



February 10, 2015

REPORT #E15-005

Agricultural Irrigation Initiative: Grower Experience

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Acknowledgments

Twelve growers participating in the 2014 Northwest Energy Efficiency Alliance (NEEA) demonstrations agreed to be interviewed by phone or to participate in a site visit to provide the NEEA team their feedback on using the Precision Flat Rate (PFR) irrigation solution, as well as their thoughts on what it takes for growers to adopt new solutions.

Jac Le Roux (Irrinet), Bob Low (Western AgTech Solutions), Troy Peters (Washington State University), and David Little (United Ag) provided valuable insights as they interacted with growers during the NEEA demonstrations. They also analyzed manufacturers' equipment, looking for areas of difficulty or ease-of-use for growers. They are true champions for "the voice of the grower."

Eric Silverthorn of Semaphore Mobile provided expert feedback on issues impacting the grower experience.

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Executive Summary

Market adoption of precision irrigation practices and technologies requires acceptance and use by growers within the contexts of their farm operations and agronomic practices. While these technologies offer the promise of improved yield and corresponding savings in energy and water costs, they also come with the burden of time and effort for the growers to implement. Some precision agricultural analysts have stated that these technologies have often been developed without considering the knowledge levels, skills, and abilities of growers and service providers to effectively and economically manage these tools (Sadler et al. 2005). In addition, the equipment is often expensive and the economic returns from adopting these technologies have not been easy to consistently demonstrate.

Many of the solutions today require significant time and expertise to install, use, and to measure the benefits from their usage. Opportunities exist to improve the grower's experience with these solutions by saving them time and effort. These improvements can be in the form of hardware integration, software integration, and user interfaces.

As part of its Agricultural Irrigation Initiative, the Northwest Energy Efficiency Alliance (NEEA) conducted a series of market activities to reduce irrigation energy use by identifying a product solution for center pivots that enabled integrated precision irrigation technology. The NEEA study team's market activities included multiple visits to growers who participated in Initiative demonstrations on precision irrigation delivery systems during the 2014 season.

Precision irrigation is a particularly intricate area for improving the grower experience, because the solutions involve the integration of a range of hardware devices, such as soil sensors, weather stations, data loggers, and pivots. These must be integrated with data sources and software solutions in order for a grower to use a precision methodology for irrigation.

Rather than taking a hardware-centric view that prioritizes selling pieces of equipment, Industry stakeholders such as manufacturers, solution providers, and service organizations are better served by taking a "grower-centric" point of view when designing, developing, marketing, and supporting the integration of components that make up precision irrigation solutions.

This report outlines the key factors that impact the likelihood of growers adopting an integrated irrigation solution for precision agriculture. It is based on the simple proposition that the value of changing an agronomic farm practice and related farm operations must result in a positive net benefit for the grower, and that the experience has to be easy enough so that the grower does not revert to old practices.

This report is one of twelve in a series addressing specific areas of NEEA's experiences during the three years of its Agricultural Irrigation Initiative. All twelve reports are available at <http://neea.org/reports>.

Vendors designing precision irrigation solutions should keep these key considerations in mind:

- Reduce the amount of time and difficulty of installing and operating equipment
- Make information displayed on computers, laptops and mobile devices easy to read and interpret
- Design products and services so that growers can start with part of a solution and continue building
- Where feasible, partner with other vendors to provide a seamless experience across multiple brands of products
- Use standards to provide a consistent experience across multiple brands of equipment
- Provide transparency as to how a grower's data will be used and shared

1. Introduction

The Northwest Energy Efficiency Alliance (NEEA) is an alliance funded by more than 140 Northwest utilities and energy efficiency organizations in Idaho, Oregon, Montana, and Washington working to accelerate the innovation and adoption of energy-efficient products, services, and practices in the Northwest. In 2011, NEEA launched the Agricultural Irrigation Initiative with the goal of agricultural irrigation energy use by twenty percent by 2020 through a series of market activities to test and promote a product solution for center pivots that enabled integrated precision irrigation technology.

As part of these market activities, the NEEA study team conducted multiple visits to growers who participated in Initiative demonstrations on irrigation delivery systems during the 2014 season. Some growers used Precision Flat Rate (PFR) irrigation, while others used combinations of PFR, Variable Speed Irrigation (VSI), and Variable Rate Irrigation (VRI).

NEEA also conducted unstructured phone interviews with growers using the PFR solution to learn about their experiences using the PFR software on their tablets and mobile devices. The “first-hand” experience for this report comes from those interviews and from the observations of growers, as well as from input NEEA received during conversations with pivot manufacturers. The NEEA technical team also provided feedback as its members interacted with the growers and analyzed the ease of use of various pieces of equipment and software.

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The grower experience is a blend of the grower’s physical encounters with the equipment and services compared against the grower’s expectations across all moments of contact with the irrigation solution’s marketing, irrigation planning, equipment setup, use, and support. Growers that the NEEA team interviewed said that while they do not particularly care about NEEA’s mission to save energy, they do want to farm more profitably and/or sustainably. At the end of the day, most growers care about the basic financials of farming: *“Am I going to get enough yield to make my profit goals?”*

Growers accrue positive experiences by interacting with solutions that consistently meet or exceed their expectations of how easily and completely they should work. The agricultural market is highly referential. Growers want to know: *“Did it work for my neighbor? Show me the results. Let me see it in action.”*

In a 2014 survey, researchers at the University of Florida questioned growers on their “adoption attitude,” or their self-perceived willingness to adopt new technologies. A majority (62%) of these grower-respondents chose the response “I normally wait to see others' success with new technologies and production methods.” The survey researchers labeled those respondents “coat-tailers.” Based upon other responses to this question, the researchers termed approximately 18% of the respondents “early adopters” and roughly 13% as “slow-to-adopt.”¹

These survey findings imply that most growers are more comfortable basing their technology adoption decisions on the results their earlier-adopting neighbors experience with a particular technology. Even though agriculture is carried out in wide-open spaces, its practitioners constitute a tight-knit community.

Given the industry-specific or scientific natures of some terms used in this report, please refer to the [AgGateway AgGlossary \(http://agglossary.org/wiki/index.php/main_page\)](http://agglossary.org/wiki/index.php/main_page) for definitions.

1.1. Key Factors in Willingness to Adopt New Irrigation Practices

Based upon the grower interviews and site visits, the NEEA team discovered certain key factors that have major impacts on whether or not a grower will choose to adopt new irrigation practices. These factors, which are fairly typical for adoption of any new technology practices, include:

- Motivation of the grower to change current practices (The pain of change has to be less than the pain of staying the same)
- Clarity of the value proposition (The service clearly states what is in it for the grower)
- Hassle (The change should not add cost, difficulty and/or time)
- Anxiety regarding harvest yield, data privacy, and other considerations (To what extent will the grower’s anonymity and privacy be maintained)

1.1.1. Motivation to Change

In the Northwest, growers are seldom motivated to change their irrigation practices simply to reduce water or energy use. NEEA and vendor partners often heard “Better to overwater rather than to get behind” from growers. In order to mitigate this attitude, industry stakeholders (such as vendors, manufacturers, NEEA, utilities, and extension agents) should demonstrate to growers a solid, easy-to-understand return on investment for new irrigation practices. The growers most likely to adopt new irrigation practices have one or more of the following characteristics:

1. They have a requirement or a compelling need (either through natural causes or through government regulations) to reduce irrigation water use
2. They generally must manage multiple brands of equipment
3. They already have a sophisticated level of farm management practices
4. They have one or more employees dedicated to farm data management and integration
5. Their overall attitude toward farming technology is forward-directed
6. They are trying to reduce overall costs (labor and any other inputs) to increase profitability

¹ Six percent did not respond to the question.

The first two characteristics begin to address specific pain points that growers may have. The opportunity to save a few dollars in energy costs may be an insufficient motivator for growers to spend the money or to take the necessary time and effort to implement a new solution. The more strongly that a market entity such as NEEA can connect its solutions to the growers' pain points, the higher the likelihood of adoption.

1.1.2. Clarity of the Value Proposition

While growers in the Northwest are always interested in reducing their costs, the costs of energy and water seldom make the top of their lists. Even when they see the advantages of lowering these costs, selling them on the additional time and effort required to analyze soil, weather, and other data is a tall order.

The premise of using less water and energy without sacrificing yield and profit is dependent on multiple pieces of equipment and data coming together. Of all the items in which growers can invest, the industry stakeholders must convince them of the benefits of investing in new irrigation practices. Ideally, they should present the value proposition as an "elevator pitch" specific to the grower's situation, hitting pain points as described above. An example value proposition for growers who need to reduce the amount of water they use for irrigating crops, perhaps due to water district restrictions, might be "The integrated ag irrigation system lets you cut back on water usage without sacrificing yield and profitability." The motivation in this value proposition focuses on water rather than on energy usage per se, as most growers in the Northwest do not see energy costs as a problem to be solved.

1.1.3. Hassle (Time and Difficulty)

While many growers are technologically savvy, they have neither the time nor the patience to "fool around with technology." Solutions that demand a large amount of time or that present difficulties in execution, including setting up equipment such as sensors and probes or dealing with telemetry and other bandwidth issues over an uneven landscape, are likely candidates for abandonment by growers.

Complicating this situation is the fact that designing and selling technology solutions to the agricultural market is difficult, as each grower's situation may require a unique solution with a high degree of customization so that the solution can fit within their existing farm management practices. An off-the-shelf solution is difficult to offer with so many grower-specific variances in the manner in which the application may be used. That being said, hardware and software vendors should continue to not only improve the ease of use of their own solutions, but should also look for opportunities to partner together to design seamless solutions for growers. Specific issues with and recommendations for the irrigation equipment that NEEA used in its demonstrations are documented in the *Instrumentation and Hardware Best Practices in Precision Agriculture* report.

1.1.4. Anxiety

1.1.4.1. Effects on Harvest Yield

Farming is an inherently risky proposition and growers often look for ways to reduce those risks. So many factors are outside of their control (weather, market prices, and regulations) that they are hesitant to adopt new procedures that could damage their yields. In the NEEA demonstrations, growers exhibited a range of degrees of willingness to adopt new technologies. Some were willing to be early adopters, wanting to move their farming practices into the future. Others were hesitant to use new technologies until they were fairly well proven.

1.1.4.2. Data Privacy and Security

Growers are also leery of sharing data or sending it “off-farm” for analysis, especially to manufacturers. They want to protect the privacy of their farm data. Several stated concerns that the major farm equipment manufacturers are collecting data for their own marketing purposes. Some of the growers NEEA interviewed indicated that they may be willing to look to a third-party, brand-agnostic data warehouse that can be trusted to store and protect their data.

In November 2014, a coalition of major farm organizations and precision ag technology providers reached an agreement on a set of Data Privacy and Security Principles, focused on transparency in how grower data will be used.² Several major agricultural firms and associations have undersigned this principles document, including John Deere, Monsanto, Raven Industries, the National Association of Wheat Growers, the National Corn Growers Association, and the National Farmers Union. Even so, concern about data privacy and security is likely to remain a potential barrier to adoption for a large portion of the addressable market.

1.1.4.3. Impacts on Water Rights and Allocations

Growers are also fearful that if they use less water today, the regulatory body that controls that water will reduce their allotment. While this issue is outside of NEEA’s areas of responsibility, the appropriate regulatory bodies should address the issue of water rights and allocation in order to encourage adoption of water- and energy-saving practices.

² As reported in the December, 2014 issue of “Voices of Agriculture” by the American Farm Bureau

2. Findings

2.1. The Experience Matters

Although the advent of new technologies and data access have facilitated irrigation practices getting “smarter,” they still have a way to go to becoming “easier” as well. Providing a successful experience of precision irrigation for growers is critical for more widespread market adoption. As noted, growers willing to try new technologies often look to their peers for confirmation or proof that new technologies will provide a good return on investment. Realizing the benefits takes time and additional investments; as one irrigation-product manufacturer noted, “Investing in precision agriculture has a learning curve and patience will be rewarded.” Given that growers have repeatedly stated that time is a valuable asset, manufacturers and suppliers should do what they can to reduce that learning curve.

Growers also need to feel confidence in the new irrigation technologies’ data. In studies conducted on grower adoption of precision technologies, including precision irrigation, researchers in Australia found that “The further they [growers] get down the PA (precision ag) road and the more data that is collected, the more questions are raised. The biggest challenge is to answer some of the questions and confidently set future directions. This issue faces many growers who have invested time, energy and money into PA and can result in a slump in motivation” (AG RIRDC 2014).

A successful precision irrigation experience starts with engaging the growers on the real-time, profitable value of changing their current irrigation practices. Growers just do not have time to “fool around” with time-consuming tasks that are frustratingly difficult. Vendors, suppliers, and agronomists need to come together to create solutions that are relatively simple and that work together.

2.2. Themes among Growers

While the individual growers who participated in NEEA’s 2014 demonstrations had unique backgrounds and varying levels of involvement with the PFR, VSI and/or VRI applications, they shared the following common themes with regard to their willingness to adopt integrated irrigation solutions. NEEA heard these themes throughout the three years of demonstrations:

- Start with the End in Mind (yield and profitability)
- Take Baby Steps
- Three Years to Prove It
- Never Enough Time
- It’s My Call
- Keep My Water Rights
- Multilingual Environment

2.2.1. Start with the End in Mind

First and foremost, growers care about yield and quality of crop, both of which drive profit. While yield uniformity is also important, it serves mainly an indicator of yield. Consultants and those advising growers should determine the yield a grower hopes to achieve with a crop from a particular field and include this information in the grower's crop plan. Irrigation consultants should review crop plans with the growers before making assessments of irrigation requirements.

The impact of precision irrigation practices on yield and quality varies not only with conditions such as soil and weather; its impact is also very crop-specific. Taking this into account can contribute to the creation of precision irrigation solutions more attractive to growers. For example, in 2013 Syngenta and Lindsay announced their introduction of a combined package of modified corn seeds and an irrigation prescription designed for those seeds.

2.2.2. Take Baby Steps

Growers juggle a multitude of responsibilities and tasks. They have neither the ability nor the time to make large-scale changes at once. Modularizing integrated irrigation solutions so that a grower can introduce additional components over time will likely increase the rate of market adoption of such solutions.

1. Identify the crop and one or two fields with which to start
2. Select an irrigation technology that is compatible with the current farm practices and irrigation equipment
3. Try the technology on twenty-five percent of the field(s)
 - a. Limit the parameters for decision-making (for example, the soil conditions for the majority of the field, crop requirements, near-term weather forecast)
4. Try the technology on the whole field without over-committing to the entire practice
5. Record and evaluate the results as inputs for year two

2.2.3. Three Years to Prove It

Because weather plays such a dominant role in farming, growers are dubious about relying on results from any single year. Reports that tout the advantages of using precision irrigation solutions should cover a period of three years and should document the details of changes made to the irrigation system, how they were executed, and yield/profitability results achieved over those three years. Such reports should include:

- The historical results of previous irrigations (minimum one year) as a baseline
- The grower's goals and crop plan, and any changes to these as the seasons evolved
- Specifics of changes made to the previous irrigation plan, including equipment and software/services
- The conditions under which the grower made the changes (weather, economics, impacting the choice of crops)
- The results in application
- The results in yield
- The results in terms of economic benefits (profitability, cost reductions, higher-quality and better transactions and/or reputations with buyers)

2.2.4. Never Enough Time

Time is the scarcest resource for most growers. Many work additional jobs to help support their families. As one grower said, “There seems to be always something around here that needs my attention.” Most growers wear multiple hats: financial planner, commodity trader, mechanic, irrigation specialist, manager, and many more. For these reasons, manufacturers and service providers should work together to reduce the amount of time needed to install and use integrated irrigation solutions.

Limited time also impacts growers’ abilities to read up on solutions to technical issues or best practices. Their attendance at “off-season” conferences varies based on other commitments they may have, such as working a secondary job. Several growers cited podcasts and YouTube as preferred information dissemination methods for coming up to speed on new practices, as they can listen to them in their trucks as they drive from field to field.

2.2.5. It’s My Call

The growers NEEA interviewed indicated a strong preference for making the final irrigation decisions either themselves or through a trusted consultant. They would not allow a software decision support system to automatically generate an irrigation schedule or prescription and send it directly to a pivot controller without a review by a human being. Growers want that final check that the data matches ground reality and that no other factors exist that would impede precision irrigation. They have a strong sense that, at the end of the day, they are personally responsible for the decisions made on their farms. While this attitude may change over time, the approach is deeply seated in farm practices today.

2.2.6. Keep My Water Rights

Although NEEA’s Agricultural Irrigation Initiative, by design, did not address the issue of water rights, this issue nonetheless holds sway over growers’ irrigation decisions. Several growers emphatically stated that they would be willing to reduce their use of water, but only if they were not going to be “punished” for doing so by having their water allocation reduced. They worried that the results of a “good year” with plenty of rainfall and use of precision irrigation practices would come back to haunt them the next year if a drought occurred. Although these issues are beyond the scope of this Initiative, they must eventually be addressed at a regional level by the appropriate regulatory bodies.

2.2.7. Multilingual Environment

Although exact numbers are unavailable, thousands of farmworkers in the Northwest either have first languages other than English or do not speak or read English at all. Providing multiple language options for precision ag solutions, including those for precision irrigation, can help to ensure the safe and effective operation of farm equipment.

Manufacturers have approached this issue in different ways. Some pivot manufacturers design the user interface to open in the default user interface (UI) language (such as English) and offer the option to change to other languages

2.2.7.1. Use of Icons and Symbols to Convey Information

Using internationally-recognized icons and avoiding text can also help when providing information and instructions for a multilingual work environment. User interface (UI) designers should consider a mix of universal and local solutions in the design of metaphors, mental models, navigation, appearance, and interaction. By managing the user's experience of familiar structures and processes, the user interface designer can create compelling forms that render the user interface more usable by and acceptable to a wider range of users.

The International Organization for Standardization (ISO) has defined internationally-accepted requirements for designs, colors, content, and shapes of graphical symbols. These symbols convey important messages about product features, directions, and other aspects of daily work and home life. Critical areas include health- and safety-related warnings, prohibitions, and mandatory actions. Some of these standards are outlined in Table 1 below.

Table 1. ISO Required Standards for International Icons and Symbols

Standard Series	Purpose
ISO 3864	Specifies design requirements, including shapes and colors, for safety signs
ISO/IEC 80416	Specifies basic principles for graphical symbols for use on equipment
ISO 7000	Specifies graphical symbols for use on equipment
ISO 7010	Specifies graphical symbols with regard to safety colors and safety signs

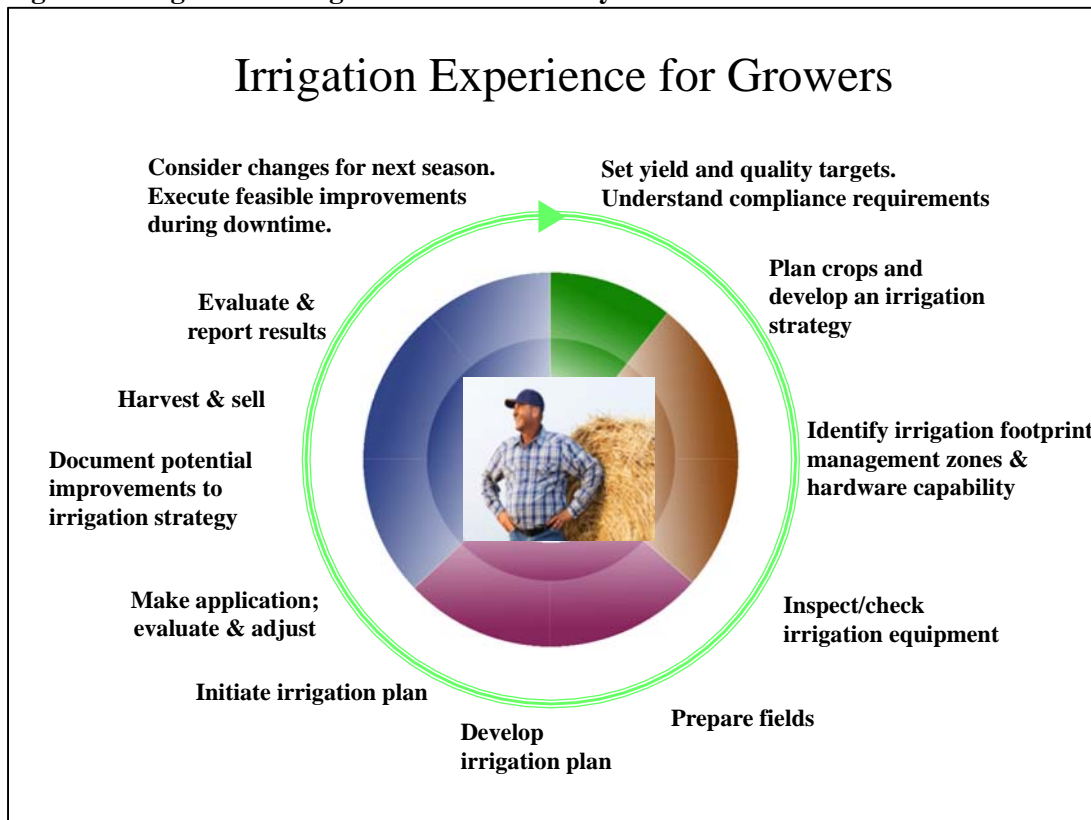
Other tips for designing multilingual user interfaces include:

- Provide lots of white space to accommodate the use of icons and symbols
- Isolate all user interface elements from the program source code. Put them in resource files, message files, or separate databases
- Keep in mind that dialog boxes will need extra room for localization because some word translations are much longer in a localized format
- Avoid text in bitmaps and icons, as these are difficult to localize
- Test localized versions of messages and screens with native speakers

2.3. Service Providers and Growers Should Develop a Clear Plan

The grower must make hundreds of decisions both large and small throughout the year, and when to irrigate is just one of those. As Figure 1 shows, integrated irrigation depends upon close links among agronomic goals, farm conditions, soil and weather data, and the capabilities of available equipment.

Figure 1. Irrigation Management Includes Many Decisions



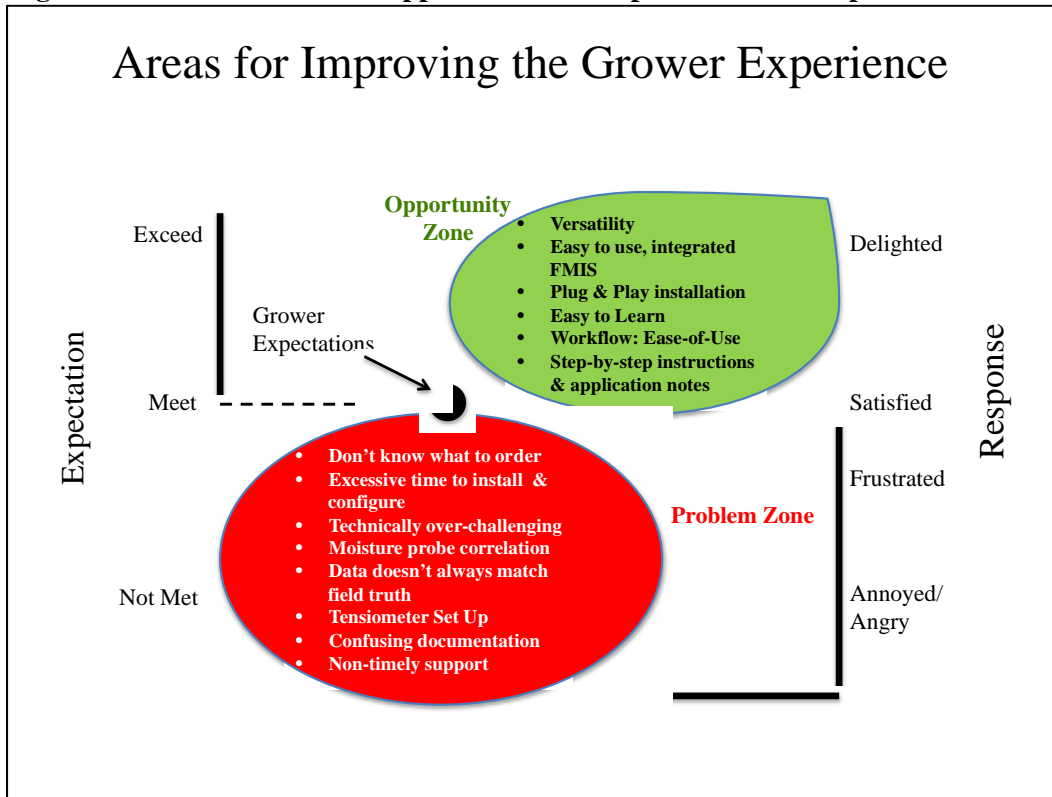
Knowing when and how much to invest in precision irrigation can be a daunting task. In order to create a process that functions as smoothly as possible, growers and agronomic consultants should use the following checklist when considering the adoption of precision agriculture technology products and services:

1. Establish a clear objective when adopting precision agriculture technologies and/or practices
2. Select technologies that can be used for multiple operations
3. Identify tools that can be easily moved among different pieces of farm equipment
4. Choose technologies that will be compatible with current and future farm equipment
5. Ensure that precision agricultural equipment can be easily and inexpensively upgraded
6. Determine the level of sensor and equipment accuracy required for specific operations
7. Ensure that recorded data will be easily transferrable
8. Determine the future needs for the farming operation and how current precision agriculture technologies can play a role
9. Understand the time requirements for adoption of precision agriculture systems and determine a timeline for implementation
10. Take advantage of the training, support, and service tools that are available for the new products and practices

2.4. Vendors Can Improve the Grower Experience

During the NEEA demonstrations, the technical team identified areas in which growers experienced difficulty in selecting, installing, integrating, and using irrigation equipment, as illustrated in Figure 2 below.

Figure 2. Problem Areas and Opportunities to Improve Grower Experience



Specific hardware issues are documented in the *Instrumentation and Hardware Best Practices in Precision Agriculture* report.

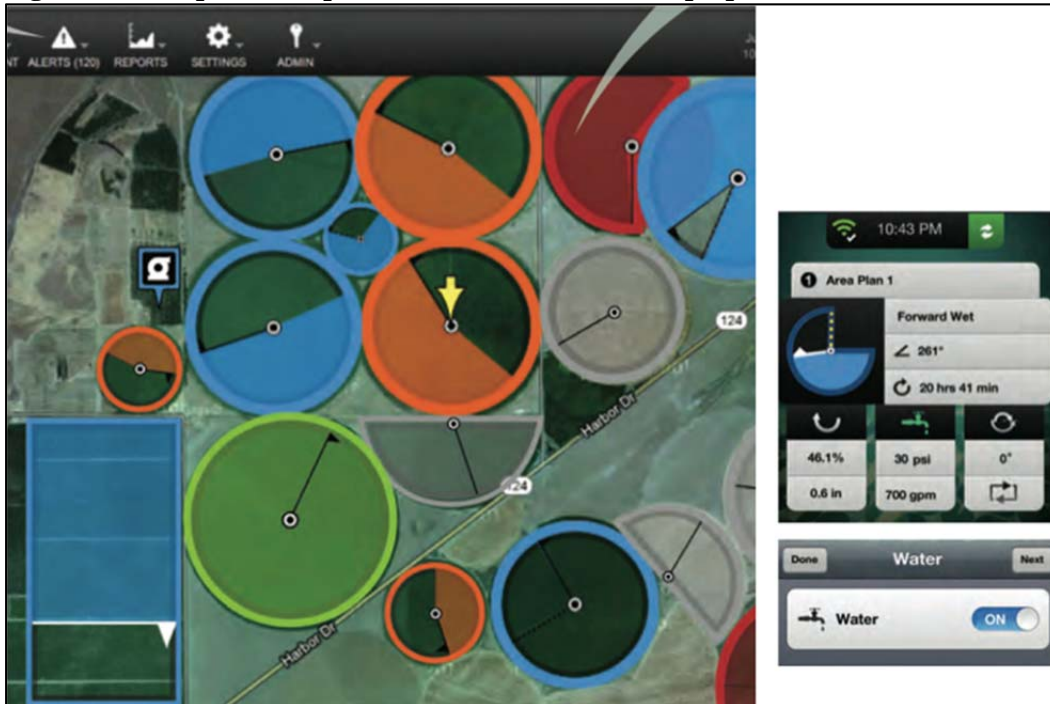
2.5. Recommendations for Designing a User Interface for Irrigation Applications

Because so many of growers' interactions with irrigation equipment are now taking place via smartphones, tablets and/or laptops, vendors should ensure that the user interfaces for their applications provide a simple and consistent way of displaying data so that growers can easily use these data as actionable information. Guiding principles include the following:

1. Be consistent in the placement of information and user controls
2. Use color effectively to help users understand text and graphics
3. Provide easy navigation through the visual hierarchy, and organize information in discrete sections
4. Scale user interface and graphics to match mobile devices
5. Plan for the localization needs of users

Figure 3 illustrates an example of how manufacturers (Lindsay Corporation, in this example) are using graphical user interfaces. Figure 3 further details the guidelines above.

Figure 3. Example of Graphical User Interfaces for Laptops and Mobile Devices



Note: Examples from Lindsay Corporation's FieldNET and FieldNET mobile applications

3. Risks and Challenges

3.1. Risks

The greatest risk to adoption of precision irrigation technologies is that growers may not consider the benefits of changing irrigation practices to be worthwhile due to the time and difficulty of installing and using new equipment and changing agronomic practices. Growers at larger farms realize that they need a full-time IT resource to keep all of the technology running, especially if existing public infrastructure provides inadequate service. Industry stakeholders can mitigate this risk by documenting case studies and using testimonials from growers showing that adopting precision irrigation practices results in improved quality, uniformity, and yield, with a positive impact on the grower's bottom line.

Encouraging adoption of these new irrigation technologies is especially difficult because the solution depends upon multiple pieces of equipment and multiple sources of data. No stakeholder in the current market provides or directs an end-to-end grower experience for precision irrigation. The market also lacks vertical integrators to guide growers in planning and executing precision irrigation solutions year after year, at competitive prices that the market can bear.

NEEA and other industry stakeholders should leverage the relationships built through the NEEA Agricultural Irrigation Initiative demonstrations and the Precision Ag Irrigation Leadership (PAIL) data standards work. Vendors have indicated a desire to continue to promote more seamless integration of precision irrigation solutions. The *Data Exchange Standards* report discusses this issue in greater detail.

3.2. Challenges

Simple is hard. It goes beyond ease-of-use. It requires multiple vendors and service providers coming together to master the complexity of precision irrigation and turn it into a competitive advantage for the grower. "Simple" is not about discarding current irrigation equipment and farm practices that growers have in place, but is rather about integrating precision technologies within the grower's existing farm practices. The ultimate goal is getting all of the technology to work together and run simply so that growers can not only adopt new irrigation practices themselves, but spread the word to their neighbors and trade groups.

Simple can also be expensive to undertake, given the numerous interfaces that abound in the market today. Vendors must be willing to give up some of their proprietary interfaces and data-sharing mechanisms if market adoption is going to take place. Providing a consistent view of important data, such as under-watering and overwatering states, can help increase the market adoption of precision irrigation solutions.

4. Lessons Learned, Value of Findings, Next Steps

4.1. Lessons Learned

4.1.1. Make It Easy to Understand “Why” and Easy to Do

Providing a clear value proposition and a simple solution are key requirements for increasing the rate of grower adoption of new precision irrigation solutions. Growers need to see direct links between their investments in precision irrigation practices and their bottom lines.

While incentives can play a role in early adopters’ decisions to install and use new precision agriculture irrigation technologies, the manufacturers and growers who provided feedback for this study did not fully understand their impacts. While growers may be motivated to purchase by incentives such as equipment upgrades or reductions in their utility bills, changing a farming practice is not an easy undertaking. Moreover, reaping the benefits of an integrated irrigation solution occurs over many years, and growers may abandon new practices after the perceived value of the incentive has worn off. These perceptions and assumptions suggest the value of scientifically-designed future research to quantify the ongoing value of specific incentives and the manners in which they impact growers’ rates of adoption and farming practices.

4.1.2. Make It Simple for Growers

Focusing on usability can help manufacturers and solution providers define a “minimum viable product” that would have a higher chance of adoption over a “home-run” solution, especially in the initial years of market development.

The findings in this report point to the need for developing local “beta tests” of integrated solutions before they are ready for market adoption. Ideally, growers would use solutions that fit within their current farm systems and would receive documentation and training to install and use those solutions on their own, with NEEA representatives observing their interactions and noting areas of success and frustration.

4.2. Next Steps

Hardware and software vendors should continue to look for ways to integrate and simplify the precision irrigation experience for growers. Consistency in terminology and definitions constitutes a good starting point; efforts to create consistency have begun with the publication of the AgGateway AgGlossary. In addition, vendors should continue to simplify and integrate their individual solutions, especially with other vendors and service providers

Major irrigation solution vendors, such as Lindsay and Valmont, have questioned the role of incentives in transforming this market; they believe that providing better value for growers would be a more successful route. These vendors would like to see regional research specifically designed to study the role of incentives in long-term market adoption of new irrigation practices.

The precision irrigation industry should develop a deeper understanding of the grower market. For example, differentiations among grower solutions are generally based on the size of the farm. This report has noted that solutions need to be highly customized to specific growers' circumstances; however, getting to mass customization is so expensive that it is an unrealistic goal. A market segmentation study could provide vendors with the insights to design modularized solutions that could be put together without having to create a one-to-one solution for each grower.

4.3. Value of Findings

Vendors participating in the NEEA demonstrations and/or the PAIL data standards project have expressed strong interest in the results of the grower experience analysis. These vendors have rarely had the opportunity to work together when a grower's solution involves multiple products from multiple vendors, or when a grower uses multiple brands of one product. Feedback from growers participating in the NEEA demonstrations provided insights for many areas of improvement. NEEA shared the issues and opportunities shown earlier in Figure 3 with its participating vendors. Some of them, such as Ranch Systems and Farm Systems, are already taking specific actions to address these grower-specified problems and opportunities.

Findings from the NEEA demonstrations offer vendors the capabilities to develop and execute business strategies focused on excellent and inimitable customer experience. Joe Russo, president of ZedX, Inc.,³ stated in a 2014 PrecisionAg online article:

“Customers interested in precision agriculture services want programs that can be easily integrated into their current decision-making habits. If a program is too complicated or takes too much time, it could result in a delayed or bad decision. A program that requires a lot of effort to get tangible results will be perceived as a burden and not a benefit. Furthermore, the mistimed introduction of a program that results in a bad experience will make a customer hesitant about trying a new precision agriculture service. This reluctance negatively affects not only the customer, but the industry as a whole.”

By adopting precision irrigation practices, NEEA posits that growers can reduce their water and electrical energy use and increase yield.⁴ Focusing on the grower experience is critical to market adoption of precision irrigation solutions. As NEEA stakeholders look toward focusing on integrated irrigation solutions for smaller-sized farms, the need for easy-to-use irrigation solutions will increase.

³ ZedX, Inc. is a leading developer of agricultural business intelligence and information technology (IT) products and services for the sustainable agricultural industries.

⁴ NEEA's research to date supports these claims; however, readers should consider them advisory/ directional rather than generalizable due to the small numbers of responding growers and manufacturers and to the non-scientific nature of the interviews.

5. References

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Appendix A – Guidelines for Designing a User Interface for Ag Irrigation Applications

The guidelines below are designed as a place to start in the development of market approaches and user interfaces for agricultural digital design, including mobile (phone, tablet) and computers. The examples used are primarily from agricultural interfaces with growers as the primary target users.

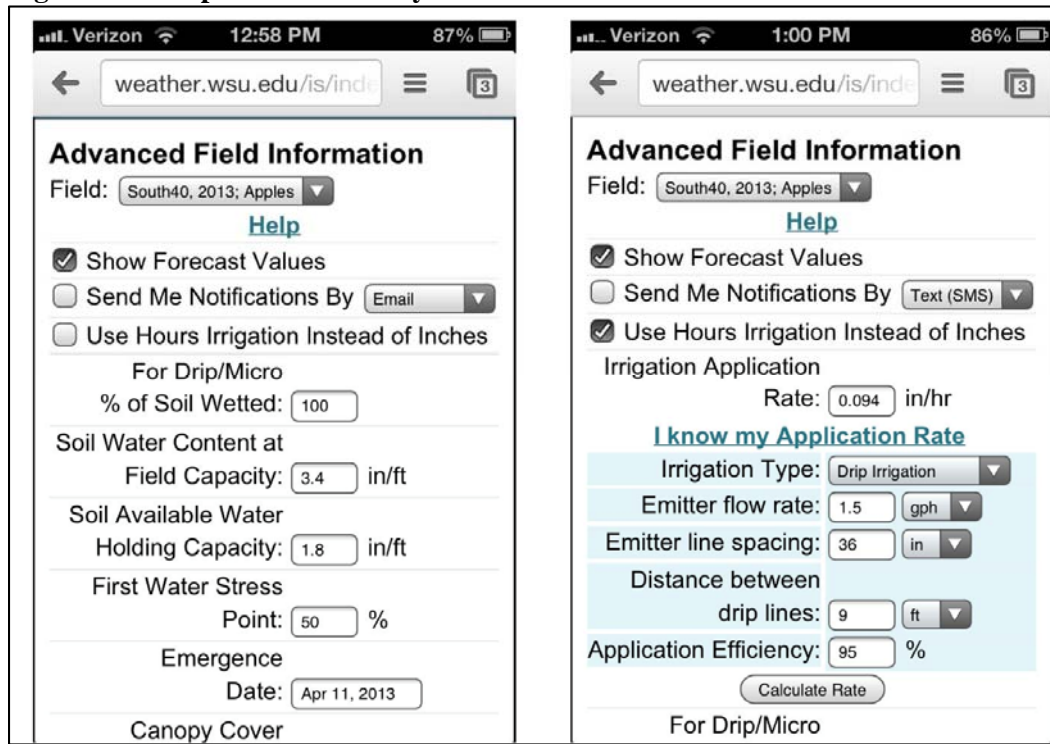
Create Consistency

Put information and controls in consistent locations on all screens, as shown in Figure 4. Place controls and data displays that serve the same function in the same position on each screen on which they appear. Use the same colors and text fonts. Avoid tiny fonts or patterned backgrounds. All digital interface designs must provide intuitive ways for users to navigate forward, backward, or to a specific location. Designers should provide consistent navigation tools located in the same place on every screen.

- **Green** is good
- **Amber** is caution
- **Red** requires immediate attention
- **Blue** is too much

Texts or other messaging outside of normal announcement times require immediate attention.

Figure 4. Example of Consistency in the User Interface



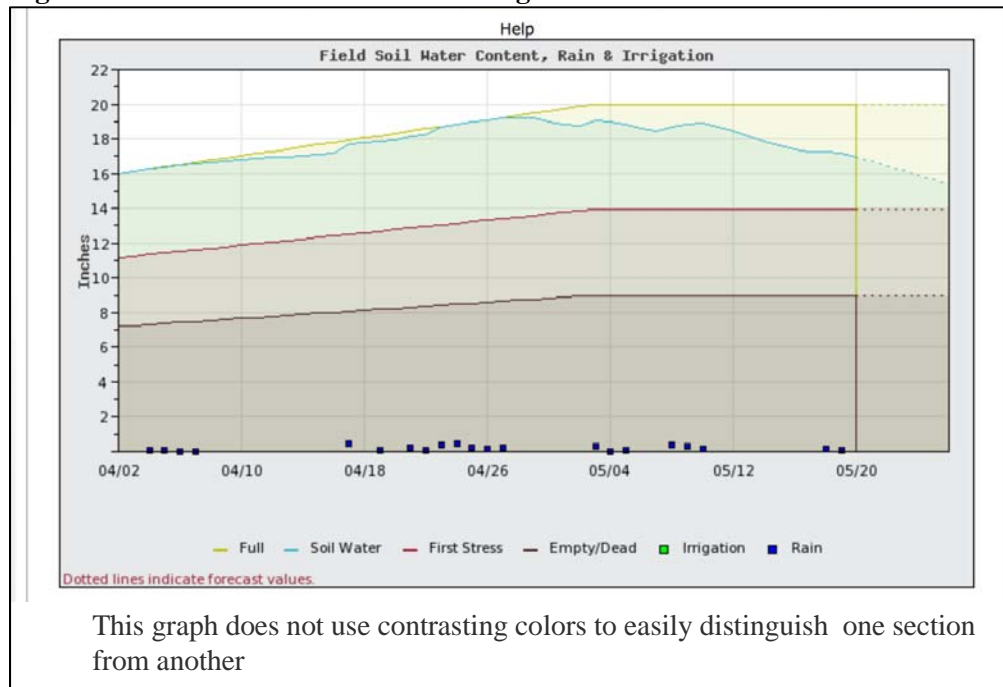
Use Color Wisely

The proper use of color is very important in helping users to understand text and graphics, given that these tools are used in the field and must be readable in all weather and light conditions.

When designing user screens with color, keep in mind:

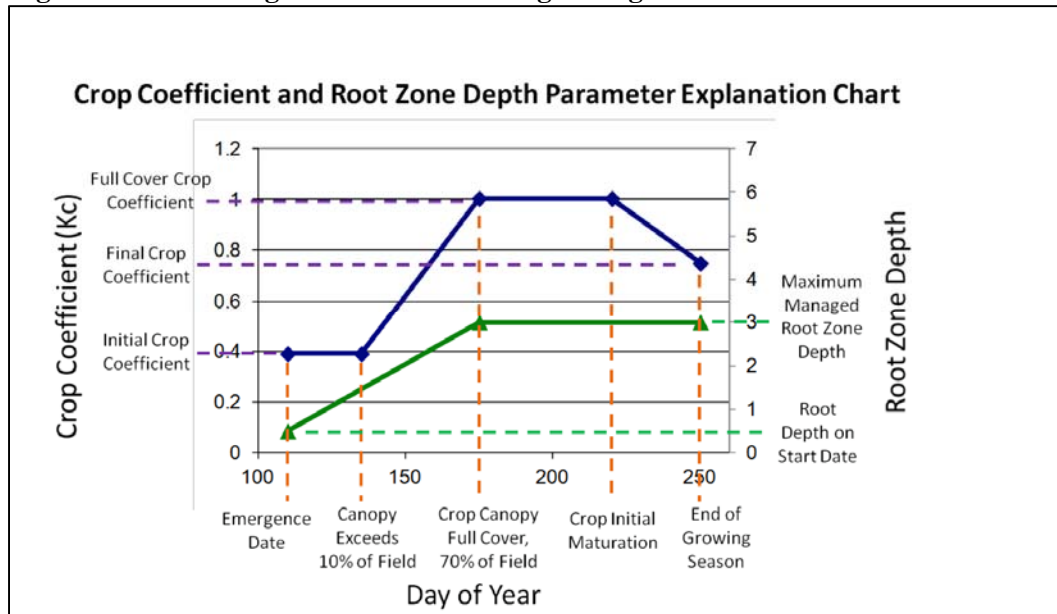
- Pale colors are difficult to tell apart, as Figure 5 illustrates.
- Distinguishing among the colors of small or thin objects (such as lines, icons) is difficult.
- Similarly, fonts composed of thin lines increase the difficulty of determining the exact color of the text.
- Patches of color separated from one another increase the difficulty of distinguishing among their colors, especially if the separation is great enough to require eye motion between patches.

Figure 5. Pale Colors Are Hard to Distinguish



Increasing the contrast between colors, as shown in Figure 6 below, helps the user to quickly distinguish the difference between lines.

Figure 6. Contrasting Colors Aid in Distinguishing between Lines



Design for Color-Blindness

Designers should keep in mind accessibility guidelines⁵ for disabled individuals during the design of all software applications and websites. They often fail to consider color-blind users during the design process; accommodating these individuals' visual needs requires some specific design strategies. Color-blindness does not mean an inability to see colors, but rather a difficulty in distinguishing among certain pairs of colors. Key design guidelines include:

- Distinguish colors by saturation and brightness as well as by hue. Avoid subtle color differences. Make sure the contrast between colors is high (as exemplified in Figure 7. Contrasting Colors.
- Use distinctive colors: red, green, yellow, blue, black, and white.
- Avoid color pairs that color-blind people cannot distinguish. Such pairs include dark red vs. black, dark red vs. dark green, blue vs. purple, and light green vs. white.
- Use dark reds, blues, and violets only against light yellows and greens, not against any dark colors.
- Use differing shapes instead of, or in addition to, different colors to further distinguish among unique datasets (see Figure 8).

⁵ The Americans with Disabilities Act (ADA) website www.ada.gov provides additional information.

Figure 7. Contrasting Colors

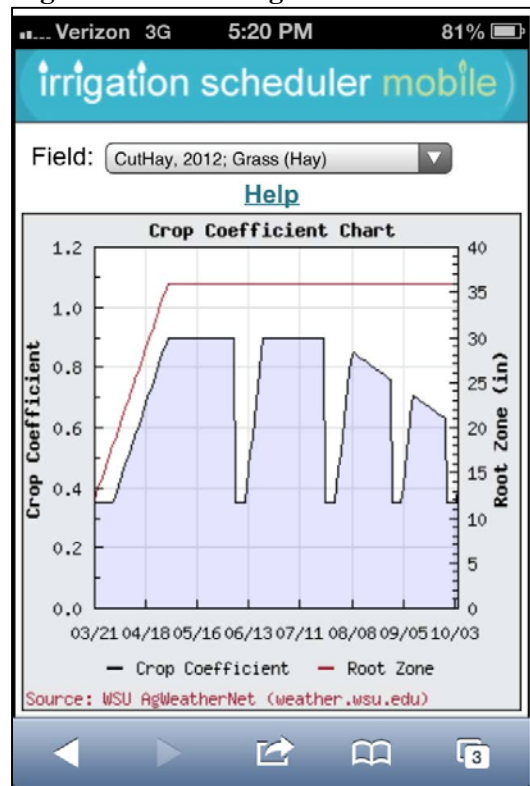
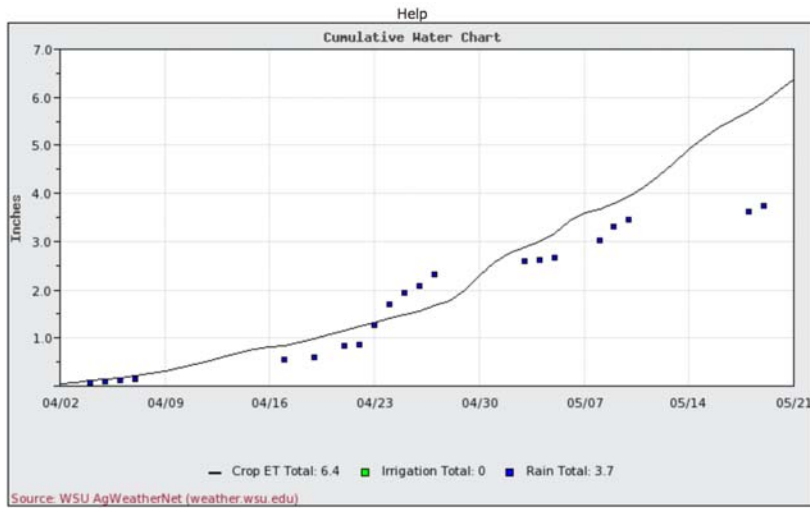
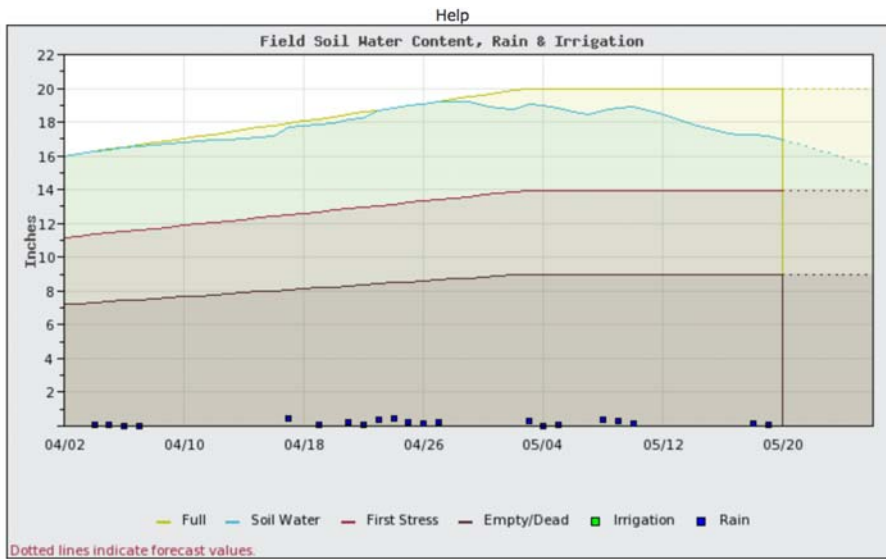


Figure 8. Contrast Is More Pronounced with Dots vs. Lines over Colors Only



High contrast using dots rather than color is easy to read

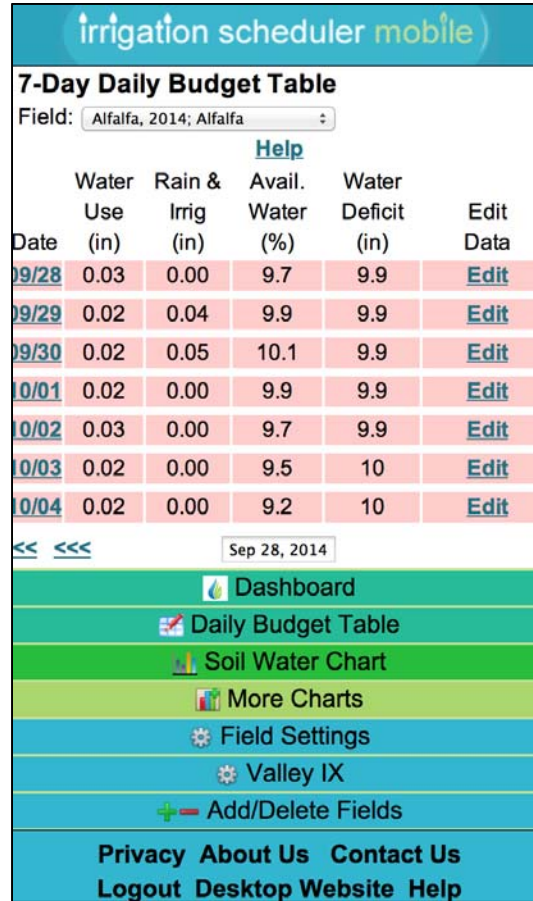


Red-green color-blind people cannot distinguish dark red from black or light green from white. This graph would be difficult for them to read.

Create a Visual Hierarchy

Creating a visual hierarchy and organizing information into distinct sections helps users to identify and quickly scan relevant information, particularly numbers. The example below in Figure 9 shows a good visual hierarchy with its use of color for grouping similar content for easy navigation.

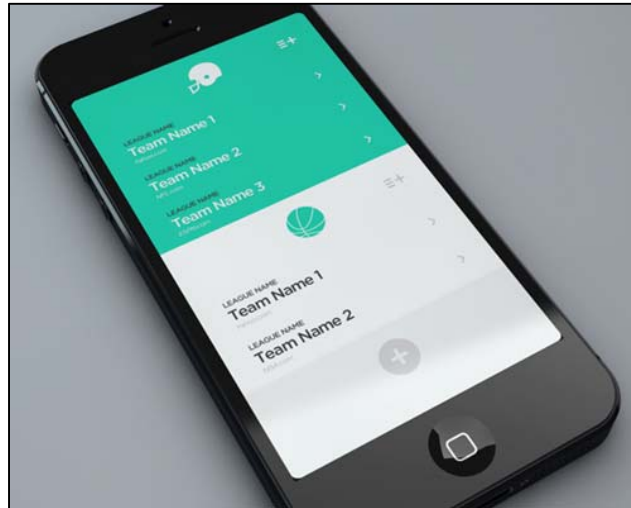
Figure 9. Visual Hierarchy Aids Readability



Mobile Design Tips

- Most users view websites and apps from their mobile devices. Given the range of screen sizes among device types, even on the same mobile platform, scaling user interfaces and graphics to the screen size will help to create a consistent look and feel across all devices.
- Screen resolutions vary. Retina displays such as those on many Apple products show incredible detail (see Figure 10), so all visual elements must be high-resolution.

Figure 10. Example Smartphone Screen



- Make messages visible. Put them where users are looking, in predictable places.
- Reserve red for errors. Using red for any other type of information invites misinterpretation.
- Use pop-up dialog boxes and beeping alerts sparingly. Most users consider these types of alerts annoying.
- Implement the ability for users to mouse over a location to get exact data if they need or want it.
- Design for touch: tablets and mobile phones use the “tap” or “swipe” conventions vs. the ubiquitous “click” on a computer. Use visual cues to indicate that an item can be touched to expand or lead to a new screen.
- Design mobile apps to incorporate gestures, such as swiping forward and back, pinching to zoom, and pulling down to refresh. Keep main menus and selectors at either the bottom or the top of the screen where they are easy to touch and swipe.
- Design apps to function without Wi-Fi. Growers are typically out in their fields where Wi-Fi access is often absent.
- Limit screen text. Put important information at the top of the screen so users do not have to scroll. For screens displaying considerable content, use scrollable text frames or create a swipe to move the user to another section of text.
- Limit the amount of white text on black background. It is hard to read.
- Make it simple: users lose interest quickly if an app is not easy to use.