The Science of Golf

Test Lab Toolkit
The Course: Water

Facilitator Guide
Grades 6-8

USGA

Science | Technology | Engineering | Mathematics

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Test Lab Toolkits bring math and science to life by showing how STEM studies play a big role in the game of golf. They are funded by the United States Golf Association (USGA).

USGA

Welcome to the Test Lab Toolkit!

Sometimes the study of science and math can seem a little disconnected from the "real" world. Yet a closer look reveals that science and math are everywhere in the world around us, in familiar and surprising ways.

Take something fun, like the game of golf. Sure, there's math, because you have to keep score. But there's also science, technology, and engineering hidden in the game — from the physics of how you swing, to the mechanics of a golf club, to the remote sensors that tell you when to water the golf course.

To get students more excited about science, technology, engineering, and math (STEM), the United States Golf Association has created a multi-media educational platform that uses golf to bring those fields to life. Hands-on learning experiences let students move beyond the textbook and classroom to explore science as an essential part of a real-world game.

The **TEST LAB TOOLKITS** use the USGA Test Center as inspiration for a fun series of golf-focused science activities. At the Test Center, scientists and engineers play around with golf balls, clubs, and other equipment every day to learn how they work. Since people keep thinking of new ways to improve the game, the Test Center needs to test new equipment to make sure it works with the game's traditions and doesn't give any unfair advantages. And now students can do some of the same experiments that the Test Center does.

Each Toolkit presents a specific topic related to one of the major elements of golf: The Swing, The Club, The Ball, The Course, and The Score. In the **WATER** Toolkit, you will find background information and instructions for four hands-on activities, including:

1. **Experiment with evaporation and transpiration (and learn how they affect a golf course)**
2. **Investigate different kinds of soil (and discover which captures or loses the most water)**
3. **Design your own golf course (and figure out how to give it the water it needs)**
4. **Measure water use in your own home (and come up with easy water conservation strategies)**

We hope you enjoy using this Test Lab Toolkit, and that it leads you to try others. The more Toolkits you do, the more your students will become experts at science — and golf!

How to Use the Toolkit

Background

Each Toolkit includes information about the science and math concepts behind a specific golf topic. Each Toolkit also relates directly to one or more videos in the NBC Learn: Science of Golf series — for **WATER,** the related video is "Water Conservation."

You can have the group review this information and watch the video as an introduction before doing any of the activities.

Activities

The four activities in this Toolkit can each be done independently, but they also build on each other:

- **Investigate:** In these two activities, students explore fundamental scientific concepts through hands-on experiments. You can run them informally as a large group activity, or have students do them as more formal science labs with standard scientific procedure (hypothesis, observation, conclusion, etc.)

- **Create:** This activity encourages creative thinking by challenging students to design their own version of a fundamental component of golf, such as a club, a golf ball, a putting green, etc. Students will rely on the scientific concepts they explored in the *Investigate* activities.

- **Connect:** While all Toolkit activities relate to the real world through the golf focus, this activity actually sends students out into the world to explore science in context. Using the concepts they first investigated through simulations, they will see what happens in an actual golf game or environment.

The student Toolkit includes full instructions and sample charts to record data for each activity. This Facilitator Guide includes each student activity, as well as further instructions for the facilitator.

Materials

Each activity has been designed to require only inexpensive, easy-to-find materials.

Test Lab Log

All of the activities in this Toolkit, and across the other Toolkits, are designed to work together to teach interconnected science and math concepts.

But they can also help students learn more about the game of golf, so that they can improve their understanding and skill.

After each activity, we recommend that students document what they learned in some way — notes, photos, video, diagrams, etc. They can then compile all their results into an ongoing Test Lab Log, which they can use as both a summary of their work and a handbook for the game. Depending on your available resources, the Test Lab Log can be as low-tech or high-tech as you like. Recommendations include:

- **Binder notebook:** Keep a single notebook for the entire class to use, or have students create their own binders of individual and shared materials.

- **Tumblr** (tumblr.com): Use this free site to create a customized microblog for the group, where students can easily upload results, post comments, and build conversations. The microblog can be public, or can be made private through the password protection option.

- **Wordpress** (wordpress.com): Use this free site to create a customized blog for the group. With a username and password, students can easily access the blog, upload results, and post comments.

Investigate: Evapotranspiration
Facilitator Guide

Water

Grades 6-8

S T E M

In addition to testing golf equipment, the USGA also promotes **environmental sustainability** on golf courses by studying how to keep courses beautiful and healthy, while conserving resources. One of the most important resources is water. To be able to conserve it, knowing when you need to irrigate and when you don't, you have to understand the **water cycle.** In this activity, you'll investigate the phase of the water cycle called **evapotranspiration** — the double process of **evaporation** from land and **transpiration** (breathing out water vapor) by plants.

Learning Objectives

To understand the concepts of **evaporation** and **transpiration.**

To understand how evapotranspiration affects a golf course.

To conduct an experiment.

STEM Fields

Science: water cycle

Time Requirement

Two sessions 45 min each, at least 24 hours apart

Activity Type

Plan ahead (gather materials)

Indoors

What Do You Do?

1 Introduce the Activity

- Read *Background Information.*
- Watch the NBC Learn video "Water Conservation" at www.nbclearn.com/science-of-golf.
- Review the concept of the water cycle, using the diagram in the activity instructions.

2 Set Up the Experiment

Investigate: Evapotranspiration, steps 1-4

- You can use any flowers as long as they are white, so that they show the effect of the food coloring.
- Trim the ends of the flowers, so that they are short enough to rest in the cups without tipping over.

3 Run the Experiments

Investigate: Evapotranspiration, steps 5-7

- The experiment works best if you wait a substantial amount of time, at least 12 hours, before checking the water levels.
- If you can check the experiment multiple times over several days, the effects of evaporation and transpiration will be more noticeable.
- Before checking the experiment, ask for predictions about what will happen. Afterwards, ask about what did happen and why.

What Happens?

Have students create a short report about the activity to add to their Test Lab Log. The report could include notes, photos, diagrams, etc.

What Does it Mean?

Have the group reflect on the activity and encourage them to draw conclusions based on their data.

- How accurate were their predictions?
- What were they surprised by?
- What did they learn about evaporation and transpiration?
- How does evapotranspiration affect a golf course?

Challenge!

After it rains, go outside and find a large puddle. Have students draw its outline in chalk. Check on the puddle every few hours, or even days, depending on its size. Each time, draw a new outline. How long does it take to evaporate?

Investigate: Evapotranspiration

Water

Grades 6-8

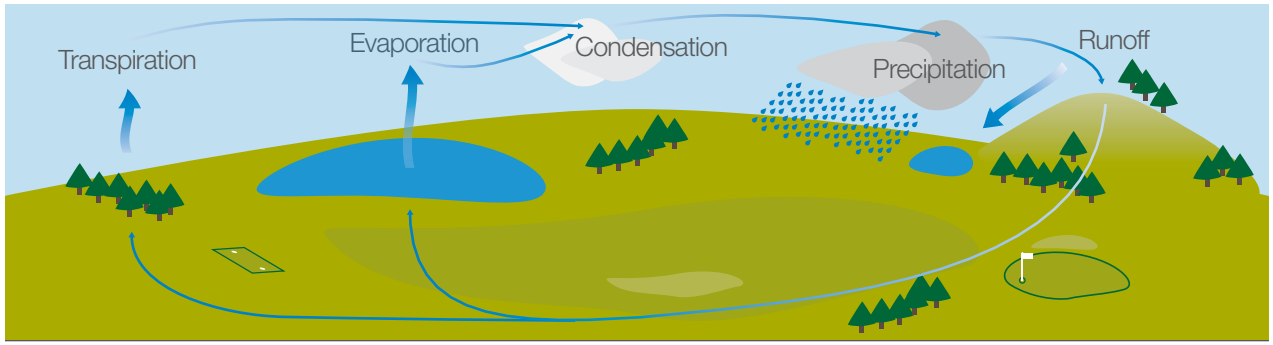
S T E M

How does water change from a liquid to a gas?

In addition to testing golf equipment, the USGA also promotes **environmental sustainability** on golf courses by studying how to keep courses beautiful and healthy, while conserving resources. One of the most important resources is water. To be able to conserve it, knowing when you need to irrigate and when you don't, you have to understand the **water cycle.** In this activity, you'll investigate the phase of the water cycle called **evapotranspiration** — the double process of **evaporation** from land and **transpiration** (breathing out water vapor) by plants.

What Do You Need?

- 5 clear plastic cups or other clear containers, all the same size, at least 6 inches high
- Masking tape
- Ruler
- Marker
- Water
- Aluminum foil
- Scissors
- 2 white carnations (or other white flowers)
- Food coloring in 2 colors



Water Cycle

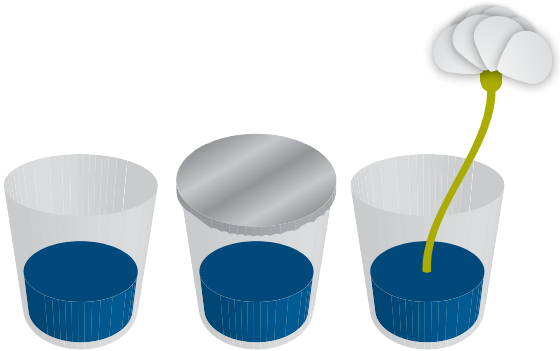
What Do You Do?

1. Put a piece of tape up the side of 3 cups. Mark the tape every ¼ inch, up to 5 inches.
2. Pour water into all 5 cups, up to 4 inches.
3. For the 3 containers with tape: cover one with aluminum foil, put a carnation in the second, and leave the third alone. Put them all by a sunny window.
4. For the other 2 containers, put a few drops of different food coloring in each. Split the stem of the second carnation in half, from the bottom up about 7 inches. Put the carnation in between the 2 cups, so that half its stem is in each.
5. Let all containers sit at least 24 hours.
6. When you return, measure the level of the water in the 3 cups with tape. What happened?
7. Look at the carnation in the food coloring. What happened?

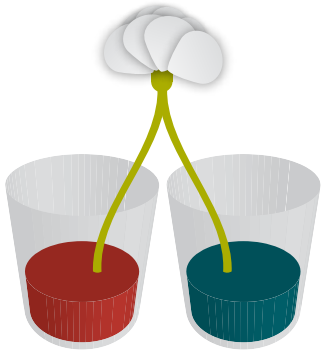
Challenge!

After it rains, go outside and find a large puddle. Draw its outline in chalk. Check on the puddle every few hours, or even days, depending on its size. Each time, draw a new outline. How long does it take to evaporate?

Evaporation Experiment



Transpiration Experiment



What Happens?

Use the chart to record your results, and make more as needed.

What Does it Mean?

- What did you learn about evaporation and transpiration?
- Which container had the least water after 24 hours, and why?
- How do you think evapotranspiration would affect a golf course?

Find Out More

- Read *Key Concepts* at the back of this Toolkit.
- Read *Water: Background Information.*
- Watch the NBC Learn video “Water Conservation” at www.nbclearn.com/science-of-golf.

Cup	Water Level		
	Day/Time	Day/Time	Day/Time
Aluminum Foil	*4 inches*	*3 1/2 inches*	*3 inches*
Carnation			
Just Water			

Add this chart to your Test Lab Log!

Investigate: Water Retention
Facilitator Guide

Water

Grades 6-8

S T E M

On a golf course, turfgrass plays an important role in **water retention.** By looking at how much water the course "captures" through natural sources (such as **rainfall**) and how much it loses (through **runoff**), you can figure out how much is retained and how much needs to be replaced through **irrigation.** The USGA studies the water retention of different turfgrasses to help golf course managers make the best selections. In this activity, you'll explore how well turfgrass holds onto water compared to other soils.

Learning Objectives

To understand the concept of **water retention.**

To understand the role of turfgrass in water retention for a golf course.

To conduct an experiment.

STEM Fields

Science: water conservation

Time Requirement

One session 45 min

Activity Type

Plan ahead (gather materials)

Indoors and **outdoors**

What Do You Do?

1 Introduce the Activity

- Read *Background Information*.
- Watch the NBC Learn video "Water Conservation" at www.nbclearn.com/science-of-golf.

2 Set Up the Experiment

Investigate: Water Retention, steps 1-3

- You can have students bring in different turf and soil samples from near their homes, or ask a golf course for samples.

3 Run the Experiment

Investigate: Water Retention, steps 4-7

- Before the experiment, ask for predictions about what will happen. Afterwards, ask about what did happen and why.

What Happens?

Have students create a short report about the activity to add to their Test Lab Log. The report could include notes, photos, diagrams, etc.

What Does it Mean?

Have the group reflect on the activity and encourage them to draw conclusions based on their data.

- How accurate were their predictions?
- What were they surprised by?
- What did they learn about water retention?
- How does the turfgrass affect a golf course?

Challenge!

Have students try this experiment with common grasses used on golf courses, such as bent grass, bermudagrass, or Kentucky bluegrass. You can ask your local golf course for samples, or grow them from seed.

Investigate: Water Retention

Water

Grades 6-8

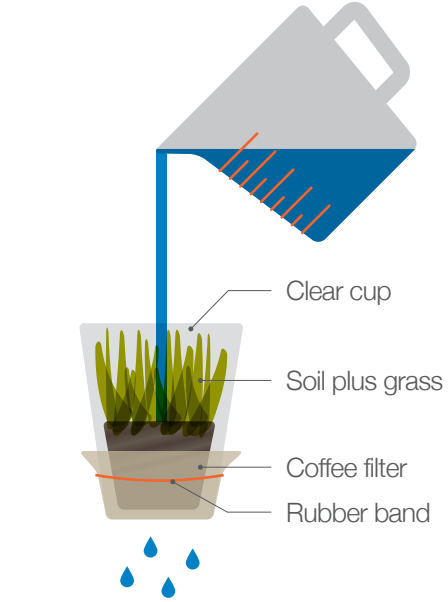
S T E M

How can you tell how much water different kinds of soil capture?

On a golf course, turfgrass plays an important role in **water retention.** By looking at how much water the course "captures" through natural sources (such as **rainfall**) and how much it loses (through **runoff**), you can figure out how much is retained and how much needs to be replaced through **irrigation.** The USGA studies the water retention of different turfgrasses to help golf course managers make the best selections. In this activity, you'll explore how well turfgrass holds onto water compared to other soils.

What Do You Need?

- 4 plastic cups
- 1 sample of turf (grass plus soil), about 4 inches deep
- 3 different soil samples (sand, gravel, soil without grass, etc.), each about 4 inches deep
- 4 paper coffee filters
- 4 rubber bands
- Bowl
- Scissors
- Measuring cup
- Water
- Scale (optional)



This activity is adapted from NBC Learn: Science of Golf, "Water Conservation"

What Do You Do?

1. Collect the turf and soil samples from your local park, backyard, garden store, etc.
2. Cut off the bottom of each cup. Place each cup inside a coffee filter and attach it with a rubber band.
3. Put a turf or soil sample in each cup, about 4 inches deep. If you want to be precise, you can weigh each cup with sample. Label the different samples.
4. Hold a cup over a bowl and pour in 6 oz of water.
5. When water stops dripping out of the cup's bottom, pour the water in the bowl back into a measuring cup. Record the amount.
6. If you have a scale, weigh the cup again and record the new amount.
7. Repeat steps 4-6 with the other cups.

Challenge!

Try this experiment with common turfgrasses used on golf courses, such as bent grass, bermudagrass, or Kentucky bluegrass. You can ask your local golf course for samples, or grow them from seed.

◀ **Different types and cuts of turf at Harbour Trees Golf Club**

What Happens?

Use the chart to record your results, and make more as needed.

What Does it Mean?

- What did you learn about water retention?
- Which type of soil retained the most water and why?
- How do you think turfgrass affects a golf course?

Find Out More

- Read *Key Concepts* at the back of this Toolkit.
- Read *Water: Background Information.*
- Watch the NBC Learn video "Water Conservation" at www.nbclearn.com/science-of-golf.

	Water Added ounces	**Water Lost** ounces	**Water Retained (added - lost)** ounces	**Weight before Water** pounds	**Weight after Water** pounds
Turf (soil plus grass)	*6*	*4*	*2*	*.2*	*.3*
Soil only					
Sand					
Gravel					

Add this chart to your Test Lab Log!

Create: Golf around the World
Facilitator Guide

Water

Grades 6-8

S T E M

How much water a golf course needs depends a lot on **local climate.** For example, a golf course in a desert climate may need more or less water than one in New England, depending on the type of **turfgrass** used. That's why the USGA Green Section recommends using turfgrass adapted to the natural environment. In this activity, you'll design your own golf course and think about how much water you would need (and how you would supply it) to keep the course healthy.

Learning Objectives

To understand the concepts of **climate** and **natural environment.**

To understand how environment affects water needs on a golf course.

To develop creative thinking.

STEM Fields

Science: climate, biomes

Time Requirement

One session 45 min
Research and create one golf course

Two sessions 45 min each
Research and create multiple golf courses

Activity Type

Plan ahead (gather materials)

Indoors

What Do You Do?

1 Introduce the Activity

- Read *Background Information*.
- Watch the NBC Learn video "Water Conservation" at www.nbclearn.com/science-of-golf.

2 Research the Course

Create: Golf around the World, steps 1-2

- If you have only one session, students should work collaboratively to design one golf course. If you have multiple sessions, students can each research and design their own course.

3 Create the Course

Create: Golf around the World, steps 3-5

- Have students decide on a common measurement scale to use for all drawings, so that they are easier to compare, such as 10 yards = 1 inch.
- They can include a short description of the natural environment.

What Happens?

Have students create a short report about the activity to add to their Test Lab Log. The report could include notes, photos, diagrams, etc.

What Does it Mean?

Have the group reflect on the activity and encourage them to draw conclusions based on their data.

- What were they surprised by?
- How does the local environment affect water needs?
- What did they learn about golf course design?

Create: Golf around the World

Water

Grades 6-8

S T E M

How would you design a golf course for a different environment?

How much water a golf course needs depends a lot on **local climate.** For example, a golf course in a desert climate may need more or less water than one in New England, depending on the type of **turfgrass** used. That's why the USGA Green Section recommends using turfgrass adapted to the natural environment.

In this activity, you'll design your own golf course and think about how much water you would need (and how you would supply it) to keep the course healthy.

What Do You Need?

- Computer
- Paper and markers
- OR foam board and craft materials

▼ **Pebble Beach Golf Links (coastal golf course)**

What Do You Do?

1. Pick a location somewhere in the world for your golf course. Research its biome (climate, rainfall, temperature, vegetation, etc.) at earthobservatory.nasa.gov/Experiments/Biome or elsewhere.

2. Decide how your course will compare to its natural environment. Will it use the same kinds of terrain, vegetation, and water features, or will you create a different environment? For example, you could design a grasslands course in a grasslands environment, or a grasslands course in a desert environment.

3. Create at least one hole of your golf course on paper or with craft materials, showing vegetation and water sources, as well as the surrounding natural environment.

4. Based on your research, estimate whether your course will need a little or a lot of water. How much will be available from rainfall and onsite water sources? How much irrigation will be necessary? A course that uses plants adapted to the natural environment may need less irrigation.

5. Compare your course with the ones your friends made. Which ones need the most and least water?

◀ **Desert Forest Golf Club (desert golf course)**

What Happens?

Compare golf courses and note the results.

What Does it Mean?

- How does the local environment affect water needs?
- What did you learn about golf course design?

Find Out More

- Read *Key Concepts* at the back of this Toolkit.
- Read *Water: Background Information.*
- Watch the NBC Learn video “Water Conservation” at www.nbclearn.com/science-of-golf.

Connect: Water in Your Home
Facilitator Guide

Water

Grades 6-8

S T E M

The USGA Green Section helps golf course managers maintain courses so that they conserve water as much as possible. But **water conservation** isn't just an important issue on a golf course — it's important throughout the world, including in your own home. In this activity, you'll explore how much water you use at home, and think about ways to conserve it.

Learning Objectives

To understand the concept of **water conservation.**

To apply scientific concepts in a real-world context.

STEM Fields

Science: water conservation

Time Requirement

Session One 45 min
Set up the activity

One week
Fill out the chart

Session Two 45 min
Discuss the activity

Activity Type

Plan ahead (gather materials)

Indoors

What Do You Do?

1 Introduce the Activity

- Read *Background Information.*
- Watch the NBC Learn video "Water Conservation" at www.nbclearn.com/science-of-golf.

2 Set Up the Activity

Connect: Water in Your Home, step 1

- Students can adapt the chart by adding or deleting activities, so that it better reflects how they use water in their homes.
- To find out average water usage for additional activities, check out www.threeactionsproject.org/Actions.

3 Run the Activity

Connect: Water in Your Home, steps 2-5

- Ask students NOT to alter their habits for the first week, so that they can see how much water they typically use.
- After one week, brainstorm ways to conserve water. Afterwards, students can record their water consumption for a second week, to see if they notice any changes.

What Happens?

Have students create a short report about the activity to add to their Test Lab Log. The report could include notes, photos, diagrams, etc.

What Does it Mean?

Have the group reflect on the activity and encourage them to draw conclusions based on their data.

- What were they surprised by?
- What did they learn about their water consumption?
- What are some ways to conserve water at home?

Connect: Water in Your Home

Water

Grades 6-8

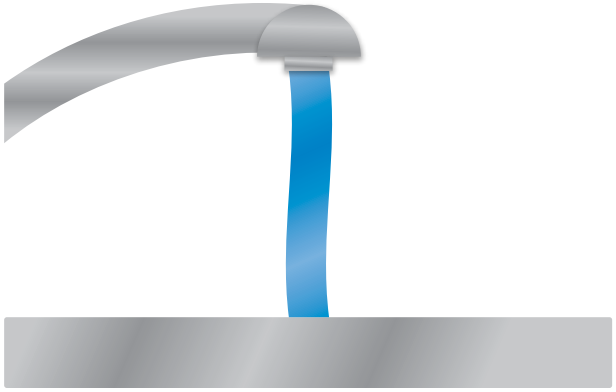
S T E M

How can you conserve water at home?

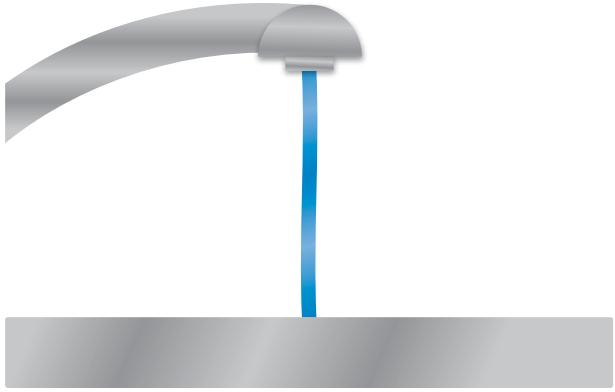
The USGA Green Section helps golf course managers maintain courses so that they conserve water as much as possible. But **water conservation** isn't just an important issue on a golf course — it's important throughout the world, including in your own home. In this activity, you'll explore how much water you use at home, and think about ways to conserve it.

What Do You Need?

- Chart
- Pencil
- Stopwatch



Full on



Half on

Dripping

This activity is adapted from the Three Actions Project (www.threeactionsproject.org/Actions/Track-Your-Daily-Water-Use.php)

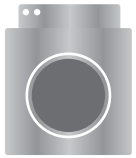
What Do You Do?

1. Use the chart to calculate how much water you (or your entire family) use in a week. Record **how many times** you do each of the activities each day.
2. At the end of the week, **add up the total** for each activity and **multiply** by the Average Water Usage.
3. Compare your results with friends. Who had the lowest and highest weekly water consumption? Why?
4. Brainstorm ways to conserve water at home. Check out www.threeactionsproject.org/Actions for ideas.
5. You can also work with friends to figure out how much water your golf course or school uses.

If the faucet is run for 4 minutes a day...

4,000 gal/yr

If you do just 2 loads every week...



5,000 gal/yr

If every other day you took a 15-minute shower...

19,000 gal/yr

If a toilet is flushed 15 times per day...

33,000 gal/yr

This chart is adapted from eLocal.com (http://www.elocal.com/content/home-expert-network/water-home-wasting-infographic-431)

What Happens?

Use the chart to record your results, and make more as needed.

What Does it Mean?

- What did you learn about your water consumption?
- What are some ways to conserve water at home?

Find Out More

- Read *Key Concepts* at the back of this Toolkit.
- Read *Water: Background Information.*
- Watch the NBC Learn video "Water Conservation" at www.nbclearn.com/science-of-golf.

	Monday	Tuesday	Wednesday	Thursday	Friday	Saturday	Sunday	Total for Week	Average Water Usage gallons	Total Water Usage gallons
Toilet flush									x 3.5	
Wash hands (half-on)									x .25	
Wash face (half-on)									x .5	
Brush teeth (half-on)									x .5	
Shower (10 min)									x 20	
Kitchen faucet (1 min)									X .5	
Wash Dishes by hand (fill basin)									x 10	
Dishwasher									x 12	
Washing machine									x 42	
Lawn sprinkler (5 min)									x 10	
								Total Weekly Water Usage		

This activity is adapted from the Three Actions Project (www.threeactionsproject.org/Actions/Track-Your-Daily-Water-Use.php)

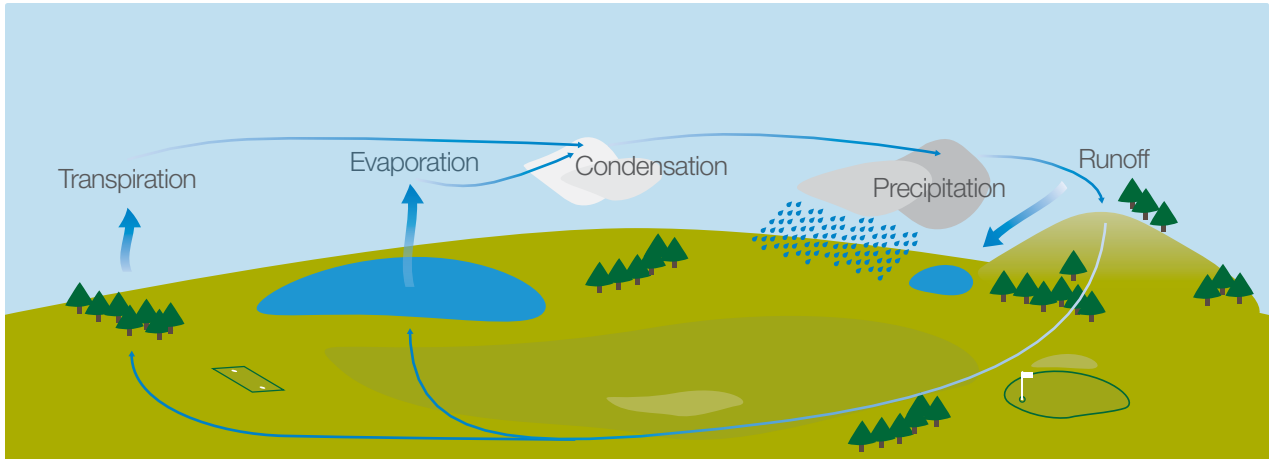
Add this chart to your Test Lab Log!

The Course: Water
Background Information

With rolling fairways and manicured greens, golf is closely tied to its environment. But creating these playing surfaces requires one of nature's most precious resources: water. Exactly how much water does a golf course need? It depends on a lot of factors: climate, season, available water sources, type of turfgrass, and more. That's why golf course managers use science and math to figure out exactly how much water they need, and how to supply it as efficiently as possible.

Water, Water Everywhere

It all begins with understanding water. Water is everywhere in the world — in obvious places like rivers and oceans, but also as ice and snow in the mountains, moisture in the soil, and water vapor in the air (which we feel as **humidity**). Water is also constantly in motion. For example, when snow melts, it flows into rivers and seeps into the ground. That water then **evaporates** from land and water surfaces, or is absorbed by plant roots only to later **transpire** (be breathed out) through the leaves as water vapor. Up in the atmosphere, the vapor **condenses** into clouds and eventually falls back to the ground as **precipitation** (rain or snow). This constant process of transformation and motion is called the **water cycle,** and it helps sustain life on Earth.



▲ **The Water Cycle**

Understanding the water cycle is the key to knowing when to irrigate and how much.

Every Drop Counts

The fact that water is everywhere around us doesn't mean it's always enough water. Some golf courses are able to get a lot of the water they need from natural sources, such as rainfall. But most still need to **irrigate,** a little or a lot, by adding water via sprinklers and other man-made methods. Golf courses in cooler climates with high rainfall need to irrigate less than one acre-foot of water per acre each year, while courses in dry hot climates may need as much as six acre-feet of water per acre per year. This may not sound like much, but one acre-foot of water would cover an entire football field to a depth of one foot — equal to 325,851 gallons! So golf courses definitely need A LOT of water, no matter the climate.

That's why **water conservation** is such a big issue for golf courses. And it's why the USGA, in addition to testing golf equipment, also studies how to keep courses well-maintained while conserving resources.

Back in 1920, the USGA created a special environmental science team called the Green Section, made up of **agronomists** who specialize in understanding turf and soil. This team researches all aspects of golf course management, including vegetation, soils, fertilizers, pest control, irrigation methods, and more. And they use this research to develop "best practices" that they can share with golf course managers around the country. When it comes to water conservation, two important methods they promote are selecting the most appropriate turfgrass, and using technology to understand a course's water needs.

Not Just Any Grass

Turfgrass is a special kind of grass that's used to create turf (outdoor playing surfaces), for sports like golf or baseball. But golf courses don't all use the same kind, because different turfgrasses have different water needs, which makes some better suited to one environment over another. Warm-season grasses (such as such as bermudagrass and buffalograss) require less water than cool-season grasses (such as Kentucky bluegrass and tall fescue), which means that warm-season grasses would be better suited to a hotter, dryer climate.

Turfgrass also plays an important role in **water retention.** When water is added to a golf course, through either rainfall or irrigation, the turfgrass captures some of it and some of it is lost through **runoff.** The better the turfgrass is at capturing and retaining water, the less you'll need to irrigate. That's why understanding turfgrass helps golf course managers choose the varieties that conserve water best, and helps scientists develop even better varieties for the future.

◀ The USGA Green Section and Water Use

In 1920, E.J. Marshall was in charge of preparing the Inverness Club in Toledo, OH, for the U.S. Open Championship. He tried to find expert information about turfgrass and water use, but couldn't, so he turned to the USGA and the US Department of Agriculture. The two organizations agreed to collaborate, and the result was the creation of the USGA Green Section — the largest, private environmental research effort in the history of golf. (Copyright USGA/John Mummert)

Bring on the Tech

How do you figure out how exactly how much water the turfgrass retains and uses? With new high-tech probes that can detect soil moisture levels, **salinity** (salt content), and the rate of evapotranspiration. Some kinds of probes can be implanted in the soil to provide constant measurements, while others are portable, so that golf course managers can spot check different areas. With these measurements, managers can calculate a course's **water deficit** (how much water is lost to runoff and evapotranspiration) and **water requirement** (how much water needs to be supplied through irrigation). By knowing exactly how much water the turfgrass needs, they can deliver just the right amount of water to keep it healthy, without wasting any.

Thanks to science, math, and technology, golf course managers are able to save thousands of gallons of water on just a single course!

Key Concepts

Agronomist
A scientist who specializes in turf and soil management.

Condensation
The conversion of water from a gas or vapor to a liquid due to cooling.

Evaporation
The conversion of water from a liquid to a gas or vapor due to heat. Water can evaporate from both soil and bodies of water (lakes, rivers, oceans).

Evapotranspiration (ET)
The combined processes of evaporation and transpiration. Golf course managers use this term to refer to the total loss of liquid water from a course via both evaporation and transpiration.

Humidity
The amount of moisture in the air. Even in the desert, the air always contains water vapor that has evaporated from land and water sources, or transpired from plants.

Irrigation
To apply water to the land via artificial means (such as a sprinkler) rather than natural means (such as rainfall). Irrigation is used on golf courses and farms when water from natural sources isn't enough for healthy plant growth.

Precipitation (Rainfall)
The process by which water vapor in the air condenses to a liquid and falls to the ground as rain. Precipitation can also take a solid form (hail, sleet, or snow).

Runoff
Water that flows away from the soil surface, often into a nearby body of water (river, pond, etc.), rather than being absorbed by the soil. To figure out the water deficit of a golf course and how much to irrigate, managers need to know how much rainfall is lost to runoff.

Salinity
The salt content of a substance. Excessive salinity in the soil slows down the growth of turfgrass.

Transpiration
The movement of water through a plant from the moment it's absorbed by the roots until it's released as a gas through the plant's leaves.

Turfgrass
A variety of grass used to grow turf (outdoor playing surfaces), for sports like golf or baseball. Different types of turfgrass are well-suited to different climates and seasons. Warm-season grasses (such as such as bermudagrass and buffalograss) require less water than cool-season grasses (such as Kentucky bluegrass and tall fescue).

Water Conservation
The effort to protect the purity of water sources, reduce the need of environments and populations for water, and use water as efficiently as possible with little waste. Water conservation is an important issue in many areas of the world where water quality and quantity are both at risk.

Water Cycle (Hydrologic Cycle)
The natural process by which water constantly changes its state and moves from the surface of the Earth into the atmosphere (via evaporation and transpiration), and then back to the surface again (via precipitation).

Water Deficit
On a golf course, the amount of rainfall that is lost to evapotranspiration and runoff, instead of being retained by the soil.

Water Retention
The ability of an object or surface (like turfgrass) to retain water.

Water Requirement
The amount of water that needs to be applied to a golf course through irrigation, in order to make up for the water deficit.

Additional Resources

To further explore the science of **WATER** or the game of golf, please check out the following resources:

Science of Golf

USGA STEM Resources
www.usga.org/stem
Portal to a variety of STEM-related experiences

USGA: Golf's Use of Water Resource Center
www.usga.org/greensectionMicrosite.aspx?id=21474860377
Information about water use and conservation

USGA: Course Care & Environment
www.usga.org/CourseCareLanding.aspx?id=21474846413
Information about the Green Section, golf course management, and more

USGA Test Center
www.usga.org/equipment/overview/Equipment-Standards-Overview
Information about the Test Center and the Rules of Golf

NBC Learn: Science of Golf
www.nbclearn.com/science-of-golf
Videos and lesson plans about the science of golf

Sports 'n Science: Golf
sportsnscience.utah.edu/science-behind-the-sport/sport/golf
Information about the science of golf, as well as other sports

STEMZone and the World of Golf (Kid Scoop News)
www.kidscoopnews.com/downloads/stem-zone/ksn_stemzone.pdf
Information and activities related to the science of golf

Golf

USGA
www.usga.org
Official Rules of Golf, equipment standards, golf course information, and more

USGA Museum
www.usgamuseum.com
Online exhibits and photos related to the history of golf

Education Standards

Test Lab Toolkits are designed to support Next Generation Science Standards, Common Core Mathematics Standards, and the 21st-century skills of communication, collaboration, critical thinking, and creativity. The specific Common Core Mathematics Standards related to this Toolkit include:

Earth's Systems

MS-ESS2-4
Develop a model to describe the cycling of water through Earth's systems driven by energy from the sun and the force of gravity.

Human Impact

MS-ESS3-3
Apply scientific principles to design a method for monitoring and minimizing a human impact on the environment.

Engineering Design

MS-ETS1-1
Define the criteria and constraints of a design problem with sufficient precision to ensure a successful solution, taking into account relevant scientific principles and potential impacts on people and the natural environment that may limit possible solutions.

MS-ETS1-2
Evaluate competing design solutions using a systematic process to determine how well they meet the criteria and constraints of the problem.

MS-ETS1-3
Analyze data from tests to determine similarities and differences among several design solutions to identify the best characteristics of each that can be combined into a new solution to better meet the criteria for success.