## Statement of Work

**WATER ACTIVITY NAME** - Improvement of lysimeter operations and consumptive use quantification in high-altitude, irrigated meadows in the Yampa /White Basin.

**Colorado Climate Center and Colorado Division of Water Resources**

**INTRODUCTION AND BACKGROUND**

In an effort to improve the quantification of consumptive use in the high-altitude meadow environments of the Yampa/White basin, a new lysimeter testing site is being proposed to be installed at the Carpenter Ranch owned by the Nature Conservancy. A recent evaluation of the historical lysimeter data and derived crop coefficients in the Yampa/White basin were determined to be questionable due to method of lysimeter operation and its representativeness of the actual meadow irrigation operations in the Yampa basin which are not continuously flooded. As a result of this, it was decided that a new lysimeter monitoring effort would benefit the basin.

The plan for this site is to install four bucket lysimeters that will be weighed weekly. Two of the lysimeters will be seeded with an ET grass reference crop and the other two will be seeded to mimic the irrigated meadow environment surrounding the lysimeters. From the lysimeter observations, new crop coefficients can be determined and compared to those derived from historical lysimeter observations to see how they vary.

In addition to installing bucket lysimeters, an automated weather station will also be installed that collects temperature, humidity, solar radiation, wind speed and direction, soil temperature and precipitation. The weather station data will be used to calculate evapotranspiration using the ASCE Standardized Penman-Moneith equation. Once these calculations are made, the ASCE ET estimates can be calibrated to temperature based equations, like Hargreaves. This relationship can then be used to estimate ET from the ASCE equation using only temperature observations which can be taken at a finer spatial resolution to monitor the entire basin.

**OBJECTIVES:**

**TASKS**
Provide a detailed description of each task using the following format

**TASK 1 – Installation**
Description of Task - Installation of lysimeters and weather station will be conducted on the West end of Carpenter Ranch to minimize effects of the power plant. Two lysimeters will be seeded with Grass ET reference crop and two seeded with representative meadow species.

Method/Procedure - Work with Carpenter Ranch and Division 6 Water Resources staff to locate representative locations for lysimeters and weather station. Colorado Climate Center staff will install and maintain the weather station and data collection. Carpenter Ranch and Division 6 Water Resources staff will maintain the lysimeters and take observations.

Deliverable – Photos and data collected.

**TASK 2 – Development of Crop Coefficients**

Description of Task - Use data from the bucket lysimeters to calculated crop coefficients. These coefficients can then be applied to any future weather-based calculations of ET.

Method/Procedure - The use of two different species on the plots will provide both a grass ET reference and a crop ET. From these two measurements, crop coefficients can be determined directly.

Deliverable- Crop coefficients.

**TASK 3 –Calculate Crop ET**

Description of Task - Calibration of ASCE ET weather based calculations to temperature-based Hargreaves method.

Method/Procedure - Use weather station data to calculate ASCE standardized equation grass reference ET. These estimates will then be calibrated to the Hargreaves temperature based method. Once this relationship is established and crop coefficients are determined, crop ET can be determined anywhere in the basin temperature is monitored.

Deliverable- Summary of findings.

**SCHEDULE**

Provide a project schedule including key milestones for each task and the completion dates or time period from the Notice to Proceed (NTP). This dating method allows flexibility in the event of potential delays from the procurement process. Sample schedules are provided below. Please note that these schedules are examples and will need to be adapted to fit each individual application.

Task 1 – Installation April 2011
Task 2 – Development of Crop ET April through October 2011, 2012, 2013, 2014, and 2015
Task 3 – Calculate Crop ET Final Report deliverable December 15, 2015.

**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.

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**Colorado State University**

**Improvement of lysimeter operations and consumptive use quantification in high-altitude, irrigated meadows in the Yampa/White Basin**

**CWCB Water Supply Reserve Account Budget**

| | | Yr 1 | Yr 2 | Yr 3 | Yr 4 | Yr 5 | Total |
|---|---|---|---|---|---|---|---|
| **Equipment** | | | | | | | |
| Weather Station* | Breakdown for year 1 is below | 9,731 | 1,667 | 1,667 | 1,667 | 1,667 | 16,399 |
| Lysimeter | | 1,083 | - | - | - | - | 1,083 |
| **Total Direct Costs** | | 10,814 | 1,667 | 1,667 | 1,667 | 1,667 | 17,482 |
| **IDC @ 20% TDC** | | 2,164 | 333 | 333 | 333 | 333 | 3,496 |
| **Total** | | 12,978 | 2,000 | 2,000 | 2,000 | 2,000 | 20,978 |

*Includes Operation and Maintenance Cost of $2k/year

Justification:
Equipment needed to install a weather station and lysimeters on the West end of Carpenter Ranch
*breakdown

| Instrument | Description | Unit cost |
|---|---|---|
| CR1000 | Data Logger | $1,440.00 |
| CM6 | 6 Foot Instrument Tripod | $475.00 |
| CM206 | Crossarm | $96.00 |
| 015ARM | Pyranometer Mounting Arm | $85.00 |
| SC12 | Datalogger Connector Cable | $14.50 |
| CM220 | Right Angle Mounting Kit | $28.00 |
| 1049 | Nu-RAIL Crossover Fitting | $18.00 |
| 17953 | 1x1 Nu-rail Crossover Fitting | $20.00 |
| 7623 | Threaded pipe mount for 17992 | $19.00 |
| ENC14/16 – SC | Enclosure | $275.00 |

| | | | |
|---|---|---|---|
| PS100 | 12v Power Supply | $245.00 | |
| SP20 | 20w Solar Panel | $415.00 | |
| | | | |
| HMP45C-L (6') | Temp/Humidity Sensor | $595.00+$0.67/ft | $599.02 |
| SW12V | Power Switch Assembly | $68.00 | $68.00 |
| TE525-L (10') | Raingage – 0.01 inch increments | $375.00+$0.44/ft | 379.4 |
| 107-L (8') | Soil Temp Sensor (2ea) | $85.00+$0.44/ft | $177.04 |
| LI200X (10') | Silicon Pyranometer | $360.00+$0.44/ft | $364.40 |
| 03002-L (8' cable each) | RM Young Wind Sentry | $595.00+.67/ft | $600.36 |
| 41003-5 | 10 Plate Gill Radiation Shield | $185.00 | $185.00 |
| LI2003S | Pyranometer Leveling Base | $75.00 | $75.00 |
| | | | |
| | **Total for Station WITHOUT data retrieval Equipment** | **$5,578.72** | |

**Communications Options**

| | | |
|---|---|---|
| **RF450 Communications** | NOTE: LAN connection to the internet required at base station | |
| | RF450 (2) | $1,990.00 |
| | 9db Omni antenna | $195.00 |
| | 9db Yagi antenna | $195.00 |
| | NL100 Network Interface | $428.00 |
| | Misc: Coax. Cable and connectors | $200.00 |
| | | |
| | **Station with Radio Telemetry** | **$3,008.00** |

**Verizon Digital Data Service:**

| | | |
|---|---|---|
| Raven 100 | CDMA Cellular Digital Modem (Verizon) | $505.00 |
| 14454 | 9dBd Yagi Antenna w/10' cable | $195.00 |
| SC932A | DCE Interface | $92.00 |
| 14394 | Mounting kit for modem | $23.00 |
| 18663 | Null Modem Cable | $4.00 |

| | | |
|---|---|---|
| | **Station with Verizon Service** | **$819.00** |

*NOTE: This service has monthly cell service bills from Verizon associated with it and Verizon service must be available.*

**Landline Phone Service:**

| | | |
|---|---|---|
| COM220-US | Telephone Modem | $325.00 |
| | **Station with landline service** | **$325.00** |

*NOTE: This service has monthly landline service costs associated with it and phone lines must be run to the station.*