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# A Graduate-Level Field Course in Irrigation and Agricultural Water Management for an Immersive Learning Experience

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# A Graduate-Level Field Course in Irrigation and Agricultural Water Management for an Immersive Learning Experience

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**ABSTRACT.** *Effective irrigation and agricultural water management (IAWM) is critical for food security and water security. A key requirement in designing, implementing and operation of IWM is the necessary knowledge and capacity on the farm, in the service industry and within the supply chain. Educational opportunities that not only teach the relevant principles of irrigated agriculture, but also the necessary applied skills are essential. An Irrigation Field Course was initiated by the IHE Delft Institute for Water Education (IHE Delft) and was later developed as a joint field course with IHE Delft, the University of Nebraska-Lincoln (UNL), and the Daugherty Water for Food Global Institute (DWFI). The field course was designed as a two-week course, an immersive experience. The field course was a combination of hands-on laboratory exercises (both lab and field), brief lectures to prepare students for the labs, data analysis, lab reports, and tours. Laboratory topics included surface, sprinkler, and drip irrigation systems; flow in pipelines and open channels; and irrigation well hydraulics. Tours addressed broader topics including IAWM extension programs, technology for irrigation management, manufacturing, water resources management, and impacts on ecosystems. One of the benefits of the field course is that it provides a vantage point from which a student gains a clearer systems perspective of irrigated agriculture, whether their home country is in an irrigation development phase or a water conservation phase. Students often use the data collection skills from the field course in their graduate research projects. A survey was conducted to assess which components of the course were most helpful to the students, and to compare the format of the field course to a typical semester-long course. Students indicated that the immersive two-week experience, with hands-on learning and tours providing a systems perspective, were particularly helpful (60% "strongly agree") compared to a lecture-based irrigation course.*

***Keywords.*** *Experiential Learning, Field Course, Hands-On Assignments, Irrigation, Teaching and Learning*

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# Introduction: Need for Irrigation Education

Effective irrigation and agricultural water management (IAWM) is fundamental to the intensification and improved resilience of global agriculture. This applies across the continuum of rainfed to fully irrigated situations and from the large-scale operations in Nebraska and the mid-west to small-scale systems typically found in Rwanda and other countries in sub-Saharan Africa (DWFI, 2018).

Achieving water-wise global food security depends on successfully applying fit-for-purpose technology, practice and policy solutions across a kaleidoscope of conditions. It is especially important to consider the nuances of the region, including available water and land resources, management and governance capabilities, the present level of development, and the existing knowledge and capacity of the farmers.

The effectiveness of specific initiatives depend on what is feasible in each context and can range from enhancing rainfed systems by incorporating no-till or cover crops to using highly efficient drip irrigation to ensure every drop captured is productively utilized. Where conditions permit, and along with increased investments in crop breeding and management (Mekonnen, 2019), farmers are increasingly turning to some form of irrigation to reduce risk, increase productivity and/or returns and adapt to changing conditions (Rimsaite, et al 2021; Merrey et al, 2020).

A key requirement in designing, implementing and managing irrigation systems is the necessary knowledge and capacity on the farm, in the service industry and within the supply chain. Educational opportunities that not only teach the relevant principles of irrigated agriculture, but also the necessary applied skills of successfully developing, managing and integrating it into a range of agricultural systems, are essential. The immersive learning field course presented here, developed in collaboration between the IHE Delft Institute for Water Education (IHE Delft) and the University of Nebraska–Lincoln (UNL), is a unique opportunity to strengthen these increasingly essential insights and skills.

In recent decades, there has been a growing interest in irrigation engineering and management courses. Porter et al. (2020) describes an ongoing need for irrigation expertise, a decline in available expertise, and a decline in curricula/degree programs in irrigation. Irmak and Djaman (2015) describe how agricultural engineers, and irrigation engineers in particular, are uniquely qualified to address water and food challenges. This is because irrigation engineers integrate basic sciences, engineering fundamentals, agricultural machinery/infrastructure, technology, and a systems approach. Riley (2015) underscores the need for irrigation engineers and the importance of providing educational programs at both the undergraduate and graduate levels.

The Irrigation Association (IA) and the Irrigation Innovation Consortium (IIC) led an "Irrigation Industry Survey and Needs Assessment" including both a survey (n=414) and interviews (n=20). Responses highlighted a need for more training and workforce development in irrigation, along with a need for educational programming and standards for irrigation curriculum (Hutton and Kremen, 2022).

The objectives of this paper are to present the concept of a field course in IAWM and to share our experiences with the course. While a field course is popular in some disciplines (e.g., geology), it is not yet common in agricultural and biological systems engineering.

### History and Development of the Irrigation Field Course

IHE Delft initially developed the Field Experiments in Irrigation course out of a recognition of the value of hands-on learning for students in irrigation. The course was for master's students coming from different countries, sometime least developed countries, with different educational backgrounds and also different opportunities in practical field skills development. An important learning objective of this course is to become able to select, organize, and apply different, appropriate field instrumentation and measurement methods in practice, considering the availability of tools and resources in different areas of the world where students will return to their home countries. We demonstrate and include a wide variety of techniques and instrumentation from the traditional, simple ones to the most up-to-date, modern ones.

In 2011 a partnership began between IHE Delft and the Daugherty Water for Food Global Institute (DWFI) and the University of Nebraska-Lincoln (UNL). One component of the partnership was that IHE Delft's field course would be hosted in Nebraska in even-numbered years, beginning in 2012. This was a positive collaboration, combining IHE Delft's experience with the Irrigation Field Course and UNL's expertise in irrigated agriculture. The partnership helped to further develop the course incorporating a range of experiences and expertise; this broadened the view of the students in critical analysis of field results, recognizing possible areas of error or uncertainty, and integrating quantitative measurements with qualitative terrain observations (Figure 1).

Irrigated agriculture is an area where a multidisciplinary overview of actual technical, research and organizational activities in the fields of water management, hydraulic engineering, hydrology and agronomy are all important; demonstrating all these in the field is of key importance in the Irrigation Field Course. This experiential learning course also gave students the practical skills they needed for their applied research project. Many of the students would subsequently return to their home countries and utilize the skills from the field course and their project (for example, Banda et al., 2019).

Certainly not all graduates will use all the field skills in their own career and practical work, but at a minimum the field skills help them to develop an approach and intuition, which prove to be useful when working together with others in a variety of situations.

**Figure 1. Hands-on lab activities, including solid-set sprinkler irrigation (upper left); center pivot irrigation (upper right); streamflow measurement (lower left, photo credit: Jordan Opp); and furrow irrigation (lower right).**

## Course Overview

The Irrigation Laboratory and Field Course is a graduate-level course cross-listed in Mechanized Systems Management (MSYM 854), which is similar to agricultural systems technology programs, and Agricultural Engineering (AGEN 854). The course is not open to undergraduate students. An introductory course in either irrigation engineering or irrigation management is required as a prerequisite.

Enrollment in the course has ranged from 10 to 22 students. When the course was initially hosted by UNL, the enrollment was comprised entirely of students from IHE Delft; over time, UNL students began taking the course as well. In 2020 the course was cancelled due to COVID. In 2022, the IHE students did not participate due to COVID uncertainties, so the course was entirely UNL students. Six of the 10 students from 2022 were from developing countries, and plan to return to their career in their home country after their education.

**Course Format**

The field course is designed as a two-week course, an immersive experience. Class typically meets five to six days per week, with most days being 10-12 hours. Assigned reading and some of the lab reports are completed outside of class time. The course format allows non-traditional students who are working full time to take the course with a minimum numbers of days off from work.

The field course is a combination of hands-on laboratory exercises (both in the hydraulics laboratory and at various field sites, Figure 1), brief lectures to prepare students for the labs, data analysis, lab reports, and tours (Figure 2). One of the benefits of a field course is that it provides a vantage point from which a student gains a clearer systems perspective of irrigated agriculture.

**Figure 2. Tours, including linear move irrigation at the Panhandle Research and Extension Center (upper left, photo credit: Thomas Monroe); subsurface drip irrigation with fertigation at the West Central Research, Extension and Education Center (upper right, photo credit: Thomas Monroe); diversion dam on the Platte River (lower left); and canal with radial sluice gate in the Central Nebraska Public Power and Irrigation District (lower right).**

The last three days of the course are designed for a three-day and two-night field trip to several university IAWM research facilities and non-university projects across Nebraska covering 675 km (Figure 3). The university research/project sites included three university facilities: South-Central Agricultural Laboratory, West Central Research, Extension and Education Center, and the Panhandle Research, Extension and Education Center. The irrigation management specialist at each research site was asked to provide a lecture about their various irrigation research projects along with the objectives and methodology of the given project. The irrigation extension educators also participated and shared their knowledge and experiences in irrigation management practices with the students and how they cooperate with the farmers. The non-university IAWM project sites included Johnson Lake and Jeffrey Reservoir, with tours of dams, canals, hydroelectric plants, and the Paxton siphon.

A team-based learning approach is used in the course. Teams are formed to create diversity, both in terms of home country and previous coursework. This ensures that each team has a range of strengths (e.g., quantitative understanding of irrigation system design, previous experience with practical irrigation management). Students also learn much from teammates from other countries during discussions of water issues and the practice of irrigation in their respective home regions. Teams have some time to work on the lab reports in the classroom while the lab activities are fresh on their minds. This creates a highly interactive environment for both the students and the instructors.

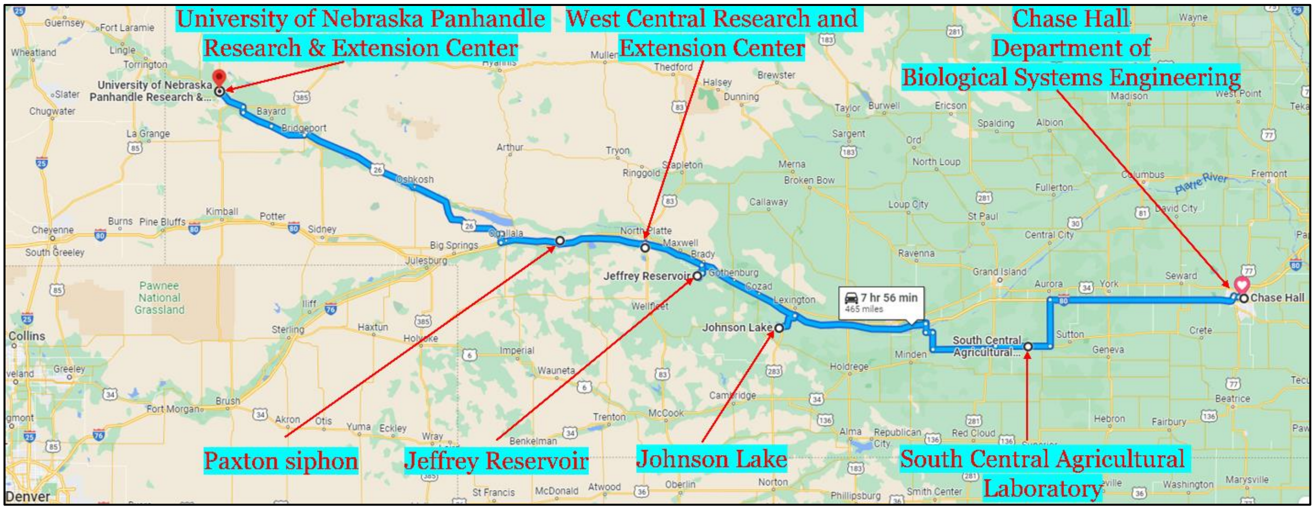


**Figure 3. Locations of irrigation research facilities and irrigation projects visited during the field course, ranging from Lincoln to Scottsbluff, Nebraska, USA.**

## Course Content

The Irrigation Field Course emphasizes IAWM water supply and distribution systems, in the context of irrigated crop production and water resources management. Laboratory topics include performance of surface, sprinkler, and drip irrigation systems; flow in streams, canals, and irrigation pipelines; and irrigation well hydraulics. The field trip includes visits to irrigation field research sites, irrigation extension programs, subsurface drip irrigation systems, and technology for irrigation management. For a textbook, the field course uses *Irrigation Systems Management* (Eisenhauer et al., 2021) which is open-access and available both digitally and in hard copy. The associated Instructor Kit (Heeren & Eisenhauer, 2022) is used for some of the lab assignments.

The field course includes the following learning objectives. Following the course, students should be able to:

- Measure water flow rates in irrigation pipelines and open channels, calculate water application rates and volumes, and calculate water measurement accuracy.
- Measure the water application uniformity and application efficiency of sprinkler and furrow irrigation systems.
- Select, describe, and evaluate sprinkler, microirrigation, and surface irrigation systems.
- Measure drawdown in irrigation wells and calculate the specific capacity of a production well.
- Define the impacts of irrigation on water resources and ecosystems.
- Appreciate the many facets that are needed to successfully develop and manage irrigated agricultural production.

An example schedule of the lab assignments and tours is shown in Table 1. Tours vary each time the course is offered, but generally include industry tours (center pivots, drip irrigation, pumps), a surface water delivery system (Central Nebraska Public Power and Irrigation District), UNL Research and Extension Centers (e.g., the Eastern Nebraska Research and Extension Center), and Natural Resources Districts (NRDs).

As future irrigation engineers and management specialists, it's essential that students can apply their knowledge in practical settings and adapt it to meet local stakeholders' needs. This course provides tours to satellite research and extension centers located throughout the state, giving students exposure to different extension programs. By transitioning from a class setting to field research stations, students gain firsthand experience with localized water management challenges and how extension programs address them. This opportunity allows them to connect classroom concepts with real-world issues. For instance, students have the chance to analyze soil water content graphs from actual growers' fields, which can be influenced not only by crop water use and natural conditions but also by water delivery and disease management issues. This experience enables students to understand the critical role that extension programs play in addressing real-world challenges.

Example laboratory assignments are included in the appendix. Besides the laboratory assignments, students are also required to write a memorandum which describes the linkages among industry, government, farmers, and research and educational institutions, and the important role that they each play in successful development and management of irrigated crop production.

Two of the labs were directly related to water resources, both important for understanding water sustainability and water use for irrigation. Each group of students was given a pressure transducer to measure the pressure and equivalent water depth in a bucket of water and how the depth and temperature varied over time as they added water and ice. This is the same method used to measure water depth in both streams and water wells. To measure discharge in a nearby stream, students used two methods, a FlowTracker and a float on the water surface (an orange). This lab gave them the opportunity to use the latest technology and compare it to the results using materials that are easily accessible (orange and tape measurer).

**Table 1. Example schedule for the field course from 2022.**

| Date | Topic | Reading | Location | Lab Assignment | Comments |
|---|---|---|---|---|---|
| 7-6 | Welcome & Introduction | | Chase 112 | | 8:00 |
| 7-6 | Valmont Industries Tour | | Valley, NE | | 9:00 Depart (CHA 112)<br>10:00 Tour |
| 7-6 | Sensors for Water Depth Measurement | | Chase 141 Hydraulics Lab | Pressure Transducer Lab | 2:00 |
| 7-6 | Flow Measurement in Pipelines and Open Channels | Chapter 3 | Chase 141 Hydraulics Lab | Flow Measurement Lab | 3:30 |
| 7-7 | Streams and Riparian Ecosystems | Chapter 3 | Salt Creek (Pioneers Blvd) | Stream Flow Lab | 8:00 Depart (CHA 112)<br>8:30 Arrive |
| 7-7 | Natural Resources Districts | | Upper Big Blue NRD | | 1:15 Depart<br>2:30 Presentation |
| 7-8 | Irrigation Production Wells | Chapter 9 | Arbor Grove Produce | Well Drawdown Lab | 7:45 Depart (CHA 112)<br>9:00 Arrive |
| 7-8 | Surface Irrigation, System Evaluations | Chapter 10 | Arbor Grove Produce | Furrow Irrigation Lab | 10:00 |
| 7-8 | Solid-Set Sprinkler Irrigation, System Evaluations | Chapter 5 | Arbor Grove Produce | Solid-Set Sprinkler Lab | 1:30 |
| 7-9 | The Soil Water Reservoir | Chapter 2 | Chase 139 | Soil Water Measurement Lab | 8:00 |
| 7-9 | Water Resources and Ecosystems | Chapter 9 | Chase 112 | | 11:00 |
| 7-9 | Team Time (work on lab reports) | | Chase 112 | | 1:00 |
| | | | | | |
| 7-27 | Center Pivots, UAS, Tour | Chapter 13 | UNL South-Central Ag Lab | Center Pivot Lab | 8:00 Depart (CHA 112)<br>Lodging in North Platte |
| 7-28 | Internet of Things, Subsurface Drip Irrigation, Extension, Tour | Chapter 14 | UNL Panhandle Research and Extension Center | | 8:00 Depart from hotel<br>Lodging in North Platte |
| 7-29 | Linear Move Sprinkler Systems, Extension | Chapter 13 | UNL West Central Research, Extension and Education Center | Linear Move Lab | 7:00 Depart from hotel lobby |
| 7-30 | Friction Loss in Pipelines | Chapter 8 | Chase 141 Hydraulics Lab | Pipeline Hydraulics Lab | 8:00 |
| 7-30 | Linkages among Farms, Water Resources, Governance, and Research/Teaching Institutions | | Chase 112 | Memorandum on Irrigated Crop Production | 11:00 |
| 7-30 | Team Time (work on lab reports) | | Chase 112 | | 1:00 |

The course also highlights the impact of IAWM on ecosystems. It is becoming increasingly important for students to be aware of the interactions between production agriculture and the surrounding agroecosystems and natural ecosystems (Dale et al., 2021), and how field-scale management decisions have an impact on a much larger scale.

## Student Feedback

A survey was used to evaluate student perceptions of the field course. A hard copy of the survey was distributed at the end of the 2022 field course, with all 10 of the students completing the survey. Students were asked to what extent they agree with 10 statements (strongly disagree, disagree, neutral, agree, strongly agree). All statements were positive statements, such that agreeing with the statement would indicate a favorable attitude toward the class. Statements 1-5 were designed to assess which components of the course were most helpful to the students, and statements 6-10 were intended to compare the format of the field course to a typical semester-long course. Seven of the 10 students had taken a prior irrigation course at a university. The survey instrument is included in the appendix; an example of the results is presented in Table 2.

**Table 2. Example survey data.**

| Statement on Survey: | Agree (%) | Strongly Agree (%) |
|---|---|---|
| Having hands-on labs improved my learning experience compared to an irrigation course without labs. | 30 | 60 |
| This course gave me a better understanding of the theory and principles of irrigation compared to other irrigation courses. | 50 | 40 |
| Having a two-week course (an immersive experience) improved my learning experience compared to a semester-long irrigation course. | 30 | 50 |
| I had sufficient time to absorb concepts in this class compared to a semester-long irrigation course. | 60 | 30 |
| This class gave me a better understanding of a systems perspective of irrigated agriculture compared to a lecture-based irrigation course. | 30 | 60 |

Students responded favorably to the five statements comparing the field course format (in terms of their learning experience) to a traditional course format; at least 80% selected "agree" or "strongly agree" for each of these five statements (Table 2). Students indicated that the hands-on learning and the systems perspective were particularly helpful (60% "strongly agree") compared to a lecture-based irrigation course. The lowest responses were for an improved understanding of theory (40% "strongly agree") and having sufficient time to absorb class concepts (only 30% "strongly agree") compared to a semester-long course. As expected, with the short time frame of the course, students did not learn course topics to the same level of detail as what would be obtained from a semester-long course.

Survey results indicated an overall positive attitude toward the course, with at least eight of the students (80%) responding "agree" or "strongly agree" for each of the five statements on the various components of the course. Students put the most value on the hands-on experiments (70% strongly agree) and put the least value on reading assignments (only 40% "strongly agree").

Qualitative feedback has also been documented over the years. In 2016, an unsolicited email from a student stated that "the class [was] one of the most memorable I've taken at UNL. It was really neat to interact with the IHE students and gain a different perspective on common challenges in land management." A closing panel was held on the last day of the 2018 field course to solicit feedback from students, which was primarily positive. One student noted that, "My heart bleeds that I will be leaving my friends." For recommended improvements, students suggested that the class be expanded from two weeks to three weeks and suggested that the book be better organized including a table of contents. (Since then, a table of contents has been added and the book has been published). Some students have commented that the field course was the highlight of their graduate school experience.

## Summary and Conclusions

There is a significant need for more educational opportunities in irrigation and agricultural water management (IAWM). A field course in IAWM at the graduate level has been offered to help address this need. The field course is designed as a two-week immersive experience. It is a combination of hands-on laboratory exercises, brief lectures to prepare students for the labs, data analysis, lab reports, and tours. The course emphasizes a systems perspective of irrigated crop production, helping students identify important components of the system and the linkages between components; this is a key perspective for students, whether their home country is in an irrigation development phase or a water conservation phase.

Recognizing that this type of course is not common in agricultural and biological engineering, this paper is intended to share the course concept, format, and content with a broad audience. Feedback from students is consistently positive. Survey results show that students put an especially high value on the hands-on laboratory exercises. Students often use the data collection skills from the course in their graduate research projects. Although this field course is focused on IAWM, it is expected that field courses on other topics could also be beneficial in agricultural and biological engineering programs.

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# Appendix

The survey form used for data collection is included on the following page. Example lab assignments are also provided, including furrow irrigation, solid-set irrigation, and well drawdown.

# Survey on Class Format

**AGEN/MSYM 854 Irrigation Lab & Field Course**

**July 29, 2022**

***For each line, circle the appropriate answer:***

| | | | |
|---|---|---|---|
| Degree: | MS | PhD | |
| Major: | Ag Eng | MSYM | Other |
| Origin: | Domesitc (USA) | International | |
| Have you take an irrigation class at a university before? | | Yes | No |

***To what extent would you agree with each of the following statements?***

| | Strongly Disagree (1) | Disagree (2) | Neutral (3) | Agree (4) | Strongly Agree (5) |
|---|---|---|---|---|---|
| 1. The reading assignments were helpful for my learning. | | | | | |
| 2. The lectures were helpful for my learning. | | | | | |
| 3. The hands-on experiments were helpful for my learning. | | | | | |
| 4. The data analysis was helpful for my learning. | | | | | |
| 5. The tours were helpful for my learning. | | | | | |
| 6. Having hands-on labs improved my learning experience compared to an irrigation course without labs. | | | | | |
| 7. This course gave me a better understanding of the theory and principles of irrigation compared to other irrigation courses. | | | | | |
| 8. Having a two-week course (an immersive experience) improved my learning experience compared to a semester-long irrigation course. | | | | | |
| 9. I had sufficient time to absorb concepts in this class compared to a semester-long irrigation course. | | | | | |
| 10. This class gave me a better understanding of a systems perspective of irrigated agriculture compared to a lecture-based irrigation course. | | | | | |

***Do you have any suggestions for how this course format could be improved in future years?***

**Irrigation Lab & Field Course (AGEN/MSYM 854)**
**Summer 2022**
**Furrow Irrigation Lab**

## Background:

Irrigation is the artificial application of water to ensure adequate water for plant growth. In practice, the ability to meet this goal depends on the design and in the management of the system. It is important to apply water uniformly and efficiently so that water resources are conserved, energy is saved, the environment is not harmed, and the needs of the crop are met.

## Educational Objectives:

By completing this exercise students will better understand:

- How to analyze the water distribution and efficiency of a furrow irrigation system.

## Procedure:

Place flags at 3-m intervals along the furrow
Set flumes at inlet and downstream end (the downstream end location should be an integer multiple of 3 m)
Start water into furrow and start stopwatch
Measure inflow rate with flume
Use stopwatch to record advance time
Measure runoff at 3-minute intervals
Record shutoff (cutoff time)
Record recession time (when runoff stops)

## Graphics:

Graph the advance curve, recession curve, and opportunity time curve for your furrow.
Graph the runoff hydrograph.

**Questions** -- Attach answers to these questions to your report.

1. Determine the depth of applied in mm. The wetted furrow spacing is 1.5 m.
2. Use numerical integration to determine inflow and runoff volumes in L.
3. Determine runoff depth in cm.
4. Determine average infiltration depth in cm.
5. Estimate $d_{LQ}$ from attached table (medium texture soil) and compute DU.

## Example Calculations:

Include example calculations as necessary.

## Data Sheet 1 (Furrow Irrigation Lab)

Date: ______________ Team:____________________

**System Data:**
Furrow spacing (m)______________
Furrow length (m)____________

### Advance-Recession Data

| Location (m) | Advance Time | Recession Time |
|---|---|---|
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## Data Sheet 2 (Furrow Irrigation Lab)

Date: ______________ Team:____________________

### Runoff Data

| Time | Head (cm) | Q (L/s) |
|---|---|---|
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Infiltration Factors (approximate $d_{LQ}/d_g$)

| Cutoff ratio | Soil texture: Fine | Medium | Coarse |
|---|---|---|---|
| 0.1 | 0.19 | 0.32 | 0.50 |
| 0.2 | 0.32 | 0.45 | 0.61 |
| 0.3 | 0.42 | 0.55 | 0.68 |
| 0.4 | 0.51 | 0.62 | 0.71 |
| 0.5 | 0.59 | 0.66 | 0.72 |
| 0.6 | 0.65 | 0.69 | 0.71 |
| 0.7 | 0.70 | 0.70 | 0.69 |
| 0.8 | 0.73 | 0.69 | 0.66 |
| 0.9 | 0.74 | 0.66 | 0.61 |

$d_{LQ}$ = depth in low quarter

$d_g$ = gross depth applied

Cutoff ratio = advance time to end of furrow/cutoff time

**Irrigation Lab & Field Course (AGEN/MSYM 854)**
**Summer 2022**
**Solid-Set Sprinkler Irrigation Lab**

**Background:**
Irrigation is the artificial application of water to ensure adequate water for plant growth. In practice, the ability to meet this goal depends on the design and in the management of the system. It is important to apply water uniformly and efficiently so that water resources are conserved, energy is saved, the environment is not harmed, and the needs of the crop are met.

**Educational Objectives:**
By completing this exercise students will better understand:

- How to analyze the water distribution of a solid set sprinkler system.
- The linkage between water delivered to a field and how much is caught in catch containers, how uniformly water is distributed, and possible water “losses” during application.

**Procedure:**
Each team will be assigned a specific location to layout catch cans and measure within the grid of a solid set sprinkler system.

1. Sprinkler catch can data. Catch cans or rain gauges will be placed in a grid fashion in a stationary sprinkler irrigated area. Following water application, the depth of water in each can will be measured and recorded on the attached data sheet. The data from all five teams will be pooled for analysis.
2. Each team should return their copies of Data Sheet 1 at the end of the lab.

**Graphics:**
Develop a graph of cumulative percent area versus depth similar to Figure 5.6.

**Questions** -- Attach answers to these questions to your report.

1. Fill in the blanks of Data Sheets 1 by completing the appropriate calculations.

2. Based on the CU, do you consider the water distribution of the system tested to be acceptable? Justify your answer.

3. Based on your observations during this experiment, would you think that using one rain gauge under a sprinkler system would be a good way to estimate the depth applied? If not, how many rain gauges do you think you would need to get a good estimate?

**Data Sheet 1 (Solid-Set Sprinkler Irrigation Lab)**

Date: ______________ Team:____________________

**System Data:**

Type of system______________

Time of operation____________ min

Pressure _______ kPa

Full-circle sprinkler discharge ___ L/s Half-circle sprinkler discharge ___ L/s

Spacing between sprinklers on lateral ________ (m)

between laterals ________ (m)

Catch can spacing _____ (m) × _____ (m)

Precipitation rate (application rate) _________cm/h

Depth applied _____________ cm

**Data Analysis:**

1. Average depth caught in cans: _____________ cm
2. Average depth of infiltration ($d_z$): ____________ cm
3. Distribution Uniformity (DU): _____________ (Eqn. 5.2)
4. Coefficient of Uniformity (CU): ______________ % (Eqn. 5.3)
5. Effective depth of irrigation ($d_e$):___________ cm (assume the SWD = 5 cm Eqn. 5.9 and 5.10)
6. Application efficiency of the low quarter: _________ % (Eqn. 5.11)

**Catch Can Data:**

| Row Number | Can Number | Depth (cm) |
|---|---|---|
| | 1 | |
| | 2 | |
| | 3 | |
| | 4 | |
| | 5 | |
| | 6 | |
| | 7 | |
| | 8 | |
| | 9 | |
| | 10 | |
| | 11 | |
| | 12 | |
| | 13 | |
| | 14 | |
| | 15 | |

**Irrigation Lab & Field Course (AGEN/MSYM 854)**
**Summer 2022**
**Well Drawdown Lab**

**Background:**
Drawdown in a well is the difference between the static (non-pumping) water level and pumping water level. Drawdown is dependent on the pumping rate (discharge). As a **first approximation**, drawdown is sometimes considered to be linear with discharge.

**Educational Objectives:**

By completing this exercise students will better understand:

- How drawdown varies with discharge.

**Procedure:**

The water levels in the irrigation well will be measured with an air-line bubbler system.

1. Record depth to end of bubbler line.
2. At each discharge, measure the pressure required to bubble air from the line.
3. Compute water level at each discharge
4. Compute drawdown at each discharge

**Graphics:**

Plot drawdown (vertical axis) vs discharge (horizontal axis). Compute the specific capacity (SC) which is the inverse of the slope (Q/s).

**Questions** -- Attach answers to these questions to your report.

1. Fill in the blanks of Data Sheets 1.
2. Is drawdown linearly related to discharge?
3. What is specific capacity, SC (L/s/m)?
4. Determine the maximum acceptable discharge for this well to keep air from getting into the pump. Use a 1.5-m margin of safety.

**Example Calculations:**

Include example calculations and tables from spreadsheets as necessary.

**Data Sheet 1 (Well Drawdown Lab)**

Date: ______________ Team:____________________

Well diameter _________ in. _______ mm
Well depth ___________ ft ________ m
Depth to pump ___________ ft ________ m
Airline length _________ft ________ m
Factor of safety ________ m

| Volume (gal) | Time (min) | Q (gpm) | Q (L/s) | Air Pressure (psi) | Air Pressure (kPa) | Depth of Water Column (m) | Water Level (m) | Drawdown (m) |
|---|---|---|---|---|---|---|---|---|
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