Matching Irrigation Water Delivery on Irrigated Pasture to Local Transpiration and a Comparison with the Proposed CSKT Compact Water Use Agreement Irrigation Water Delivery-St. Ignatius, MT July – September, 2012

By

J.R. (Jerry) Laskody*

I. Introduction

As a result of proposed Flathead Irrigation Project water deliveries specified in the CSKT Water Use Agreement, the author began a study of applied water on MacDonald silt loam soils on irrigated pastures located approximately 5 miles Northeast of St. Ignatius, Montana. (T19NR19W Sec 29 W ½ of the SE ¼) The author measured pressure at the midpoint of a wheel line sprinkler system at several field positions and using sprinkler nozzle data obtained from the Bureau of Reclamation (BuRec)'s Agrimet Irrigation Guide (Ref.1) and determined the water delivery from the sprinkler system during an irrigation set. Irrigation scheduling was determined by using the Kimberly-Penman evapo-transpiration data for pasture grass obtained from the BuRec Agrimet Station located at the St. Ignatius Airport (SIGM) (Ref.2) to determine water transpired from pasture grass. The soil is assumed to hold 2 inches of water per foot of soil, the rooting depth is assumed to be two feet and the 50% depletion is assumed at wilt (Ref. 1). (These are typical values for the MacDonald soil types 105 and 106 in a pasture application.) This then implies a requirement for two (2) inches of water in the root zone to meet the plant's requirements. The land in question has a duty rating of 2.0 and the basic quota in 2012 was 12 inches. Thus target water delivery was 24 inches for the irrigation season. It should be pointed out that the land's duty is not recognized in the proposed CSKT Water Use Agreement although it represents historic usage in the Flathead Irrigation Project.
The analysis contained herein conclusively demonstrates that the Compact proposed allocations of water in the Mission Irrigation District of the Flathead Irrigation Project are significantly less (52 % less) than historic usage, thus refuting the Compact Commission's repeated assertions that "...historic usage is protected in the Compact...".

II. Analysis

The typical irrigation process is to fill the soil profile with an irrigation set, wait until the two inches of water has been transpired by the plant and then re-fill the profile, continuing this process throughout the growing season. Since the transpiration varies as a strong function of weather conditions and since the actual delivery of water from the nozzle to the root zone is not 100% efficient (strongly driven by atmospheric conditions also) the time between repeat irrigations is not necessarily a constant time interval. In cool, humid, and calm conditions it is a longer interval than when the weather is hot, dry, and windy. For

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example if the average transpiration is 0.25 inches /day, and our irrigation efficiency was 67% and our nozzle delivery was 3 inches per set, we Would deliver 2 inches of water to the root zone (3.0 inches/set x 0.67=2.0) every 8 days (2.0 inches/0.25 inch/day=8 days). In the specific case reported here, the transpirations rates were closer to 0.2 inches per day and so the irrigation cycle was repeated every 10 days (2.0 inches/ 0.20 inches/day = 10 days).

The big unknown in this scheduling is "what is the irrigation efficiency?" Measurements have been made on our ranch in hot (95°F,) dry (10%-15% relative humidity), and windy conditions (10mph and gusting) of 46%. This implies that 54% of the water issuing from the nozzle never gets into the ground! It is possible that for a few hours during the night, when the temperatures are cool (55°F), it's humid (>80% relative humidity) and calm and perhaps the irrigation efficiency may reach 70% for short time period. The Montana State University Irrigation Guide (Ref.3) and the BuRec's Agrimet Irrigation Guide recommend irrigation efficiencies 65% for wheel line sprinklers and hand line sprinklers, but based on my experience, 60% is a better value for ambient conditions here in the Mission Valley. Nonetheless, required applied water was determined using a range of efficiencies to show the impact of efficiency on applied water to meet plant needs

The attached sheets graphically display the daily transpiration as measured at the SIGM site approximately 4 miles from our ranch, as well as the individual daily transpiration data. From the time period of July 2, 2012 through September 16, 2012, summing the daily transpiration data yields a value of 14.67 inches of transpired water from the plants. We had 0.8 inches of precipitation during this time period, and assuming 100% irrigation efficiency for the rainfall, would yield a net transpiration requirement of 13.87 inches to be supplied to the root zone to meet plant requirements. (It should be noted the pastures were used in a rotational grazing system for 16 cow calf pairs, 2 first calf heifers a mature bull and a butcher steer so actual transpiration requirements might have been greater. Nonetheless, grass pasture evapo-transpiration data was used to determine plant needs and hence irrigation scheduling.)

Assuming efficiencies of 60%, 65%, and 70%, would imply that for these conditions 23.1 inches, 21.3 inches and 19.8 inches of applied water respectively would be required to meet plant demands.

An analysis of the water actually applied during this time period utilized information from the BuRec Agrimet Irrigation Guide for 13/64" nozzles operating at mean pressures of 49 psi on 40x60 spacing. These yields 0.34 inches of applied water per hour, so for an 11 hour set, 3.74 inches of water would be delivered per set. My records for the E ½ of the N40 (20 acres) show six irrigations in this time period so total delivered water during this time period was 22.4 inches. Additionally, due to abnormally dry conditions, one irrigation in

May, 2012 was needed, so this put the total irrigation requirement for the 2012 irrigation year at 26.1 inches. This compares with the 12.5 inches of delivered water proposed for Mission Irrigation District delivery in the 2012 CSKT Compact Water Use Agreement.

The above data represents one irrigation season and does not take into account yearly variations. The standard deviation of transpiration during this time period, based on a 20 year sample from 1992-2011 in Ref. 4 implies the expected standard deviation of transpiration from year to year to be about +/- 10% of the average for the measured monthly time interval. Applying that to the 2012 data for the July2-September 16 would imply a +/- 1.4 inches variation of Etosgr. This would lead to an expected yearly variation in applied water of 2.3 inches (eta =0.6), 2.1 inches (eta=0.65) and 2.0 inches (eta=-0.7). So natural yearly variations in evapo-transpiration cannot explain the allocation quantities proposed in the CSKT Water Use Agreement.

Based on this analysis, the CSKT Compact Water Use Agreement proposes to deliver 52% less water to our ranch than our historic usage!

III. Conclusions

The above results conclusively demonstrate that:

1. The historic Flathead Irrigation Project water deliveries are significantly greater than the proposed delivery in the CSKT Water Use Agreement for irrigators in the Mission Irrigation District. It also validates the use of the duty system for water allocations. This data counters the oft repeated claim by the Montana Reserved Water Rights Compact Commission (COMCOMM) that "...historic usage is protected..." in the CSKT Compact.
2. Since the proposed water delivery was based on CSKT's HYDROSS modeling of the irrigation system and average cropping distributions within the Project, the data presented herein point to a gross error in the modeling/cropping assumptions. The COMCOMM was also apparently concerned about the use of HYDROSS for quantification purposes as noted in their October 25, 2010 letter to the CSKT (Ref.5)
3. This under prediction of water delivery results from flawed modeling of the system by the CSKT and the unwillingness of the CSKT and the COMCOMM to utilize actual "on ranch" usage data to calibrate the HYDROSS model. Calibration of model results to accurate data sets is an absolute necessity! The author proposed this course of action to the Flathead Joint Board of Control and their consultant and also to the COMCOMM in 2012. No response from either party was ever received to this proposal.

IV. Recommendations

In a June, 2013 meeting with Duane Meacham, the Solicitor for the Portland Regional Office of the BIA , stated that in all the compacts the BIA was involved in, irrigators "...never lost a single drop of water as a result of the compacting process". While the results presented herein are taken from a single ranch in the Mission Irrigation District, the gross error between the CSKT Water Use Agreement proposed irrigation water deliveries and the actual plant transpiration required applied water, demand that the *entire question of water delivery in the Compact Water Use Agreement be critically* scrutinized.

Further, this scrutiny should be conducted in a public forum, by independent agronomists and others independent experts familiar with the irrigation systems. Such scrutiny must include on farm measurements of representative farms and ranches in all the irrigation districts in the Flathead Irrigation Project. Only then can "historic use" be quantified, only then can irrigators have assurance that they will not lose a single drop of water in this adjudication.

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*The author holds a B.S. Aeronautical Engineering from Purdue University (1965) and an M.S. Engineering (1972) from the University of Washington. Employed as a Propulsion Engineer by the Boeing Company for 34+ years, he was a member of the NASA Aeronautics Propulsion Systems Advisory Committee from 1996 until his retirement in 1999. Retiring as Chief Engineer-Propulsion Research & Preliminary Design, his career specialty was Propulsion Aerodynamics and encompassed both theoretical and empirical work. He was responsible for development of performance specification for propulsion systems and validation methods to verify installed performance as well as the aerodynamic development of engine nacelles. He holds three US Patents for propulsion related devices and led developments teams on the 757, 7J7, 777, 737NG Programs and was Propulsion System Manager for the NASA/Boeing/Douglas High Speed Civil Transport (HSCT) Program. He and his wife operate a small, irrigated cattle ranch near St. Ignatius, MT. Mr. Laskody is Chairman of the Mission Irrigation District in the Flathead Irrigation Project.

V. References

1. "Agrimet Irrigation Guide", US Bureau of Reclamation Agrimet Website
2. "Crop Water Usage-SIGM- 2012" US Bureau of Reclamation Agrimet Website
3. Irrigation Water Management When and How Much to Irrigate" Montguide MT8901, Revised September , 1990
4. "Crop Water Usage-Evapotranspiration Totals and Averages 1992-2011-SIGM" US Bureau of Reclamation Agrimet Website
5. Letter dated October 25, 2010, Bill Schultz (RWRCC) to Clayton Matt (CSKT) Re: Review of HYDROSS Model Jocko and Mission Baseline Condition

VI. Nomenclature

Etosgr - Kimberly-Penman daily transpiration for pasture grass~ inches

aveEtosgr - monthly average Etosgr ~inches

sumEtosgr - $\sum$ Etosgr in a given month ~inches

stddev - standard deviation of daily Etosgr during given month ~inches

stddev/ave - stddev /aveEtosgr (dimensionless)

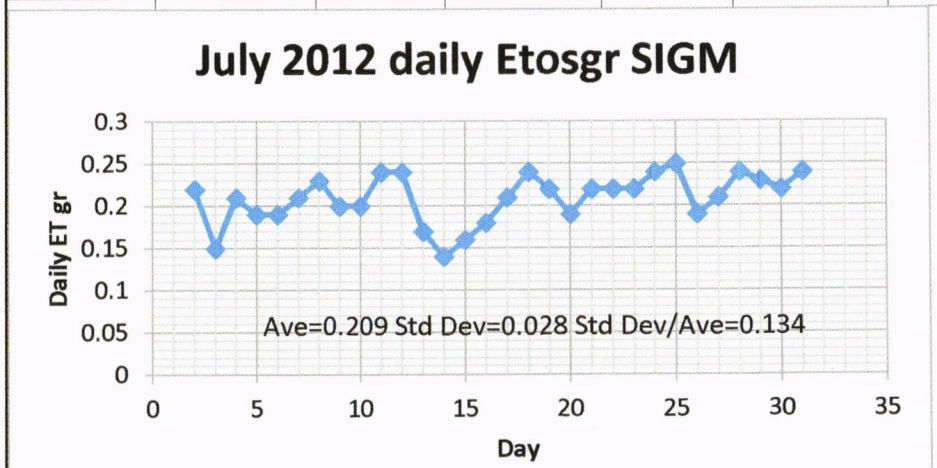
Precip - monthly precipitation ~inches

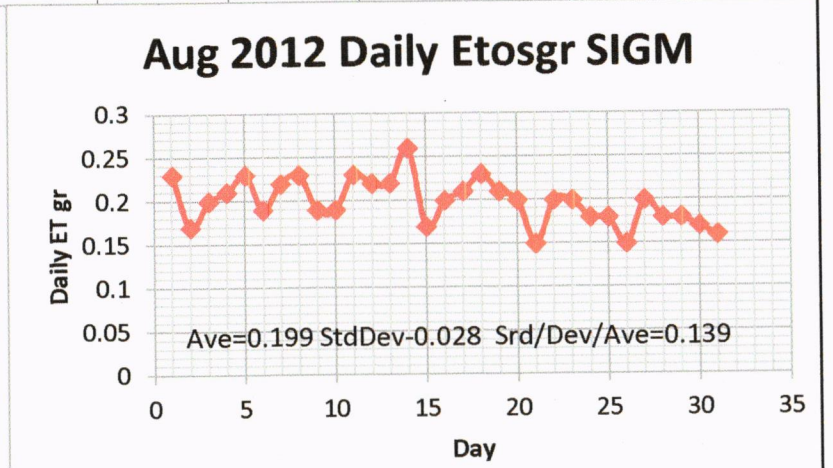
eta-irrigation efficiency =applied water reaching the root zone/applied water (dimensionless)

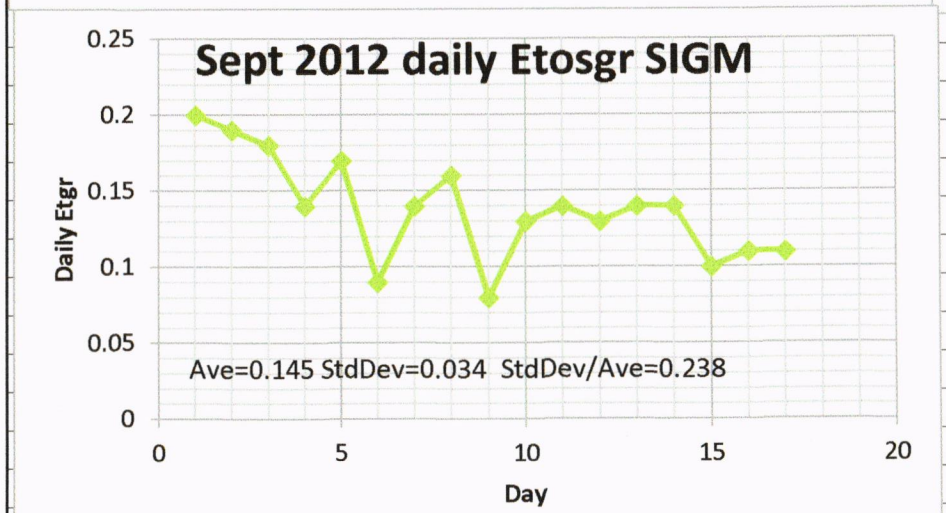
Etosgr Data-SIGM

	July '12	Aug '12	Sept '12
ave Etosgr	0.209	0.199	0.145
sum Etosgr	6.270	6.160	2.24
std dev	0.028	0.028	0.034
stdev/ave	0.134	0.139	0.238
Precip	0.8	0	0

Summary of Results					
tot Etosgr		Net Etosgr	eta*	Applied H2O	Actual Appld
14.67	inches T	13.87		7/2 to9/16	H20
			0.6	23.12	
			0.65	21.34	22.4
			0.7	19.81	
			* -irrigation efficency		







Etosgr Data-SIGM

			Kimberly - Penman Evapotranspiration-SIGM July 2-September 17, 2012								
July	Etos(grass)	August	Etos(grass)	Sept	Etos(grass)						
		1	0.23	1	0.2						
2	0.22	2	0.17	2	0.19						
3	0.15	3	0.2	3	0.18						
4	0.21	4	0.21	4	0.14						
5	0.19	5	0.23	5	0.17						
6	0.19	6	0.19	6	0.09						
7	0.21	7	0.22	7	0.14						
8	0.23	8	0.23	8	0.16						
9	0.2	9	0.19	9	0.08						
10	0.2	10	0.19	10	0.13						
11	0.24	11	0.23	11	0.14						
12	0.24	12	0.22	12	0.13						
13	0.17	13	0.22	13	0.14						
14	0.14	14	0.26	14	0.14						
15	0.16	15	0.17	15	0.1						
16	0.18	16	0.2	**16**	0.11						
17	0.21	17	0.21	17	0.11						
18	0.24	18	0.23	18	0.13						
19	0.22	19	0.21	19	0.12						
20	0.19	20	0.2	20	0.11						
21	0.22	21	0.15	21	0.1						
22	0.22	22	0.2	22	0.08						
23	0.22	23	0.2								
24	0.24	24	0.18								
25	0.25	25	0.18								
26	0.19	26	0.15								
27	0.21	27	0.2								
28	0.24	28	0.18								
29	0.23	29	0.18								
30	0.22	30	0.17								
31	0.24	31	0.16								

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October 25, 2010

Clayton Matt
Confederated Salish & Kootenai Tribes
PO Box 278
Pablo, MT 59855

RE: Review of Hydross Model Jocko and Mission Baseline Condition

Dear Mr. Matt:

Thank you for providing the Montana Reserved Water Rights Compact Commission ("Commission") with copies of the Draft Jocko HYDROSS Model Baseline Conditions, August 2010 and the Draft Mission HYDROSS Model Baseline Conditions August 2010. Commission technical staff has carefully reviewed the reports. From their review, I offer the following comments.

The models clearly reflect a substantial investment of time and effort by the Tribes and DOWL HKM, which we greatly appreciate, and the results appear to be of very high quality. The baseline model runs appear to be based on reasonable assumptions and contain outputs that line up with the measured data reasonably well. Page 1 states that HYDROSS is a planning model, not a daily operations model. The Commission agrees that the best use of the model is to facilitate planning, and we believe it to be a very useful tool for that purpose.

That said, it is important to bear in mind some of the models' inherent limitations.

Although there is a strong database of existing flow records in the Jocko and Mission valleys, development of the model nevertheless required estimates upon estimates. For example, the model is heavily reliant upon the 2009 canal seepage study. Even though estimates of canal seepage losses are based upon data acquired under careful quality-controlled constraints, the estimates nevertheless carry some statistical uncertainty and apply only to a single irrigation season. To take these somewhat uncertain estimates and extend them to multiple irrigation seasons over the full length of the canals (which themselves have wide variability) leads to even wider uncertainty. Certainly, however, the estimates are the best available information at the time and we believe it is appropriate to use them in the manner applied in the model. In a similar vein, the estimate that 95% of delivery system and on-farm inefficiencies make their way to the next downstream node appears to be appropriate for the Jocko area, but given the vast amount of

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wetlands in the Mission area, we expected lower returns on the Mission (or conversely, higher returns on the Jocko). These estimates should be revisited at such time that estimates of water use by irrigation-affected wetlands, riparian areas, and groundwater become available (METRIC).

Our concerns about the models' limitations are eased by Wade Irion's assurance that they have been 'stress tested'. By this we assume that they have been subjected to extreme scenarios (for example, lining of all canals, non-use of selected canals, extreme adjustments to the 95% estimate of return flows, or something similar) to see if they produce reasonable results.

It would also be helpful to reorganize table 2.3.8, capacity limits, by canal and sub-canal so that flow amounts can be tracked and tied back to their sources. Organizing outputs by Node ID produces results that appear somewhat scrambled. I recognize, however, that given the complex linkages between canals, this approach might prove unworkable.

None of the foregoing, however, should be read to detract from the Commission's appreciation for the time, resources, and effort the Tribes have invested in developing the HYDROSS models or the Commission's belief that the August 2010 Draft HYDROSS Model Baseline Conditions for Jocko and Mission Valleys are an appropriate basis for moving ahead with Compact negotiations.

Sincerely,

Bill Schultz

Bill Schultz, Program Manager
Reserved Water Rights Compact Commission

Cc: Wade Irion
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