USDA Natural Resources Conservation Service

Irrigation Toolbox Chapter 3

Irrigation System Design

IRRIGATION SYSTEM DESIGN

Introduction

- The material provided in this section is intended to serve as a framework for irrigation system design training.
- Trainers should modify the training material referenced as necessary to achieve the planned skill level for the trainees.
- Trainers are encouraged to include locally developed training materials to complement and/or supplement the referenced material.
- As new training materials are developed by trainers, they are encouraged to furnish copies to the Irrigation ToolBox Manager for inclusion in future versions of the assembled material.

Suggested Objectives

1. Determine which type of irrigation system is appropriate for given specific site conditions, i.e. soil properties and crop data.
2. Specify materials and components to make a complete system that optimizes the balance between capital investment and operation and maintenance costs.
3. Prepare a performance table for the system listing total application versus time based on the average application rate.
4. Develop complete drawings and specifications for system layout, and operation.

Suggested Outline

I. Introduction

II. Body

A. Irrigation System Selection Based on Specific Site Conditions

1. Types of systems

2. Advantages/disadvantages

3. Theory of selected system

4. Specific site requirements

B. Materials and Components for a Cost-Effective System

1. Specific construction requirements

2. Materials vs. cost

C. Performance Table

D. Drawings and Specifications

III. Summary

Note: Note all copies of documents that were contained in the original Irrigation Training Toolbox are available electronically.

If you are unable to find a hard copy of a document in your state, you may be able to borrow a copy from the Water Management Engineer at your regional National technology Support Center.

Irrigation System Design

1. Fixed (Solid Set) Sprinkler Irrigation Design.
2. Periodic Move Sprinkler Irrigation Design.
3. Center Pivot Sprinkler Irrigation Design.
4. Traveling Gun Sprinkler Irrigation Design.
5. Lateral Move (Linear Move) Sprinkler Irrigation Design.
6. Level Border Irrigation Design.
7. Graded Border Irrigation Design.
8. Level Furrow Irrigation Design.
9. Graded Furrow Irrigation Design.
10. Subsurface Irrigation System Design.
11. Contour Ditch Irrigation System Design.
12. Trickle Irrigation System Design.
13. Pumping Plant Design.
14. Chemigation/Fertigation Design.
15. Filtration Design.
16. Low Energy Precision Application (LEPA)/Low Pressure In Canopy Application (LPIC)".
17. Level Basin/Levee Design.
18. Well Design.
19. Tailwater Recovery.

Material covered in this section

- Reference Material,
- Toolbox Material,
- Facilitation Options, and
- Evaluation.

Irrigation System Design

1. Fixed (Solid Set) Sprinkler Irrigation Design

Reference Material

- NEH Part 652 National Irrigation Guide: Chapter 6: Irrigation System Design.
- NEH 15 Chapter 11: Sprinkle Irrigation
- FOTG, Section IV.
- Publication "Design and Operation of Farm Irrigation Systems" ASABE Monograph Chapter 16.

Toolbox Material

- Publication "Irrigation Hydraulics", Instructors Manual, Hunter Industries.
- Publication "Irrigation Hydraulics", Student Manual, Hunter Industries.
- Publication "Precipitation Rates and Sprinkler Irrigation", Instructor's Manual, Hunter Industries.
- Publication "Sprinkler Irrigation Systems", Mid West Plan Service, MWPS-30

Facilitation Options

- Self-paced,
- Facilitator guided, or
- Formal classroom training.

Evaluation

- Each state should develop an evaluation procedure which addresses the level of competence desired before and after training is provided.

2. Periodic Move Sprinkler Irrigation Design

Reference Material

- NEH Part 652 National Irrigation Guide: Chapter 6: Irrigation System Design.
- NEH 15 Chapter 11: Sprinkle Irrigation
- FOTG Section IV.
- Publication "Design and Operation of Farm Irrigation Systems" ASABE Monograph Chapter 16.

Toolbox Material

- Publication "Irrigation Hydraulics", Instructors Manual, Hunter Industries.
- Publication "Irrigation Hydraulics", Student Manual, Hunter Industries.
- Publication "Precipitation Rates and Sprinkler Irrigation", Instructor's Manual, Hunter Industries.
- Publication "Sprinkler Irrigation Systems", Mid West Plan Service, MWPS-30

Facilitation Options

- Self-paced learning.
- Facilitator guided, or
- Formal classroom training.

Evaluation

- Each state should develop an evaluation procedure which addresses the level of competence desired before and after training is provided.

3. Center Pivot Sprinkler Irrigation System

Reference Material

- NEH Part 652 National Irrigation Guide: Chapter 6: Irrigation System Design.
- NEH 15 Chapter 11: Sprinkle Irrigation
- FOTG, Section IV.
- Publication "Design and Operation of Farm Irrigation Systems" ASABE Monograph Chapter 16.

Toolbox Materials

- Publication "Sprinkler Irrigation Systems", Mid West Plan Service, MWPS-30
- Lesson Plan "Selecting Sprinkler Packages for Center Pivot Systems", University of Nebraska
- Publication "Sprinkler Design Problem", NRCS, Kansas.

Facilitation Options

- Self-paced.
- Facilitator guided.
- Formal classroom training.

Evaluation

- Each state should develop an evaluation procedure which addresses the level of competence desired before and after training is provided.

4. Traveling Gun Sprinkler Irrigation Design

Reference Material

- NEH Part 652 National Irrigation Guide: Chapter 6: Irrigation System Design.
- NEH 15 Chapter 11: Sprinkle Irrigation
- FOTG Section IV.
- Publication "Design and Operation of Farm Irrigation Systems" ASABE Monograph Chapter 16.

Toolbox Material

- Publication "Irrigation Hydraulics", Instructors Manual, Hunter Industries.
- Publication "Irrigation Hydraulics", Student Manual, Hunter Industries.
- Publication "Sprinkler Irrigation Systems", Mid West Plan Service, MWPS-30

Facilitation Options

- Self-paced,
- Facilitator guided, or
- Formal classroom training.

Evaluation

- Each state should develop an evaluation procedure which addresses the level of competence desired before and after training is provided.

5. Lateral Move (Linear Move) Sprinkler Irrigation Design

Reference Material

- NEH Part 652 National Irrigation Guide: Chapter 6: Irrigation System Design.
- NEH 15 Chapter 11: Sprinkle Irrigation
- FOTG Section IV.
- Publication "Design and Operation of Farm Irrigation Systems" ASABE Monograph Chapter 16.

Toolbox Material

- Publication "Irrigation Hydraulics", Instructors Manual, Hunter Industries.
- Publication "Irrigation Hydraulics", Student Manual, Hunter Industries.
- Publication "Sprinkler Irrigation Systems", Mid West Plan Service, MWPS-30

Facilitation Options

- Self-paced,
- Facilitator guided, or
- Formal classroom training.

Evaluation

- Each state should develop an evaluation procedure which addresses the level of competence desired before and after training is provided.

6. Level Border Irrigation Design

Reference Material:

- NEH Part 652 National Irrigation Guide: Chapter 6: Irrigation System Design.
- NEH Part 623: Chapter 4 DRAFT: Surface Irrigation (04/2006)
- NEH 15 Chapter 4: Border Irrigation
- FOTG Section IV.
- Publication "Design and Operation of Farm Irrigation Systems" ASABE Monograph Chapter 14.

Toolbox Material

- Publication "The Surface Irrigation Manual", ITRC, Cal-Poly.

Facilitation Options

- Self-paced,
- Facilitator guided, or
- Formal classroom training.

Evaluation

- Each state should develop an evaluation procedure which addresses the level of competence desired before and after training is provided.

7. Graded Border Irrigation Design

Reference Material

- NEH Part 652 National Irrigation Guide: Chapter 6: Irrigation System Design.
- NEH Part 623: Chapter 4 DRAFT: Surface Irrigation (04/2006)
- NEH 15 Chapter 4: Border Irrigation
- FOTG Section IV.
- Publication "Design and Operation of Farm Irrigation Systems" ASABE Monograph Chapter 14.

Toolbox Material

- Publication "The Surface Irrigation Manual", ITRC, Cal-Poly.

Facilitation Options

- Self-paced,
- Facilitator guided, or
- Formal classroom training.

Evaluation

- Each state should develop an evaluation procedure which addresses the level of competence desired before and after training is provided.

8. Level Furrow Irrigation Design

Reference Material

- NEH Part 652 National Irrigation Guide: Chapter 6: Irrigation System Design.
- NEH Part 623: Chapter 4 DRAFT: Surface Irrigation (04/2006)
- NEH 15 Chapter 5: Furrow Irrigation
- FOTG Section IV.
- Publication "Design and Operation of Farm Irrigation Systems" ASABE Monograph Chapter 14.

Toolbox Material

- Publication "The Surface Irrigation Manual", ITRC, Cal-Poly.

Facilitation Options

- Self-paced,
- Facilitator guided, or
- Formal classroom training.

Evaluation

- Each state should develop an evaluation procedure which addresses the level of competence desired before and after training is provided.

9. Graded Furrow Irrigation Design

Reference Material

- NEH Part 652 National Irrigation Guide: Chapter 6: Irrigation System Design.
- NEH Part 623: Chapter 4 DRAFT: Surface Irrigation (04/2006)
- NEH 15 Chapter 5: Furrow Irrigation
- FOTG Section IV.
- Publication "Design and Operation of Farm Irrigation Systems" ASABE Monograph Chapter 14.

Toolbox Material

- Publication "The Surface Irrigation Manual", ITRC, Cal-Poly.

Facilitation Options

- Self-paced,
- Facilitator guided, or
- Formal classroom training.

Evaluation

- Each state should develop an evaluation procedure which addresses the level of competence desired before and after training is provided.

10. Subsurface Irrigation System Design

Reference Material

- NEH Part 652 National Irrigation Guide: Chapter 6: Irrigation System Design.
- NEH Part 624: Chapter 10: Water Table Control.
- FOTG Section IV.
- Publication "Design and Operation of Farm Irrigation Systems" ASABE Monograph Chapter 18.

Toolbox Material

- None

Facilitation Options

- Self-paced,
- Facilitator guided, or
- Formal classroom training.

Evaluation

- Each state should develop an evaluation procedure which addresses the level of competence desired before and after training is provided.

Irrigation System Design

11. Contour Ditch Irrigation System Design

Reference Material

- NEH Part 652 National Irrigation Guide: Chapter 6: Irrigation System Design.
- NEH 15.
- FOTG Section IV.
- Publication "Design and Operation of Farm Irrigation Systems" ASABE Monograph Chapter 14.

Toolbox Materials

- None

Facilitation Options

- Self-paced,
- Facilitator guided, or
- Formal classroom training.

Evaluation

- Each state should develop an evaluation procedure which addresses the level of competence desired before and after training is provided.

12. Trickle Irrigation Design

Reference Material

- Industry Videos from Manufacturers & Suppliers.
- NEH Part 652 National Irrigation Guide: Chapter 6: Irrigation System Design.
- NEH 15, Chapter 7: Trickle Irrigation.
- FOTG Section IV.
- Publication "Design and Operation of Farm Irrigation Systems" ASABE Monograph Chapter 17.

Toolbox Material

- Publication "Drip and Microirrigation for Trees, Vines, and Row Crops", ITRC, Cal-Poly.

Facilitation Options

- Self-paced,
- Facilitator guided, or
- Formal classroom training.

Evaluation

- Each state should develop an evaluation procedure which addresses the level of competence desired before and after training is provided.

13. Pumping Plant Design

Reference Material

- NEH Part 652 National Irrigation Guide: Chapter 6: Irrigation System Design.
- NEH 15 Chapter 8: Irrigation Pumping Plants
- FOTG Section IV.
- Publication "Design and Operation of Farm Irrigation Systems" ASABE Monograph Chapter 12.

Toolbox Material

- Publication "The Surface Irrigation Manual", ITRC, Cal-Poly.
- Publication "Understanding Pumps", Irrigation Association.
- Video 009 "Pump Selection, Application and Use", Certified Irrigation Designer's Video Series, Step 2, VEP, Cal-Poly (57:32)

Facilitation Options

- Self-paced,
- Facilitator guided, or
- Formal classroom training.

Evaluation

- Each state should develop an evaluation procedure which addresses the level of competence desired before and after training is provided.

14. Chemigation/Fertigation Design

Reference Material

- NEH Part 652 National Irrigation Guide: Chapter 7.
- FOTG Section IV.
- Publication "Design and Operation of Farm Irrigation Systems" ASABE Monograph Chapter 19.

Toolbox Material

- Publication "The Surface Irrigation Manual", Cal-Poly IT & RC.
- Publication "Fertigation", ITRC, Cal-Poly .

Facilitation Options

- Self-paced,
- Facilitator guided, or
- Formal classroom training.

Evaluation

- Each state should develop an evaluation procedure which addresses the level of competence desired before and after training is provided.

15. Filtration Design

Reference Material

- FOTG Section IV.

Toolbox Material

- Publication "Drip and Microirrigation for Trees, Vines, and Row Crops", Burt, ITRC, Cal-Poly.
- Publication "The Surface Irrigation Manual", ITRC, Cal-Poly.
- Video 010 "Sand Media Filtration for Drip and Microirrigation", ITRC, Cal-Poly (50:30)
- Video 011 "General Filtration for Drip and Microirrigation", ITRC, Cal-Poly (50:27)

Facilitation Option

- Self-paced,
- Facilitator guided, or
- Formal training course.

Evaluation

- Each state should develop an evaluation procedure which addresses the level of competence desired before and after training is provided.

Irrigation System Design

16. Low Energy Precision Application (LEPA)/Low Pressure in Canopy Application (LPIC) System Design

Reference Material

- FOTG Section IV.

Toolbox Material

- Video 006 "LEPA - Saving Water for Future Producers", Texas Agricultural Extension Service/Texas A&M University (31:31)
- Video 028 "Assuring Efficient Center Pivot Irrigation", Department of Biological Systems Engineering, University of Nebraska. (43:32)

Facilitation Options

- Self-paced,
- Facilitator guided, or
- Formal classroom training.

Evaluation

- Each state should develop an evaluation procedure which addresses the level of competence desired before and after training is provided.

Irrigation System Design

17. Level Basin/Levee Design

Reference Material

- NEH Part 652 National Irrigation Guide: Chapter 6: Irrigation System Design.
- NEH Part 623: Chapter 4 DRAFT: Surface Irrigation (04/2006)
- FOTG Section IV.
- Publication "Design and Operation of Farm Irrigation Systems" ASABE Monograph Chapter 14.

Toolbox Materials

- Publication "The Surface Irrigation Manual", ITRC, Cal-Poly.

Facilitation Options

- Self-paced,
- Facilitator guided, or
- Formal classroom training.

Evaluation

- Each state should develop an evaluation procedure which addresses the level of competence desired before and after training is provided.

18. Well Design

Reference Material

- NEH Part 631 Chapter 32 - DRAFT Well Design and Spring Development
- FOTG Section IV.
- "Groundwater and Wells", Johnson Div., UOP Inc.
- "Developing The Ground Water Supply", D. Barefoot and D. Schwab, Oklahoma State University.

Toolbox Materials

- Video 008 "Private Rural Water Protection Series"
    i. Module 1, Introduction (13:46)
    ii. Module 2, Well Plugging Techniques (15:36)
    iii. Module 3, Water Quality (16:08)
    iv. Module 4, Water Treatment (16:23)
    v. Module 5, Well Location (11:54)
    vi. Module 6, Well Design and Construction (14:46)
    vii. Module 7, Well Maintenance and Rehabilitation (13:33)

Facilitation Options

- Self-paced,
- Facilitator guided, or
- Formal classroom training.

Evaluation

- Each state should develop an evaluation procedure which addresses the level of competence desired before and after training is provided.

19. Tailwater Recovery

Reference Material

- NEH Part 652 National Irrigation Guide: Chapter 7.
- FOTG Section IV.

Toolbox Material

- Publication "The Surface Irrigation Manual", ITRC, Cal Poly.

Facilitation Options

- Self-paced,
- Facilitator guided, or
- Formal classroom training.

Evaluation

- Each state should develop an evaluation procedure which addresses the level of competence desired before and after training is provided.

Irrigation System Design

Overview

Reference Material

- "Agricultural Drainage and Subirrigation Systems, Maumee Valley RC&D" Defiance, Ohio, 1/94.
- "_____Managing Agricultural Drainage Waters in Today's Environment", 1995, Overholt Drainage School, Ohio State University, 3/95.
- "Subirrigation and Controlled Drainage", H.W. Belcher,et.al., Library Of Congress 94-30888.

Contents of Toolbox

Publications

- Publication Drip and Microirrigation for Trees, Vines, and Row Crops", ITRC, Cal-Poly
- Publication "Fertigation", ITRC, Cal-Poly
- Publication "Irrometer Design Manual" (Packet of material in folder), Irrometer Company
- Publication "Precipitation Rates and Sprinkler Irrigation" - Student and Instructor Manuals, Hunter Industries
- Publication "Irrigation Hydraulics" - Student and Instructor Manuals, Hunter Industries
- Publication "The Surface Irrigation Manual", Chapter 1, Cal-Poly (Located in the Soil-Water-Plant Relationship Toolbox)
- Publication "Understanding Pumps", Irrigation Association
- Publication "Design and Operation of Farm Irrigation Systems" ASABE Monograph

Lesson Plans

- Lesson Plan "Sprinkler Design Problem", NRCS, KS
- Lesson Plan "Selecting Sprinkler Packages for Center Pivots", Nebraska
- Lesson Plan "CPNOZZLE Program", NRCS

National Engineering Handbook

- NEH Part 652 National Irrigation Guide
- NEH Part 623 Irrigation (formerly NEH Section 15)

Videos

- Video 008 "Private Rural Water Protection Series"
    i. Module 1, Introduction (13:46)
    ii. Module 2, Well Plugging Techniques (15:36)
    iii. Module 3, Water Quality (16:08)
    iv. Module 4, Water Treatment (16:23)
    v. Module 5, Well Location (11:54)
    vi. Module 6, Well Design and Construction (14:46)
    vii. Module 7, Well Maintenance and Rehabilitation (13:33)
- Video 009 "Pump Selection, Application and Use", Certified Irrigation Designer's Video Series, Step 2, VEP, Cal-Poly (57:32)
- Video 010 "Sand Media Filtration for Drip and Microirrigation", ITRC, Cal-Poly (50:30)
- Video 011 "General Filtration for Drip and Microirrigation", ITRC, Cal-Poly (50:27)
- Video 006 "LEPA - Saving Water for Future Producers", Texas Agricultural Extension Service/Texas A&M University (31:31)
- Video 027 "Surface Irrigation"
    i. 027E "Surface Irrigation" (English) (18:27)
    ii. 027S "Surface Irrigation" (Spanish) (22:23)

- Video 028 "Assuring Efficient Center Pivot Irrigation", Department of Biological Systems Engineering, University of Nebraska. (43:32)