



SOIL&WATER

CONSERVATION VIRTUAL FIELD TRIP SERIES

U of A DIVISION OF AGRICULTURE
RESEARCH & EXTENSION
University of Arkansas System

USDA United States Department of Agriculture
Natural Resources Conservation Service

Improve Water Quality and Reduce Water Use with Surge Irrigation Virtual Field Trip



3D-Student Science Performance

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9-12th grade: Integrated Biology

Integrated Chemistry, Environmental Science, Agricultural Science

Lesson Topic:

Life and Earth Systems
Human Impacts on Earth Systems
Water Solubility
Sustainability
Water Conservation in Farming
Technology in Water Conservation

Performance Expectations (Standard) from State Standards or NGSS:

Integrated Chemistry:

Topic One: Matter and Chemical Reactions

CI-ESS2-5: Plan and conduct an investigation of the properties of water and its effects on Earth materials and surface processes. [Clarification Statement: Emphasis on mechanical and chemical investigations with water and a variety of solid materials to provide the evidence for connections between the hydrologic cycle and system interactions commonly known as the rock cycle. Examples of mechanical investigations include stream transportation and deposition using a stream table, erosion using variations in soil moisture content, or frost wedging by the expansion of water as it freezes. Examples of chemical investigations include chemical weathering and recrystallization (by testing the solubility of different materials) or melt generation (by examining how water lowers the melting temperature of most solids.)]

CI1-ETS1-2: Design a solution to a complex real-world problem by breaking it down into smaller, more manageable problems that can be solved through engineering. [AR Clarification Statement: Examples of real-world problems could include wastewater treatment, production of biofuels, and the impact of heavy metals or phosphate pollutants on the environment.]

Connections to the Arkansas Disciplinary Literacy Standards:

WHST.9-12.7: Integrate and evaluate multiple sources of information presented in diverse formats and media in order to address a question or solve a problem.

Connections to the Arkansas Mathematic Standards:

HSN.Q.A.3: Choose a level of accuracy appropriate to limitations on measuring when reporting.

MP.4: Model with mathematics.

Environmental Science:

Topic One: Systems

EVS-ESS2-5: Plan and conduct an investigation of the properties of water and its effects on Earth materials and surface processes. [Clarification Statement: Emphasis on mechanical and chemical investigations with water and a variety of solid materials to provide the evidence for connections between the hydrologic cycle and system interactions commonly known as the rock cycle. Examples of mechanical investigations include stream transportation and deposition using a stream table, erosion using variations in soil moisture content, or frost wedging by the expansion of water as it freezes. Examples of chemical investigations include chemical weathering and recrystallization (by testing the solubility of different materials) or melt generation (by examining how water lowers the melting temperature of most solids.)]

EVS1-ETS1-1: Analyze a major global challenge to specify qualitative and quantitative criteria and constraints for solutions that account for societal needs and wants. [AR Clarification Statement: Qualitative and quantitative constraints can be used to analyze a major global challenge. Examples could include water quality with relation to biosphere, atmosphere, cryosphere, and geosphere.]

Topic 4: Sustainability

EVS-ESS3-2: Evaluate competing design solutions for developing, managing and utilizing energy and mineral resources based on cost-benefit ratios. [AR Clarification Statement: Emphasis is on conservation, sustainability, (e.g., recycling and reuse of resources), and minimizing impacts (e.g., Low Impact Design).]

EVS-ESS3-4: Evaluate or refine a technological solution that reduces impacts of human activities on natural systems. [AR Clarification Statement: Examples of data on the impacts of human activities could include the sequencing of traffic lights, adding lanes to main traffic arteries, docking and dredging of waterways, transportation of goods to market, use of drones, and use of alternate energies.]

EVS-LS2-7: Design, evaluate and refine a solution for reducing the impacts of human activities on the environment and biodiversity. [AR Clarification Statement: Emphasis in this course is on Arkansas-specific solutions. Examples of human activities can include land use (agriculture, forestry, recreation, industry; sustainable and non-sustainable practices) crop rotations, eradication of invasive species; and solution resources may include Low Impact Design (LID) or bioremediation (Faulkner County, AR; Gulf of Mexico hypoxia zone.)]

EVS-LS4-6: Create or revise a simulation to test a solution to mitigate adverse impacts of human activity on biodiversity. [AR Clarification Statement: Emphasis is on designing solutions for a proposed problem (e.g., micro-bead pollution, invasive species, effects of sedimentation on the Arkansas Fatmucket, White-nose Syndrome affecting bat populations, and environmental pollution from hormones and antibiotics.)]

EVS4-ETS1-3: Evaluate a solution to a complex real-world problem based on prioritized criteria and tradeoffs that account for a range of constraints, including cost, safety, reliability, and aesthetics as well as possible social, cultural, and environmental impacts. [AR Clarification Statement: Modeling complex real-world problems using computer software could include simulating future population growth in terms of limited resources or evaluating water flow through different Earth and geoengineering materials.]

Connections to the Arkansas Disciplinary Literacy Standards:

WHST.9-12.7: Integrate and evaluate multiple sources of information presented in diverse formats and media in order to address a question or solve a problem.

RST.11-12.7: Integrate and evaluate multiple sources of information presented in diverse formats and media (e.g.: quantitative data, video, multimedia) in order to address a question or solve a problem.

RST.11-12.8: Evaluate the hypotheses, data, analysis, and/or conclusions in a science or technical text, verifying the data when possible and corroborating or challenging conclusion with other sources of information.

RST.11-12.9: Synthesize information from a range of sources into a coherent understanding of a process, phenomenon or concept, resolving conflicting information when possible.

RST.9-10.8: Assess the extent to which the reasoning and evidence in a text support the author's claim or a recommendation for solving a scientific or technical problem.

RST.11-12.1: Cite specific textual evidence to support analysis of science and technical texts, attending to important distinctions the author makes and to any gaps or inconsistencies in the account.

WHST.9-12.7: Conduct short and well as more sustained research projects to answer a question or solve a problem; narrow or broaden the inquiry when appropriate; synthesize multiple sources on the subject, demonstrating understanding of the subject under investigation.

WHST.9-12.5: Develop and strengthen writing as needed by planning, revising, editing, rewriting, or trying a new approach, focusing on addressing what is most significant for a specific purpose and audience.

Connections to the Arkansas Mathematic Standards:

HSN.Q.A.3: Choose a level of accuracy appropriate to limitations on measuring when reporting.

MP.2: Reason abstractly and quantitatively.

MP.4: Model with mathematics.

HSN.Q.A.1: Use units as a way to understand problems and to guide the solution of multi-step problems; choose and interpret units consistently in formulas; choose and interpret the scale and the origin in graphs and data displays.

HSN.Q.A.2: Define appropriate quantities for the purpose of descriptive modeling.

Physics:

Topic 1: Motion

P-PS1-1AR: Create a model of motion and forces, including vectors graphed on the coordinate plane, to describe and predict the behavior of a system. [Clarification Statement: Emphasis is on vector addition for 1-D (frame of reference), 2D motion (projectile, rotational motion), vectors applied to force diagrams, and vector direction for gravitational forces.]

P-PS2-1: Analyze data to support the claim that Newton's second law of motion describes the

mathematical relationship among the net force on a macroscopic object, its mass, and its acceleration.

[Clarification Statement: Examples of data could include tables and graphs of position or velocity as functions of time for objects subject to a net unbalanced force (falling object, object rolling down a ramp, moving object

being pulled by a constant force.)]

P1-ETS1-2: Design a solution to a complex real-world problem by breaking it down into smaller, more manageable problems that can be solved through engineering. [AR Clarification Statement: Problems could include acceleration factors (one-dimensional motion), vectors (two-dimensional motion), and gravity (Newton's laws).]

Topic 2: Work and Energy

P-PS2-5AR: Use mathematical representations to support the claim that the change in kinetic energy of a system is equal to the net work performed upon the system. [Clarification Statement: Emphasis is on quantitative kinetic energy in interactions.]

Topic 3: Heat and Thermodynamics

P-PS3-3AR: Use mathematical representations to model the conservation of energy in fluids.

[Clarification Statement: Emphasis is on fluid dynamics as expressed in Bernoulli's equation and Pascal's principle.]

Connections to the Arkansas Disciplinary Literacy Standards:

RST.9-10.7: Translate quantitative or technical information expressed in words in a text into visual form (e.g., a table or chart) and translate information expressed visually or mathematically (e.g., in an equation) into words.

RST.11-12.1: Cite specific textual evidence to support analysis of science and technical texts, attending to important distinctions the author makes and to any gaps or inconsistencies in the account.

RST.11-12.7: Integrate and evaluate multiple sources of information presented in diverse formats and media in order to address a question or solve a problem.

WHST.9-12.9: Synthesize information from a range of sources (e.g., texts, experiments, simulations) into a coherent understanding of a process phenomenon, or concept, resolving conflicting information when possible.

Connections to the Arkansas English Language Arts Standards:

SL.11-12.2: Integrate multiple sources of information that is gained by means other than reading (e.g., texts read out loud, oral presentations or charts, graphs, diagrams, speeches) in order to make informed decisions and solve problems, evaluating the credibility and accuracy of each source and noting any discrepancies among the data.

SL.11-12.4: Present information, findings, and supporting evidence, conveying a clear and distinct perspective, such that listeners can follow the line of reasoning, alternative or opposing perspectives are addressed, and the organization, development, substance, and style are appropriate to purpose, audience, and a range of formal and informal tasks.

Connections to the Arkansas Mathematic Standards:

MP.2: Reason abstractly and

quantitatively. MP.4: Model with

mathematics.

HSN.Q.A.1: Use units as a way to understand problems and to guide the solution of multi-step problems; choose and interpret units consistently in formulas; choose and interpret the scale and the origin in graphs and data displays.

HSN.Q.A.2: Define appropriate quantities for the purpose of descriptive modeling.

HSN.Q.A.3: Choose a level of accuracy, appropriate to limitations on measurement when reporting quantities.

HSN.VM.A.1: Recognize vector quantities as having both magnitude and direction; represent vector quantities by directed line segments, and use appropriate symbols for vectors and their magnitudes.

HSN.VM.A.3: Solve problems involving velocity and other quantities that can be represented by vectors.

HSN.VM.B.4: Add and subtract vectors: add vectors end-to-end, compound-wise, and by the parallelogram rule. Understand that the magnitude of a sum of two vectors is typically not the sum of the magnitudes; given two vectors in magnitude and direction form, determine the magnitude and direction of their sum; understand vector subtraction **$\mathbf{v} - \mathbf{w}$ as $\mathbf{v} + (-\mathbf{w})$** , where $-\mathbf{w}$ is the additive inverse of \mathbf{w} , with the same magnitude as \mathbf{w} and pointing in the opposite direction; represent vector subtraction graphically by connecting the tips in the appropriate order; perform vector subtraction component-wise.

HSA.SSE.B.3: Choose and produce an equivalent form of expression to reveal and explain properties of the quantity represented by the expression.

HSA.CED.A.3: Represent and interpret constraints by equations or inequalities, and by systems of equations and/or inequalities.

HSA.CED.A.4: Rearrange literal equations using the properties of equality.

HSF.IF.C.7: Graph functions expressed algebraically and show key features of the graph, with and without technology; graph linear and quadratic functions and, when applicable, show intercepts, maxima, and minima; graph square root, cube root, and piecewise-defined functions, including step functions and absolute value functions; graph polynomial functions, identifying zeros when suitable factorizations are available, and showing end behavior; graph rational functions, identifying zeros and asymptotes when

suitable factorizations are available, and showing end behavior; graph exponential and logarithmic functions, showing intercepts and end behavior, graph trigonometric functions, showing period, midline, and amplitude.

Lesson Performance Expectations:

- **Students will understand the importance of irrigation conservation in farming.**
- **Students will understand the importance of collaboration with local agencies and farmers.**
- **Students will understand how different irrigation techniques will impact water flow, soil moisture content and tail water waste.**
- **Students will see how STEM is highly involved in irrigation control.**

Phenomenon: Conventional irrigation causes water and nutrient waste plus inconsistent soil moisture through tail water loss. Furrow and surge irrigation with Poly Pipe computer precision water flow means less water loss, more dependable moisture transfer and nutrients stay in with the plants.

Gather:

1. Students will break into groups to define the following word groups:

- Furrow irrigation
- Tail water loss
- Automated runoff monitoring station
- Automated distribution of irrigation flow
- Surge irrigation
- Poly Pipe tubing furrow irrigation
- Water flow pacing
- Pipe Planner Computer Program
- Soil moisture sensors
- Water quality analysis; focus on nitrates, phosphates, total phosphorous and total solids in water.

***Reason** (In this section students are generally: evaluating information, analyzing data, using mathematical/computational thinking, constructing explanations, developing arguments, and/or using models to reason, predict, and develop evidence.)*

2. Students in groups will come up with two questions they have about the above word groups that may be answered in the video.

Class Discussion:

Q: How do farmers water their crops?

Q: How do farmers control irrigation water to prevent waste? Q: How important is soil moisture depth and irrigation?

Q: Considering the properties of water and the interaction water has on the environment, how could farmers decrease water usage, thus decrease fertilizer waste and yet give adequate moisture to their crops?

Q: How are soil moisture depth and irrigation related?

Teaching Suggestion:

Do a KWL Chart about irrigation. How do farmers water their crops? How do farmers control irrigation water to prevent waste? How important is soil moisture depths and irrigation?

Get students thinking about the drawbacks of irrigation runoff (tail water loss) by asking students how do farmers keep plants healthy (fertilizers) and do they think all the fertilizer that is placed on the field goes into the plant? If not, where does the excess fertilizer go? Considering the properties of water and the interaction water has on the environment, how could this excess fertilizer impact our ecosystem? How can farmers measure excess fertilizer in water, and what can they do to prevent this? What can farmers do to decrease water (and fertilizer) loss yet have optimum soil moisture depth for their crops?

Tell the students that they are going to watch a video titled '*Improve Water Quality & Reduce Water Use with Surge Irrigation*' Virtual Field Trip. Before they start the video, have the students break into groups to define the word groups found on pages above.

BEFORE THE VIDEO be sure the students understand that irrigation water is a precious commodity both economically and ecologically. Water that is getting to the plant roots isn't becoming runoff and isn't taking fertilizer with it. Farmers must be constantly aware of the amount of water they use to irrigate their crops. Farmers are always looking for ways to conserve and increase efficiency of their irrigation water; lower water usage means less cost, better sustainability and less contaminated water runoff. Working with local agencies not only helps farmers, it helps citizens by keeping our water plentiful and clean.

If you are in chemistry, this is a good time to discuss the water cycle, the properties of water, the structure and function of the dipole molecule and its impact on systems around it, and water chemistries.

Environmental Science concepts could involve ecosystem dynamics, natural resources, human impact and the role of water in surrounding systems.

Physics teachers: This video covers the physics of flow (open and closed channel) involving diameter of pipe holes, volume, height, pressure flow and velocity of water. It also discusses the velocity of particulates in a water stream. Consider developing some problems beforehand for your students to work on after the video.

Communicate *(In this section students will be communicating information, communicating arguments (written and oral for how their evidence supports or refutes an explanation, and using models to communicate their reasoning and make their thinking visible.)*

After the video, break the students into three groups: the *Furrow Irrigation with Poly Pipe* Group, the *Surge Irrigation* group, and the *Water Quality Analysis* group. Have each group brainstorm how their 'area of study'

affects their daily lives. Tell students they need to come up with at least five ways and then report them to the rest of the class.

Students will turn in a two-paragraph reflection paper on what they learned and how these conservation efforts affect their personal lives.

Formative Assessment for Student Learning

Elicit Evidence of Learning:

Evidence of Student Proficiency *Description of the evidence of learning expected for the three-dimensional performance.*

Students will understand that Conventional irrigation causes water and nutrient waste plus inconsistent soil moisture through tail water loss. Furrow and surge irrigation with Poly Pipe computer precision water flow means less water loss, more dependable moisture transfer and nutrients stay in with the plants.

This section provides a range of typical student responses, often using a three-point scale.

Descriptors of grade-level appropriate student responses:

- *Full understanding: Student will have all the vocabulary defined, two questions for the video and will participate fully in the post video discussion, coming up with six different ways their irrigation technique has good and bad points. Reflection paper will show full connection between what they experienced and understand.*
- *Partial understanding: student will have 75% of the vocabulary defined, one question for the video and from the post video group. Reflection paper will only show partial connection between what they experienced and understand.*
- *Limited understanding: Student will have 50% or less of vocabulary defined, no questions for the video and show no understanding of what was learned in the reflection paper.*

Acting on Evidence of Learning *This is a brief description of the instructional actions to take based on the students' performance. When the action includes extensive descriptors and/or materials, you may wish use **Appendix C.***

Description of instruction action and response to support student learning.

- *Action for student who displays partial or limited understanding: student will be partnered with a student who has full understanding and material will be reviewed with mentoring from the teaching student.*
- *Extensions of learning for student who displays full understanding: Assign a brainstorming project that allows students to design their own alternate irrigation method.*

Science Practices:

Planning and Carrying Out Investigations (CI-ESS2-5) (EVS-ESS2- 5)

Constructing Explanations and Designing Solutions (CI1-ETS1-2) (EVS-LS2-7)

Asking Questions and Defining Problems (EVS1-ETS1-1)

Engage an Argument from Evidence (EVS-ESS3-2)

Using Mathematics and Computational Thinking (EVS-LS4-6) (P-PS1-2AR)

Developing and Using Models (EVS- ESS3-3) (P-PS1-1AR)

Analyzing and Interpreting Data (P- PS2-1)

Science Essentials:

- Plan and conduct an investigation individually and collaboratively to produce data to serve as the basis for evidence, and in the design: decide on types, how much, and accuracy of data needed to produce reliable measurements and consider limitations on the precision of the data and refine the design accordingly.
- Design a solution to a complex real-world problem, based on scientific knowledge, student-generated sources of evidence, prioritized criteria, and trade-off considerations.
- Analyze complex real-world problems by specifying criteria and constraints for successful solutions.
- Evaluate competing design solutions to a real-world problem based on scientific ideas and principles, empirical evidence, and logical arguments regarding relevant factors.
- Create a computational model or simulation of a phenomenon, designed device, process, or system.
- Use mathematical representations of phenomena to support claims.
- Use a model to predict the relationships between systems or between components of a system.
- Analyze data using tools, technologies, and/or models in order to make valid and reliable scientific claims or determine an optimal design solution.

Crosscutting Concepts:

Structure and Function (CI-ESS2-5) (EVS-ESS2-5) (P-PS2-1)

Influence of Engineering, Technology and Science on Society and the Natural World (EVS1-ETS1-1)

Science Addresses Questions About the Natural and Material World (EVS- ESS3-2)

Stability and Change (EVS-LS2-7) (EVS-ESS3-3)

Cause and Effect (EVS-LS4-6) (EVS-LS4-6)

Systems and System Models (EVS-ESS3-6) (P-PS1-1AR)

Interdependence of Science and Technology (P1-ETS1-2)

Energy and Matter (P-PS2-5AR) (P-PS3-3AR)

Science Essentials:

- The functions and properties of natural and designed objects and systems can be inferred from their overall structure, the way their components are shaped and used, and the molecular substructures of its various materials.
- New technologies can have deep impacts on society and the environment, including some that were not anticipated. Analysis of costs and benefits is a critical aspect of decisions about technology.
- Science knowledge indicates what can happen in natural systems-not what should happen. The latter involves ethics, values and human decisions about the use of knowledge.
- Change and rates of change can be quantified and modeled over very short or very long periods of time. Some system changes are irreversible.
- Empirical evidence is required to differentiate between cause and correlation and make claims about specific causes and effects.
- When investigating or describing a system, the boundaries and initial conditions of the system need to be defined and their inputs and outputs analyzed and described using models.
- Science and engineering complement each other in the cycle known as research and development (R&D). Many R&D projects may involve scientists, engineers, and others with wide ranges of expertise.
- The total amount of energy and matter in closed systems is preserved.

Disciplinary Core Ideas:

ESS2.C: The roles of water in Earth's Surface Processes

ETS1.C: Optimizing the Design Solution

ETS1.A: Defining and Delimiting Engineering Problems

ESS3.A: Natural Resources

ETS1.B: Developing Possible Solutions

ESS3.C: Human Impacts on Earth Systems

LS4.C: Adaptation

LS4.D: Biodiversity and Humans PS2.A: Forces and Motion

ETS1.C: Optimizing the Design Solution

PS3.C: Relationship between Energy and Forces

PS3.B: Conservation of Energy and Energy Transfer

- The abundance of liquid water on Earth's surface and its unique combination of physical and chemical properties are central to the planet's dynamics. These properties include water's exceptional capacity to absorb, store and release large amounts of energy, transmit sunlight, expand upon freezing, dissolve and transport materials, and lower the viscosities and melting points of rocks.
- Criteria may need to be broken down into simpler ones that can be approached systematically, and decision about the priority of certain criteria over others may be needed.
- Humanity faces major global challenges today, such as the need for supplies of clean water and food or for an energy source that minimizes pollution, which can be addressed through engineering. These global challenges also may have manifestations in local communities.
- Resource availability has guided the development of human society.
- Both physical models and computers can be used in various ways to aid in the engineering design process. Computers are useful for a variety of purposes, such as running simulations to test different ways of solving a problem or to see which one is most efficient or economical, and in making a persuasive presentation to a client about how a given design will fit his or her needs.
- Scientists and engineers can make major contributions by developing technologies that produce less pollution and waste and that preclude ecosystem degradation.
- Changes in the physical environment whether naturally occurring or human induced, have thus contributed to the expansion of some species, the emergence of new distinct species as populations diverge under different conditions, and the decline-and sometimes the extinction of some species.
- Humans depend on the living world for the resources and other benefits provided by biodiversity. But human activity is also having adverse impacts on biodiversity through overpopulation, overexploitation, habitat destruction, pollution, introduction to invasive species, and climate change. Thus, sustaining biodiversity so that ecosystem functioning and productivity are maintained is essential to supporting and enhancing life on Earth. Sustaining biodiversity also aids humanity by preserving landscapes of recreational or inspirational value.

- Momentum is defined for a particular frame of reference; it is the mass times the velocity of the object.
- When two objects interacting through a force field change relative position, the energy stored in the force field is changed.
- Mathematical expressions, which quantify how the stored energy in a system depends on its configuration and how kinetic energy depends on mass and speed, allow the concept conservation of energy to be used to predict and describe system behavior.
- Criteria may need to be broken down into simpler ones that can be approached systematically, and decisions about the priority of certain criteria over others (trade-offs) may be needed.

Appendix A - Student Prompts

Student Prompts for the Lesson

Phenomenon: Conventional irrigation causes water and nutrient waste plus inconsistent soil moisture through tail water loss. Furrow and surge irrigation with Poly Pipe computer precision water flow means less water loss, more dependable moisture transfer and nutrients stay in with the plants.

Group Performances:

1. Ask questions to plan an investigation for understanding that collaboration over furrow/surge/Poly Pipe irrigation can save water, nutrients, and benefits the local ecology.
2. Plan an investigation by defining the words necessary and having questions ready for the video.
3. Construct an explanation by forming groups and discussing how collaboration over conservation irrigation can affect a person's everyday life.
4. Use a model to explain how furrow and surge irrigation with Poly Pipe computer precision water flow means less water loss, more dependable moisture transfer, and nutrients stay in with the plants.

Class Discussion Individual

Performances:

1. Develop an argument for how collaborating on new irrigation techniques can and does help our economy and ecology.

Appendix B –

Materials:

- go to www.uaex.uada.edu/soywhatsup and click on the 'Virtual Field Trips and lessons'

icon on the left-hand side of the page. This will take you to the link for the Surge Irrigation video.

- Paper writing utensils for students.

Preparation:

It is highly recommended that you, the teacher, watch *The History of Discovery Farms Virtual Field Trip* before the *Improve Water Quality & Reduce Water Use with Surge Irrigation* VFT as it will give you a strong understanding about how and why Discovery Farms work in Arkansas. This will provide background when explaining the *Improve Water Quality & Reduce Water Use with Surge Irrigation* video to your students. It is also recommended that you familiarize yourself with the vocabulary words.

No other significant preparation is necessary.

Time Duration: 1-2 class periods

The video is about 45 minutes long. Assume about 15 minutes for students to look up vocabulary and prepare questions for the video session, 15 minutes to teach essential concepts and about 15 minutes for group discussion and reflection after the video.

Appendix C - Below are good resources for understanding irrigation techniques better.

<http://www.pipeplanner.com/>

https://www.youtube.com/watch?v=e9_wtk5i9Mc

https://www.youtube.com/watch?v=oo1AtCmx_3E

https://www.youtube.com/watch?v=A0i8noMevyU&feature=youtu_gdata_player

