Conference Call 4-19-06

More NRD Comments

GW Mound Task

Find which ones are already surveyed - to compare to USGS - GW Mound Credit scope (well 139)

Addressed Thorburn's NRD or Sub-Basin water budgets can be generated by Chuck Spalding as part of the IWS study

Elwood leakage

Dan Smith - you need to use more upland wells. The Ogallala is not connected to the alluvium. He likes Thorburn's analysis and the report.

Actual vs est. 20 ft error in well height is a public perception issue

A good gw elev. record is from:
- Long term record
- Away from a pumping well
- Away from a stream
- Away from a leaky Canal
- Level of Ground Elevation

NRD's can suggest the monitoring wells we should use

Dan Smith - USGS should have the NRD readings

Maybe DNR should come up a list of wells that NRDs should be monitoring that the USGS dropped. Get record of USGS program changes since 2000.

Rich Holloway - are stream bed elevation problems worth checking + fixing

McDonald In total they must balance - water in = water out, it might not be at the exact spot that real life shows, but it will be ok in the larger sense. It would not change the answer.

Larry Land - Phreatophytes in model ~ 20% of total water budgets
Extinction Depth of draw from plants may need to be looked at
Literature + Expert search could be done to develop a work plan

Invasive Brush - Upland Cedars etc, may upset the water budget

How accurate was phreatophyte development in the model

$10,000 looks high to Ann ...
Ann wants to cut out the upland part of the analysis
ET Max rate
ET shut off } Depths

Pumping - Marc Groff

Land Conservation Practices - Mike McDonald - could it be an additional 100,000AF of recharge (terraces
tillage
~17,000AF 100,000AF range)
Could it be as small as ~17,000AF per year

Bias

Dan Smith – terraces may only have a lot of water in 4 years because that may be the then year the land is fallow.

Dan Smith — Cultural practices are terraces & farm ponds

Dan Smith — Range Practices have used a lot of water

I'S the model correcting the water balance by assigning more CU to CU pumping when it may be better assign

model does not represent surface runoff

Jasper – recharge regression shows a positive correlation to increase conservation practices

available to roots due to tillage + planting

Jasper – more rainfall may increase water available for roots + thus increase ET. Is that being interpreted in the model as an increase in stream depletion from gw pumping. Does it blur the computation between GW pumping + conservation practices.

Marc – Buried in recharge curves
- curves were adjusted over time of calibration to reflect changes in development

CONFIDENTIAL
Attorney/Client Privileged – Republican River Basin Compact Compliance
Republican NRD Database Review Overview

DRAFT MEMORANDUM

TO: Mike Thompson
FROM: Marc Groff
RE: Metered Pumpage And Acreage Database Review Overview
DATE: 19 April 2006

The Nebraska Department of Natural Resources (DNR) is currently conducting a general evaluation of the Republican River Compact Administration Ground Water Model (RRCA Model). As part of this evaluation, information contained in the irrigation well metering databases compiled by the Republican River Basin (Basin) Natural Resource Districts (NRDs) is being reviewed by The Flatwater Group, Inc. (TFG). The review is being conducted to provide an internal quality control check to identify and assist in correcting data discrepancies or locating missing information prior to the data vetting the other Compact States will likely perform when Nebraska seeks to change its methodology for providing groundwater pumpage and irrigated acreage input values for the RRCA Model.

Following is a brief summary of the database review efforts being conducted. More complete information is being prepared in the form of individual memos covering each NRD database reviewed.

The quality control checks are focusing on three main areas:

- Number of Active Irrigation Wells between each entities totals
- Pumpage Volumes – is it complete or not
- Irrigated Acreage – distribution of recharge

Number of Active Irrigation Wells

Prior to Nebraska changing input methodologies, the discrepancy in the number of active irrigation wells as reported in the State Well Registration Database and the individual NRD databases needs to be resolved. This task involves reviewing the classification of several hundred wells in the Basin.

The State Well Registration Database is the official record of active irrigation wells within the State and as such will be the database used in any comparison efforts to check the completeness of any alternate systems. In addition, unless Basin wide maps showing irrigated areas can be developed, the location of irrigation wells will still be used in the distribution of irrigated acres within the RRCA Model.

Pumpage Volumes

Reported pumpage volumes and depths which appear to be outliers need to be reviewed. Potential problem areas identified so far include:

- Wells which have unreasonable depths of application. There are several dozen wells which have record application depths greater than 75 inches. It is highly unlikely that this occurred and could be caused by several things including:
  - transcription errors
  - incorrect acreage assignments
  - volume calculation errors due to meter rollover or other meter issues
  - incorrect meter readings

  In addition, there are several dozen more wells which appear to have unreasonably low recorded application depths (less that 0.05"). Again, these depths are possible, but warrant further review.

- Wells which have recorded pumpage in 2005 greater than their three year allocation. This issue affects a couple dozen wells. While this is also unlikely, if a review of these wells does show this to be accurate, then proper documentation showing enforcement of NRD rules needs to be available.

- Wells which have pumpage volumes recorded in 2004, but have no recorded pumpage in 2005. This issue affects a couple of hundred wells. Again, this is possible due to retirement programs such as CREP and indeed some of the wells with this issue do have notes to that effect. However, there are a large number of these wells which have no notes associated with them. The results for these wells need further review.

- Wells without pumpage volumes recorded in either 2004 or 2005. This issue affects close to a hundred wells. The classification of these wells as active irrigation wells may need to be reviewed if the pumpage information for these wells is correct.

Irrigated Acreage

Issues related to irrigated acreage values include:

- Wells classified as active irrigation wells having recorded pumpage, but no assigned irrigated acreage.
- Wells having reported irrigated acreage, but no reported pumpage volume.
- The acreage value assigned to an acreage pool not matching the summation of the individual acreages assigned to each well within the pool.

Recommendations

As a path forward, TFG recommends the following:

- Correct the identified problems and make any systematic changes that my help prevent these type of problems in the future.

- After the databases are corrected, develop a groundwater modeling scenario using 2005 information from the NRD databases. Use this scenario to:

    - Fine tune the format of the information requested from the NRDs. This scenario should allow for the development of the template which will be used to load future years data into the input pre-processor.

    - Evaluate the affect the additional irrigated acreage will have on the model. The certified acres recorded in the NRD databases are roughly 20% greater than the irrigated acreage in the model currently based on National Agricultural Statistics Service (NASS) information. Nebraska should be prepared for a request from the other Compact States to provide some level of verification for these additional acres.

    - Evaluate the affect a non-uniform pumpage volume input coverage may have. The current pumpage input file uses a uniform depth across a county. Having well by well metered pumpage data would allow for varying the pumpage rates by well and thus introduce greater spatial variability in the pumpage file input. The affect this has should be reviewed and a decision made as to whether or not to increase the spatial distribution of reported pumping.

- Develop a reporting schedule with the NRDs. For instance, requesting that the NRDs provide information in the refined format by March 1 would allow both the NRDs time to collect and enter the previous year's metering information and would also allow DNR time to review the individual NRD datasets and combine them into a single model input file. Developing a schedule before the end of this year's irrigation season would help both NRD and DNR staffs be prepared should a decision be made to use the NRD database information exclusively for developing the 2006 RRCA Model groundwater input files.

McDonald Morrissey Associates, Inc.

Memo

To: Ann Bleed

From: Mike McDonald and Chuck Spalding

CC: Dave Cookson, Justin Lavene, Dan Morrissey

Date: April 11, 2006

Re: Proposed Study to Review of RRCA Ground-Water Model Calculation of the Imported Water Supply Credit

---

Introduction and Study Objectives

Water imported from the Platte River into the Republican River Ground-Water Basin supplies canals, surface water irrigation, and power plant cooling needs. Accretions to the Republican River and its tributaries that result from ground-water recharge from these imported waters are considered to be a credit for Nebraska in the Republican River Compact. This credit is referred to as the "Imported Water Supply Credit" or the "Mound" Credit and is calculated through simulations using the Republican River Compact Administration (RRCA) ground-water model.

From 1981 to 2000, the calculated Mound credit appeared to be rising (Figure 1) with an annual average value of about 16,000 acre-feet. Since 2000, however, the Mound Credit has fallen significantly and in 2003 reached its lowest level ever at about 9,800 acre-feet. If the Mound Credit is broken out into RRCA Compact accounting subregions, much of this decline has occurred in the Swanson to Harlan Reservoir reach of the main-stem of the Republican River (Figure 2). The decline in Mound Credit has been a concern to the Nebraska DNR and the Nebraska NRDs.

The study proposed in this memo is intended to establish the reasons the RRCA model calculates components of flow that result in decline in the mound credit. The results of the study should assist the Nebraska DNR and the Nebraska NRDs to anticipate future changes in the mound credit and, possibly, to plan responses to anticipated changes.

McDonald Morrissey Associates, Inc. (MMA) has identified a number of RRCA ground-water model simulations and prepared this outline of our approach. It is our understanding that as necessary we will receive assistance from The Flatwater Group (TFG) and HDR, Inc. in completing these tasks.

Approach

The study will be conducted by searching for correlations between mound credit and components of flow. The mound credit will be calculated for each of the last 30 years. It will

be compared with components of flow for a variety of sub-regions to visually identify correlations. Sensitivity runs will be prepared to help in the identification of components of flow that correlate with mound credit.

The Mound Credit is calculated using two simulations of the RRCA ground-water model. First, a "base" run simulation is completed where all standard model stresses, ground-water pumping, surface-water recharge, canal leakage, precipitation recharge are considered. As part of this simulation, the model –calculated stream baseflows at selected locations are recorded. Then a second simulation is completed. In the second simulation, all of the same stress specifications are used except for any recharge that is affected by water imported from the Platte River.

As before, the resulting stream baseflows as calculated by the ground-water model are recorded. The Mound Credit is the difference in stream baseflows calculated by these two runs.

Methods and Procedures

The study would include a focused review of model input and output for stream reaches, well pumping, canal leakage specifications and all recharge terms, and all model specifications that might affect stream depletions.

The general approach would include the following steps:

1. Run the RRCA ground-water model from 1918 to 2004 with imported water on.
2. Run the RRCA ground-water model from 1918 to 2004 with imported water off.
3. Calculate stream depletions.
4. Review stream depletion calculations for subregions of the model to identify potential areas of focused reviews.
5. Calculate mass-balances for Nebraska and subregions of the model by NRD groundwater basins and for aggregates of stream cells.
6. Identify the factors contributing to stream depletion and accretions and the role of the mound credit.
7. Characterize and quantify the factors contributing to the lag effect.
8. Characterize areas that have an increased influence on stream depletion and understand why.
9. Characterize the relationship between model calculated water levels and stream depletion.
10. Perform sensitivity analysis of stream depletions to multipliers on factors contributing to stream depletion.
11. Complete a report describing study objectives, methods and conclusions.

Cost Estimate and Scheduling

The estimated total cost for MMA's portion of this investigation is $65,000 including $2000 in expenses. It estimated that the study could be completed within 4 months of the approval of work.

Privileged and Confidential
Attorney Work Product

DRAFT

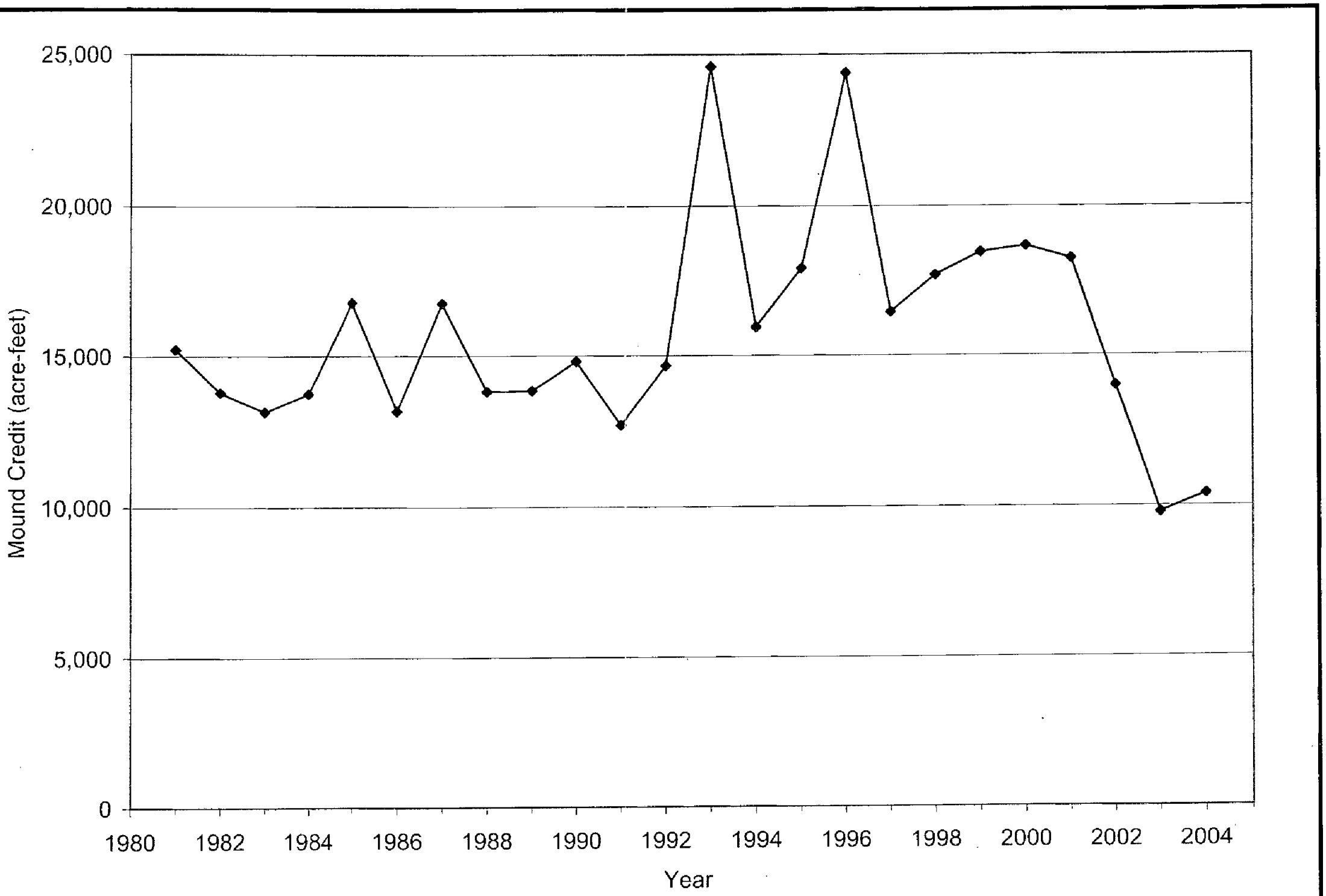
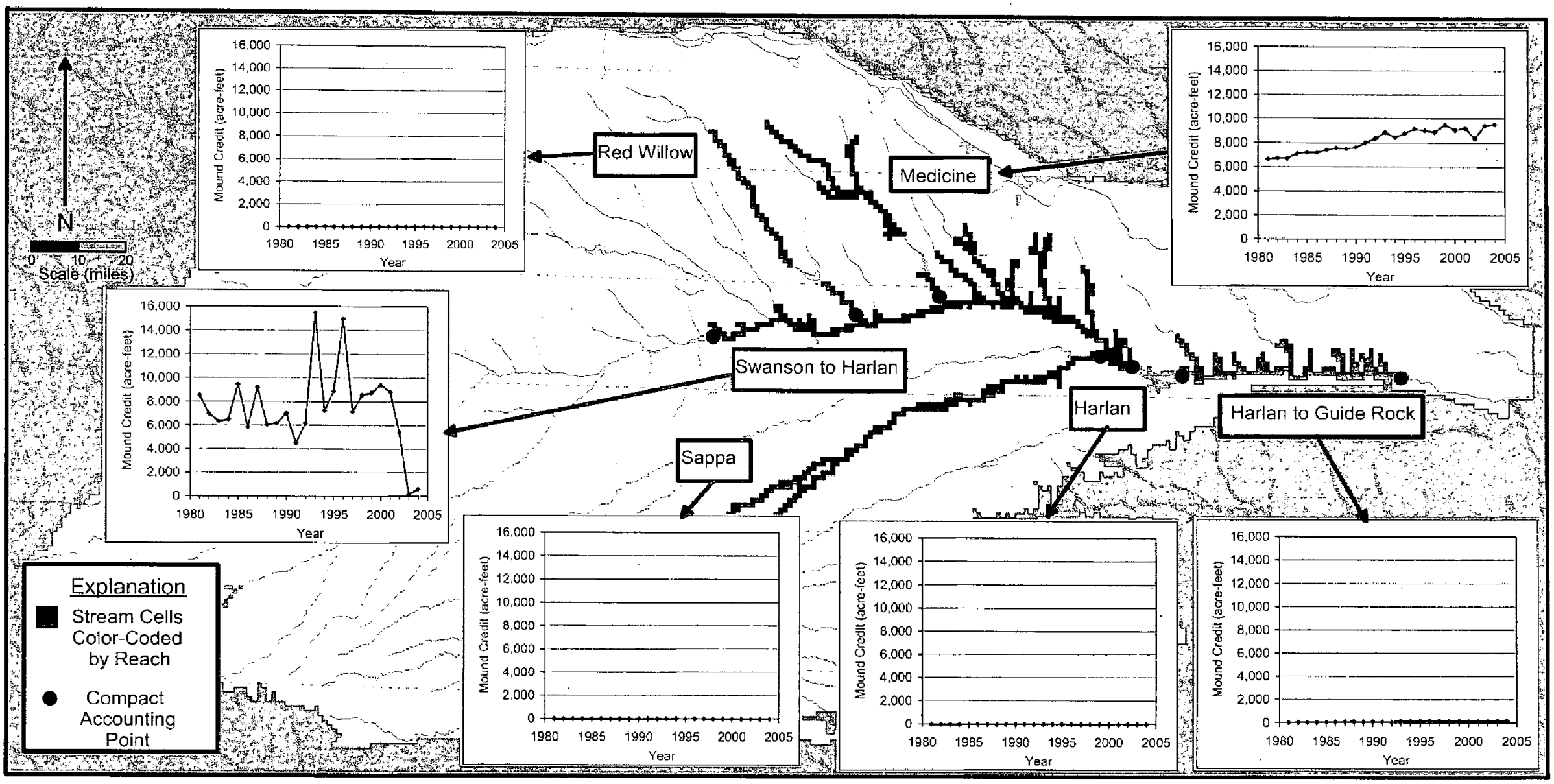


Figure 1. Total Mound Credit from 1981 to 2004 as calculated by the RRCA ground-water model.

Privileged and Confidential
Attorney Work Product

DRAFT



Data from RRCA Compact Website.

Figure 2. Changes in Mound Credit from 1981 to 2004 in Republican River compact accounting reaches with a mound credit greater than zero.

McDonald Morrissey ASSOCIATES, Inc.

DNR 018118

McDonald Morrissey Associates, Inc.

Memo

To: Ann Bleed

From: Mike McDonald and Chuck Spalding

CC: Dave Cookson, Justin Lavene, Dan Morrissey

Date: April 19, 2006

Re: Simulation of Land Conservation Practices in the RRCA Ground-Water Model

---

Introduction

Some stakeholders in the Republican River Basin have questioned whether the Republican River Compact Administration (RRCA) Ground-Water Model properly represents impacts of conservation practices. Such practices include land terracing, minimum tillage, and construction of farm ponds. This memorandum discusses aspects of the issue and describes steps that may be taken to assure the stakeholders that the model is appropriate for the purposes for which it was developed.

Description of RRCA Ground-Water Model Objectives

The RRCA ground-water model was developed by representatives of the State of Colorado, the State of Kansas, and the State of Nebraska with participation from the United States Bureau of Reclamation and the United States Geological Survey. The purpose of the model was "...to determine the amount, location, and timing of streamflow depletions caused by well pumping and to determine streamflow accretions from recharge of water imported from the Platte River Basin into the Republican River Basin" (RRCA Ground Water Model Report, July 1, 2003). The RRCA model is a ground-water model. It represents, among other aspects of the ground-water system, the discharge of water from the ground-water system to the surface water system. Such discharge is referred to as baseflow. It is not a surface water model, nor is it a deep percolation model. It does not represent streams or deep percolation other than the impacts of those features on the ground-water system.

Total stream flow as measured at gaged locations in the Republican River Basin consists of runoff on the land surface and water discharged from the ground to the river --- baseflow.

The impacts of land conservation practices which affect the runoff component of stream total flow were not evaluated. Simulation of these impacts would require a surface water model and did not meet the objectives of the RRCA ground-water model. Land conservation practices may have an impact on stream baseflow, however, these were considered to be small relative to the accuracy with which other sources and sinks could be estimated. Therefore in developing the RRCA model representation of impacts of conservation practices were pretermitted.

Description of Conservation Practices and Hydrological Impact

Land terracing, minimum tillage, and construction of farm ponds may well affect the hydrology of the Republican River Basin. It is my recollection that while the model was being developed the impacts were discussed and considered and estimated. My understanding of those impacts is as follows (terms are taken from a proposal by Martin and Koelliker, 2004):

> Terracing is designed to conserve soil and sometimes water. Blocked outlet terracing is meant to conserve both. Outlet terracing is designed to conserve soil.
>
> Blocked outlet terracing, which predominates in western part of the basin in Nebraska, would intercept surface runoff and direct it to a low point where it would infiltrate into the ground or evaporate. Ground water recharge on the contributing slope area would be unaffected. Ground-water recharge in the channel area would be increased because of the presence of ponded water. Runoff from the field would be reduced thereby reducing the runoff component of streamflow.
>
> Outlet terraces, which, are frequently used in the eastern part of the basin in Nebraska, would intercept runoff from the terraced filed and route it through retention structures form which it would flow or be pumped to the natural drainage system. Ground-water recharge might be increased slightly under the retention structure and arrival of runoff at the rivers would be slightly delayed but total surface runoff to the river would not be affected.
>
> Minimum tillage is designed to conserve both water and soil. It is intended to retain some of the precipitation, that otherwise would have been runoff, where it falls for use by crops or to recharge the ground-water system.
>
> Farm ponds are designed to retain water and soil for conservation and to act as a source of water for livestock. Although farm ponds are numerous their area is relatively small so that they represent a relatively small component of the flow system. They would be expected to reduce surface runoff and enhance ground-water recharge.

All of the conservation practices listed above could cause ground-water recharge to increase and surface water runoff to decrease. The magnitude of such changes would be difficult to determine. The changes to runoff are irrelevant with respect to the RRCA Ground-water model. The changes to ground-water recharge are relevant.

Estimate of Hydrological Impact

Ground-water recharge from retained surface runoff could be significant. It could be higher because retained surface water could be as high as 3 inches. Some, if not most of that 3 inches, may be taken up by crops in the channel area of the terrace. But supposing that half of the retained water recharges the aquifer then recharge on a representative acre in a terraced field is 1.5 inches higher than currently represented in the RRCA model. For the roughly 800,000 acres of terraced filed in the Republican River Basin in Nebraska that corresponds to 100,000 acre-feet/year (800,000 acres terraced * 1.5 inches/year retained runoff consumed by crops * /12 inches/foot).

There is also some suggestion that, in spite of the fact that terracing by itself would not reduce ground-water recharge, terracing combined with changes in cropping regimen, such as increased crop density in the terrace channel, would consume not only the retained runoff but also part of the natural ground-water recharge. Assuming that the channel area is 25% of the area of terraced fields then the reduction of recharge would be on the order 16,600 acre-feet/year (.25 * 800,000 acres terraced * 1 in/year /12 inches/foot).

The estimates shown above --- 100,000 are-feet/year under-representation of recharge and 16,600 acre-feet/year over-representation of recharge --- are based on simple conceptual models of precipitation partitioning and terraced field operation. Detailed study of those simple models would be likely to result in a smaller error band. They represent the extremes of the error band on changes to ground-water recharge that should be reasonably tested with the model. The more detailed study are not in the area of expertise of me or my colleagues at MMA Inc. They might be better performed by Mark Groff of The Flatwater Group.

The 100,000 acre-feet/year extreme-case under-representation of recharge represents about 6% of the recharge represented to the ground-water system in Nebraska under current conditions. The 16,600 acre-feet/year extreme-case over-representation represents about 1% of the recharge represented to the ground-water system in Nebraska under current conditions.

It is our judgment that a change of 6% may be detectable in model runs whereas a change of 1% will not be detectable. The estimates of other major flows, however, may well be in error on the order of 6%. Thus to maintain calibration with respect to base flow the model might have to be recalibrated to maintain the relationship between observed and calculated base flow changes. Of special concern is that the terracing occurred in about the same time interval as the growth in irrigation. To maintain the model calibration we might have to increase specifications of irrigation pumping. In that case we may see no net change in accretions or depletion to baseflow.

Improvements in tillage practices and increases in farm ponds would be expected to cause increases in ground-water recharge. Intuition suggests that impacts on model calculations from such practices would be small. To estimate the increases of those practices would entail a substantial data collection program and analysis. Data to be collected to represent improved tillage practices would include distribution, size and specific tillage practice of all fields in the study area. Data to be collected to represent farm ponds would include distribution, size, drainage area, source of water and representative water budgets. Analysis would be best done by scientists familiar with agricultural practices and deep percolation models.

Summary and Conclusions

It is likely that conservation practices may cause a modest increase in ground-water recharge, less than 100,000 acre-feet/year. There is also some chance that in combination with changes in crop density conservation practices might cause a slight decrease in ground-water recharge, less than 16,600 acre-feet/year. Both such changes are likely to be smaller than the accuracy of other components of flow. With a considerable amount of data collection and analysis we might be able to refine those estimates. Before investing resources in data collection and analysis it may be cost effective to determine if the results of the model are likely to be significantly affected.

Proposed Task

Conduct an experiment to establish if changes in ground-water recharge from terracing are of sufficient magnitude to justify a data collection program on terraces. Evaluate information already collected. If data is found to be adequate develop a reasonable hypothetical model of the extent and distribution of terracing in the model area (the Nebraska portion of the Republican River Basin). Develop a reasonable hypothetical model of runoff and ground-water recharge from terraced areas as a function of precipitation. Using the hypothetical models described above modify the RRCA model to represent ground-water recharge. Use the output of the RRCA model to estimate changes in accretion and depletion streams. Submit results to Nebraska DNR for inclusion in accounting procedures to determine whether further study is warranted.

References

RRCA, 2003. Republican River Compact Administration, Ground-Water Model Report, July 1, 2003.

Lindley, Kohler, and Paulhus, 1982. Hydrology for Engineers, pages 204-205.

Martin, D.L. and Koelliker, J.K., 2004. Appendix C: Modeling and Field Experimentation to Determine the Effects of Terracing and Nonfederal Reservoirs on Water Supplies in the Republican River Basin above Hardy, Nebraska.

DRAFT

State of Nebraska
Department of Natural Resources

Preparation of Work Plan for Reviewing and Improving Representation of Phreatophytes in the Republican River Basin Groundwater Model, Nebraska

HDR Engineering, Inc.
April 6, 2006

SCOPE OF WORK

Introduction

Since the Settlement on the Republican River Basin Compact in 2003, the delivery of water to Kansas has diminished, and Nebraska is having great difficulty in meeting the Settlement's requirements. Some individuals and organizations are saying much or all of the declining streamflows can be attributed to vegetation along the streams and to conservation practices. The proposed scope is limited to vegetation as it affects the water budget. Based on the recent model results, ET accounts for about 450,000 acft/yr of water losses while irrigation pumpage accounts for about 2,000,000 acft/yr. Also, the vegetation is located very near the streams and is expected to have an immediate and direct impact.

Because of the complexity of the impact of vegetation on the water balance in the Republican River Basin, the proposed scope of work is the preparation of a work plan for reviewing and improving the representation of phreatophytes, instead of conducting a study on the basis of many major assumptions.

Tasks

In the formulation of the ET component of the groundwater model, each of the states provided coverage of a few types of vegetation. For MODFLOW, parameters on the extent, potential evapotranspiration rates, and the depths for maximum and no ET had to be estimated. The major weaknesses or sources for error in the formulation are the controlling depths of when ET is at its maximum rate and when ET ceases. Of concern is the ability of deep rooted plants to adapt to changing water table elevations and to continue extracting groundwater at their desired rate.

Another concern, separate from the ET component, is the effect of the infestation of brush in the unfarmed areas. This loss of water is not expected to be direct extractions from the water table, but a reduction in recharge.

For these two concerns, the proposed scope of work is intended to:

- Conduct a literature review with regard to a more accurate representation of phreatophytes along the major streams with MODFLOW and the impact of brush infestations on recharge,
- Formulate a study plan, and
- Prepare a detailed scope of work.

Estimated Schedule and Cost

The estimated schedule for completing the report is May 31; and, the estimated cost is $10,000.

Larry Land, P.E.