RECLAMATION
Managing Water in the West

Arkansas Basin from John Martin Reservoir to Garden City, Kansas

Plan of Study

Final

Prepared in partnership with:

Bureau of Reclamation, Great Plains Region

Southwest Kansas Groundwater Management District #3

U.S. Department of the Interior
Bureau of Reclamation

August 2015

Mission Statements

The mission of the Department of the Interior is to protect and provide access to our Nation's natural and cultural heritage and honor our trust responsibilities to Indian Tribes and our commitments to island communities.

The mission of the Bureau of Reclamation is to manage, develop, and protect water and related resources in an environmentally and economically sound manner in the interest of the American public.

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List of Acronyms and Abbreviations

af/yr	Acre-foot per year
AVC	Arkansas Valley Conduit
Compact	Arkansas River Compact
GMD	Groundwater Management District
GPRO	Great Plains Regional Office
KWO	Kansas Water Office
MAY	Maximum Annual Yield
MOA	Memorandum of Agreement
NWIS	National Water Information System
OTAO	Oklahoma-Texas Area Office
POS	Plan of Study
Reclamation	Bureau of Reclamation
SWA	Secure Water Act
SWB	Soil Water Balance
TSC	Technical Service Center
USGS	United States Geologic Survey
VIC	Variable Infiltration Capacity

Introduction

Southwest Kansas Groundwater Management District # 3's (GMD3) application for a Plan of Study (POS) was selected through the Bureau of Reclamation's (Reclamation) Basin Study Program. Therefore GMD3 and Reclamation have partnered to develop a POS for a full Basin Study to evaluate water quality issues in the Arkansas River Basin from John Martin Reservoir in Colorado to Garden City, Kansas.

The Basin Study would be carried out under Reclamation's WaterSMART Program pursuant to the authority and mandates of the Secure Water Act (SWA), Subtitle F (P.L. 111-11). Under the SWA, Reclamation can partner with entities in the 17 Western United States to: (1) evaluate projections of water supply and demand within a basin, including an assessment of the risks associated with climate change; (2) analyze how existing water and power infrastructure and operations will perform in the face of increasing demands; (3) develop adaptation and mitigation strategies to meet future demands; and (4) conduct trade-off analyses and make recommendations on strategies to secure present and future water supplies. Detailed information about the requirements of WaterSMART Basin Studies can be found at:
http://www.usbr.gov/watersmart/bsp/index.html

Through the Basin Study Program, Reclamation works in partnership with state and local entities and in collaboration with basin stakeholders to conduct comprehensive studies to define options for meeting future water demands in river basins where imbalances in supply and demand or other issues exist.

This POS describes the need for an effort to address water quality issues and concerns in the area and discusses the preliminary objectives of a full Basin Study. In addition, the POS details the potential Basin study tasks to be undertaken.

Study Objectives

Colorado and Kansas, as well as others are currently working on these issues, however collaboration and coordination between the entities is minimal. Therefore the overarching objective of the proposed Arkansas River Basin Study is to provide a vehicle for the study partners and stakeholders in Colorado and Kansas to develop tools and gather information to assist them to collaboratively develop water management alternatives that enhance water utility and water quality in the Study Area.

GMD3 is actively seeking study partners to participate in a full Basin Study and the addition of study partners would require further discussion of tasks and objectives listed in the POS.

Description of the Study Area

The Arkansas River is the sixth longest river in the United States and a major tributary to the Mississippi-Missouri system. The Arkansas River Basin is the largest river basin within Colorado with over 28,000 square miles of drainage area. The basin covers 27 percent of the surface area of the state. The headwaters of the Arkansas River begin near the Leadville area of the Rocky Mountains in central Colorado. The mainstem flows approximately 330 miles through Colorado in a generally south-southeasterly direction towards Coaldale. The river then turns more easterly, flowing through deep canyons west of Cañon City, Colorado, before exiting the mountains and flowing easterly across the plains to the Colorado-Kansas border. The river eventually flows a total of 1,469 miles into the Mississippi River. Average annual flow of the Arkansas River at the stateline into Kansas is approximately 154,800 acre-feet per year (af/yr). [1] Approximately 270,000 acres are irrigated within the Lower Arkansas Basin in Colorado. Irrigation occurs through surface water diverted downstream of Pueblo and John Martin Reservoirs and alluvial groundwater.

The proposed Study Area consists of the Lower Arkansas Basin in Colorado and the Upper Arkansas Basin in Kansas or from John Martin Reservoir located in Colorado to Garden City, Kansas. Figure 1 shows the Study Area in relation to the Arkansas River Basin, and Figure 2 provides a detailed look at the proposed Study Area.

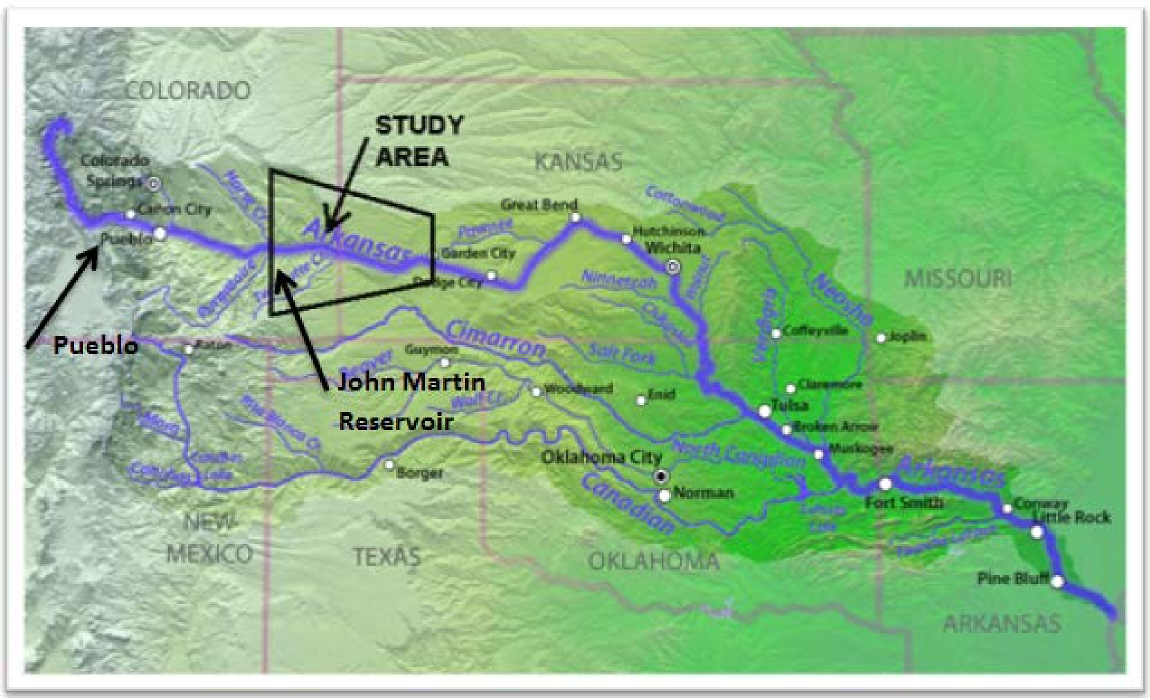

Figure 1 Arkansas River Basin

[1] Arkansas River Decision Support System Feasibility Study, December 2011 Report

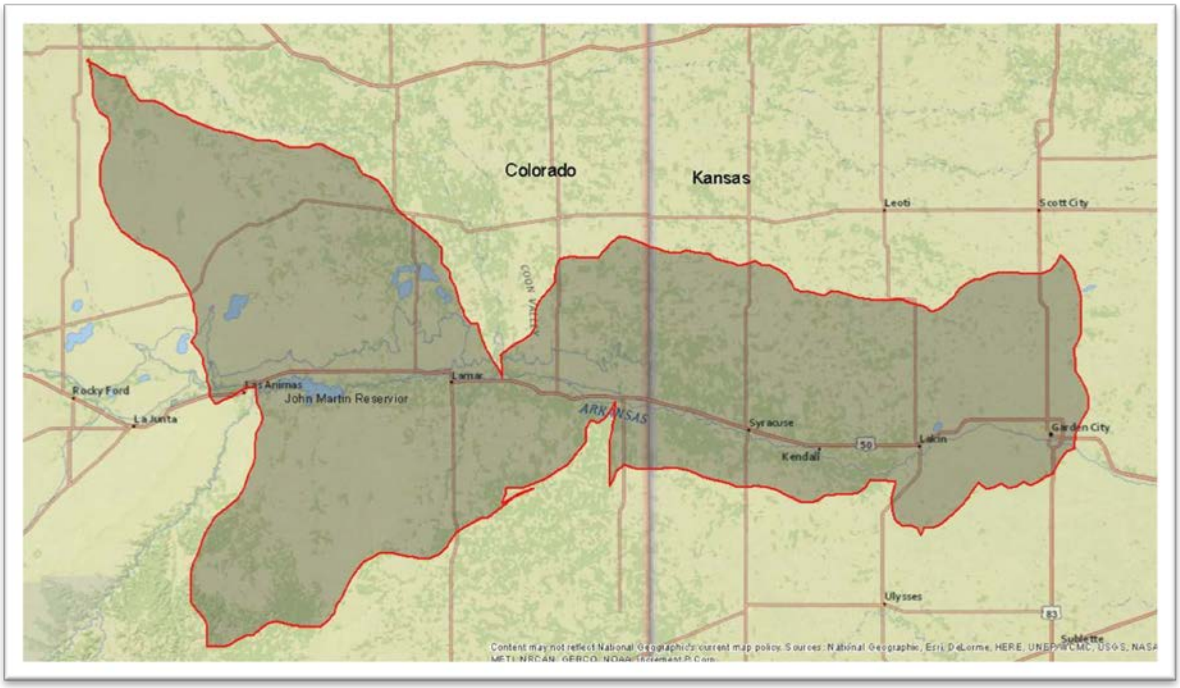

Figure 2: Proposed Study Area

Disclaimer

Additional Study Partners would fully modify and develop the information in this POS in order to accomplish the goals of a Basin Study.

Partners chosing to participate in a POS leading to a Basin Study (Study) understand that a Study provides multi-state collaborative opportunities to explore management alternatives in the context of sustaining a long-term balance between water users and supplies in the Arkansas River Basin. Any findings of a Study do not and will not compromise any state's position in litigation or any other dispute between or among the states, nor will they be binding upon any state as a result of that state's participation. No statements made or positions taken by any state's representatives may be used in any way as part of any present or future dispute between or among the states. However, data, study results, and potential projects generated or exchanged as part of this study may be used by any state for any purpose.

Study findings and analyses do not constitute a position of the Federal government to support or recommend for implementation any adaptation strategies/alternatives identified and evaluated. Reclamation will continue to work within its authorities to collaborate with the Study Partners (i.e. states) as it relates to Federal projects/interests within the Basin, unless otherwise directed by Congress, it is the responsibility and at the discretion of the Study Partners to undertake additional investigations and/or implement the Study adaptation strategies/alternatives.

Background

The Arkansas River Compact (Compact) of 1948 apportions the waters of the Arkansas River between Colorado and Kansas, while providing for the operation of John Martin Reservoir as a shared benefit between the two states. The compact is "not intended to impede or prevent future beneficial development… as well as the improved or prolonged functioning of existing works: Provided, that the waters of the Arkansas river… shall not be materially depleted in usable quantity or availability…"[2] A primary tool agreed to annually for administering the Arkansas River Compact is the 1980 Operating Principles, which provide for storage accounts in John Martin Reservoir and the release of water from those accounts for Colorado and Kansas water users.

Colorado and Kansas have litigated claims concerning Arkansas River water since the early 20th century, which led to the negotiation of the Compact. In 1995, Colorado was found to have depleted usable stateline flows in violation of the Compact through the expanded use of tributary groundwater. As a result, the Colorado State Engineer developed well administration rules to bring Colorado into compliance with the compact, and Colorado compensated Kansas for damage claims (approximately $34 million). Recently, the Colorado State Engineer developed irrigation efficiency rules, which require augmentation for any upgrades to water delivery systems, such as drip irrigation or sprinkler systems. The purpose of the rules are to preserve the historic return flows that comprise part of the historical water supply to Kansas available at the time of the compact.

The Arkansas Basin will face several key concerns and challenges with respect to water management issues and needs over the next 40 years, which are identified as follows[3]:

- Arkansas River Compact requirements, existing uses and water rights result in little to no water availability for junior water rights and new uses. All junior or new uses, and many irrigation efficiency improvements, require augmentation
- Growth in the headwaters region will present challenges to securing augmentation water for new demands
- Concerns over agricultural transfers and the impacts to rural economies are significant in the lower portion of the basin downstream of Pueblo Reservoir
- Recreational in-channel diversions or water rights for recreation will have an impact on the development of augmentation plans for agricultural transfers. The Arkansas River has been called the most rafted river in the world, but those recreational flows could be threatened unless there is continued, thoughtful collaboration on water resources
- Concerns over water quality and suitable drinking water exist in the lower basin
- Possible federal listing of the Arkansas darter fish as a threatened or endangered species could affect water management in the basin
- Replacement of existing municipal supplies, plus growth in urban areas will result in an increase in the demand for municipal water supplies

[2] Arkansas River Decision Support System Feasibility Study, December 2011 Report
[3] Colorado's Water Plan/Draft Chapter 3, 12/10/2014

Water Quality Issues

The Arkansas River has long sustained a belt of valuable agricultural production, an appealing rural lifestyle, and scenic vistas across Colorado's southeastern high plains. Now, it seems that without sound and timely intervention, the Lower Arkansas River Valley (Colorado) eventually may succumb to the ill effects of shallow groundwater tables (waterlogging), excessive salt buildup, and high selenium (Se) concentrations, both on the land and in the larger river ecosystem. Options for mitigating these problems, that are based upon an accurate knowledge of field conditions and that comply with legal and economic constraints, are needed to ensure sustainability of the Valley's productive agricultural base, to preserve and revitalize its rural communities, and to enhance the overall river environment.[4]

In this 2006 report, Colorado State University (CSU) identified the following problems facing irrigated agriculture and the environment in the Lower Arkansas River Basin within Colorado:

- Excess irrigation, canal seepage, and inadequate drainage have contributed to saline shallow groundwater tables and saline soils under irrigated lands throughout the Arkansas River Valley
- Soil water salinity in irrigated fields has been found to range from moderate to high
- Significant reductions in crop yield due to soil water salinity have been documented
- Seepage losses from earthen irrigation canals are substantial
- Excess irrigation and canal seepage contribute to subsurface dissolution of native salts and selenium, and drive these dissolved constituents toward the river
- Salt concentrations in the river water and in applied irrigation water are moderate to high throughout the river valley
- A significant relationship exists between water table depth and salinity of overlying soils
- Selenium concentrations in ground water and in surface waters are moderate to high in the Downstream Study Region
- Upward flow from shallow water tables under fallow ground and under irrigated grounds during the off-season contributes to substantial non-beneficial water consumption
- Soil water salinity and crop evapotranspiration can be accurately estimated using remote sensing with satellite imagery

After the 2006 report, CSU conducted irrigation monitoring during several irrigation seasons in representative study regions upstream and downstream of John Martin

[4] Toward Optimal Water Management in Colorado's Lower Arkansas River Valley,(2006) Timothy K. Gates, Luis A Garcia and John W Labadie

Reservoir and summarized the methods, analysis, results and implications of the monitoring in CWI Completion Report No. 221.[5]

The results and findings in this report indicate that:

- Approximately 50% of applied water is evapo-transpired, concentrating salts in remaining water
- A portion of remaining water percolates downward, causing the water table to rise and groundwater salinity to increase
- Additional salts are dissolved into water from geologic formations (shale and weathered shale); as soils dry between irrigations, saline groundwater flows upward from the water table into the soil root zone - increasing soil salinity and depressing crop yields
- The saline groundwater flow into the Arkansas river is considerably more than the estimated salt loading to the irrigated fields, indicating substantial dissolution of additional salts from shale and shale derived soils

Increasing selenium concentrations in the river and its tributaries derived both from natural and irrigation induced return flows have also become a major concern in the basin. At high concentrations, selenium can be toxic to fish, invertebrates, and birds. Selenium may also pose a risk to humans who eat fish and drink water that contains excessive concentrations. Concentrations of selenium in the Arkansas River in Colorado have regularly been found to exceed the nationally recommended aquatic wildlife standard. [6]

Uranium in the Arkansas River in Southwest Kansas usually exceeds the drinking water maximum contaminant level (MCL) of 30 micrograms per liter. Uranium concentrations are well correlated with conductance in the Arkansas River in Southwest Kansas, allowing estimation of concentrations and loads from conductance monitoring.[7]

The Arkansas Valley Conduit (AVC) was an original feature of the Bureau of Reclamation's Fryingpan-Arkansas (Fry-Ark) Project. The original legislation in 1962 was proposed to deliver drinking water from Pueblo Reservoir to the lower Arkansas River Valley in Colorado, however it was not constructed at that time due to financial limitations. Now in an effort to comply with regulatory requirements of the Safe Drinking Water Act, Congress amended the authorizing legislation of the Fry-Ark Project in 2009, changing the financial limitations and allowing the AVC to proceed. The AVC would serve two needs: (1) to supplement or replace existing poor-quality water to communities downstream from Pueblo Reservoir; and (2) to meet a portion of the AVC participants'

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[5] Irrigation Practices, Water Consumption, and Return Flows in Colorado's Lower Arkansas River Valley, (2012) Timothy K. Gates, Luis A. Garcia, Ryan A. Hemphill, Eric D. Morway, and Aymn Elhaddad.
[6] Filling the Gap, Meeting Future Urban Water Needs in the Arkansas Basin, March 2012, Western Resource advocate, Trout Unlimited, Colorado Environmental Coalition
[7] Conclusions form from Uranium in the Upper Arkansas River and Impact on the Ogallala-High Plains Aquifer presentation by Donald Whittemore at the Water and the future of Kansas Conference

projected water demands through 2070.[8] The proposed AVC would deliver from Pueblo Reservoir to forty towns and rural domestic water supply systems located in Pueblo, Crowley, Otero, Bent, Prowers, and Kiowa counties ending near Lamar.[9]

However, the AVC will not service communities downstream of Lamar (Granada and Holly), nor address water quality issues for individual homesteads and agricultural supplies in Colorado. Eastern Colorado and western Kansas along the Arkansas Valley Basin are experiencing or are at risk for similar water quality issues as are the purposes of the AVC but without the AVC option.

Ground-water declines in the High Plains aquifer have also decreased the amount of fresh subsurface flow to the alluvium that diluted salinity and other constituent concentrations in the past. Another groundwater quality problem in the upper Arkansas River corridor is increasing nitrate concentrations. Municipal groundwater supplies that are or may be impacted by salinity and nitrate contamination include those for Syracuse, Lakin, Deerfield, Holcomb, Garden City, Cimarron, and Dodge City.[10]

The Arkansas River Decision Support System Feasibility Study[11] recongnizes that water quality and quantity are closely linked. This study goes on to state that the needs for the Arkansas Basin include:

1. Tools to help analyze water quality management scenarios in the basin
2. Tools to assess the impacts of water resource management decisions on water quality
3. Need for streamflow forecasting data and tools
4. Need to understand socioeconomic impacts of water resources management decisions
5. Need to incorporate water quality analysis and modeling into the ArkDSS

The City of Lakin cannot meet current drinking water standards for uranium, and is installing a nano-filtration facility, as well as a deep wastewater disposal well, to address these concerns. This is costing Lakin, a city with a population of only 2200, roughly $6 million. The city of Deerfield does currently meet the Environmental Protection Agency's (EPA) MCL for uranium, but uranium levels have increased over time.[12]

The states of Colorado and Kansas, Reclamation, GMD3 and others have funded research into irrigation practices, water consumption and water quality issues in the Study Area. In Colorado, CSU has conducted extensive studies to develop insight into the current water-related problems and to identify promising solution strategies for

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[8] Simulated Effects of Proposed Arkansas Valley Conduit on Hydrodynamics and Water Quality for Projected Demands through 2070, Pueblo Reservoir, Southeastern Colorado, USGS Scientific Investigations Report 2013–5119 August 2008, R.F. Ortiz

[9] Planning and design of the AVC are currently on going.

[10] Upper Arkansas River Corridor Study, A Report to the Kansas Water Office, Donald O. Wittemore

[11] Arkansas River Decision Support System Feasibility Study, December 2011. Prepared for the Colorado Water Conservation Board and the Colorado Division of Water Resources

[12] Conservation with Mark Rude

consideration by water managers and users in deciding how to best meet the needs of the Lower Arkansas River Valley in Colorado.

In Kansas, the Kansas Geological Survey has conducted studies to develop insight into the water quality related concerns of supply and aquifer recharge. This document can be found at http://www.kgs.ku.edu/HighPlains/OHP/2002_30.pdf .

There is a need to address these water quality issues affecting both municipal entities and irrigated agriculture both in Colorado and in Kansas. Interstate cooperation and management is needed to address poor quality basin water that is impacting or threatening additional public and private water supply wells along the Arkansas River corridor and over the Ogallala Aquifer in the study area. Additional protection of the fresh groundwater in the region is critical for municipal, industrial and agricultural uses.[13]

Study Approach

Initial outreach by GMD3 and Reclamation has not yielded any study partners and for a study encompassing the water quality issues in the Arkansas River basin to move forward, it is imperative that a diverse group of stakeholders be involved, as well as the states of Kansas and Colorado. Therefore rather than develop a full scope of work, this POS must be flexible and only generally defines the tasks that the current study partners feel are necessary for a basin study to address the water quality issues in the Arkansas River and basin groundwater.

Institutional Barriers

The Compact is part of a body of federal laws that are applicable to the interstate nature of the basin and apportions waters of the Arkansas River Basin to Colorado and to Kansas. State laws in Colorado and Kansas govern water rights. The Study will need to review and comment on any compact or state laws that could inadverntatly hinder an effort to improve water quality.

The Arkansas River Compact Administration may be the only potential basin wide study partner that has not established an operating office boundary at the Colorado-Kansas Stateline.

Federal agencies boundaries may unintentionally function as institutional barriers limiting communications and collaboration within the proposed study area by potential partners and stakeholders. Each area office has developed its own set of stakeholder partners that may not normally be involved in issues or project concerns outside of the agency office area. Viable solutions to address the water quality problems across the proposed interstate study area may depend significantly on an added level of success in overcoming operational boundaries of federal agencies and other potential study partners in the study area. Federal agencies with operation office boundaries that end at the Colorado-Kansas Stateline in the proposed basin study area include: Reclamation, US

13 Upper Arkansas Basin High Priority Issue Interstate Cooperation to Address Water Quality January 2009, Kansas Water Office

Army Corps of Engineers, EPA, US Geological Survey, and the US Fish and Wildlife Service.

Study Tasks

The following is a synopsis of major tasks and subtasks included in a Basin Study. These study tasks include many of the needs identified in the previous reports by Colorado and Kansas. Future Study Partners would fully modify and develop these tasks in order to accomplish the goals of a Basin Study.

Work for the project falls into the following tasks:

Task 1: Stakeholder and Public Involvement

Task 2: Current and Projected Demands

Task 3: Develop Basin Tools

Task 4: System Reliability and Impact Analysis

Task 5: Identification of Adaptation Strategies

Task 6: Analysis and Recommendations

Task 7: Draft Report Compilation and Review

Task 8: Finalize Report

Task 1: Stakeholder and Public Involvement

Objective: The objective is to develop study partners and determine the scope (extent) of the study. The study partners would refine the study objectives and conduct public outreach with stakeholders. Study partners would develop task, schedule, budget, and roles/responsibilities for achieving study objectives.

Potential study partners and key stakeholder groups may include:

Basin-wide:

- Arkansas River Compact Administration
- Reclamation
- EPA
- U.S. Fish and Wildlife Service
- U.S. Army Corps of Engineers
- U.S. Geological Survey
- U.S. Department of Agriculture, Natural Resource Conservation Service

Kansas:

- Municipalities, Counties, Rural Water Districts and other entities in Upper Arkansas River Basin
- Kansas Department of Health and Environment

- Irrigators and producers
- Upper Arkansas River Basin Advisor committee
- Kansas Department of Wildlife, Parks and Tourism
- Kansas Department of Agriculture, Division of Water Resources
- Kansas Water Office
- County Conservation Districts
- Kansas Geological Survey
- Universities
- Southwest Kansas Groundwater Management District No.3

Colorado:

- Municipalities, Counties, Rural water Districts and other entities in Lower Arkansas River Basin
- Lower Arkansas Valley Super Ditch Company
- District 67 Surface Water Association
- Colorado Water Quality Board
- Arkansas Ground Water users association
- Lower Arkansas Valley Water Conservancy District
- Southeastern Colorado Water Conservancy District
- Groundwater Management conservation Districts
- Colorado Water Conservation Board
- Arkansas River Basin Round Table
- Colorado Division of Parks and Wildlife
- Colorado Geological Survey
- Colorado Department of Public Health and Environment

Stakeholder and Public Involvement Strategies

Stakeholder and public communication and involvement would include a combination of briefings and/or fact sheets, informational meetings, and interactive meetings. Study partners would tailor briefings and/or fact sheets to reach stakeholders and the public within its portion of the study area and seek to inform and involve them in the study. Meetings would be essential for public and stakeholder involvement throughout the study, including kick-off meetings, project update meetings, and project results/recommendations.

Task 2: Existing Supplies and Projected Demands

Objective: Compile information on existing supplies and demands and project future demands. Assess the need for additional information, develop, calibrate, verify, and upload data into modeling tools; and develop no action and action alternatives, as described in this section basin and sub-basin levels. Estimate the effects of projected future climates on water resources, management, quality, and availability for current and future water rights, and natural and ecological water needs.

Existing Supplies

Quantify the existing water supply and present demands in the study area, including but not limited to domestic, municipal, industrial, and agricultural demands

1) Characterize and quantify the surface water supplies in the study area:
    a) Stream flow
        i) Transient loss data - identify additional required
        ii) Components of stream flow
            (1) analyze the availability and quality of information needed to identify the components of streamflow
    b) Surface water diversions
        i) Review for incomplete data
    c) Reservoir Data
        i) Review historic operations of Pueblo reservoir affecting the study area
        ii) Review historic operations of Trinidad reservoir affecting the study area
        iii) Review historic operations and the accounting of water in John Martin reservoir storage
            (1) Methods of determining compact storage
            (2) Efficiencies of accounting

2) Characterize and quantify the groundwater aquifers in the study area:
    a) Review well pumping data for municipal, agricultural and other demands
    b) Understand aquifer configuration and properties. Aquifer configuration includes the horizontal and vertical extent of the aquifers in the study area
        i) Review of the published references is anticipated to reveal that additional data will be needed to better characterize the geologic and aquifer properties of all the alluvial and bedrock aquifer systems
        ii) Identify additional data to be developed: (1) in the upper basin, (2) along the tributaries in the lower basin, and (3) in the bedrock aquifer
        iii) Collect information on the quantity and movement of water in the Paleo Aquifer in Hamilton County, Kansas
    c) Groundwater levels
        i) Continuous water level data should be collected at strategic locations to identify the time varying aspect of return flows
        ii) Identify location of additional monitoring wells required

3) Characterize and quantify the hydraulic interaction between the Arkansas River and its associated tributaries and the aquifers
    a) Characterize the hydraulic interaction between the aquifers
    b) Collect information on the location and timing of return flows to the Arkansas River and its tributaries and the relationship to water quality
    c) Define the impact of water quality on the related use (municipal, irrigation, stock, domestic, industrial)

Projected Demands

Update future demand projections for the purposes of evaluating adaptation strategies

Climate Analysis

Estimate the effects of Climate Variability on demands (agricultural and municipal)

1) Estimate future demands based on projected future climate scenarios
    a) Compile historical meteorological data for baseline conditions
    b) Compile cropping data for baseline conditions
    c) Develop five projected future climate scenarios
    d) Compute three future period demand change projections using daily time-step dual crop coefficient Penman-Monteith Model

2) Analyze the risks to water supply reliability under projected future climate and future water conditions.

3) Develop future climate projections [14]
    a) Characterize future temperature and precipitation
    b) Develop time-series plots for hydroclimate indicator variables for the period 1950-2099, including annual total precipitation, annual mean temperature, April 1 snow equivalent, annual runoff, winter runoff, and spring/summer runoff
    c) Develop spatial plots of the study area showing projected changes in precipitation and temperature computed to a reference period
    d) Develop projections of evapotranspiration and runoff generation through the basin under projected future climate conditions using the Variable Infiltration Capacity (VIC) model
    e) Develop projections of future streamflow at selected points by routing VIC runoff projections to surface-water control points of interest

Task 3: Develop Basin Tools

Objective: The development of scientifically defensible hydrologic and economic modeling tools to ascertain the future water supply quantity and quality. It will include the best available information to aid in conjunctive surface/groundwater management planning. These tools will be used to assess system performance and evaluate structural and/or non-structural management alternatives under current and projected future water supply and demand conditions in support of integrated surface and groundwater management planning in the Basin.

Develop tools to analyze the temporal and spatial patterns of releases and in stream flow, intervening runoff, diversions, and return flows affect the concentration of the constituents of concern.

1) Relate operational releases and river pass-through from John Martin Reservoir to water quality (conductivity (salinity), sulfate, selenium, uranium and others)
    a) Develop an index for evaluating the value of water based on water quality for beneficial uses in the study area
    b) Develop analysis to assess the effects of the climate change scenarios on future water supply projections and quality
    c) Evaluate the impact of potential water conservation improvements to the irrigation lands or systems and the resulting effect to water quality

[14] A minimum of three scenarios will be simulated: (1) warmer, dryer; (2); median; (3) cooler, wetter.

2) Develop tools to evaluate and quantify the hydraulic interaction between the aquifers and the Arkansas River and associated tributaries and ditches
   a) Develop a model to determine the sustainable yield of the Paleo aquifer
   b) Develop pumping models of Dakota wells to minimize the impact of water quality from these wells in Prowers County, Colorado, (Holly and Granada) and Hamilton, Kearny, and Finney Counties (Coolidge and Kendall) of Kansas

Task 4: System Reliability and Impact Analysis

Objective: Assuming a future with no actions (i.e., maintaining the status quo with regards to <u>existing</u> procedures), assess the current and future capability of existing infrastructure and operations to meet demands and water supply challenges, including operational risk and the reliability of the system.

1) Assess impacts on municipal and agricultural operations
   a) Analyze impacts on water quality
   b) Analyze impacts to recreation, fish and wildlife habitat, applicable threatened or endangered species, water quality, and flood control

2) Identify Reclamation opportunities for construction assistance through the Water and Energy Efficiency Grants

3) Evaluate the sustainable yield of a local Paleo Aquifer, a supply of fresh water for Syracuse, Kansas, and other users, which located at the Colorado and Kansas state line, south of the Arkansas River Channel

Task 5: Identification of Adaptation Strategies

Objective: Identify "what if" scenarios and impacts on groundwater and surface water quality. Develop options to improve operations and infrastructure to address water quality in the future.

1) Identify constraints and objectives

2) Formulate viable non-structural strategies for further analysis, including (but not limited to): operational, regulatory, and/or permitting options and legal/institutional implications

3) Evaluate the conjunctive use of operational releases and managed recharge to improve the water quality
   a) Identify alternative strategies for river and reservoir operation, the distributed use of operational releases and intervening flows, including return flows, to improve the water quality. The results of this examination can be used by water administrators and users in the Arkansas Valley to determine how to implement improvements in a way that ensures non-injury to Colorado water users or Kansas water users
   b) Identify potential water conservation improvements to irrigated lands or systems and the resulting effect to water quality
   c) Identify Reclamation opportunities for construction assistance through the Water and Energy Efficiency Grants
   d) Identify opportunities for assistance from USDA grants

   e) Estimate water quality at and below stateline based on stateline flows that are a varied blend of releases from John Martin Reservoir and intervening flows

4) Formulate viable structural alternatives for further analysis

Task 6: Analysis and Recommendations

Objective: Perform a trade-off analysis of the strategies identified, considering screening criteria related to technical aspects; costs, legal, political and regulatory frameworks; environmental impacts; public acceptance; etc.

1) Phase I Preliminary Alternatives Assessment
   a) Evaluate alternatives based on screening criteria; engineering will be based on preliminary design
   b) Select preferred infrastructure alternative(s) to meet planning objectives

2) Phase II Appraisal-Level Assessment
   a) Evaluate alternatives, as necessary, based on four screening criteria; engineering will be based on Reclamation's appraisal-level design standards
   b) Select preferred infrastructure alternative(s) to meet planning objectives

3) Perform financial capability and rate structure analysis on preferred alternative(s)

Task 7: Draft Report Compilation and Review

Objective: Compile draft report and solicit review and comments from study sponsors and stakeholders.

1) Disseminate draft basin study report to Reclamation's Great Plains Regional Office for policy review. Concurrently transmit draft basin study report to study partners for review and comment

2) Incorporate comments and disseminate draft basin study report to agencies and stakeholders for review and comment

3) Incorporate agency/stakeholder comments and disseminate draft basin study report back to study partners for final review and comment

4) Incorporate comments and transmit final draft basin study report to Reclamation's Policy and Administration Office for final policy review and approval

Task 8: Finalize Report

Objective: Complete final reports and disseminate to the public.

1) Disseminate electronic and hard copies of the final report to study partners, agencies, and stakeholders

Schedule
(To be developed)

Budget
(To be developed)

Study Management

This study will be managed jointly by Reclamation and various study partners.

Current Study Managers and Partners

Bureau of Reclamation
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Special Projects Coordinator
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Austin, Texas 78745
512-899-4166

Groundwater Management District #3
Mark Rude
Executive Director
2009 E. Spruce St.
Garden City, Kansas 67846
620- 275-7147

Administrative Record: Study managers from Reclamation and Study Partners will be responsible for maintaining the administrative record of all electronic and paper documents that substantively relate to completion of this study. This will include outreach materials, public comments and in a centralized electronic filing system.

Peer Review Plan
The final report and associated deliverables will undergo discretionary peer review, comprised of both a policy review and technical sufficiency review.

Policy Review

Reclamation's study team, led by Oklahoma-Texas Area Office, will be responsible for ensuring that the basin study adheres to SWA provisions (Section 9503) and Basin Study Framework, as well as Reclamation policy; directives and standards; guidelines with respect to planning; engineering design and cost estimating; hydrology; economics; environmental impacts; or any other technical aspects of the study. Reclamation's Great Plains Regional Office will both perform policy reviews on key deliverables and on draft final study report. The Policy and Administration Office will perform a final policy review on the draft final study report.

Technical Sufficiency Review

Technical memoranda and reports completed at key milestones will be independently reviewed by third party subject matter experts to ensure that the assumptions, findings, and conclusions of the study's scientific information are clearly stated and supported, and that limitations and uncertainties are documented accordingly. Scientific data generated or analyzed by Reclamation will be reviewed by qualified Reclamation technical reviewers not involved with the study. Scientific data and analyses generated by others will be reviewed by various technical agencies. The study leads will have oversight responsibility to ensure technical sufficiency reviews are appropriately conducted.