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Date: **October 12, 2005**

To: **Bruce Cody, Bonneville Power Administration**

From: **Hossein Haeri, Kerstin Rock**

Re: **Interim Evaluation of GWMA Irrigation Scheduling Pilot Project**

Introduction

The Columbia Basin Ground Water Management Area (GWMA) was started in February of 1998 by the Washington Administrative Code. It is a complex multi-partner effort to improve and protect ground water quality in the Adams, Franklin, Lincoln, and Grant Counties of Washington State. GWMA promotes best management practices, which are available to reduce nitrate transport to the groundwater. GWMA endorses and adopts Scientific Irrigation Scheduling (SIS) or Irrigation Water Management (IWM) as a best management practice (BMP) to prevent or reduce leaching of nitrates through the soil profile and from reaching the groundwater. IWM also helps irrigators reduce the amount of water used in crop production and to improve pumping energy use.

GWMA's stated goal for the 2005 growing season was to implement IWM on roughly 10% of total irrigated acreage in the entire four county area, or 88,774 acres. In all, 190 different growers participated in the GWMA program. To offset a portion of its costs and to better leverage implementation of IWM in the area, GWMA applied for a pilot project (project) grant from the Bonneville Power Administration (Bonneville) in early 2005. Bonneville provided $275,000 in funding to finance implementation of IWM on 48,026 acres during the 2005 growing season.

Bonneville retained Quantec, LLC, to develop a detailed evaluation of the project addressing the following four objectives:

1. To document the project's background, implementation approach and processes,

2. To provide reasonable estimates of "gross" and "net" water and electricity savings resulting from implementation of the project,

3. To assess project performance as a means for Bonneville to acquire cost-effective conservation savings, and

4. To explore the region-wide potential of the project and examine its implications in the context of Bonneville's Conservation and Renewables Discount (C&RD).

Since the growing season in the area typically tends to extend into November, the complete evaluation report is scheduled for publication in late December 2005. This memorandum provides the interim findings and results of the evaluation as they pertain to objectives 2 and 3 above, using data available to date. These findings should therefore be considered preliminary and subject to change as more data becomes available.

Program Overview

GWMA has established a close working relationship with the six Conservation Districts (CDs) that are located within its boundaries. Each of the CDs is tied to GWMA through "inter-local" agreements that commit the CDs to ensuring that their assigned GWMA projects are carried out and completed. Franklin Conservation District has been designated as the lead fiscal district for bookkeeping and monetary handling of GWMA tasks for all CDs. The CDs are responsible for publicizing GWMA's IWM program and recruiting growers to participate in it. Once growers sign up for the program, it is the responsibility of the CD to monitor and certify compliance with the IWM program standards, and to provide ongoing technical assistance to growers within their boundaries. The CDs maintain sign-up forms and detailed technical material for growers to guide them and to ensure their compliance. They also calculate cost-share amounts and coordinate subsidy payments at the end of the growing season.

GWMA operates its IWM program in conjunction with the Natural Resource Conservation Service (NRCS) IWM EQUIP program. Participating growers are expected to meet or exceed U.S. Department of Agriculture's (USDA)-NRCS practice Code 449-Irrigation Water Management standards. Specifically, these standards require that all participating farmers comply with a ten-point set of comprehensive knowledge and performance requirements that include:

1. Measure and document Power Conversion Coefficient (PCC) value for each irrigation system.
2. Have some type of water measurement in place for each field
3. Use daily crop evapotranspiration (ET) data in the determination of daily water requirements.
4. Monitor soil erosion throughout the season. If appropriate, take measures to control erosion and adjust irrigation accordingly.
5. Supply proof of proper irrigation system design, or results from in-field irrigation system evaluation.

6. Document uniformity of water application by means of aerial photography or other appropriate tests.
7. Install deep soil measurement devices below the crop rooting depth, and supply readings to GWMA.
8. Keep and supply records of irrigation water application throughout the season.
9. Take soil moisture readings at least once per week and supply records to GWMA.
10. Ensure that the total season measured average irrigation does not exceed the ideal crop consumptive use by more than 10%.

If the farmer meets all of the requirements, and GWMA can establish that IWM was successfully implemented, the farmer is eligible for a subsidy.

IWM requires that the farmer combine knowledge of the actual soil moisture content, weather conditions, and crop water use to determine the amount and timing of irrigation. While the latter two items are available from a variety of sources, including Agrimet, PAWS, or commercial irrigation service providers, growers are required to install soil moisture measurement devices on site. A farmer generally has two options, depending on the time interval the information is read and transmitted. The more traditional and currently more widespread method is referred to as the “standard-time” method. Using this method, the farmer receives soil moisture measurements weekly. Depending on whether the farmer hires a consultant or installs and operates the equipment with internal staff, the average cost per acre for a standard time system ranges from $8 to $12 per acre.

The second method, which has seen an increase in use in the Columbia Basin area over the past few years, is the “real time” method. Using this method provides the farmer with soil moisture readings data continuously, transmitted to that farmer on a real-time basis. The typical cost per acre for this method ranges from $14 to $20 per acre. Based on GWMA’s historical records, and accounting for the mix in systems used throughout the Basin, the average cost for IWM is estimated at roughly $12 per acre.

To offset a portion of the grower’s costs related to implementing IWM, GWMA pays each qualifying farmer a per-acre subsidy of either $4 for the standard-time system or $8 for a real-time system. While GWMA has seen a trend toward using real-time system over the past few years, GWMA estimates that the average subsidy per acre in the 2005 growing season was $5.73.

Findings

As part of the project, GWMA implemented IWM on 48,026 acres. While the final evaluation will analyze water and energy savings from all 48,026 project acres, the current analysis is limited to the farms for which both complete field data and actual PCC measurements are currently available. The remainder of the field data will be available in late November.

Table 1 summarizes data available for the interim update report; GWMA provided field information for nearly half the project acreage. GWMA provided power conversion coefficient measurements for 82 fields, representing 23% of the project acreage. Since the estimation of electricity and water savings requires other field data not yet available, this interim analysis uses data from 77 farms, representing 21% of all project acreage.

Table 1. Summary of Available Interim Data

	Number of Fields	Number of Acres	% Acres Represented
Measured PCC	82	10,877	23%
Field Data	179	23,627	49%
Complete Data	77	10,205	21%

Estimated Benefits

To determine the cost-effectiveness of the pilot project, the estimated total project benefits need to be identified. The primary benefits related to IWM consist of water and electricity savings. Other benefits include increased generation potential in the Bonneville dam network along the Columbia River, reduced fertilizer use by farmers, and a variety of other environmental benefits. For the purpose of this interim analysis, we have developed preliminary estimates of the water and electricity savings, as well as savings related to reduced fertilizer usage. The final evaluation will provide information on the increased generation potential, and also other non-energy and water related benefits. Table 2 outlines the specific benefits incorporated in each report.

Table 2. Savings Estimates by Report

Type of Savings	Interim Report	Final Report
Water Savings	√	√
Electricity Savings		
Primary Pumping	√	√
Secondary Pumping	√	√
Tertiary (Infield) Pumping	√	√
Avoided Line Loss	√	√
Increased Generation Potential		√
Other Benefits		
Reduction in Fertilizer Use	√	
Other Environmental Benefits		√

Water

The estimation of average, per acre, water savings is straightforward and based on the following three steps:

1. Using the Washington Irrigation Guide, we identified net water requirements per acre by crop and microclimate.

2. Applying the 10% water savings assumptions (documented in Phase II of this project) to the net water requirement per acre to estimate likely water savings per acre.
3. Dividing total water savings by total acreage of fields in the sample.

Using field information for the sample of 10,205 acres, estimated average water savings per acre are 3.7 inches.

Electricity

Due to the natural landscape and hydrological conditions of most of the Columbia Basin, large-scale irrigation is required for successful farming in the region. While the Columbia Basin spans much of Adams, Franklin, Grant, and Lincoln counties as well as parts of eastern Oregon, GWMA's service area is limited to the four county area. Recent estimates show that there are over 928,000 irrigated acres in the area. Nearly 65% of this acreage is fed by water from the Columbia Basin River Project (River Project), while the remaining 35% is irrigated using water from private wells or river pumping stations.

Regardless of whether irrigators use water that was pumped via the River Project, private river stations, or from private wells, the geography of the area makes the process of pumping water highly intensive in electricity. Specifically, this is due to the difference in elevation between the primary water source and the farms on the Columbia plateau. Therefore, implementing IWM in this area is likely to offer greater electricity savings potentials than most other areas in the Northwest. As shown schematically in Figure 1, the pumping system in the area can be broken down into three major components: primary pumping, secondary pumping, and tertiary pumping.

Primary Pumping represents the electricity used by the Grand Coulee Pump-Generation plant to pump water from Roosevelt Lake to the 1.6 mile-long feeder canal for delivery into Banks Lake. Banks Lake is a 27-mile long reservoir that feeds the Columbia River water into the main irrigation canal. The electricity use for pumping is significantly impacted by the total dynamic head, or simply stated, the elevation the water needs to be pumped. The greatest elevation, and hence pump lift, occurs at the primary pumping stage. Therefore, the greatest energy savings are gained by not pumping water from Lake Roosevelt. The electricity savings calculation related to primary pumping is based on the following assumptions:

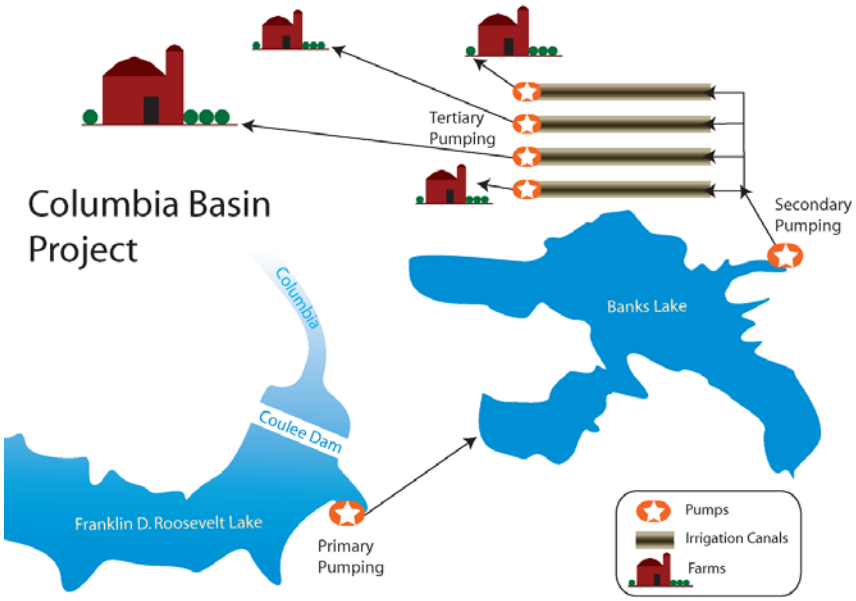
- Rated capacity of the pumping plant of 525,000 HP[1]
- 70% of the water pumped is used for irrigation
- 80% pump load factor
- 50% duty cycle

[1] Bureau of Reclamation website www.usbr.gov/dataweb/html/columbia.html

- 10% reduction in pumping due to IWM
- Pilot project represents roughly 10% of total irrigation acreage

Based on these data, electricity savings resulting from primary pumping are estimated at approximately 75 kWh per acre.[2]

Figure 1. Pumping System Layout Schematic



Secondary Pumping represents pumping power needed to lift water from Banks Lake and the Main Canal into a large system of irrigation facilities, including canals and laterals. The Bureau of Reclamation estimates that the irrigation system contains over 300 miles of main canals and about 2,000 miles of laterals. The calculation of electricity savings related to primary pumping is based on the following assumptions:

- Annual pumping energy ranges from 175 to 200 MWh

[2] With additional information expected from the Bureau of Reclamation, this estimate will be refined.

- 40% of the pumping plants can reduce operation
- 10% electricity savings due to IWM
- Applicable to 550,000 acres given that 65% of total irrigation acres is supplied with water from the Columbia Basin River Project

Based on preliminary data, total electric power savings resulting from reduced secondary pumping is estimated at 12 kWh per acre.

Tertiary (Infield) Pumping. Based on findings from Phase II of this study, estimated water savings related to implementing IWM are on average 10%. If less water is needed to raise crops, the farmer will need to pump less water and will thus see a reduction in electricity use. While the potential energy savings vary greatly depending on the required pump lift, findings from Phase II suggest that implementation of IWM will result, on average, in an electricity savings of approximately 13%. This estimate was derived by converting water savings into electricity savings by means of applying a system-specific PCC. For the purposes of this analysis, the amount of electricity savings due to reducing tertiary pumping was estimated by applying each farm's measured PCC to the estimated water savings related to implementing IWM. Using this methodology, the average savings per acre are estimated at 136 kWh per acre.

T&D Benefit represents the avoided energy generation associated with average transmission and distribution losses on the Bonneville system. Based on Bonneville data, the transmission and distribution benefits are assumed to be 2.5% and 5%, respectively, for a total of 7.5%. Applying this assumption to all three pumping system stages results in a combined T&D benefit of 16 kWh per acre. Table 3 provides a summary of the estimated water and electricity savings by source.

Table 3. Summary of Water and Electricity Savings

Water Savings	
Water Savings (acre-inch)	3.7
Electricity Savings	
Primary Pumping (kWh/Acre)	75
Secondary Pumping (kWh/Acre)	12
Tertiary (Infield) Pumping (kWh/Acre)	136
T&D Benefit (kWh/Acre)	16
Increased Generation Potential	To Be Determined

Cost-Effectiveness Analysis

The project's economic performance is assessed using a benefit-cost analytic framework consistent with the guidelines established by the Northwest Power and Conservation Council.

Cost-effectiveness is analyzed from three distinct perspectives: total resource cost (regional perspective), Bonneville and growers.

Estimated pilot project costs and heretofore calculated benefits are shown in Tables 4 and 5, respectively. Total program costs are a combination of GWMA and Bonneville administration, plus infield installation costs, for a total of $13.56 per acre. Bonneville's contributions amounted to $5.73 per acre to offset the infield installation costs. Avoided energy benefits to participants and the region were calculated assuming an average irrigation retail rate of $0.06[3] per kWh and an avoided energy cost of generation of $0.04 per kWh.

Table 4. Project Costs

Program Costs	$/Acre	Total Cost
GWMA Administrative Costs	$1.31	$62,914
Bonneville Administrative Costs	$0.25	$12,000
Infield Installation Costs	$12.0	$576,312
Incentive	$/Acre	Total Cost
Bonneville Pilot Project Costs	$5.73	$275,000

Table 5. Project Benefits

Benefits	kWh/Acre	$/Acre	Total Benefit
Primary Pumping	75	$3.00	$144,078
Secondary Pumping	12	$0.48	$23,052
Tertiary (Infield) Pumping	136	$5.46	$262,011
T&D Benefit	16	$0.67	$32,186
Increased Generation Potential	TBD	TBD	TBD
Water Bill Savings (inch/acre)	NA	TBD	TBD
Reduction in Fertilizer Use	NA	$6.00[4]	$288,156
Other Environmental Benefits	TBD	NA	TBD

This evaluation assesses the project's cost-effectiveness from the perspectives of the region (total resource-cost test), the growers (participant test), and Bonneville (utility cost test). Table 6 outlines the distribution of costs and benefits from various stakeholder perspectives.

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[3] Represents average cost of electricity per kWh based on data provided by Franklin PUD. Estimate includes energy and peak costs, customer charges and taxes.

[4] Based on estimates provided by GWMA, implementation of IWM is expected to reduce use of fertilizer by 15 pounds per acre. Given an assumed cost of $0.40 per pound, a conservative estimate, the estimate cost savings per acre is $6.

Table 6. Distribution of Costs and Benefits

	Region	Growers	Bonneville
Costs			
GWMA Administrative Costs	√		
Bonneville Administrative Costs	√		√
Infield Installation Costs	√	√	
Bonneville Incentive to Grower			√
Benefits			
Primary Pumping	√		√
Secondary Pumping	√		√
Tertiary (Infield) Pumping	√	√	√
T&D Benefit	√		√
Increased Generation Potential	√		√
Bonneville Incentive to Grower		√	
Value of Water Savings		TBD	
Environmental Benefits	TBD		TBD
Reduction in Fertilizer Use	√	√	

Table 7 below shows the preliminary evaluation of total project costs and benefits from the perspectives of the region, (TRC), Bonneville (Utility Cost Test), and participants (Participant Cost Test) . Looking only at energy-related benefits, this preliminary analysis finds that for both the growers and for Bonneville, this project exceeds the threshold for cost-effectiveness (i.e., BC ratio of greater than one). Yet, from a regional perspective, the total cost is less than the total benefits, as shown in Table 7.

Table 7. Summary of Costs, Benefits and BC Ratio

Perspective	Costs	Benefits	Net Benefits	BC Ratio
Region	$651,226	$461,327	($189,899)	0.71
Bonneville	$275,000	$461,327	$186,327	1.68
Grower	$576,312	$668,016	$91,704	1.16

However, when non-energy related benefits are included in the analysis, specifically the reduction in fertilizer use, the project is cost effective even from the regional perspective. Table 8 summarizes the corresponding benefit-cost ratios.

Table 8. Summary of Costs, Benefits and BC Ratio

Perspective	Costs	Benefits	Net Benefits	BC Ratio
Region	$651,226	$749,483	$98,257	1.15
Bonneville	$275,000	$461,327	$186,327	1.68
Grower	$576,312	$956,172	$379,860	1.66

There are other expected benefits which are likely to improve the benefit-cost ratios further, although they were not included as part of this preliminary analysis. These include reduction in water use, increased generation potential, and other environmental benefits.

Summary

When only accounting for the energy-related benefits, this preliminary analysis finds that the project is cost-effective from the perspectives of Bonneville and growers. Yet, from a total-resource (regional) perspective, the costs are not justified by the benefits. However, when non-energy related benefits such as the reduced use in fertilizer are included, the project is cost-effective from all three perspectives, including the regional perspective. The addition of further benefits as part of the December report is likely to firm up this finding further.

The results presented in this report should be considered indicative, rather than conclusive. This is due to the need to verify some of the assumptions underlying the electricity savings calculations, and also to this analysis being based on only a sample of the project data.,. Final estimates will be made available in the comprehensive evaluation report in December 2005.