MILK-ST. MARY RIVER SYSTEM BASIN STUDY

A RIVER-SYSTEM MODELING APPROACH TO INVESTIGATING THE EFFECTS OF CLIMATE CHANGE ON FUTURE WATER SUPPLIES AND THE ADEQUACY OF THE EXISTING SYSTEM TO MEET INCREASING WATER DEMANDS, WITH AN ANALYSIS OF OPTIONS FOR THE FUTURE

PURPOSE

The purpose of this Basin Study is to model future operations of the Milk-St. Mary River system to enable the Bureau of Reclamation (Reclamation) and the Department of Natural Resources and Conservation (DNRC) to identify options for meeting increasing water delivery requirements in a changing climate and with an aging infrastructure.

In the Milk River basin, water shortages have been well documented and the primary challenge facing basin residents is securing an adequate supply of water to support municipalities, rural water users, fish, wildlife and recreation, and the region's agricultural economy in the face of these competing demands for a limited water resource. According to Reclamation's 2004 North Central Montana Regional Feasibility Report, the current system of canals and storage reservoirs supply irrigators with only one-third to one-half of the water needed for full crop production in a normal year and Reclamation shortage criteria were exceeded in about two-thirds of the years in the period of record. There is a likelihood that current imbalances between supply and demand will be intensified by the following factors: 1) effects of climate change on decreasing snow pack in headwaters, and resulting changes in the amount and timing of runoff, 2) aging and unreliable diversion and conveyance infrastructure; 3) lack of infrastructure for the U.S. to take its full entitlement of water under the Boundary Waters Treaty, 4) the need to provide water for fish and wildlife, and to protect endangered species, and 5) heightened completion for finite water from impacts associated with potential construction of new storage facilities and expanded irrigation on the Milk River in southern Alberta, and development of Federal reserved water rights on the Fort Belknap and Blackfeet Indian Reservations.

The proposed study would evaluate how changes to the operation of water supply systems, modifications or replacements to existing facilities, and other non-structural changes might be used conjunctively to ease the imbalances between supply and demand and meet future water needs. The effects of new water development in southern Alberta and the development of federal reserved water rights on St. Mary and Milk River water supplies also would be examined. Because DNRC has lost significant storage capacity due to sedimentation in its reservoir on Frenchman Creek, and Reclamation has lost significant storage in Fresno Reservoir, the model could be used to investigate how this loss of storage has affected water supplies and the potential for and benefits of recapturing or expanding reservoir storage in the Milk River watershed.

DESCRIPTION OF STUDY AREA

The project study area is the St. Mary and Milk Rivers in western and north-central Montana. These two rivers are linked by the St. Mary Canal which is owned and operated by Reclamation. Sherburne Reservoir, also a Reclamation facility, is the only major storage reservoir (capacity 67,850 acre-feet) in the United States headwaters of the St. Mary River. The flow of the St. Mary Canal is diverted into the North Fork of the Milk River just upstream of where it crosses the International Boundary. The Milk River then flows for about 200 river miles in southern Alberta, Canada before entering back into Montana at the “Eastern Crossing”. The flows of the Milk River and St. Mary Rivers are split between the United States and Canada by the Treaty.

Fresno Reservoir, which is about 50 miles downstream of the Eastern Crossing, regulates the flow of Milk River water to irrigated lands that begin just below Havre and continue for about 400 miles downstream to the Milk River's confluence with the Missouri River near Glasgow. The numerous irrigation diversion dams and pumping stations along the river supply water to about 140,000 acres. One of these diversions, the Dodson South Canal near Malta, supplies water to Nelson Reservoir, an off-stream Reclamation storage reservoir, and to the Lake Bowdoin National Wildlife Refuge. The Milk River also supplies the municipal water needs of several communities including that for Havre, the largest community in north-central Montana. Map 1 is a location map of the project area. One other important structure in the watershed is the Frenchman Dam, which is a State of Montana owned facility on the Frenchman Creek, the largest Milk River tributary.

WORKPLAN

Reclamation and DNRC will work together to review and refine hydrologic input data, revise and more fully develop the existing DNRC RiverWare model of the Milk-St. Mary system, model scenarios, and consult with stakeholders to increase our ability to meet future water delivery requirements in the watersheds. This workplan will be divided into five elements.

Workplan Element 1 - Review and refine the existing baseline input data for the daily time-step RiverWare model of the Milk-St. Mary River system. Reclamation and DNRC will work together on this workplan element.

Workplan Element 2 - Further develop and refine the existing daily time-step model of the Milk-St. Mary River system that was developed by DNRC, with Reclamation funding assistance. Reclamation and DNRC will work together on the model development and refinements, and train their respective staff on how to use the model.

Workplan Element 3 - Develop model input files for future scenarios that take into account a changing climate and increased future water demands. These input files will be generated by Reclamation with DNRCs input. Elements 1, 2, and 3 will commence and be conducted simultaneously.

Workplan Element 4 - Develop and calibrate the model for baseline conditions, and the future scenarios developed in Element 3. Element 4 will be implemented following completions of Elements 1, 2 and 3.

Workplan Element 5 – Work with stakeholders in the development, modeling, evaluation and prioritization of options and conduct a trade-off analysis of potential solutions.

Workplan Element 6 – With stakeholder input, prepare findings and conclusions and make recommendations, as appropriate, in a report. Reclamation and DNRC will work together with the stakeholders on this workplan element.

WORKPLAN ELEMENT 1

Refine Baseline Input Data for the Milk-St. Mary System Model

The existing DNRC RiverWare model of the Milk-St. Mary system operates on a daily time-step, and simulates system operations for a 1959-2003 base period. The model requires extensive input files that were developed by DNRC, although many of these input files were based on Reclamation's input data for its HYDROS model. Reclamation and DNRC will work together to review and refine these model input files so that they are representative of baseline conditions that exist today.

Tasks

1) *Review base period used in the model and possibly expand:* Model input data is currently available for a 1959-2003 period of record. This period will be updated to include the most recent available hydrologic information, based on data availability and level of effort required. The variability represented by the period of record will be documented to clarify how well it captures drought conditions and wet periods.
2) *Review the streamflow input data used in the model:* Naturalized daily streamflow input files for the 1959-2003 period were compiled by DNRC for the upper St. Mary watershed and the upper Milk River watershed. DNRC also developed historical tributary inflows to the Milk River downstream of Fresno Reservoir which reflect historical tributary operations and depletions above the inflow locations. The data and methods used will be reviewed by Reclamation for accuracy and consistency.
3) *Review irrigation data input files:* Input data used to model irrigation demands includes acres irrigated for each Milk River Project irrigation district, the Fort Belknap Reservation and other users. Canal capacities, irrigation efficiencies, crop water requirements (for each day of the 45-year period), and return flow factors are other required input data. These inputs were developed for the RiverWare model by DNRC, often based on input files from Reclamation's monthly HYDROS model and in some cases other available data. The data and methods used will be reviewed by Reclamation and DNRC, and refined where appropriate. A fresh perspective will be undertaken as well to make diversion demands more representative of specific irrigation requirements typically found in the Milk River Watershed.

4) *Review other input files:* Other input data to be examined include those that characterize municipal water uses, water consumption by riparian vegetation, and evaporation losses from reservoirs and the Milk River channel. Reservoir data files, such as elevation volume tables and outlet capacity tables, will be reviewed and approved by Reclamation.

WORKPLAN ELEMENT 2

Develop and Refine Milk-St. Mary System Model

Improvements and updates are needed so that the RiverWare model can fully represent current operations, and so that the model can simulate the system with infrastructure and operational changes that might be made in the future. Reclamation and DNRC will work together to review the model rules and model structure and make improvements and refinements where necessary.

Tasks

1. *Review simulated operations of the Upper St. Mary River system:* This includes simulating operations of the St. Mary Canal and Sherburne Reservoir to maximize delivery of the U.S. share of St. Mary River flow to the Milk River, while maintaining Canadian shares of flow at the International Boundary per the 1921 Order and Boundary Waters Treaty.
2. *Refine simulated operations of the Milk River in Canada:* This will include review of modeled computations of U.S. and Canada shares of Milk River natural flow and modeling of Canadian consumptive uses. It will include developing the model so that it can simulate future scenarios of increased Canadian water use and potential development of a new Alberta Milk River storage reservoir. Ownership of St. Mary's and Milk River water as it flows through Canada will be tracked to facilitate accurate apportionment of evaporative losses.
3. *Refine simulated operations of Fresno Reservoir:* Current model operating rules for Fresno Reservoir will be reviewed and refined. Logic to track the Tribal and Federal storage accounts in Fresno Reservoir will be developed. Model structure will be implemented that allows flexible definition of Fresno Reservoir storage capacity, enabling studies of future losses of capacity due to sedimentation, and potential future reservoir storage expansions.
4. *Improve simulation of municipal water uses:* This task will further develop the way demands for the city of Havre are represented, separating indoor and outdoor uses. Other municipalities that use Milk River contract water will be added to the model. Modeling of winter releases from Fresno Reservoir for municipal users will be reviewed.
5. *Refine simulations of water deliveries to irrigation districts, The Fort Belknap Tribe, and contract holders:* Model rules that enable sharing of water shortages on Milk River Project irrigated lands will be developed. Model rules that deliver Milk River natural flows to Fort Belknap Indian Reservation demands per the Fort Belknap Compact also will be added.
6. *Refine simulated operations of Dodson South Canal and Nelson Reservoir:* A review of the representation of these facilities will be undertaken including their use in meeting demands for irrigation and the Lake Bowdoin National Wildlife Refuge. Rules to store and release water from Nelson Reservoir for lower Malta and Glasgow Irrigation District irrigation will be further developed and refined. Modeling of water transfers to Nelson Reservoir from Fresno Reservoir will be reviewed and refined.

7. *Review and refine routing of Milk River flows:* The routing of river flows to account for time lags will be reviewed, as will procedures for estimating Milk River channel losses, including evaporation and seepage. The possible need to account for Milk River channel and bank storage in modeling will be assessed.
8. *Develop logic to represent operations on the Frenchman River (tributary)*: The State of Montana Frenchman storage reservoir will be added to the model. This will include the capability of modeling possible future expanded storage in this reservoir. Hydrology inputs and irrigation on the Frenchman River also will be added to the model.
9. *Review and refine overall integrated operations of Milk-St. Mary River system:* This task will be to review and test the model to ensure that the various components are correctly integrated so that it simulates the Milk-St. Mary system as a whole.
10. *Train staff on how to use the model:* Reclamation and DNRC will train their respective technical staff so that they understand the model and can use it.

WORKPLAN ELEMENT 3

Develop Model Input Files that Incorporate a Changing Climate and Increased Water Demands

A surface water hydrologic model will be developed to estimate streamflow runoff in the Milk and St. Mary River watersheds under potential future climate conditions. This information will be used to modify the natural streamflow input data that drives the RiverWare model and allow operation under the future climate to be simulated. Consumptive use needs by irrigated agriculture might change as well with a warming climate. Associated modifications to ET requirements and projected land use changes also will be developed for use in the future conditions model runs. Reclamation staff will be the lead on this element, but DNRC will be involved to learn and help when necessary.

Tasks

1. *Selection, review, and refinement of an appropriate surface water hydrologic model:* A Snow-17/SacSMA (Snow Accumulation and Ablation / Sacramento Soil Moisture Accounting) model of the area is available from NOAA's Missouri Basin River Forecast Center. Developed by Riverside Technologies Inc. in Fort Collins, CO in 2006, this application encompasses the St. Mary headwaters area and the Milk River watershed from its headwaters to its confluence with the Missouri River. Given its recent development and conformity with the proposed study area, this would be the most likely selection for a rainfall/runoff analysis tool to be used in the basin study. An application of the VIC (Variable Infiltration Capacity) model for the study area is also available through the University of Washington. An investigation into which of these applications would best serve the study purpose will be undertaken, and a selection made and justified.
2. *Select Climate Change Scenarios:* A set of 4-6 climate change scenarios produced by combinations of general circulation models, greenhouse gas emissions pathways, and initial conditions will be chosen to represent potential future climate in the Milk-St. Mary

watersheds. These scenarios will be selected to bracket the range of potential climate change for the study area.

3. *Develop downscaled temperature and precipitation inputs for the surface water hydrology model:* Temperature and precipitation results from the selected climate scenarios will be downloaded from the Downscaled Climate Projections archive. The "downscaling" takes data from the more global-scale climate models and translate it to the finer-scale spatial grid needed for this regional assessment. These climate model results will serve as inputs to the surface water hydrologic modeling tool chosen in Task 1.
4. *Run the surface water hydrologic model and produce streamflow input files for the RiverWare model to be used in modeling future scenarios:* The surface water hydrologic model will be run to assess surface water runoff responses in the Milk and St. Mary River watersheds for each climate projection. The projected streamflow runoff produced by the surface water model, under existing and future climate conditions, will be compared and the observed relationships used to make changes to the input streamflow data that is used to drive the RiverWare model. With these data sets, it will then be possible to run the RiverWare model for the selected climate-change scenarios.
5. *Develop revised water demands/land use for future climates:* Consumptive use needs by irrigated agriculture under future climate scenarios will be determined by associated modifications to ET requirements and any projected land use changes assumed as part of the future condition. Crop irrigation requirement and possibly other irrigation input files to the RiverWare model will be modified for modeling the future scenarios.

WORKPLAN ELEMENT 4

Develop and Model Baseline and Future Conditions

A baseline run of the RiverWare model will be prepared, portraying existing facilities and regulatory logic under current hydrologic conditions. The baseline scenario will be calibrated to recent historical hydrologic records for streamflows, storage and deliveries, assuring that the model adequately and appropriately characterizes current river system operations. The calibrated model will then be run with the revised input files that reflect the future climate scenarios. Comparisons between result for the future conditions scenarios and current condition scenario will allow the characterization of potential imbalances between water supply and demand. Based on this comparison and an analysis of water shortages that are identified by the modeling, planning objectives will be developed to guide the development of water management options for addressing these imbalances in Workplan Element 5.

Reclamation and DNRC will work together on this Workplan element with stakeholder input.

Tasks

1. *Refine and calibrate baseline (existing) conditions scenario:* Model output for the 1959-2003 period will be compared with actual recorded streamflow, reservoir, and canal diversion data for same period. Adjustments will be made to model rules and parameters until baseline model output reasonably matches recent historic data.
2. *Model the system for future climate scenarios:* The model will be run for the future climate scenarios using the model input data developed in Workplan Element 3. Future scenario model output will be compared to that for baseline conditions. Water imbalances and shortages that are occurring will be characterized.

WORKPLAN ELEMENT 5
Stakeholders Consultation, Communication Plan, Options Development, and Trade-off Analysis

In the early stages of the study, Reclamation and DNRC will inform stakeholders of the study goals and timelines by attending regular scheduled meetings of stakeholder groups, such as those of the Milk River Joint Board of Control and St. Mary Rehabilitation Working Group, and Blackfeet and Fort Belknap Reservation Tribal Councils. As the study progresses and model results become available, issue/activity-specific meetings will be scheduled with stakeholders to solicit input for developing future water management options and alternatives to model. These options could include structural measures, such as more efficient delivery and irrigation systems, increasing reservoir capacities on the Milk River and tributaries (to provide new stored water or to offset losses in reservoir capacity due to sedimentation), and canal capacity improvements. The options also could include operational changes for reservoirs and canals, or changes in water sharing arrangements during times of shortage. The options will be modeled, performance assessed, and analysis made of the trade-offs associated with the various options with stakeholder input.

Communications Plan:

- Phase I: Information sharing/evaluating level of interest.
- Phase II: Meetings with stakeholders to define issues, modeling scenarios, and constraints (all meetings will be open to the general public as well).
- Phase III: Regular status meetings with stakeholders to report progress and review interim results.
- Phase IV: Initial modeling results, conduct tradeoff analysis, refine as needed.
- Phase V: Draft final report distribution for review and comments.
- Phase VI: Final report distribution. Stakeholder and public meetings as needed.

All stakeholder meetings held jointly by Reclamation and DNRC. These meetings also will be open to the general public. A list of stakeholder groups and entities that might be involved in this effort includes the following.

- *Milk River Joint Board of Control:* Consists of representatives from the eight irrigation districts in the Milk River Valley. Works with Reclamation in developing annual operations plans and in setting annual water allotments.
- *St. Mary Rehabilitation Working Group:* A group of stakeholders that seeks rehabilitation of the St. Mary Canal. Includes representatives from irrigation district, Indian Tribes, municipalities, counties, recreational groups, and local economic development groups.
- *Blackfeet Tribe:* Administers Blackfeet Indian Reservation in the headwaters of the St. Mary and Milk River watersheds. Has substantial Federal Reserved Water Rights in both watersheds.
- *Fort Belknap Indian Reservation:* The Gros Ventre and Assiniboine Tribes of the Fort Belknap Indian Reservation have substantial Federal Reserved Water Rights to the natural flow of the Milk River and some tributaries.
- *Montana Department of Fish, Wildlife, & Parks (MFW&P)*: Responsible for management of Fish and Wildlife Resources in the lower Milk River watershed.
- *International Joint Commission*: The IJC, established by Boundary Waters Treaty of 1909, has six members appointed by the governments of Canada and the U.S.
- *U. S. Fish and Wildlife Service*: Responsible for compliance with the Endangered Species Act.

Other Stakeholders:

- U. S. Geological Survey
- U. S. Bureau of Indian Affairs
- U. S. National Park Service
- Province of Alberta, Canada
- University of Lethbridge, Alberta, Canada

Tasks

1. *Develop criteria for evaluating options:* Because criteria are used for judging options, they must be things that are important to DNRC, Reclamation, and the stakeholders. Candidate criteria should reflect contributions to the study's planning objectives.
2. *Review initial model results with stakeholders:* Validate modeling of baseline conditions with stakeholders. Review interim model results with stakeholders and develop ways of presenting model output so that it is understandable to all.
3. *Model management option:* Options for addressing water imbalances and shortages will be developed. The options will be modeled and their performance assessed. Options will be refined and rerun until model output approaches option goals.
4. *Implement Communication Plan*

WORKPLAN ELEMENT 6
Report

A final report on the study will be developed by Reclamation and DNRC. The final report will document the purpose of the study, methods used, options developed and analyzed, and the results. The fully developed RiverWare model also will be a deliverable of this study.

SCHEDULE

This schedule assumes that the study will commence in November, 2009 and continue for two years, through October, 2011. Workplan Elements 1, 2, and 3 can be worked on concurrently.

Workplan Element 1: Refine Baseline Input Data for the Milk-St. Mary System Model
1. Review base period used in the model: November – December 2009
2. Review the streamflow input data used in the model: January-April 2010
3. Review irrigation data input files: January-April 2010
4. Review other input files: January-April 2010

Workplan Element 2: Develop and Refine Milk-St. Mary System Model
1. Review simulate operations of the Upper St. Mary River system: April-June, 2010
2. Refine simulated operations of the Milk River in Canada: April-June, 2010
3. Refine simulated operations of Fresno Reservoir: April-June, 2010
4. Improve simulation of municipal water uses: April-June, 2010
5. Refine simulations of water deliveries to irrigation districts, The Fort Belknap Tribe and contract holders: July-October, 2010
6. Refine simulated operations of Dodson South Canal and Nelson Reservoir: July-October, 2010
7. Review and refine routing of Milk River flows: July-October, 2010
8. Develop logic to represent operations on the Frenchman River: July-October, 2010
9. Review and refine overall integrated operations of Milk-St. Mary River system: November, 2010

Workplan Element 3: Develop Model Input Files that Incorporate a Changing Climate and Increased Water Demands
1. Selection, review, and refinement of an appropriate surface water hydrologic model: November-December, 2009
2. Select climate scenarios: January – March, 2010
3. Develop downscaled temperature and precipitation inputs for the surface water hydrology model: January – March, 2010
4. Run the surface water hydrologic model and produce streamflow input files for the RiverWare model to be used in modeling future scenarios: April– June, 2010
5. Develop revised water demands/land use for future climates: April-June, 2010

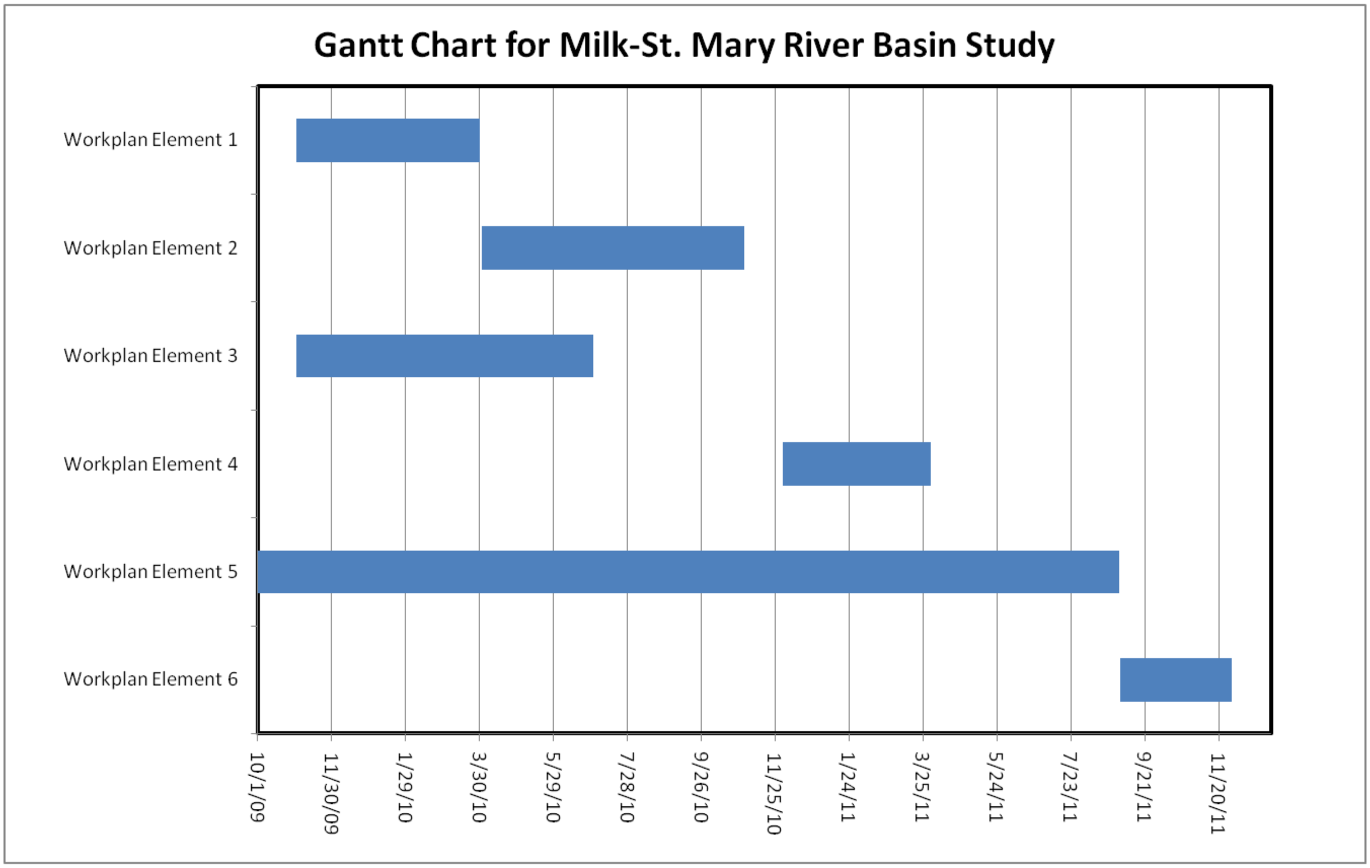
Workplan Element 4: Develop and Model Baseline and Future Conditions
1. Refine and calibrate baseline (existing) conditions scenario: December, 2010-January, 2011
2. Model the system for future climate scenarios: February-March, 2011

Workplan Element 5: Stakeholders Consultation, Options Development, and Trade-off analysis

1. Attend stakeholder meetings to provide background information on study: October-December, 2009
2. Consult with stakeholders on development and modeling of alternatives/options: April – May, 2011
3. Model management option: May-August, 2011

Workplan Element 6: Report

1. Produce Final Report: September-November, 2011



Study Budget

The total costs of this River Basin Study is anticipated to be $700,000, half of which will be provided by Reclamation under the Water for America Program, and half of which will be provided by DNRC through matching. The table below summarizes how study funds will be allocated among the various tasks.

	Reclamation		State of Montana	
	Unit Costs:	$ 1,000.00		$ 500.00
	Days	Amount	Days	Amount
WorkPlan Element 1: Refine Baseline Input Data for RiverWare Model				
Review Model Base Period	5	$ 5,000.00	10	$ 5,000.00
Review Streamflow Input Data Used in Model	20	$ 20,000.00	40	$ 20,000.00
Review Irrigation Data Input Files	20	$ 20,000.00	40	$ 20,000.00
Review Other Input Files	15	$ 15,000.00	30	$ 15,000.00
Workplan Element 2: Develop and Refine RiverWare Model				
Review Simulations to Eastern Crossing of International Boundary	10	$ 10,000.00	20	$ 10,000.00
Refine Simulations of Fresno Rervoir Including Storage Accounting	20	$ 20,000.00	40	$ 20,000.00
Refine Simulations of Water Deliveries for Irrigation and Municipal Use	10	$ 10,000.00	20	$ 10,000.00
Refine Simulations of Operations of Dodson South Canal and Nelson Reservoir	20	$ 20,000.00	40	$ 20,000.00
Refine Routing of Milk River Flows and Accounting of Channel Losses	5	$ 5,000.00	10	$ 5,000.00
Add DNRC Frenchman Reservoir to Model	10	$ 10,000.00	30	$ 15,000.00
Integrate System Operations, Refine Water Allocation and Management Strategies	20	$ 20,000.00	40	$ 20,000.00
Workplan Element 3: Develop Climate Change Input Files for Future Scenarios				
Select/Review/Refine Appropriate SWHM Model Application	10	$ 10,000.00	10	$ 5,000.00
Select Climate Scenarios (GCM/GHG/IC)	5	$ 5,000.00	5	$ 2,500.00
Develop Downscaled Climate Data (temp and precip)	10	$ 10,000.00	10	$ 5,000.00
Perform SWHM Model Runs, Review/Refine, Derive Inputs for RiverWare Model	15	$ 15,000.00	15	$ 7,500.00
Develop Revised Water Demands/Land Use for Future Climates	10	$ 10,000.00	10	$ 5,000.00
Workplan Element 4: Model Baseline and Future Conditions and Options				
Refine and Calibrate Existing Conditions Scenario	20	$ 20,000.00	40	$ 20,000.00
Develop and Refine Future Climate Scenarios	20	$ 20,000.00	40	$ 20,000.00
Model Water Management Options for Addressing Imbalances	30	$ 30,000.00	100	$ 50,000.00
Workplan Element 5: Stakeholder Meetings and Final Report	40	$ 40,000.00	65	$ 32,500.00
Describe Study and Share Study Information				
Develop Alternatives/Options for Addressing Imbalances				
Produce Final Report				
Project Management Activities	25	$ 25,000.00	25	$ 12,500.00
Non-Labor Costs				
Travel		$ 10,000.00		$ 10,000.00
RiverWare licenses, equipment and supplies				$ 20,000.00
Totals		$ 350,000.00		$ 350,000.00