Indefinite Delivery Indefinite Quantity Contract for Insuring Irrigation

Task Order 1: Limited Irrigation Analysis & Evaluation

Deliverable 2: Limited Irrigation Feasibility Report

Contract Number: D13PC00032
Order Number: D13PD00306

Submitted to:
USDA-RMA
COTR: Claire White
6501 Beacon Drive
Kansas City, Missouri 64133-4676
(816) 926-5131

Submitted by:
Watts and Associates, Inc.
4331 Hillcrest Road
Billings, Montana 59101
(406) 252-7776
twatts@wattsandassociates.com

Due Date: May 23, 2013

Table of Contents

List of Tables

List of Appendices

SECTION I. EXECUTIVE SUMMARY

This second deliverable under the Indefinite Delivery Indefinite Quantity (IDIQ) Contract for Insuring Irrigation has two fundamental purposes: 1) to evaluate the yield adjustment tables established by the University of Nebraska – Lincoln (UNL) for corn and soybeans in Colorado, Kansas, and Nebraska, and 2) to evaluate whether it is feasible to insure acreage to which a reduced amount of water is applied as irrigated practice. The Government posed several questions in the Task Order relating to these topics.

For the reasons summarized below, the Contractor believes the UNL tables are not the appropriate vehicle for managing the crop insurance offer when the amount of water applied to a unit is reduced. However, the Contractor believes feasible approaches are possible. More development of alternatives is needed.

The UNL tables fundamentally are based in a plant growth model, models that are notorious for ability to predict in-sample (i.e., replicating the results of the data used for estimation), but for lack of predictive ability out-of-sample (i.e., when data other than the data used for estimation of the model are substituted). As the Government stated in the questions it posed, the model is based on experimental plot research results under limited regimes of moisture stress. Some of the data are relatively dated and may have resulted from hybrids that no longer are in production. Considering the rapid advances in seed technology in recent years, the reaction of modern varieties to the same stress may differ materially.

Importantly, producers who attended the listening sessions did not agree that the amount of reduction indicated by the UNL tables was justified. They believed management of other attributes of the production process – tillage, better timed irrigation applications, improved varieties, etc. – could (to varying degrees) offset the effects of moderate reductions in available irrigation water supplies. In its review, the Contractor agrees that the observations used to estimate the model may not replicate actual production conditions. The extent to which it overstates the required adjustments is not known.

These limitations of the UNL model raise questions about the advisability of incurring the significant time and expense associated with replicating it for all crops and states. Required data most likely will not be found in some cases. However, as producers in other production areas become aware of changes to the policy regarding irrigated acreage that is occurring in Kansas, they too will want assistance for managing crop insurance guarantees in the face of reduced water supplies, thereby placing demands on the Risk Management Agency (RMA) of the United States Department of Agriculture (USDA) to respond.

The Government asked the Contractor to consider the effects of a reduced APH yield due to adjustments made to reflect reduced water supplies on premium rate requirements. The Contractor considered a number of factors related to the existing premium rating structure and concluded use of the current irrigated premium rate schedule is appropriate for small to moderate reductions in water use. The irrigated premium rate schedule already is applied without knowledge of the amount of water actually used to achieve the

approved APH yield, which varies significantly within a county. The Contractor acknowledges that a lower APH yield can be the result of numerous factors – quality of land and management, varieties grown, tillage, others – but water use must be considered as one of those factors. A high yielding producer in the county might be using 15 inches of water while a lower yielding producer is using 12 inches. Both presently are insured with the same rating schedule, with the lower yielding producer paying a higher premium rate due to the lower ratio of actual yield to reference yield. Suppose a reduction of three inches in water availability to the producer who has historically used approximately 15 inches of water causes an expected loss in yield to a level consistent with that established by the producer who presently uses 12 inches. The Contractor could identify no reason why Producer A (historical 15 inches, now 12 inches) should pay a different premium rate than Producer B (historical 12 inches, now 12 inches) for the same approved yield.

The Government also asked that the Contractor consider the question as to whether the non-irrigated premium rating schedule would be appropriate for rating reduced approved yields due to reductions in water supply. The Contractor concluded that the differences in the reference yield and the impact of the ratio of the unit yield to the reference yield were so great in some cases that the resulting premium rates would be inappropriate. At extreme reductions in water availability – where the expected yield approaches the non-irrigated yield – using the lesser of the rate developed for the irrigated or the non-irrigated practice might be appropriate.

The Government also asked whether acceptable records on applied irrigation (such as timing, frequency, and location of historical irrigation practices) are available and accessible for insurance companies to establish accurate insurance offers and guarantees for limited irrigation. The Contractor pursued this question in the listening sessions. Based on the feedback obtained in those sessions, it would appear that information on total water pumped could be available, perhaps at a well level for the most recent years (those within the record retention period specified in the Basic Provisions), but further detail most likely is not. In particular, there may be no records of water transfer from a well to a different site of use or of water applied to a specific crop insurance unit, especially if third-party verification is deemed an essential part of the documentation.

The Government asked that the Contractor provide a list of pros/cons associated with using limited irrigation in place of current policy and procedure for the irrigated practice. The most important ‘pro’ in response to this issue is the lack of acceptance of the insured population with current policy and procedure. There is absolutely no acceptance among stakeholders of the idea that any reduction in water availability relative to historical use automatically triggers a reduction in insured acres or demotion of the acreage to non-irrigated practice. This was evident from the comments made during the listening sessions. Other ‘pros’ are that the Agency will be perceived as responsive to emerging trends in the agricultural sector and as providing a needed service to agriculture.

The Contractor identified the proposed approach for irrigation as the major con. Producers are not willing to accept the idea that water is the only limiting resource affecting yields, which is the current policy. In addition, the level of detailed information

required for a written agreement is daunting. Using written agreements to extend coverage consumes time and resources and this approach cannot be scaled up in a practical framework.

The Government asked the Contractor to "Suggest modifications and improvements to the limited irrigation methodology developed by UNL and RMA's drafted procedures." The Contractor was not able to suggest usable modifications to the methodology used by UNL. As noted earlier, it has certain deficiencies that render it less than applicable in actual practice. The effects of multiple factors affecting crop production are not considered in its estimates. It requires data not routinely available in many areas for many crops. With regard to RMA's drafted procedure, the Contractor suggested changes to the language to make the document more specific and internally consistent. But, note that these suggestions are premised on the basis that the UNL yield adjustment tables are the basis for the 2013 insurance offer.

As requested by the Government, the Contractor proposed various alternatives for managing limited irrigation for crop insurance purposes. As requested, these are in the nature of "brain-storming" conceptual approaches without any limitations imposed by current policy and procedure. There may be argument as to whether some are feasible. However, the intent is to stimulate thought about the alternatives in keeping with the general rules for brain-storming.

Finally, the Contractor advanced several recommendations to move forward. Some are implicit in the previous statements made in this Executive Summary. The Contractor concludes that improvements to the treatment of limited irrigation are possible and certain actions are proposed. Most importantly, the recommendations call for taking steps to assure that the data from the 2013 crop year are available for analysis. Among the remaining recommendations are proposals that analysis be undertaken to determine the potential approaches that can improve treatment of limited irrigation. In particular, attention is given to the imprecise nature of the present policy and procedure that assumes any reduction, no matter how small, in water availability will result in impairment of production capability to the extent that the acreage must be declared as non-irrigated.

SECTION II. INTRODUCTION

Solicitation D13PS59998 (Solicitation) identifies the objective of the first task order under the IDIQ Contract on Insuring Irrigation as conducting two reviews regarding Limited Irrigation. The first review addressed existing RMA documents, policies, and procedures for insuring irrigated crops, and the impact of reduced irrigation on those policy and procedures. In this second review:

> "*The contractor …* [evaluates] *if limited irrigation would be a feasible alternative crop insurance product*…" This includes a review and evaluation of *"all RMA provided documents for limited irrigation including the University of Nebraska – Lincoln (UNL) developed methodology, yield reduction tables for corn and soybeans in Nebraska, Kansas and Colorado, and the RMA drafted limited irrigation underwriting procedures.*[1]

The term "irrigated practice" is defined in the Basic Provisions as:

> "*A method of producing a crop by which water is artificially applied during the growing season by appropriate systems and at the proper times, with the intention of providing the quantity of water needed to produce at least the yield used to establish the irrigated production guarantee or amount of insurance on the irrigated acreage planted to the insured crop*."[2]

This is the only term related to irrigation defined in the provisions for crop insurance. Details about the irrigated practice as it applies to insurance are incorporated into several crop insurance underwriting documents, including the Crop Insurance Handbook (CIH), the Loss Adjustment Manual Standards Handbook (LAM) and the Irrigated Practice Guidelines. The Irrigated Practice Guidelines are Exhibit 48 of the Document and Supplementary Standards Handbook (DSSH).

Section 6B(11) of the CIH directs Approved Insurance Providers (AIPs) to provide a copy of the Irrigated Practice Guidelines annually to all insureds to whom the information might apply. Section 12A of the CIH contains irrigated practice guidelines for the insurance provider, a compilation of various provisions in different sections of the Basic Provisions affecting irrigated practice. The section of the CIH labeled "IRR practice guidelines for planted or perennial crop acreage" (Section 12(A)(1)) and Exhibit 48 in the DSSH do not contain identical language, but rather incorporate congruent guidance aimed at the two audiences, the insurance provider and the insured, respectively. What is identical in these two documents is the list of factors an insured must be able to document to the AIP's satisfaction to show that adequate facilities and water supply existed at the time insurance attached. This list includes:

- Water source history, trends, and forecasting reliability;
- Water supply availability and usage;
- Pump efficiency and capacity;

[1] USDA, RMA, 2012, Solicitation, Statement of Work, Section 2.4.2.

[2] USDA, RMA, 2010, Common Crop Insurance Policy: Basic Provisions (11-BR), pp. 3-4, with the same language appearing in 05-BR for policies on crops harvested before the 2011 crop year.

- Water requirements (amount and timing) of all crops to be irrigated;
- Water rights (primary, secondary, urban versus agricultural use, etc.);
- Contingency plans to handle shortages;
- Acres to be irrigated;
- Ownership of the water (state or federal versus landowner);
- Meters, measuring devices, and methods used;
- Soil types, soil moisture levels, and pre-plant irrigation needs;
- Water conservation methods, devices used, and plans utilized (if applicable);
- Past crop planting history and tillage methods;
- Quantity and quality of the water supply;
- Supplemental water availability and usage (including return flow);
- Recommendations from local County Extension Service (CES) or National Resource Conservation Service (NRCS), and other sources (recognized by CES or NRCS to be an expert in this area) regarding irrigation and crop production;
- Factors considered in reporting acreage to be insured under an irrigated practice; and
- Information the insured knew (or should have known) and when the insured knew (or should have known) such information pertinent to supporting a good irrigation practice.

The CIH speaks to the amount of water available for irrigation in Section 9(C)(2), stating:

> *"For irrigated acreage… there is not a reasonable expectation of having adequate water to carry out an irrigated practice.*
>
> *"If the insured knew or had reason to know on or before the final planting date or during the late planting period (for crops with a late planting period) that the insured's water* ***will be reduced****, then no reasonable expectation of having adequate water to carry out an irrigation practice exists. Available water resources will be verified using information from State Departments of Water Resources, U.S. Bureau of Reclamation, NRCS, or other source whose business includes collection of water data or regulation of water resources."* [emphasis added]

RMA has required the Contractor to address in this report specific questions concerning the impact of limited irrigation on prevented planting. Section 9C(7)(f) of the CIH provides information about the maximum number of eligible acres for prevented planting coverage when "irrigation facilities" are added for the current crop year. Section 9C(10)(k) states that prevented planting coverage is not provided on any acreage based on an irrigated practice unless adequate irrigation facilities are in place to carry out an irrigated practice on the acreage prior to the insured cause of loss that prevented the insured from planting the insured crop. Additional comments concerning language addressing irrigation in the CIH and LAM from the first deliverable under this IDIQ are incorporated into this report by reference.

To assure precision in the use of language in the remainder of the report, the Contractor provides the following definitions:

Deficit Irrigation – Irrigation using less water than the amount required to achieve maximum evapotranspiration.

Irrigation – Artificially applying water to cropland at the proper times by appropriate systems.

Limited Irrigation – Applying water to a crop artificially by appropriate systems at inappropriate times or applying less water during the appropriate times than the quantity of water that was used to establish the irrigated production guarantee or amount of insurance on the irrigated acreage planted to the insured crop.[3]

RMA has used the term "Reduced Irrigation" without definition, but meaning implicitly: "Irrigation using less water than the quantity of water used to establish the approved yield on the irrigated acreage planted to the insured crop." The reader will note the difference between the meaning of reduced irrigation and the meaning of limited irrigation; limited irrigation is a subset of reduced irrigation.

A crucial element of the definition of "Irrigated Practice" in the Basic Provisions is that the producer is not required to maximize the yield, i.e., achieve maximum evapotranspiration. The definition only states that each producer is expected to follow practices intended to achieve the approved yield for the unit in any year. The producer is free to follow whatever practices make the greatest economic sense in his/her situation. The only requirement is that the producer must follow the practice of providing irrigation sufficient to result in a yield at least equal to the yield on which the production guarantee is based (i.e., the approved yield). This quantity may be greater or lesser in any particular year due to the amount and timing of rainfall and soil moisture at the beginning of the season.

The water used in irrigation is a production input that like most agricultural inputs follows the law of diminishing returns. If all other inputs are held constant, eventually lower per-unit increases of output (i.e., yield) are realized with the addition of another unit of water. In fact, if carbon dioxide or a mineral becomes limiting, adding more water can result in reduced yields as the excess water washes away required mineral inputs or increases the spread of disease.

The definition of Irrigated Practice makes it appropriate for a producer to use deficit irrigation to optimize his or her economic outcome. Deficit irrigation is also an important tool for reducing irrigation water use. However, the language in Section 9(C)(2) of the CIH does not speak to the amount of reduction in the supply of irrigation water, only to the knowledge that the supply will be reduced.

[3] The Contractor notes the definition of "Limited Irrigation" in the contract would better be the definition for "Limited Irrigation Practice" and has provided a definition of the irrigation process. When the practice is addressed in this report, the definition from the Solicitation for **Limited irrigation**: "A method of producing a crop by which less water is artificially applied during the growing season by appropriate systems and at the proper times than the quantity of water that was used to establish the irrigated production guarantee or amount of insurance on the irrigated acreage planted to the insured crop" will be used.

Consequently, in the report on the review of existing RMA documents, policies, and procedures for insuring irrigated crops, the Contractor concluded that the knowledge of a reduced supply of irrigation water prior to planting would require the insured to either irrigate fewer acres (so the amount of water per acre on the irrigated acreage was not reduced) or report the acreage with reduced irrigation as acreage managed under a non-irrigated practice.

Sources of Irrigation Water

Only relatively fresh water (i.e., with a relatively low concentration of dissolved minerals) is useful for irrigation. In the United States, surface and ground water are the primary sources of irrigation water.[4] Surface water is water from precipitation that has collected to form relatively still or moving bodies of water. Lakes and ponds are still bodies of water. While lakes are generally bigger than ponds, there is no standard for classification.

By volume, Lake Superior is the largest lake in North America. It contains more than 10,000 cubic kilometers of fresh water.[5] Most lakes contain fresh water. A vast majority of lakes and ponds have outlets that flow into streams, rivers, etc. Lakes without outlets (i.e., those located in closed basins such as the Great Salt Lake) tend to accumulate minerals and often become highly saline. Since lakes are ephemeral (on a geological timescale all lakes are drying up), the smallest lakes are disappearing and many of these small lakes are becoming too salty for use as irrigation sources. Reservoirs are constructed lakes or ponds.

Branches, brooks, creeks, forks, kills, rivers, runs, streams, and washes are moving bodies of fresh water. As a rule, rivers are the largest followed by forks and branches, which in turn are larger than the rest. However, these terms are used colloquially and some larger moving bodies of water may be called creeks, kills, or runs in the local vernacular. These moving bodies of water may be permanent (i.e., always flowing) or ephemeral (i.e., seasonal, sometimes dry). Canals and ditches are constructed rivers and streams.

Groundwater is water that resides within the soil and rock beneath the Earth's surface. A unit of contiguous groundwater is called an aquifer. Aquifers can be constrained (trapped between two impervious layers) or unconstrained (sitting on top of the highest layer of impervious rock). Aquifers supply water to wells. Unconstrained aquifers are generally recharged (replenished) by precipitation that percolates through the soil and rock from the surface, or are refilled by water flowing from higher elevations through a series of underground channels.[6]

Generally, aquifers are less affected by short droughts than are surface water features. However, since constrained aquifers are trapped between two impervious layers of rock,

[4] In some countries desalinated sea water is used for irrigation, but this practice is rare in the U.S. agricultural economy.
[5] Almost 10 billion acre feet of water.
[6] In many instances the channels are nothing more than the spaces between the soil, subsoil, or bedrock particles.

they can be drained of usable water if the water is extracted by human actions (e.g., from wells). Unconstrained aquifers are more subject to the effects of natural conditions, while both constrained and unconstrained aquifers can be significantly affected by use as an irrigation source.

The Ogallala Aquifer is an aquifer underlying much of the Great Plains. The northern parts are unconstrained, while the southern parts are largely constrained. The Ogallala Aquifer contains about one third as much water as Lake Superior. Between about 1930 and 2005, 253 million acre feet (312 km^3 or about 9 percent of the total) were withdrawn from the aquifer.[7] The Ogallala Aquifer is recharged very slowly. The largest recharge rates are in the northern High Plains (2.76–4.37 in./yr.) where the aquifer is largely unconstrained, followed by the central High Plains (0.20–2.13 in./yr.) and then the southern High Plains (0.008–1.26 in./yr.).[8] In 1966, the United States Geological Survey (USGS) estimated the aquifer is recharged over its entire area at an average rate of less than an inch per year, but the area-weighted average extraction rate for the Ogallala aquifer water in 2005 was almost 55 inches per year.[9]

Irrigation Facilities

Irrigation has been used to improve agricultural production for more than 8,000 years.[10] Initially, surface water and shallow wells were used to supply water for manual irrigation using buckets. Manual irrigation is not appropriate for commercial production in the United States, but is used for small holdings in developing countries. The economic costs of manual irrigation are very low.

Surface or Gravity Irrigation Systems

Water is introduced and distributed by gravity using the soil as the medium in surface irrigation systems.[11] The simplest surface irrigation system is flood irrigation. In flood irrigation, a level field surrounded by dikes is flooded. This works well for fields that are level; for fields that are not level, water supplied at the higher side will flow down the gravitational gradient. The flow can be better controlled if the field is furrowed perpendicular to the gravitational gradient.[12] Surface irrigation systems tend to be less costly to develop and maintain than most other types of irrigation systems. Surface irrigation systems tend to be less affected by climatic and water quality issues, are more suited for use when water supplies are available less frequently, and when the supply is more variable in rate and duration. However, it is more difficult to quantify the availability of water to the crops irrigated by gravitational flows on the soil surface.

[7] McGuire, V.L., 2007, Changes in Water Levels and Storage in the High Plains Aquifer, Predevelopment to 2005, U.S. Geological Survey Fact Sheet 2007-3029, http://pubs.usgs.gov/fs/2007/3029/, accessed April, 2013.
[8] Gurdak, J.J. and C. D. Roe, USGS, 2009, Recharge Rates and Chemistry Beneath Playas of the High Plains Aquifer—A Literature Review and Synthesis, http://pubs.usgs.gov/circ/1333/pdf/C1333.pdf, accessed April, 2013.
[9] McGuire, V.L., 2007, *op cit*.
[10] Ashkenazi, E., 2012, Ancient Well Reveals Secrets of First Jazreel Valley Farmers, Haaretz, November 9, 2012, http://www.haaretz.com/news/national/ancient-well-reveals-secrets-of-first-jezreel-valley-farmers-1.476288, accessed April, 2013.
[11] Drought Advisory, Surface Irrigation Systems, Cooperative Extension, Washington State University, EM4828, March 2003.
[12] UN, FAO, 1989, FAO Irrigation and Drainage Papers: Surface Irrigation Systems, http://www.fao.org/docrep/T0231E/ t0231e04.htm, accessed March, 2013.

Surface irrigation systems tend to be less efficient at supporting evapotranspiration. Within a field irrigated by a surface system, some areas are over-watered and others are under-watered. [13]

Sprinkler Irrigation

Sprinkler irrigation is a commonly used type of irrigation in the United States and is suitable for most row, field, and tree crops. In sprinkler or overhead irrigation, water is piped, usually by pumping, to one or more locations within the field and distributed by an overhead system of sprinklers or high-pressure guns. Sprinkler irrigation is a method of applying irrigation water that is more similar to natural rainfall than a surface irrigation system. The water is sprayed into the air so it breaks up into small water drops which fall onto the crop and the ground. The pump supply system, sprinklers, and operating conditions must be designed to provide a uniform application of water over the irrigated acreage.[14] Sprinkler irrigation can be used on most soil types and farmable slopes. Sprinkler irrigation systems can be designed to water from above or into the canopy of the crop being watered, and allow the producer to change the irrigation intensity (amount of water being applied to the land). Fertilizer and pesticides can also be distributed through sprinkler irrigation systems. If there is an adequate supply of water at the appropriate times and it is economically feasible, soil moisture can be maintained at levels that optimize the transpiration element of evapotranspiration.[15] However, as noted earlier, deficit irrigation is often practiced to optimize economic outcomes, while optimizing transpiration would be used to maximize the yield. There is strong correlation between yield and evapotranspiration, which has been the subject of academic research for more than 50 years.[16]

The initial cost of a sprinkler irrigation system is relatively high. These systems require relatively high energy inputs, and adverse weather conditions (e.g., high winds and temperatures) tend to diminish the efficacy of the system. Depending on the spray pattern, water losses to evaporation can be quite large. Furthermore, untimely above canopy sprinkling can wash pesticides from the plants.

Subsurface Irrigation/Drainage (Sub-irrigation)

If the soil water balance is poor (i.e. saturated, overly dry, etc.) crop productivity is reduced. Initially, large portions of Arkansas, Illinois, Indiana, Iowa, Louisiana, Minnesota, Mississippi, Missouri, Ohio, and Texas were unsuited to cultivation because the soils frequently were too wet. Pipe or tile drainage systems reduced the soil saturation to a point where a balance was achieved. Most of the drainage of these fields occurred in the early 1900s in response to improvements in drainage technology and government support for development of drainage districts. Despite the Depression, the

[13] UN, FAO, 1989, FAO Irrigation and Drainage Papers: The Practice of Irrigation, http://www.fao.org/docrep/T0231E/ t0231e03.htm, accessed March, 2013.
[14] Brouwer, C., K. Prins, M. Kay, and M. Heibloem, UN, FAO, 1989, Training Manual 5, Irrigation Water Management: Irrigation Methods:: Sprinkler Irrigation, http://www.fao.org/docrep/S8684E/s8684e06.htm, accessed March, 2013.
[15] Ibid
[16] Allison, F.E., E.M. Roller and W.A. Raney, 1958, Relationship Between Evapotranspiration and Yields of Crops Grown in Lysimeters Receiving Natural Rainfall, Agronomy Journal, 50:506-511.

federal government provided financial assistance in the 1920s and 1930s to maintain and expand drainage systems. Drainage of irrigated lands in the west expanded at the same time. By the late 1970s, the federal government began discouraging wetland drainage.[17] By integrating a water source (i.e., an irrigation reservoir) in the upland portion of the subsurface drainage system, a producer can create a subsurface irrigation system. The system can capture excess water from precipitation leaching into the drainage system in a run-off reservoir. This excess precipitation is pumped into the irrigation reservoir for use when needed. During irrigation, water from the irrigation reservoir flows through the drains and into the soil beneath the roots of the crop (usually 4 to 5 feet below the surface). Capillary rise, water moving vertically upward through tiny spaces between the soil particles, brings the water from the deeper soil to the crop root zone. A subsurface irrigation/drainage system has very high initial installation costs; however tiling is gaining popularity in many regions in the United States because of its efficiency of water usage.

Localized Irrigation

Localized irrigation is the distribution of water under low pressure through a piped network adjacent to plants (also known as drip irrigation). A localized irrigation system can be very effective for areas where a water source is limited and individual plants can be watered. Localized irrigation provides a means to deliver light and frequent watering. This keeps salt concentration in the soil water to a minimum.[18] Localized irrigation provides many advantages over traditional surface or sprinkler irrigation, especially when water resources are scarce and/or costly. Drip irrigation can cover a much larger, highly-targeted zone with the available water. Since the irrigated area is shaded by the plants being watered, evaporation is minimized and the amount of water required to maintain appropriate soil moisture levels in the root zone is reduced. Fertilizer usage can also be minimized by using the same drip system to target the application area rather than spreading the fertilizer over the entire field. By keeping the foliage dry, the risk of disease is reduced. The soil remains properly aerated. Furthermore, the output of each nozzle can be controlled, allowing different levels of water application according to the needs of the individual plant, without additional labor once the system has been set up. However, because the nozzles need to be cleaned periodically, maintenance costs in areas with high mineral content in the irrigation water can be high. Providing localized irrigation to row or field crops is difficult, but the system works well for tree, perennial, and some fruit and vegetable crops. The initial capitalization needed to design, purchase and install a localized irrigation system is very high.

Irrigation Regulations

The next section addresses laws and regulations governing the irrigation water by state for Colorado, Kansas, and Nebraska. These three states utilize a version of a system known as the prior appropriation doctrine that is common in the western United States.

[17] NRCS East National Technology Support Center, 2011, Drainage: the Invisible Infrastructure of the Midwest, http://soilquality.org/history/history_drainage_midwest.html, accessed March, 2013; Ahmet, K, 2011, Subirrigation in Field Crops and Usage in Greenhouses, http://www.agriculturegeuide.org/subirrigation-in-field-crops-and-usage-in-greenhouses/, accessed March, 2013.

[18] Savva, A.P., and K. Frenken, UN, FAO, 2002, Irrigation Manual, ftp://ftp.fao.org/agl/aglw/docs/irrigman9.pdf, accessed March, 2013.

In the eastern United States, the riparian doctrine is most common. Under the riparian doctrine, the owner of land adjacent to a water source has first rights to the water; under the prior appropriation doctrine, the first user of the water generally has superior rights.

Colorado

Water in Colorado is owned and managed by the state of Colorado through its Division of Water Resources (DWR). Colorado, like Nebraska and Kansas, follows the First in Time, First in Right doctrine for water accessibility. Colorado is unique in that it is the first state to implement management of the distribution of water by public officials.[19] There are seven division offices of the DWR throughout the state:

- Division 1 Greeley Office – South Platte River Basin,
- Division 2 Pueblo Office – Arkansas River Basin,
- Division 3 Alamosa Office – Rio Grande Basin,
- Division 4 Montrose Office – Gunnison River Basin,
- Division 5 Glenwood Springs Office – Colorado River Basin,
- Division 6 Steamboat Springs Office – Yampa/White River Basin, and
- Division 7 Durango Office – San Juan/Delores River Basin.

Each of these divisions is further broken into a total of 78 water districts. In addition, there are advisory committees and rulemaking groups. Advisory committees are permanent groups which recommend policies for better irrigation water management. Rulemaking groups are temporary committees that hold hearings and provide input to the State Engineer Office (SEO) concerning water policy administration.[20]

Surface Water

The Colorado Constitution appropriated all surface water as property of the public. Furthermore, the Constitution states, "The right to divert the unappropriated waters of any natural stream to beneficial uses shall never be denied." It prioritizes the diversion of water during times when water availability cannot meet demand to domestic uses followed by agriculture and then manufacturing uses.[21] A unique feature of the Colorado surface water governance is that precipitation is considered property of the state. Consequently, it is illegal in Colorado to capture precipitation without a permit from the DWR. Colorado has the most extensive surface water monitoring system in the lower 48 states. The system provides near real-time monitoring of the level of surface water features. For more than 25 years, surface water in Colorado has been monitored using over 500 gauges on surface water features throughout the state.[22] The state manages day to day use of surface water for irrigation using these data.

[19] Colorado Division of Water Resources, no date specified, History of Water Rights, http://water.state.co.us/SurfaceWater/ SWRights/Pages/WRHistory.aspx, accessed March, 2013.
[20] Colorado Division of Water Resources, no date specified, Rulemaking Groups and Advisory Committees, http://water.state.co.us/SurfaceWater/RulemakingAndAdvising/Pages/default.aspx, accessed March 2013.
[21] Colorado Division of Water Resources, Joseph Grantham, Revised Edition, 2011, Synopsis of Colorado Water Law.
[22] Thomas W. Ley, Ph.D., PE; Phil L. DeArcos; Russell V. Stroud; David G. Hutchens; 2010;The Colorado Satellite-Linked Water Resources Monitoring System: 25 Years Later; http://water.state.co.us/DWRIPub/DWR%20General%20Documents/USCIDColoradoSMSpaper_Ley.pdf, accessed March, 2013

Ground Water

Colorado monitors groundwater levels by measuring water levels in more than 1,500 wells. In addition to monitoring these wells, DWR works with the Colorado Ground Water Commission (CGWC) to regulate the use of ground water in the state. Permits are required to use groundwater. The permits are considered property rights, and can be sold independently of the land where the well is located. The CGWC has designated eight ground water basins in eastern Colorado with 13 Ground Water Management Districts (GWMDs) within these basins. The GWMDs have additional administrative authority within their boundaries. The GWMDs are authorized to adopt rules and regulations to help administer ground water use within a district. However, only the CGWC can issue or change permits.[23] Since 1967, permits for large-capacity wells[24] have not been issued for any proposed well in the same aquifer closer than a half mile from an existing large-capacity well. Since 1990, permits are not issued for a new well if that well will deplete the groundwater in a three-mile radius by 40 percent within 100 years. Obtaining permits or increasing the draw on an existing well is difficult because of these two standards.

In general, irrigation water for corn and soybeans is primarily used in the eastern plains of Colorado. Surface irrigation is a commonly used irrigation practice. However, as access to water statewide is controlled, monitored, and managed by the DWR offices, not only do producers face the risk of too little precipitation during the growing season, they also face the risk of available water being withheld by the state during "appropriate times" for crop production.

Kansas

The state of Kansas owns the water in the state and dedicates it for "the use of the people of the state, subject to the control and regulation of the state…"[25] The Department of Agriculture regulates water resources through the Division of Water Resources (DWR). Water rights permits for both surface water diversion and wells are issued by the DWR. The DWR also monitors water usage. Unless the water is used for domestic purposes, it is illegal to use water in Kansas without a water right from the DWR.[26] Water rights holders provide yearly reports on use. There are five field offices of the DWR in Kansas which each employ a water commissioner and staff familiar with local water issues. These field offices administer available water supplies, determine water right compliance, conduct data collection, respond to public inquiries, process certain water right changes, conduct field inspections and investigations, and provide access to water right records. Nearly 85 percent of water used in Kansas is used for irrigation.[27] Some of the field offices assess "safe yield" while others assess "allowable depletion." Safe yield requires

[23] Colorado Division of Water Resources, no date specified, Ground Water Administration and Well Permitting, http://water.state.co.us/GROUNDWATER/Pages/default.aspx, accessed March 2013.
[24] Wells whose capacity exceeds 50 gallons per minute.
[25] KANSAS WATER APPROPRIATION ACT, K.S.A. 82a-701 through 82a-737 and 82a-740 through 82a-742 and K.S.A. 42-303 and 42-313, Revised December, 2012.
[26] Kansas defines Domestic use as: "the use of water by any family unit for household purposes, watering farm and domestic animals, and watering lawns, orchards or gardens not exceeding 2 acres in size." http://www.gmd4.org/LawSum/lawsum.htm
[27] Kansas Water Resources, 2009, Kansas Department of Agriculture, http://www.ksda.gov/includes/document_center/dwr/ Publications/KansasWaterResources.pdf, accessed March, 2013.

that total water use in a district must be an allowable percentage of the aquifer recharge in the area. Allowable depletion focuses on depletion of the supply by a specific amount in a specified time.

Surface Water

Only about one quarter of the 5 to 6 million acre-feet (6.2 to 7.4 km^3) of water used annually in Kansas is diverted from surface water, mainly rivers. In the western areas of Kansas, surface water is very limited; groundwater rights permits are far more prevalent in this area. In the eastern areas of Kansas, surface water is relatively abundant. The DWR has been actively involved in providing for future access to water supplies in eastern Kansas by building, expanding and maintaining reservoirs to store water for periods of shortage.

Groundwater

In Kansas, anyone with a well who has been pumping water from a well since June 28, 1945 has a vested right and can use groundwater for nondomestic purposes as long as the use is for "beneficial purposes." These wells are essentially exempt from regulation within limits based on historical use. Otherwise, groundwater is managed under the authority of local groundwater management districts (GMD), including:

- Western Kansas Groundwater Management District No. 1;
- Equus Beds Groundwater Management District No. 2;
- Southwest Kansas Groundwater Management District No. 3;
- Northwest Kansas Groundwater Management District No. 4; and
- Big Bend Groundwater Management District No. 5.

These districts provide guidance for and regulation of "future water use development…" and "plan for future water needs."[28] GMDs are governed by a locally-elected Board of Directors. GMDs create policy and regulations concerning the use of groundwater in the respective districts. The policy and regulation are subject to approval by the DWR.

In addition to GMDs, the DWR chief engineer has had the authority since 1978 to designate areas as Intensive Groundwater Use Control Areas (IGUCAs). In IGUCAs, extensive public input is sought for flexible solutions to complex water access issues rather than simply relying on the First-in-Time, First-in-Right doctrine. To further enhance local input regarding water usage, Local Enhanced Management Areas (LEMAs) were authorized by the Kansas Legislature in 2012. LEMAs provide GMDs a regulated process to address groundwater declines and other conditions of concern through locally-generated management plans that include specific goals and corrective control provisions. LEMAs are different from IGUCAs in that enforcement of the management process remains under local authority rather under the DWR.[29] To date, the

[28] Western Kansas Groundwater Management District No.1, no date Specified, News and Information, http://www.gmd1.org/index-1.html, accessed March, 2013.

[29] Kansas DWR Chief Engineer Order of Decision obtained from http://www.ksda.gov/water_management_services/?cid=2021.

one LEMA accepted by the DWR affects portions of Thomas and Sheridan Counties ("Sheridan 6 LEMA").[30]

Nebraska

Water in Nebraska is "held by the state for the benefit of its citizens."[31] Water rights are issued and managed by the Nebraska Department of Natural Resources (NDNR) and the rights are "legally attached to a parcel of land or a position in the state and is transferred with the land to subsequent owners."[32] Surface and ground water are governed by different laws, with different regulatory bodies managing these resources. Surface waters are regulated by five field offices for the NDNR, which provide local contacts with NDNR personnel. Groundwater usage is regulated by Natural Resource Districts (NRD). Each NRD has an elected Board which works cooperatively with the NDNR. Currently, there are 23 NRDs in Nebraska. Where there is no NRD, residents follow the correlative rights doctrine that residents must share when groundwater supplies are limited.

Surface Water

Access to and use of surface waters in Nebraska are governed by the state constitution and subsequent legislation. The primary rule governing use of surface water in Nebraska is the Appropriative First-in-Time, First-in-Right Rule.[33] This rule, in essence, provides for the "diversion of water from the surface waters of the state based on the date the water right was obtained" and entitles "land owners or organizations to remove a set amount of water from a specific location."[34] When situations arise in which surface waters are insufficient to meet the demands of all users this rule protects those who were first to obtain the water rights. However, there is a hierarchy of users defined in the legislative rules governing water rights with domestic use having a higher ranking than agricultural uses which in turn ranks higher than manufacturing.[35]

Groundwater

Groundwater access and usage is governed under the Correlative Rights Rules in Nebraska. These rights allow land owners to extract groundwater from an underlying aquifer for "beneficial purposes." The determination of what constitutes "beneficial purposes" is made by the NRD's Board of Directors. Once a water well permit has been issued by the local NRD, the land owner is allowed to develop the well and use as much groundwater as needed until it is determined that the use of the water is no longer beneficial. All water wells in Nebraska must be registered with the NDNR which keeps a statewide database. NRDs are required to maintain a groundwater management plan for both water quality and quantity.

[30] Kansas DWR, 2013, Order of Designation Approving the Sheridan 6 Local Enhanced Management Area within Groundwater management District 4, http://dwr.kda.ks.gov/LEMAs/SD6/LEMA.SD6.OrderOfDesignation.20130417.pdf, accessed April, 2013.
[31] Nebraska Department of Natural resources, 2007 Groundwater Management and protection, http://www.dnr.state.ne.us/ Publications/GWMgmt_ProtectionActStatutes_0807.pdf, accessed March, 2013.
[32] UNL Water, Agricultural irrigation Team, 2012, Regulations & Policies: Surface Water, Groundwater, Chemigation, and Natural Resources Districts, http://water.unl.edu/web/cropswater/regulations, accessed March, 2013.
[33] Nebraska Legislature, 1920, Nebraska State Constitution Article XV-6, http://nebraskalegislature.gov/laws/articles.php?article=XV-6, accessed March, 2013.
[34] UNL Water, Agricultural irrigation Team, 2012, *op cit*.
[35] Nebraska Legislature, 1920, *op cit*.

Since 1996 Nebraska has passed additional regulations and created boards to study, review, and recommend changes to the state's water legislation, all in an effort to try to maintain enough water to meet the needs of its citizens. The state recognized links between surface and ground water and began exploring ways to assess impacts of water usage to the overall water availability for the state's citizens. To that end, the state created a Water Policy Task Force[36] which was tasked to:

1) Review existing laws related to the integrated management of hydrologic surface water and groundwater and determine if any changes are needed to adequately address Nebraska's conjunctive use and integrated management of these resources;
2) Evaluate the utility of allowing permanent and temporary transfers and leasing of water rights and creating a water banking system; and
3) Determine what issues related to inequities between surface water and groundwater users need to be addressed and what actions need to be taken.

Following the creation of this task force, Nebraska enacted a law addressing both ground and surface waters, which identified criteria to classify watersheds as being under, fully, or over-appropriated. Nearly half the state has since been classified as being fully or over-appropriated. In 2009, the legislature passed a law limiting new development of irrigated acres within areas surrounding surface water resources in areas that were classified as fully appropriated by NDNR. However, the development limitations have subsequently been reversed.[37] Recent limitations on irrigation water use have been temporary rather than permanent.

Limited Irrigation

As noted earlier, crop insurance policy and procedures presently mandate that a producer who knows or who has reason to know that water availability will be restricted for a crop year must reduce the number of acres to which water is applied so the historical amount of water can be applied to the reduced acreage. If this is not done (i.e., the producer maintains the same acreage but applies a lesser amount of water per acre), the entire unit is to be reported as a practice other than irrigated if such practice is offered. Otherwise, the acreage is uninsurable.

RMA's criteria for feasibility identify the requirements to establish an appropriate feasibility recommendation for a crop insurance product in the broadest terms.

The proposed insurance coverage must conform to RMA's enabling legislation, regulations, and procedures that cannot be changed. The enabling legislation is Title 7, Chapter 36, Subchapter I of the U.S. Code, as amended.[38] Amendment of this code requires an act of Congress. The Regulations and Procedures implementing this Act are the responsibility of the FCIC Board of Directors and USDA RMA. This criterion provides no absolute barrier to the insurance of crops under limited irrigation.

[36] Initially made up of 49 members.
[37] http://water.unl.edu/web/cropswater/regulations
[38] See for example http://www.law.cornell.edu/uscode/text/7/chapter-36/subchapter-I.

Producers or their agents must be willing to pay the appropriate price for the insurance. The willingness of producers or their agents to pay will be influenced by the coverage available and the costs associated with the insurance offer. Producers in Colorado, Kansas, and Nebraska generally participate in crop insurance programs, and unless the costs or procedures for insuring crops under limited irrigation are particularly onerous, the Contractor would expect producers to be willing to pay the appropriate price for the insurance.

The insurance product must be effective, meaningful and reflect the actual risks of the producers. Corn and soybeans are already insured in Colorado, Kansas, and Nebraska. The actual insurable risks the producer faces appear to be addressed by the existing insurance. However, the insureds' perceptions of the utility of the insurance and of the ability of the insurance to protect the insured from financial failure affect the meaningfulness of the product. Consequently, the approach used to address limited irrigation scenarios may impact whether the insurance is considered meaningful.

The perils affecting production must be identified and categorized as insurable and non-insurable. Since insurance for corn and soybeans already exists, the only barrier under this criterion is whether there is an antagonistic effect of limited irrigation on losses due to other causes.

The insurance product must be ratable and operable in an actuarially sound manner. It must be possible for an actuarially-sound premium rate to be determined. This is fundamentally a question of data availability in terms of quantity of statistically valid observations or of the quality of non-quantifiable (judgmental) observations. This is a fundamental question addressed in this report.

The insurance product must contain underwriting, rating, pricing, loss measurement, and insurance contract terms and conditions. Appropriate management practices have been defined and required of stakeholders under the existing insurance. Again, the only barrier under this criterion is whether there is an antagonistic effect of limited irrigation on losses due to other causes.

There must be an appropriate geographic distribution of production to ensure a sound financial insurance program. An appropriate geographic distribution of insurance risk is required to address the need for insurance that is responsible to the taxpayer, since stakeholders operating in a limited geographic area could face collective catastrophic loss not protected by the insurance pool funds. The Contractor understands this requirement to apply to the entire FCIC portfolio in the aggregate, which is distributed throughout the United States. This criterion is therefore not a barrier to the insurance of crops under limited irrigation.

There must be enough interest for the risk to be spread over an acceptable pool of insureds. An appropriate pool size is also required to address the need for insurance that is responsible to the taxpayer, since a limited pool could face collective catastrophic loss not protected by the insurance pool funds. A sufficient number of stakeholders, who are

not identically affected by perils, must be willing to buy the insurance as part of an overall farm risk management strategy. Without an appropriate pool of insured enterprises, the insurer faces the risk of catastrophic losses. Indemnities in excess of the realized premiums may occur, increasing the subsidy costs to the taxpayer. The Contractor understands this requirement also applies to the entire FCIC portfolio in the aggregate, which involved more than 1.1 million policies and almost $110 billion of insured liability in 2012. This criterion is therefore not a barrier to the insurance of crops under limited irrigation.

Customers must not be able to select insurance only when conditions are adverse. At the time of enrollment the purchaser must be unable to predict the outcome. If the purchaser can predict the outcome at the time of enrollment, not only will adverse selection occur, but unscrupulous purchasers could "farm" the insurance to maximize profits. Only unpredictable outcomes fall into the category of appropriately insurable risks. Predictable outcomes do not include risks, but are characterized by certainty. However, because the insured with limited irrigation water supply can choose where to apply that water, this criterion is an issue that is addressed in the report.

Moral hazards must be avoidable or controllable. There must be a clearly defined outcome or phenomenon to be insured and the outcome must be subject to random variation; the variation in outcome must be separable into that part which can or might be manipulated, and that part which cannot be controlled. Again, because the insured with limited irrigation water supply can choose where to apply that water, this criterion is an issue that is addressed in the report.

There can be no chance of beneficial gain. If an insured individual benefits unduly from participation in the program, that gain introduces the possibility that the insurance would change the status of the insured within the pool of stakeholders. Insurance should be only a vehicle to manage risk; there should be no possibility that indemnity payments will become a fundamental element of the typical income stream. As long as the rating and underwriting are appropriate, this criterion is not a barrier to the insurance of crops under limited irrigation.

There must be no unacceptable change in market behavior or unacceptable market distortions in terms of either a change in quantity supplied or shift in the supply curve. Although the production of corn and soybeans in Colorado, Kansas, and Nebraska is substantial, the global nature of these crops as commodities makes the issues of market behavior and distortion moot.

Consequently, the remainder of this report addresses the feasibility of introducing limited irrigation as an alternative crop insurance product and incorporates the Contractor's assessments of eleven specific concerns, including:

- The basis for establishing the yield reduction estimates;
- The focus of the proposed adjustment technique on yield rather than yield variability;
- The availability of acceptable records for implementation of the approach;

- Effects on prevented planting claims and rate;
- Long-term data maintenance;
- The applicability of the current continuous rating function for estimating risk;
- The effects of substitution of the non-irrigated practice for limited irrigation;
- Whether separate limited irrigated rates are required;
- Irrigation underwriting requirements for each APH database;
- Potential impacts of implementing a limited irrigation product on RMA; and
- Potential impacts of implementing a limited irrigation product on AIP systems, forms, and processing.

SECTION III. DATA AVAILABILITY AND APPLICABILITY

By contract, this report focuses on corn and soybeans in Colorado, Kansas, and Nebraska. However, inherent in the question of the feasibility of insuring limited irrigation is the need to avoid market distortion. Consequently, consideration of other crops and states other than the study crops and states is important.

There are many data available for corn and soybean production including annual, aggregate estimates of acreage planted, acreage harvested, yields, and value by state and county maintained by the USDA National Agricultural Statistics Service (NASS). The information for NASS statistics is gathered in many ways, including: "…surveys, telephone interviews, face-to-face interviews, and field observations."[39] Based on the responses to data collection, NASS publishes estimates for acreage, production, yield by practice and county, by practice and agricultural district, and by practice and state.

The Census of Agriculture

Once every five years, the National Agricultural Statistics Service (NASS) conducts a nationwide survey, the Census of Agriculture (Census). For selected crops, including the major field and row crops, the Census reports data on farm numbers, acreage planted, acreage harvested, production, value, and data on irrigated and non-irrigated acreage. These data are available at the national (Table 1), state, and county levels. The Census also reports voluminous demographic data on the characteristics of farms and producers.

[39] USDA, NASS, 2009, NASS Surveys: The Foundation of Estimates, http://www.nass.usda.gov/Education_and_ Outreach/Understanding_Statistics/Foundation_of_Estimates/index.asp, accessed may, 2013.

Table 1. United States Specified Field and Row Crops by Extent of Irrigation on Individual Farms,[1] 2007

Crop	Attribute	Extent of Irrigation		
		Entire Crop	Part of the Crop	None of the Crop
Corn for Grain	Farms	17,927	20,984	308,849
	Acreage Irrigated	6,103,769	7,053,000	
	Dryland Acreage		6,435,486	66,656,287
	Average Yield	180.0	150.0	144.3
Corn for Silage	Farms	8,173	1,491	
	Acreage Irrigated	1,369,278	128,010	
	Dryland Acreage		164,203	74,653
	Average Yield	24.8	17.0	15.1
Soybean	Farms	7,007	13,326	258,777
	Acreage Irrigated	2,175,069	3,062,006	
	Dryland Acreage		3,396,716	55,282,030
	Average Yield	45.3	40.8	40.2
Wheat (All)	Farms	7,695	7,518	145,597
	Acreage Irrigated	1,806,902	1,557,177	
	Dryland Acreage		3,703,599	43,865,291
	Average Yield	80.3	42.7	37.0
Grain Sorghum	Farms	2,092	2,391	21,759
	Acreage Irrigated	443,599	401,615	
	Dryland Acreage		670,030	5,254,590
	Average Yield	86.9	74.7	69.2

[1] Yields are in bushels except for corn silage for which yield is reported in tons.
Source: The Contractor's Research Department after data from the 2007 Census of Agriculture Table 32. Specified Crops Harvested - Yield per Acre Irrigated and Non-irrigated: 2007, published in 2009.

The Farm and Ranch Irrigation Survey (Irrigation Survey) is a supplement to the Census and is the only single source of national and state-level information on irrigation and agricultural water use for which the data are collected by a uniform, published methodology. The information collected includes application methods, equipment, facilities and expenditures, irrigated crop acreage, and irrigated yields. NASS last conducted this survey for the 2008 crop year as a follow-up to the 2007 Census. According to the 2008 Irrigation Survey supplementing the 2007 Census, 54,929,915 acres were irrigated in 2008 on 89,646 farms.[40] In the 3 study states, just over 14 million acres (Table 2) were irrigated in 2008 on 41,143 farms (Table 3), representing 25.5 percent of the irrigated acreage in the United States and 45.9 percent of farms with irrigation. However, it is important to note the estimates reported in the Irrigation Survey are constrained by the level of response from the subjects of the survey. The Census data provide a one in five years snapshot of the nation's agricultural economy. Though useful for establishing the potential impact of changes in crop insurance programs, the applicability of these data to insurance development efforts is quite limited.

[40] USDA, NASS, 2010, 2007 Census of Agriculture: Farm and Ranch Irrigation Survey (2008).

Table 2. Total Irrigated Acreage in the Three Study States by Irrigation Type, 2008

State	Acreage by Irrigation Type			
	Gravity	Sprinkler	Drip	Sub-irrigation
Colorado	1,547,072	1,402,688	23,061	2,495
Kansas	184,624	2,435,812	9,268	-
Nebraska	1,669,351	6,724,262	4,189	-

Source: The Contractor's Research Department after data from the 2007 Census of Agriculture: Farm and Ranch Irrigation Survey (2008), published in 2010.

Table 3. Total Number of Irrigated Farms in the Three Study States by Irrigation Type, 2008

State	Farms			
	Gravity	Sprinkler	Drip	Sub-irrigation
Colorado	10,252	4,337	524	13
Kansas	1,475	3,811	153	-
Nebraska	6,506	14,018	54	-

Source: The Contractor's Research Department after data from the 2007 Census of Agriculture: Farm and Ranch Irrigation Survey (2008), published in 2010

The Irrigation Survey also includes state-level data on major crops. In the study states, more corn is grown than soybeans on both an acreage and production basis. In each study state, more of each of these crops is grown with irrigation than without. Under irrigation, the yields for corn for grain differs from state to state while the yields for soybeans and corn for silage are very similar across the three state study region (Table 4).

Table 4. Irrigated and Non-Irrigated Production of Corn and Soybeans in the Study States, 2008

Crop	Attribute	Colorado		Kansas		Nebraska	
		Irrigated	Non-irrigated	Irrigated	Non-irrigated	Irrigated	Non-irrigated
Corn for Grain	Farms	2,337	257	2,896	1,454	12,530	8,525
	Acreage Harvested	796,040	87,610	1,368,126	475,908	5,058,195	1,230,756
	Yield	177	48	185	71	184	129
Corn for Silage	Farms	848	20	394	230	1,115	524
	Acreage Harvested	92,563	1,720	75,978	19,111	89,346	20,430
	Yield	23	8	22	18	22	17
Soybean	Farms	30	-	2,148	1,079	10,541	7,560
	Acreage Harvested	4,832	-	396,613	281,995	2,272,944	957,491
	Yield	57	-	53	36	57	43

Source: The Contractor's Research Department after data from the 2007 Census of Agriculture: Farm and Ranch Irrigation Survey (2008), published in 2010.

The Census provides useful information on the role of crops in the agricultural economy as well as useful demographic information about farm structure at the national, state, and county levels. The Irrigation Survey provides an overview of the role irrigation plays in the production of major crops at the national and state levels. It also provides useful information concerning the complexity of developing insurance that takes into account the crop irrigated and the state where the production occurs. However, both the Census and the Irrigation Survey are conducted only once every five years. Neither provides farm-level data on the effects of irrigation or the risks inherent in changing the amount of irrigation water applied. Nor do these surveys provide information about precipitation or soil moisture.

NASS Quick Stats

The largest single NASS data collection each year is the June Agricultural Survey. Producers are sampled by both geographic location and operational characteristics. For the area sampling, approximately 10,000 locations within the total U.S. land mass are studied through interviews with approximately 50,000 producers or producer representatives (sampling about 2.25 percent of total U.S. farms and ranches). Large farms are sampled at high rates, while small farms (e.g., less than 50 acres of cropland) are randomly selected at very low rates. The December survey is supplemented with a mailing to a county sample of about 300,000 farm operators (about 15 percent of U.S. farms) to collect information to support the County Data program. The responses from this supplemental sample are combined with those from the December survey and aggregated to a county summary.

NASS publishes annual agricultural U.S., state, and county-level data for many commodities based on surveys of representative samples of producers. The Quick Stats online application allows the NASS databases to be queried by commodity, state, and year. County-level data for each state are prepared and published by individual NASS State Statistical Service Offices. The NASS state offices aggregate data totals for Agricultural Statistics Districts (multi-county groupings) and for each state. County data are "assembled" starting from state estimates and working back to the county level. Since NASS uses sample surveys, it is not possible to publish information for all counties (Table 5). This is due to low response rates; non-disclosure rules; and other technical and policy considerations.

Table 5. Counties Reporting Corn Production to NASS, by Study State, 2008[41]

State	Counties	NASS County Numbers		
		Practice Not Specified	Irrigated	Non-irrigated
Colorado	63	20	7	7
Kansas	105	49	13	13
Nebraska	93	18	75	75

Source: The Contractor's Research Department after data from USDA, NASS, Quick Stats, accessed May, 2013.

There are 63, 105, and 93 counties in Colorado, Kansas and Nebraska, respectively. NASS maintains cooperative agreements with state Departments of Agriculture and/or land grant

[41] The Contractor reports the 2008 data to provide an easy comparison between the Irrigation Survey data and the other data reported herein.

universities to assist with data collection. Funding limits the information availability for crops, data elements, and years. Since for so many counties the corn yields have data without information about the irrigation used, the Quick Stats data have limited potential to reflect the impact of irrigation on yields in many counties. Yet, there is useful information about the impact of irrigation of yields for some counties (Table 6 and Appendix A, Exhibit 1), including information about the county-level variability of those yields from year to year.

Table 6. Metadata on County-level Corn Yields (bushels/acre) in the Study States, 2008

State	Practice Not Specified			Irrigated			Non-irrigated		
	Low	High	Acre-weighted Mean	Low	High	Acre-weighted Mean	Low	High	Acre-weighted Mean
Colorado	39	214	139	153	192	177	39	76	48
Kansas	72	183	133	150	193	185	30	125	71
Nebraska	114	190	162	136	204	184	42	159	129

Source: The Contractor's Research Department after data from USDA, NASS, Quick Stats, accessed May, 2013

However, since the NASS annual county data focus on the major grains, oilseeds, cotton, dry edible beans, sugar and tobacco,[42] there are many irrigated crops whose annual irrigated and non-irrigated yields cannot be inferred from these data. Furthermore, the Quick Stats data are not structured to reflect the RMA definition of irrigated practice and cannot reflect the risks inherent in changing the amount of irrigation water applied. Nor do these NASS data provide information about precipitation or soil moisture. Consequently, while these data have some applicability to crop insurance development, the applicability to development of insurance for limited irrigation is constrained.

National Oceanographic and Atmospheric Administration: National Climate Data Center

The National Oceanographic and Atmospheric Administration (NOAA) is an agency of the U.S. Department of Commerce. NOAA is responsible for maintaining current and historical weather data. NOAA's National Climatic Data Center (NCDC) maintains the world's largest climate data archive. Records in the archive include paleoclimatic data, hand written journals, and recent and current digital weather data. NCDC has developed numerous U.S. datasets which can be used to understand the risks caused by weather and, to some extent, by climate variability.

The NCDC Cooperative Summary of the Day (DSI-3200)[43] and the Quality Controlled Local Climate Dataset (QCLCD) provide raw data for risk assessment related to amounts of precipitation (and consequently, in aggregate, of soil moisture content). The DSI-3200 includes data from 1850. The data were collected at almost 30,000 stations. Some stations have been in operation since 1850; some reported data for a single year. The DSI-3200 data are originally reported as DSI-3201 and DSI-3202. These preliminary series contains daily data for cooperative stations throughout the United States, but have not been reviewed or have received only limited review.

[42] Reflecting the use of these data in national crop programs.
[43] Preliminary Cooperative Summary of the Day (DSI-3202/3201) datasets are published with a shorter lag time, but with limited quality control.

The cooperative station network is comprised primarily of stations operated by universities, state services, and the National Weather Service (NWS). The vast majority of the NWS observers are volunteers (non-paid, private individuals). However, the network also includes the NWS principal climatological stations operated by highly trained observers. The network also includes stations supported by other federal agencies (e.g., the Department of Interior and Department of Transportation). Commonly the observers at these stations are employees of the Federal Aviation Administration, National Park Service, Bureau of Land Management, U.S. Forest Service, U.S. Geological Survey, and Tennessee Valley Authority. A few stations in the network are stations of the U.S. Department of Defense, primarily at military bases.

The observing equipment used at all DSI-32NN stations, whether at volunteer sites or federal installations, is calibrated and maintained by NWS field representatives. There is also Federal supervision of the initial data reporting quality control processes. When data entry is not automated, the preliminary data are manually edited prior to manual entry. They are then double entered, with discrepancies between the two files corrected. Finally, the dataset is run through a program to validate aspects of the minimum and maximum temperatures recorded for the day. However, these processes leave gaps in the data when a measurement was not recorded or was deleted because of the Quality Control (QC) process. Furthermore, data from one set of instruments can be reported in the NCDC datasets as coming from more than one location, while historical data from different stations at the same location are not linked.

Data from the QCLCD consist of hourly, daily, and monthly summaries for approximately 1,600 U.S. locations. Most of the stations reporting to QCLCS are included in the DSI-3200 dataset. QCLCD data have undergone more thorough QC than DSI-3200, but gaps in the data are not filled. QCLCD values for precipitation are available beginning with 2005 and continue through current readings (with a 48 hour lag for the QC process). Due to gaps in the data, issues with values from a single set of instruments being reported more than once, and changes in the instrumentation, the raw NCDC data cannot be used for insurance development without substantial data management.

The Contractor in a private development effort has examined the active DSI-32NN stations. There are almost 7,000 stations that have consistently reported both precipitation and temperature. The Contractor cleaned data from these stations (to remove aberrant values), filled gaps in the data (to provide appropriate values for the station's history), and back-cast the station dataset (to provide a uniform long-term data history for each currently active station). The Contractor then made scaling adjustments to both historical and filled values to assure the data variability associated with risk are captured in the dataset, while variations resulting from instrumentation changes are eliminated. The result of this effort is a proprietary weather dataset based on the NCDC raw data but structured appropriately for risk assessment.

The Contractor can extract data from the proprietary weather dataset to reflect the precipitation available for crop production (Appendix A, Exhibit 2 displays growing season (April 1 through September 30) daily precipitation for a single location for every fifth year beginning in 1972 and ending in 2012; complete daily precipitation for this location for all years October 1, 1971 to September 30, 2012 are available upon request). For the few counties where a weather station is not available, the data from stations in adjacent counties can be aggregated using either a simple

average or a distance weighted average. The cumulative precipitation by crop year in Sheridan County, Kansas, illustrates the nature of such an extraction and aggregation (Table 7). On the advice of the local extension agent, the Contractor aggregated precipitation data for the study of soil moisture available to a corn crop beginning the day after the end of the harvest season of the prior crop year (October 1) through the end of the harvest for the crop year (September 30 the following year). The mean annual crop year precipitation was 21.2 inches with a standard deviation of 5.2 inches.

Table 7. Aggregate Annual Crop Year Precipitation[1] (Inches) in Sheridan County, 1972 through 2012[2]

Year	Precipitation	Year	Precipitation	Year	Precipitation
1972	23.3	1986	17.7	2000	13.6
1973	26.5	1987	20.5	2001	25.8
1974	16.0	1988	15.2	2002	8.9
1975	26.2	1989	15.4	2003	16.0
1976	20.1	1990	22.3	2004	19.2
1977	23.1	1991	20.3	2005	25.0
1978	15.3	1992	30.3	2006	18.8
1979	21.0	1993	37.7	2007	23.2
1980	21.3	1994	17.7	2008	18.8
1981	21.5	1995	27.6	2009	26.7
1982	21.0	1996	26.1	2010	14.8
1983	18.5	1997	18.0	2011	22.8
1984	23.9	1998	20.8	2012	22.6
1985	23.8	1999	25.9		

Source: The Contractor's Research Department after data from NOAA, NCDC, cleaned, filled, back-cast, and scaled to reflect variability.

[1] The precipitation for the crop year was aggregated from October 1 (the day after the end of the harvest season of the previous crop year) through September 30 (the end of harvest for the crop year).

[2] The period was chosen to coincide with the availability of yield data from NASS's Quick Stats 2.0.

From 1972 through 2012, there were only 2 years when the natural precipitation in Sheridan County was 30 inches or more,[44] 1992 and 1993. In those 2 years the non-irrigated corn yields for Sheridan County reported in the NASS Quick Stats 2.0 dataset were 86.4 and 74.1 bushels per acre, respectively. However, even during these wet years, the non-irrigated yields in Sheridan County were just 58 and 55 percent of the irrigated yields (148.3 and 135.3 bushels per acre).[45] Crop year 1993 was exceptionally cold, so yields were likely limited by the available growing degree days.

[44] This precipitation value was chosen as the amount to support full evapotranspiration for short season corn as documented in Howell, T.A., J.A.Tolk, A.D.Schneider, and S.R. Evett, 1998, Evapotranspiration, Yield, and Water Use Efficiency of Corn Hybrids Differing in Maturity, Agronomy Journal, 90: 3–9. The UNL model is also based on a maximum application of 30 inches of irrigation water.

[45] Some of the yield reduction in 1993 could also be accounted for by the excessively wet year, which restricts respiration in the plant root system, disrupts pollination, and increases losses to disease. The disparity between irrigated and non-irrigated yields could result from numerous factors including, but not limited to, planting densities, amounts of mineral nutrients applied, and varietal selections.

While the extension agent recommendation concerning the effect of precipitation on soil moisture available for corn production initially seemed imprudent, there was a stronger correlation between non-irrigated yields of corn in Sheridan County and the entire year's aggregate precipitation (un-weighted) than between those yields and other periods of precipitation, whether the precipitation was weighted by the time the precipitation occurred or un-weighted (Table 8).

Table 8. Correlations between Precipitation (inches) in Sheridan County and Crop Yields (Bu/Acre) by Irrigation Approach, 1972 through 2010

	April to September	January to September	January to September	October to September	October to September	October to September	October to September
Precipitation Weighting	None	None	Simple	None	Simple	Three Periods	Monthly
Irrigated	0.01	-0.02	-0.05	0.08	0.05	0.02	-0.01
Non-irrigated	0.43	0.42	0.39	0.49	0.47	0.45	0.43

Source: The Contractor's Research Department after data from NOAA: NCDC, cleaned, filled, back-cast, and scaled to reflect variability and from NASS.

[1] The simple weighting valued precipitation before April 1 at half the actual value. The three period weighting valued precipitation from October 1 through December 31 at one quarter the actual value and precipitation from January 1through March 31 at half the actual value. The monthly weighting increased the relative fractional value of precipitation from October through March, by month.

The unexpected impact of the full annual precipitation in Sheridan County on non-irrigated corn yields raises an import point in the consideration of the insurance of irrigated corn crops grown under reduced or limited irrigation. The soil water capacity and the loss of soil water to evaporation can both have important impacts on the "quantity of water needed to produce at least the yield used to establish the irrigated production guarantee or amount of insurance on the irrigated acreage planted to the insured crop." While in one area October precipitation may make an important contribution to a crop's water balance, in another the precipitation in February will hardly affect the moisture available to a crop.

Insurance Data

RMA, the AIPs, and insurance agents keep voluminous data on the crop insurance they underwrite and sell. There are more data for corn than for any other crop, followed closely by the data for soybeans. In terms of quantity, wheat data are a distant third, with about half the amount of data available for soybeans. This distribution reflects the total acreage of the crops. With well over 100 crops insured under the different plans RMA manages, the depth and breadth of data by crop vary widely.

Data Available from RMA

- **Acreage Insured under the Irrigated Practice** – by plan, by crop, by unit, policy, county, and state, by year.
- **Acreage Insured under a Non-irrigated Practice**[46] – by plan, by crop, by unit, policy, county, and state, by year.
- **Approved Yield** – by policy, practice, and unit, by year.
- **Insurance Experience** – by plan, by crop, by county and state, by practice, by year.

[46] Including continuous cropping, summer fallow, not following another crop and the non-irrigated practice codes.

- **Limited Irrigation Yield Adjustment** – University of Nebraska tables.
- **Number of Producers[47] Insuring Both Irrigated and Non-irrigated Practices for a Crop during the Same Year** – can be derived by crop, by county and state, by year.
- **Number of Producers Insuring Only in the Irrigated Practice for a Crop** – can be derived by crop, by county and state, by year.
- **Number of Producers Insuring Only in the Non-irrigated Practice for a Crop** – can be derived by crop, by county and state, by year.
- **RMA Rainfall "Index" Value** – by grid, by year for 64 years (not available for western Colorado and many other parts of the United States).
- **Yield under the Irrigated Practice** – by crop, by county and state, by year, and by unit and policy, by year for the approved yield database history.
- **Yield under the Non-irrigated Practice** – by crop, by county and state, by year, and by unit and policy, by year for the approved yield database history.

Data Theoretically Available from AIPs or Producers

- **Irrigation Source** – by policy and unit.
- **Irrigation Supply** – percent of normal by policy and unit.
- **Irrigation Well Flow** – gallons per minute.
- **Expected Curtailments of Supply** – by producer or water district.

Data Whose Availability is Questionable

- **Total Acre Inches of Water Applied to a Unit** – by crop, by year.
- **RMA Rainfall "Index" Rainfall** – The index is a derived number and reflects relative rather than absolute rainfall. The underlying data should be available from the contractor who derives the index values for RMA, but the cost of such data is likely to be substantial.

For the most part, the question is not "Are data available," but rather "Were the data collected in a manner that makes them applicable to the analysis of risk required for development of an actuarially-sound insurance product for limited irrigation?" This is complicated by few types of data whose availability is truly limited, including data on:

- Soil moisture at planting and during the growing season,
- The timing of application of irrigation water (e.g., Colorado tells producers when they can draw river water and that period can vary from year to year),
- The varieties planted, and
- The growing season length.

Nonetheless, the wealth of data available in the RMA datasets provides a basis for evaluation of numerous elements of any limited irrigation approach as illustrated by the analysis in this report.

[47] The term "producer" reflects an insured person. A producer may be more than one person (sole proprietorship, partnership, etc.).

SECTION IV. ANALYSIS OF THE UNL MODEL

The UNL partnership model[48] is discussed in detail in this section of the report. In addition to a general review of the model, the Contractor specifically addresses the following comments and questions from the Solicitation.

> *"The* [model] *methodology appears to be based on yield trial data from relatively limited areas, additional research is needed to determine if the model results are applicable to other areas and especially other soil types. This is critical because an inappropriate yield adjustment could dramatically over or underinsure producers.*"
>
> *"The methodology was focused on the effect of irrigation on yield levels, but has not addressed the effect on yield variability. This is needed because the variability of yields is what determines losses and premium rates. Without a sufficient understanding of how much yield risk increases as irrigation decreases, RMA does not have a basis to establish actuarially sound premium rates.*"
>
> "*Are acceptable records available and accessible on applied irrigation (such as timing, frequency, and location of historical irrigation practices) for insurance companies to establish accurate insurance offers and guarantees for limited irrigation?"*
>
> *"Are the data supporting limited irrigation models sustainable and maintainable in the future so appropriate coverage and premium rates can be properly updated?***"**

In addition to these matters, the Contractor addresses two fundamental questions regarding the model: "Is it feasible to use the model function to offer insurance for limited irrigation for corn and soybean in Sheridan and Thomas Counties, Kansas, for the short term?" and "Is it feasible to use the model yield adjustment approach to offer insurance for limited irrigation for any insured irrigated crop for the long term?"

The UNL partnership team used a crop production function approach to represent the impact of water stress on crop yield, building on the procedure of Stewart and Hagan[49] and that of Martin, Watts, and Gilley.[50] As RMA has noted, the first of these studies focuses on limited field trials grown under three levels of water stress, while the second is a generalized simulation based on the available literature at the time. Based primarily on these studies, the UNL partnership team extrapolates from a linear relationship of crop yield to seasonal evapotranspiration (ET):

$$Y = Y_n + b\,(ET - ET_n)$$

[48] The document "Procedures for Adjusting APH when Implementing a Deficit Irrigation Insurance Practice," provided to the Contractor by RMA, is incorporated into this report in its entirety by reference. The authors of that document used the term "deficit irrigation" without definition, but in the same sense implicitly as the Contractor uses the term "reduced irrigation." Specific elements of the UNL procedures document will be cited as elements of the analysis of the UNL model.

[49] Stewart, J.I., and R.M. Hagan, 1973, Functions to Predict Effects of Crop Water Deficits. Journal of Irrigation and Drainage Engineering, 99: 421-439.

[50] Martin, D.L., D.G. Watts and J.R. Gilley, 1984, Model and production function for irrigation management. Journal of Irrigation and Drainage Engineering, 110: 149-164.

where Y is the yield at harvest, Y_n is the yield at harvest without irrigation, b is the slope of the yield-ET relationship, ET is the crop evapotranspiration at a specified irrigation level and ET_n is the evapotranspiration for the non-irrigated crop. While the UNL partnership team correctly states numerous researchers have shown, under experimental conditions, this linear relationship exists for many irrigated crops grown in the Great Plains. But the UNL team does not emphasize the experimental nature of these studies, which include among other characteristics:

- Limited periods of water stress;
- Consistent planting densities;
- Changes in water losses to evaporation with differing planting densities;
- Consistent planting approaches (i.e., tillage, etc.);
- Careful timing of the stress to address plant growth stages; and
- A single variety within a trial.

These experimental conditions do not reflect the management approaches that have been used by each producer to develop an APH for establishing an approved yield, since over the years water is applied either when such application is allowed or when it is most likely to be efficacious; planting densities have changed to reflect the variety chosen and seed company recommendations; applications of nutrients have changed to reflect soil tests and planting densities; and tillage practices may have been modified to conserve water. Thus, though the models provide information about the relative effects of different amounts of irrigation, they do not reflect time series production patterns as does an APH.

The partnership model does address Stewart and Hagan's conclusion that "the Y versus [added irrigation water] function is convex, reflecting decreasing irrigation efficiency [percentage of irrigated water utilized for evapotranspiration] as actual crop ET approaches fulfillment of maximum requirements." They expand on Martin et al.'s production functions for the linear yield-ET relationship based on five constants:

- Y_n,
- ET_n,
- The yield when the crop is fully irrigated,
- The ET when the crop is fully irrigated, and
- The amount of gross irrigation required to produce the full yield (D_f).

However, in the analysis, they assume (based on the 1973 and 1984 studies) that the slope of the yield-ET relationship should equal the slope of the yield-ET relationship when the production function is evaluated at zero irrigation. That is the element of the relationship with the highest efficiency. Evidence that this slope is appropriate under actual field conditions (as opposed to experimental conditions) is limited. Its use is based on a simplifying assumption that consequently maximizes the apparent effects of reducing irrigation.

Nonetheless, the UNL partnership team has developed an elegant model for adjusting approved yields for corn and soybean in selected production regions. The data required by RMA to maintain the approved yield procedure are the D_f (which changes as new varieties and practices are introduced), yield per inch of ET (which is a function of the variety grown), and water use efficiency at full irrigation (values defined by the partnership team, by crop and irrigation system type for each location).

The challenge in this analysis is to integrate the knowledge and information available concerning limiting factors on crop growth/development: weather data and historic weather patterns in the areas affected by limited irrigation; water availability, and soil moisture at planting. To test the success of the model in capturing these attributes, the Contractor selected five counties (one in eastern Colorado and one each in eastern and western Kansas and Nebraska). The weather data for these counties was extracted and two measures of precipitation were calculated: total annual crop year precipitation (October through September of the following year) and growing season precipitation (April through September). These values were then compared with the amount of water required to achieve full irrigation and the yield boost resulting from full irrigation (Tables 9 and 10).

Table 9. Relationship between Total Annual Crop Year Precipitation and Yield Boost from Full Irrigation

County	Total Cumulative Precipitation (inches)	Irrigation to produce Full ET (inches)	Total Annual Water from Precipitation and Irrigation	Yield boost from Full irrigation (bushels per acre)
Kit Carson County, Colorado	15.90	20	36	152.4
Perkins County, Nebraska	20.75	18	39	143.3
Sheridan County, Kansas	21.07	17	38	146.1
Butler County, Nebraska	29.02	12	41	90.1
Washington County, Kansas	31.74	13	45	85.3

Source: The Contractor's Research Department after data from NOAA: NCDC, cleaned, filled, back-cast, and scaled to reflect variability and from The UNL Partnership tool.

Table 10. Relationship between Total Growing Season Precipitation and Yield Boost from Full Irrigation

County	Cumulative Precipitation (inches) during the Growing Season	Irrigation to produce Full ET (inches)	Total Growing Season Water from Precipitation and Irrigation	Yield boost from Full irrigation (bushels per acre)
Butler County, Nebraska	10.58	12	23	90.1
Kit Carson County, Colorado	12.53	20	33	152.4
Sheridan County, Kansas	15.88	17	33	146.1
Perkins County, Nebraska	16.11	18	34	143.3
Washington County, Kansas	23.33	13	36	85.3

Source: The Contractor's Research Department after data from NOAA: NCDC, cleaned, filled, back-cast, and scaled to reflect variability and from The UNL Partnership tool.

The two counties with the greatest amount of annual crop year precipitation (Washington County, Kansas, and Butler County, Nebraska) require the least amount of irrigation to produce full evapotranspiration. Full irrigation in these counties provides the smallest yield boost. These results are as expected. However, the growing season precipitation has a much weaker

relationship with the amount of water required for full irrigation (r = - 0.21) than does the annual precipitation (r = - 0.96).

In its report to RMA, the partnership team suggests the approved yields for crop insurance for both reduced and limited irrigation practices require reductions to reflect decreases in the available irrigation water supply. This is based on the assumption that a producer's approved yield overstates yield expectations when known irrigation water supplies for a year are less than historical amounts. Challenges to this inference include changes in the water requirements for seeds for commercial production in areas where irrigation is a common practice; changes in the management practices that affect evapotranspiration; and limiting factors other than evapotranspiration on crop growth/development. It would also be useful if the model could include analysis of historic weather trends in the areas affected by limited irrigation as the Contractor has seen both positive and negative trends depending on the region of the country being studied. Once these are considered, the effects of water availability can be more clearly assessed.

Seed

Most seed companies provide "drought tolerance" ratings for the hybrids they market for both irrigated and non-irrigated production. These ratings provide producers an effective tool for seed selection under limited irrigation conditions. New hybrids from DuPont, Pioneer, and Syngenta were commercially available for the 2012 crop year, while Monsanto introduced several new hybrids for the 2013 crop year. The companies emphasize that the enhanced drought tolerance associated with these hybrids is not associated with "yield drag." The hybrids are bred for use in areas where corn growers are looking for ways to reduce irrigation and conserve water supplied by aquifers. The performance of these hybrids during the 2012 drought suggests a yield improvement of 5 to 10 bushels per acre under drought (or limited irrigation) conditions have been achieved and further progress is anticipated.[51]

Management Practices that Affect Evapotranspiration

Evapotranspiration incorporates two components: evaporation of water from the soil and transpiration of water from the plant tissues. Soil structure introduces yet another element into the water balance as any runoff of precipitation and irrigation water from the soil decreases water use efficiency. Tillage more than any other management practice affects evaporation of soil moisture. The more the soil is worked, the greater the amount of evaporation. Concurrently, tillage increases oxidative degradation of soil organic molecules, reducing infiltration of the soil by water and in the worst cases leading to runoff. Finally, passages over the field by heavy equipment lead to compaction, which also increases runoff.[52]

[51] Thomison, P. A. Lindsey, A. Geyer, R. Minyo, , 2013, Drought tolerant corn hybrids, http://www.agprofessional.com/resource-centers/corn/seeds/seed-news/Drought-tolerant-corn-hybrids-202130431.html?view=all, accessed May, 2013.

[52] Peiretti, R.A., 2004, No Till Improves Soil Functioning and Water Economy, World Soybean Congress, http://www.fao.org/fileadmin/templates/agphome/images/iclsd/documents/wk1_c2_Peiretti.pdf, Accessed may, 2013; van Donk, S.J. and N.L. Klocke, 2012, Tillage and Crop Residue Removal Effects on Evaporation, Irrigation Requirements, and Yield, http://www.ksre.ksu.edu/irrigate/OOW/P12/vanDonk12.pdf, accessed May, 2013.

Both academic researchers and producers have long understood the effects of planting densities on evapotranspiration.[53] Since each plant acts as a wick to carry soil moisture into the atmosphere, the greater the planting density, the greater the potential for transpiration. Corn is particularly sensitive to these density effects. The C_4 photosynthetic pathway used by corn maintains open stomata even under mild water stress. In contrast, the stomata of soybean plants closes relatively early in stressful situations, limiting loss of both water and yields.

Limiting Factors Other than Evapotranspiration

Since early in the 20th century, biologists have studied the conditions that limit plant growth. The result of this research, generally known as the principle of limiting factors, states the maximum possible rate of plant growth at any moment in time is limited by the single basic resource in least supply. These potentially limiting resources include light, water, carbon dioxide, major minerals, (the nitrogen, potassium, phosphorus of commercial fertilizers) and a variety of micronutrients including boron, calcium, magnesium, iron, sulfur manganese, and zinc. The condition of the soil can also limit growth. Compacted soils can limit the access of roots to oxygen for respiration and porous, loose soils can limit the availability of water to the plant and physically constrain the growth of roots. Each crop plant (species and variety) has a specific range of tolerance for particular environmental conditions, and each condition has a different effect. In general, in agricultural scenarios, climate factors are the most important constituents limiting plant growth and development. The three most important climatic factors are sunlight, temperature, and precipitation.

The collective knowledge concerning plant growth limiting factors has affected agricultural management practices. Soil analyses allow application of appropriate fertilizers and micronutrients. Pesticides can control the limitations imposed by disease, insects, and competition from weeds. The spacing of the planted seed optimizes the availability of light for photosynthesis. Producers schedule planting and harvest to optimize yields (or revenue) and minimize risks associated by inclimate and/or inclement temperatures. Soil texture is managed by introducing amendments and by tillage practices. Outside of very costly semi-permanent tiling and soil drainage systems, there are few tools to address excessive moisture (which can also starve a plant root system for oxygen, inhibit root development, and encourage growth of potentially harmful fungi). The producer's principal tool to address insufficient moisture is irrigation.

Solicitation Questions

With regard to the specific question in the Solicitation concerning the approved yield adjustment model, the Contractor has the following responses:

> *The* [approved yield reduction] *methodology appears to be based on yield trial data from relatively limited areas, additional research is needed to determine if the model results are applicable to other areas and especially other soil types. This is critical because an inappropriate yield adjustment could dramatically over or underinsure producers.*

[53] Kirby, E.J.M., 1970, Evapotranspiration from barley grown at different plant densities, The Journal of Agricultural Science 75: 445-450.

The Contractor agrees the approved yield adjustment model methodology is based primarily on yield trial data from relatively limited areas. The model uses an engineering approach to quantify changes in plant production resulting from changes in available water. Plant growth models are notorious for their success at capturing the growth when tested in-sample (i.e., with elements of the data used to create the model) and for their failure to predict production of out-of-sample populations.[54] The yield adjustment model uses an approach which is likely more complex than it needs to be to achieve an estimate of reduction that is likely expressed with more precision than appropriate considering the limitations on the sample data available. Furthermore, the partnership team uses NASS data to establish yield under maximum irrigation; the Contractor believes RMA data would be more reflective of the production of the insured population.

> *The methodology was focused on the effect of irrigation on yield levels, but has not addressed the effect on yield variability. This is needed because the variability of yields is what determines losses and premium rates. Without a sufficient understanding of how much yield risk increases as irrigation decreases, RMA does not have a basis to establish actuarially sound premium rates.*

This topic is discussed in detail in the section on rating approaches. The RMA continuous rating function already captures yield-related differences in yield variability. The yield ratio curve provides higher premium rates as the approved yield decreases relative to the reference yield. Due to the uncertainties regarding the practices that were used in establishing an approved yield in the RMA database and conditions that existed when those crops were grown, the Contractor believes it would most likely be appropriate to use the rating for irrigation based on the vast and enormously varied experience represented in the RMA insurance experience rather than trying to develop a theoretical construct for limited irrigation yield variability whose statistical basis would at best be static and in the worst cases would not exist.

> *Are acceptable records available and accessible on applied irrigation (such as timing, frequency, and location of historical irrigation practices) for insurance companies to establish accurate insurance offers and guarantees for limited irrigation?*

There is no evidence these records are generally available. While the insurance policy requires the producer be able to produce such records, the nature of the irrigation documentation actually available is constantly changing. Producers most likely would be challenged by an AIP to produce such records only in the event of a claim for indemnity that was based in water availability; in the event of a loss due to hail or a similar situation, such records most likely would not be requested. It is reasonable to expect the most detailed records available are the newest records. Testimony from producers and agents suggests the records available from third parties vary considerably depending on location and local water administration policies. Some

[54] See for example Körner, C., 1991, Some often overlooked plant characteristics as determinants of plant growth – a reconsideration. Functional Ecology 5: 162-173; Heuvelink E. 1999. Evaluation of a dynamic simulation model for tomato crop growth and development. Annals of Botany 83: 413–422.; Hu, B.G. and M. Jaeger, 2003, Plant growth modeling and applications, Proceedings 2003 International symposium on plant growth modeling, simulation, visualization and their applications, Beijing: Tsinghua University Press/Springer.

digital records will be available from some producers, but many of those will not include third party verification.

> *Are the data supporting limited irrigation models sustainable and maintainable in the future so appropriate coverage and premium rates can be properly updated?*

Inasmuch as the model is a theoretical construct, the model itself can be updated using the partnership methodology. However, the Contractor does not believe development of separate rates for the limited irrigation practice is practical or appropriate. Please see the section on rating approaches.

Regarding the additional question posed by the Contractor: "Is it feasible to use the partnership model to adjust approved yields in offering insurance for limited irrigation for corn and soybean in Sheridan and Thomas Counties, Kansas, for the short term?" The Contractor believes the partnership model provides an appropriate estimate of the reduction in yield that will occur under limited irrigation if the producer makes no changes to his or her management practices other than decreasing the amount of irrigation water applied. For the short term, this is an expeditious approach to providing insurance for limited irrigation and a much better alternative than the policy alternatives of requiring a reduction in irrigated acres or requiring the crop to be insured with a non-irrigated practice.

Regarding the additional question posed by the Contractor: "Is it feasible to use the partnership model to adjust approved yields in offering insurance for limited irrigation for any insured irrigated crop for the long term?" The data do not exist to replicate the partnership approach everywhere that corn and soybean are grown with irrigation. Nor do all the requisite data exist to replicate the partnership approach for other irrigated crops. Consequently, the Contractor believes it would be in the best interests of the Agency to use the partnership project as a means to test alternative, simpler models for offering insurance with a reduced approved yield for crops grown under limited irrigation.

SECTION V. ANALYSIS OF THE RMA UNDERWRITING DRAFT

The RMA Underwriting Guidelines for limited irrigation are contained in a six-page "Informational Memorandum Draft Procedures" (IMDP) provided to the Contractor for this review. The draft procedures are limited to "selected counties in Colorado, Kansas, and Nebraska" where availability of limited irrigation coverage is provided through Special Provisions statements. The Contractor was able to identify only two counties – Sheridan and Thomas Counties, Kansas – where the Special Provisions statements were incorporated for 2013. Concurrently, the state of Kansas implemented a Local Enhanced Management Area (LEMA) in designated sections of these two counties. The LEMA limits total water use to 55 acre-inches during 5 years beginning 2013 in the designated sections.

The draft guidelines incorporate the UNL reduction tables as the mechanism by which limited irrigation is to be implemented. Limited irrigation is not implemented as a separate practice but is considered to be the irrigated practice since the adjusted APH yield is regarded as the "yield upon which the insurance guarantee is based, meeting the definition of irrigated practice." But, to differentiate crop insurance experience accrued under the adjusted yields (Section 5 of the Guidelines):

> *For the 2012 and subsequent crop years, the limited irrigation corn or soybeans must be recorded on the insured's acreage report. A separate line entry is required on the acreage report when full irrigation and limited irrigation are carried out on the same unit. In addition, the limited irrigation acreage must be identified and reported to RMA through the Policy Acceptance and Storage System (PASS) on the applicable Type 11 Acreage Record. The PASS limited irrigation code is xxxxx.*

The APH database is not to be modified (Section 2 of the Guidelines). An adjusted APH yield is to be designated on the Type 15 record by a yet to be specified "yield limitation flag." The term presumably means the "yield limitation code" (field 31 of the Type 15 record). This is a two-byte field and there are ample available numerical designators to include this information. This situation also requires a modification of the rules for field 45 (approved yield) of the Type 11 record. The rule "Approved Yield must equal reduced Approved Yield when Yield Limitation Code equal Approved Yield Reduced Inconsistent Approved Yields, "10" or Approved Yield Reduced Different Production Methods, "11" in the Type 11 record would need modification to incorporate the situation when the approved yield has been reduced for limited irrigation.

The Contractor notes that the proposed treatment of limited irrigation allows the producer to use previously certified APH data as a basis for determining the approved yield and the guarantee for the current crop year. This avoids the need to start anew with transitional yields (or modified transitional yields), a situation that frequently becomes an issue when a new practice/type are included on the actuarial documents.

The statement "The PASS limited irrigation code is xxxxx" is unclear. The indicated length is five bytes. The Type 11 record contains the following five byte fields: insured share percent, experience factor, yield conversion factor, warehouse code, guarantee

adjustment factor, and residual factor. It is not intuitively clear where the information is to be entered.

These technical matters presumably would be rectified if and when the Guidelines are issued for implementation. Meanwhile, for crop year 2013, RMA did not provide the Contractor with any instructions that had been issued to the AIPs regarding the manner for processing any requests for limited irrigation that may be filed by producers in the designated sections of Sheridan and Thomas Counties, Kansas. It appears the draft Guidelines have not been issued to the AIPs. Further, the statements in the Special Provisions do not provide guidance.

The draft expands the amount of information required of the insured. In addition to the normal requirements for certifying production and acreage for prior crop years, the insured also is required to provide "historical water use records for at least the most recent 4 years of APH yields" (section 8) to qualify for the limited irrigation treatment of planted acreage. The records must be "third party verified." Elsewhere in this report, the Contractor has noted potential difficulties with obtaining historical water use data specific to a unit level, but also noted more recent data should be more readily available. This particular provision does alleviate to a degree any concerns about lack of availability of records in general but does not necessarily address the issue of unit level information. However, if the most recent four years of APH yields extend more than four years into the past, the issue about availability of records may still be of concern.

The Contractor raises a question about the applicability of the Paperwork Reduction Act to the additional information requirements. The Contractor does not have knowledge of the respondent burden hours allotted for completion of acreage reports, but in the proposed rule published July 14, 2006 FCIC estimated the respondent burden to be 0.4 hours per response, with an average of 3.6 responses per respondent. [55] The statement notes "Producers are required to report specific data when they apply for crop insurance and report acreage, yields, and notices of loss." The additional information required to obtain irrigated coverage on acreage subject to limited irrigation might affect this estimate.

The requirement that the water records be "third party verified" may not present an issue at the producer level but may be an issue at a unit level. Further, while not an issue at the producer level in states with strongly regulated use of surface and ground waters, this requirement could become an issue in an area where water allocations are less stringently monitored.

Section 6 of the draft does require entry of a unique yield descriptor code to identify actual annual yields reported under a regime of limited irrigation. This provides an opportunity to perform analyses of the reliability of the yield reduction scheme that is adopted (UNL tables or alternative) by comparing those yields to yields in the database that were certified when the water restrictions were not known to be effective.

[55] Federal Register, Vol. 71, No. 135, page 40195.

Section 1 of the draft Guidelines advises AIPs that they may "develop their own election document or use an example document found on the Topeka Regional Office web page: http://www.rma.usda.gov/aboutrma/fields/ks_rso/." The example document duplicates most of the information already contained on a valid APH database (see Crop Insurance Handbook, pages 620 *ff*). It also indicates need to enter water use in both acre-feet and acre-inches. It seems the primary purpose of the form should be to: 1) tie water use to a specific unit already designated on a Production Report, and 2) document that water use. Copying information from one form to another seems superfluous. In addition, entry of both acre-feet and acre-inches seems excessive and prone to error. For example, suppose the usage was 0.9 acre-feet. This corresponds to 10.8 acre-inches. Does the user enter 0.9 acre-feet and 10.8 acre-inches? The UNL tables use whole inches as the unit of measure, and the draft Guidelines do not indicate any need to interpolate. In fact, all instructions describe usage of the UNL tables as being in gross inches. Thus, entry of 11 acre-inches would seem to be a sufficient documentation.

Section 4 provides guidance on how to use the UNL tables. The last step directs the user to "Enter the resulting yield in the approved APH yield block" (block 25 on the sample form). However, the "Examples of Completed APH Databases" (CIH, pages 620 *ff)* also require entry of the approved APH yield.

The Contractor believes if this form is to be used, it should be simplified to require documentation only of the gross acre-inches of water applied (rounded to the nearest whole inch, as in the examples of how to apply the UNL tables). Once this information is documented, the user should be instructed to enter the approved yield in the appropriate field of the APH database form for the affected unit with an entry in the field "Other" to note the APH yield has been adjusted to reflect intended reduction of x inches of irrigation water for the current crop year.

Section 7 constitutes most of the draft Guidelines. This section depicts a 10 year progression of the change in the approved yield when historical water use is reduced from 12 to 9 acre-inches. The illustrations show a reduction of 27 bushels per acre in the first 2 years, 19 bushels in the next 4 years, 10 bushels in the next 3 years, and 0 thereafter. However, the UNL tables in Section 3 of the draft procedures contains a reduction of 25.8 bushels (rounds to 26 bushels applicable to a reduction from 12 to 9 inches), a reduction of 17.8 bushels (rounds to 18 bushels) for a reduction from 11 to 9 inches, and a reduction of 9.2 bushels (rounds to 9 bushels) for a reduction from 10 to 9 inches. The indicated adjustments in Section 7 most likely are appropriate for some county but do not conform to the illustrated county. There should be consistency in the examples relative to the illustration of the UNL tables.

The IMDP use the UNL yield reduction tables as the mechanism by which limited irrigation insurance is to be implemented. Limited irrigation is treated as the irrigated practice with an adjusted APH yield as the "yield upon which the insurance guarantee is based." With appropriate adjustments, as suggested by the Contractor, the IMDP could provide appropriate guidance for implementation of the proposed limited irrigation insurance approach.

SECTION VI. RATING APPROACHES

This section of the report focuses on rating insurance for corn and soybeans in the relevant production areas. In particular, the Contractor addresses the utility of the premium rate generated under the irrigated practice continuous rating function for limited irrigation yields; consideration of insuring limited irrigation using the non-irrigated rate function versus the irrigated rate function; consideration of a separate limited irrigated practice with applicable rates; quantification of the effect of limited irrigation on yield variability; and additional research needed to determine if the model results are applicable to other areas and especially soil types.

FCIC base premium rates fundamentally are an average of loss cost ratios over a defined experience period. The loss cost ratio is the result of dividing the indemnity amount by the liability amount. Since crop insurance offers a variety of coverage levels, RMA adjusts the historical data to a common coverage level (65 percent). Actual losses at the various coverage levels are recalculated and liabilities are adjusted to amounts that would have been observed at that common coverage level. The resultant ratios of adjusted indemnity to adjusted liability form the loss cost ratios used for the rate adequacy analysis. The Contractor notes that certain adjustments are made to actual indemnities before these calculations are made. These include such policy provisions as prevented planting, high risk land, replanting payments, adjusting revenue coverage plans to a yield basis, etc. The goal is to achieve an estimate of the indemnity that would have been observed at the base coverage level under a pure loss of yield insurance plan for the majority of producers in the county.[56]

Obviously, there are no empirical observations of loss experience under a limited irrigation regime, or at least there are no identifiable observations. Hence, the fundamental approach for ratemaking utilized by RMA cannot be applied to provide guidance regarding questions about the appropriate premium rate for a limited irrigation practice. The Contractor instead must rely on logical constructs from statistics and from the structure of the University of Nebraska Lincoln (UNL) adjustment tables.

It is a fundamental axiom of statistics that:

$$\text{Variance}(y) = \text{Variance}(y - c)$$

where y is a random variable and c is a constant. In this case, y represents the dataset of all irrigated approved yields in a county and c represents an amount to be deducted from each of those approved yields to establish the basis of a limited irrigation guarantee.[57] Since the variance of the dataset of transformed yields is identical to the variance of the dataset of the original approved yields, the coefficient of variation (c.v.) is greater. The c.v. is a measure formed as the ratio of the standard deviation of a dataset to its mean, and is a measure of relative risk. To illustrate this relationship, the Contractor compared two counties: Sherman County, Kansas, and Perkins County, Nebraska. These two counties have similar yield profiles but significant differences in premium rates. Data for these counties for the 2011 crop year for corn are

[56] This paragraph is a summary of pages 15-26 of "A Comprehensive Review of the RMA APH and COMBO Rating Methodology" located at http://www.rma.usda.gov/pubs/2009/comprehensivereview.pdf, accessed May 2, 2013.

[57] It makes no difference if the dataset is all yields in the county or is a subset of all yields in the county that are subject to reduction due to reduced water availability.

included in Tables 11 and 12. Both counties have significant acreage of both irrigated and non-irrigated practice corn. Approved yields in both counties vary over a wide range, and should provide a reasonable foundation for examining rating issues. **It should be noted the APH data do not incorporate specific knowledge of the amount of water applied (artificial + natural) to achieve the approved yield.** It is possible the range of APH approved yields reflects different total amounts of water for the different insured units. The existing APH premium rates are likely already applied to different levels of total water available for evapotranspiration, as the chance that all units are receiving the same precipitation and all insureds are applying the same per acre quantities of water approaches zero. In addition, the approved yield for a unit may include non-irrigated acreage in the corners of a center pivot irrigation system, depending on the planting and harvest practices used by the insured. To the extent this occurs, the approved yield for irrigated acreage will be biased downward relative to units that reported the irrigated circles and the non-irrigated corners separately.

Table 11. Yields and Actuarial Data for Corn for the 2011 Crop Year, Sherman County, KS and Perkins County, NE

Practice	Average Approved Yield	Standard Deviation	Coefficient of Variation	Base Premium Rate*	Reference Yield
Sherman County, KS					
Non-irrigated (003)	58.4	15.5	26.5%	29.8%	40
Irrigated (002)	185.1	22.1	11.9%	8.7%	156
Perkins County, NE					
Non-irrigated (003)	66.8	10.6	15.9%	14.1%	53
Irrigated (002)	182.1	16.5	9.0%	5.1%	168

* Base premium rate is the sum of the base rate and the fixed load.
Source: The Contractor's Rating Department after RMA data.

Table 12. Reported Acres, Premium, Indemnity, and Liability for Ranges of Approved Yields, Sherman County, KS and Perkins County, NE for 2011 Crop Year

Sherman County Irrigated Practice					Sherman County Non-irrigated Practice				
Approved Yield Range	Reported Acres	Premium ($1,000)	Indemnity ($1,000)	Liability ($1,000)	Approved Yield Range	Reported Acres	Premium ($1,000)	Indemnity ($1,000)	Liability ($1,000)
130-140	2,313	204	0	1,032	20-30	714	28	0	47
140-150	3,506	230	43	1,489	30-40	15,085	542	66	1,187
150-160	5,641	208	39	1,517	40-50	23,484	1,054	145	2,731
160-170	15,930	910	208	7,016	50-60	25,010	891	156	3,505
170-180	17,371	1,003	357	7,957	60-70	30,405	1,280	414	5,784
180-190	32,429	1,614	159	13,952	70-80	13,825	429	34	2,116
190-200	27,771	1,365	135	12,700	80-90	1,509	88	34	445
200-210	17,893	958	54	8,933	90-100	1,061	56	16	276
210-220	15,249	718	97	8,635	110-120	320	9	0	51
220-230	3,200	152	1	1,595	Total	111,413	4,378	865	16,142
230-240	718	40	0	365					
Total	142,022	7,402	1,092	65,192					
Perkins County Irrigated Practice					Perkins County Non-irrigated Practice				
120-130	123	6	0	61	30-40	242	3	0	9
140-150	1,656	87	54	675	40-50	5,280	244	3	717
150-160	4,114	247	165	2,109	50-60	30,099	939	79	4,404
160-170	13,673	728	222	7,545	60-70	73,864	2,383	380	13,710
170-180	35,929	1,793	873	18,833	70-80	44,549	1,611	569	11,045
180-190	40,596	1,791	1,448	20,957	80-90	11,228	443	95	3,158
190-200	29,309	1,347	2,007	15,804	90-100	439	13	0	97
200-210	11,972	645	1,470	7,327	100-110	6	0	0	1
210-220	6,696	369	67	4,311	Total	165,706	5,635	1,126	33,142
220-230	260	15	0	223					
Total	144,327	7,028	6,305	77,845					

Source: The Contractor's Rating Department after RMA data.

As shown in Table 11, higher base premium rates are associated with higher c.v. values. Note also, although the reference yields and the average approved yields[58] for the irrigated practice are similar for the two counties, the base premium rate in Sherman County is much higher, as is the c.v. for that county. However, the difference in base premium rates for the irrigated practice are not nearly as pronounced as the difference in the base premium rates for the non-irrigated practice, reflecting the differences in the c.v. values. These empirical results are consistent with the theoretical argument that premium rates are related to the c.v. of the yield data.

The UNL adjustment tables compare a current reduction (in inches) of available water to the amount of irrigation water applied historically. For each inch of current reduction relative to a specific historical amount, the tables specify an amount by which the yield is expected to decrease *on average*. Alternatively, the tables also can be interpreted to indicate the increase in

[58] The data are simple averages. However, an acreage weighted average yield is within two bushels of the values shown.

yield *(again, on average)* expected by application of additional water. For example, Table 13 contains the adjustment table for Sherman County, Kansas.

Table 13. UNL Yield Adjustment Table for Limited Irrigation, Sherman County, KS

1) Select State

Kansas

2) Select County

Sherman

3) Select Irrigation System

Pivot System (AE = 0.85)

4) Select Crop

CORN

Historical Water Use, Inches	Reduction in Historical Water Supply, Inches of Gross Irrigation														
	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15
	Reduction in Bushels per Acre														
1	-12.2	na	na	na	na	na	na	na	na	na	na	na	na	na	na
2	-12.0	-24.2	na	na	na	na	na	na	na	na	na	na	na	na	na
3	-11.8	-23.8	-36.0	na	na	na	na	na	na	na	na	na	na	na	na
4	-11.5	-23.3	-35.3	-47.5	na	na	na	na	na	na	na	na	na	na	na
5	-11.3	-22.8	-34.6	-46.5	-58.8	na	na	na	na	na	na	na	na	na	na
6	-11.0	-22.3	-33.8	-45.5	-57.5	-69.8	na	na	na	na	na	na	na	na	na
7	-10.7	-21.7	-33.0	-44.5	-56.2	-68.2	-80.5	na	na	na	na	na	na	na	na
8	-10.4	-21.1	-32.1	-43.4	-54.9	-66.6	-78.6	-90.9	na	na	na	na	na	na	na
9	-10.1	-20.5	-31.2	-42.2	-53.4	-64.9	-76.7	-88.7	-100.9	na	na	na	na	na	na
10	-9.7	-19.8	-30.2	-40.9	-51.9	-63.1	-74.7	-86.4	-98.4	-110.6	na	na	na	na	na
11	-9.3	-19.0	-29.1	-39.5	-50.2	-61.2	-72.5	-84.0	-95.7	-107.7	-120.0	na	na	na	na
12	-8.9	-18.2	-27.9	-38.0	-48.4	-59.1	-70.1	-81.3	-92.9	-104.6	-116.6	-128.8	na	na	na
13	-8.4	-17.3	-26.6	-36.3	-46.4	-56.8	-67.5	-78.5	-89.7	-101.2	-113.0	-125.0	-137.2	na	na
14	-7.8	-16.2	-25.1	-34.4	-44.1	-54.2	-64.6	-75.3	-86.3	-97.5	-109.1	-120.8	-132.8	-145.0	na
15	-7.1	-14.9	-23.3	-32.2	-41.5	-51.2	-61.3	-71.7	-82.4	-93.4	-104.7	-116.2	-127.9	-139.9	-152.2

Source: The UNL Partnership Team, 2013 Deficit Irrigation Insurance Template.

The UNL tables are constructed such that adjustments are made up to a specified maximum of 15 inches of reduction in historical water use.[59] The table may be interpreted as follows. Assume a producer has historically added one inch of irrigation water to the acreage. If this one inch is no longer applied, the table indicates the yield will decline by 12.2 bushels per acre, i.e., it will be reduced to a non-irrigated yield. Stated another way, the addition of the one inch of water is expected to increase the yield by 12.2 bushels per acre relative to the non-irrigated yield. If two inches of irrigation water historically have been applied, the expected increase in yield is 24.2 bushels relative to the non-irrigated yield (12.0 bushels compared to the first inch of irrigation water). Similarly, as additional amounts of irrigation water are added, the expected yield increases but the rate of increase decreases until a maximum is achieved at 15 inches of irrigation water, which results in an increase in yield of 152.2 bushels per acre relative to the non-irrigated yield for Sherman County. The adjustment table for Perkins County is similar, and maximizes the increase in yield at 143.3 bushels per acre with 15 inches of irrigation water.[60]

The amount of adjustment in an approved yield is indicated by the row in which the historical amount of irrigation water occurs. For example, if 15 inches historically have been applied, a reduction of one inch in availability reduces the expected yield by 7.1 bushels. Reducing water availability by two inches reduces the expected yield by 14.9 bushels, with additional reductions in expected yield until the entire 15 inches are reduced, at which point the reduction in yield is the same as the increase that was expected at that level.[61] Note that each inch of reduction in water use results in a yield change that is substantially the same as the increase associated with use of additional water. For example, the 7.1 bushel reduction amount cited above compares to the increase in yield between use of 14 and 15 inches of water (e.g., 154.4 – 145.0 = 7.2). The differences are rounding.

It is evident from Table 13 that each incremental inch of reduction in irrigation water results in a larger adjustment to the expected irrigated yield, i.e., the value of *c* in the expression above becomes larger. As the constant *c* increases, both the expected yield and the c.v. approach the values for the non-irrigated yields.[62] The theoretical construct indicates the base premium rate must be increased if approved yields are reduced to accommodate a limited irrigation practice. Unfortunately, this requires a different amount of adjustment in the base premium rate for every inch of decrease in available water since the value of *c* is based on the amount (in inches) that water is reduced, a factor that would expand the actuarial documents significantly.

[59] The term "gross inches" in the table refers to the total amount of irrigation water applied. Since water distribution systems are not 100 percent efficient, not all the water that is applied can be utilized by the crop.

[60] The data are for a center pivot system that is considered to have 85 percent efficiency in use of gross inches of applied water. The yield "boost" would be lower for other irrigation systems. For example, a gravity system has an efficiency of only 60 percent and the yield "boost" at 15 inches of gross water application is only 127 bushels per acre.

[61] Note that, in contrast to the reduced marginal response to additional applications of water when applications are increasing, there is an increased marginal response to reductions.

[62] The Contractor notes that very low irrigated approved yields will be limited (cupped) at the non-irrigated reference yield (or the producer's proven non-irrigated approved yield) if available water is reduced by a very large amount. In this case, the c.v. will be smaller than the original amount due to the number of fixed yields in the dataset. The Contractor did subtract the maximum 152.2 bushels from the irrigated approved yields for Sherman County. This corresponds to a combination of 15 inches of historical use and a reduction of 15 inches. Since more than half the adjusted approved yields were cupped at the non-irrigated reference yield, the resulting average adjusted approved yield is 45.6 bushels and the c.v. is 21.6.

The Contractor used the information of Table 13 to construct a set of average yields relative to the non-irrigated reference yield for the two counties. For example, if one inch of water is historically applied, the UNL tables for Sherman County indicate the estimated yield is 40.0 + 12.2 bushels, or 52.2 bushels if the non-irrigated reference yield for the county is accepted as the base. The maximum implied irrigated yield, assuming the non-irrigated reference yield as the base, occurs with supplemental water equal to 15 inches (40 bushels + 152.2 bushels). The yields at all other levels of water application reflect the adjustment factor appropriate for that level of water application. For example, the entry of 150.6 bushels for historical water use of 10 inches represents the 40.0 bushel non-irrigated reference yield + 110.6 bushels from irrigation (from Table 13). The results of analysis using this approach are contained in Table 14.

Table 14. Estimated Yield Levels, Premium Rates (65% Coverage Level), and Premiums per Acre for Corn, Sherman County, KS and Perkins County, NE with UNL Adjustment Factors Incorporated Using Non-irrigated Reference Yield as the Base (2011 Crop Year Parameters)

Historical Water Use	Implied Yield	Irrigated Premium Rate	Total Premium in Bushels	Non-irrigated Premium Rate	Total Premium in Bushels
Sherman County, KS					
15	192.2	6.0%	7.56	14.7%	18.37
14	185.0	6.3%	7.57	14.7%	17.68
13	177.2	6.6%	7.61	14.7%	16.94
12	168.8	7.0%	7.67	14.7%	16.13
11	160.0	7.5%	7.76	14.7%	15.29
10	150.6	8.1%	7.89	14.7%	14.39
9	140.9	8.8%	8.07	14.7%	13.47
8	130.9	9.8%	8.33	14.7%	12.51
7	120.5	11.1%	8.67	14.7%	11.52
6	109.8	12.8%	9.15	14.7%	10.49
5	98.8	15.3%	9.81	14.7%	9.44
4	87.5	18.9%	10.73	14.7%	8.36
3	76.0	23.2%	11.48	14.7%	7.26
2	64.2	23.2%	9.70	14.7%	6.14
1	52.2	23.2%	7.89	18.0%	6.10
0	40.0	23.2%	6.04	27.3%	7.10
Base Rate		4.6%		23.4%	
Fixed Load		3.1%		3.9%	
Reference Yield		156		40	
Exponent		-2.131		-1.906	
Perkins County, NE					
15	196.3	4.3%	5.47	7.6%	9.74
14	190.1	4.4%	5.48	7.6%	9.44
13	183.1	4.6%	5.50	7.6%	9.09
12	175.5	4.8%	5.53	7.6%	8.71
11	167.4	5.1%	5.57	7.6%	8.31
10	158.6	5.5%	5.64	7.6%	7.87
9	149.5	5.9%	5.73	7.6%	7.42
8	140.0	6.4%	5.86	7.6%	6.95
7	130.2	7.1%	6.03	7.6%	6.46
6	120.0	8.0%	6.27	7.6%	5.96
5	109.5	9.2%	6.58	7.6%	5.44
4	98.7	10.9%	7.00	7.6%	4.90
3	87.7	13.3%	7.58	7.6%	4.35
2	76.4	14.3%	7.11	8.1%	4.01
1	64.8	14.3%	6.03	10.3%	4.33
0	53.0	14.3%	4.94	14.1%	4.86
Base Rate		3.0%		11.9%	
Fixed Load		2.1%		2.2%	
Reference Yield		168		53	
Exponent		-2.027		-1.932	

Source: The Contractor's Rating Department after RMA data.

The premium rates at each yield level in Table 14 are calculated from the rating parameters shown below the data for each county. Rates are cupped or capped as appropriate when the ratio

of the implied yield to the reference yield is less than 0.50 or greater than 1.50, consistent with RMA procedure. Premium amounts per acre are in bushels per acre and are based on a 65 percent coverage level guarantee.

Application of the non-irrigated rates to these irrigated yields results in a flat-rated schedule with premium amounts that are more than double the premium calculated using the irrigated premium rating parameters for the highest yield ratios, because of the large differences in the reference yields and the base premium rates between the two practices. For low yield ratios, the irrigated premium rate schedule produces higher premium rates and costs than does the non-irrigated premium rate schedule.

One might ask about the impact of relaxing the constraints that the yield ratio cannot be less than 0.50 or greater than 1.50. Removing the 1.50 yield ratio constraint from the non-irrigated rate values results in a premium rate of 5.1 percent and reduces the total premium by 1.23 bushels per acre (16.1 percent) for the 192.2 bushel yield in Sherman County. Considering the large amount of data that have been incorporated into the irrigated practice rates, it clearly would be inappropriate to charge a smaller total premium for production under limited irrigation than that generated by the continuous rating function irrigated premium rate parameters for an approved yield of 192.2 bushels per acre. At the other extreme, the indicated premium rate if the 0.50 constraint is relaxed results in a premium rate of 310 percent for a yield of 40 bushels under irrigated practice in Sherman County. This also clearly is inappropriate.

The Government posed the following question in the Task Order:

> *"If the lower limited irrigated yield seeks the appropriate rate level (a higher rate) on the irrigated practice rate table, why wouldn't the limited irrigated yield seek the appropriate rate (since the higher limited irrigated yield relative to the reference yield would generate a lower rate) on the non-irrigated practice rate table?"*

The foregoing discussion illustrates the large differences in base premium rates and reference yields between the two practices result in inappropriate premium rates for the irrigated practice yields if the non-irrigated premium rate schedule is used to develop the premium rates for limited irrigation acreage. Furthermore, since it is unlikely producers are claiming an irrigated practice if they have irrigated with just one, two, or three inches of water rather than eight, nine, ten or more inches, building down from the irrigated parameters rather than up from the non-irrigated parameters seems more logical. The Contractor recommends the alternative of using the non-irrigated practice rate table not be considered.

The Contractor constructed a set of adjusted yields based on the UNL yield adjustments if the available water supplies are reduced by one to 15 inches and the producer had historically used 15 inches of water (an amount nearer to the "typical" irrigation application). Those results are included in Table 15.

Table 15. Indicated Yields, Premium Rates, and Total Premiums Associated with Water Reductions Assuming Historical Use of 15 Inches of Water, Sherman County, KS and Perkins County, NE

Sherman County, KS				Perkins County, NE			
Reduction in Use	Adjusted Yield	Irrigated Premium Rate	Total Premium in Bushels	Reduction in Use	Adjusted Yield	Irrigated Premium Rate	Total Premium in Bushels
1	185.1	6.3%	7.56	1	190.1	4.4%	5.48
2	177.3	6.6%	7.57	2	183.1	4.6%	5.50
3	168.9	7.0%	7.61	3	175.5	4.8%	5.53
4	160.0	7.5%	7.67	4	167.3	5.1%	5.57
5	150.7	8.1%	7.76	5	158.6	5.5%	5.64
6	141.0	8.8%	7.89	6	149.5	5.9%	5.73
7	130.9	9.8%	8.07	7	140.0	6.4%	5.86
8	120.5	11.1%	8.33	8	130.2	7.1%	6.03
9	109.8	12.8%	8.67	9	120.0	8.0%	6.27
10	98.8	15.3%	9.15	10	109.5	9.2%	6.58
11	87.5	18.9%	9.81	11	98.7	10.9%	7.00
12	76.0	23.2%	10.73	12	87.7	13.3%	7.59
13	64.3	23.2%	11.48	13	76.4	14.3%	7.11
14	52.3	23.2%	9.70	14	64.8	14.3%	6.03
15	40.0	23.2%	7.89	15	53.0	14.3%	4.94

Source: The Contractor's Rating Department after RMA data.

Table 15 demonstrates that the effect of the adjustments is to move the implied yield and premium rate downward by one inch of water. For example, the yield and premium rate that occur for a reduction of 1 inch of water relative to historical use of 15 inches as shown in Table 15 are the same as the information shown in Table 14 for historical application of 14 inches of water. If the historical use had been 14 inches, the adjusted yield and premium for a 1 inch reduction would be the same as the yield and premium that would have existed for historical use of 13 inches of water. If historical use had been 13 inches, the effect of a 1 inch reduction is the same as historical use of 12 inches, and so forth.

In both counties, the high fixed load relative to the magnitude of the base rate creates an increase in premium cost per acre as the yield declines. Hence, reducing the approved yield on which the guarantee is based for limited irrigation increases premiums per acre for that practice slightly relative to the premium for full irrigation, but under the limited irrigation practice there is a lower guarantee. Since the fixed rate loads apply over wide areas and irrigated premium rates tend to be low, this characteristic exists for many more counties that the two sample counties.

In the Task Order, the Government posed the question:

> *"The methodology [of the UNL adjustments] was focused on the effect of irrigation on yield levels, but has not addressed the effect on yield variability. This is needed because the variability of yields is what determines losses and*

premium rates. Without a sufficient understanding of how much yield risk increases as irrigation decreases, RMA does not have a basis to establish actuarially sound premium rates."

As the Contractor noted earlier, the set of approved yields that currently exists has no information attached to it regarding the quantities of water used to produce those yields. In addition, the impact of the corners of center pivot irrigation systems may have resulted in smaller irrigated approved yields on a unit basis than was actually achieved on the acres that were actually irrigated.[63] Under the current insurance, producers already most likely are insuring approved yields produced with a variety of amounts of applied water.

The Contractor considered the contribution of irrigation to increasing a producer's approved yield by examining the difference between the non-irrigated approved yield and the irrigated approved yield for those policy numbers for which both practices were reported for crop year 2011. The goal is to examine the range of approved yields already insured with irrigated practice premium rates. The data are presented in Table 16.

Table 16. Policy Number Counts, Ranges of Approved Yields, and Increases in Approved Yields for Irrigated Practice for Policy Numbers with Both Irrigated and Non-irrigated Practice, Sherman County, KS and Perkins County, NE, 2011 Crop Year

	Sherman County, KS	Perkins County, NE
Total Number of Policy Numbers	559	599
Policy Numbers with Both Practices	206	250
Minimum Irrigated Yield for Policy Numbers with Only Irrigated Practice	135.0	127.0
Minimum Irrigated Yield for Policy Numbers with Both Practices	133.6	140.0
Maximum Irrigated Yield for Policy Numbers with Only Irrigated Practice	226.9	210.0
Maximum Irrigated Yield for Policy Numbers with Both Practices	238.0	220.0
Minimum Difference in Approved Yields for Policy Numbers with Both Practices	71.1	74.0
Maximum Difference in Approved Yields for Policy Numbers with Both Practices	177.0	160.0

Source: The Contractor's Rating Department after RMA data.

Both counties have a significant number of policies that reported corn for insurance in the 2011 crop year, with about 40 percent reporting acreage of both irrigated and of non-irrigated practice. The results are not based on a small number of policies. The minimum irrigated yield and the maximum irrigated yield are comparable for each group of policies within a county regardless of whether the producer specialized in irrigated practice or reported both practices. The minimum difference in approved yields for policies that reported both practices is very similar in both counties while there is about a ten percent difference in the maximum differences.

[63] A discussion of the impact of this factor is found later in this section.

The last two rows of the table provide interesting data that sheds light on the question posed by the Government. The row that reports the minimum differences is the most difficult to interpret because it could represent situations in which the producers reported irrigated units with included non-irrigated corners as well as pure irrigated units that happened to have low yields due to relatively small use of irrigation water. Or, it could represent situations in which the producer had an irrigated unit on which the water availability had been restricted and the producer only was able to pump a limited amount of water. The data included in the FCIC database do not permit any firm assessments of the reasons for the difference in yields.

The maximum differences provide a more meaningful basis for comparisons. Consider, for example, the indicated increase in yield associated with application of 15 gross inches of water of 152.2 bushels in Sherman County, Kansas and 143.3 bushels in Perkins County, Nebraska. The maximum difference in both counties is within 10 to 15 percent of the maximum increase included in the UNL tables. The UNL data represent an expected or mean outcome; there can be situations where the actual amount of difference is higher or lower depending on management ability, soil characteristics, variety planted, and other variables not recognized by the UNL tables. Hence, the similarity of the data supports the idea that the UNL tables are representative of outcomes under production conditions.

The Contractor also examined the difference of the irrigated and non-irrigated yield on policies that reported both practices as reported in Table 17. For example, the yield range 70 to 80 in Sherman County, Kansas is the result of subtracting the average approved yield for non-irrigated practice acreage from the average approved yield for irrigated practice acreage on policies that reported both practices. The average yield is the mean of the difference for the acreage included in the range. The column labeled total acres represents the number of acres (both irrigated practice and non-irrigated practice) included in the range. Reasons for the wide range of yield "boost" (between 70 and 180 bushels per acre) can include soil types, irrigation systems and efficiency, typical date of planting, variety planted, amount of fertilizer applied, and amount of water applied, among other factors. The point is that the acreage insured under irrigated practice under the present crop insurance offer already includes a very wide range of yield "boost" relative to yields for non-irrigated practice. Recall the statistical law presented at the beginning of this section. This law is based on the premise that the random variable *y* is generated by a statistical distribution that has specific and consistent properties. That condition may not hold with regard to the distribution of approved yields for irrigated practice acreage. Hence, the variability cited in the issue posed by the Government may already be accommodated under the present rating structure for the irrigated practice.

Table 17. Average Difference of Irrigated Yield Relative to Non-irrigated Yield on Policies with Both Practices and Reported Acres

Sherman County, KS				Perkins County, NE			
Yield Range	Average Yield	Total Acres	Percent of Acres	Yield Range	Average Yield	Total Acres	Percent of Acres
70-80	73	2,565	1%	70-80	74	262	0%
80-90	85	1,537	1%	80-90	86	1,466	1%
90-100	95	6,981	4%	90-100	95	14,832	7%
100-110	104	6,274	4%	100-110	106	56,115	25%
110-120	115	24,823	14%	110-120	115	58,785	26%
120-130	125	37,099	21%	120-130	125	62,617	28%
130-140	135	34,105	19%	130-140	133	25,844	12%
140-150	146	41,826	23%	140-150	145	4,211	2%
150-160	154	15,888	9%	150-160	160	212	0%
160-170	162	5,819	3%				
170-180	176	1,982	1%				
Total		178,899		Total		224,344	

Source: The Contractor's Rating Department after RMA data.

In the Task Order, the Government posed the following questions: "Is the premium rate generated under continuous rating for the lower limited irrigated yield using the irrigated practice rate table a reasonable estimate of the risk?" "Should there be a separate limited irrigated practice with applicable rates?"

The Contractor believes it is useful to discuss these questions jointly since the two are related.

The report "A Comprehensive Review of the RMA APH and COMBO Rating Methodology" cited earlier contains the following statements regarding the yield ratio (page 37):

> "*The yield ratio curve, based on the negative exponent in equation 4.2, is part of a mechanism to individualize the county-level unloaded rate to reflect differences in expected loss costs for insured units depending on the relationship between the individual rate yield and the reference yield. As discussed above, this approach essentially implies that premium rates should be inversely related to individual average (rate) yields. That is, farmers with higher yields relative to the county have lower rates and those with yields lower than the county have higher rates.*
>
> *As Milliman and Robertson (2000, p. 33) point out, the rationale for using this approach stems from RMA research that demonstrated that "on average, the probability of a loss is greater for producers with a yield lower than the average for an area and vice versa [for producers with yields higher than the area average]." This finding indicates that as an individual's mean yield increases relative to the county average; their proportional yield variability decreases such that it lowers the likelihood of an indemnified loss. Hence, premium rates are structured to decline with increases in individual rate yields.*"

It is important to note the distinction between premium rates and premiums per acre. As the cited material states, the yield ratio curve **does** result in lower premium rates as the approved yield increases relative to the reference yield. However, it is possible for total premium per acre to **remain relatively flat** over a range of yield ratios or it may **increase** because the percentage increase in yield (guarantee) is greater than the percentage decrease in the premium rate. This outcome results from the treatment of the two components of the premium rate: the base rate, which is subject to the yield ratio adjustment, and the fixed load which is not. The fixed load becomes a larger percentage of the total rate as the base rate decreases. For the two counties included as examples, the premium per acre does decrease as the yield increases. Conversely, the total premium per acre increases as the approved yield is decreased to reflect the lower expected yields under limited irrigation.

Due to the uncertainties regarding the actual interpretation of the approved yields in the RMA database, and due to the small differences in total premium in the range in which most approved yields fall, the Contractor believes it would be difficult to justify a separate rating schedule that generated two different premium rates for the same yield. That is, if the approved yield is 185 bushels under standard APH procedures and the adjusted yield is 185 bushels, how does one explain a rationale to charge a higher premium rate in the second case? In spite of any hypothetical differences in yield variability under the irrigated and limited irrigation practices, the imperfections of the data make it difficult to develop a convincing argument. FCIC was perfectly willing to accept a premium rate of x percent for a yield of 185 bushels that may have been the result of applying 14 inches of irrigation water historically. An adjusted yield based on applying 14 inches of water should be conceptually identical.

The Contractor notes that premium rates and premium amounts do differ, sometimes materially, when the irrigated yield is low, especially if that adjusted yield is less than 50 percent of the reference yield. The Contractor believes this situation can be managed by inserting a rule that the premium rate be the lesser of the amount determined with the irrigated or the non-irrigated rating schedule.

In the Task Order, the Government posed the following question: "Are the data supporting limited irrigation models sustainable and maintainable in the future so appropriate coverage and premium rates can be properly updated?"

The UNL model is discussed in detail in Section IV of this Deliverable. Specific considerations affecting its ability to be extended and updated are contained in that section. In the present section, the Contractor notes that maintenance on a continuing basis will depend on the ability of RMA to identify the specific data points generated by units on which the limited irrigation practice is followed. With this ability, loss cost ratios for those units could be compared to units on which the irrigated and non-irrigated practices are followed. These loss cost ratios would allow updating in accordance with the normal RMA procedure, defined in "A Comprehensive Review of the RMA APH and COMBO Rating Methodology" (page 38) as follows:

> "*The current RMA rating procedure for type/practice is described in an internal document titled "RMA Type/Practice Rating Methodology Interim Underwriting Guidelines". In the current system, crop type/practice is accounted for by*

multiplying the variable rate component of the county target rate by a type/practice factor (TpFactor) for each type/practice combination. In constructing these type/practice factors the RMA uses experience at a multi-county level, at the state level, or at a multi-state level. Deciding on the proper level of aggregation for any crop and region is a matter of balancing two primary considerations: homogeneity of risks and volume of data. The risks associated with each crop type/practice are more homogeneous at a disaggregate level; however, aggregation provides a greater volume of data. The approach taken to address this problem varies by region. For example, in deriving the Tp Factors for irrigated and non-irrigated practices in the Western States, grouping a smaller number of geographically clustered counties within the state is more typical since the average rainfall (and the importance of irrigation) changes significantly over shorter distances."

The Contractor earlier had raised a topic regarding the inclusion of the production and acreage of the non-irrigated corners of a center pivot irrigation system in an irrigated practice under some conditions. The average yield included in the irrigated practice APH database includes the production from both the irrigated and non-irrigated portions of the unit divided by the total unit acres. This raises the question: "Does forcing inclusion of the non-irrigated acres and production in the irrigated unit have any bearing on the UNL tables for limited irrigation?"

Assume the producer is using a center pivot system without the corner extension units on a 160 acre quarter section. The area of the inscribed circle constitutes 78.5 percent of the area of a square of this size. The entire quarter section is planted to corn.

Further assume the acreage is located in Perkins County, Nebraska. The average yield for the irrigated portion of the acreage is 168 bushels per acre and the average yield for the non-irrigated portion is 53 bushels per acre.[64] First consider the case that the practices are separately reportable, are reported separately, and ignoring the loss of acreage that would occur to create a divider between the two practices. Guarantees and premiums are shown in Table 18.

Table 18. Acres Insured, Guarantees per Acre, and Premiums for Irrigated and Non-irrigated Practices Separately Insurable in a Quarter-Section with Pivot Irrigation System

	Irrigated	Non-irrigated	Total
Acres insured	125.7	34.3	160.0
Approved Yield	168	53	
Guarantee/acre (65%)	109	34	
Total guarantee (bu.)	13,701	1,166	14,868
Premium rate	0.051	0.141	
Total premium (bu.)	699	164	863

Source: The Contractor's Rating Department after RMA data.

[64] The Contractor acknowledges that these data are not separately maintained in the APH databases. These are the reference yields for the county and in this example are used as the basis for establishing the approved yield.

Now assume the acreage does not meet the conditions for establishing separate irrigated and non-irrigated units. The guarantee and premium for this situation are shown in Table 19.

Table 19. Acres Insured, Guarantee per Acre, and Premium for Irrigated Practice when Corners of a Center-pivot Irrigation System are Included in the Irrigated Practice Acreage

	Irrigated
Acres insured	160
Approved Yield	143
Guarantee/acre (65%)	93
Total guarantee (bu.)	14,880
Premium rate	0.063
Total premium (bu.)	937

Source: The Contractor's Rating Department after RMA data.

Now suppose this producer had been using 15 inches of irrigation water but is required to reduce usage by five inches. According to the UNL adjustment tables for Perkins County, the expected irrigated practice yield decreases by 86.8 bushels. The adjusted data for separately reportable practices are shown in Table 20.

Table 20. Acres Insured, Guarantees per Acre, and Premiums for Irrigated and Non-irrigated Practices Separately Insurable in a Quarter-Section with Pivot Irrigation System, Irrigated Yield is Reduced by 86.8 Bushels per Acre

	Irrigated	Non-irrigated	Total
Acres insured	125.7	34.3	160.0
Adjusted Yield	81	53	
Guarantee/acre (65%)	53	34	
Total guarantee (bu.)	6,662	1,166	7,828
Premium rate	0.143	0.141	
Total premium (bu.)	953	164	1,117

Source: The Contractor's Rating Department after RMA data.

Table 21 contains the data that would apply if the entire unit was reported as irrigated practice.

Table 21 Acres Insured, Guarantee per Acre, and Premium for Irrigated Practice when Corners of a Center-pivot Irrigation System are Included in the Irrigated Practice Acreage and Yield is Reduced by 86.8 Bushels per Acre

	Irrigated
Acres insured	160
Adjusted Yield	56
Guarantee/acre (65%)	36.4
Total guarantee (bu.)	5,824
Premium rate	0.143
Total premium (bu.)	833

Source: The Contractor's Rating Department after RMA data.

Applying the adjustment amount to the adjusted yield sharply reduces the total guarantee when the total acreage in the area with a center pivot system is planted to the same crop and the practices do not qualify to be reported separately. However, this situation can be rectified by adjusting the amount in the UNL tables to reflect the proportion of the acreage that is affected by the center pivot system. As noted earlier, the area of the inscribed circle composes 78.5 percent of the area of the square. Thus, rather than reducing the adjusted yield by 86.8 bushels, it should be reduced by 68.1 bushels. The results of this adjustment are shown in Table 22.

Table 22. Acres Insured, Guarantee per Acre, and Premium for Irrigated Practice when Corners of a Center-pivot Irrigation System are Included in the Irrigated Practice Acreage and Yield is Reduced Proportionately by 68.1 Bushels per Acre

	Irrigated
Acres insured	160
Adjusted Yield	75
Guarantee/acre (65%)	48.75
Total guarantee (bu.)	7,800
Premium rate	0.143
Total premium (bu.)	1115

Source: The Contractor's Rating Department after RMA data.

These results are substantially the same as those contained in Table 20 where the practices are separately reportable.

In the Task Order, the Government posed the following question:

> "*Allowing limited irrigation acreage to be reported as an irrigated practice would seem to inflate future eligibility for irrigated prevented planting payments since a producer would not have to reduce the number of planted irrigated acres under limited irrigation. What potential premium rate increase would this present?*"

Whether or not allowing limited irrigation acreage to be reported as an irrigated practice would inflate future eligibility for irrigated prevented planting payments depends on the manner the

limited irrigation is introduced. If it is introduced as a separately identified practice (i.e., distinct from practice 002), the effect will be to reduce prevented planting payments for practice 002 and introduce prevented planting payments for practice nnn. This situation is identical to that described in the Prevented Planting Loss Adjustment Standards Handbook ((FCIC-25370-3) at section E(5)(a) (page 77): "There is a total of 100 acres of wheat in unit 0001-001OU. The insured claims all 100 acres as summerfallow, but only has a history of 50 acres summerfallow and 50 acres of continuous cropping on the unit. The insured cannot be paid PP on 100 acres of summerfallow unless all 100 acres claimed as PP qualify for a summerfallow practice."

However, if limited irrigation was introduced under practice code 002 then the prevented planting payments also would be made under practice code 002. Or, if limited irrigation is not allowed and acreage upon which reduced irrigation is applied must be reported as a non-irrigated practice, the prevented planting payments would accrue under that non-irrigated practice.

The Contractor notes that the eligibility for prevented planting payments is established as the maximum number of acres of the crop/practice/type in any one of the four most recent crop years. This could delay the impact of reduced irrigation for some years into the future since the database would include practice 002 acreage and the producer could assert intent to apply water consistent with practice 002.

The prevented planting payment amount per eligible acre equals the prevented planting payment factor (default value or the value chosen by the insured for an additional premium amount) multiplied by the approved yield, the coverage level percentage, and the projected price. The total prevented planting payment equals the payment amount per acre multiplied by the number of prevented planting acres and by share.

Under the current Basic Provisions, an irrigated prevented planting insurance guarantee will be established only if there are adequate water and irrigation facilities. If limited irrigation was introduced as an insured practice, the approved yield would be reduced to reflect the expected yield with lesser water applied during the growing season. This reduces the payment amount per acre.

Allowing limited irrigation acreage to be reported as an irrigated practice may have no effect on the acreage eligible for a prevented planting insurance guarantee for a crop, or the effect may be delayed for several years. The outcome depends on the number of crop years of data included in the APH database for the crop and the producer's adjustments in cropping patterns that would occur in the absence of allowing a limited irrigation practice. The prevented planting payment amount per acre most likely would be reduced if limited irrigation acreage can be reported as an irrigated practice but separate from practice 002.

With regard to the impact on premium rate loads if limited irrigation acreage is allowed to be reported as an irrigated practice, the following considerations apply. A premium rate represents two factors: the frequency that an insurable event results in an indemnity and the severity (percent of loss) on insured acreage when the event occurs. Severity is known with certainty for prevented planting: it is, for example, 60 percent of the guarantee per acre for a timely planted crop for most crops. This means the frequency that prevented planting occurs is the only factor

influencing the appropriate premium rate load. Since frequency is a result of natural causes beyond the control of the producer, there is no reason to expect a change in frequency with introduction of limited irrigation. Introduction of limited irrigation practice would have be no impact on the premium rate load for prevented planting.

The argument also can be framed as follows. Suppose a producer has planted 160 acres of corn for each of the previous 4 most recent crop years and has reported those acres as irrigated practice (as defined in the Basic Provisions). An insurable cause of loss prevents planting of 100 acres in the current crop year. This is less than the least amount of acreage reported in any 1 of the 4 most recent crop years; therefore, the producer is eligible for a prevented planting guarantee on the 100 acres. Suppose the approved yield is 200 bushels per acre and the coverage level is 65 percent. The guarantee is 130 bushels per acre and the prevented planting payment is 78 bushels per acre. The loss cost ratio is 60 percent.

Now suppose instead the producer has planted 160 acres of corn for each of the previous 4 most recent crop years and has reported those acres with a limited irrigation practice. All other factors are as stated in the previous paragraph. Suppose the yield for limited irrigation practice has been reduced by 10 percent, to 180 bushels per acre. The guarantee is 117 bushels per acre and the preventing planting guarantee is 70.2 bushels per acre. The loss cost ratio is 60 percent.

Within limits, appropriate adjustments to the approved yield for acreage grown under limited irrigation result in appropriate rates for the insurance of that acreage. The limits include the amount of reduction in irrigation water, the proportion of irrigation water to natural precipitation, and limited changes to other management practices (amount of fertilizer, planting practices, variety chosen, etc.). The effects of these limitations on the Contractor's recommendations are incorporated into the Contractor's feasibility recommendations.

SECTION VII. STAKEHOLDER INPUT

The Contractor gathered stakeholder input during discussions with producers, insurance industry representatives, educators, and government personnel in two listening sessions and in one-on-one conversations. The listening sessions were broadly advertised. A press release (Appendix B, Exhibit 1) was prepared with RMA's cooperation. On the advice of agricultural educators in the region, the Contractor provided the press release to newspapers serving the western half of Kansas, radio stations with an agricultural focus in Nebraska, and "The Progressive Farmer" (an agricultural magazine with a significant online presence). The press release was also sent to water regulatory offices in Colorado, Kansas, and Nebraska; agricultural educators; and the RMA Topeka Regional Office (RO). RMA distributed the release to AIPs to recruit insurance industry stakeholders. Insurance agencies were encouraged to extend invitations to key producers. An advertisement (Appendix B, Exhibit 2) for the meetings was placed in the regional Colby newspaper (with a subscription base of about 1,000) and the local free advertising weekly distributed to about 1,000 rural customers who do not subscribe to the newspaper.

The listening sessions conducted in Colby, Kansas, on March 13, 2013, and in Kearney, Nebraska, on March 14, 2013, were well attended. All totaled, 125 individuals attended the 2 sessions (not counting the Contractor's representatives and counting RMA personnel who attended both sessions only once). Attendees included 53 insurance industry representatives, 7 state government officials all representing offices with authority over irrigation water extraction, 5 growers association representatives, 4 educators/researchers, a representative from each of the Kansas U.S. Senator's offices, an irrigation engineer, and representatives of the USDA Farm Services Agency (FSA) and Natural Resources Conservation Service (NRCS). RMA personnel at both meetings included two professionals from Kansas City and one from the Topeka RO. Additional conversations outside the listening session venues were held with RMA personnel in Kansas and the Topeka RO, including individuals who did not attend the listening sessions. Only four attendees specifically identified themselves as producers on the sign-in sheets. The 14 attendees who provided only their name and address during sign-in and the 28 attendees who did not sign in are most likely producers. In the Contractors experience, representatives of producer organizations and some of the insurance agents are most likely producers as well. Consequently, the Contractor believes at least 45 producers attended the listening session and the number may have been as high as 70. The producers indicated they grow corn, soybeans, wheat, and sorghum. It is likely some also grow other crops, particularly sunflowers and feed crops such as hay, milo, and oats.

Input was obtained from stakeholders from 5 states: Colorado (at least 8 stakeholders), Iowa (1 stakeholder); Kansas (at least 42 stakeholders), Nebraska (at least 35 stakeholders), and Texas (1 stakeholder).

Information was gleaned from stakeholder comments in compliance with the contract requirements regarding the Paperwork Reduction Act. The flow of the meeting was controlled by an agenda (Appendix B, Exhibit 3). The Contractor refrained from asking questions in any way that might be construed as a survey of the group; however individuals were queried to seek clarification of comments they made. Information obtained in this manner is qualitative and cannot be construed to represent a statistically valid sample. Nevertheless, the information gleaned from the voluntary comments of stakeholders provides substantial value concerning

agricultural management processes; risks, acceptance of the existing risk management products, and reaction to possible new risk management approaches like the RMA-proposed Limited Irrigation construct. Although the Contractor provided an email address for comments, no input was received through this channel.

Summary of Stakeholder Input

To preserve the anonymity of individual stakeholders, comments gathered at the two listening sessions are summarized collectively. Individual comments and anonymous characterization of their sources are documented in Appendix B, Exhibit 4.

At each session, as much as half the input from stakeholders was in the form of questions about the existing insurance for corn, soybeans, and other crops and the impact of reduced irrigation on that insurance. After providing summary information reflecting the first deliverable under this contract, the Contractor referred stakeholders to RMA policy and underwriting documents for answers to their specific questions. RMA personnel, primarily from the Topeka RO, responded to some of the follow-on questions. From these questions it was clear producers and insurance industry stakeholders were concerned by the constraints current policy language places on their options if the supply of irrigation water is reduced. There was special concern about the insurance options if knowledge of the reduction in irrigation water supply precedes the acreage reporting date.

Producers indicated that from year to year, soil moisture at planting and precipitation will affect how much irrigation water is required to grow a crop. Furthermore, different crops require different amounts of irrigation water. From region to region, soil quality, slope, and the aspect of the slope (the direction the slope faces) also impact how much water is needed to have a good economic outcome.

Virtually all stakeholders in every category recognize the importance of irrigation to agricultural production and the changes in production under the irrigated practice that are likely to occur as irrigation water becomes more limited. Stakeholders from Colorado, Kansas, and Nebraska all indicated that reductions in water allocations **are** occurring or are expected to occur in the near future. Different producers have responded or are likely to respond to respond to changes in supply of irrigation water differently. Some will water fewer acres. Others will provide less water per acre to their irrigated land, still others will change the crops they grow or change the way they treat their corners on land irrigated using center pivot irrigation systems (e.g., planting crops requiring less water in the corners). One of the things producers have seen is yields from crops irrigated with 80 percent of the water used historically can be as high as the historical yields achieved with application of 100 percent of the historical amount of water.

Producers, producer associations, and insurance industry personnel believe crop insurance is a vital risk management tool for producers. Maximizing yield on fewer acres is not viewed as the best way to optimize economic outcome. However, crop insurance is viewed as an essential tool for developing appropriate strategies to optimize economic outcomes. Being required to report crops grown with reduced irrigation as non-irrigated (if allowed) or uninsurable is viewed as unfair. An insurance program for limited irrigation for corn is considered essential. No similar observation about soybeans was made. Concern was expressed about how reduced irrigation

affects the preventive planting program. The impact of the timing of application of water was raised. In some western Kansas counties, the soil moisture for the new crop accumulates from the dry down of the previous years' crop. In other areas, irrigation water is applied shortly before planting, but rarely during the growing season itself. Producers from Colorado were concerned because the government regulation of the access to water includes designation of specific days they have access to water. While this has always been the case, the insurance requirements that irrigation water be applied at the appropriate time and changes in the timing water is available to the producer can create loss adjustment issues with human actions outside the producer's control.

Insurance industry personnel expressed concern about how these various management strategies could be addressed with either the existing insurance or with the existing insurance and a limited irrigation product. In some irrigated areas, the applied irrigation water is not metered. Insurance records indicate that the amount of irrigation water applied is inversely related to soil moisture and precipitation. However, the Contractor is not confident that the timing and amount of water applied historically will be as well documented as would be required for implementation of the Limited Irrigation product. Concern was also expressed about the impact of having non-irrigated crops being watered. Since the underwriting for the non-irrigated crops does not as clearly address changes in the amount of water applied, this could introduce gaming of the insurance.

The Sheridan 6 LEMA was supported as a logical approach to changes in the available water supply. However, the uncertainty associated with decisions about water supply made independently by regulatory authorities is a particular concern of producers. Producers said they would like to conserve the water in their wells rather than focus on short-term returns. It was considered appropriate that the public policy provide appropriate incentive for good water management.

The National Sorghum Producers representative indicated his association was concerned that the proposed Limited Irrigation product for corn and soybeans would distort the markets for crops in the region and lead fewer producers to grow crops with limited water requirements. He indicated that the T-yields for irrigated sorghum and corn are already creating disincentives for switching from corn to soybeans, and adding limited irrigation insurance for corn would only exacerbate that situation.

As noted earlier, the most noteworthy inputs were:

- Limited availability of irrigation water is a fact of life and will continue to be an issue for agricultural producers for the foreseeable future;
- Changes in management strategies have allowed the producers to achieve better yields with less water;
- Conserving water for all purposes is an appropriate public policy, even for agricultural production; and
- Having a Limited Irrigation product for only a few crops will exacerbate what some perceive as an already distorted market.

SECTION VIII. IMPACT OF IMPLEMENTATION

Introducing a mechanism to insure limited irrigation will impact the insured, the insurance agent, the AIP, and RMA. Not doing so will primarily impact the insured. This impact on the insured if a mechanism to insure limited irrigation is not developed was addressed in the first deliverable under this Task Order:

> [Regarding] *the situation wherein a producer either voluntarily reduces water usage or is required to reduce usage and has established an APH yield which is based totally or in part on a regime of greater water availability/usage. If the anticipated yield under the reduced irrigation is less than "the yield used to establish the irrigated production guarantee or amount of insurance on the irrigated acreage planted to the insured crop," crop insurance policy and procedures presently mandate that a producer reduce the number of acres to which water is applied so the historical amount of water can be applied to the reduced acreage. If this is not done (i.e., the producer maintains the same acreage but applies a lesser amount of water per acre with an anticipated lower yield than that used to establish the guarantee), the entire unit is to be reported as a practice other than Irrigated.*[65]

It was clear from the stakeholder input during listening sessions that producers and insurance industry stakeholders were concerned about the constraints current policy language places on the insurance alternatives if the supply of irrigation water is reduced (as it already has been in some cases). There was special concern about the insurance options if knowledge of the reduction in irrigation water supply precedes the acreage reporting date. Not providing options for an insured who is dealing with a reduction in irrigation supply imposes a burden on the insured that is deemed by stakeholders to be unacceptable. The remainder of this section addresses the impact of the limited irrigation insurance approach proposed for Sheridan and Thomas Counties in Kansas and the impact if that approach is expanded to corn and soybeans grown under irrigation in all of Colorado, Kansas, and Nebraska.

The proposed limited irrigation insurance approach is documented in a Special Provisions statement for Sheridan and Thomas Counties, which reads:

> *"If you intend to apply less irrigation water than was used to establish your irrigated approved APH yield and you are in a Local Enhanced Management Area (LEMA), you may qualify for a written agreement to establish coverage for a limited irrigation practice. In addition to providing the minimum supporting documentation for a type/practice written agreement, you must also provide:*
>
> *1. Your LEMA order from the Chief Engineer or delegate to apply less irrigation water within a five year period than historically used to support your irrigation practice;*
>
> *2. Your historical water use for each unit or APH data base for which a limited irrigation practice yield is requested. Water use records must be provided for at least the most recent 4 years of APH yields to be considered. Acceptable water use records include your annual water use*

[65] The Contractor, 2013, Indefinite Quantity Indefinite Delivery Contract for Insuring Irrigation: Task Order 1: Limited Irrigation Analysis & Evaluation: Deliverable 1: Review of RMA's Current Policies and Procedures, page 5.

reports, as recorded on the State's Water Right Information System (WRIS) or the water right file in the Division of Water Resource's Stockton office and must be expressed in gross acre inches;

3. *Your intended maximum level of irrigation for the current year, in gross acre-inches;*
4. *Your type of irrigation system (Center Pivot, Improved Gravity, or Gravity); and*
5. *Any other pertinent information to establish the distribution of irrigation water from a point of diversion to multiple fields, if applicable.*

The request for written agreement and all supporting documentation must be submitted to the Regional Office through your crop insurance agent on or before the acreage reporting date. The following site provides additional information that may be useful in making the request to the Regional Office: http://www.rma.usda.gov/aboutrma/fields/ks_rso/

To assist insureds and agents in organizing the data necessary to support a written agreement, RMA provides a documentation tool at http://www.rma.usda.gov/fields/ks_rso/2012/template.pdf (Appendix C). The data required to document historical production, assess approved yields, and provide sufficient protections to avoid adverse selection and moral hazard likely impose significant new data collection requirements on the insured and the insurer.

Section 6B(11) of the CIH directs the AIP to annually provide a copy of the Irrigated Practice Guidelines to all insureds to whom the information might apply. The guidelines are contained in the Document and Supplementary Standards Handbook (FCIC-24040-01 (06-2012), page 146ff). Subsection 48(2)(A) of the Document and Supplementary Standards Handbook states:

Insured must be able to demonstrate, to the approved insurance provider's satisfaction, that adequate facilities and water existed, at the time insurance attached, to carry out a good irrigation practice for the insured crop. Some factors that the insured should be able to document and/or demonstrate would include, but are not limited to the following;

a. Water source history, trends, and forecasting reliability;
b. Supplemental water supply availability and usage (including return flow);
c. Pumping plant efficiency and capacity;
d. Water distribution uniformity and flexibility of the system or district;
e. Water requirements (amount and timing) of all crops to be IRR;
f. Water rights (primary, secondary, urban versus agricultural use, etc.);
g. Contingency plans available to handle water shortages;
h. Acres to be IRR, amount of water to be applied, and expected yield;
i. Ownership of water (state or federal versus landowner);
j. Use of meters and other measuring devices or methods;
k. Soil types, soil moisture levels, and pre-plant irrigation needs;
l. Water conserving methods, devices, and plans utilized;
m. Past crop planting history, trends, and recommended local practices;
n. Prudent activities and practices utilized by non-insured insureds;
o. Irrigation water supply (both quantity and quality) and facilities;

p. Recommendations from local CES or NRCS, and other sources recognized by CES or NRCS to be an expert in this area regarding irrigation and crop production; and

q. Information the insured knew (or should have known), and when the insured knew (or should have known) such information.[66]

The operative language in these statements is: "Insured must be able to demonstrate, **to the approved insurance provider's satisfaction,** that adequate facilities and water existed, at the time insurance attached, to carry out a good irrigation practice for the insured crop." (emphasis added) If the AIP required all the records implicit in the Subsection 48(2)(A) statement, then the producer has maintained all the records required to implement the proposed Limited Irrigation approach. However, if the AIP was satisfied with lesser documentation in the past, it is reasonable an insured would have assumed maintenance of these more limited records was appropriate. The provision only requires the insured demonstrate that adequate facilities and water existed at the time insurance attached to the AIP's satisfaction. Creating that state of satisfaction might be as simple as an interview between the agent and the insured:

"Did you believe you would have adequate water to carry out the irrigated production practice this year?"

"Yes. I did not receive any notification from the [ditch company or other appropriate authority] that water would be restricted."

Which might or might not lead to a follow-up with the authority:

"Did you advise producers that water might be restricted?"

"No."

Consequently, there may be no record accessible 10 or even 4 years later of the quantity of water applied to any particular acreage. Furthermore, the requirements for recordkeeping to satisfy the AIP, though implicit in the Irrigated Practice Guidelines, is not specified as an obligation of the insurance under the irrigated practice.

One issue is when the insured must be able to demonstrate that adequate irrigation water was available. The Basic Provisions state:

"If insurance is provided for an irrigated practice, you must report as irrigated only that acreage for which you have adequate facilities and adequate water, or the reasonable expectation of receiving adequate water at the time coverage begins, to carry out a good irrigation practice. If you knew or had reason to know that your water may be reduced before coverage begins, no reasonable expectation exists."[67]

The proposed procedures to insure limited irrigation as the irrigated practice require an insured to agree to a reduction of the approved APH yield in accordance with published Yield Reduction

[66] USDA, RMA, 2013, Document and Supplementary Standards Handbook (FCIC-24040-02), 147.
[67] USDA, RMA, 2010, Common Crop Insurance policy (11-BR), 17.

Tables. The reduced approved APH yield becomes the yield upon which the insurance guarantee is based, thereby meeting the definition of irrigated practice in the policy.

There is potential for disagreement between the insured and the insurer over the phrase "the expectation of applying less irrigation water than what **is required** to produce the yield upon which their guarantee is based." Over the period during which the APH was established, water was applied either when such application was allowed (by a regulatory body) or when it is most likely to be efficacious (based on the producer's judgment). Planting densities in a unit may have changed to reflect the variety chosen and seed company recommendations. Applications of nutrients may have changed to reflect soil tests and planting densities, with a resulting change in the amount of irrigation water required. Furthermore, tillage practices may have been modified to conserve water. Thus, though the published Yield Reduction Tables provide a basis for adjusting the APH, they do not necessarily reflect time series production patterns the APH does. Nonetheless, for the purpose of this analysis, assume agreement is reached between the insured and the AIP on the amount of irrigation water required to produce the yield upon which the guarantee is based. Then the calculations for the APH are those that are used for all crops and the adjustment to the APH is a relatively mechanical process imposing a limited burden on the AIP and their agent.

The insured is required to report the limited irrigation acreage on his or her acreage report. Separate line entries are required on the acreage report when full irrigation and limited irrigation are carried out on the same unit. In addition, the limited irrigation acreage must be identified and reported to RMA by the AIP through the Policy Acceptance and Storage System (PASS) on the applicable Type 11 Acreage Record. Following production under a Limited Irrigation practice, the actual yield must be recorded into the insured's Irrigated Practice APH database. These actual yields from limited irrigation must be identified with the appropriate limited irrigation yield descriptor. These procedures impose relatively minor burdens on the AIP, the AIP's agent and RMA, hardly different from existing requirements.

It is important to note the proposed approach for insuring limited irrigation does **not** require a separate APH database be established. The AIPs and RMA instead use a "yield limitation flag" to identify an approved APH yield that has been reduced according to the Yield Reduction Tables for limited irrigation. Yet, since yield reductions to the approved APH yield continue to be made until the approved APH yield is representative of the yield upon which the guarantee is based (given the expected irrigation water application), the AIP is maintaining an irrigation database. If additional reductions in irrigation water supply are made, additional appropriate adjustments to the APH need to be made until the APH history reflected this new level of available water. It is conceivable that changes in water supply could be made often enough in some regions so the approved APH yield in the RMA database is never representative of the available water supply.

The data required to document historical production, determine approved yields, and to avoid adverse selection and moral hazard does not technically impose substantial new data collection requirements on the insured and the insurer. It is, however, possible that many (or even most) insureds will be hard pressed to provide appropriate documentation of historical water

application, especially at the smallest unit level. This issue may be much more difficult for crop years for which the record retention period has expired.

Providing insurance for limited irrigation through Written Agreements will impose an unacceptable burden regarding review and approval of those agreements by the Government. Finally, if the proposed approach is expanded to other areas and/or other crops, RMA will be required to generate additional Yield Reduction Tables for publication. Due to data limitations, that task will be much more difficult for corn and soybeans in states other than Colorado, Kansas and Nebraska and for any other crops.

SECTION IX. RESEARCH FINDINGS

In the 2008 Irrigation Survey, NASS reported 54,929,915 acres in the United States on 206,834 farms, irrigated with 91,235,036 acre feet of water.[68] In 2003, the NASS estimates were 52,492,687 acres on 210,106 farms,[69] irrigated with 86,757,665 acre feet of water.[70] Consequently, there was a 0.49 percent **increase** in the average amount of irrigation water applied per irrigated acre in the United States between the two surveys. In Colorado, the average amount of irrigation water applied per irrigated acre between the two surveys increased by 1.9 percent, while in Kansas and Nebraska, that amount decreased by 1.0 and almost 29 percent, respectively (Table 23). Furthermore, anecdotal testimony indicates that since the 2008 survey the amount of irrigation water applied per acre on some operations has decreased, in some cases significantly.

Table 23. A Comparison of Irrigation in Colorado, Kansas, and Nebraska in 2003 and 2008

	Colorado		Kansas		Nebraska	
	2003	2008	2003	2008	2003	2008
Farms with Irrigation	11,567	12,778	4,878	4,508	16,278	14,812
Irrigated Acres	2,562,329	2,865,840	2,543,950	2,570,003	7,516,171	8,365,545
Irrigation Water Applied (Acre-feet)	3,984,941	4,541,276	3,145,502	3,146,607	8,450,468	6,699,545
Acre-feet Irrigation Water Applied per Acre	1.56	1.58	1.24	1.22	1.12	0.80
Percent Change from 2003		1.9		-1.0		-28.8

Source: The Contractor's Research Department after data from Table 12 in the 2007 Census of Agriculture: Farm and Ranch Irrigation Survey (2008), published in 2010 and Table 12 in the 2002 Census of Agriculture: Farm and Ranch Irrigation Survey (2003), published in 2004.

Not introducing a mechanism to insure limited irrigation will impact the insured, and may lead to problems with underwriting and loss adjustment. The impact on the insured was addressed in the first deliverable under this Task Order:

> [Regarding] *the situation wherein a producer either voluntarily reduces water usage or is required to reduce usage and has established an APH yield which is based totally or in part on a regime of greater water availability/usage. If the anticipated yield under the reduced irrigation is less than "the yield used to establish the irrigated production guarantee or amount of insurance on the irrigated acreage planted to the insured crop," crop insurance policy and procedures presently mandate that a producer reduce the number of acres to which water is applied so the historical amount of water can be applied to the reduced acreage. If this is not done (i.e., the producer maintains the same acreage but applies a lesser amount of water per acre with an anticipated lower yield than that used to establish the guarantee), the entire unit is to be reported as a practice other than Irrigated.*[71]

[68] The 2013 survey has yet to be distributed to respondents.
[69] USDA, NASS, 2010, 2007 Census of Agriculture: Farm and Ranch Irrigation Survey (2008), Table 1.
[70] USDA, NASS, 2010, 2007 Census of Agriculture: Farm and Ranch Irrigation Survey (2008), Table 12, page29.
[71] The Contractor, 2013, Indefinite Quantity Indefinite Delivery Contract for Insuring Irrigation: Task Order 1: Limited Irrigation Analysis & Evaluation: Deliverable 1: Review of RMA's Current Policies and Procedures, page 5.

It was clear from input during the listening sessions that producers and insurance industry stakeholders were concerned about the constraints current policy language places on the insurance alternatives when the supply of irrigation water is reduced. There was special concern about the insurance options if knowledge of the reduction in irrigation water supply occurs before the insurance attaches (or if the reason for the reduction is "man-made," i.e., a regulatory action). Not providing options for an insured who is dealing with a reduction in irrigation supply imposes a burden on the insured that is deemed by stakeholders to be unacceptable.

The remainder of this section addresses the impact of the limited irrigation insurance approach proposed for Sheridan and Thomas Counties in Kansas and the impact if that approach is expanded to corn and soybeans grown under irrigation in all of Colorado, Kansas, and Nebraska.

On Wednesday, April 17, 2013, the Chief Engineer of the Kansas Department of Agriculture Division of Water Resources issued his Order of Designation setting forth the complete terms for the Sheridan 6 LEMA.[72] The LEMA limits total water use per acre to 55 acre-inches during the 5 years beginning with 2013 in the "designated sections" of Sheridan and Thomas Counties. Consideration of the changes in irrigation the LEMA might require, the effects of similar regulatory actions in other areas, and voluntary reductions in the amount of irrigation water applied to acres insured under the irrigated practice led RMA to develop preliminary procedures for addressing limited irrigation. A partnership project with the UNL addressed theoretical reductions in yields for corn and soybeans in selected counties in Colorado, Kansas, and Nebraska.

The objective of this task under the task order was to determine if the proposed limited irrigation approach would be a feasible alternative crop insurance product. RMA's criteria for feasibility identify the requirements to establish an appropriate feasibility recommendation for a crop insurance product in the broadest terms. An initial review of RMA's 12 criteria for feasibility of an insurance product indicated that 7 required additional evaluation. These included:

- The perils affecting production must be identified and categorized as insurable and non-insurable;
- The insurance product must be ratable and operable in an actuarially sound manner;
- The insurance product must contain underwriting, rating, pricing, loss measurement, and insurance contract terms and conditions;
- Customers must not be able to select insurance only when conditions are adverse;
- Moral hazards must be avoidable or controllable;
- The insurance product must be effective, meaningful and reflect the actual risks of the producers; and
- Producers or their agents must be willing to pay the appropriate price for the insurance.

RMA crop insurance for corn and soybeans already exists. The perils affecting corn and soybean production have already been identified and categorized as insurable and non-insurable as elements of this existing insurance. The barrier under this criterion is whether there is a

[72] Barfield, D.W., 2013, Order of Designation Approving the Sheridan 6 Local Enhanced Management Area within Groundwater Management District No. 4, http://dwr.kda.ks.gov/LEMAs/SD6/LEMA.SD6.OrderOfDesignation.20130417.pdf, Accessed May, 2013.

significant antagonistic effect of limited irrigation on losses due to other causes sufficient to require a separate identification and categorization of these corollary effects.

There are limited data on such antagonistic effects. Though there are references to greater susceptibility of stressed plants to disease, there do not appear to be substantial data to quantify that increased susceptibility for most crops in most regions. However, RMA loss data, and the accompanying information about causes of loss, suggest the primary effects of weather on productivity are much greater than any corollary effect of susceptibility to disease due to water stress. Both primary and corollary effects of weather on productivity have been, and will continue to be, captured in the actual yields of producers and incorporated into the insurance rates. Therefore, the existing identification and categorization is sufficient for the purposes of a limited irrigation insurance construct. Consequently, identification and categorization of corollary damage due to water stress is not a barrier to any form of limited irrigation insurance.

The Contractor has addressed the rating of limited irrigation insurance in detail earlier in this report, noting that within limits, appropriate adjustments to the approved yield for acreage grown under limited irrigation result in appropriate rates for the insurance of the acreage grown under limited irrigation. The limits include the amount of reduction in irrigation water, the proportion of irrigation water to natural precipitation, and limited changes to other management practices (amount of fertilizer, planting practices, variety chosen, etc.). Since these latter factors have affected the yield from irrigated acreage over time, an amount of reduction in irrigation supply over time that would affect an approved yield by less than one [two] standard deviation[s] of the actual yields used to calculate the approved yield might not appropriately be considered less than the amount required "to establish the irrigated production guarantee or amount of insurance on the irrigated acreage planted to the insured crop." Conversely, if reduction of the amount of irrigation water is so great as to result in an expected yield near that of a non-irrigated crop (e.g., within one [two] standard deviation[s] of the actual yields resulting in the producers approved yield for the crop when it is not irrigated or the county yield for the non-irrigated crop), then the crop might not appropriately be considered irrigated.

As noted in the section on rating, the outcome regarding prevented planting of allowing limited irrigation acreage to be reported as an irrigated practice will depend on the number of crop years of data included in the APH database for the irrigated crop and any reduction of irrigated acreage that would have occurred in the absence of allowing insurance for limited irrigation. Any adjustments to rates will need to consider the approved approach to insure limited irrigation. Consequently, the Contractor believes rating is not a barrier to insuring limited irrigation and the existing continuous rating function should be used, with appropriate adjustments to the premium for prevented planting once the insurance approach is finalized.

Appropriate management practices for insured crops have been defined and required of stakeholders under the existing insurance. The Contractor has provided suggestions regarding changes to the policies and procedural documents required for the insurance of limited irrigation. The potential impact of the antagonistic effect of limited irrigation on losses due to other causes was addressed as related to the identification and categorization of perils. No additional underwriting should be required for these corollary effects. The primary barrier related to the underwriting is the requirement for documentation of water applied to a unit. This barrier is

especially challenging if written, third-party documentation applicable to an insured unit is required. Most likely some compromises will be necessary to provide a mechanism for certification of the amounts of water applied to a unit and for mechanisms to verify compliance with the requirements for application of irrigation water. Since the insured with limited irrigation water supply can choose where to apply that water, this underwriting is a potential barrier to feasibility. In addressing this barrier, there should be consideration of the extent to which irrigation documentation has heretofore been required. It seems likely that procedures comparing losses between insureds in a county may be sufficient to provide the tools for compliance with RMA procedures.

Corn and soybeans are already insured in Colorado, Kansas, and Nebraska. Most producers participate in the insurance program. The actual insurable risks the producer faces appear to be addressed by the existing insurance. However, the insureds' perceptions of the utility of the insurance and of the ability of the insurance to protect the insured from financial failure affect the meaningfulness of the product. Consequently, the approach used to address limited irrigation scenarios might impact whether the insurance is considered meaningful by a producer. While no insured indicated a willingness to forego insurance so he or she could reduce the irrigation water applied to acreage currently insured under the irrigated practice, none indicated that a reduction of his or her approved yield was an attractive alternative.

Most irrigation in the affected area is by pivot circles, and often a circle will have its own water supply. Consequently, the choices a producer has regarding how much acreage to irrigate and how much water to apply to a circle are likely more limited than the many alternative reduced irrigation scenarios that can be conceive when these constraints need not be considered.

Ultimately, the willingness of producers to pay will be influenced by the coverage available and the costs associated with the insurance offer. Unless the costs or procedures for insuring crops under limited irrigation are particularly onerous, the Contractor would expect producers to be willing to pay the appropriate price for the insurance.

Although the limited irrigation insurance as proposed would be cumbersome (e.g., it is built on written agreements and requires the insured to provide data that may be hard to obtain) and challenging to maintain (e.g., it requires careful monitoring of the effects on rates and development of Yield Reduction Tables for other states and other crops), the approach is feasible but expensive.

The Yield Reduction Tables provided to the Contractor are logical, but may be over-engineered, with a precision that ignores the disparity between the data used to create the tables and the data used to develop APHs. For the level of precision provided in the output, the tables should incorporate the length of the growing season for the variety planted, since that has an important effect on the total evapotranspiration. The yield reductions should also be truncated at low initial levels of historic irrigation water applied. That is to say, if a producer is adding just two inches, he or she is not really irrigating but rather adding supplemental water to a non-irrigated crop (most likely just prior to planting). Even if that were the basis of developing the irrigated database, the impact of eliminating half the irrigation water on yield variability would argue for calling the new practice non-irrigated rather than adjusting the old irrigated yield. Research is

required to determine what would be considered a reasonable range for added irrigation water in a county to determine where such truncation would be made.

Finally, if Colorado, Kansas, and Nebraska insureds get limited irrigation insurance for corn and soybeans, every insured producer who adds water to their corn and soybean crop will want limited irrigation insurance if they are required to or choose to reduce the amount of irrigation water they apply to their crops. Likewise, if all corn and soybeans get limited irrigation insurance, anyone who irrigates any crops will want the option.

Alternatives for Addressing Limited Irrigation

The Government requested the Contractor supply brief summaries of alternative approaches for addressing insurance of crops grown under reduced/limited irrigation. The purpose of this request was not to determine if an alternative is better, nor to evaluate the applicability of alternatives to other crops or regions, nor to develop the concept. Instead, this activity was undertaken to stimulate thinking and consideration of courses the Government might take. By presenting a wide variety of alternative approaches, the Contractor hopes to stimulate thoughts about changes, whether subtle or major, that might make the final insurance product for crops grown under reduced/limited irrigation better. Consequently, even outrageous ideas were included in the following list, which presents only the basis of the concept, the most obvious issues with the approach, and the general data requirement. If the only outcome of a reader reviewing this list is the reader saying: "But what about …," then this activity has served its purpose.

Option 1: Maintain Existing Policy Language and Procedures with Very Limited Changes.

Approach: Two practices, Irrigated (IRR) and Non-irrigated (NI). Irrigated practice definition continues to focuses on achieving the approved yield.

Problems:

- Adjustments to management practices to increase yield have not been treated as new practices under the existing insurance.
- Clearer guidelines are required to determine when reduced water application changes an irrigated practice to some form of non-irrigated production.
- Surface water shortfalls may be indemnified as **failure** of irrigation supply, but ground water **restrictions** are not.
- Many insureds will consider the requirements of the existing policy language and procedures unfair when regulators require them to reduce water.
- Many insureds will consider the requirements of the existing policy language and procedures unfair when land receiving reduced irrigation has to be treated as some form of not irrigated production.
- Producers believe they can achieve their approved yield by adjusting planting practices, irrigation timing and equipment, and varieties.

Data requirements: No new data are required.

Option 2: Add a Limited Irrigation Practice with Its Own Practice Code.

Approach: Add a limited irrigation (LI) practice in counties where the Irrigated Practice already exists. The irrigated practice definition continues to focuses on achieving the approved yield. Limited irrigation results in a decrease in the approved yield.

Problems:

A new database will need to be created and maintained.

Clear guidelines are required to determine when reduced irrigation changes an irrigated practice to limited irrigation production.

Some insureds will consider this approach unfair since under existing rules transitional yields must be used when there are fewer than four actual yields representing the practice.

Producers believe they can achieve their approved yield by adjusting planting practices, irrigation timing and equipment, and varieties.

Data requirements: Tables like the UNL Yield Reduction Tables will be required for any crop in any area where regulations or availability require reducing irrigation.

Option 3a: Maintain Existing Irrigation Policy and Procedures but Change the Definition for Irrigated Practice.

Approach: Two practices, Irrigated (IRR) and Non-irrigated (NI). Irrigated practice definition focuses on **all practices collectively** that are required to obtain the approved yield.

Problems:

Substantial underwriting changes will need to address the new approach.

Most likely the developer will need to integrate yield trend and irrigation amounts.

Data requirements: Data about multiple management approaches, including comprehensive data on irrigation amounts to assess how "all practices collectively" affect yield.

Option 3b: Maintain Existing Irrigation Policy and Procedures but Change the Definition for Irrigated Practice.

Approach: Two practices, Irrigated (IRR) and Non-irrigated (NI). Irrigated practice definition focuses on all practices collectively that are required to obtain the **guaranteed yield**.

Problems:

Effectively eliminates the deductible.

Rating would need to address this structure and a change in the Act would likely be required.

Substantial underwriting changes will need to address the new approach.

Data requirements: No new data required.

Option 4: Maintain Existing Irrigation Practices and Insurance Procedures but Allow a Database Restart using T-yields under Reduced/Limited Irrigation.

Approach: Two practices, Irrigated (IRR) and Non-irrigated (NI). Irrigated practice definition continues to focuses on achieving the approved yield.

Problems:

IRR T-yield would need to be revisited.

NI corners may or may not be included in IRR approved yield, that difference could either reward or short-change the producer during a restart.

All producers who elect new T-yields are not equally affected by reducing the irrigation (as demonstrated by the UNL Yield Reduction Tables)

Some good producers would be penalized by low T-yields.

Data requirements: Yield estimates of a crop grown under a regime with less water are needed to establish T-yields for the "restart."

Option 5: Maintain Existing Irrigation Practices and Insurance Procedures but Allow a Database Restart using Personal T-Yield under Reduced/Limited Irrigation.

Approach: Two practices, Irrigated (IRR) and Non-irrigated (NI). Irrigated practice definition continues to focuses on achieving the approved yield.

Problems:

An adjustment factor for a producer's relative yield experience in county would need to be developed.

Adjustments to management practices to increase yield have not been treated as new practices under the existing insurance. This could distort any personal T-yields generated.

Underwriting would need to be revisited to assure the approach does not result in beneficial gain.

Data requirements: No new data required.

Option 6: Add a Third Practice Called Supplemental Irrigation.

Approach: Three practices, Irrigated (IRR), Non-irrigated (NI), and Supplemental irrigation (SI). Irrigated practice definition continues to focuses on achieving the approved yield. Supplemental irrigation builds on new T-yields that build up from non-irrigated rather than down from irrigated. Non-irrigated is more discrete than irrigated because irrigated sometimes includes non-irrigated land but the reverse seems to be less often true.

Problems:

A new database will need to be created and maintained.

Clear guidelines are required to determine when reduced irrigation causes a change to supplemental irrigation production.

The production from IRR and NI practices may have been comingled.

Some insureds will consider this approach unfair since under existing rules transitional yields must be used when there are fewer than four actual yields representing the practice.

Data requirements: For corn and soybeans in the study states, no new data required if the UNL data are accepted for drawing the lines between the three practices. Tables like the UNL Yield Reduction Tables will be required for any crop in any area where regulations or supply require reducing irrigation.

Option 7: Use the Suggested Limited Irrigation Insurance approach, but Replace the Yield Reduction Tables with a Formula Based on Average Annual Rainfall for the County and the Insured's Historic and Expected Irrigation Amounts.

Approach: Two practices, Irrigated (IRR) and Non-irrigated (NI). Irrigated practice definition continues to focuses on achieving the approved yield. Insureds with limited irrigation adjust their approved yield by a factor that is (annual county rainfall + expected irrigation)/ (annual county rainfall + historic irrigation), a major simplification of the yield function underlying the Yield Reduction Tables.

Problems:

Might oversimplify the yield reduction function.

Requires appropriate underwriting so the acreage under irrigation is not manipulated for beneficial gain.

Data requirements: Annual County Average Rainfall, Insured's Historic water application.

SECTION X. RECOMMENDATIONS

This section of the report contains the recommendations of the Contractor for consideration by RMA. In accordance with the Task Order, these recommendations focus on a continuation of information development oriented toward ultimately designing a workable solution for the issue of limited irrigation.

Limited irrigation is a complex issue; one that cannot be easily and readily addressed. The subject of irrigation has been one of significant discussion within RMA, with the AIPs, and with insured persons and their representatives. The present rules and procedures regarding irrigation were developed over many years. A major impetus driving the issue has been surface water availability. Increased population and concurrent demand for water for household use have placed increasing stress on available water, especially when coupled with below normal snowpack in many years. Recently, concerns about withdrawal rates from the Ogallala aquifer in parts of Kansas have resulted in restrictions on water use by agricultural producers in those areas.

The Contractor believes that more restrictions on availability of water for agricultural use are likely in the coming years. This will place increasing pressure on RMA to adapt its policy on insuring irrigated acreage. The Contractor believes it will be increasingly difficult to continue the position that acreage with impaired water availability relative to historical availability must either be reduced for insurance purposes or be reported as a non-irrigated practice. But, since actuarially responsible answers are difficult to determine, a focused effort will be needed to be responsive to the issue.

Recommendation 1: Fully implement the Special Provisions statements for Sheridan and Thomas Counties, Kansas for the 2013 crop year.

The Contractor is not aware that guidance has been given to the AIPs with regard to implementing the limited irrigation alternative for these two counties. At the very least, the Contractor has not found a Product Management bulletin on this subject. The Topeka RO website has only the Documentation Tool and a completed example of it under the Limited Irrigation link. It is important that the 2013 data be identifiable and subject to analysis so that the impacts of reduced water use can be better understood.

Recommendation 2: Use the available weather data, RMA historical yield data, and Irrigation Survey data to explore, to the extent possible, the mitigation of effects of deficit irrigation in Nebraska (between 2003 and 2008) by other management practices.

There was nearly a 29 percent reduction in water applied to each irrigated acre in Nebraska between 2003 and 2008. According to NASS data, the irrigated corn yields in the state those two years were almost identical. NASS, RMA, and proprietary weather data can be mined to understand better the changes in irrigated yields between those two years. This can provide useful information about the extent to which the yield under reduced irrigation is affected by management strategies other than irrigation. RMA data provides a mechanism to mine farm level data by county to appreciate the degree to which the mitigation is a general phenomenon.

Recommendation 3: Use available weather data, UNL Yield Reduction tables, RMA historical yield data, and RMA summary of business data to model, to the extent possible, the maximum effects on indemnities of allowing limited irrigation to be insured as an

irrigated practice without a yield adjustment. Determine the extent to which modeled increases in indemnities, if any, would result in beneficial gain.
The limited data available for Nebraska suggest that producer management decisions might offset some, or even all, of the effects of reduced irrigation, at least in the short run. If yield trend increases offset limited irrigation yield reductions, RMA could establish a set of underwriting rules allowing a producer to maintain some, or all, of the APH database already established for his or her irrigated crops. The rules would require the producer to address the change in available irrigation water by strategies acceptable to the insurer. However, this approach is only feasible if beneficial gains can be avoided. Data are available that could be used to model outcomes under this approach to determine whether an actuarially sound construct might exist. If that is the case, draft underwriting rules would be developed.

Recommendation 4: Analyze as soon as possible the acceptance of the Limited Irrigation offer extended via the Special Provisions for Sheridan and Thomas Counties, Kansas for the 2013 crop year.
The Special Provisions offer was limited to those parts of Sheridan and Thomas Counties where a LEMA was effective for the 2013 crop year. This encompasses land in 101 sections, or a total of 64,640 acres. Testimony during the review process that established the LEMA focused on the flexibility of the five-year allocation and the ability to move water rights among different points of diversion, a factor that producers who testified during the hearings stated would enable them to farm acreage profitably during the proposed LEMA period of five years. The response of producers in these 101 sections will be illustrative. Will these producers accept the reduction in the APH yield? Or will they reduce irrigated acreage but apply the historical amount water to the reduced acreage? Or will they move water among units, allowing those with lower performing wells to become non-irrigated practice and moving the water to another unit that will be irrigated at higher amounts of water?

Some answers perhaps will be found by examining the requests for and acceptance of Written Agreements to become eligible for reduced irrigated guarantees. This information would be available from the Topeka RO. But existence of a Written Agreement does not mean the producer reported acreage under its terms. Hence, it would be interesting to find: 1) how many producers filed a request, 2) how many were approved by the RO and accepted by the insured, 3) the historical amount of water applied and the average approved yield, 4) the amounts of reduction in water use that were anticipated, and 5) the number of approved requests that resulted in an adjusted yield as reported on an acreage report. Since the area is limited, the rate of acceptance of the UNL tables should be identifiable before the insurance experience is available.

Recommendation 5: Analyze the performance of the reduced yields for limited irrigation for the 2013 crop year.
This recommendation cannot be completed in the near term. In contrast to Recommendations 2, 3, and 4, the analysis for this recommendation cannot be undertaken until the yields for 2013 are reported. This could be as late as the Production Reporting Date (approximately May 1, 2014). However, it is essential that comparisons of yields on units with limited irrigation adjustment and units without adjustment begin as soon as possible to improve knowledge of: 1) the validity of the UNL tables, and 2) quantification of the "yield drag" associated with reduced water application. Even so, since information about differences in tillage practices, varieties planted,

fertilizer use, and a host of other variables that affect yield will not be known, these results will not be complete.

Recommendation 6: Do not rely upon the UNL yield adjustment table approach as the appropriate means to respond to the limited irrigation issue on a long-term basis in the three-state study area and do not expand it to include other states and crops.
The Contractor acknowledges that the approach utilized by the UNL study team does utilize information available at the time the study was done. But, as RMA correctly noted in the questions included in the Task Order, it is based on the results of small plot research under experimental conditions. More particularly, several of the observations are dated and might be representative of hybrid varieties no longer in production. Seed technology has moved with seemingly lightning speed in recent years. Round-up Ready corn seed makes management of weeds that compete for moisture more effective. Varieties that control corn rootworm make the plant more efficient in using available water. Other genetic improvements have made the plant more efficient in using available water, sunlight, and other inputs affecting growth. The expanding acreage of corn and soybeans in the Northern Plains, an area where the crops traditionally never were grown, is evidence of significant genetic improvement in the seeds. Attempting to replicate the UNL model in other states and for other crops likely will prove time-consuming and costly. The basic information needed to construct the estimates may not exist in many cases, thereby rendering appropriate estimates impossible. The Contractor believes resources will be better utilized by considering alternative approaches that are simpler and less burdensome on producers, AIPs, and RMA.

The Contractor acknowledges that the state of Kansas has put urgency into the need to take short-term measures in that state. Since there is no other alternative at this time, the UNL yield adjustment tables should be used where a LEMA has been established in that state. Based on the listening sessions, the Contractor believes producer satisfaction with the amounts of reduction in yield will be low, thus giving urgency to seeking alternatives. While developing an alternative to the UNL model may not be possible for the 2014 crop year, emphasis should be given in the near term to refining the estimated yield drag to determine if the adjustments can be made more palatable to producers.

Recommendation 7: Investigate the potential for developing better targeted measures of the effect of reduced water usage.
Presently, the Basic Provisions and associated Handbooks all take the position that any reduction in available water is *de facto* proof that a unit will be unable to produce the yield upon which the guarantee is based. Stakeholders do not accept this position, believing that other inputs or alternate management approaches can be substituted effectively and economically to replace this reduced input.

The UNL yield reduction procedures essentially are a continuation of the premise that any reduction in available water will be unable to produce the yield on which the guarantee is based. The procedures assume a fine granularity of data and a long history of uniform practices. Any fix needs to address other levels of granularity and history lengths that better represent the yield potential under reduced application of water. Producers believe they need some flexibility in managing their irrigation. Tillage, seed, and other production inputs and practices used currently

are not the same as those used historically. The challenge is to find a solution that does not create procedures that burden the insured, the AIP, and the Government unduly.

One approach might be to consider the effect of trend adjustments to the approved yield and how these might be modified to acknowledge reduced application of irrigation water.

Recommendation 8: Evaluate several alternative conceptual approaches to management of insurance for irrigated acreage chosen from among those advanced by the Contractor, by RMA, or by any other source.

Based on the results of this feasibility study, the Contractor believes additional investigations into the potential yield drag, if any, associated with reduced application of irrigation water under field conditions are needed. These investigations must be targeted to be achievable under the constraints of the crop insurance system.

Appendix A

Samples of Available Data

Exhibit 1. NASS 2008 Quick Stats 2.0 Data for Corn, by County in Colorado, Kansas, and Nebraska
Exhibit 2. Daily Precipitation Data for the Growing Season (April 1through September 30), Sheridan County, Kansas, Every Fifth Year 1972 to 2012

Exhibit 1. NASS 2008 Quick Stats 2.0 Data for Corn, by County

Colorado

County	Acres Planted	Grain - Acres Harvested	Grain - Production bu	Grain - Yield bu/acre	Irrigated Acres Planted	Grain - Irrigated Acres Harvested	Grain - Irrigated Production	Grain - Irrigated Yield	Non-irrigated Acres Planted	Grain - Non-irrigated Acres Harvested	Grain - Non-irrigated Production bu	Grain - Non-irrigated Yield bu/acre	Silage - Acres Harvested	Silage, Irrigated - Acres Harvested	Silage, Non-Irrigated - Acres Harvested
Adams	14,600	10,100	946,000	94											
Baca	102,000	48,600	5,231,000	108									3,600	1,300	2,300
Bent	12	143	1,762,000	149									1,100		
Boulder													1,000		
Cheyenne	39,500	31,400	2,879,000	92									1,700		
Delta	4,800	2,500	500,000	200											
Elbert	8,200	7,700	338,000	44											
El Paso	800	800	122,000	153											
Kiowa	15,900	12,400	750,000	60											
Kit Carson	191,000	168,000	16,765,000	100	98,000	89,100	13,650,000	153	93,000	78,900	3,115,000	39	8,100	5,200	2,900
Larimer	13,500	4,800	590,000	123											
Lincoln	33,500	28,000	1,080,000	39											
Logan	74,000	70,400	9,688,000	138	55,000	52,700	8,538,000	162	19,000	17,700	1,150,000	65	2,900		
Mesa	2,900	1,600	205,000	128											
Montrose	11,000	7,800	1,396,000	179											
Morgan	62,800	39,000	6,413,000	164											
Otero	16,700	14,400	2,680,000	186											
Phillips	107,500	105,800	16,110,000	152	72,000	71,500	13,500,000	189	35,500	34,300	2,610,000	76			
Prowers	33,100	26,500	3,480,000	131											
Pueblo	7,500	5,800	1,240,000	214											
Washington	66,800	52,400	4,070,000	78											
Weld	123,800	73,400	12,357,000	168											
Yuma	240,200	224,200	40,685,000	181	220,000	206,500	39,570,000	192	20,200	17,700	1,115,000	63			
Others (4 counties)	65,000	61,800	8,943,000	145	271,500	187,400	32,052,000	171	154,800	125,600	5,240,000	42	0	21,900	7,600
Totals	1,118,500	938,700	130,291,000	139	716,500	607,200	107,310,000	177	322,500	274,200	13,230,000	48	12,700	27,100	10,500

Kansas

County	Acres Planted	Grain - Acres Harvested	Grain - Production bu	Grain - Yield bu/acre	Irrigated Acres Planted	Grain - Irrigated Acres Harvested	Grain - Irrigated Production	Grain - Irrigated Yield	Non-irrigated Acres Planted	Grain - Non-irrigated Acres Harvested	Grain - Non-irrigated Production bu	Grain - Non-irrigated Yield bu/acre	Silage - Acres Harvested
Atchison	57,500	56,000	7,440,000	133									
Barton	25,500	23,200	3,783,000	163									
Bourbon	7,600	7,300	650,000	89									
Brown	104,500	103,600	14,460,000	140									
Butler	55,400	52,600	6,139,000	117									
Cherokee	49,100	47,700	3,807,000	80									
Clay	18,700	17,900	2,822,000	158	11,000	10,900	1,950,000	179	7,700	7,000	872,000	125	
Comanche	1,500	1,300	176,000	135									
Cowley	12,500	11,300	981,000	87									
Doniphan	81,300	80,000	14,635,000	183									
Douglas	25,600	24,900	2,872,000	115									
Edwards	66,700	64,300	10,220,000	159									
Ellis	4,500	4,000	358,000	90									
Finney	97,100	92,400	15,180,000	164									4,500
Geary	6,700	6,300	879,000	140									
Gove	62,100	57,600	5,010,000	87									
Gray													5,200
Harper	3,500	2,800	202,000	72									
Harvey	40,000	38,300	5,290,000	138									
Hodgeman	16,800	12,800	2,100,000	164									
Jefferson	37,000	35,900	5,070,000	141									
Kearny	50,000	47,800	8,615,000	180									2,000
Kingman	9,600	9,200	1,387,000	151									
Labette	33,200	31,600	2,664,000	84									
Lincoln	1,900	1,600	160,000	100									
Lyon	24,800	22,000	2,677,000	122									
McPherson	25,300	23,700	3,845,000	162									
Marion	26,100	22,700	2,055,000	91	900	800	120,000	150	25,200	21,900	1,935,000	88	
Marshall	73,800	71,200	9,792,000	138									
Miami	15,600	14,800	1,541,000	104									
Mitchell	9,200	8,400	1,090,000	130	3,000	2,900	500,000	172	6,200	5,500	590,000	107	
Morton	21,500	20,000	3,335,000	167									
Nehama	82,800	78,800	9,787,000	124									
Ness	7,400	6,900	540,000	78									
Osage	29,500	29,000	3,010,000	104									
Osborne	9,100	8,600	1,072,000	125									
Ottawa	2,600	2,000	293,000	147	1,100	1,100	184,000	167	1,500	900	109,000	121	
Pawnee	41,200	39,500	6,590,000	167									
Pottawatomie	32,800	30,500	4,655,000	153									

County	Acres Planted	Grain - Acres Harvested	Grain - Production bu	Grain - Yield bu/acre	Irrigated Acres Planted	Grain - Irrigated Acres Harvested	Grain - Irrigated Production	Grain - Irrigated Yield	Non-irrigated Acres Planted	Grain - Non-irrigated Acres Harvested	Grain - Non-irrigated Production bu	Grain - Non-irrigated Yield bu/acre	Silage - Acres Harvested
Pratt	65,800	64,700	9,370,000	145									
Republic	60,100	58,900	9,650,000	164									
Rice	31,600	30,800	4,145,000	135									
Rooks	7,700	6,800	700,000	103	500	400	70,000	175	7,200	6,400	630,000	98	
Saline	2,900	2,400	300,000	125	800	700	120,000	171	2,100	1,700	180,000	106	
Sedgwick	36,800	35,100	4,590,000	131									
Sheridan	126,000	123,300	15,571,000	126									
Sherman	115,500	108,900	14,125,000	130									
Stafford	71,600	69,100	9,320,000	135									
Sumner	21,500	20,000	1,720,000	86									
Thomas	152,500	148,700	16,708,000	112									
Washington	40,900	37,200	4,527,000	122	6,200	6,100	1,045,000	171	34,700	31,100	3,482,000	112	
Wichita	47,400	35,500	5,085,000	143									
Woodson	11,600	11,600	1,382,000	119									
Others (9 counties)	1,788,100	1,668,500	224,045,000	134	1,503,500	1,458,100	269,621,000	185	1,065,400	945,500	65,222,000	69	33,300
Totals	3,173,700	2,979,600	397,008,000	133	1,516,000	1,470,100	271,660,000	185	1,142,300	1,013,000	72,148,000	71	35,300

Nebraska

County	Acres Planted	Grain - Acres Harvested	Grain - Production bu	Grain - Yield bu/acre	Irrigated Acres Planted	Grain - Irrigated Acres Harvested	Grain - Irrigated Production	Grain - Irrigated Yield	Grain - Non-irrigated Acres Planted	Grain - Non-irrigated Acres Harvested	Grain - Non-irrigated Production bu	Grain - Non-irrigated Yield bu/acre	Silage - Acres Harvested	Silage, Irrigated - Acres Harvested	Silage, Non-Irrigated - Acres Harvested
Adams	174,000	172,300	31,229,000	181	150,000	149,100	28,329,000	190	24,000	23,200	2,900,000	125			
Antelope	185,000	180,000	31,630,400	176	150,000	146,200	28,216,600	193	35,000	33,800	3,413,800	101			
Banner	10,700	9,900	1,030,500	104	6,300	6,000	816,000	136	4,400	3,900	214,500	55			
Boone	163,000	155,000	26,385,400	170	114,000	107,300	19,850,500	185	49,000	47,700	6,534,900	137			
BoxButte	51,400	47,600	6,671,700	140	48,000	44,500	6,541,500	147	3,400	3,100	130,200	42			
Boyd	26,500	23,700	2,884,300	122	3,500	3,500	682,500	195	23,000	20,200	2,201,800	109			
Brown	40,000	37,300	6,961,500	187								111			
Buffalo	202,000	197,200	34,101,200	173	176,000	172,000	31,304,000	182	26,000	25,200	2,797,200				
Burt	123,000	121,700	19,377,700	159	35,000	34,600	6,574,000	190	88,000	87,100	12,803,700	147			
Butler	138,000	136,300	21,839,500	160	70,000	68,900	12,470,900	181	68,000	67,400	9,368,600	139			
Cass	113,000	112,000	16,089,800	144											
Cedar	170,000	162,000	25,752,000	159	66,000	64,700	12,616,500	195	104,000	97,300	13,135,500	135			
Chase	166,000	163,000	28,628,500	176	139,000	137,500	26,537,500	193	27,000	25,500	2,091,000	82			
Cherry	20,500	17,700	3,356,100	190											
Cheyenne	31,600	28,700	4,011,500	140	26,300	23,900	3,752,300	157	5,300	4,800	259,200	54			
Clay	164,000	160,100	30,473,900	190	133,000	129,300	25,730,700	199	31,000	30,800	4,743,200	154			
Colfax	102,000	97,900	15,354,800	157	42,000	40,100	7,378,400	184	60,000	57,800	7,976,400	138			
Cuming	156,000	150,000	24,061,900	160	34,000	32,300	6,524,600	202	122,000	117,700	17,537,300	149			
Custer	247,000	236,600	38,662,000	163	188,000	180,200	32,796,400	182	59,000	56,400	5,865,600	104			
Dakota	58,000	57,400	9,856,700	172											
Dawson	205,000	200,100	35,367,000	177	194,000	189,600	34,128,000	180	11,000	10,500	1,239,000	118			
Deuel	18,200	17,400	2,463,600	142											
Dixon	103,000	101,200	16,397,500	162											
Dodge	135,000	131,800	20,536,500	156	61,000	59,900	10,542,400	176	74,000	71,900	9,994,100	139			
Douglas	25,000	19,700	2,612,700	133											
Dundy	98,000	94,000	14,340,000	153	68,000	66,500	12,635,000	190	30,000	27,500	1,705,000	62			
Fillmore	183,000	181,700	32,786,500	180	141,000	140,000	26,740,000	191	42,000	41,700	6,046,500	145			
Franklin	78,000	77,200	13,349,600	173	55,000	54,600	10,592,400	194	23,000	22,600	2,757,200	122			
Frontier	88,000	86,100	11,722,000	136	42,000	40,700	7,000,400	172	46,000	45,400	4,721,600	104			
Furnas	100,000	98,700	12,971,100	131	31,800	32,000	5,946,600	187	68,000	66,900	7,024,500	105			
Gage	140,000	138,000	19,414,600	141	33,000	32,600	5,607,200	172	107,000	105,400	13,807,400	131			
Garden	25,000	24,500	3,785,700	155											
Garfield	11,500	9,600	1,640,000	171	10,300	8,600	1,548,000	180	1,200	1,000	92,000	92			
Gosper	84,000	82,800	13,283,300	160	56,000	55,300	10,285,800	186	28,000	27,500	2,997,500	109			
Greeley	70,000	68,400	11,742,400	172	57,000	56,000	10,304,000	184	13,000	12,400	1,438,400	116			
Hall	191,000	186,500	31,911,800	171	178,000	174,200	30,485,000	175	13,000	12,300	1,426,800	116			
Hamilton	200,000	198,700	38,116,200	192	184,000	183,000	35,839,700	196	16,000	15,700	2,276,500	145			
Harlan	91,000	89,400	14,291,100	160	49,000	48,700	9,447,800	194	42,000	40,700	4,843,300	119			
Hayes	70,000	68,300	10,784,500	158	45,000	44,100	8,775,900	199	25,000	24,200	2,008,600	83			

County	Acres Planted	Grain - Acres Harvested	Grain - Production bu	Grain - Yield bu/acre	Irrigated Acres Planted	Grain - Irrigated Acres Harvested	Grain - Irrigated Production	Grain - Irrigated Yield	Grain - Non-irrigated Acres Planted	Grain - Non-irrigated Acres Harvested	Grain - Non-irrigated Production bu	Grain - Non-irrigated Yield bu/acre	Silage - Acres Harvested	Silage, Irrigated - Acres Harvested	Silage, Non-Irrigated - Acres Harvested
Hitchcock	56,000	54,600	5,602,800	103	17,000	16,800	3,108,000	185	39,000	37,800	2,494,800	66			
Holt	173,500	166,600	30,595,600	184	164,000	159,200	29,929,600	188	9,500	7,400	666,000	90			
Howard	101,000	99,400	16,282,800	164	84,000	82,800	14,490,000	175	17,000	16,600	1,792,800	108			
Jefferson	89,000	87,300	14,096,600	161	43,000	42,500	7,735,000	182	46,000	44,800	6,361,600	142			
Johnson	40,000	39,600	5,137,200	130	8,000	8,000	1,440,000	180	32,000	31,600	3,697,200	117			
Kearney	162,000	157,200	28,607,600	182	142,000	137,500	25,987,500	189	20,000	19,700	2,620,100	133			
Keith	98,000	96,900	15,291,600	158	70,000	69,300	13,028,400	188	28,000	27,600	2,263,200	82			
Keya Paya	12,500	10,500	1,591,200	152	9,500	8,600	1,462,000	170	3,000	1,900	129,200	68			
Knox	128,000	122,100	16,502,400	135	38,000	37,200	6,993,600	188	90,000	84,900	9,508,800	112			
Lancaster	119,000	117600	16,460,800	140	9,000	8,500	1,445,000	170	110,000	108,800	15,015,800	138			
Lincoln	206,000	197,800	32,885,800	166	172,000	165,400	29,937,400	181	34,000	32,400	2,948,400	91			
Logan	24,000	23,600	3,674,700	156	16,600	16,300	2,966,600	182	7,400	7,300	708,100	97			
Loup	8,500	7,500	1,274,300	170											
Madison	128,000	122,700	18,402,900	150	63,000	61,300	10,482,300	171	65,000	61,400	7,920,600	129			
Merrick	134,000	131,800	20,244,600	154	126,000	124,800	19,593,600	157	8,000	7,000	651,000	93			
Morrill	65,000	61,500	9,764,800	159											
Nance	80,000	78,200	12,940,600	165	47,000	46,400	8,584,000	185	33,000	31,800	4,356,600	137			
Nehama	74,000	67,300	9,579,000	142	6,000	5,400	1,036,800	192	68,000	61,900	8,542,200	138			
Nuckolls	89,000	88,200	14,494,200	164	35,000	34,800	6,751,200	194	54,000	53,400	7,743,000	145			
Otoe	114,000	113,000	14,818,700	131	4,000	3,900	635,700	163	110,000	109,100	14,183,000	130			
Pawnee	39,000	38,400	5,058,600	132	3,000	3,000	492,000	164	36,000	35,400	4,566,600	129			
Perkins	188,000	186,700	27,548,000	148	108,000	107,400	20,728,200	193	80,000	79,300	6,819,800	86			
Phelps	174,000	169,600	33,721,000	199	163,000	158,900	32,415,600	204	11,000	10,700	1,305,400	122			
Pierce	130,000	126,500	21,690,300	171	76,000	74,400	14,656,800	197	54,000	52,100	7,033,500	135			
Platte	192,000	186,800	32,901,000	176	126,000	122,200	23,340,200	191	66,000	64,600	9,560,800	148			
Polk	130,000	125,900	20,042,800	159	104,000	100,700	16,514,800	164	26,000	25,200	3,528,000	140			
Red Willow	80,000	78,100	10,841,500	139	34,000	33,300	6,227,100	187	46,000	44,800	4,614,400	103			
Richardson	93,000	91,600	12,870,400	141	3,000	2,900	452,400	156	90,000	88,700	12,418,000	140			
Rock	26,000	25,000	4,745,400	190											
Saline	121,000	120,600	19,397,200	161	58,000	57,800	10,982,000	190	63,000	62,800	8,415,200	134			
Sarpy	32,000	31,300	4,715,700	151	4,000	4,000	648,000	162	28,000	27,300	4,067,700	149			
Saunders	162,000	148,700	22,141,000	149	52,000	44,600	7,983,400	179	110,000	104,100	14,157,600	136			
Scotts Bluff	88,000	84,800	12,710,100	150											
Seward	137,000	135,600	21,968,100	162	79,000	78,100	13,745,600	176	58,000	57,500	8,222,500	143			
Sheridan	34,400	30,300	4,670,200	154											
Sherman	77,000	75,400	12,796,300	170	60,000	58,900	11,014,300	187	17,000	16,500	1,782,000	108			
Sioux	15,200	12,000	1,812,000	151											
Stanton	85,000	82,600	11,786,600	143	21,000	20,200	3,737,000	185	64,000	62,400	8,049,600	129			
Thayer	129,000	128,200	22,945,600	179	88,000	87,800	17,208,800	196	41,000	40,400	5,736,800	142			
Thurston	89,000	87,600	14,239,900	163											

County	Acres Planted	Grain - Acres Harvested	Grain - Production bu	Grain - Yield bu/acre	Irrigated Acres Planted	Grain - Irrigated Acres Harvested	Grain - Irrigated Production	Grain - Irrigated Yield	Grain - Non-irrigated Acres Planted	Grain - Non-irrigated Acres Harvested	Grain - Non-irrigated Production bu	Grain - Non-irrigated Yield bu/acre	Silage - Acres Harvested	Silage, Irrigated - Acres Harvested	Silage, Non-Irrigated - Acres Harvested
Valley	72,000	69,500	11,882,900	171	63,000	61,300	10,972,700	179	9,000	8,200	910,200	111			
Washington	82,000	80,600	12,403,100	154	10,000	9,300	1,636,800	176	72,000	71,300	10,766,300	151			
Wayne	122,000	117,200	19,613,800	167	27,000	26,100	5,220,000	200	95,000	91,100	14,393,800	158			
Webster	72,000	70,300	11,153,600	159	33,000	32,100	6,034,800	188	39,000	38,200	5,118,800	134			
Wheeler	34,000	31,500	4,764,000	151	31,000	29,000	4,524,000	156	3,000	2,500	240,000	96			
Other (8 Counties)	33,500	29,200	3,937,600	135	411,000	372,100	62,777,200	169	363,800	363,000	51,900,700	143	160,000	24,000	13,500
Totals	8,596,000	8,347,900	1,356,479,400	162	5,194,300	5,038,700	926,918,000	184	3,414,000	3,319,100	429,561,400	129	160,000	24,000	13,500

Exhibit 2. Daily Precipitation Data for the Growing Season (April 1through September 30), Sheridan County, Kansas, Every Fifth Year 1972 to 2012

Data are available for all days October 1, 1971 through September 30, 2012 upon request.

Date	Precipitation	Date	Precipitation	Date	Precipitation	Date	Precipitation	Date	Precipitation
4/1/1972	0.00	5/12/1972	0.46	6/22/1972	0.03	8/2/1972	0.00	9/12/1972	0.00
4/2/1972	0.00	5/13/1972	0.13	6/23/1972	0.00	8/3/1972	1.38	9/13/1972	0.00
4/3/1972	0.00	5/14/1972	0.00	6/24/1972	0.00	8/4/1972	0.04	9/14/1972	0.00
4/4/1972	0.00	5/15/1972	0.00	6/25/1972	0.00	8/5/1972	0.00	9/15/1972	0.00
4/5/1972	0.00	5/16/1972	0.00	6/26/1972	0.83	8/6/1972	0.00	9/16/1972	0.00
4/6/1972	0.00	5/17/1972	0.00	6/27/1972	0.13	8/7/1972	0.00	9/17/1972	0.00
4/7/1972	0.00	5/18/1972	0.00	6/28/1972	0.26	8/8/1972	0.00	9/18/1972	0.00
4/8/1972	0.00	5/19/1972	0.00	6/29/1972	0.00	8/9/1972	0.00	9/19/1972	0.00
4/9/1972	0.00	5/20/1972	0.00	6/30/1972	0.00	8/10/1972	0.00	9/20/1972	0.95
4/10/1972	0.00	5/21/1972	0.00	7/1/1972	0.00	8/11/1972	0.00	9/21/1972	0.15
4/11/1972	0.01	5/22/1972	0.00	7/2/1972	0.00	8/12/1972	0.00	9/22/1972	0.00
4/12/1972	0.00	5/23/1972	0.16	7/3/1972	0.12	8/13/1972	0.00	9/23/1972	0.00
4/13/1972	0.00	5/24/1972	0.00	7/4/1972	0.18	8/14/1972	0.00	9/24/1972	0.00
4/14/1972	0.00	5/25/1972	0.60	7/5/1972	0.00	8/15/1972	0.00	9/25/1972	0.00
4/15/1972	0.00	5/26/1972	0.00	7/6/1972	0.00	8/16/1972	0.00	9/26/1972	0.00
4/16/1972	0.47	5/27/1972	0.58	7/7/1972	0.57	8/17/1972	0.00	9/27/1972	0.00
4/17/1972	0.00	5/28/1972	0.39	7/8/1972	0.00	8/18/1972	0.00	9/28/1972	0.00
4/18/1972	0.00	5/29/1972	0.02	7/9/1972	0.00	8/19/1972	0.00	9/29/1972	0.00
4/19/1972	0.00	5/30/1972	0.00	7/10/1972	0.00	8/20/1972	0.00	9/30/1972	0.00
4/20/1972	0.01	5/31/1972	0.00	7/11/1972	0.01	8/21/1972	0.00	4/1/1977	0.00
4/21/1972	0.02	6/1/1972	0.00	7/12/1972	0.00	8/22/1972	0.12	4/2/1977	0.12
4/22/1972	0.00	6/2/1972	0.00	7/13/1972	0.00	8/23/1972	0.00	4/3/1977	0.00
4/23/1972	0.00	6/3/1972	0.00	7/14/1972	0.00	8/24/1972	0.00	4/4/1977	0.38
4/24/1972	0.00	6/4/1972	0.00	7/15/1972	0.33	8/25/1972	0.91	4/5/1977	0.00
4/25/1972	0.00	6/5/1972	0.00	7/16/1972	0.03	8/26/1972	0.00	4/6/1977	0.00
4/26/1972	1.28	6/6/1972	0.00	7/17/1972	0.00	8/27/1972	0.00	4/7/1977	0.00
4/27/1972	0.13	6/7/1972	0.00	7/18/1972	0.00	8/28/1972	0.00	4/8/1977	0.00
4/28/1972	0.00	6/8/1972	0.00	7/19/1972	0.00	8/29/1972	0.00	4/9/1977	0.00
4/29/1972	0.01	6/9/1972	0.00	7/20/1972	0.00	8/30/1972	0.11	4/10/1977	0.00
4/30/1972	0.00	6/10/1972	0.00	7/21/1972	0.15	8/31/1972	0.00	4/11/1977	0.00
5/1/1972	0.32	6/11/1972	1.15	7/22/1972	0.00	9/1/1972	0.09	4/12/1977	0.07
5/2/1972	0.00	6/12/1972	0.00	7/23/1972	0.00	9/2/1972	0.64	4/13/1977	0.36
5/3/1972	0.00	6/13/1972	0.00	7/24/1972	0.00	9/3/1972	0.00	4/14/1977	0.00
5/4/1972	0.00	6/14/1972	0.05	7/25/1972	0.55	9/4/1972	0.02	4/15/1977	0.09
5/5/1972	0.00	6/15/1972	0.00	7/26/1972	0.25	9/5/1972	0.00	4/16/1977	0.28
5/6/1972	0.67	6/16/1972	0.00	7/27/1972	2.32	9/6/1972	0.00	4/17/1977	0.00
5/7/1972	0.01	6/17/1972	0.00	7/28/1972	0.46	9/7/1972	0.00	4/18/1977	0.29
5/8/1972	0.00	6/18/1972	0.38	7/29/1972	0.00	9/8/1972	0.00	4/19/1977	0.00
5/9/1972	0.00	6/19/1972	0.00	7/30/1972	0.00	9/9/1972	0.00	4/20/1977	0.86
5/10/1972	0.29	6/20/1972	0.00	7/31/1972	0.00	9/10/1972	0.00	4/21/1977	0.12
5/11/1972	0.36	6/21/1972	0.15	8/1/1972	0.80	9/11/1972	0.00	4/22/1977	0.00

Date	Precipitation	Date	Precipitation	Date	Precipitation	Date	Precipitation	Date	Precipitation
4/23/1977	0.00	6/3/1977	0.62	7/14/1977	0.00	8/24/1977	0.01	4/4/1982	0.00
4/24/1977	0.00	6/4/1977	0.00	7/15/1977	0.46	8/25/1977	0.24	4/5/1982	0.00
4/25/1977	0.00	6/5/1977	0.00	7/16/1977	0.00	8/26/1977	0.00	4/6/1982	0.00
4/26/1977	0.00	6/6/1977	0.01	7/17/1977	0.00	8/27/1977	0.00	4/7/1982	0.01
4/27/1977	0.00	6/7/1977	0.00	7/18/1977	0.00	8/28/1977	0.00	4/8/1982	0.00
4/28/1977	0.01	6/8/1977	0.00	7/19/1977	0.00	8/29/1977	0.00	4/9/1982	0.00
4/29/1977	0.00	6/9/1977	0.00	7/20/1977	0.00	8/30/1977	0.00	4/10/1982	0.00
4/30/1977	0.31	6/10/1977	0.00	7/21/1977	0.25	8/31/1977	0.01	4/11/1982	0.00
5/1/1977	0.00	6/11/1977	0.00	7/22/1977	0.19	9/1/1977	0.00	4/12/1982	0.00
5/2/1977	0.01	6/12/1977	0.64	7/23/1977	0.00	9/2/1977	0.04	4/13/1982	0.00
5/3/1977	0.00	6/13/1977	0.73	7/24/1977	0.00	9/3/1977	0.00	4/14/1982	0.00
5/4/1977	0.00	6/14/1977	0.42	7/25/1977	0.50	9/4/1977	0.00	4/15/1982	0.00
5/5/1977	0.00	6/15/1977	0.00	7/26/1977	0.91	9/5/1977	0.00	4/16/1982	0.00
5/6/1977	0.00	6/16/1977	0.00	7/27/1977	0.14	9/6/1977	0.00	4/17/1982	0.23
5/7/1977	0.00	6/17/1977	0.00	7/28/1977	0.00	9/7/1977	0.00	4/18/1982	0.00
5/8/1977	0.00	6/18/1977	0.00	7/29/1977	0.00	9/8/1977	0.00	4/19/1982	0.00
5/9/1977	0.00	6/19/1977	0.01	7/30/1977	0.00	9/9/1977	0.00	4/20/1982	0.00
5/10/1977	0.01	6/20/1977	0.59	7/31/1977	0.00	9/10/1977	0.00	4/21/1982	0.00
5/11/1977	0.00	6/21/1977	0.12	8/1/1977	0.00	9/11/1977	0.00	4/22/1982	0.00
5/12/1977	0.00	6/22/1977	0.40	8/2/1977	0.27	9/12/1977	0.04	4/23/1982	0.00
5/13/1977	0.00	6/23/1977	0.00	8/3/1977	0.00	9/13/1977	0.00	4/24/1982	0.00
5/14/1977	0.00	6/24/1977	0.00	8/4/1977	0.08	9/14/1977	0.00	4/25/1982	0.00
5/15/1977	1.96	6/25/1977	0.28	8/5/1977	0.09	9/15/1977	0.00	4/26/1982	0.00
5/16/1977	0.00	6/26/1977	0.00	8/6/1977	0.03	9/16/1977	0.00	4/27/1982	0.14
5/17/1977	0.06	6/27/1977	0.00	8/7/1977	0.01	9/17/1977	0.00	4/28/1982	1.46
5/18/1977	0.00	6/28/1977	0.00	8/8/1977	0.00	9/18/1977	0.00	4/29/1982	0.00
5/19/1977	0.81	6/29/1977	0.00	8/9/1977	0.00	9/19/1977	0.00	4/30/1982	0.00
5/20/1977	0.00	6/30/1977	0.00	8/10/1977	0.00	9/20/1977	0.00	5/1/1982	0.00
5/21/1977	0.58	7/1/1977	0.00	8/11/1977	0.58	9/21/1977	0.00	5/2/1982	0.00
5/22/1977	0.76	7/2/1977	0.00	8/12/1977	0.00	9/22/1977	0.00	5/3/1982	0.00
5/23/1977	0.00	7/3/1977	0.00	8/13/1977	0.00	9/23/1977	0.00	5/4/1982	0.00
5/24/1977	0.00	7/4/1977	0.00	8/14/1977	0.39	9/24/1977	0.00	5/5/1982	0.14
5/25/1977	1.20	7/5/1977	0.00	8/15/1977	0.03	9/25/1977	0.00	5/6/1982	0.29
5/26/1977	0.65	7/6/1977	0.00	8/16/1977	0.11	9/26/1977	0.00	5/7/1982	0.00
5/27/1977	0.22	7/7/1977	0.00	8/17/1977	0.15	9/27/1977	0.00	5/8/1982	0.00
5/28/1977	0.00	7/8/1977	0.00	8/18/1977	0.00	9/28/1977	0.00	5/9/1982	0.00
5/29/1977	0.45	7/9/1977	0.00	8/19/1977	0.00	9/29/1977	0.39	5/10/1982	0.01
5/30/1977	0.00	7/10/1977	0.41	8/20/1977	0.00	9/30/1977	0.00	5/11/1982	0.00
5/31/1977	0.02	7/11/1977	0.00	8/21/1977	0.03	4/1/1982	0.00	5/12/1982	0.01
6/1/1977	0.00	7/12/1977	0.00	8/22/1977	0.00	4/2/1982	0.00	5/13/1982	0.25
6/2/1977	0.00	7/13/1977	0.00	8/23/1977	0.31	4/3/1982	0.04	5/14/1982	1.00

Date	Precipitation	Date	Precipitation	Date	Precipitation	Date	Precipitation	Date	Precipitation
5/15/1982	0.00	6/25/1982	0.05	8/5/1982	0.00	9/15/1982	0.00	4/26/1987	0.00
5/16/1982	0.00	6/26/1982	0.50	8/6/1982	0.00	9/16/1982	0.00	4/27/1987	0.00
5/17/1982	0.00	6/27/1982	0.44	8/7/1982	0.00	9/17/1982	0.00	4/28/1987	0.00
5/18/1982	0.00	6/28/1982	0.00	8/8/1982	0.00	9/18/1982	0.00	4/29/1987	0.00
5/19/1982	0.00	6/29/1982	0.00	8/9/1982	0.00	9/19/1982	0.00	4/30/1987	0.00
5/20/1982	0.00	6/30/1982	0.12	8/10/1982	0.33	9/20/1982	0.00	5/1/1987	0.00
5/21/1982	0.18	7/1/1982	0.60	8/11/1982	0.01	9/21/1982	0.00	5/2/1987	0.00
5/22/1982	0.00	7/2/1982	0.00	8/12/1982	0.00	9/22/1982	0.00	5/3/1987	0.11
5/23/1982	0.00	7/3/1982	0.00	8/13/1982	0.00	9/23/1982	0.00	5/4/1987	0.27
5/24/1982	0.02	7/4/1982	0.00	8/14/1982	0.00	9/24/1982	0.00	5/5/1987	0.30
5/25/1982	0.77	7/5/1982	0.00	8/15/1982	0.00	9/25/1982	0.00	5/6/1987	0.09
5/26/1982	0.25	7/6/1982	0.00	8/16/1982	0.00	9/26/1982	0.00	5/7/1987	0.00
5/27/1982	0.18	7/7/1982	0.00	8/17/1982	0.00	9/27/1982	0.00	5/8/1987	0.00
5/28/1982	0.17	7/8/1982	0.00	8/18/1982	0.00	9/28/1982	0.00	5/9/1987	0.00
5/29/1982	0.96	7/9/1982	0.12	8/19/1982	0.00	9/29/1982	0.00	5/10/1987	0.00
5/30/1982	0.50	7/10/1982	0.52	8/20/1982	0.00	9/30/1982	0.00	5/11/1987	0.00
5/31/1982	0.19	7/11/1982	0.00	8/21/1982	0.08	4/1/1987	0.00	5/12/1987	0.00
6/1/1982	0.00	7/12/1982	0.01	8/22/1982	0.00	4/2/1987	0.00	5/13/1987	0.05
6/2/1982	0.47	7/13/1982	0.00	8/23/1982	0.07	4/3/1987	0.00	5/14/1987	0.00
6/3/1982	0.07	7/14/1982	0.00	8/24/1982	0.00	4/4/1987	0.00	5/15/1987	0.00
6/4/1982	0.17	7/15/1982	0.40	8/25/1982	0.00	4/5/1987	0.00	5/16/1987	0.00
6/5/1982	0.00	7/16/1982	0.00	8/26/1982	0.00	4/6/1987	0.00	5/17/1987	0.00
6/6/1982	0.00	7/17/1982	0.00	8/27/1982	0.00	4/7/1987	0.00	5/18/1987	0.05
6/7/1982	0.01	7/18/1982	0.00	8/28/1982	0.00	4/8/1987	0.00	5/19/1987	0.28
6/8/1982	0.00	7/19/1982	0.00	8/29/1982	0.00	4/9/1987	0.00	5/20/1987	0.01
6/9/1982	0.05	7/20/1982	0.00	8/30/1982	0.00	4/10/1987	0.00	5/21/1987	0.81
6/10/1982	0.00	7/21/1982	0.00	8/31/1982	2.07	4/11/1987	0.00	5/22/1987	0.00
6/11/1982	0.08	7/22/1982	0.00	9/1/1982	0.15	4/12/1987	0.00	5/23/1987	0.00
6/12/1982	0.09	7/23/1982	0.00	9/2/1982	0.00	4/13/1987	0.58	5/24/1987	0.12
6/13/1982	0.49	7/24/1982	0.00	9/3/1982	0.00	4/14/1987	0.86	5/25/1987	0.02
6/14/1982	0.00	7/25/1982	0.00	9/4/1982	0.00	4/15/1987	0.00	5/26/1987	0.03
6/15/1982	0.18	7/26/1982	0.00	9/5/1982	0.00	4/16/1987	0.00	5/27/1987	0.00
6/16/1982	0.05	7/27/1982	0.69	9/6/1982	0.00	4/17/1987	0.00	5/28/1987	0.00
6/17/1982	0.00	7/28/1982	0.00	9/7/1982	0.00	4/18/1987	0.00	5/29/1987	0.00
6/18/1982	0.23	7/29/1982	0.00	9/8/1982	0.00	4/19/1987	0.00	5/30/1987	0.00
6/19/1982	0.02	7/30/1982	0.24	9/9/1982	0.15	4/20/1987	0.00	5/31/1987	0.00
6/20/1982	0.00	7/31/1982	0.00	9/10/1982	0.00	4/21/1987	0.00	6/1/1987	0.00
6/21/1982	0.00	8/1/1982	0.00	9/11/1982	0.00	4/22/1987	0.00	6/2/1987	0.00
6/22/1982	0.16	8/2/1982	0.00	9/12/1982	0.33	4/23/1987	0.00	6/3/1987	0.00
6/23/1982	0.00	8/3/1982	0.00	9/13/1982	0.20	4/24/1987	0.00	6/4/1987	0.00
6/24/1982	0.00	8/4/1982	0.42	9/14/1982	0.20	4/25/1987	0.00	6/5/1987	0.00

Date	Precipitation	Date	Precipitation	Date	Precipitation	Date	Precipitation	Date	Precipitation
6/6/1987	0.00	7/17/1987	0.00	8/27/1987	0.00	4/7/1992	0.05	5/18/1992	0.00
6/7/1987	0.00	7/18/1987	0.12	8/28/1987	0.00	4/8/1992	0.00	5/19/1992	0.00
6/8/1987	0.00	7/19/1987	0.00	8/29/1987	0.00	4/9/1992	0.00	5/20/1992	0.00
6/9/1987	0.00	7/20/1987	0.00	8/30/1987	0.00	4/10/1992	0.00	5/21/1992	0.00
6/10/1987	0.18	7/21/1987	0.00	8/31/1987	0.00	4/11/1992	0.00	5/22/1992	0.00
6/11/1987	0.55	7/22/1987	0.00	9/1/1987	0.00	4/12/1992	0.00	5/23/1992	0.00
6/12/1987	0.00	7/23/1987	0.00	9/2/1987	0.00	4/13/1992	0.00	5/24/1992	0.00
6/13/1987	0.00	7/24/1987	0.00	9/3/1987	0.00	4/14/1992	0.00	5/25/1992	0.13
6/14/1987	0.00	7/25/1987	0.00	9/4/1987	0.00	4/15/1992	0.38	5/26/1992	0.03
6/15/1987	0.00	7/26/1987	0.00	9/5/1987	0.01	4/16/1992	0.01	5/27/1992	0.25
6/16/1987	0.01	7/27/1987	0.00	9/6/1987	0.00	4/17/1992	0.00	5/28/1992	0.22
6/17/1987	0.10	7/28/1987	0.00	9/7/1987	0.04	4/18/1992	0.00	5/29/1992	0.00
6/18/1987	0.00	7/29/1987	0.00	9/8/1987	0.00	4/19/1992	0.01	5/30/1992	0.00
6/19/1987	0.00	7/30/1987	0.00	9/9/1987	0.00	4/20/1992	0.00	5/31/1992	0.02
6/20/1987	0.00	7/31/1987	0.00	9/10/1987	0.00	4/21/1992	0.00	6/1/1992	0.24
6/21/1987	0.21	8/1/1987	0.00	9/11/1987	0.10	4/22/1992	0.00	6/2/1992	0.12
6/22/1987	0.00	8/2/1987	0.01	9/12/1987	0.00	4/23/1992	0.01	6/3/1992	0.07
6/23/1987	0.00	8/3/1987	0.00	9/13/1987	0.00	4/24/1992	0.00	6/4/1992	0.34
6/24/1987	0.54	8/4/1987	0.00	9/14/1987	0.00	4/25/1992	0.00	6/5/1992	0.65
6/25/1987	0.07	8/5/1987	0.00	9/15/1987	0.00	4/26/1992	0.00	6/6/1992	0.75
6/26/1987	0.00	8/6/1987	0.00	9/16/1987	0.30	4/27/1992	0.00	6/7/1992	0.00
6/27/1987	0.12	8/7/1987	0.25	9/17/1987	0.00	4/28/1992	0.00	6/8/1992	0.15
6/28/1987	0.00	8/8/1987	0.16	9/18/1987	0.11	4/29/1992	0.03	6/9/1992	0.00
6/29/1987	0.53	8/9/1987	0.00	9/19/1987	0.00	4/30/1992	0.00	6/10/1992	0.68
6/30/1987	0.01	8/10/1987	0.00	9/20/1987	0.00	5/1/1992	0.00	6/11/1992	1.02
7/1/1987	0.00	8/11/1987	0.00	9/21/1987	0.00	5/2/1992	0.00	6/12/1992	0.00
7/2/1987	0.60	8/12/1987	0.00	9/22/1987	0.00	5/3/1992	0.00	6/13/1992	0.00
7/3/1987	0.10	8/13/1987	0.76	9/23/1987	0.00	5/4/1992	0.00	6/14/1992	0.00
7/4/1987	1.13	8/14/1987	0.00	9/24/1987	0.00	5/5/1992	0.00	6/15/1992	0.05
7/5/1987	0.00	8/15/1987	0.00	9/25/1987	0.00	5/6/1992	0.00	6/16/1992	0.00
7/6/1987	0.00	8/16/1987	0.00	9/26/1987	0.00	5/7/1992	0.00	6/17/1992	0.00
7/7/1987	0.00	8/17/1987	0.00	9/27/1987	0.00	5/8/1992	0.00	6/18/1992	0.00
7/8/1987	0.76	8/18/1987	0.00	9/28/1987	0.00	5/9/1992	0.00	6/19/1992	0.00
7/9/1987	0.16	8/19/1987	0.00	9/29/1987	0.00	5/10/1992	0.00	6/20/1992	0.00
7/10/1987	0.00	8/20/1987	0.00	9/30/1987	0.00	5/11/1992	0.00	6/21/1992	0.02
7/11/1987	0.00	8/21/1987	0.00	4/1/1992	0.00	5/12/1992	0.00	6/22/1992	0.01
7/12/1987	1.54	8/22/1987	0.00	4/2/1992	0.00	5/13/1992	0.00	6/23/1992	0.00
7/13/1987	0.00	8/23/1987	0.18	4/3/1992	0.00	5/14/1992	0.16	6/24/1992	0.00
7/14/1987	0.00	8/24/1987	0.08	4/4/1992	0.00	5/15/1992	0.00	6/25/1992	0.00
7/15/1987	0.05	8/25/1987	0.07	4/5/1992	0.00	5/16/1992	0.00	6/26/1992	0.14
7/16/1987	0.00	8/26/1987	0.00	4/6/1992	0.00	5/17/1992	0.18	6/27/1992	0.24

Date	Precipitation	Date	Precipitation	Date	Precipitation	Date	Precipitation	Date	Precipitation
6/28/1992	0.12	8/8/1992	0.00	9/18/1992	0.02	4/29/1997	0.00	6/9/1997	0.01
6/29/1992	0.00	8/9/1992	0.00	9/19/1992	0.00	4/30/1997	0.23	6/10/1997	0.00
6/30/1992	0.00	8/10/1992	0.00	9/20/1992	0.15	5/1/1997	0.00	6/11/1997	0.00
7/1/1992	0.00	8/11/1992	0.17	9/21/1992	0.00	5/2/1997	0.20	6/12/1997	0.01
7/2/1992	0.00	8/12/1992	0.82	9/22/1992	0.00	5/3/1997	0.04	6/13/1997	0.01
7/3/1992	0.00	8/13/1992	0.00	9/23/1992	0.00	5/4/1997	0.00	6/14/1997	0.00
7/4/1992	0.00	8/14/1992	0.00	9/24/1992	0.00	5/5/1997	0.00	6/15/1997	0.00
7/5/1992	0.00	8/15/1992	0.00	9/25/1992	0.00	5/6/1997	0.01	6/16/1997	0.00
7/6/1992	0.00	8/16/1992	0.00	9/26/1992	0.05	5/7/1997	0.00	6/17/1997	0.00
7/7/1992	0.00	8/17/1992	0.00	9/27/1992	0.00	5/8/1997	0.00	6/18/1997	0.00
7/8/1992	0.98	8/18/1992	1.90	9/28/1992	0.00	5/9/1997	0.01	6/19/1997	0.05
7/9/1992	1.22	8/19/1992	0.00	9/29/1992	0.00	5/10/1997	0.00	6/20/1997	0.00
7/10/1992	0.00	8/20/1992	0.00	9/30/1992	0.00	5/11/1997	0.00	6/21/1997	0.00
7/11/1992	0.00	8/21/1992	0.00	4/1/1997	0.00	5/12/1997	0.00	6/22/1997	0.01
7/12/1992	1.46	8/22/1992	0.00	4/2/1997	0.01	5/13/1997	0.00	6/23/1997	0.00
7/13/1992	0.67	8/23/1992	0.00	4/3/1997	0.01	5/14/1997	0.00	6/24/1997	0.01
7/14/1992	0.00	8/24/1992	0.00	4/4/1997	0.03	5/15/1997	0.01	6/25/1997	0.67
7/15/1992	0.00	8/25/1992	0.40	4/5/1997	0.01	5/16/1997	0.00	6/26/1997	0.48
7/16/1992	0.41	8/26/1992	0.03	4/6/1997	0.01	5/17/1997	0.00	6/27/1997	0.00
7/17/1992	0.00	8/27/1992	0.00	4/7/1997	0.00	5/18/1997	0.01	6/28/1997	0.00
7/18/1992	0.00	8/28/1992	0.00	4/8/1997	0.00	5/19/1997	0.25	6/29/1997	0.76
7/19/1992	0.00	8/29/1992	0.00	4/9/1997	0.00	5/20/1997	0.01	6/30/1997	0.01
7/20/1992	0.12	8/30/1992	0.00	4/10/1997	0.10	5/21/1997	0.00	7/1/1997	0.00
7/21/1992	0.00	8/31/1992	0.00	4/11/1997	0.22	5/22/1997	0.00	7/2/1997	0.00
7/22/1992	0.03	9/1/1992	1.21	4/12/1997	0.06	5/23/1997	1.27	7/3/1997	0.00
7/23/1992	0.00	9/2/1992	0.00	4/13/1997	0.00	5/24/1997	0.01	7/4/1997	0.00
7/24/1992	0.00	9/3/1992	0.00	4/14/1997	0.00	5/25/1997	0.05	7/5/1997	0.00
7/25/1992	0.09	9/4/1992	0.09	4/15/1997	0.00	5/26/1997	0.08	7/6/1997	0.41
7/26/1992	0.23	9/5/1992	0.00	4/16/1997	0.00	5/27/1997	0.05	7/7/1997	0.22
7/27/1992	0.00	9/6/1992	0.00	4/17/1997	0.00	5/28/1997	0.00	7/8/1997	0.00
7/28/1992	0.00	9/7/1992	0.06	4/18/1997	0.00	5/29/1997	0.00	7/9/1997	0.14
7/29/1992	0.30	9/8/1992	0.03	4/19/1997	0.00	5/30/1997	0.19	7/10/1997	0.01
7/30/1992	0.07	9/9/1992	0.00	4/20/1997	0.00	5/31/1997	0.01	7/11/1997	0.00
7/31/1992	0.00	9/10/1992	0.00	4/21/1997	0.00	6/1/1997	0.00	7/12/1997	0.01
8/1/1992	0.69	9/11/1992	0.00	4/22/1997	0.01	6/2/1997	1.06	7/13/1997	0.00
8/2/1992	0.00	9/12/1992	0.00	4/23/1997	0.00	6/3/1997	0.50	7/14/1997	0.00
8/3/1992	0.92	9/13/1992	0.00	4/24/1997	0.00	6/4/1997	0.04	7/15/1997	0.10
8/4/1992	0.35	9/14/1992	0.00	4/25/1997	0.10	6/5/1997	0.00	7/16/1997	0.00
8/5/1992	2.70	9/15/1992	0.00	4/26/1997	0.09	6/6/1997	0.00	7/17/1997	0.00
8/6/1992	0.00	9/16/1992	0.00	4/27/1997	0.04	6/7/1997	0.00	7/18/1997	0.00
8/7/1992	0.04	9/17/1992	0.00	4/28/1997	0.00	6/8/1997	0.00	7/19/1997	0.00

Date	Precipitation	Date	Precipitation	Date	Precipitation	Date	Precipitation	Date	Precipitation
7/20/1997	0.00	8/30/1997	0.15	4/10/2002	0.00	5/21/2002	0.00	7/1/2002	0.00
7/21/1997	0.00	8/31/1997	0.01	4/11/2002	0.01	5/22/2002	0.00	7/2/2002	0.00
7/22/1997	0.00	9/1/1997	0.01	4/12/2002	0.00	5/23/2002	0.00	7/3/2002	0.00
7/23/1997	0.00	9/2/1997	0.00	4/13/2002	0.00	5/24/2002	0.12	7/4/2002	0.00
7/24/1997	0.00	9/3/1997	0.01	4/14/2002	0.03	5/25/2002	0.64	7/5/2002	0.00
7/25/1997	0.00	9/4/1997	0.01	4/15/2002	0.00	5/26/2002	0.00	7/6/2002	0.11
7/26/1997	0.00	9/5/1997	0.01	4/16/2002	0.00	5/27/2002	0.00	7/7/2002	0.00
7/27/1997	0.00	9/6/1997	0.00	4/17/2002	0.01	5/28/2002	0.00	7/8/2002	0.00
7/28/1997	1.35	9/7/1997	0.01	4/18/2002	0.00	5/29/2002	0.00	7/9/2002	0.00
7/29/1997	0.01	9/8/1997	0.00	4/19/2002	0.00	5/30/2002	0.00	7/10/2002	0.00
7/30/1997	0.68	9/9/1997	0.01	4/20/2002	0.00	5/31/2002	0.00	7/11/2002	0.00
7/31/1997	0.01	9/10/1997	0.01	4/21/2002	0.05	6/1/2002	0.00	7/12/2002	0.00
8/1/1997	0.00	9/11/1997	0.00	4/22/2002	0.01	6/2/2002	0.00	7/13/2002	0.00
8/2/1997	0.00	9/12/1997	0.00	4/23/2002	0.00	6/3/2002	0.00	7/14/2002	0.00
8/3/1997	0.00	9/13/1997	0.00	4/24/2002	0.00	6/4/2002	0.18	7/15/2002	0.00
8/4/1997	0.00	9/14/1997	0.01	4/25/2002	0.00	6/5/2002	0.07	7/16/2002	0.00
8/5/1997	0.01	9/15/1997	0.08	4/26/2002	0.00	6/6/2002	0.01	7/17/2002	0.00
8/6/1997	0.88	9/16/1997	0.00	4/27/2002	0.04	6/7/2002	0.00	7/18/2002	0.00
8/7/1997	0.40	9/17/1997	0.01	4/28/2002	0.03	6/8/2002	0.00	7/19/2002	0.00
8/8/1997	0.00	9/18/1997	0.00	4/29/2002	0.00	6/9/2002	0.00	7/20/2002	0.00
8/9/1997	0.00	9/19/1997	0.00	4/30/2002	0.00	6/10/2002	0.00	7/21/2002	0.00
8/10/1997	0.02	9/20/1997	0.01	5/1/2002	0.00	6/11/2002	0.00	7/22/2002	0.34
8/11/1997	0.57	9/21/1997	0.08	5/2/2002	0.01	6/12/2002	0.00	7/23/2002	0.00
8/12/1997	0.00	9/22/1997	0.19	5/3/2002	0.00	6/13/2002	0.19	7/24/2002	0.00
8/13/1997	0.00	9/23/1997	0.10	5/4/2002	0.00	6/14/2002	0.07	7/25/2002	0.00
8/14/1997	0.01	9/24/1997	0.01	5/5/2002	0.00	6/15/2002	0.00	7/26/2002	0.00
8/15/1997	0.00	9/25/1997	0.01	5/6/2002	0.00	6/16/2002	0.00	7/27/2002	0.00
8/16/1997	0.00	9/26/1997	0.00	5/7/2002	0.01	6/17/2002	0.00	7/28/2002	0.00
8/17/1997	0.96	9/27/1997	0.00	5/8/2002	0.02	6/18/2002	0.00	7/29/2002	0.01
8/18/1997	0.00	9/28/1997	0.00	5/9/2002	0.00	6/19/2002	0.00	7/30/2002	0.00
8/19/1997	0.62	9/29/1997	0.00	5/10/2002	0.00	6/20/2002	0.05	7/31/2002	0.00
8/20/1997	0.00	9/30/1997	0.00	5/11/2002	0.06	6/21/2002	0.00	8/1/2002	0.00
8/21/1997	0.24	4/1/2002	0.00	5/12/2002	0.01	6/22/2002	0.00	8/2/2002	0.00
8/22/1997	0.46	4/2/2002	0.00	5/13/2002	0.01	6/23/2002	0.00	8/3/2002	0.00
8/23/1997	0.00	4/3/2002	0.00	5/14/2002	0.00	6/24/2002	0.00	8/4/2002	0.00
8/24/1997	0.00	4/4/2002	0.00	5/15/2002	0.00	6/25/2002	0.00	8/5/2002	0.08
8/25/1997	0.00	4/5/2002	0.00	5/16/2002	0.32	6/26/2002	0.27	8/6/2002	0.00
8/26/1997	0.00	4/6/2002	0.00	5/17/2002	0.28	6/27/2002	0.01	8/7/2002	0.00
8/27/1997	0.00	4/7/2002	0.00	5/18/2002	0.00	6/28/2002	0.00	8/8/2002	0.00
8/28/1997	0.00	4/8/2002	0.04	5/19/2002	0.00	6/29/2002	0.00	8/9/2002	0.98
8/29/1997	0.07	4/9/2002	0.01	5/20/2002	0.00	6/30/2002	0.00	8/10/2002	0.03

Date	Precipitation	Date	Precipitation	Date	Precipitation	Date	Precipitation	Date	Precipitation
8/11/2002	0.00	9/21/2002	0.00	5/2/2007	0.00	6/12/2007	0.00	7/23/2007	0.00
8/12/2002	0.01	9/22/2002	0.00	5/3/2007	0.00	6/13/2007	0.43	7/24/2007	0.01
8/13/2002	0.62	9/23/2002	0.00	5/4/2007	0.00	6/14/2007	1.15	7/25/2007	0.00
8/14/2002	0.00	9/24/2002	0.00	5/5/2007	0.01	6/15/2007	0.01	7/26/2007	0.00
8/15/2002	0.00	9/25/2002	0.00	5/6/2007	0.01	6/16/2007	0.00	7/27/2007	0.00
8/16/2002	0.00	9/26/2002	0.00	5/7/2007	0.00	6/17/2007	0.00	7/28/2007	0.00
8/17/2002	0.00	9/27/2002	0.00	5/8/2007	0.00	6/18/2007	0.00	7/29/2007	0.41
8/18/2002	0.00	9/28/2002	0.00	5/9/2007	0.00	6/19/2007	0.00	7/30/2007	0.01
8/19/2002	0.00	9/29/2002	0.03	5/10/2007	0.00	6/20/2007	0.17	7/31/2007	0.01
8/20/2002	0.00	9/30/2002	0.00	5/11/2007	0.00	6/21/2007	0.01	8/1/2007	1.04
8/21/2002	0.00	4/1/2007	0.00	5/12/2007	0.00	6/22/2007	0.00	8/2/2007	0.01
8/22/2002	0.01	4/2/2007	0.00	5/13/2007	0.00	6/23/2007	0.00	8/3/2007	0.05
8/23/2002	0.18	4/3/2007	0.00	5/14/2007	0.00	6/24/2007	0.00	8/4/2007	0.00
8/24/2002	0.28	4/4/2007	0.00	5/15/2007	1.06	6/25/2007	0.00	8/5/2007	0.00
8/25/2002	0.00	4/5/2007	0.00	5/16/2007	0.00	6/26/2007	0.00	8/6/2007	0.50
8/26/2002	0.00	4/6/2007	0.03	5/17/2007	0.00	6/27/2007	0.01	8/7/2007	0.02
8/27/2002	0.14	4/7/2007	0.01	5/18/2007	0.00	6/28/2007	0.01	8/8/2007	0.04
8/28/2002	0.04	4/8/2007	0.00	5/19/2007	0.00	6/29/2007	0.00	8/9/2007	0.00
8/29/2002	0.00	4/9/2007	0.01	5/20/2007	0.00	6/30/2007	0.00	8/10/2007	0.00
8/30/2002	0.00	4/10/2007	0.17	5/21/2007	0.00	7/1/2007	0.00	8/11/2007	0.00
8/31/2002	0.00	4/11/2007	0.01	5/22/2007	0.01	7/2/2007	0.00	8/12/2007	0.00
9/1/2002	0.00	4/12/2007	0.01	5/23/2007	0.10	7/3/2007	0.00	8/13/2007	0.00
9/2/2002	0.00	4/13/2007	0.15	5/24/2007	0.05	7/4/2007	0.00	8/14/2007	0.00
9/3/2002	0.00	4/14/2007	0.41	5/25/2007	0.00	7/5/2007	0.00	8/15/2007	0.00
9/4/2002	0.00	4/15/2007	0.01	5/26/2007	0.05	7/6/2007	0.00	8/16/2007	0.00
9/5/2002	0.00	4/16/2007	0.00	5/27/2007	0.00	7/7/2007	0.00	8/17/2007	0.01
9/6/2002	0.00	4/17/2007	0.00	5/28/2007	0.00	7/8/2007	0.00	8/18/2007	0.00
9/7/2002	0.00	4/18/2007	0.00	5/29/2007	0.00	7/9/2007	0.19	8/19/2007	0.00
9/8/2002	0.00	4/19/2007	0.00	5/30/2007	0.84	7/10/2007	0.00	8/20/2007	0.00
9/9/2002	0.00	4/20/2007	0.00	5/31/2007	0.00	7/11/2007	0.18	8/21/2007	0.00
9/10/2002	0.42	4/21/2007	0.01	6/1/2007	0.01	7/12/2007	0.22	8/22/2007	0.04
9/11/2002	0.01	4/22/2007	1.31	6/2/2007	0.01	7/13/2007	0.16	8/23/2007	1.46
9/12/2002	0.00	4/23/2007	0.01	6/3/2007	0.00	7/14/2007	0.02	8/24/2007	0.20
9/13/2002	0.15	4/24/2007	0.10	6/4/2007	0.00	7/15/2007	0.00	8/25/2007	0.42
9/14/2002	0.10	4/25/2007	0.18	6/5/2007	0.00	7/16/2007	0.00	8/26/2007	0.00
9/15/2002	0.00	4/26/2007	0.10	6/6/2007	0.00	7/17/2007	0.00	8/27/2007	0.01
9/16/2002	0.00	4/27/2007	0.14	6/7/2007	0.00	7/18/2007	0.00	8/28/2007	0.00
9/17/2002	0.00	4/28/2007	0.00	6/8/2007	0.00	7/19/2007	0.01	8/29/2007	0.00
9/18/2002	0.00	4/29/2007	0.00	6/9/2007	0.00	7/20/2007	0.00	8/30/2007	0.00
9/19/2002	0.10	4/30/2007	0.00	6/10/2007	0.00	7/21/2007	0.00	8/31/2007	0.00
9/20/2002	0.01	5/1/2007	0.00	6/11/2007	0.00	7/22/2007	0.00	9/1/2007	0.00

Date	Precipitation	Date	Precipitation	Date	Precipitation	Date	Precipitation	Date	Precipitation
9/2/2007	0.00	4/13/2012	0.00	5/24/2012	0.10	7/4/2012	0.00	8/14/2012	0.12
9/3/2007	0.00	4/14/2012	0.00	5/25/2012	0.00	7/5/2012	0.00	8/15/2012	0.00
9/4/2007	0.00	4/15/2012	0.04	5/26/2012	0.00	7/6/2012	0.00	8/16/2012	0.00
9/5/2007	0.00	4/16/2012	0.11	5/27/2012	0.00	7/7/2012	2.80	8/17/2012	0.00
9/6/2007	0.00	4/17/2012	0.00	5/28/2012	0.00	7/8/2012	0.15	8/18/2012	0.00
9/7/2007	0.00	4/18/2012	0.00	5/29/2012	0.00	7/9/2012	0.00	8/19/2012	0.00
9/8/2007	0.01	4/19/2012	0.00	5/30/2012	0.18	7/10/2012	0.00	8/20/2012	0.00
9/9/2007	0.00	4/20/2012	0.05	5/31/2012	0.07	7/11/2012	0.00	8/21/2012	0.00
9/10/2007	0.06	4/21/2012	0.00	6/1/2012	0.00	7/12/2012	0.00	8/22/2012	0.00
9/11/2007	0.29	4/22/2012	0.00	6/2/2012	0.00	7/13/2012	0.00	8/23/2012	0.40
9/12/2007	0.00	4/23/2012	0.00	6/3/2012	0.00	7/14/2012	0.00	8/24/2012	1.80
9/13/2007	0.00	4/24/2012	0.00	6/4/2012	0.00	7/15/2012	0.00	8/25/2012	0.00
9/14/2007	0.00	4/25/2012	0.00	6/5/2012	0.00	7/16/2012	0.00	8/26/2012	0.00
9/15/2007	0.18	4/26/2012	0.02	6/6/2012	0.00	7/17/2012	0.00	8/27/2012	0.00
9/16/2007	0.00	4/27/2012	0.74	6/7/2012	0.00	7/18/2012	0.00	8/28/2012	0.00
9/17/2007	0.00	4/28/2012	0.03	6/8/2012	0.00	7/19/2012	0.00	8/29/2012	0.00
9/18/2007	0.28	4/29/2012	0.00	6/9/2012	0.00	7/20/2012	0.00	8/30/2012	0.00
9/19/2007	0.00	4/30/2012	0.00	6/10/2012	0.00	7/21/2012	0.00	8/31/2012	0.00
9/20/2007	0.01	5/1/2012	0.00	6/11/2012	0.00	7/22/2012	0.00	9/1/2012	0.00
9/21/2007	0.00	5/2/2012	0.00	6/12/2012	0.00	7/23/2012	0.00	9/2/2012	0.00
9/22/2007	0.00	5/3/2012	0.00	6/13/2012	0.00	7/24/2012	0.00	9/3/2012	0.00
9/23/2007	0.00	5/4/2012	0.00	6/14/2012	0.48	7/25/2012	0.00	9/4/2012	0.35
9/24/2007	0.00	5/5/2012	0.00	6/15/2012	0.00	7/26/2012	0.00	9/5/2012	0.00
9/25/2007	0.01	5/6/2012	0.00	6/16/2012	0.30	7/27/2012	0.00	9/6/2012	0.00
9/26/2007	0.00	5/7/2012	0.13	6/17/2012	0.00	7/28/2012	0.00	9/7/2012	0.10
9/27/2007	0.00	5/8/2012	0.13	6/18/2012	0.00	7/29/2012	0.00	9/8/2012	0.00
9/28/2007	0.00	5/9/2012	0.00	6/19/2012	0.00	7/30/2012	0.14	9/9/2012	0.00
9/29/2007	0.11	5/10/2012	0.00	6/20/2012	0.00	7/31/2012	0.00	9/10/2012	0.00
9/30/2007	0.01	5/11/2012	0.00	6/21/2012	0.00	8/1/2012	0.15	9/11/2012	0.00
4/1/2012	0.00	5/12/2012	0.00	6/22/2012	0.00	8/2/2012	0.00	9/12/2012	0.49
4/2/2012	0.57	5/13/2012	0.00	6/23/2012	0.00	8/3/2012	0.00	9/13/2012	0.00
4/3/2012	1.57	5/14/2012	0.00	6/24/2012	0.00	8/4/2012	0.00	9/14/2012	0.00
4/4/2012	0.49	5/15/2012	0.00	6/25/2012	0.00	8/5/2012	0.00	9/15/2012	0.00
4/5/2012	0.03	5/16/2012	0.00	6/26/2012	0.00	8/6/2012	0.00	9/16/2012	0.00
4/6/2012	0.00	5/17/2012	0.00	6/27/2012	0.00	8/7/2012	0.00	9/17/2012	0.00
4/7/2012	0.00	5/18/2012	0.00	6/28/2012	0.17	8/8/2012	0.00	9/18/2012	0.00
4/8/2012	0.00	5/19/2012	0.06	6/29/2012	0.00	8/9/2012	0.00	9/19/2012	0.00
4/9/2012	0.00	5/20/2012	0.00	6/30/2012	0.24	8/10/2012	0.00	9/20/2012	0.00
4/10/2012	0.00	5/21/2012	0.00	7/1/2012	0.00	8/11/2012	0.00	9/21/2012	0.00
4/11/2012	0.00	5/22/2012	0.00	7/2/2012	0.00	8/12/2012	0.00	9/22/2012	0.00
4/12/2012	0.06	5/23/2012	0.00	7/3/2012	0.00	8/13/2012	0.00	9/23/2012	0.00

Date	Precipitation
9/24/2012	0.00
9/25/2012	0.00
9/26/2012	0.00
9/27/2012	0.00
9/28/2012	0.00
9/29/2012	0.00
9/30/2012	0.00

Exhibit 3a. Cumulative Precipitation Metadata for Five Study Area Counties, Crop Years 1951 through 2012

County		Cumulative Precipitation (inches)		
		Growing Season	Prior to Growing Season	Total Precipitation
Kit Carson County, Colorado	Average	12.53	3.37	15.90
	Standard Deviation	3.04	1.41	3.48
	Low	6.28	1.03	8.95
	High	20.16	6.78	24.35
Sheridan County, Kansas	Average	15.88	5.19	21.07
	Standard Deviation	4.71	2.33	5.17
	Low	5.92	1.37	8.16
	High	28.77	10.57	37.67
Washington County, Kansas	Average	23.33	8.42	31.74
	Standard Deviation	6.53	3.37	8.37
	Low	10.81	2.84	15.10
	High	43.20	19.45	57.62
Butler County, Nebraska	Average	10.58	18.44	29.02
	Standard Deviation	5.53	6.04	6.31
	Low	3.75	4.50	16.27
	High	26.26	32.00	44.70
Perkins County, Nebraska	Average	16.11	4.64	20.75
	Standard Deviation	4.96	1.65	5.38
	Low	8.09	1.78	11.32
	High	32.27	9.19	35.29

Exhibit 3b. Annual Crop Year Precipitation for Five Study Area Counties, Crop Years 1951 through 2012

Year	Kit Carson County, Colorado			Sheridan County, Kansas			Washington County, Kansas			Perkins County, Nebraska			Butler County, Nebraska		
	Apr. 1 to Sept. 30	Oct. 1 to Sept. 30	Oct. 1 to Mar. 31	Apr. 1 to Sept. 30	Oct. 1 to Sept. 30	Oct. 1 to Mar. 31	Apr. 1 to Sept. 30	Oct. 1 to Sept. 30	Oct. 1 to Mar. 31	Apr. 1 to Sept. 30	Oct. 1 to Sept. 30	Oct. 1 to Mar. 31	Apr. 1 to Sept. 30	Oct. 1 to Sept. 30	Oct. 1 to Mar. 31
1951	15.15	16.44	1.28	26.60	29.25	2.65	43.20	53.19	9.99	26.94	29.19	2.25	24.37	33.31	8.94
1952	8.41	12.16	3.76	11.25	14.31	3.06	16.99	25.97	8.98	11.95	17.36	5.41	9.42	21.87	12.45
1953	9.13	11.09	1.96	17.50	20.66	3.16	20.12	26.55	6.43	11.36	14.96	3.60	4.34	26.17	21.83
1954	6.28	10.06	3.78	12.08	17.71	5.63	28.62	35.74	7.12	9.74	15.27	5.53	3.76	16.27	12.51
1955	8.01	10.72	2.71	14.99	18.71	3.72	14.97	19.77	4.80	12.70	16.18	3.48	8.39	19.05	10.67
1956	6.88	9.30	2.42	5.92	8.16	2.24	13.03	15.87	2.84	10.52	12.86	2.34	11.86	38.91	27.06
1957	18.41	22.08	3.67	25.08	29.80	4.72	23.16	28.94	5.78	18.62	24.24	5.62	10.62	27.59	16.98
1958	15.25	18.43	3.18	16.53	23.85	7.32	30.17	37.30	7.13	21.15	27.62	6.47	10.23	35.43	25.21
1959	10.06	12.87	2.81	16.60	21.64	5.04	27.57	31.99	4.42	14.43	19.38	4.95	5.75	27.10	21.35
1960	9.62	14.36	4.74	13.98	22.03	8.05	25.38	36.60	11.22	9.51	16.69	7.18	8.17	25.02	16.85
1961	13.14	18.19	5.05	23.49	28.45	4.96	26.67	32.65	5.98	15.45	19.23	3.78	7.02	29.30	22.28
1962	12.69	15.35	2.66	22.91	29.03	6.12	24.01	34.94	10.93	24.17	27.22	3.05	8.03	28.69	20.66
1963	12.60	15.55	2.95	15.10	20.54	5.44	22.34	30.31	7.97	19.11	22.65	3.54	10.27	28.88	18.61
1964	6.79	8.95	2.16	13.23	15.82	2.59	19.60	24.13	4.53	10.71	14.35	3.64	5.88	37.16	31.28
1965	18.33	20.09	1.76	19.86	23.30	3.44	25.80	33.35	7.55	21.61	23.84	2.23	3.75	19.80	16.05
1966	11.65	13.99	2.34	11.86	18.14	6.28	15.53	18.59	3.06	13.32	18.38	5.06	6.64	34.53	27.90
1967	13.76	14.79	1.03	13.36	15.82	2.46	26.88	30.77	3.89	13.80	15.58	1.78	9.91	33.56	23.65
1968	11.23	13.02	1.79	16.73	18.10	1.37	21.52	25.28	3.76	13.18	15.37	2.19	5.74	23.76	18.03
1969	13.78	15.47	1.69	11.98	16.94	4.96	21.41	33.33	11.92	14.30	17.95	3.65	7.04	24.92	17.88
1970	9.90	14.87	4.97	13.64	20.52	6.88	19.06	24.83	5.77	9.73	14.45	4.72	8.20	27.22	19.02
1971	11.21	14.77	3.55	17.43	20.50	3.07	18.14	25.59	7.45	20.33	25.72	5.39	16.78	40.27	23.49
1972	14.41	16.67	2.26	19.08	23.28	4.20	24.52	33.22	8.70	15.20	18.26	3.06	9.16	37.14	27.98
1973	11.61	18.39	6.78	17.71	26.45	8.74	31.62	51.07	19.45	18.09	22.88	4.79	10.42	23.68	13.26
1974	8.48	12.37	3.88	11.40	16.00	4.60	15.36	25.96	10.60	10.86	15.33	4.47	10.90	24.90	14.01
1975	10.18	12.31	2.13	22.54	26.20	3.66	20.89	28.48	7.59	14.14	17.33	3.19	7.77	18.50	10.73
1976	8.98	11.40	2.42	16.36	20.12	3.76	21.46	30.61	9.15	12.23	15.52	3.29	12.69	40.46	27.77
1977	11.45	14.12	2.68	19.37	23.06	3.69	31.11	36.58	5.47	15.03	21.72	6.69	13.82	33.11	19.29
1978	10.11	11.62	1.51	12.33	15.31	2.98	27.10	34.37	7.27	10.00	12.97	2.97	12.60	24.41	11.81
1979	15.61	19.50	3.89	13.55	20.95	7.40	19.54	31.35	11.81	15.14	20.20	5.06	4.14	18.39	14.26
1980	12.15	17.70	5.55	11.19	21.34	10.15	12.94	25.82	12.88	12.70	18.84	6.14	11.25	31.27	20.03
1981	11.48	15.65	4.17	16.95	21.51	4.56	26.28	33.88	7.60	15.09	19.82	4.73	12.70	44.70	32.00
1982	14.39	16.29	1.90	17.15	21.04	3.89	27.02	36.64	9.62	21.11	25.46	4.35	16.61	37.10	20.49

Year	Kit Carson County, Colorado			Sheridan County, Kansas			Washington County, Kansas			Perkins County, Nebraska			Butler County, Nebraska		
	Apr. 1 to Sept. 30	Oct. 1 to Sept. 30	Oct. 1 to Mar. 31	Apr. 1 to Sept. 30	Oct. 1 to Sept. 30	Oct. 1 to Mar. 31	Apr. 1 to Sept. 30	Oct. 1 to Sept. 30	Oct. 1 to Mar. 31	Apr. 1 to Sept. 30	Oct. 1 to Sept. 30	Oct. 1 to Mar. 31	Apr. 1 to Sept. 30	Oct. 1 to Sept. 30	Oct. 1 to Mar. 31
1983	11.06	16.00	4.94	9.85	18.46	8.61	18.97	28.48	9.51	10.89	17.02	6.13	10.04	31.80	21.77
1984	9.75	14.72	4.97	15.89	23.87	7.98	25.96	37.57	11.61	14.54	19.19	4.65	9.79	33.77	23.98
1985	11.55	15.24	3.69	16.43	23.76	7.33	32.47	44.04	11.57	12.61	16.22	3.61	10.93	39.52	28.60
1986	11.02	13.48	2.46	13.98	17.65	3.67	32.61	42.56	9.95	14.48	18.91	4.43	4.78	23.53	18.76
1987	13.90	18.68	4.78	12.43	20.47	8.04	23.94	39.11	15.17	16.73	22.76	6.03	4.30	22.25	17.95
1988	12.11	14.72	2.61	11.73	15.34	3.61	15.15	21.17	6.02	16.36	21.43	5.07	4.61	21.70	17.10
1989	12.59	14.02	1.43	12.45	15.44	2.99	27.53	31.72	4.19	15.15	17.95	2.80	9.01	27.84	18.83
1990	11.94	14.76	2.82	18.18	22.32	4.14	26.25	33.71	7.46	14.40	17.81	3.41	11.32	28.81	17.49
1991	14.84	18.36	3.53	17.21	20.28	3.07	17.24	23.32	6.08	16.33	22.02	5.69	10.42	34.84	24.42
1992	13.29	19.30	6.02	21.29	30.26	8.97	25.18	35.90	10.72	14.03	21.64	7.61	5.27	32.86	27.60
1993	12.40	15.54	3.15	28.77	37.67	8.90	42.50	57.62	15.12	18.97	24.52	5.55	10.49	30.39	19.91
1994	12.14	15.66	3.52	14.31	17.74	3.43	18.99	24.53	5.54	15.39	20.78	5.39	6.26	23.64	17.38
1995	18.45	24.35	5.90	20.74	27.63	6.89	27.72	36.32	8.60	20.85	29.08	8.23	7.45	30.39	22.93
1996	15.71	17.77	2.05	24.06	26.12	2.06	24.87	28.22	3.35	21.87	26.23	4.36	11.11	29.41	18.30
1997	15.79	17.38	1.59	14.65	17.95	3.30	16.49	23.32	6.83	32.27	35.29	3.02	9.66	27.63	17.97
1998	15.53	21.64	6.10	13.66	20.81	7.15	28.02	40.91	12.89	17.42	23.94	6.52	5.70	26.00	20.31
1999	20.16	23.05	2.88	18.88	25.91	7.03	23.94	34.48	10.54	23.85	28.70	4.85	9.57	25.52	15.95
2000	12.92	16.94	4.01	8.48	13.57	5.09	14.53	20.09	5.56	8.98	13.19	4.21	7.52	22.70	15.18
2001	13.43	17.93	4.50	18.93	25.84	6.91	32.25	44.71	12.46	20.70	26.94	6.24	6.14	23.36	17.22
2002	9.08	11.46	2.38	6.21	8.87	2.66	10.81	15.10	4.29	8.09	11.32	3.23	10.01	27.56	17.55
2003	12.97	16.81	3.84	10.58	16.03	5.45	15.98	22.76	6.78	14.19	18.14	3.95	11.96	25.96	14.00
2004	12.50	14.07	1.57	16.75	19.20	2.45	19.73	31.23	11.50	17.09	19.73	2.64	9.15	24.46	15.31
2005	11.53	14.46	2.93	19.17	25.02	5.85	29.16	35.70	6.54	14.91	19.76	4.85	10.90	30.36	19.46
2006	10.56	15.77	5.20	13.25	18.82	5.57	25.21	32.26	7.05	14.32	18.24	3.92	14.63	36.54	21.91
2007	14.04	19.25	5.22	12.58	23.15	10.57	23.31	34.95	11.64	20.50	27.80	7.30	25.59	34.13	8.54
2008	17.50	20.83	3.33	16.20	18.78	2.58	21.70	34.25	12.55	21.82	25.05	3.23	26.03	34.61	8.58
2009	18.26	23.47	5.21	19.62	26.65	7.03	19.27	25.48	6.21	24.07	33.09	9.02	20.91	32.19	11.28
2010	16.27	22.13	5.87	7.64	14.79	7.15	31.08	44.17	13.09	20.75	29.94	9.19	25.48	35.95	10.47
2011	14.76	17.06	2.30	20.58	22.81	2.23	19.40	26.54	7.14	25.80	29.36	3.56	26.26	30.76	4.50
2012	9.63	12.53	2.89	12.07	22.56	10.49	14.04	24.21	10.17	9.37	13.86	4.49	12.71	18.41	5.70

Appendix B

Stakeholder Input

Exhibit 1. Press Release
Exhibit 2. Newspaper Advertisement
Exhibit 3. Listening Session Agenda
Exhibit 4. Stakeholder Comments

Exhibit 1. Press Release

PRESS RELEASE:
Growers and Other Stakeholders Invited to Listening Session on Federal Insurance for Crops Produced with Reduced Irrigation.

Farmers know better than most people that fresh water is a precious commodity. In some areas, major crops are generally irrigated, while in other areas irrigation is used primarily to supplement natural rainfall. Each state has unique systems for determining who gets water and how much they get. Throughout the United States there are areas where the amount of irrigation water available to producers can vary from year to year, and can be significantly impacted by drought. In some areas, this means less water is available for agricultural use, particularly in recent years.

Because some farmers are being required to use less water while others are being offered alternative approaches to their water allocations, production of irrigated crops is changing. Many producers already face reductions from their historical water use; others will in the future. These reductions come from a variety of reasons including reduced well capacity, compliance with interstate river compacts, Intensive Groundwater Use Control Areas (IGUCAs), and water right administration policies. The reduction in the supply of irrigation water creates challenges for the farmers who use the water, the organizations that manage water use, and the public/private sector programs that insure farmers' yields or revenues.

As a result, the United States Department of Agriculture (USDA), Risk Management Agency (RMA) is evaluating how Federal Crop Insurance currently addresses producers intending to apply reduced irrigation. Furthermore, RMA is evaluating the feasibility of establishing a limited irrigation guarantee for producers who apply less water than they may have historically applied to their irrigated acreage. This USDA initiative has led RMA to issue a contract to study initially the impacts of "limited irrigation" on crop insurance offers for corn and soybeans in select counties in Colorado, Kansas, and Nebraska. For the study, "limited irrigation" is defined by RMA as "a method of producing a crop by which **less water** is artificially applied during the growing season by appropriate systems and at the proper times than the quantity of water that was used to establish the irrigated production guarantee or amount of insurance on the irrigated acreage planted to the insured crop."

As part of the contract study, two listening sessions are being held to gather input from interested stakeholders. One will be in Colby, Kansas, Community Building (285 E. 5th Avenue) on March 13, 2013 at 9:00 AM. The second will be in Kearney, Nebraska, at the Buffalo County Extension Building at the Fairgrounds (1400 E. 34 Street) on March 14, 2013 at 10:00 A.M. Grower, insurance industry, and other interested stakeholders are encouraged to attend and share their concerns and feedback about limited irrigation and ideas to address the crop insurance consequences of the changing irrigation water situation in future years.

For more information contact:

Randy Landgren
Project Manager
Watts and Associates, Inc. under contract to USDA RMA
rlandgren@wattsandassociates.com
406-252-7776

Exhibit 2. Newspaper Advertisement

Colby Free Press
and
The Country Advocate

ATTENTION PRODUCERS
You're Invited

to discuss a United States Department of Agriculture (USDA), Risk Management Agency (RMA) evaluation of Federal Crop Insurance for irrigated crops. RMA is evaluating the feasibility of establishing a limited irrigation guarantee for producers who apply less water than they may have historically applied to their irrigated acreage for corn and soybeans in select counties in Colorado, Kansas, and Nebraska. For the study, "limited irrigation" is defined by RMA as "a method of producing a crop by which less water is artificially applied during the growing season by appropriate systems and at the proper times than the quantity of water that was used to establish the irrigated production guarantee or amount of insurance on the irrigated acreage planted to the insured crop."

As part of the contract study, two listening sessions are being held

Colby, Kansas Community Building 285 E. 5th Avenue March 13, 2013 9:00 a.m.	Kearney, Nebraska Buffalo County Extension Building 1400 E. 34 Street March 14, 2013 10:00 a.m.

Grower, insurance industry, and other interested stakeholders are encouraged to attend and share their concerns and feedback about limited irrigation and ideas to address the crop insurance consequences of the changing irrigation water situation in future years.

For more information contact:
Randy Landgren • Project Manager
Watts and Associates, Inc. under contract to USDA RMA
rlandgren@wattsandassociates.com
406-252-7776

Exhibit 3. Listening Session Agenda

Insuring Irrigation
Feasibility Study for Limited Irrigation
Listening Session Agenda

- Introductions
  - Watts and Associates, Inc.
  - Attendees

- Purpose
  - Share Background Information
  - FCIC Insurance Feasibility Contracts
  - Identify Insurance Issues Involving Managing Risk
  - Gather Interest in the Concept
  - W&A to make assessment of feasibility under the Act

- Feedback
  - Interest
  - Production Activities
  - Risks/Perils
  - Available Data
  - Alternative Approaches

- Questions

Exhibit 4. Stakeholder Comments (sorted by theme[1])

[1] Comments were made by producers unless marked with an (a) to identify a comment made by a producer association representative, an (i) to identify a comment made by an insurance industry stakeholder. The Contractor believes many insurance industry representatives who made comments are also producers.

Comments addressing whether producers have knowledge of the existing crop insurance program:

Crop insurance is recognized as a vital tool, not [just a] *valuable* [tool], *a vital tool for producers.* (i)

As part of a circle you cut back on your acres and you planted that as dryland but then to incorporate chemicals you water that part once or twice you are going to get slapped down to dryland yield.

As many farmers there are in here I guarantee you that there are that many different ways to deal with this.

We support LEMA.

Comments addressing risk management needs:

The same situation you are dealing with [in Kansas] *is what we are dealing with across the state* line [in Colorado] *and we support this type of program*.

How does this reduced water affect the preventive planting program? (i)

To encourage producers to reduce irrigated acres, in order to have a full yield on a small subset of acres is a long ways away from the optimal most of the time. It is important to the grower to have a way to move away from maximize yields on less acres.

Producers have a great concern in our area because we count on surface water, we count on ground water, and we count on natural water and part of the biggest issue is that maybe not knowing what the restrictions are going to be. (i)

Cities are going to have to come into line as well as industries [regarding water conservation].

To make a decision on seed population and to have a successful program, *at least three things you have to predict, to make that decision on your seed. One is the amount of water you have in the soil today, second thing you don't know what the precipitation, and the third thing is that we don't know how much water we are going to be able to pump because the aquifer is declining.*

Right now we have new farmers that might have a well on the land that they just bought and they chose not to irrigate because they don't quite have enough to make the county yield. So you aren't even giving them a chance to do a better practice. If you are going to do a limited you have to do it both ways (referring to the definition of limited irrigation tied to irrigated only) (i)

Comments addressing willingness to participate in a crop insurance program

In corn we definitely need a limited water practice.

Insurance needs to protect that limited irrigation (i)

Producers say they would like to conserve water in their wells (i)

Comments addressing management:

One of the things we've seen in our practices is just because water use is reduced 20%, what we finding is that our yields can be just as high with 80% water.

Comments addressing potential underwriting requirements:

I got a farmer that does this; he puts two inches of water on his wheat every fall. He immediately takes his sprinklers and puts it on his corn the rest of the year. Is that [wheat] *irrigated or dryland? It is limited irrigation is what it is.* (i)

What if 2 or 3 years down the road you built your APH up [applying water to a non-irrigated practice] *and then you decided to not apply that limited water* [to the non-irrigated crop]*?* (i)

Is there a number of inches of rain that need to be considered to produce an irrigated crop?

What is reasonable expectation?

Is scheduling of when regulated water [can be applied] *factored in*? (i)

[You] *have to examine what irrigation system was used.*

Depleted soil moisture is an issue to consider and how it relates to watering after harvest [to raise the soil moisture for the next year].

In the state of Oklahoma we don't have meters, are you going to require them to meter their sprinklers? (i)

Our records and our data show that the producer's water application is directly proportionate to rainfall. (i)

Comments addressing what type of risk management insurance would be appropriate for limited irrigation:

[The insurance should] *show support for our limited irrigation* [LEMA] *program.*

Create a monetary incentive to use less water

Who needs to have to reset [of their approved yield] *when* [producers] *actually have better yields. If you are going to* [adjust approved yields] *you have to look at skip-row cotton and adjust things back.* (i)
[Yield] *is based on what* [crop a producer] *irrigates, not based on natural precipitation. That difference needs to be taken into consideration*. (i)

Comments addressing market distortion

As an organization we are opposed to this. One, it is too complicated and it is also excluding sorghum. (National Sorghum Producers)

There is a big discrepancy between the t-yields for irrigated sorghum and irrigated corn it pushes guys to stay corn even though the water keeps dropping. (National Sorghum Producers)

There are sunflowers grown and milo, too.

[Limited Irrigation] s*till doesn't address issues of raising corn fully irrigated for years and then a change in practice in this year or the next five years with this LEMA, you want to go to pre-watered milo, which you may have done.*

Appendix C

Documentation Tool for Written Agreements Regarding Limited Irrigation

Documentation Tool for Limited Irrigation

1. Crop Year:			10. Crop:	
2. State:			11. Type:	
3. County			12. Practice:	

4. Producer Name:			13. FSA FN:	
5. Address:			14. Tract:	
6. City, ST, Zip:			15. Field:	
7. Phone:			16. Unit Number:	
8. SSN/EIN:			17. Legal Description:	
9. Policy Number:			18. KS Well ID:	

19. Year	20. Acres	21. Yield	22. [1]Water (Acre-Feet)	23. Water (Acre-Inch)
Average				

24. Rate Yield:			26. Max Intended Irrigation Current Year:	
25. Approved APH Yield:			27. Irrigation System Type:	
Notes:				

***Please note if a well is providing water to more than one section**

[1]Include all available years-Please attach all hard record documentation of water use.