5-152

CONSERVATION INNOVATION GRANTS
Final Project Report

Grantee Name: Propane Education & Research Council (PERC)	
Project Title: Air Quality, Water, and Soil Conservation Demonstration Project at a California Agricultural High School	
Project Director: Mark Leitman	
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Period Covered by Report: October 1, 2005 – September 30, 2007	
Project End Date: September 30, 2007	

Background

The Lincoln, CA High School (LHS) Farm is a 280-acre facility designed to give students practical experience in the areas of agriculture and natural resources. The LHS goal is to expose as many students as possible to the school farm and demonstrate how agriculture and the environment can co-exist.

About the Farm

- Acquired in 1974 as surplus property from the McClellan Air Force Base Communication Annex. It took many years to remove tower footings and erect the fencing
- Shop built in 1984
- Hay barn built in 1989
- Classrooms arrived in 1998

Current agricultural enterprises

- Orchard – Planted over the past few years; includes apples, plums, pears, peaches, cherries, and other varieties. Students continue to plant new trees each year.
- Hay – Approximately 40 acres are planted in oats, wheat or barley and subsequently fed to the LHS cattle and/or sold locally.
- Cattle – Cows calve in September and October and then are weaned in May. Some are kept for student projects and/or replacements. Students are responsible for feeding and management of the cow herd.
- Pond/wetland – Approx. 20 acres are dedicated to water fowl and wildlife habitat. LHS staff and students have documented a noticeable increase of waterfowl species and shore birds.

Classes taught at the LHS Farm include:

- Ag. Biology/Special Projects
- Ag. Science II/Ag. Projects
- Ag. Chemistry
- Farm and Ranch Management
- Natural History

Project Activities and Results
The project stakeholders met in Lincoln, CA on December 5, 2005. Following a tour of the farm grounds –including an inspection of the existing irrigation pump system—the project team met and discussed priorities, critical path scheduling, organizational issues, the work scope, outreach opportunities, and next steps.

As outlined in the grant documents, it was agreed the project equipment would consist of:

- A new, 3.0L low-emission certified propane engine with catalytic converter and air fuel control;
- A complete, mobile, trailer-mounted centrifugal pump package with suction hose to access the irrigation ditch;
- A new propane-fueled organic thermal weed control machine ("Stinger") primarily at the LHS farming operation, secondarily at farms in the region; and lastly,
- An intelligent remote telemetry/global positioning (GPS) moisture management system; this system will gather and transmit field moisture conditions via satellite to an internet-based server. Field moisture data will then be accessed by internet and computer at the LHS classroom, allowing for real-time monitoring and adjustments to pumping operations.

The first priority was to build-out, deliver, and install the equipment to accommodate LHS objectives, including properly sizing the propane fueling tanks for future farm growth. The grantee is currently worked with LHS staff to specify the pump and moisture management designs and initiated the equipment supply review options, scheduling, and synchronization of the procurement, delivery, and installation procedures among the grantee, LHS, and the equipment vendors.

Project-Funded Equipment
Irrigation Pump Engine – The grantee specified a 3.0-liter, clean-burning, dedicated propane engine from Kem Equipment (located in Tualatin, OR) with the following parameters:

- 3.0 liter / 181 cubic inch diameter displacement
- Skid-mounted
- CARB-certified
- Low-emission
- Weather-shrouded
- Shielded catalyst

Kem delivered the engine and skid to the pump fabricator (see below) in April 2006.

Mobile Irrigation Pump System – During follow-up project discussions LHS staff decided against a deep well, so the grantee engaged an experienced firm (TGP West, Inc. of Visalia, CA) to design and build a customized, mobile, low-lift centrifugal pump system for the project.

The concept of pump portability (over a stationary pumping system) allows LHS staff and students to drive to a point in the irrigation canal, drop the intake snorkel to the water and quickly commence irrigation operations.

The irrigation pumping system was designed to the following specifications:

- Intake assembly: 8" diameter pipe, snorkel, and boom
- In-service flow rate of 450 gallons per minute at 75 PSI;

- 10 feet of lift;
- 30 HP at 2000 rpm
- 250-gallon propane feed tank

TGP West mounted the Kem propane engine and the feed tank on a trailer and built the pump apparatus around the engine during the June - July 2006 timeframe (see photo below). The 250-gallon tank provides enough propane to operate the pump engine for at least a week before need of refilling. This is an appropriate tank size for the pumping system and the 17 acres of irrigated land at the school. Trailer-mounting the feed tank also obviated the need for a re-fueling station at the LHS Farm since it is located within the local propane retailer's bobtail delivery service area.

Demonstration of mobile irrigation pump at LHS Farm

The pump vendor delivered the irrigation pump trailer on August 8, 2006. After topping off the feed tank, the TGP West representative demonstrated the equipment at the canal and gave a thorough tutorial to LHS's Mike Trueblood on the operational and safety features of the system.

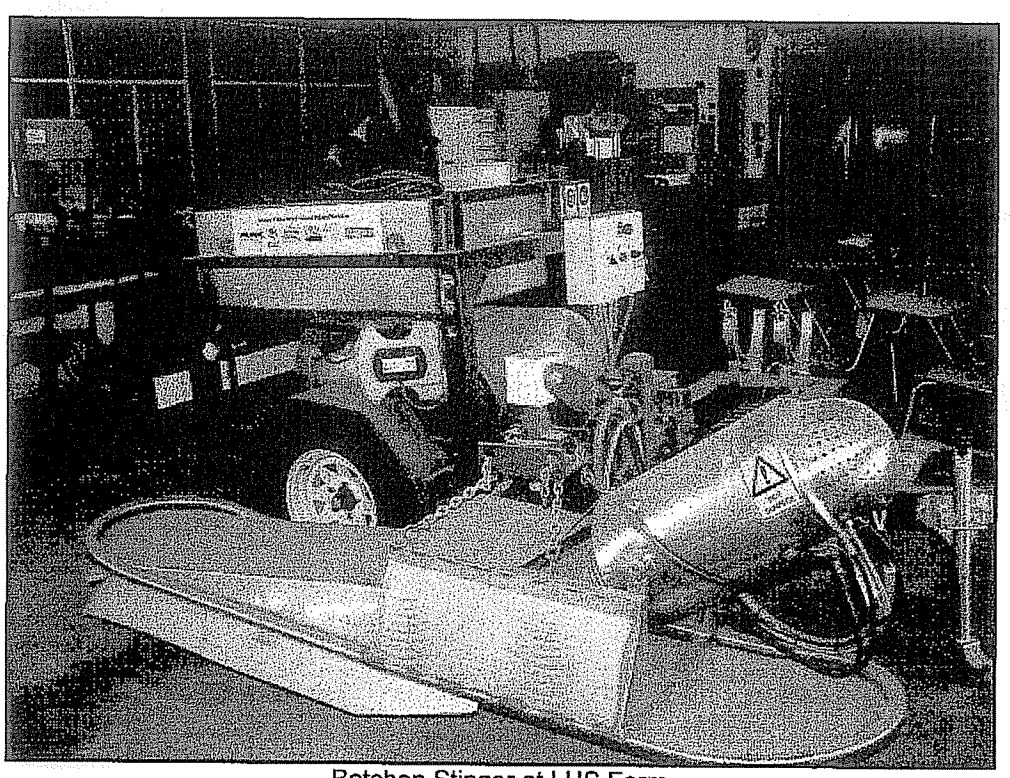
In April 2007 the grantee arranged for the vendor to install a hand-operated primer for the irrigation pump. This upgrade greatly eased the start-up process by helping to introduce canal water into the intake, thereby improving the seal and starting the flow of water much faster than was previously possible.

By July the pump had commenced continuous irrigation operations on a neighboring rice farm, consuming approximately 80 gallons of clean-burning propane per day and concurrently reducing NOx emissions by well over 60% in comparison to a diesel engine. As a further benefit to local air quality, the propane engine produces none of the toxics associated with diesel particulate emissions.

The irrigation pump was able to run 24 hours per day during periods when the ambient outdoor air temperature stayed below 95°F. At that temperature or above, the pump engine shuts itself off from an overheat condition.

"Batchen Stinger" (see photo below) –Driven by steam-quenched combustion, the Stinger uses a generator to convert combusting propane fuel and water into a moist, high-velocity, 806°F air flow. When heat is applied to the weed, the temperature of the moisture in the plant cells quickly rises, causing the plant cell structure to rupture. This kills the weed as it prevents nutrients and water from entering the weed's stalks and leaves.

This innovative thermal weed control machine for orchards and vineyards was first introduced to the agricultural community at the 2005 World Ag Expo in Tulare, CA and returned for the 2006 Expo (February 14-16, 2006) following a significant redesign in response to field trials and feedback from agricultural producers.



Batchen Stinger at LHS Farm

Considerable grower interest led to commercial production of the units by its Australian manufacturer (D.J. Batchen, Pty. Ltd). Field tests measured the productivity of the Stinger in a range of operating speeds, on various weed types that were at different levels of maturity, and through various vineyard and environmental conditions, including flat and hilly terrain. During field tests, the Stinger produced dramatic results in controlling all weed types at early growth stages, reducing average weed coverage from 85 percent to two percent after three days. Thirty days after treatment, average weed re-growth was only 30 percent.

The grantee was a sponsor of the Expo's California Crop Center, which allowed PERC and Batchen representatives to present the Stinger technology to growers and media representatives. Crop Center exposure, along with demonstrations and other outreach activities, generated 21 requests for on-farm demonstrations from organic and sustainable growers in California, Oregon, and Washington in 2005.

For this demonstration project, the Stinger technology is used between rows in the LHS orchard and along irrigation ditches to control weeds on the farm. Since the Stinger uses heat to provide chemical-free weed control, the use of this technology is considered an organic production practice.

The grantee placed its purchase order with Batchen in January 2006.

On May 3, 2006 agriculture students and instructors at LHS participated in an in-depth training session for the Stinger. U.S. Batchen representative Kevin Smith, who led the session, stated: "This is a technology that a very limited number of growers in the United States have even seen. "It's been a pleasure to train Lincoln students on equipment that's redefining weed management in agricultural applications."

The Stinger experienced some minor technical difficulties midway through the project period. Most of these involved the thermal sensors communicating erratic numbers to the computer, pressure sensor issues, and some electrical wiring problems.

Engineer Ian Johnstone of Batchen Australia conducted a site visit to perform several upgrades on the Stinger unit in order to improve reliability. The upgrades included a second water pump (so that each burner has it own dedicated pump) and longer burn tubes, allowing for a consistent temperature mixture as the heat exits the burners. These improvements were noticed immediately upon start-up, as there were no long temperature fluctuations on the readouts.

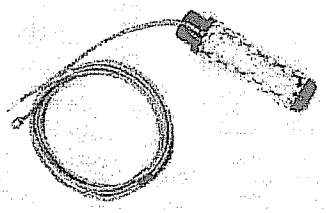
Remote Moisture Management – Rather than utilizing a more complex satellite component (which would have added months of design time to the project), the grantee and LHS opted for a radio-based system connected to the moisture sensors in the field which send data to a receiver placed in the classroom.

Irrometer (www.irrometer.com) sells an off-the-shelf application along with proprietary software which was deemed appropriate for this project. The vendor offered the grantee reduced pricing at an educational institution discount, which helped keep project costs within budget.

The grantee purchased the "Watermark Monitor" package from Irrometer. This consists of a complete datalogger (including a soil temperature sensor); seven (7) Watermark soil moisture sensors; serial cable, WaterGraph software; a solar recharging battery pack and antenna; and the 900 MHz Base Radio telemetry module (consisting of the transmitter and receiver).

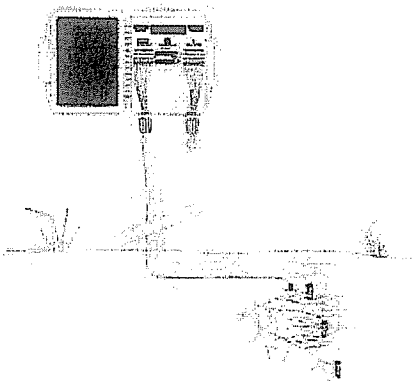
The monitoring and transmitting equipment, along with the solar panel, fit into a lockable circuit breaker panel with a standpipe cemented into a cement-filled tire, thereby rendering the device too heavy to steal. The receiver remains in the classroom where the agriculture students collect and evaluate data for daily irrigation choices, along with storing the data over the timeline of usage.

Two stations consisting of three moisture sensors each (see image next page) were buried in the LHS east orchard area. The three sensors for each station were buried at specific depths in the crop root zone to gauge when the bottom depth is getting dry (need irrigation) and the top soil is becoming moist (end irrigation). Station locations were based on the different types of trees and their various root depths and water needs.



Irrometer Moisture Sensor

The sensors were then wired to the field station (see below), which consists of a solar panel power supply, battery, and the radio transmitter. The system was placed in a secure storage box, all of which was fixed to a stable pole in line of sight with the classroom and radio receiver.



Irrometer Field Monitor

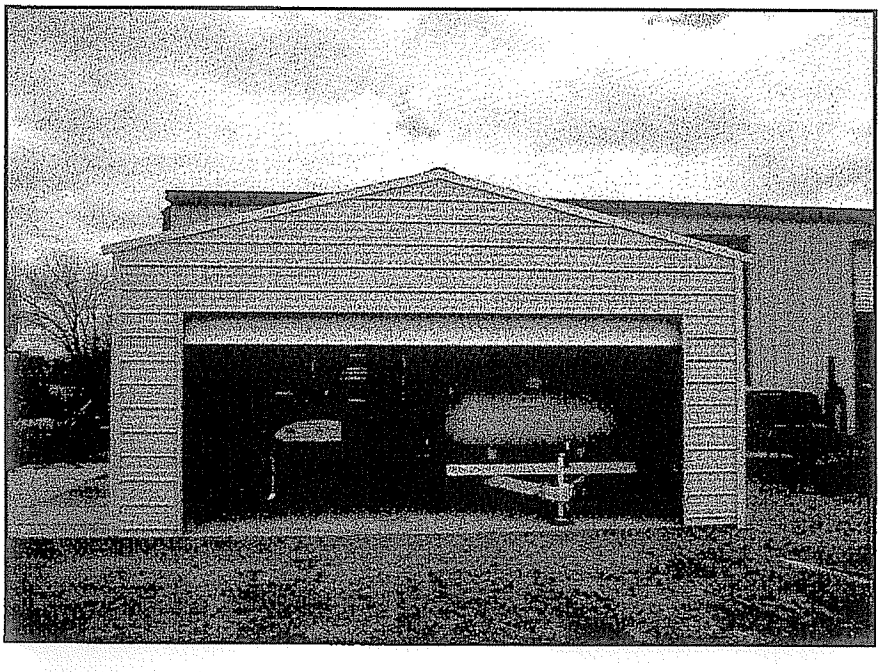
In the classroom, a receiver modem is set up to receive the signal from the transmitter and transfer the data to the classroom computer via the Watermark software included with the Irrometer system. The software launches the datalogger, downloads the recorded moisture history, and graphically displays the moisture levels at the two stations in order to determine an appropriate irrigation schedule.

Project Outreach – The PlacerGrown Conference was held Saturday, February 4, 2006 at Lincoln High School. "PlacerGrown" is a nonprofit membership organization formed to assist Placer County farmers with marketing their products and bringing producers together to maintain and enhance the viability of agriculture in the County.

The grantee provided a poster, equipment, and project talking points to Joanne Neft (Placer County marketing director) to use at the event. This outreach material was designed to raise awareness about the Stinger and to direct conference attendees to see live demonstrations of the technology at the World Ag Expo held the following week in Tulare, CA.

Equipment Storage – In March 2006 the grantee made arrangements with a local supplier to install a storage shed (paid from grantee matching funds) to securely house and protect the Stinger and mobile engine/pump system. The building is 20' x 20' with 16' roll-up panel door. The cost of the building, labor, steel and appropriate ventilation totaled approximately $8,500.

The storage shed is located at the entrance to the LHS farm, providing long term visibility for the project, the technologies, and the supporting organizations that have helped advance a few ecologically important agriculture programs (see photos below).



Equipment Storage Shed (above) and signage (below) at LHS Farm

Funding Received and Expended
All USDA funds are committed; however the final grant payment from NRCS remains outstanding as of this writing. The table below outlines the final financial status of the project:

	Actual Outlays (as of 9/30/07)	
	PERC	**NRCS**
Propane Pump & Engine, and Components	$19,572	
Batchen Stinger		$ 32,877
Remote Telemetry Equipment; related components		$ 4,839
Contractual, coordination, implementation	$10,288	
Propane Storage Tank and related components		$ 1,443
Travel	$2,500	
Storage Structure - Added by grantee (post award)	$8,569	
Other Direct Costs		$ 841
Total	**$40,929**	**$40,000**

less previous Federal payments $31,468.25 − $8531.75

Potential for Transferability of Results
The environmentally beneficial equipment scoped, purchased, and placed at the Lincoln High School Farm has considerable technology transfer potential. Although the equipment introduced at the farm required a methodical introductory period and learning curve, all parties agree that the CIG project ultimately bore fruit.

The equipment co-funded by NRCS and the grantee now in operation at the LHS farm represents a replicable model for other farmers interested in promoting the organic control of weeds and a significantly lower-emitting irrigation engine solution (compared to diesel).

Beginning in the spring of 2008, the propane supplier will assist the school in placing the pump system on local farms when not in use at the LHS farm. This will ensure that the low-emission engine and irrigation pump stays operational during optimal periods.

The Batchen Stinger will continue to be refined and used on the LHS farm's orchards, vineyard, and along the fence lines. When not in use at the school farm, it will be made available on loan to farmers in the region via assistance of the local Placer County Farm Bureau.

A diverse mix of growers are interested in learning how the Stinger can be used in their operations including those farming table grapes, wine grapes, stone fruit, almonds, blueberries, citrus and olives. A growing number of traditional farmers are also interested in the technology because the Stinger represents an alternative to reduce some of the chemical volume used on their farms.

Two local growers in particular (one with 500 acres of organic almonds and the other with 20 citrus acres) are interested in borrowing the unit next spring. LHS and the grantee have agreed there will be no rental fees involved in the loan-out of the Stinger and have developed a rental agreement stipulating the typical concerns and protections involved with loaning out capital agriculture equipment.

The sharing of the Stinger with these two influential organic producers highlights one of the key original goals of the grant, which was to share the new technologies with the local growing

community. Beyond these two, there are several dozen additional growers anxious to sign up to use the machine on their own crops.

The remote moisture-sensing system allows for real-time monitoring and adjustments to pumping operations during the irrigation season. Proper management of soil moisture produces better quality and higher yields. The resulting reduction of irrigation engine operation will concurrently reduce water use and labor; fuel consumption; and engine emissions.

The grantee will continue working with LHS after the grant performance period to install a sample moisture sensor above ground (the 7th sensor included in the Irrometer package, but not buried in the field). This sensor will not be connected to the monitor, but will rather serve as a demonstration to allow visitors and students to gain a greater conceptual understanding of the moisture sensing system in its entirety.

Conclusion

The equipment specification, procurement, design, fabrication, and installation lead times took slightly longer than the optimistic three months envisioned in the proposal. Fortunately, the 12-month extension granted by the NRCS in September 2006 obviated any potential negative project effects and permitted the grantee to work with its vendors and LHS to properly place and test all grant-funded equipment.

LHS agricultural students worked with the equipment over the course of the project period and have thus gained invaluable experience in working with emerging technologies that benefit growers, the community, and the environment.

Batchen's Kevin Smith set up a web log to communicate some application Best Practices to the students, and they have since used the device to control weeds between rows in the LHS orchard, on the perimeter of their row crops, and along the berm of the irrigation canal which runs through the farm. The students kept records of their trials, logging drive speeds, weather conditions, and weed maturities.

LHS teacher Mike Trueblood reported that the Stinger does a great job at controlling weeds where it is used and expressed plans to make the unit a much more important tool in the farm's overall weed control next Spring, as well as sharing it with the high school's grounds-keepers.

The grantee will continue to support this project long after the completion date of the grant agreement. Most of this support begins in the spring and will take the form of managing the loan-out of the equipment, transporting the equipment to local farms when necessary, and training local growers in the proper and safe use of the equipment. We will also assist with the interpretation of data that will be provided by the Irrometer moisture management system once the 2008 irrigation season commences.