have learned, students will be asked to play the role of wildlife managers assessing sites to find an appropriate place to relocate beavers. Students will apply their new understanding to decide where the beavers’ presence will be most useful as environmental restorers.

The Driving Question

A driving question is one that drives the teaching and learning for a given unit, or even an entire school year. It provides context for the purpose of student exploration and understanding of a phenomenon. This e-book is written around the driving question:

*How do environmental changes affect the plants and animals that live in that ecosystem?*

Three-Dimensional Learning and the *Beavers Building Ecosystems* E-book

You will notice throughout the document that certain words and phrases are highlighted in different colors: blue, green, and orange. These colors correspond to the *science and engineering practices* (blue), *crosscutting concepts* (green), and *disciplinary core ideas* (orange). The book also incorporates *engineering design* (purple). This will help you quickly notice how each of the three dimensions and engineering design are used on a page. Refer back to this section for the full descriptions.

This e-book does not use all of the grade-level elements for the practices and crosscutting concepts, but that does not mean that you should not be aware of the other practices and concepts your students need to know. For a full list of all grade-level elements for the science and engineering practices and crosscutting concepts, refer to Appendix A.

For engaging in literacy ideas, refer to Appendix B.
Beavers As Ecosystem Engineers

By the end of the topic, students will be able to:

• identify beavers and state how parts of their bodies are used for building and survival;
• observe how beavers build dams that change the environment around them;
• use models to describe how the environment changes once a beaver has built a dam; and
• interpret graphs, charts, and observational data that show how plants and animals in the environment change over time to create a new ecosystem.
Students will identify the dam as a structure that a beaver built. Many students will know that beavers build dams; however, they may not think of dam building as engineering. Analyze what beavers need to do to design and build this dam. Discuss how they would need to find a stream, select a spot to build the dam, locate and move materials, and finally put the dam together so it will hold back the water. You can also see evidence of design in the dam itself. Have students observe the pattern of sticks in the pile. Do they see a pattern in how the sticks are placed? Beavers actually place a large number of sticks on the downstream side of their dams. This provides strength to the dam and helps keep it up despite the water pressure on the far side.

**Thinking Beyond**

Do all beaver dams look the same? Do a search on the internet for beaver dams and take a look at several pictures. What differences and similarities do you see? People sometimes walk right over a beaver dam without even realizing it. Dams that have been around longer look very different from new dams like the one shown on page 3 of the e-book. The look of a dam changes with time as it blends in more with its environment. Without careful observation, you may not even realize that one side of a wetland you are looking at was engineered by beavers.

**Language Arts Connection**

The longest beaver dam ever discovered is in Alberta, Canada and was discovered by aerial imagery. A wonderful book written about the beavers at the Alberta dam is *Build, Beaver, Build!* *Life at the Longest Beaver Dam* by Sandra Markle.
calculations for rectangles and rectangular prisms. For example, look at the cross section of the pond below.

If we partition the cross section into rectangles, we can use the formula for the area of a rectangle to find the area. Do this for all the rectangles, add up the amounts, and the result is an approximate area of the cross section of the pond. If we multiply this by the width of the slice we want to measure (using the same unit we used for the width of the cross section), we have the volume for that slice of the pond. We then move to the next slice of the pond and do the same calculations again. The volume will never be exact, but it will be a good approximation. What if we were to make the rectangular prisms smaller? Would that increase the accuracy? Fortunately, with modern computers researchers can feed millions of measurements into a computer and it will process all these calculations for them!
Topic 1: Beavers As Ecosystem Engineers

Page 10

On this page students will carry out an investigation of what species of branches beavers eat most often. They will observe the sticks beavers eat and organize the data on a chart in order to see patterns that suggest beavers’ favorite trees to eat. This activity is based on an actual experiment done by researchers. For seven nights students will leave out three different kinds of sticks. Each morning, they check to see what the beaver took and record it on the chart. On the right side of the page, students can click through the days. On the left, they place marks in the boxes that indicate which sticks were gone in the morning. Filling out the data should result in a table that looks like the one below.

<table>
<thead>
<tr>
<th>Tree</th>
<th>Day 1</th>
<th>Day 2</th>
<th>Day 3</th>
<th>Day 4</th>
<th>Day 5</th>
<th>Day 6</th>
<th>Day 7</th>
</tr>
</thead>
<tbody>
<tr>
<td>Aspen</td>
<td>X</td>
<td></td>
<td>X</td>
<td>X</td>
<td></td>
<td>X</td>
<td></td>
</tr>
<tr>
<td>Poplar</td>
<td>X</td>
<td>X</td>
<td></td>
<td>X</td>
<td></td>
<td></td>
<td>X</td>
</tr>
<tr>
<td>Red Maple</td>
<td>X</td>
<td></td>
<td></td>
<td>X</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Willow</td>
<td></td>
<td>X</td>
<td>X</td>
<td></td>
<td>X</td>
<td></td>
<td>X</td>
</tr>
<tr>
<td>Ash</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td>X</td>
<td>X</td>
<td></td>
</tr>
<tr>
<td>White Pine</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
</tbody>
</table>
This page begins a closer exploration of the ecosystem changes that occur after a beaver builds a dam. It is important to note that some changes happen quickly and some happen over long periods of time. As you go through the next few pages, you may want to ask students how quickly they think this change will happen.

Mathematics Connections
Estimation is a mathematical concept that younger students struggle with. Estimating changes over time can be particularly difficult. You can discuss estimating time in many ways throughout this e-book. How long do you think it would take to build a dam that size? How long would it take to fill up that pond? How long will it take for a tree to die? Encourage students to think in terms of days, weeks, months, and years. Being able to create estimates for some of these things will give them a better sense of how quickly or slowly systems change. Change is measured in terms of differences over time and may occur at different rates. You could construct a timeline of events and how quickly students think they will occur.

Thinking Beyond
The following pages will show how a forest turns into a beaver wetland. It is important to note that beavers can colonize many areas and not all will look like this forested area. Obviously, there must be trees in the area for beavers to survive, but students may be surprised at the
This page, based on a research study, compares bird sightings at a beaver pond and a stream site. Students will look at the data recorded here for a single day and compare it across the two locations. The evidence in the data supports the conclusions that there is a greater variety of bird species at the beaver pond site, as well as larger numbers of birds. Bird-savvy students may notice that unlike the other birds on this list, woodpeckers aren’t water birds. Why might they be attracted to the beaver pond site? Have them think back to the dead trees we saw earlier in the book. Trees make excellent nesting sites and support many delicious insects that woodpeckers like to eat.

In reality, a researcher would not use one day’s worth of data to draw conclusions. Researchers use observation and collect data many times, over many days to help them understand and describe large, complicated systems such as wetlands. By recording data on charts and graphs, they can start to see patterns in the data. Why is it important to observe the two sites many times? Encourage students to think about how the data might change at different times of year. Due to cycles of migration and breeding, bird populations change drastically over the course of the year. Only long-term observation can reveal larger patterns of bird habitation.

Thinking Beyond
What kinds of tools might researchers use to collect this data? Plan a trip to the school playground to observe some birds. How can students record what they see? What recording
Do you remember how slowly the water moved through the watershed when we added the beaver dams? Do you wonder if that is doing something to change the sediment in the water? Look at the interactive on this page. Use the controls to change the speed of the water. Watch what happens to the sediment as the water speed changes.

Give students some time to explore this interactive and use the model to explain how water speed is related to sediment in the water. They should be able to articulate that the speed of the water keeps the sediment in the water. When the water flow slows, the sediment can slow down and drift to the bottom of the stream. Remember the page where they used the model to see how quickly water flows through a system with and without beaver dams? If you made charts and still have them, pull them out now. Beaver dams slow the water speed. This allows the sediment to sink to the bottom of the stream.

**Thinking Beyond**
See if students can come up with other places they see this relationship in action. Maybe have them picture leaves on a windy day. What happens to the leaves? What do the leaves do when the wind dies down? Are there other examples they can think of in which the speed of one variable affects the distribution of another?

**Differentiation**
For students who don’t understand this concept, show them a number of small strips of tissue paper tied to a fan. When the fan is turned on the tissue pieces are blown in the air away from the fan. When the fan is turned off, the tissue pieces settle to the floor.
Page 31

We have learned a lot about how wetlands provide a clean habitat for many plants and animals. Do you think it is important that beavers engineer new wetland ecosystems? Let’s look at some data that might help us.

How much of the land in the United States is a wetland?

Many endangered and threatened species in the United States depend on wetlands to survive. That list includes birds, plants, insects, amphibians, reptiles, and mammals. Look at the graph in the middle of the page.

What percentage of endangered species live in wetlands?

What percentage of all bird species live in the wetlands?

Now think about the information on all three graphs. Do you think it is important that beavers create new wetland habitats for plants and animals? Support your answer with data from the graphs.

This page provides students with the opportunity to read graphs and draw conclusions from the data. The pie charts make it easy to visualize the data, but you should also encourage students to look carefully at the percentages listed.

Give students time to analyze the data in the graphs using the three questions and “Check Your Thinking” buttons on the page. Then have them formulate a response to the question posed at the bottom: Do you think it is important that beavers create new wetland habitats for plants and animals? Students must use at least two pieces of data from the graphs to support their answer.

**Mathematics Connection**

Pie charts make it easy to compare fractions and percentages. Can your students turn the percentages shown on this page into fractions? Can they estimate fractions and find exact fractions?

**Language Arts Connection**

Have students write their answers in paragraph form to practice stating an opinion and supporting it with evidence.