Exhibit A

Statement of Work

WATER ACTIVITY NAME – Radar Monitoring & Hydrologic Modeling in the Upper Rio Grande Basin to Develop Accurate Streamflow Forecasting

GRANT RECIPIENT – Conejos Water Conservancy District

FUNDING SOURCE – Water Supply Reserve Account - $237,000
($200,000 Statewide; $37,000 Basin)

INTRODUCTION AND BACKGROUND

Erroneous seasonal water supply forecasts in the Upper Rio Grande (URG) River basin have a profound impact on water management, agricultural production and economic vitality. A recent analysis by the Colorado Water Conservation Board (CWCB) and Colorado Division of Water Resources (CDWR) illustrated that seasonal water supply forecasts based primarily on Natural Resources Conservation Service (NRCS) 'SNOw TELemetry' (SNOTEL) data has struggled with accuracy particularly in wet and dry years in the last several years. The high error rate in the Apr. 1 forecasts translates into millions of dollars lost annually due to reduced agricultural productivity on irrigated lands. Working with the DWR Division Engineer the CWCB helped determine that the economic positive and negative impact of those water supply forecast errors were $15.1M in Water Year 2005 and $19.03M in Water Year 2007. According to CDWR Engineer Craig Cotten, "Inaccurate streamflow forecasts can cause unnecessary curtailment of ditches, over- or under-delivery of Colorado's compact obligations, and a disruption of the priority system." Because of such tight operating margins and the unequivocal, severe costs associated with erroneous projections, this project evaluates and implements new data collection, data integration and modeling methods to reduce errors in water supply forecasts.

OBJECTIVES

1. To develop an enhanced in-situ snowpack and hydrologic collection system;
2. To assess new experimental precipitation and snowpack estimation products;
3. To compare those against currently operational products;
4. To develop and evaluate experimental streamflow forecasts in comparison with currently operational forecasts;
5. To share these assessments with the full project team, with water managers in the Upper Rio Grande Basin, and with water users throughout the San Luis Valley;
6. To leave in place, as a legacy of this project, instrumentation from this project, providing water managers nearly twice the in-situ observing capacity in monitoring snowpack, snowmelt and streamflow conditions than they presently have; and
7. To submit a final report by 12/31/14

Task 1 – **District Administration and Direct Costs**

Task 1: Conejos Water Conservancy District Administration and Direct Costs ($27,000)

Description of Task - The District will provide administrative oversight of the project; assist with written reports and otherwise facilitate/support internal and external communication; coordinate and assist with the logistics of the scientific team's bi-weekly telecasts and teleconferences; coordinate stakeholder and other meetings; pursue additional grant funds as the team's needs evolve and as situations may require; assist scientific team in preparing and submitting reports, including periodic and final CWCB reports; provide grant administration and manage invoicing and reimbursement; assist with Rio Grande Basin Roundtable presentations and coordination of public/academic meetings/events; help maintain whatever level of press/media exposure the team wants and help prepare press and media releases as appropriate; provide other administrative/logistical support and assist in troubleshooting, smoothing the way for the entire project, as best we can.

Method/Procedure – To provide assistance to the project from the District Manager and from one part time technical writer / administrative support staff person. The District will provide administrative support, as needed, for all reporting, invoicing, and final deliverable.

Deliverable – The efforts of the various team members and scientists will be supported, saving time, greasing the wheels of communication, and ensuring that the goals of this project are achieved efficiently, promoting optimum human synergy.

Task 2: -- Radar deployment, data collection, and data processing ($0)

This task is not a part of the WSRA funding and contracts. It is being handled in a separate project contract between the CWCB and NOAA using CWCB a separate construction fund appropriation.

Task 3: -- Deploy and Evaluate currently operational snowfall and snowpack estimation products

Description of Task – (a) Purchase of instrumentation; **(b)** Assembly, testing and deployment of instrumentation; and **(c)** data collection/evaluation. In-situ automated measurements of snowdepth and precipitation will be used to evaluate snowfall estimates from the radar and from operational snowpack and precipitation estimates from other sources. Instruments deployed under this grant will complement those being requested with support from the U.S. Bureau of Reclamation and will constitute a legacy observing system in the URG basin over project completion.

Method/Procedure - We will compare measurements from our topographically-distributed network against radar estimated precipitation and against existing NRCS basin-scale snowpack and water supply products, the National Weather Service (NWS)/NOHRSC SNODAS product and the NWS weather model analyses of precipitation and snowpack.

The data feed from most of the sites will be in real-time once per day via cell phone modem or RF-link where feasible. Sites not within real-time communication will be visited and downloaded periodically during the project.

In this manner we will be able to provide real-time assessment of the demonstration radar and existing operational products during the project and we will be able to share these assessments with the full project team and water managers within the URG.

During near peak SWE conditions in late March/early April we will also conduct limited field surveys of SWE conditions across our sites. New instruments for the URG to support this work will be procured, installed, and maintained through funding of $60,000.

Deliverable - The specific deliverables from this Task include

- Updated station, basin and gridded comparisons of snowpack conditions from SNODAS and in situ measurements;
- Weather model validation of predicted precipitation;
- Comparison of energy forcing data from models and in situ observation and observed versus forecasted streamflow conditions from operational products
- These instruments are to be left in the Upper Rio Grande Basin as a legacy of this project, providing water managers nearly twice the in-situ observing capacity in monitoring snowpack, snowmelt and streamflow conditions than they presently have.

TASK 4 – Production and evaluation of hydrologic forecasts

Description of Task - Deploy experimental hydrologic forecast models and assess the performance of experimental and existing operational forecast models against currently operational data and data collected by this project. Funding of $150,000 for this Task will support this hydrological model prediction and evaluation effort and cover direct costs of the team's staff time.

Method/Procedure - The three different hydrological prediction models will be compared and include the NRCS seasonal water supply forecast model, the spatially-distributed and lumped versions of the NWS River Forecast System model and an experimental, physics-based distributed routing version of the operational community Noah land surface model.

Each week we will run each of these models at NCAR in an identical manner to which they are run at the operational center, except that we will use the experimental radar data and available in-situ field measurements to initialize and run the models. Staff will:

- Integrate data, execute and evaluate models and synthesize findings;
- Coordinate the delivery and assessment of each of these products with the project team through bi-weekly web-casts and teleconference;

- Provide team members from the entire project with access to the project web pages where they can view observation and forecast data; and
- Conduct webcasts to go over the most significant results from the project, evaluate differences between currently operational and experimental monitoring products, analyze past forecast performance and discuss future forecasts.

Deliverable - The overarching goal of this task is to evaluate operational streamflow prediction models with spatially-distributed and ground validated precipitation and snowpack information collected as part of this project. In doing so, we will:

- Quantify the impact of the experimental observations;
- Assess the performance of newer, physics-based modeling system against currently operational streamflow prediction models;
- Disseminate the results of these forecast assessments to the project team via the NCAR web portal and the CWCB URG-DSS.
- In this manner, as described above, all project participants will gain a clear understanding of the value of the experimental products in direct contrast to currently operational products.
- During the springtime melt and runoff seasons these forecasts will contribute to the 10-day update reports developed by the CDWR State Engineer.

REPORTING AND FINAL DELIVERABLE

Reporting: The applicant shall provide the CWCB a progress report every 6 months, beginning from the date of the executed contract. The progress report shall describe the completion or partial completion of the tasks identified in the statement of work including a description of any major issues that have occurred and any corrective action taken to address these issues.

Final Deliverable: At completion of the project, the applicant shall provide the CWCB a final report that summarizes the project and documents how the project was completed. This report may contain photographs, summaries of meetings and engineering reports/designs.

BUDGET

B U D G E T				
	WSRA GRANT FUNDS			
	Labor	Direct Costs	Matching Funds	Total Project
Task 1 – District Administration & Direct Costs Plus Matching funds (District's fund-raising and consciousness-raising campaign)	$27,000	(not known yet)	$ 20,000	$ 47,000
Task 2 – NCAR modeling and Interpretation – CWCB funds			$ 215,000	$ 215,000
Task 3 - Procurement, deployment, operation and maintenance of in-situ measurement systems		$ 60,000		$ 60,000
Task 4 - Production and evaluation of hydrologic forecasts	$150,000			$ 150,000
Matching Funds USBR-NCAR Technical Support and expertise – Estimated			$ 89,000	$ 89,000
Total Matching Contributions				
Total Costs:	$177,000	$ 60,000	$ 324,00.00	$561,000
GRANT REQUEST	$ 237,000			

SCHEDULE

Time frame for completion: The field deployment of instrumentation will occur between December 1, 2013 and December 31, 2015. A final report will be completed by December 31, 2015.

Project Timeline:

Task	Project Timeline							
	2014				2015			
	Q1	Q2	Q3	Q4	Q1	Q2	Q3	Q4
Task 1								
District Administration and Direct Costs								
Task 2 (Separate NOAA Contract)								
Radar Deployment, data collection & processing								
Task 3								
Purchase of Instrumentation								
Assembly, Testing and Deployment of Instr.								
Data Collection & Evaluation								
Task 4								
Hydrological Model Setup and Calibration								
Data and Model Integration with RTI-DSS								
Coordinated Data Assimilation w/ Radar								
Operational Streamflow Forecasting								
Report Generation								

- color shading indicates intensity of activity with darker colors indicating more intense activity

PAYMENT

Payment will be made based on actual expenditures and invoicing by the applicant. Invoices from any other entity (i.e. subcontractors) cannot be processed by the State. The request for payment must include a description of the work accomplished by major task, and estimate of the percent completion for individual tasks and the entire water activity in relation to the percentage of budget spent, identification of any major issues and proposed or implemented corrective actions. The last 5 percent of the entire water activity budget will be withheld until final project/water activity documentation is completed. All products, data and information developed as a result of this grant must be provided to the CWCB in hard copy and electronic format as part of the project documentation. This information will in turn be made widely available to Basin Roundtables and the general public and help promote the development of a common technical platform.

Exhibit A

Statement of Work

Full details follow this SOW in Exhibits A-1 and A-2.

WATER ACTIVITY NAME – Radar Monitoring & Hydrologic Modeling in the Upper Rio Grande Basin to Develop Accurate Streamflow Forecasting

GRANT RECIPIENT – Conejos Water Conservancy District

FUNDING SOURCE – Water Supply Reserve Account - $237,000
($200,000 Statewide; $37,000 Basin)

INTRODUCTION AND BACKGROUND
Provide a brief description of the project. (Please limit to **no more than 200 words**; this will be used to inform reviewers and the public about your proposal)

Erroneous seasonal water supply forecasts in the Upper Rio Grande (URG) River basin have a profound impact on water management, agricultural production and economic vitality. A recent analysis by the Colorado Water Conservation Board (CWCB) and Colorado Division of Water Resources (CDWR) illustrated that seasonal water supply forecasts based primarily on Natural Resources Conservation Service (NRCS) 'SNOw TELemetry' (SNOTEL) data has struggled with accuracy particularly in wet and dry years in the last several years. The high error rate in the Apr. 1 forecasts translates into millions of dollars lost annually due to reduced agricultural productivity on irrigated lands. Working with the DWR Division Engineer the CWCB helped determine that the economic positive and negative impact of those water supply forecast errors were $15.1M in Water Year 2005 and $19.03M in Water Year 2007. According to CDWR Engineer Craig Cotten, "Inaccurate streamflow forecasts can cause unnecessary curtailment of ditches, over- or under-delivery of Colorado's compact obligations, and a disruption of the priority system." Because of such tight operating margins and the unequivocal, severe costs associated with erroneous projections, this project evaluates and implements new data collection, data integration and modeling methods to reduce errors in water supply forecasts.

OBJECTIVES

1. To develop an enhanced in-situ snowpack and hydrologic collection system;
2. To assess new experimental precipitation and snowpack estimation products;
3. To compare those against currently operational products;
4. To develop and evaluate experimental streamflow forecasts in comparison with currently operational forecasts;
5. To share these assessments with the full project team, with water managers in the Upper Rio Grande Basin, and with water users throughout the San Luis Valley;
6. To leave in place, as a legacy of this project, instrumentation from this project, providing water managers nearly twice the in-situ observing capacity in monitoring snowpack, snowmelt and streamflow conditions than they presently have; and
7. To submit a final report by 12/31/14

TASKS
Provide a detailed description of each task

Task 1 – **District Administration and Direct Costs**

Task 1: Conejos Water Conservancy District Administration and Direct Costs ($27,000)

Description of Task - The District will provide administrative oversight of the project; assist with written reports and otherwise facilitate/support internal and external communication; coordinate and assist with the logistics of the scientific team's bi-weekly telecasts and teleconferences; coordinate stakeholder and other meetings; pursue additional grant funds as the team's needs evolve and as situations may require; assist scientific team in preparing and submitting reports, including periodic and final CWCB reports; provide grant administration and manage invoicing and reimbursement; assist with Rio Grande Basin Roundtable presentations and coordination of public/academic meetings/events; help maintain whatever level of press/media exposure the team wants and help prepare press and media releases as appropriate; provide other administrative/logistical support and assist in troubleshooting, smoothing the way for the entire project, as best we can.

Method/Procedure – To provide assistance to the project from the District Manager and from one part time technical writer / administrative support staff person. The District will provide administrative support, as needed, for all reporting, invoicing, and final deliverable.

Deliverable – The efforts of the various team members and scientists will be supported, saving time, greasing the wheels of communication, and ensuring that the goals of this project are achieved efficiently, promoting optimum human synergy.

Task 2: -- Radar deployment, data collection, and data processing ($0)

This task is not a part of the WSRA funding and contracts. It is being handled in a separate project contract between the CWCB and NOAA using CWCB a separate construction fund appropriation.

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Description of Task – (a) Purchase of instrumentation; **(b)** Assembly, testing and deployment of instrumentation; and **(c)** data collection/evaluation. In-situ automated measurements of snowdepth and precipitation will be used to evaluate snowfall estimates from the radar and from operational snowpack and precipitation estimates from other sources. Instruments deployed under this grant will complement those being requested with support from the U.S. Bureau of Reclamation and will constitute a legacy observing system in the URG basin over project completion.

Method/Procedure - We will compare measurements from our topographically-distributed network against radar estimated precipitation and against existing NRCS basin-scale snowpack and water supply products, the National Weather Service (NWS)/NOHRSC SNODAS product and the NWS weather model analyses of precipitation and snowpack.

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Deliverable - The specific deliverables from this Task include

- Updated station, basin and gridded comparisons of snowpack conditions from SNODAS and in situ measurements;
- Weather model validation of predicted precipitation;
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- These instruments are to be left in the Upper Rio Grande Basin as a legacy of this project, providing water managers nearly twice the in-situ observing capacity in monitoring snowpack, snowmelt and streamflow conditions than they presently have.

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Description of Task - Deploy experimental hydrologic forecast models and assess the performance of experimental and existing operational forecast models against currently operational data and data collected by this project. Funding of $150,000 for this Task will support this hydrological model prediction and evaluation effort and cover direct costs of the team's staff time.

Method/Procedure - The three different hydrological prediction models will be compared and include the NRCS seasonal water supply forecast model, the spatially-distributed and lumped versions of the NWS River Forecast System model and an experimental, physics-based distributed routing version of the operational community Noah land surface model.

Each week we will run each of these models at NCAR in an identical manner to which they are run at the operational center, except that we will use the experimental radar data and available in-situ field measurements to initialize and run the models. Staff will:

- Integrate data, execute and evaluate models and synthesize findings;
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Deliverable - The overarching goal of this task is to evaluate operational streamflow prediction models with spatially-distributed and ground validated precipitation and snowpack information collected as part of this project. In doing so, we will:

- Quantify the impact of the experimental observations;
- Assess the performance of newer, physics-based modeling system against currently operational streamflow prediction models;
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- In this manner, as described above, all project participants will gain a clear understanding of the value of the experimental products in direct contrast to currently operational products.
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REPORTING AND FINAL DELIVERABLE

Reporting: The applicant shall provide the CWCB a progress report every 6 months, beginning from the date of the executed contract. The progress report shall describe the completion or partial completion of the tasks identified in the statement of work including a description of any major issues that have occurred and any corrective action taken to address these issues.

Final Deliverable: At completion of the project, the applicant shall provide the CWCB a final report that summarizes the project and documents how the project was completed. This report may contain photographs, summaries of meetings and engineering reports/designs.

NOTE: For a full discussion of this Scope of Work, including background, scientific context, multiple benefits, and the integrated collaboration of all participants, please see the following:

Exhibit A-1

Confirms and expands upon this Statement of Work between the Conejos Water Conservancy District and the Colorado Water Conservation Board

Exhibit A-2

Confirms and describes the separate but related contractual relationship between the Conejos Water Conservancy District and NCAR's Research Application Program

EXHIBIT A-1
Improving Streamflow Forecasts in the Upper Rio Grande
A Statement of Work to the Colorado Water Conservation Board
by Conejos Water Conservancy District
Total Contract Amount $237,000

NOTE: This Statement of Work is for Task 1, Tasks 3 and 4 in the WSRA application budget table, which are: administration of the project ($27,000), AND procurement, deployment, operation and maintenance of in-situ measurement systems ($60,000), AND production and evaluation of hydrologic forecasts ($150,000). Task 2 is handled by CWCB and is a contract with NOAA for mobile radar services and is not a part of the WSRA application, funding, or scope of work.

The project timeline as stated in the WSRA application is slipped one year due to late approvals for funding and the federal shutdown. This was agreed to in emails to the CWCB staff by the Rio Grande BRT Chair, CWCB Basin Board member, and local sponsor which is the Conejos Water Conservancy District.

Background:
Erroneous seasonal water supply forecasts in the Upper Rio Grande (URG) River basin have a profound impact on water management, agricultural production and economic vitality. A recent analysis by the Colorado Water Conservation Board (CWCB) and Colorado Division of Water Resources (CDWR) illustrated that seasonal water supply forecasts based primarily on Natural Resources Conservation Service (NRCS) 'SNOw TELemetry' (SNOTEL) data has struggled with accuracy particularly in wet and dry years in the last several years. The high error rate in the Apr. 1 forecasts translates into millions of dollars lost annually due to reduced agricultural productivity on irrigated lands. Working with the DWR Division Engineer the CWCB helped determine that the economic positive and negative impact of those water supply forecast errors were $15.1M in Water Year 2005 and $19.03M in Water Year 2007. According to CDWR Engineer Craig Cotten, "Inaccurate streamflow forecasts can cause unnecessary curtailment of ditches, over- or under-delivery of Colorado's compact obligations, and a disruption of the priority system." Because of such tight operating margins and the unequivocal, severe costs associated with erroneous projections it is imperative that new data collection, data integration and modeling methods are evaluated and implemented to reduce the errors in water supply forecasts.

Over the last six years the CWCB worked with federal and private partners to improve the description of spring snowpack conditions and the use of hydrologic models. One of the snowpack models being used is the NOAA/National Operational Hydrologic Remote Sensing Center's snow model called SNODAS (SNOw Data Assimilation System). Data from SNODAS has been provided to the Rio Grande Division Engineer since 2007. SNODAS is thirty years newer than some of the currently operational forecasting models and offers promise to provide another means of "assessing" our watersheds more comprehensively during the snowmelt part of the hydrologic cycle. One of the recommendations after the final phase of the CWCB-sponsored SNODAS project was to seek more inputs and forcing data for the SNODAS model beyond

SNOTELs and numerical weather prediction model forecasts. Although the CWCB has invested in additional SNOTEL stations, there presently exist only 7 stations in the entire Upper Rio Grande River basin which encompasses over 7,000 square miles. Due to the point nature of SNOTELs and limitations of model forecasts of precipitation, it is anticipated that precipitation radars can provide high-resolution spatial observations. The consensus is that well-calibrated radar data has the potential to simulate the precipitation observations of hundreds of SNOTEL sites that are unfeasible to deploy in Colorado in our lifetime. While the deployment and collection of radar data is supported through a different CWCB contract the work proposed here seeks to obtain support for the deployment of a network of surface instrumentation which will be used to calibrate radar precipitation estimates and to monitor local snowpack and meteorological conditions in the URG. These instruments, to be left in the basin as a legacy of this project, will provide water managers nearly twice the in-situ observing capacity in monitoring snowpack, snowmelt and streamflow conditions than they presently have.

A second and equally important component to improving seasonal water supply forecasts is advancing the state of hydrologic forecasting models. Owing to a sparcity of spatially-distributed data, the West Gulf River Forecast Center and the Natural Resources Conservation Service models in use today are highly calibrated to the few point observations of snowpack and streamflow conditions available in the URG. Given that radical changes in watershed conditions are now occurring due to widespread wildland fire and insect-induced forest mortality, more dynamic or 'evolving' streamflow prediction models are needed. Furthermore, recent court rulings in the URG basin regarding the conjunctive management of hydrologically-connected surface waters and groundwater should also motivate more state-of-the-art modeling approaches. Research and development over the years has lead to new advanced models that can incorporate more accurate spatial snowpack observations, spatially-distribute precipitation estimates that come from radar and additional information from streamflow and groundwater monitoring stations.

This pre-proposal outlines the joint in-situ observation and streamflow modeling components of a larger-scope pilot demonstration project to improve the description and prediction of the full hydrologic cycle in the Upper Rio Grande Basin. A proposal for Phase I funding for this larger project was recently submitted to the Bureau of Reclamation by NCAR; the CWCB was a partner in that proposal, providing the needed cost-sharing funds.

Project Description:

Task 1: Conejos Water Conservancy District Administration and Direct Costs ($27,000)

Description of Task - The District will provide administrative oversight of the project; assist with written reports and otherwise facilitate/support internal and external communication; coordinate and assist with the logistics of the scientific team's bi-weekly telecasts and teleconferences; coordinate stakeholder and other meetings; pursue additional grant funds as the team's needs evolve and as situations may require; assist scientific team in preparing and submitting reports, including periodic and final CWCB reports; provide grant administration and manage invoicing and reimbursement; assist with Rio Grande Basin Roundtable presentations and coordination of public/academic meetings/events; help maintain whatever level of press/media exposure the team wants and help prepare press and media releases as appropriate;

provide other administrative/logistical support and assist in troubleshooting, smoothing the way for the entire project, as best we can.

Method/Procedure – District Manager staff time plus one part time technical writer / administrative support staff person. In order to raise consciousness and appreciation for this project and to enlist broad participation. ,

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Deliverable – The efforts of the various team members and scientists will be supported, saving time, greasing the wheels of communication, and ensuring that the goals of this project are achieved efficiently, promoting optimum human synergy

Task 2: Radar deployment, data collection, and data processing ($0)

As discussed in the WSRA application this task is not a part of the WSRA funding and contracts. It was handled in a separate project contract between the CWCB and NOAA using CWCB a construction fund appropriation.

Task 3: Deploy additional in-situ measurement stations in the URG and evaluate currently operational snowfall and snowpack estimation products. ($60,000)

In-situ automated measurements of snowdepth and precipitation will be used to evaluate snowfall estimates from the radar and from operational snowpack and precipitation estimates from other sources. Instruments deployed under this grant will complement those being requested with support from the U.S. Bureau of Reclamation and will constitute a legacy observing system in the URG basin over project completion. We will compare measurements from our topographically-distributed network against radar estimated precipitation and against existing NRCS basin-scale snowpack and water supply products, the National Weather Service (NWS)/NOHRSC SNODAS product and the NWS weather model analyses of precipitation and snowpack. The data feed from most of the sites will be in real-time once per day via cell phone modem or RF-link where feasible. Sites not within real-time communication will be visited and downloaded periodically during the project. In this manner we will be able to provide real-time assessment of the demonstration radar and existing operational products during the project and we will be able to share these assessments with the full project team and water managers within the URG. Near peak SWE conditions in late March/early April we will also conduct limited field surveys of SWE conditions across our sites. To support this work we are requesting $60,000 for the procurement, installation and maintenance of new instruments in the URG. The specific deliverables from Task 1 include updated station, basin and gridded comparisons of snowpack conditions from SNODAS and in situ measurements, weather model validation of predicted precipitation, comparison of energy forcing data from models and in situ observation and observed versus forecasted streamflow conditions from operational products. Task 3 is not to exceed $60,000.

Task 4: Deploy experimental hydrologic forecast models and assess the performance of experimental and existing operational forecast models against currently operational data and data collected by this project. ($150,000)

The three different hydrological prediction models will be compared and include the NRCS seasonal water supply forecast model, the spatially-distributed and lumped versions of the NWS River Forecast System model and an experimental, physics-based distributed routing version of

the operational community Noah land surface model. Each week we will run each of these models at NCAR in an identical manner to which they are run at the operational center except that we will use the experimental radar data and available in-situ field measurements to initialize and run the models. The overarching goal of this task is to evaluate operational streamflow prediction models with spatially-distributed and ground validated precipitation and snowpack information collected as part of this project. In doing so we will quantify the impact of the experimental observations and we will assess the performance of newer, physics-based modeling system against currently operational streamflow prediction models. We will disseminate the results of these forecast assessments to the project team via the NCAR web portal and the CWCB URG-DSS. During the springtime melt and runoff seasons these forecasts will contribute to the 10-day update reports developed by the CDWR State Engineer. To support this hydrological model prediction and evaluation effort we request $150,000 to cover staff time to integrate data, execute and evaluate models and synthesize findings. Under this task we will coordinate the delivery and assessment of each of these products with the project team through bi-weekly web-casts and teleconference where team members from the entire project will be provided with access to the project web pages where they can view observation and forecast data as they please. We will also conduct webcasts to go over the most significant results from the project, evaluate differences between currently operational and experimental monitoring products, analyze past forecast performance and discuss future forecasts. In this manner, all project participants will gain a clear understanding of the value of the experimental products in direct contrast to currently operational products.

Time frame for completion: The field deployment of instrumentation will occur between 1 December 2013 and 31 December 2015. A final report will be completed by 31 December 2015. A full timeline of the project tasks and timeline is shown below.

Estimated Budget: $150,000 (Aforementioned $60,000 for instrumentation will stay with the Conejos Irrigation District for purchase and ownership. NCAR will consult on those purchases and will perform installation and management of instrumentation for project duration.)

Project Deliverables

The deliverables from this project will be an enhanced in-situ snowpack and hydrologic collection system, assessments of new experimental precipitation and snowpack estimation products compared against currently operational products and the development and evaluation of experimental streamflow forecasts and their comparison with currently operational forecasts. A final report will be delivered by 31 Dec. 2015.

EXHIBIT A-2
Improving Streamflow Forecasts in the Upper Rio Grande
A Statement of Work to the Conejos Water Conservancy District
by NCAR's Research Applications Program
Total Contract Amount $210,000

NOTE: This Statement of Work is for Tasks 3 and 4 in the WSRA application budget table, which are procurement, deployment, operation and maintenance of in-situ measurement systems ($60,000) AND production and evaluation of hydrologic forecasts ($150,000). Task 1 is handled in separate contract between the Conejos WCD and CWCB. Task 2 is handled in a separate contract between NOAA and CWCB and uses a CWCB construction fund allocation not WSRA funding.

The project timeline as stated in the WSRA application is slipped one year due to late approvals for funding and the federal shutdown. This was agreed to in emails to the CWCB staff by the Rio Grande BRT Chair, CWCB Basin Board member, and local sponsor which is the Conejos Water Conservancy District.

Background:

Erroneous seasonal water supply forecasts in the Upper Rio Grande (URG) River basin have a profound impact on water management, agricultural production and economic vitality. A recent analysis by the Colorado Water Conservation Board (CWCB) and Colorado Division of Water Resources (CDWR) illustrated that seasonal water supply forecasts based primarily on Natural Resources Conservation Service (NRCS) 'SNOw TELemetry' (SNOTEL) data has struggled with accuracy particularly in wet and dry years in the last several years. The high error rate in the Apr. 1 forecasts translates into millions of dollars lost annually due to reduced agricultural productivity on irrigated lands. Working with the DWR Division Engineer the CWCB helped determine that the economic positive and negative impact of those water supply forecast errors were $15.1M in Water Year 2005 and $19.03M in Water Year 2007. According to CDWR Engineer Craig Cotten, "Inaccurate streamflow forecasts can cause unnecessary curtailment of ditches, over- or under-delivery of Colorado's compact obligations, and a disruption of the priority system." Because of such tight operating margins and the unequivocal, severe costs associated with erroneous projections it is imperative that new data collection, data integration and modeling methods are evaluated and implemented to reduce the errors in water supply forecasts.

Over the last six years the CWCB worked with federal and private partners to improve the description of spring snowpack conditions and the use of hydrologic models. One of the snowpack models being used is the NOAA/National Operational Hydrologic Remote Sensing Center's snow model called SNODAS (SNOw Data Assimilation System). Data from SNODAS has been provided to the Rio Grande Division Engineer since 2007. SNODAS is thirty years newer than some of the currently operational forecasting models and offers promise to provide another means of "assessing" our watersheds more comprehensively during the snowmelt part of the hydrologic cycle. One of the recommendations after the final phase of the CWCB-sponsored

SNODAS project was to seek more inputs and forcing data for the SNODAS model beyond SNOTELs and numerical weather prediction model forecasts. Although the CWCB has invested in additional SNOTEL stations, there presently exist only 7 stations in the entire Upper Rio Grande River basin which encompasses over 7,000 square miles. Due to the point nature of SNOTELs and limitations of model forecasts of precipitation, it is anticipated that precipitation radars can provide high-resolution spatial observations. The consensus is that well-calibrated radar data has the potential to simulate the precipitation observations of hundreds of SNOTEL sites that are unfeasible to deploy in Colorado in our lifetime. While the deployment and collection of radar data is supported through a different CWCB contract the work proposed here seeks to obtain support for the deployment of a network of surface instrumentation which will be used to calibrate radar precipitation estimates and to monitor local snowpack and meteorological conditions in the URG. These instruments, to be left in the basin as a legacy of this project, will provide water managers nearly twice the in-situ observing capacity in monitoring snowpack, snowmelt and streamflow conditions than they presently have.

A second and equally important component to improving seasonal water supply forecasts is advancing the state of hydrologic forecasting models. Owing to a sparcity of spatially-distributed data, the West Gulf River Forecast Center and the Natural Resources Conservation Service models in use today are highly calibrated to the few point observations of snowpack and streamflow conditions available in the URG. Given that radical changes in watershed conditions are now occurring due to widespread wildland fire and insect-induced forest mortality, more dynamic or 'evolving' streamflow prediction models are needed. Furthermore, recent court rulings in the URG basin regarding the conjunctive management of hydrologically-connected surface waters and groundwater should also motivate more state-of-the-art modeling approaches. Research and development over the years has lead to new advanced models that can incorporate more accurate spatial snowpack observations, spatially-distribute precipitation estimates that come from radar and additional information from streamflow and groundwater monitoring stations.

This pre-proposal outlines the joint in-situ observation and streamflow modeling components of a larger-scope pilot demonstration project to improve the description and prediction of the full hydrologic cycle in the Upper Rio Grande Basin. A proposal for Phase I funding for this larger project was recently submitted to the Bureau of Reclamation by NCAR; the CWCB was a partner in that proposal, providing the needed cost-sharing funds.

Project Description:

Task 1: This is administration of the whole Project at the local level as discussed in the WSRA application. This task is not part of this contract between Conejos WCD and NCAR**.** It will be a task in the contract between the CWCB and Conejos WCD.

Task 2: This is radar deployment, data collection, and data processing as discussed in the WSRA application. It is not a part of the WSRA funding and contracts. It was handled in a separate project contract between the CWCB and NOAA using CWCB a construction fund appropriation.

Task 3: Deploy additional in-situ measurement stations in the URG and evaluate currently operational snowfall and snowpack estimation products. In-situ automated measurements of snowdepth and precipitation will be used to evaluate snowfall estimates from the radar and from operational snowpack and precipitation estimates from other sources. Instruments deployed under this grant will complement those being requested with support from the U.S. Bureau of Reclamation and will constitute a legacy observing system in the URG basin over project completion. We will compare measurements from our topographically-distributed network against radar estimated precipitation and against existing NRCS basin-scale snowpack and water supply products, the National Weather Service (NWS)/NOHRSC SNODAS product and the NWS weather model analyses of precipitation and snowpack. The data feed from most of the sites will be in real-time once per day via cell phone modem or RF-link where feasible. Sites not within real-time communication will be visited and downloaded periodically during the project. In this manner we will be able to provide real-time assessment of the demonstration radar and existing operational products during the project and we will be able to share these assessments with the full project team and water managers within the URG. Near peak SWE conditions in late March/early April we will also conduct limited field surveys of SWE conditions across our sites. To support this work we are requesting $60,000 for the procurement, installation and maintenance of new instruments in the URG. The specific deliverables from Task 1 include updated station, basin and gridded comparisons of snowpack conditions from SNODAS and in situ measurements, weather model validation of predicted precipitation, comparison of energy forcing data from models and in situ observation and observed versus forecasted streamflow conditions from operational products. Task 3 is not to exceed $60,000.

Task 4: Deploy experimental hydrologic forecast models and assess the performance of experimental and existing operational forecast models against currently operational data and data collected by this project. The three different hydrological prediction models will be compared and include the NRCS seasonal water supply forecast model, the spatially-distributed and lumped versions of the NWS River Forecast System model and an experimental, physics-based distributed routing version of the operational community Noah land surface model. Each week we will run each of these models at NCAR in an identical manner to which they are run at the operational center except that we will use the experimental radar data and available in-situ field measurements to initialize and run the models. The overarching goal of this task is to evaluate operational streamflow prediction models with spatially-distributed and ground validated precipitation and snowpack information collected as part of this project. In doing so we will quantify the impact of the experimental observations and we will assess the performance of newer, physics-based modeling system against currently operational streamflow prediction models. We will disseminate the results of these forecast assessments to the project team via the NCAR web portal and the CWCB URG-DSS. During the springtime melt and runoff seasons these forecasts will contribute to the 10-day update reports developed by the CDWR State Engineer. To support this hydrological model prediction and evaluation effort we request $150,000 to cover staff time to integrate data, execute and evaluate models and synthesize findings. Under this task we will coordinate the delivery and assessment of each of these products with the project team through bi-weekly web-casts and teleconference where team members from the entire project will be provided with access to the project web pages where they can view observation and forecast data as they please. We will also conduct webcasts to go over the most significant results from the project, evaluate differences between currently

operational and experimental monitoring products, analyze past forecast performance and discuss future forecasts. In this manner, all project participants will gain a clear understanding of the value of the experimental products in direct contrast to currently operational products.

Time frame for completion: The field deployment of instrumentation will occur Notice to Proceed and 31 December 2015. A final report will be completed by 31 December 2015. A full timeline of the project tasks and timeline is shown below.

Estimated Budget: $150,000 (Aforementioned $60,000 for instrumentation will stay with the Conejos Irrigation District for purchase and ownership. NCAR will consult on those purchases and will perform installation and management of instrumentation for project duration.)

Project Deliverables

The deliverables from this project will be an enhanced in-situ snowpack and hydrologic collection system, assessments of new experimental precipitation and snowpack estimation products compared against currently operational products and the development and evaluation of experimental streamflow forecasts and their comparison with currently operational forecasts. A final report will be delivered by 31 Dec. 2015.

BUDGET

B U D G E T				
	WSRA GRANT FUNDS			
	Labor	Direct Costs	Matching Funds	Total Project
Task 1 – District Administration & Direct Costs Plus Matching funds (District's fund-raising and consciousness-raising campaign)	$27,000	(not known yet)	$ 20,000	$ 47,000
Task 2 – NCAR modeling and Interpretation – CWCB funds			$ 215,000	$ 215,000
Task 3 - Procurement, deployment, operation and maintenance of in-situ measurement systems		$ 60,000		$ 60,000
Task 4 - Production and evaluation of hydrologic forecasts	$150,000			$ 150,000
Matching Funds USBR-NCAR Technical Support and expertise – Estimated			$ 89,000	$ 89,000
Total Matching Contributions				
Total Costs:	$177,000	$ 60,000	$ 324,00.00	$561,000
GRANT REQUEST	$ 237,000			

SCHEDULE

Time frame for completion: The field deployment of instrumentation will occur between December 1, 2013 and December 31, 2015. A final report will be completed by December 31, 2015.

Project Timeline:

Task	Project Timeline							
	2014				2015			
	Q1	Q2	Q3	Q4	Q1	Q2	Q3	Q4
Task 1								
District Administration and Direct Costs								
Task 2 (Separate NOAA Contract)								
Radar Deployment, data collection & processing								
Task 3								
Purchase of Instrumentation								
Assembly, Testing and Deployment of Instr.								
Data Collection & Evaluation								
Task 4								
Hydrological Model Setup and Calibration								
Data and Model Integration with RTI-DSS								
Coordinated Data Assimilation w/ Radar								
Operational Streamflow Forecasting								
Report Generation								

- color shading indicates intensity of activity with darker colors indicating more intense activity

PAYMENT

Payment will be made based on actual expenditures and invoicing by the applicant. Invoices from any other entity (i.e. subcontractors) cannot be processed by the State. The request for payment must include a description of the work accomplished by major task, and estimate of the percent completion for individual tasks and the entire water activity in relation to the percentage of budget spent, identification of any major issues and proposed or implemented corrective actions. The last 5 percent of the entire water activity budget will be withheld until final project/water activity documentation is completed. All products, data and information developed as a result of this grant must be provided to the CWCB in hard copy and electronic format as part of the project documentation. This information will in turn be made widely available to Basin Roundtables and the general public and help promote the development of a common technical platform.

Appendix 1
Reference Information

The following information is available via the internet. The reference information provides additional detail and background information.

- Water Supply Reserve Account main webpage:
  - http://cwcb.state.co.us/LoansGrants/water-supply-reserve-account-grants/Pages/main.aspx
- Water Supply Reserve Account – Basin Fund Application Details:
  - http://cwcb.state.co.us/LoansGrants/water-supply-reserve-account-grants/Pages/BasinWaterSupplyReserveAccountGrants.aspx
- Water Supply Reserve Account – Statewide Fund Application Details:
  - http://cwcb.state.co.us/LoansGrants/water-supply-reserve-account-grants/Pages/StatewideWaterSupplyReserveAccountGrants.aspx
- Colorado Water Conservation Board main website:
  - http://cwcb.state.co.us/
- Interbasin Compact Committee and Basin Roundtables:
  - http://cwcb.state.co.us/about-us/about-the-ibcc-brts/Pages/main.aspx/Templates/BasinHome.aspx
- House Bill 05-1177 – (Also known as the Water for the 21st Century Act):
  - http://cwcbweblink.state.co.us/DocView.aspx?id=105662&searchhandle=28318
- House Bill 06-1400 – (Adopted the Interbasin Compact Committee Charter):
  - http://cwcbweblink.state.co.us/DocView.aspx?id=21291&searchhandle=12911
- Senate Bill 06-179 – (Created the Water Supply Reserve Account):
  - http://cwcbweblink.state.co.us/DocView.aspx?id=21379&searchhandle=12911
- Statewide Water Supply Initiative 2010:
  - http://cwcb.state.co.us/water-management/water-supply-planning/Pages/SWSI2010.aspx

Appendix 2
Insurance Requirements

NOTE: The following insurance requirements taken from the standard contract apply to WSRA projects that exceed $25,000 in accordance with the policies of the State Controller's Office. Proof of insurance as stated below is necessary prior to the execution of a contract.

13. INSURANCE

Grantee and its Sub-grantees shall obtain and maintain insurance as specified in this section at all times during the term of this Grant: All policies evidencing the insurance coverage required hereunder shall be issued by insurance companies satisfactory to Grantee and the State.

A. Grantee

i. Public Entities

If Grantee is a "public entity" within the meaning of the Colorado Governmental Immunity Act, CRS §24-10-101, et seq., as amended (the "GIA"), then Grantee shall maintain at all times during the term of this Grant such liability insurance, by commercial policy or self-insurance, as is necessary to meet its liabilities under the GIA. Grantee shall show proof of such insurance satisfactory to the State, if requested by the State. Grantee shall require each Grant with Sub-grantees that are public entities, providing Goods or Services hereunder, to include the insurance requirements necessary to meet Sub-grantee's liabilities under the GIA.

ii. Non-Public Entities

If Grantee is not a "public entity" within the meaning of the GIA, Grantee shall obtain and maintain during the term of this Grant insurance coverage and policies meeting the same requirements set forth in **§13(B)** with respect to sub-Grantees that are not "public entities".

B. Sub-Grantees

Grantee shall require each Grant with Sub-grantees, other than those that are public entities, providing Goods or Services in connection with this Grant, to include insurance requirements substantially similar to the following:

i. Worker's Compensation

Worker's Compensation Insurance as required by State statute, and Employer's Liability Insurance covering all of Grantee and Sub-grantee employees acting within the course and scope of their employment.

ii. General Liability

Commercial General Liability Insurance written on ISO occurrence form CG 00 01 10/93 or equivalent, covering premises operations, fire damage, independent Grantees, products and completed operations, blanket Grantual liability, personal injury, and advertising liability with minimum limits as follows: **(a)**$1,000,000 each occurrence; **(b)** $1,000,000 general aggregate; **(c)** $1,000,000 products and completed operations aggregate; and **(d)** $50,000 any one fire. If any aggregate limit is reduced below $1,000,000 because of claims made or paid, Sub-grantee shall immediately obtain additional insurance to restore the full aggregate limit and furnish to Grantee a certificate or other document satisfactory to Grantee showing compliance with this provision.

iii. Automobile Liability

Automobile Liability Insurance covering any auto (including owned, hired and non-owned autos) with a minimum limit of $1,000,000 each accident combined single limit.

iv. Additional Insured

Grantee and the State shall be named as additional insured on the Commercial General Liability and Automobile Liability Insurance policies (leases and construction Grants require additional insured coverage for completed operations on endorsements CG 2010 11/85, CG 2037, or equivalent).

v. Primacy of Coverage

Coverage required of Grantee and Sub-grantees shall be primary over any insurance or self-insurance program carried by Grantee or the State.

vi. Cancellation

The above insurance policies shall include provisions preventing cancellation or non-renewal without at least 45 days prior notice to the Grantee and the State by certified mail.

vii. Subrogation Waiver

All insurance policies in any way related to this Grant and secured and maintained by Grantee or its Sub-grantees as required herein shall include clauses stating that each carrier shall waive all rights of recovery, under subrogation or otherwise, against Grantee or the State, its agencies, institutions, organizations, officers, agents, employees, and volunteers.

C. Certificates

Grantee and all Sub-grantees shall provide certificates showing insurance coverage required hereunder to the State within seven business days of the Effective Date of this Grant. No later than 15 days prior to the expiration date of any such coverage, Grantee and each Sub-grantee shall deliver to the State or Grantee certificates of insurance evidencing renewals thereof. In addition, upon request by the State at any other time during the term of this Grant or any sub-grant, Grantee and each Sub-grantee shall, within 10 days of such request, supply to the State evidence satisfactory to the State of compliance with the provisions of this **§13**.

Appendix 3
Water Supply Reserve Account Standard Contract Information

NOTE: The standard contract is required for WSRA projects that exceed $100,000. (Projects under this amount will normally be funded through a purchase order process.) Applicants are encouraged to review the standard contract to understand the terms and conditions required by the State in the event a WSRA grant is awarded. Significant changes to the standard contract require approval of the State Controller's Office and often prolong the contracting process.

It should also be noted that grant funds to be used for the purchase of real property (e.g. water rights, land, conservation easements, etc.) will require additional review and approval. In such cases applicants should expect the grant contracting process to take approximately 3 to 6 months from the date of CWCB approval.

The standard contract is available here under the header "Additional Resources" on the right side:
http://cwcb.state.co.us/LoansGrants/water-supply-reserve-account-grants/Pages/BasinWaterSupplyReserveAccountGrants.aspx

Appendix 4
W-9 Form

NOTE: A completed W-9 form is required for all WSRA projects prior execution of a contract or purchase order. Please submit this form with the completed application.