



# Engineering Success

A newsletter from Biosystems and Ag Engineering Extension



## Grain Bin Safety video: Remember to think “safety”

By: Carol Jones, Associate Professor for Stored Product Engineering

The number of grain bin accidents resulting in injury and death has increased dramatically during the past two years, most likely due to the poor condition of crops coming out of the fields and being placed into storage. When grain is too moist or in poor condition, handling of that grain becomes a greater challenge and workers often find it necessary to enter the bins to unclog sumps and augers. Walls of grain or cavities under the surface of crusted grain break loose and engulf workers. Or, as grain flows to the reclaim system sumps, workers are pulled into the grain flow and ultimately into the unloading and reclaiming equipment. In most cases, these accidents can be prevented with extra precautions and training of both elevator and farm personnel.

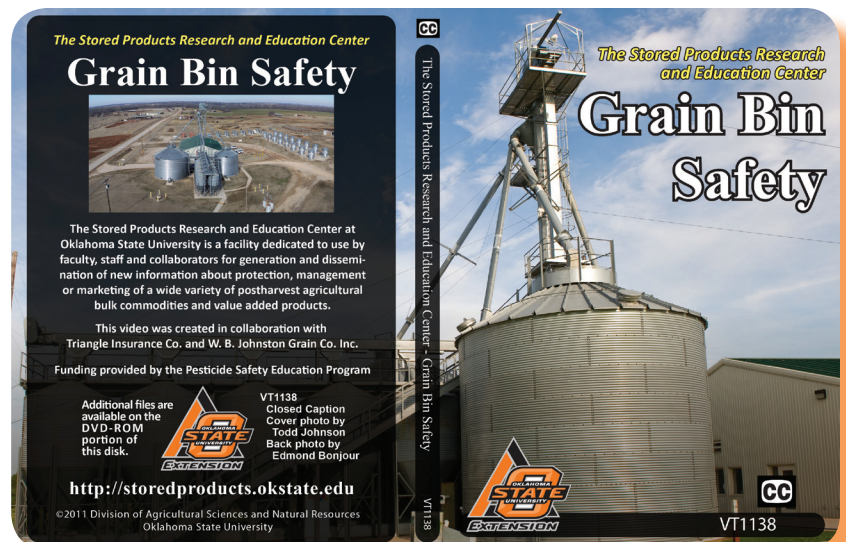
Oklahoma State University's Stored Products Research and Education Center (SPREC) have teamed up with the Cherokee Strip Connection, Triangle Insurance, the Enid Fire Department, OK CareerTech, and WB Johnson Grain Company, to produce a DVD called “Grain Bin Safety”. This video explains the dangers involved in handling and storing grain, methods of keeping grain in condition, and steps to take if an accident does occur.

The required and suggested safety procedures are emphasized in the video. Such steps as using a bin entry permit are required by law. Lock out/tag out of moving equipment helps to prevent entanglement in augers and unloading equipment. Working with a second person outside of the bin and in communication proximity as well as having a lifeline attached to a harness and tended properly are essential steps in preventing catastrophic injuries and loss of life. Proper monitoring of air quality, particularly during fumigation, and knowing how to use equipment properly is vital in order to keep workers safe when entering a bin is necessary.

The training in this video is the first of three levels of training this group will be promoting. It covers the awareness level, intended for the training of new and experienced farm and elevator personnel. The intermediate level training will cover horizontal rescue methods for personnel and fire departments involved in rescue situations. The advanced level training will cover high angle rescue methods and targets special operations and emergency rescue teams. The Cherokee Strip Connection envisions an advanced level rescue team available within short notice of every part of Oklahoma, and personnel in each county receiving intermediate level training. Every farm and elevator facility should make the video training available to all workers and employees exposed to work involving grain bin entry.

The DVDs will be sent to every fire department and elevator group in Oklahoma by the end of the year. Additional training opportunities will be provided in the near future so watch for announcements coming from OSU and SPREC during the next few months about details on how to participate in these training sessions.

Awareness of safety hazards and compliance with safety measures will go a long ways in preventing the loss of life and limb in grain bin accidents. Ultimately, keeping grain in good condition by properly managing aeration, temperature and moisture greatly reduces the reasons for entering a grain bin; and workers are less likely to risk injury and even death by entering the bin.



This video is online at <http://www.youtube.com/watch?v=DQsqWbn-3X0>.



# Microalgae: A versatile feedstock for food, feed, biofuel and industrial bioproduct manufacturing

By: Nurhan T. Dunford, Professor and Oil/Oilseed Specialist

One of the major concerns about expansion of the biofuels industry is the potential displacement of agricultural lands currently used for food crops with feedstock production

to meet the needs of the biofuels industry. Utilization of non-edible feedstock, waste bio-material and biomass that require minimal land and grow on marginal land, which is not suitable for food crops is vital for sustainability of the global biofuels industry. Better resource management and agricultural diversification to meet feedstock needs of the food, feed and biofuels industries will lead to growth of the local and global economy and strengthen the agriculture.

Plants use photosynthesis to convert solar energy into chemical energy stored in the form of oils, carbohydrates and proteins. The plants which are efficient at converting the solar energy into chemical energy have better potential for being a viable feedstock for bioproduct manufacturing. Various types of algae are among the most efficient plants taking a waste form of carbon ( $\text{CO}_2$ ) and converting solar energy to chemical energy. Microalgae are microscopic organisms that are found in both marine and freshwater environments. The green algae *Botryococcus braunii* have been found in petroleum and coal deposits in ancient oceans. It is believed that *B. braunii* has contributed to the development of these deposits.

Microalgae systems use far less water than traditional crops. More importantly, many of the algal species can grow in brackish water this means no additional demand on freshwater supplies needed for domestic, industrial and agricultural use. Microalgae can produce between 24,000 L oil/acre and 55,000 L/acre depending on the oil content of microalgae strain, which can vary between 30 percent and 70 percent (dry weight) (Chisti, 2007). As a comparison, soybean produces only 180 L oil/acre. Algal biomass and oil can easily be converted into biofuels and other industrial products. By use of microalgae it would take only 1-3 percent of the existing US crop area to replace half of the petroleum based transportation fuel with biodiesel (Chisti, 2008).

Open microalgae ponds have been utilized for several decades for the treatment of municipal and other types of wastewater, with the microalgae providing dissolved oxygen for bacterial decomposition of the organic wastes, absorbing heavy metals, removing excess nutrients, nitrogen and phosphorus, and sequestering  $\text{CO}_2$ . Furthermore, microalgae have been shown to stimulate the growth of plants due to the presence of auxine, cytokinins, gibberellins and related growth regulators.

Interests in pharmaceuticals from microalgae go back to 1500 A.D. In traditional medicine various microalgae strains were used to treat burns and gout, expel intestinal worms and as topical antibacterial ointments. The production of antibiotics from microalgae was demonstrated in the 1930s and 1940s. Some microalgae strains are a rich source of several fine chemicals of economic value such as vitamins, carotenoids, phycobiliprotein, polyols, polysaccharides, fatty acids, etc. These compounds are anti-inflammatory, anticancer, antifungal, antioxidants and immune-modulating agents (Metting and Pyne, 1986).

Research and development work on large-scale algal biomass production has started before World War II. The initial interest in microalgae stemmed from a protein shortage for food and feed use at the time. Basic concepts of optimization of microalgae growth in open ponds have been well established and commercial algal biomass production in open ponds has been implemented since the 1950s. The major problems with the cultivation of microalgae in open systems are contamination with algae predators and parasites, the difficulty of keeping the culture environment constant (temperature and nutrient composition) and high cost of biomass harvesting.

Closed photo-bioreactors have also been developed for producing mass quantities of algal biomass. Flat-plate, horizontal, inclined and serpentine tubular, bubble column, airlift and stirred tank reactor designs have been examined for their performance characteristics. Flat-panel reactors are designed for maximum utilization of solar light energy. High photosynthetic efficiencies are achievable with these reactors because of their large illumination surface. However difficulty in scale-





up, maintenance of the temperature in the reactor, biomass growth on the reactor walls and potential hydrodynamic stress for some microalgae strains are the disadvantages of the flat plate reactors. Tubular reactors made of glass or plastic tubes in the form of horizontal/serpentine, vertical, conical and inclined have been constructed outdoors. Horizontal tubular design is relatively inexpensive and has high biomass production efficiency. However, high dissolved oxygen accumulation and pH gradient along the tube are the major drawbacks of the tubular reactors. Vertical-column photo-bioreactors are promising for large scale microalgal biomass production mainly because of ease of operation and high potential for scalability. High final biomass concentration and specific growth rates are attainable in vertical column reactors. Good mass transfer, good mixing with low shear, easy sterilization and low energy consumption are some of the advantages of vertical-column photo-bioreactors.

Optimization of a photo-bioreactor requires a fundamental understanding of microalgae physiology and growth requirements. Light, CO<sub>2</sub>, as well as other physical and nutritional requirements, need to be effectively supplied to microorganisms to sustain biomass growth and production of metabolites of interest. More than 50 percent of microalgal biomass is made up of carbon. Hence this element is essential for cell growth. In aqueous media carbon may be found in several chemical forms including CO<sub>2</sub>, H<sub>2</sub>CO<sub>3</sub>, and HCO<sub>3</sub><sup>-</sup>, CO<sub>3</sub><sup>-2</sup>. It is believed that microalgae prefer CO<sub>2</sub> as their carbon source since it produces minimal pH change.

The chemical composition of some microalgae can be modified by altering cell growth conditions. A significant increase in lipid content (more than 50 percent increase) can be achieved in many microalgae after nitrogen deprivation, silicon deficiency, phosphate limitation, high salinity and stress caused by some heavy metals such as cadmium and iron. In addition to the effect on total lipid production, nutrient deprivation seems to change the types of lipids accumulated in the algal cells, specifically, an increase in the ratio of neutral to the polar membrane lipids. Neutral lipids, or triacylglycerides, are important in the production of biodiesel. Polar membrane lipids such as phospholipids possess surface active properties and they have to be removed from crude oil during refining,



otherwise they interfere with biodiesel conversion reactions and reduce process efficiency.

Microalgae have been attracting a lot of attention as a next generation biomass source for biofuel production. Today a number of business initiatives are underway to develop technologies that will enable utilization of algal biomass and oil to produce biofuels including biodiesel, jet

fuels and other hydrocarbon fuels at commercial scale. Algal biomass and oil production technology faces many research and developmental challenges today. However, it is clear that resource limitations are not barriers for viability and the sustainability of the technology. As feedstock prices continue to rise and availability diminishes, biofuel operations will face tremendous challenges to stay in production. I believe that algal biomass will play an important role in the expansion of not only biofuel industry but also other food and industrial biobased product manufacturing industry.

My research group has been examining the potential of several microalgae strains for their potential as feedstock for biofuels and other high value bioproduct development and environmental remediation for two years. Our current research focuses on growing microalgae strains native to Oklahoma on swine lagoon water and vinasse generated during bioethanol production. The research on various algal biomass harvesting technologies and reactor automation is also ongoing. A recent seed grant from the U.S. Department of Transportation and the South Central Sun Grant program will allow us to install two 30 L photo-bioreactors in the BAE greenhouse. One of our goals is to use these photo-bioreactors for student training, extension workshops and demonstrations and incorporate the knowledge gained from this project into future extension workshops and publications.

### References

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- Chisti, Y. (2008) Biodiesel from microalgae beats bioethanol. *Trends in Biotechnology*, 26, 126-131.
- Metting, B. AND Pyne, J.W. (1986) Biologically active compounds from microalgae. *Enzyme Microb. Technol.*, 8, 386-394.

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**Picture on previous page:** Dunford and Yan Zhu, graduate student, examine the microalgae cultures and algal biomass produced in the lab.

**Picture above:** Algal biomass produced at the BAE lab.



# The BAE renewable energy demonstration trailer is ready for your educational needs

By: Scott Frazier, Assistant Professor and Energy Management Specialist

We have all seen wind turbines and solar panels in pictures and videos. Most of us have also seen the large wind turbines in the western portion of Oklahoma, usually from afar. These alternative, or renewable, energy systems are showing up at more and more locations; however, few of us know how these systems work or how much power and energy we can expect them to generate.

As an institution of research, education and extension, it is part of OSU's mission to educate Oklahomans about technology that will affect their lives. Renewable energy systems will be a key part of future generations. Opportunities also exist for young engineers and scientists working with these energy systems. Part of our challenge is engaging young minds with these technologies while they are still in grade school.

One of the best methods of demonstrating technology while gaining people's interest is via the "hands-on" approach to education. Studies show a statistically significant correlation between hands-on instructional activities (projects) and retention of engineering students in university (Knight, et al., 2007). Other studies show hands-on education approaches achieve a statistically significant increase in student ability to enhance learning by reinforcing cognitive knowledge and (material) retention (Korwin and Jones, 1990).

Knowing this, myself and Paul Weckler, BAE associate professor; decided to build a demonstration trailer to showcase various types of renewable energy. Our idea was to build a portable teaching device that could demonstrate wind and solar electrical energy production. The trailer was designed to be as simple as possible while showing all the important information. For example, analog gauges were used in this first version to show voltage and amperage. The trailer was constructed in-house at the BAE lab and machine shop.

The trailer has been demonstrated at various events such as Tulsa Eco-Day, Sanger Elementary School Environmental Day, DASNR Lahoma Field Day, and other events. The trailer has also used with In-Service training as an introduction for OCEES county educators during 2011. Feedback was gathered from the county personnel about possible programs and interests in borrowing the trailer.

The target audience is wide for this teaching device. Everyone from small children to adults can benefit from learning about the technologies on the energy trailer, what changes is the level of instruction. Instruction manuals are currently being written for the county educators and their county audiences. Our goal is for county educators to borrow the trailer for events and produce a tailored lesson for their audience.

The trailer weighs approximately 700 pounds and can be towed by a full-size car or pickup. A conventional trailer hitch, full running lights, and load balancing make the trailer completely roadworthy. The trailer has been taken from Stillwater to Muskogee and back, a round trip of about 250 miles with no problems.



**Picture above:** Roof top solar photovoltaic panels at the OSU Botanical Gardens "Green Cottage".



The trailer can demonstrate the following energy systems:

- 400 Watt Air-X® Wind Turbine, completely wired and instrumented to the instrument panel;
- Two separate 120 Watt (ea.) solar panels, completely wired and instrumented to the instrument panel;
- Electric actuator control of the solar panel angle to the sun;
- 100 amp-hour lead Acid battery for energy storage;
- On-board DC/AC inverter to convert 12 volts DC to 120 volts AC, allows conventional appliances to be run from trailer battery;
- Charge controller to regulate battery charging from turbine or solar panels;
- On-board lighting experiment comparing CFL to Incandescent lamp power draw differences; and
- Full instrumentation panel with flow diagram of systems.

Future plans for the trailer include add-on instruction modules such as: human-power generation, solar thermal heat, biofuels, and etc. External funding to build more trailers so that one could be in each district is also being investigated. For inquiries contact Scott Frazier at 405-744-5289.

**References:**

Korwin, A. R., and Jones, R. E. (1990). Do hands-on, technology-based activities enhance learning by reinforcing cognitive knowledge and retention? *Journal of Technology Education*, 1(2), 39-50

Daniel W. Knight I, Carlson, L. E., and Sullivan, J. F. (2007), Improving Engineering Student Retention through Hands-On, Team Based, First-Year Design Projects. *International Conference on Research in Engineering Education, ASEE*, Honolulu, HI, June 22-24, 2007. pp 1-13.



**Picture above:** Solar photovoltaic panels on the BAE renewable energy demo trailer.

**Picture below:** Frazier and the BAE renewable energy demo trailer.



For more information about Dr. Frazier and his research and extension efforts, visit his website at <http://bioen.okstate.edu/Home/robert.frazier/index.html>.



# When does irrigation become a viable option to help deal with future expected droughts?

By: Dan Thomas, Interim Extension Irrigation Specialist, Professor and Head

Drought conditions have created significant economic stress throughout much of Oklahoma in 2011. Was this an unusual year? Or, will climate variability be even

more significant in the future? Good questions. I believe that “unusual weather conditions” will be the “norm” rather than the “exception”, at least for the near future. When extended droughts occur, the interests in irrigation increases. If you are not currently irrigating, but are considering it, the following guidelines and information will provide helpful hints as you consider possible irrigation options.

## ***Is irrigation my best choice to deal with my current situation?***

One recent question involves having irrigation available for hay/grass to provide an additional cutting/grazing during the season. Also, the lack of on-site hay and the problem with “getting” hay from other sources has been critical.

## ***If we have grass on site, can we use irrigation to help grow the grass and make more of our own hay?***

The answer is yes.

## ***Will it be completely economical, based on the cost of installing and maintaining the system for limited use?***

That’s hard to say, considering the panic situation that occurs when cows are hungry and thirsty.

In most cases, irrigation is recommended when you can actually pay it off based on the return on your investment. Amortizing the cost of an irrigation system can be quite long, if the added value of the crop (between what you get by irrigating versus not irrigating) is lower. Under a panic situation, those basic economic considerations may not be your primary concern. However, basic economics should not be ignored.

Access to water, at a reasonable distance from where you intend to irrigate, is a economic and very important consideration. Oklahoma has some excellent water resources, including some large reservoirs that might provide opportunities for irrigation. Unfortunately, extensive water resources may not be available everywhere, and the water transfer infrastructure is mostly non-existent. When a decision was made in the past to develop irrigation resources in the west, the Bureau of Reclamation was established to help provide the needed piping and canal infrastructure to move water from a source to the irrigated land. The cost (and political impetus) to implement such a system in Oklahoma could be difficult.

## ***Do you have on-site access to water for irrigation?***

Water is available from three potential sources: precipitation, surface or ground water. Obviously, if it rains when you need water for a crop, irrigation would not be a concern! For a surface supply (improved pond, lake, stream, and etc.) you must have sufficient rainfall to fill that resource so it is available when needed, at a reasonably close distance to the proposed irrigated land. Ground water can be used to supplement or replace surface supplies, if it is available. The farther you pump water (in any direction), the greater the cost. For most all water withdrawals, you need a permit. The reason for needing a permit is because water resources are not considered fully contained within a particular area. Some of the water that falls on your property is expected to move to adjacent properties. Such runoff creates our rivers and streams. Water that infiltrates beyond plant needs helps refill aquifers that may or may not be accessible from your property. The potential to use water that “passes through your property” is based on whether you negatively impact your neighbors.

Through the Oklahoma Water Resources Board, the State of Oklahoma keeps track of water resources. You can request a permit by going to their website at <http://www.owrb.ok.gov/supply/index.php>. The state is in the process of developing a comprehensive state water management plan, which can be found at <http://www.owrb.ok.gov/supply/ocwp/OCWPreports.php>. You may have been involved in meetings developing the plan, which is expected to be finalized in early 2012. It is to your best interest to be involved in how that plan is organized and how water may be managed and allocated into the future.

## ***What type irrigation system is best for my situation?***

This is where your academic-type advisory folks tend to respond with “it depends”. Critical considerations to be answered first are the amount of labor you have available, the automation you desire for the irrigation system, whether you intend to jump in completely, or start with a basic system. Many different types of irrigation systems exist. The slope, shape, and soil characteristics of your proposed irrigation land area all have an impact on which irrigation systems might be most appropriate.

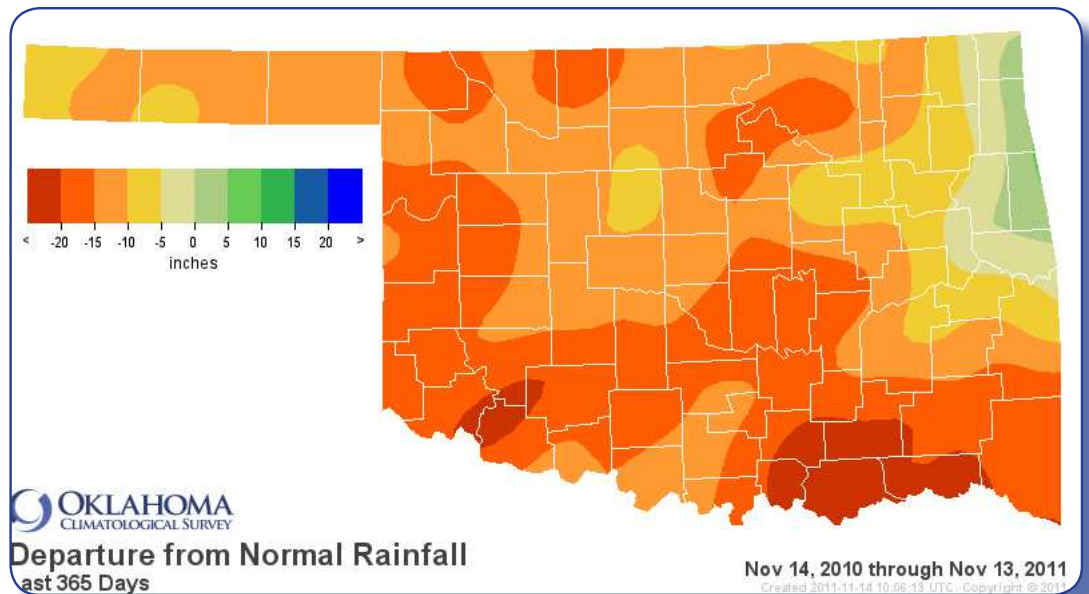
Relatively newer irrigation systems, such as surface and subsurface drip, and center pivot systems with efficient application packages are typically at the upper end when trying to use water efficiently. When someone is talking about “using



water efficiently”, that means that if someone is paying to move water from a source to the desired soil area, we want most of the water to actually get to the soil and be available to the crop. The less water that actually gets to the soil, the less efficiently that water is being used. The irrigation systems mentioned above are also the most expensive options with regard to system costs, but may require less overall labor to maintain and manage the systems due to automation options. As irrigation system options change to traveling guns, surface flood, and perhaps a few other less efficient water use options, the initial system costs go down, but the labor required maintaining and managing the irrigation system typically goes up.

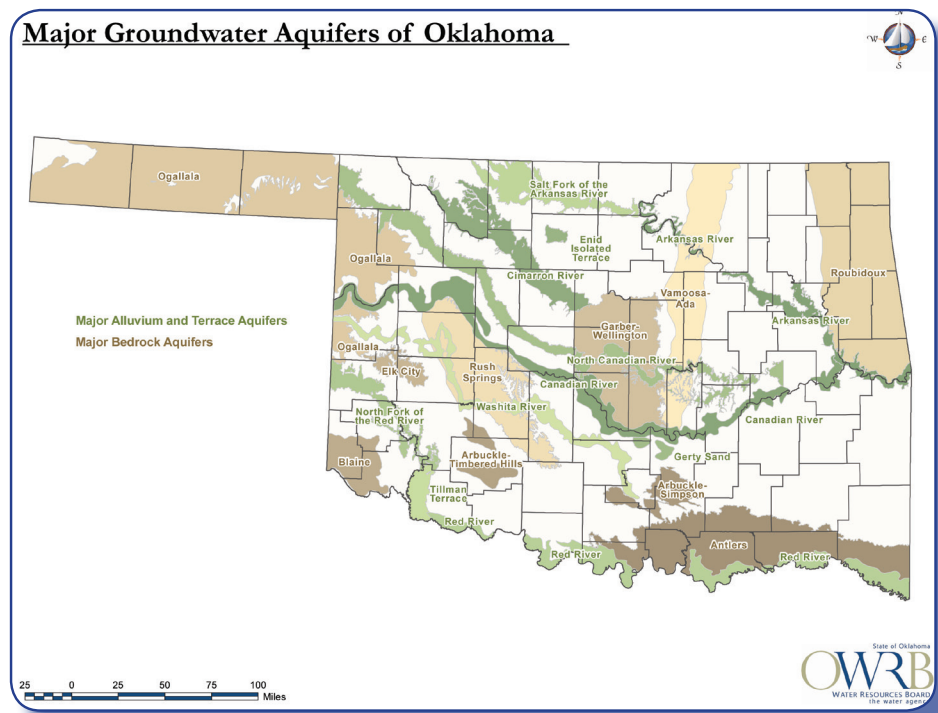
It is to your best interest to visit with your local extension educator or a local irrigation provider to evaluate your irrigation system options. Your local irrigation provider will be a highly valuable resource for replacement parts and operational advice for your irrigation system. One could buy an irrigation system via the Intranet (just like ordering a new computer). When it shows up, however, it might not be as easy to open the boxes and make it work.

If you get this far into this article, and are still committed to irrigation, you will also need to learn the best approaches for scheduling when to irrigate your particular crops, how much you will need to apply, required system maintenance, and a few other characteristics about irrigation to help make your system function better. Those issues are most critical after you have fully committed to move forward toward a particular irrigation approach, but are essential to the design of your particular system.



*Picture above:* How rainfall has varied during the last year compared to historical rainfall.

*Picture below:* Where the primary groundwater resources are located in Oklahoma.



Images provided by the Oklahoma Climatological Survey, which was established by the State Legislature in 1980 to provide climatological services to the people of Oklahoma. The Survey maintains an extensive array of climatological information, operates the Oklahoma Mesonet, and hosts a wide variety of educational outreach and scientific research projects.

View these images and more online at <http://climate.ok.gov/index.php>.

# EPA mandated Spill Prevention, Control and Countermeasure

A recent deadline, Nov. 10, for the implementation of Environmental Protection Agency (EPA) mandated Spill Prevention, Control and Countermeasure (SPCC) plans caused a flurry of interest, and probably some worry in the agricultural community. While the deadline was changed to May 10, 2013 for facilities operational after Aug. 16, 2002, this is a good opportunity to examine these requirements. It should be known that qualifying farms in operation before Aug. 16, 2002 should already have an SPCC plan in place. A news release and video created by the Oklahoma Cooperative Extension Service and SUNUP explains some basics of this issue, these are available from the links below. - *Scott Frazier, Assistant Professor and Energy Management Specialist*

View the news release at <http://www.dasnr.okstate.edu/Members/donald.stotts-40okstate.edu/epa-revises-key-deadline-for-farms>.

View the video at <http://sunup.okstate.edu/video/11-19-11/seg3.html>.

## BAE Extension Website *Spotlight*: Plans and Building Information Services

The materials on this website are designed to increase your knowledge of building and equipment requirements for agricultural enterprises and to help you compare building and equipment alternatives. It is strongly encouraged to obtain and study the appropriate handbooks or digests before any major investment in buildings or equipment. Visit <http://pbis.okstate.edu/>.

### Subscription request

To receive the Engineering Success: A newsletter from OSU Biosystems and Ag Engineering Extension, email Randy Taylor at [randy.taylor@okstate.edu](mailto:randy.taylor@okstate.edu) with **BAE Newsletter** in the subject line.

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