out-of-stream use, storage-use appropriation, etc.). The modifications may also include less traditional forms, including conjunctive management projects relying on the connections between surface water and groundwater supplies.

Both near-term and mid-term needs on the Platte River will be considered under Phase II, and it will also involve developing a test for the level of harm that would result from a given transfer action – including third party impacts. Phase II will also consider the relationship between uncertainty concerning antecedent conditions associated with a given transfer action, and different management actions – including administrative orders requiring augmentation as an offset – that could be used to mitigate for that level of uncertainty. Under that concept, greater levels of management (potentially through permit language) may be required in situations with greater levels of inherent uncertainty.

Phase II tasks could also consider the additional challenges associated with transfers across surface and groundwater divides, providing practical guidance for these sometimes-contentious issues. Statutory requirements for these interbasin transfers are more rigorous, and require additional tests and analyses beyond those used for the more standard water transfers. Transfer analysis in Phase II could also consider whether transfers during periods of water scarcity could actually make a difference downstream (instead of producing only de minimis impacts), and could examine potential feedback loops to storage supplies occurring over multiple years, as a result of certain transfer actions. As with Phase I, forecasting would likely be an important component of the transfer analysis.

To support these additional needs, the DSS Components may need to be expanded, or at least enhanced, beyond the seven identified for Phase I. For example, Phase II analyses will likely focus more on how various existing water rights impact each other than was the case under Phase I. As a result, the surface water routing and water rights platform may need to include a greater number of water rights along the surface water system, and may need greater detail and accuracy in the representation of those various water rights. This may require a more complex surface water routing platform, whether that be through a change in the choice of software or in enhancements to the existing software package. There also may need to be additional/more accurate representations of surface water storage in the routing platform to better enable the potential multi-year feedback loop impacts on storage supplies resulting from water transfers.

Besides the necessary enhancements to the surface water routing and water rights platform under Phase II, the user interface would also need to be changed to consider the new and modified requirements for water transfer analysis. This may include the addition of a more detailed and dynamic surface water system representation, showing more of the canal diversions and storage pools, and differentiating between "new" (after transfer) and "old" (before transfer) water supplies. Phase II may also require greater connections between the different geographic areas included in the DSS, which may impact the timing for implementation. As with Phase I, completion of the Central Platte region's Phase II design may not be fully possible without some level of design work in both the Upper Platte and Lower Platte regions. In addition, projects involving more unconventional conjunctive management components may require unique capabilities within the DSS to allow for better representation of the surface water and groundwater interactions, along with other physical and administrative levels of complexity associated with those more intricate approaches.

The Decision Implementation DSS Component would also likely need enhancement under Phase II, beyond the required capabilities under Phase I. As already described, successfully completing a water transfer requires navigating a variety of institutional and infrastructure requirements that include making sure that the transfer does not have an adverse impact or harm on another water user. Consideration of the consumptive use impacts, return flow impacts, and other factors is critical in conducting a water transfer analysis and must be part of the implementation process.

Phase III: Integration and Maintenance

With respect to Phase III, Integration and Maintenance, this phase would build on the results from Phase I and II, and would focus on enhancing and improving DSS capabilities while ensuring that the various modeling and other support features continue to function into the future, adapting to a changing environment. The precision associated with the various analytical tools that are part of the DSS should also improve, as data, modeling logic, and user experience advances over time. This later step would also place a greater emphasis on building the connections between the different geographic scopes, helping the different modeling tools to more accurately represent the river system and improving the ability of the DSS to estimate basin-wide impacts. In addition, some of the decision objectives determined earlier that are not part of Phase I or II could be added as new components to the DSS during this phase.

For a DSS to continue to be useful and effective into the future, it must be able to adapt with changing conditions. These changes can be both hydrological, such as prolonged droughts or periods of flooding, and institutional, such as changes and updates to Integrated Management Plans (IMPs). Phase III would include tasks to ensure that the DSS Components continue to be applicable to contemporary conditions, by maintaining and improving modeling tools and other DSS processes as needed. In most cases this will likely be possible without constructing new tools or subsystems from scratch, and will instead simply involve improving and updating the capabilities of existing DSS elements, and improving linkages with other outside tools such as NeDNR's INSIGHT system. In other cases, it may be necessary to construct new features within the DSS to allow for a more accurate and precise representation of present conditions and processes.

Changes and additions to the seven DSS Components identified for Phase I efforts will, as a result, likely focus on improvements to the modeling tools and modifications to the representation of the institutional structure and requirements. As input data formats change, and data collection requirements are altered, the DSS must adapt to continue to operate. The DSS could also become more "automated" under Phase III as the users obtain a better understanding of the various processes and relationships that govern water management in the Platte River Basin. This will hopefully include efforts under the Platte River Program, as programmatic extension is currently being considered for another decade or more into the future. All these changes and updates should help to ensure that the DSS remains sustainable under the changing and uncertain conditions of the future.

Phase III could also include addressing some of the objectives identified earlier that would not be part of either Phase I or II efforts. These objectives include supporting Water Sustainability Fund applications and incorporating flood management capabilities within the DSS. As mentioned earlier, the Water Sustainability Fund application process involves a variety of requirements related to project benefits and predicted results, and the Platte DSS could be used to calculate and estimate those impacts and benefits – on both a local and basin-wide level. Flood management capabilities within the DSS could require a more extensive update to the modeling structure as these features would likely require a shorter time step and higher dimensional analysis than the other modeling tools. The extent of the required changes to the DSS for flood routing/analysis would depend on the level of detail and precision required and the geographic extent considered for that effort. Existing tools are already in use by NeDNR and other agencies and organizations for the purpose of flood management, and it may be more practical to simply provide connections between the DSS and these existing tools, rather than creating new flood management tools within the DSS from scratch.

Phase III will also involve extensive use of the “Decision Implementation” DSS Component, identifying those areas with data gaps that negatively impact the accuracy and efficiency of the models. Those data gaps with the greatest impact on the uncertainty associated with DSS decisions should be given top priority. The Platte DSS should be structured to offset these types of uncertainty by filling data gaps and making other analytical improvements during the course of DSS development. By continually identifying the “weakest links” within the DSS structure, uncertainty can be minimized, and limited resources can be most efficiently used to get the most bang for the buck in improving the overall Platte DSS structure.

Geographic Scopes

In addition to the phased process outlined above, the Platte DSS will also divide efforts across the basin geographically, with separate “modules” for each of the three main portions of the basin considered for this effort (see Figures 1 and 6):

- **Central Platte** = McConaughy to Duncan reach
- **Upper Platte** = Upstream of McConaughy, and South Platte Basin
- **Lower Platte** = Below Duncan, including Loup and Elkhorn Basins

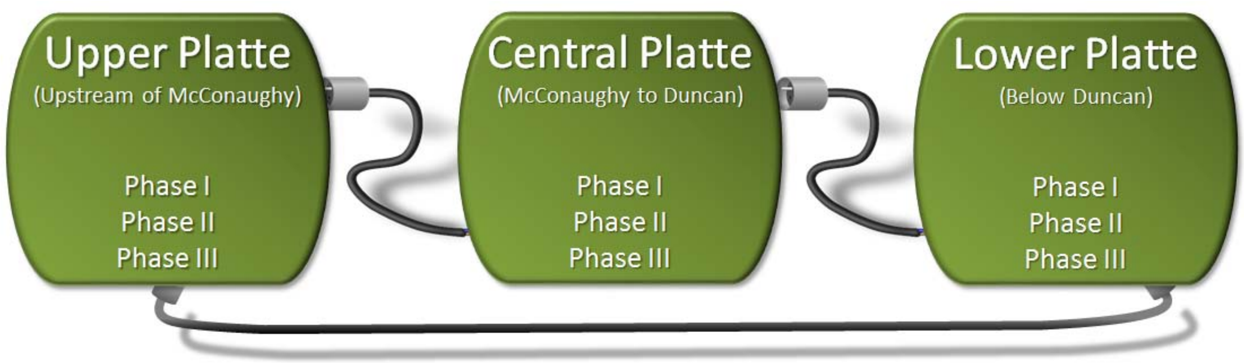


Figure 6: Phased and Modular Implementation Approach

Each of the geographic regions will use the phased approach described earlier, and DSS development will proceed for several of the geographic modules at the same time, as shown in Figure 7 below. For the Upper and Lower Platte regions, initial Phase I and Phase II work will begin concurrently with Central Platte, but will only proceed to the degree needed to support model development in the Central Platte. Some period of time after Phase III commences in the Central Platte, Phase I and then Phase II work will then be completed in the Upper Platte region. Similarly, sometime after Phase III commences in the Upper Platte, Phase I and then Phase II will be completed in the Lower Platte region. In this way, connections between the geographic modules can be established to pass data and model results from one region to the next, while allowing full completion of Phases I and II in the regions sequentially. Phase III efforts for all regions will begin after the completion of Phases I and II in their respective regions, and will continue through the lifetime of the Platte DSS, as the DSS Components are maintained and improved over time. The overall time horizon shown in Figure 7 for Phases I through III is between 3 to 5 years, but it's important to note that, as just discussed, Phase III activities would be expected to continue after that period, for the lifetime of the Platte DSS. It is anticipated that Phase III activities beyond the 3 to 5-year time period could be conducted by the NeDNR, with only auxiliary support as needed.

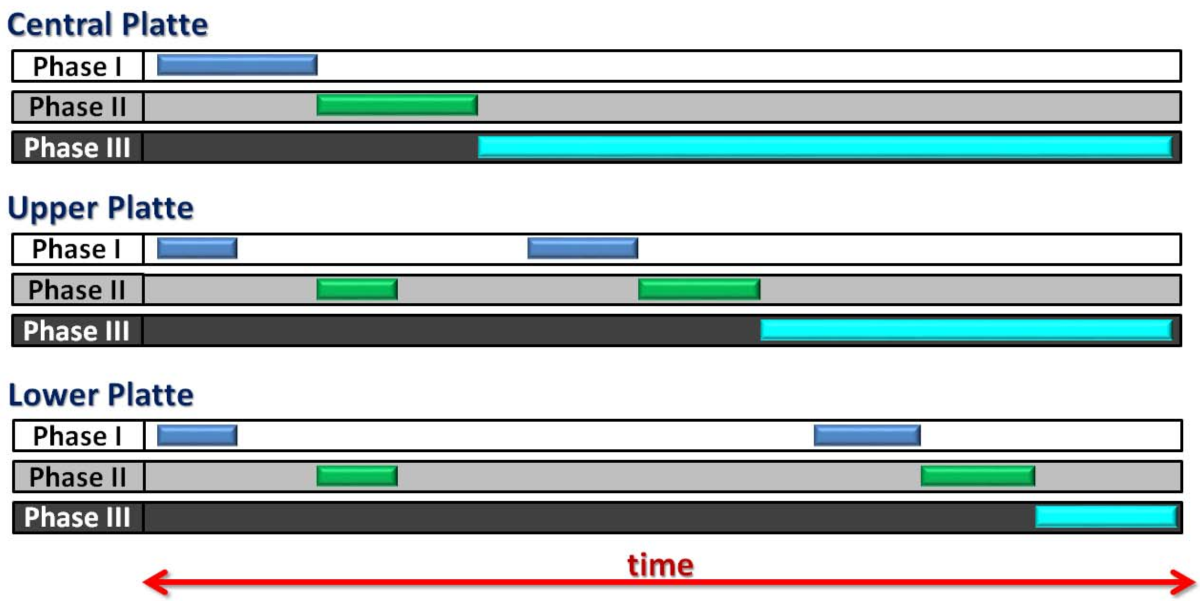


Figure 7: Generalized Timing for Phases for Each Geographic Region

Evaluation Criteria

One factor discussed over the course of several meetings with NeDNR staff was the choice of evaluation criteria to be used in future analyses with the Platte DSS. These criteria would help determine the relative feasibility of alternative water management actions, including their benefits and costs, both on a monetary and more qualitative basis. A few specific evaluation criteria that were identified are included here:

- **Integrated Management Plan (IMP) Elements** – these elements include the goals and objectives of the IMPs and the surface water controls associated with them. While the specific IMP elements vary across different areas, in essence they usually include two overall purposes: protecting the rights of existing water users, and ensuring that the prescribed management actions achieve the IMP goals and objectives.
- **PRRIP Requirements** – similarly to State's IMPs, the Platte Program has its own set of requirements, which includes a focus on protecting instream flows in the critical reaches of the Platte River. These factors, which may include public interest considerations, will also be critical in evaluating Platte DSS alternatives.

- **Statutory Requirements** – State statute provides some guidance as to the relative importance of certain requirements and objectives with respect to the rights to and uses of water. These include protections against impacts that would harm existing water users, as well as other requirements related to applications for new water appropriations and transfers or changes to existing water rights. Issues of public interest sometimes come into play as well when NeDNR must determine whether or not to approve an application – including applications related to interbasin transfers.
- **Economic Impacts** – this criterion is related to the "Economic Framework" DSS Component, and concerns the estimation of the costs and benefits of various actions and responses.

For all the evaluation criteria, the DSS must be structured to include these metrics in a way that is both as accurate, and as simple, as possible. In essence, the criteria should help identify a list of desired results and outcomes, including as much quantitative information as possible – supplemented with qualitative results as needed. In some instances, cost/benefit ratios may be available, providing a relatively simple way to evaluate management alternatives. Wherever possible, the costs associated with each alternative should be included, including O&M costs, capital costs, and other required expenditures. Lowest bidder considerations may be included as well to ensure accurate representations of these cost elements.

For Phase I efforts focusing on the Excess Flow Recharge Analysis, and likely for many of the Phase II and Phase III alternatives, perhaps the most important determination is ultimately the impact on streamflows. Positive streamflow benefits will minimize the need to regulate, and should help with respect to many of the IMP and PRRIP goals and objectives. Besides streamflows, impacts on Lake McConaughy levels and conditions could also be a part of the evaluation criteria, as these factors include a considerable economic component for irrigation and recreation interests. In weighing the relative benefits of streamflow and reservoir impacts, the DSS could also be informed by PRRIP's use of COHYST and other modeling tools to score projects and determine a ranking of alternative actions.

Turning Results into Action

A DSS is ultimately only effective if the actions that it suggests can actually be put into practice. The DSS Component on "Decision Implementation", as well as much of the efforts under Phase III, are directed at ensuring that the DSS will be a practical management tool, with results that can be turned into real-world actions by supporting real-time decision-making.

For instance, the output from the Platte DSS could be used to generate an opening notice to allow a particular canal within the basin to divert water, for a specific period of time, for recharge purposes. More ambitiously, and with the appropriate economic toolset, the DSS could also determine a price to pay for those recharge activities, based on the benefits of that recharge over time, as calculated by the DSS Components. On a longer-term basis, the DSS could also be linked with reporting activities by NeDNR, helping to track the benefits forward over time once recharge diversions are curtailed.

DSS results may also suggest specific administrative actions, to ensure the greatest overall benefits – perhaps on a basin-wide level. For example, conditions could be placed on a recharge permit to allow certain projects to divert water under explicit conditions. It is possible that multiple projects could be considered together as a group, adding an application condition requiring real-time evaluation of present hydrologic and administrative conditions, resulting in directions via the DSS as to which individual canal to allow to divert water for recharge. It may also be beneficial to add new surface water controls under existing IMPs in the basin, developing new rules based on those controls to help with the permit decision-making. These and other examples are ways in which the DSS could dovetail with current rulemaking and management processes, with a goal of managing water to maximize benefits on a basin-wide level.

Schedule

The schedule for the Platte DSS will largely follow the organizational structure of the DSS Components, particularly for the tasks under Phase I (Excess Flow Recharge Analysis). A more thorough description can be found within the Resources and Constraints section of this document. The following is a description of the various steps required to complete each of the major tasks under the three project phases. These steps will be consistent across all three geographic regions, although the time and level of difficulty associated with each step may vary considerably from region to region. Table 1 shows the relative timing of the phases and steps for each of the three geographic regions.

Phase I (Excess Flow Recharge Analysis) Tasks

- **Task 1 = Tool and Data Assembly**
  This task will involve assembling the various models, including the surface water and groundwater platforms, and the economic evaluation tool. Input data will be organized into the appropriate formats for the tools, and the models will be tested to ensure proper calibration and precision.

- **Task 2 = Data Management Subsystem Construction**
  The data management subsystem, including the main database and associated components, will be developed to allow for a smooth progression of data through the different modeling tools and GUI interfaces. Metadata will be associated with all input and output to ensure replicability of DSS runs and identification of the settings of the model tools used to derive the specific output.

- **Task 3 = Model Management Subsystem Construction**
  Once the modeling tools are assembled under Task 1, the connections between these various models will be developed under this task. For Phase I efforts, this will mainly involve the connection between the surface water and groundwater models. The economic tool will utilize hydrologic and other input data to derive monetary estimates, including costs and benefits, wherever possible. This phase will also include an investigation into the data gaps associated with overland runoff, which will lead to recommendations as to how to address those important data deficiencies.

- **Task 4 = User Interface Development**
  The graphical user interface will provide a platform for the user to interact with all the modeling tools in a user-friendly and intuitive manner. The interface will be simple enough to be managed by an individual with a general understanding of the underlying modeling tools and hydrologic processes, while being comprehensive enough to allow for the analysis of a variety of water management alternatives.

- **Task 5 = Management Alternative Development**
  This task involves the development of the different water management alternatives for subsequent evaluation. This will take place with direct interaction with NeDNR staff, and other stakeholders as necessary. The alternatives will be structured in a format that can be readily incorporated into the DSS modeling tools and processes. A list of evaluation criteria will also be finalized within this step to allow for appropriate analysis of the results.

- **Task 6 = Management Alternative Evaluation**
  Using the established management alternatives, the Platte DSS will be used to determine operational results and the relative benefits of those actions. Weighting may be used to assign relative levels of importance to the various management alternatives and determine the most optimal solutions.

- **Task 7 = Implementation Support**
  This task involves providing support as the DSS outputs and recommended actions are implemented. This may involve assistance in navigating the different institutional and legal requirements necessary to initiate management alternatives. Support would also be provided in maintaining and updating the various modeling tools and other DSS processes as necessary, to ensure the sustainability of the DSS into the future.

Phase II (Transfers of Existing Water Supplies) Tasks

- **Task 1 = Tool and Data Enhancement**
  The individual modeling tools would be modified to handle the additional requirements of water transfer analysis. These enhancements would be focused on the surface water routing tool, but would also include additional new capabilities to the economic tool to represent the costs and benefits of water transfers and third-party impacts.

- **Task 2 = Data Management Subsystem Enhancement**
  The data management subsystem would be updated to process the additional data needs related to water transfers, including those data related to water administration.

- **Task 3 = Model Management Subsystem Enhancement**
  Connections between the surface and groundwater models, and the economic tool, would be updated and enhanced.

- **Task 4 = User Interface Enhancement**
  Additional GUI features would be added to better evaluate the results from water transfer actions, including changes in diversions and water use, and resulting economic benefits and harms. The representations will need to convey the relationships between

the different water transfer participants (i.e. differentiate between transfer source and transfer destination).

- **Task 5 = Management Alternative Development**
  As with Phase I, this task involves the development of the different water management alternatives for subsequent evaluation. This will take place with direct interaction with NeDNR staff, and other stakeholders as necessary. The alternatives will be structured in a format that can be readily incorporated into the DSS modeling tools and processes. A list of evaluation criteria will also be finalized within this step to allow for appropriate analysis of the results.

- **Task 6 = Management Alternative Evaluation**
  Using the established management alternatives, the Platte DSS will be used to determine operational results and the relative benefits of those water transfer actions. Weighting may be used to assign relative levels of importance to the various management alternatives and determine the most optimal solutions.

- **Task 7 = Implementation Support**
  This task involves providing support as the DSS outputs and recommended actions are implemented. This may involve assistance in navigating the different institutional and legal requirements necessary to initiate management alternatives. Support would also be provided in maintaining and updating the various modeling tools and other DSS processes as necessary, to ensure the sustainability of the DSS into the future.

Phase III (Integration and Maintenance) Tasks

- **Task 1 = Tool and Data Assembly/Enhancement**
  Additional model tools will be developed as needed to meet the new objectives, potentially including flood management and Water Sustainability Fund application support.

- **Task 2 = Data Management Subsystem Construction/Enhancement**
  The data management subsystem would be updated to process the additional data needs related to any new modeling tools. If flood management is included as an objective, the data management structure may need to be modified to handle smaller time increments – possibly as short as hours.

- **Task 3 = Model Management Subsystem Construction/Enhancement**
  Connections between the different modeling tools would be updated and enhanced, including those connections with any new components.

- **Task 4 = User Interface Enhancement**

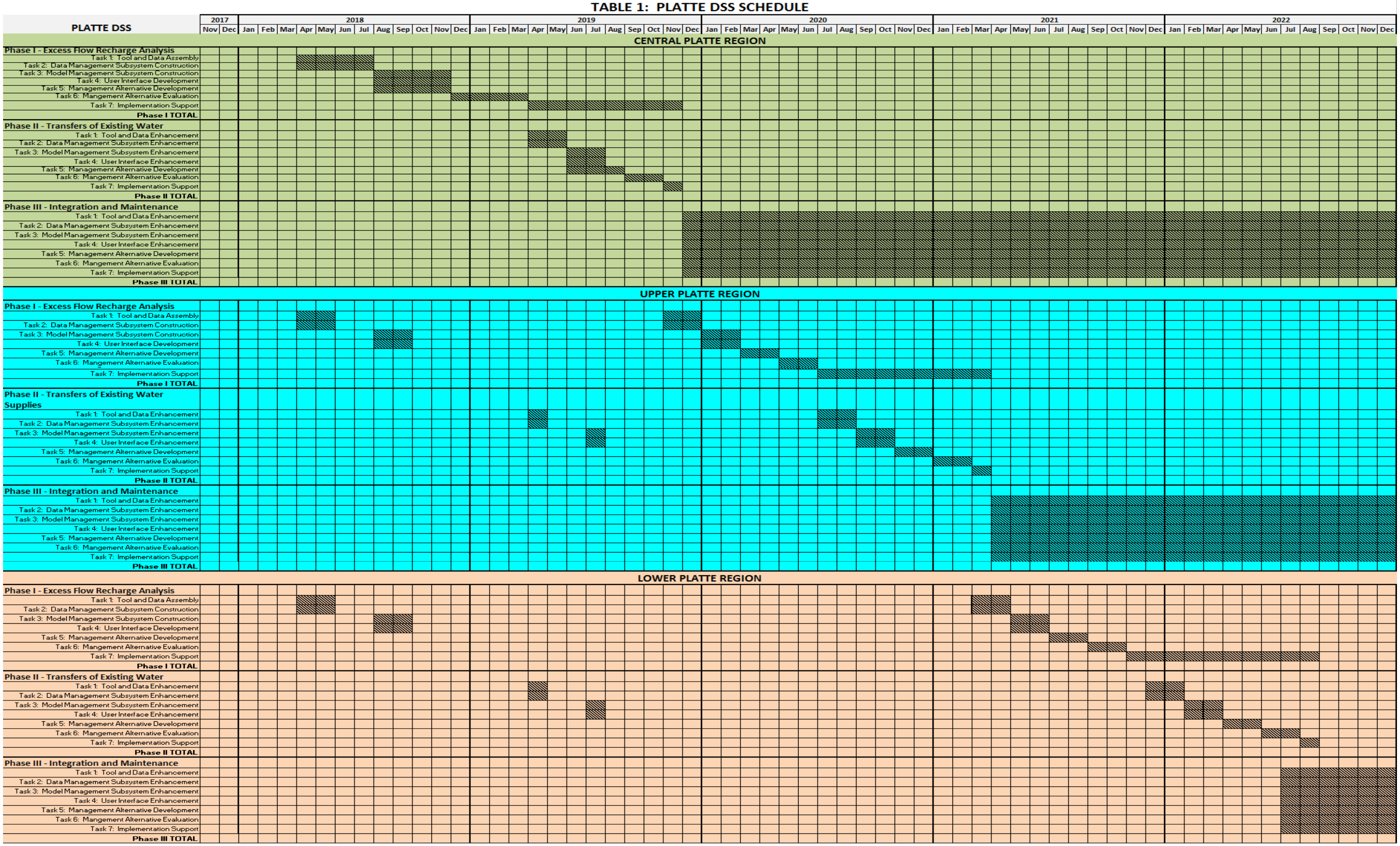
The GUI would be modified, as necessary, to handle any additional modeling tools and applications.

- **Task 5 = Management Alternative Development**
  As with Phases I and II, this task involves the development of the different water management alternatives for subsequent evaluation. This will take place with direct interaction with NeDNR staff, and other stakeholders as necessary. The alternatives will be structured in a format that can be readily incorporated into the DSS modeling tools and processes. A list of evaluation criteria will also be finalized within this step to allow for appropriate analysis of the results.

- **Task 6 = Management Alternative Evaluation**
  Using the established management alternatives, the Platte DSS will be used to determine operational results and the relative benefits of those water transfer actions. Weighting may be used to assign relative levels of importance to the various management alternatives and determine the most optimal solutions.

- **Task 7 = Implementation Support**
  This would be a focus area for Phase III, as it involves the continued maintenance and updating of the modeling tools and other DSS processes. All DSS Components would be subject to this maintenance and upgrade task, and would take place with direct input from NeDNR staff, using the latest information on legal and institutional policies, along with any data management changes or other pending technical upgrades to the modeling tools and/or database structure.

TABLE 1: PLATTE DSS SCHEDULE



Attachment A: Task 2 Matrix of Current Hydrologic Tools, Datasets, and Models

TASK 2 Review of Current Hydrologic Tools, Datasets, and Models

Available Datasets, Hydrologic Tools, and Models	Purpose	Scale for Application	Key Limitations	Data Sources	Data Linkages/Gaps/Filling	Can Tool Adress a Key DSS Need? (Surface Water Routing and Water Rights, Groundwater Impacts, Economics, Data Management System, GUI Representation)	History of Development and Participants
Surface Water Routing and Water Right Platform							
ArcHydro	To support geospatial and temporal data analyses by delineating and characterizing watersheds in raster and vector formats, defining and analyzing hydro geometric networks, managing time series data, and configuring and exporting data to numerical models.	Any user-defined extent within the U.S.	Standard GIS modeling constraints.	Any. ArcHydro can use data from any correctly formatted data source.	Dependant on data source.	Surface water routing, data management system, GUI representation	Developed by David Maidment (University of Texas at Austin) in conjunction with ESRI in mid to late 1990s.
CNPPID Hydro and Lake Operations Schedules	Provide projections as to hydropower generation and lake elevation changes for facilities along the CNPPID system below McConaughy.	Generally from Jeffrey Lake (near Brady, NE) to the J-2 hydroelectric plant (just downstream of Johnson Lake, south of Lexington)	Projections go out 11-days, and are updated each week. Subject to normal hydrologic and power demand uncertainties.	CNPPID	11-day forecasted conditions	Can inform inputs used for surface water models	
CNPPID Lake McConaughy Release Notices (Cory Steinke)	To alert downstream water users, and other interested parties, as to pending changes to Lake McConaughy releases and Keystone NPPD Diversions	Lake McConaughy (with impacts downstream)	Email notices are non-periodic and usually indicate release and diversions decisions already made. Forecasted decisions are usually only for the immediate term, and subject to change without prior notice.	CNPPID	As mentioned in the Limitations, the management decisions and forecasts are usually very limited, and subject to considerable change based on actual conditions.	Can inform inputs used for surface water models	
COHYST Stella Surface Water Model	Route surface water through Platte system, estimate flows and McConaughy storage volumes, estimate surface water diversions.	Upstream limits = NP River at Lewellan, SP River at Julesburg. Downstream limit = Platte at Kearney Return/Duncan	Lake McConaughy operation rules are simplified and have abrupt changes at threshold levels, only a very simplified representation of water right administration.	USGS and DNR gages, canal capacities, evaporation rates, reservoir storage curves.	GUI can connect with COHYST Watershed Model and COHYST Surface Water Model	Surface water routing and water rights	Developed by HDR in mid 2000s to integrate with COHYST groundwater model
INSIGHT	Provide an annual snapshot of water conditions across the state, focusing on supplies, demands, nature and extent of use, and water balance. http://data.dnr.ne.gov/insight/about.html	Basin Scale for the Niobrara, Loup, Elkhorn, Lower Platte, Big Blue, Little Blue, and Missouri Tributaries.	Simple representations of supply and demand - not suited for smaller-scale applications.	DNR, USGS, USBR, and local NRDs, CropSim. https://nednr.nebraska.gov/INSIGHT/index.html		Can provide data to support surface water modling and groundwater impacts	Developed around 2011 by NeDNR staff, including Stephanie Ashley, Jesse Bradley, and Laura Paeglis, with assistance from TFG
Lincoln LWS Wellfield Operations Info	Daily water use and well pumping records from LWS	LWS service area (Lincoln area)	Not currently real-time data, but annual reports (with daily records) submitted after the end of the year.	LWS	Data compiled by LWS.	Can be used in conjunction with surface water modeling and groundwater impacts	
Lower Platte River Consortium Forecasting and Conveyance Tool	Surface water model developed to simulate conveyance losses on a reach by reach basis for the Elkhorn, Loup, and Platte River, and to assist with management alternative evaluation and predictive forecasting elements to improve water supply reliability for municipal well fields in Lincoln and Omaha.	Loup River basin downstream of St. Paul (expansion upstream to Dunning is being considered, Elkhorn River downstream of Norfolk, Lower Platte River from Duncan to Louisville.	Limited gage data (mainly 2004 to 2015), no overland runoff or groundwater model components.	USGS and NeDNR gage data, potentially USBR, CNPPID, and NRCS data for snowpack and reservoir data related to predictive forecasting component.	2004 to 2015 period is primary data timeframe.	Surface water routing and water rights	Developed by The Flatwater Group and HDR for the Lower Platte River Consortium - initial work started in 2016.
Lower Platte River Stage Change Study	To develop information needed to evaluate the potential effects of Program water management activities on water stage and how those stage changes might affect the physical characteristics of the lower Platte River.	Lower Platte River from confluence with Elkhorn River to Missouri River confluence.		PRRIP, NGPC, USFWS		Can inform inputs used for surface water models	Began as part of PRRIP programmatic efforts.
MUD Wellfield Operations Info	Daily water use and well pumping records from MUD	MUD service area (Omaha region)	Not currently real-time data, but annual reports (with daily records) submitted after the end of the year.	MUD	Data compiled by MUD.	Can be used in conjunction with surface water modeling and groundwater impacts	
National Weather Service - Missouri Basin River Forecast Center Forecasts	Provides gage stage information for selected sites (including in Republican River Basin), along with projected flood elevations during high-flow events	Basin-wide	Limited gages are incorporated into network.	National Weather Service http://www.weather.gov/mbrfc/?n=water		Can inform inputs used for surface water models	
NEXRAD Precipitation Data	Records estimated precipitation based on radar imagery.	Basin-wide	Estimates only - not direct measurements of precipitation.	https://www.ncdc.noaa.gov/nexradinv/	Can be used in conjunction with field-based measurements to improve data accuracy.	Can inform inputs used for surface water models	Using WW II technology, the NWS operated the Weather Surveillance Radars–1957 (WSR-57) network. This was followed by Weather Surveillance Radars–1974 (WSR-74) and then Weather Surveillance Radars–1988 Doppler (WSR-88D) or NEXRAD. The NEXRAD system is a joint effort of the U.S. Departments of Commerce, Defense, and Transportation. The controlling agencies are the NWS, Air Force Weather Agency, and FAA, respectively. In 1988, the NEXRAD agencies established the WSR-88D NOAA Radar Operations Center (ROC) in Norman, Oklahoma.
NRCS Basin Data Reports	Provides precipitation, snowpack, and reservoir information for mountain states (including Colorado and Wyoming)	Colorado and Wyoming mountainous regions		www.wcc.nrcs.usda.gov/basin.html		Can inform inputs used for surface water models	
PRRIP Dewberry Forecasts for North Platte and South Platte River Basins	Forecast river basin conditions (primarily May-July streamflow at selected locations) using estimates that are revised every month, and are based on several hydro-climate indices, including the Palmer Drought Severity Index (PDSI), Nino1.2, the Pacific/North American teleconnection pattern (PNA), and the North Atlantic Oscillation (NAO), along with other factors such as Snow Water Equivalence (SWE) at certain Colorado SNOTEL sites and Glendo inflows.	The North Platte River Basin forecast includes predicted streamflow at Lewellan and reservoirs upstream of that point, and the South Platte River Basin forecast includes predicted streamflow at Julesburg and upstream at Kersey.	General limitations associated with using hydro-climate indices (in some cases based on conditions many thousands of miles away from Nebraska) to predict flow conditions. While correlations are reasonably high for some indices (between the index and downstream seasonal flows), there are many historical examples over the recent decades when conditions did not match predicted levels. The forecasts cannot serve as reliable predictions, and should only serve as a planning tool recognizing those limitations.	USGS, NeDNR, and Colorado DWR for stream gage data, USBR for some reservoir data, NOAA and other atmospheric and oceanic data sources for hydro-climate indices, USBR and/or NRCS for snow water equivalence (SWE) records. http://54.215.135.182/Platte_River_Forecast/	Linkages between several of the individual hydro-climate indices and the summary forecasts for specific PRRIP locations.	Can inform inputs used for surface water models	Developed by John F. Henz (formerly with Dewberry services firm) for PRRIP, starting with a technical white paper submitted on Jan. 5, 2012.
PRRIP Hydrologic Condition Designations	Grand Island gage using historical flow records for the annual designation, and multiple factors for the periodic (primarily monthly) designations, including Lake McConaughy content, upper South Platte reservoir content, North Platte Basin snowpack, the Palmer Drought Severity Index (PDSI), Julesburg streamflow, and Grand Island streamflow. These designations help determine PRRIP target flows depending on if conditions are "Wet", "Average", or "Dry".	Forecasts apply to Platte River at Grand Island, and consider factors throughout the Platte River Basin above that point.	Periodic hydrologic condition designations may change significantly from month to month as upstream conditions change	USGS, NeDNR, and Colorado DWR for stream gage data, USBR and Colorado DWR for some reservoir data, NOAA and other atmospheric data sources for Palmer Drought Severity Index, USBR and/or NRCS for snowpack data. www.platteriverprogram.org/PubsAndData/Pages/CurrentHydrologicCondition.aspx	Annual designations available for 1947 to present. Periodic designations available for 1995 to present.	Can inform inputs used for surface water models	Developed as part of the PRRIP Water Plan (Section 11, Appendix D) as established in Oct. 24, 2006 PRRIP Program Document. USFWS (Don Anderson and Mark Rodney) prepared calculations initially, but now calculated by the PRRIP Executive Director Office.
PRRIP Reservoir Coordination Committee (RCC) Planning - Related to McConaughy EA Operations	RCC meets twice annually, in conjunction with EA Committee, to coordinate operations plans and review reservoir accounting, inflow projections, storage and release goals, and river monitoring methods, all to coordinate CNPPID's and NPPD's water operations with the EA Manager's operation of the Environmental Account.	Focussed on Bureau Reservoirs in Wyoming and Lake McConaughy in Nebraska.	No formal planning documents are normally prepared, although RCC input influences the development of the USFWS Environmental Account AOP, as well as CNPPID and NPPD water operations.	USBR, CNPPID		Can inform inputs used for surface water models	RCC was formed under FERC relicensing requirements, as directed by the document entitled *An Environmental Account for Storage Reservoirs on the Platte River System in Nebraska* (Attachment 5, Section 5).
PWAP (Platte Water Accounting Program)	Determine the amount of natural flow, storage flow, and enviornmental account flow in the North Platte and Platte Rivers.	Sinclair, WY to Grand Island, NE	Direct precip contribution not included, small tribs not gaged, return flow contribution not measured, seepage and bank storage impacts not measured, evap losses based on monthly averages (no daily variation), can't predict changes to sw availability due to allocations	DNR and USGS gages, water rights and rates of diversion, evaporation rates		Surface water routing and water rights	Developed in early 80s as part of a larger data management system for the Platte River (primarily the N. Platte R.). H. Lee Becker, along with Ken Henneman and Dan Leighton from CDM, helped develop.

Twin Loups Irrigation District Water Supply & Weather Data Reports	Provides information on water operations, including reservoir content and releases, canal flowrates, streamflow, and other water data.	Twin Loups Irrigation District service area	Daily records, but submitted monthly.	Twin Loups ID	Standard issues with stream gage, reservoir stage, and canal readings.	Can inform inputs used for surface water models	Based on records in NeDNR's Hydrographic Reprts, these monthly reports were first submitted to NeDNR by Twin Loups Irrigation District in the fall of 1985. Initial filling of Calamus Reservoir took place in 1986 and 1987.
Unappropriated Flow Assessments	Develops estimates of unappropriated flows that may be available for use in basins throughout Nebraska.	Efforts ongoing throughout Platte River Basin in Nebraska.		NeDNR, USGS, NRDs		Surface water routing and water rights	Originally derrived from directives under Groundwater Management and Protection Act portion of State Water Code, after passage of LB 962 in 2004.
Upper Niobrara-White (UNWNRD) Surface Water Operations Model	Route surface water through Upper Niobrara system, estimate flows and Box Butte Reservoir storage volumes, estimate surface water diversions.	Niobrara River Portion of the Nebraska Panhandle	Only a very simplified representation of water right administration.	USGS and DNR gages, canal capacities, evaporation rates, reservoir storage curves.	Was developed to work in conjunction with the UNWNRD watershed and groundwater model, to develop an integrated run	Surface water routing and water rights	The UNWNRD surface water model was developed by HDR as part of the Watersmart Niobrara Basins analysis in conjuction with USBR and DNR with input from TFG
USACE Water Supply Forecast for Glendo Reservoir	To develop estimates of the water supply for Glendo Reservoir based on snowpack and other factors.	Glendo Reservoir		http://www.nwo.usace.army.mil/Missions/Civil-Works/Planning/		Can inform inputs used for surface water models	
USBR April-July Runoff Forecasts	Project runoff for upcoming April to May period at various locations, both at stream segments and at select reservoirs. Reasonable Maximum, Expected, and Reasonable Minimum runoff values (in 1000 acre-feet) are projected.	With respect to Platte River Basin, the forecast is develolped for Seminoe Reservoir, Sweetwater River above Pathfinder Reservoir, and Alcova to Glendo.	First projection done as of Feb. 1, and final projection done as of May 1 conditions - limited period available.	USBR Great Plains Region, North Platte River Basin Water Supply Reports. www.usbr.gov/gp/lakes_reservoirs/wareprts/main_menu.html#supply	Final projection May 1.	Can inform inputs used for surface water models	Art Hill (USBR) indicated these projections have been developed for a considerably long time - uncertain when process initiated.
USBR Operating Plan Reservoir Forecasts (WY and CO)	Project reservoir content, elevation, inflows, and releases over the next 12 months, using April-July Runoff Forecast, and a FORTRAN operations model.	Seminoe Reservoir to Glendo Reservoir in the North Platte River Basin.	Inflow projections outside of April-July period are based on historical averages for each month. Also, FORTRAN platform for operations model component is cumbersome and slow - currently working on migrating over to RiverWare.	USBR Great Plains Region, North Platte River Operating Plans. www.usbr.gov/gp/lakes_reservoirs/wareprts/expectednpr.pdf	FORTRAN routing model used in conjunction with projections of April-July inflows and historical inflow averages.	Can inform inputs used for surface water models	Probably started around the early 80s, according to Art Hill (USBR). Developed in FORTRAN. Planning to migrate to RiverWare
USGS Daily Flow Records	Reports daily flow estimates (along with other parameters for some gage locations) across the U.S.	Nationwide. USGS gages are found throughout the Platte River Basin.	Standard measurement accuracy issues, and preliminary data - which often includes "Ice" entries with no numerical values - take months before they are corrected and finalized.	USGS National Water Information System (NWIS). https://waterdata.usgs.gov/nwis	Gage data format allows records to be easily imported into other modeling tools	Can provide data to support surface water modling	USGS initiated National Streamgaging Program in 1888.
Western Water Use StateMOD Surface Water Model	Subset of WWUM focused on surface water operations	Platte portion of the Nebraska panhandle	Routing of reservoir releases estimated to occur simultaneously due to forecasting limitations.	USGS and DNR gages, canal capacities, evaporation rates, reservoir storage curves.	Directly integrated with WWUM Surface Water Model, and WWUM Watershed Model	Surface water routing and water rights	Developed after WWUM split from COHYST, to add surface water routing capabilities.

Groundwater Impact Representation

Big Blue Groundwater Model (BBM)	Estimate baseflow and baseflow changes given certain hydrological and groundwater management conditions. Help evaluate the appropriation status of the basin.	Little Blue and Big Blue River drainage areas	Regional model not well-suited for smaller scale applications. Not calibrated in Platte drainage area.	Aquifer parameters, groundwater levels (heads), pumping rates, stream networks	Connection with Big Blue Watershed Model	Groundwater impacts	Developed by HDR with input from TFG and DNR.
Big Blue Watershed Model	Develops etimates of the soil water balance by tying the results of the Soil Water Balance model with the local land use, soils, irrigation systems and farming practices.	Little Blue and Big Blue River drainage areas	Regional model not well-suited for smaller scale applications. Not calibrated in Platte drainage area.	CropSim, UBBNRD, LBBNRD, LBNRD, DNR, USDA soils data bases, various Nebguides and research papers related to crop production	Connection with Big Blue Groundwater Model	Supports groundwater impact and watershed modeling	Developed by HDR with input from TFG and DNR.
Central Nebraska (CNEB) Model	Simulates surface water-groundwater interactions through reproducing long-term trends under varying hydrologic and hydrogeologic conditions in the region. Supports NeDNR fully appropriated basin analysis and INSIGHT components. Characterizes water supplies, uses, and demands by incorporating a groundwater model developed using MODFLOW-NWT and CROPSIM.	Entire Loup River Basin, lands draining to the Elkhorn River above Norfolk, and portions of the Niobrara River Basin in north central Nebraska and the Lower Niobrara River and Ponca Creek drainages in South Dakota.	No surface water operations model included - but very few surface water demands in region.	CropSim, DNR, USDA soils data bases, various UNL Nebguides and research papers related to crop production	Groundwater model includes embedded connections with CROPSIM model.	Groundwater impacts	Extension and enhancement of Elkhorn-Loup Model (ELM), developed by Brown and Caldwell with support from The Flatwater Group.
COHYST Groundwater Model	Estimate baseflow and baseflow changes given certain hydrological and groundwater management conditions	Most of Central Platte Basin	Designed as regional model and not well-suited for smaller scale evaluations. Built to evaluate effects of water management actions over scales of several years to decades.	Aquifer parameters, groundwater levels (heads), pumping rates, stream networks	GUI can connect with COHYST Watershed Model and COHYST Surface Water Model	Groundwater impacts	Developed under 12 state and local agencies in Nebraska following signing of Cooperative Agreement between CO, WY, NE, and U.S. Dept. of Interior in 1997
COHYST Watershed Model	Subset of the COHYST model focused on developing etimates of the soil water balance. The watershed model ties the results of the Soil Water Balance model with the local land use, soils, irrigation systems and farming practices.	Regional model for the Central Platte portion of Nebraka from the east edge of the panhandle in the weast to the confluence of the Platte and Loup Rivers in the east. Encompassing the area between the South Loup River and Republican River.	Weather Data is interpolated between weather stations. Soil properties are representative. Fully irrigated condition used as the baseline from which impacts related to deficit irrigation are computed. Land use was developed using a statistical approach that approximated irrigated acres in probable locations. Limited focus on areas not contributing to the Platte.	CropSim, TPNRD, CPNRD, TBNRD, PRIPP, NPPID, CNPPID, Riverside, DNR, USDA soils data bases, various Nebguides and research papers related to crop production	Develops estimates of irrigation demand for Platte River irrigation districts for the SW model. Incorporates surface water deliveries from the SW model. Developes the .RCH, .WEL, and runoff contributions to stream flow for inclusion in the GW model and SW model.	Groundwater impacts	The COHYST watershed model has been under development in the COHYST model for over a decade. The model was recently updated (starting 2013) to use results directly from the soil water balance model CropSim switching from a statistical curve based approach. The model has been develop by TFG with input from DNR, TPNRD, CPNRD, TBNRD, NPPID, CNPPID, PRIPP, HDR, and LWA.
CropSIM	A soil water balance model used to aid in the prediction of evapotranspiration, deep percolation, and runoff that occurs from a range of cropped and naturally vegetated systems.	A point source, field scale model.	Operates on a daily time step; the predicted deep percolation values represent volumes of water leaving the root zone; assumes all soils are well drained; no crop kill routine for extreme drought and lacks an early crop senescence function; water is the only factor considered to limit crop production. Crop rotations.	High Plains Regional Climate Center, USDA (NRCS) soils databases, Various UNL Nebguides and research papers related to crop development.	Needs documentation completed; current runs of the model have only represented a single (fully watered) irrigation condition. Would like to update and further calibrate simfiles to improve representation of the agricultural crops and farming practices.	Supports groundwater impact and watershed modeling	Initially developed by Dr. Derrel Martin in the 1980s and has undergone several updates since that time. The model is currently used in both academia and professional practice.
Elkhorn-Loup Model (ELM)	Simulates surface water-groundwater interactions through reproducing long-term trends under varying hydrologic and hydrogeologic conditions in the region. Supports NeDNR fully appropriated basin analysis and INSIGHT components. Characterizes water supplies, uses, and demands by incorporating a groundwater model developed using MODFLOW-NWT and CROPSIM.	Entire Loup River Basin, and lands draining to the Elkhorn River above Norfolk.	No surface water operations model included - but very few surface water demands in region. Limited active model domain.			Groundwater impacts	Developed by USGS Nebraska Water Science Center in partnership with NeDNR and NRDs.
Lower Platte / Missouri Tributaries (LPMT) Watershed Model	Subset of the LPMT model focused on developing estimates of the soil water balance. The watershed modle ties the results fo the soil water balance model with local land use, soils, irrigation systems, and farming practices.	Regional model for the eastern portion of the state of Nebraska; ranging from just east of grand Island in the west to the Missouri River in the east and north with the soutwest edge being comprised of the Big Blue River. Finally the southern edge reaches to approximately the southern border of Johnson and Nemaha counties.	Weather data is interpolated between weather stations. Soils properties are representative. Land use development involves a statistical approach to assigning irrigated acres. Fully irrigated condition used as the baseline from which impacts related to deficit irrigation are computed. (Still currently under development).	CropSim, DNR, HDR, USDA soils data bases, various UNL Nebguides and research papers related to crop production	Develops .WEL and .RCH files for use in the groundwater model. (still evolving)	Supports groundwater impact and watershed modeling	The LPMT watershed model was develop by TFG inconjunction with DNR, HDR, and Tiraz Birdie (TBirdie Consulting, Inc.).
Lower Platte Missouri Trib Groundwater Models (LPMT), Northern/Central and Southern	Help water administrators understand impacts of land use development on streamflow, using groundwater modeling platform.	Areas that drain directly into the Missouri R. downstream of Niobrara R., and easternmost Lower Platte River Basin.	(Under development)	Aquifer parameters, groundwater levels (heads), pumping rates, stream networks	Connection with LPMT Watershed Model	Groundwater impacts	Developed since 2012 by HDR team (including McDonald Morrissey Associates) with input from DNR, TFG, and Tiraz Birdie (Tbirdie Consulting, Inc.)

Upper Niobrara-White (UNWNRD) Groundwater Model	Estimates the baseflow and baseflow changes given certain hydrolocal and groundwater management conditions.	Niobrara River Portion of the Nebraska Panhandle	Regional model not well-suited for smaller scale applications. Calibration is focused on the Niobrara River Drainage area	Aquifer parameters, groundwater levels (heads), pumping rates, stream networks	Connection with the UNWNRD watershed model. Can also be used in conjunction with the UNWNRD surface water operation model	Supports groundwater impact and watershed modeling	The UNWNRD groundwater model was developed by the UNWNRD with assistence from DNR and input from TFG
Upper Niobrara-White (UNWNRD) Soil Water Balance Model	Develops etimates of the soil water balance by tying the results of the Soil Water Balance model with the local land use, soils, irrigation systems and farming practices.	Niobrara River Portion of the Nebraska Panhandle	Regional model not well-suited for smaller scale applications. Calibration is focused on the Niobrara River Drainage area	CROPSIM, UNWNRD, DNR, USDA soils, various Nebguides and research papers related to crop production	Connection with the UNWNRD groundwater model. Can also be used in conjunction with the UNWNRD surface water operation model	Supports groundwater impact and watershed modeling	Developed by the UNWNRD with assistence from TFG and input from DNR
USGS Groundwater Level Data	Measures groundwater levels throughout the State of Nebraska, including in the Platte Basin, and with respect to the High Plains Aquifer	Basin-wide	Limited by number of wells, which currently must represent very large areas.	https://waterdata.usgs.gov/nwis/gw	Other State and locally maintained wells are often used in conjunction with USGS well data to fill in gaps in the geographic coverage	Groundwater impacts	Most of the USGS well data acquisition began in the late 1900s.
Western Water Use Groundwater Model (WWUM)	Groundwater model, surface water operations model, and soil-water balance model to support water management decisions - especially in FA and OA areas	Platte portion of the Nebraska panhandle	Regional model not well-suited for smaller scale applications.	Aquifer parameters, groundwater levels (heads), pumping rates, stream networks	Directly integrated with WWUM Surface Water Model, and WWUM Watershed Model	Groundwater impacts	Developed as part of COHYST in 1988, but later split from COHYST 2010 Model
WWUM Watershed Model	Subset of WWUM focused on developeing estimates of the soil water balance. The watershed model ties the results of the Soil Water Balance model with local land use, soils, irrigation systems, and farming practices.	Regional model for Platte portion of the Nebraska panhandle	Weather Data is interpolated between weather stations. Limited number of weather stations. Soil properties are representative. Only three soil classes are used. Fully irrigated condition used as the baseline from which impacts related to deficit irrigation are computed. Dataset development is limited to the SPNRD and NPNRD. Input data varies in format and development in peripheral areas. Need to run two additional models. Piecemeal approach to developing the .WEL file	CropSim, NPNRD, SPNRD, DNR, USDA soils data bases, various UNL Nebguides and research papers related to crop production	Develops estimates of NIR for WWUM SW model and WWUM GW model. Recieves surface water deliveries and comingled pumping from SW model. Proivdes .RCH file and: GW only pumping for NPNRD and SPNRD, and all pumping from the UNWNRD, TPNRD, ULNRD, and URNRD areas to the GW model	Supports groundwater impact and watershed modeling	Initially developed as part of the COHYST model's western model. Was spun off as part of the WWUM model. TFG updated the watershed model with inputs being developed by NPNRD, SPNRD, HPH, LRE, ARI, WWG.
Economic Framework							
Contingent Valuation	To estimate non-consumptive value of environmental attribute or good	Any	Survey-based, sensitive to how questions framed,			Economics	
Hedonic Pricing	To develop consumptive value of environmental attribute or good	Any	Relies on market data and attributes, can't assess impacts that don't vary across regions, implicitly assumes people actually respond to environmental quality of interest.			Economics	
Hydroeconomic Models	To represent economic impacts associated with water resources management decisions using complex hydrologic, engineering, environmental, and econoimc relationships.	Any	Complex models require large investments in money and human resources.			Economics, possibly integrated with simple surface water routing, groundwater impacts, and GUI capabilities.	
Input-Output Models (IMPLAN, REMI, REDYN, etc.)	To estimate interdependencies across different regional economies resulting from changes in outputs of different goods - changes caused by altered access to water supplies.	Any				Economics	
Separable Costs - Remaining Benefits (SCRB)	To allocate costs among the purposes of multi-purpose projects	Any				Economics	Devised and recommended by the Federal Inter-Agency Subcommittee on Benefits and Costs in its May 1950 report on "Proposed Practices for Economic Analysis of River Basin Projects".
Travel Cost Method	To develop consumptive value of environmental attribute or good	Any	Requires observat ions of number of trips to area of interest, requires regional population and estimates of opportunity costs of time and travel costs.			Economics	
Water Optimizer	Analyze different water management strategies under limited water supplies, and (for multi-field version) evaluate transfers and allocation distributions across multiple fields.	Any - focused on Nebraska		https://agecon.unl.edu/publications/water-optimizer		Economics, and could potentially inform inputs for groundwater and surface water models.	UNL - Ray Supalla and Derrel Martin.
Data Management Subsystem							
DNR WISKI data management system	Platform used by NeDNR to record and manage stream and canal gage data, along with a wide variety of additional data and document formats.	Statewide	Primarily a database only - no major modeling components are directly embedded in WISKI, but many data sources and documents related to other modeling platforms are compiled within WISKI.	Stream and canal gages, along with many other data and document formats.	WISKI includes linkages to related data sources and databases.	Only a suporting role in terms of data management	Developed by Kisters (Europe-based company) for NeDNR.

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