Introduction to Teaching Virginia's Water Resources

This curriculum packet was created with three broad goals in mind.

1. To support K–12 teachers in Virginia as they teach students material from the Virginia Standards of Learning.
2. To help meet the stated goals of the Chesapeake 2000 Agreement, signed by the states surrounding the Chesapeake Bay and by the District of Columbia.
3. To provide K–12 teachers with useful resources for teaching students a greater appreciation of our important water resources.

There are already many other excellent curriculum materials for teaching about water. We have tried to produce a packet that will stand beside these and be as Virginia-specific and teacher-friendly as possible.

Our curriculum packet is organized by the Virginia Standards of Learning (SOL). The main sections of the packet include a mixture of content chapters and lesson plans. The content chapters provide specific information about water resources and about teaching strategies. Alongside these content chapters are new lesson plans written for Virginia's classroom teachers.

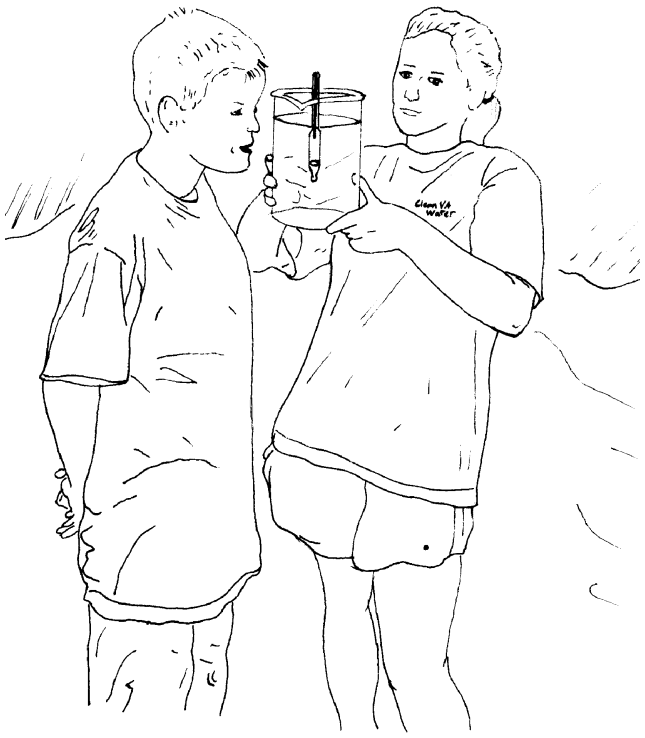
Both the content chapters and the lesson plans are written to support the Virginia SOL and also the Chesapeake 2000 Agreement. The Chesapeake 2000 Agreement (described later in this Introduction) recommends K–12 students carry out meaningful field investigations, including preplanning, investigation, and analysis and communication of findings. We have also written our materials using the inquiry-based approach to teaching science SOL. Our lessons are designed for students to answer questions. The lessons can be more teacher-directed or more student-directed depending on teacher preference, but students will prepare, investigate, then discuss and apply what they are learning.

Following this Introduction section of the curriculum packet is a section listing specific local water resource issues for Virginia. The listing is organized by Virginia counties. The main part of the curriculum packet is made of five sections, each dealing with a different aspect of water resources and corresponding SOL.
At the end of the packet is a short section describing some other curric-ulum materials available for teaching water resources and correlating available materials with the SOL. Appendices include an extensive glossary of water terms and information about obtaining materials and other resources.

A Tool to Help Students Learn About Water and Succeed with the SOL...

This curriculum packet is organized according to the Virginia Standards of Learning (SOL). Four of the five main packet sections corre spond to different groups of Science SOL. The last main section of the packet is directed to the History and Social Science SOL. Each of these five packet sections contains a mix of content chapters and lesson plans relating to the targeted SOL.

One of the sections, "How Can We Understand Our Water Resources?" is written to support the science SOL dealing with "Scientific Investigation, Reasoning, and Logic." This section contains content chapters and lesson plans dealing with the science process skills, data analysis, and experimental design. The lessons in this section also teach about water resources. The other sections target different content SOL relating to water resources. Lessons in these sections also emphasize students using science process skills appropriate for the grade level of that lesson. As mentioned above, the whole curriculum packet reflects broad recommendations that students learn by carrying out meaningful field investigations and using an inquiry approach.



The following table lists the content chapters and lesson plans in each of the main sections of this curriculum packet. The sections each contain a short introductory chapter describing the target SOL for that section in more detail.

PACKET SECTION & SOL CATERGORY	CONTENT CHAPTERS AND LESSONS
"How Can We Help Protect Our Water Resources?" SOL Strand: Resources	Litter and Debris in Our Waterways Endangered Aquatic Species Lesson 1 – Classifying Aquatic Debris (Science SOL – 1.8, 3.10) Lesson 2 – Helping Clean Up a Waterway (Science SOL – 6.9)
"How Can We Help Maintain Our Water Supply?" Earth Science & Environmental Science SOL	The Importance of Groundwater Lesson 3 – Conserving Water (Science SOL – 6.5) Lesson 4 – Nitrate Levels in Wells (Science SOL – ES.7, ES.9)
"How Healthy Are Our Waterways?" Life Science & Biology SOL	Water Quality Monitoring Lesson 5 – Evaluating a Stream (Science SOL – 6.7, LS.7, LS.11, LS.12) Lesson 6 – Restoring a Stream (Science SOL – 6.7, LS.12) Lesson 7 – Optical Brighteners and Water Quality (Science SOL – BIO.9)
"How Can We Understand Our Water Resources?" Scientific Investigation, Reasoning, and Logic SOL	Teaching the Science Process Skills Analyzing Experimental Data Designing an Experiment Lesson 8 – Observing a Stream (Science SOL – K.2, K.4, 1.8, 3.6, 3.10) Lesson 9 – Comparing Water Quality Data (Science SOL – ES.2) Lesson 10 – A Scientific Cleanup (Science SOL – BIO.9)
"What Relationships Exist Between People and Water?" Social Science SOL	Lesson 11 – Mapping a Watershed History (Science SOL – 4.8 Social Science SOL – VS.1) Lesson 12 – Making Decisions for Water Use (Science SOL – 6.5, 6.7, 6.9, LS.12 Social Science SOL CE.1, CE.7)

Although all the lessons are adaptable for different grade levels, each lesson plan in the curriculum packet has been written for use primarily at one grade level. The following table lists the lessons according to the recommended grade level.

GRADE LEVEL	LESSONS IN THIS CURRICULUM PACKET
Grade 3	Lesson 1 – Classifying Aquatic Debris Lesson 8 – Observing a Stream
Grade 4 Virginia Studies	Lesson 11 – Mapping a Watershed History
Grade 6	Lesson 2 – Helping Clean Up a Waterway Lesson 3 – Conserving Water Lesson 5 – Evaluating a Stream
Grade 7 Life Science	Lesson 6 – Restoring a Stream
Grade 7 Civics and Economics	Lesson 12 – Making Decisions for Water Use
Grade 9 Earth Science	Lesson 4 – Nitrate Levels in Wells Lesson 9 – Comparing Water Quality Data
Grade 10 Biology	Lesson 7 – Optical Brighteners and Water Quality Lesson 10 – A Scientific Cleanup

As stated above, each section of the curriculum packet is organized around a group of science SOL or, for one of the sections, a group of social science SOL. Those SOL are the main focus for that section of the packet and also the lesson plans within that section. However, each lesson plan was written to be interdisciplinary in nature. Each lesson lists related SOL in all the areas of science, social science, mathematics, English, and computers and technology. Using an interdisciplinary teaching approach is discussed later in this Introduction.

Designing a Meaningful Field Investigation...

The Chesapeake 2000 Agreement calls for all students to learn more about the Chesapeake Bay through meaningful field experiences investigating water resources during their K-12 schooling. This recommendation applies to all students living within the Chesapeake Bay watershed and also those Virginians outside of the Bay watershed. Meaningful field experiences are considered to have three separate components.

1. Advance planning
2. Field work
3. Analysis and communication of findings

A primary goal of our curriculum packet is to support teachers in providing students with such meaningful field investigations. Each of the lessons was written with the hope that teachers will involve students in simple field investigations. As much as possible, these field investigations will be carried out locally, close to the school and even on the school site itself. In addition, many of the lessons in this packet present opportunities for students to carry out or participate in action projects in their school or their community. For younger students, these projects can be carried out as class projects. Older students may extend projects as individual investigations.

The Chesapeake 2000 Agreement

The Chesapeake 2000 Agreement is intended to protect and restore the Chesapeake Bay ecosystem. The Chesapeake Bay is North America's largest and most biologically diverse estuary and home to more than 3,600 species of plants, fish, and animals. The Chesapeake 2000 Agreement was agreed and signed by Virginia, Maryland, Pennsylvania, and the District of Columbia, as well as The Chesapeake Bay Commission and the U.S. Environmental Protection Agency. The Chesapeake 2000 Agreement is a reaffirmation of earlier agreements in 1983 and 1987 that established the Chesapeake Bay Program partnership.

The Chesapeake 2000 Agreement makes specific recommendations for achieving the overall goals of protecting and restoring the Chesapeake Bay. These recommendations involve participation of everyone in the Bay watershed including businesses, individuals, and schools. The following table summarizes the Chesapeake 2000 goals and focus areas for recommendations. Full details of the Chesapeake 2000 Agreement and the different recommendations can be found at the Chesapeake Bay Program web site (*www.chesapeakebay.net/agreement.htm*).

CHESAPEAKE 2000 GOALS	SPECIFIC FOCUS AREAS
Living Resource Protection and Restoration Restore, enhance and protect the finfish, shellfish and other living resources, their habitats and ecological relationships to sustain all fisheries and provide for a balanced ecosystem.	• Oysters • Exotic Species • Fish Passage / Migratory and Resident Fish • Multi-Species Management • Crabs
Vital Habitat Protection and Restoration Preserve, protect and restore those habitats and natural areas that are vital to the survival and diversity of the living resources of the Bay and its rivers.	• Submerged Aquatic Vegetation • Watersheds • Wetlands • Forests
Water Quality Protection and Restoration Achieve and maintain the water quality necessary to support the aquatic living resources of the Bay and its tributaries and to protect human health.	• Nutrients and Sediments • Chemical Contaminants • Priority Urban Waters • Air Pollution • Boat Discharge
Sound Land Use Develop, promote and achieve sound land use practices which protect and restore watershed resources and water quality, maintain reduced pollutant loadings for the Bay and its tributaries, and restore and preserve aquatic living resources.	• Land Conservation • Development, Redevelopment, and Revitalization • Transportation • Public Access

Stewardship and Community Engagement
Promote individual stewardship and assist individuals, community-based organizations, businesses, local governments and schools to undertake initiatives to achieve the goals and commitments of this agreement.
	• Education and Outreach
	  • Beginning with the class of 2005, provide a meaningful Bay or stream outdoor experience for every school student in the watershed before graduation from high school.
	  • Continue to forge partnerships with the Departments of Education and institutions of higher learning in each jurisdiction to integrate information about the Chesapeake Bay and its watershed into school curricula and university programs.
	  • Provide students and teachers alike with opportunities to directly participate in local restoration and protection projects, and to support stewardship efforts in schools and on school property.
	• Community Engagement
	• Government by Example
	• Partnerships

USING AN INQUIRY APPROACH TO TEACHING...

The lessons in this curriculum packet have been written following an inquiry approach to teaching science. Each lesson is written around a focus question that students work to answer. The role of the teacher is to present information, lead students in answering the focus question, guide students to learn the lesson material, and make assessments of students progress to lesson objectives. One of the most important skills for a teacher using an inquiry approach is being able to prompt students with a variety of questions throughout the learning process. This skill is discussed further in the next part of this Introduction, and a selection of possible prompting questions is included in each lesson plan.

The inquiry approach for teaching science is one of the foundations of the recommendations contained within the National Science Education Standards published by the National Research Council in 1996. The essence of inquiry-based teaching is for students to develop answers to questions, using evidence and critical thinking to support their answers, and then to practice ways of communicating their answers and conclusions. Inquiry-based instruction can range from teacher-directed "structured inquiry," in which the teacher provides a question and procedure for students; through "guided inquiry," with the teacher providing the question but having students help develop the procedure to be followed; to student-directed "open inquiry," in which students are free to raise and answer their own questions. Students will use open inquiry when carrying out projects. Many shorter investigations will be structured inquiry or guided inquiry.

According to a recent article in The Science Teacher magazine, any version of inquiry-

based instruction should include students participating in the following five activities (Martin-Hansen, 2002).

1. Asking a scientifically-oriented question
2. Using evidence to answer the question
3. Building an explanation based on evidence
4. Using critical thinking to relate the explanation to existing scientific knowledge
5. Communicating and justifying the explanation

Teacher input and student ownership in each of the five steps will vary depending on the style of inquiry that is being used.

The well-known learning cycle method is an excellent inquiry-based approach for teaching new concepts in science. The basic learning cycle model includes the following three steps.

1. Concept Exploration
2. Concept Introduction
3. Concept Application

Students gather concrete experience of the topic of study by initial exploratory activities. Only then does the teacher formally introduce the concept to the students, along with new vocabulary. The third step of the learning cycle has students working to apply the new concept and relate it to previous knowledge by carrying out new activities of different kinds. In addition to the basic three steps of the learning cycle, an initial "Engagement" step is useful, and a fifth step of "Evaluation" of student learning can be carried out throughout. The Engagement step involves capturing the students' attention and interesting them in a question to be investigated. Using all of these five steps is the modified learning cycle model known as the 5Es model.

1. Engagement
2. Exploration
3. Explanation
4. Elaboration
5. Evaluation

Teachers using the lessons in this curriculum packet may teach the lessons in a more teacher-directed or more student-directed style depending on their preference and circumstances. The lessons are written so that, in either case, students will work through the five activities described above that are common to all forms of inquiry. The lessons are also written so that students will complete learning cycles of exploration and discussion, followed by concept development, followed by concept application. The inquiry steps parallel the steps of meaningful field investigations called for in the Chesapeake 2000 Agreement.

Asking Students Questions...

Beisenherz, Dantonio, and Richardson wrote a Science Scope article in 2001 about the importance of teacher questioning when using learning cycles to teach concepts to students.

They described how good questioning by the teacher can focus students' thinking and help them engage with the new concepts to be learned. They recommended a questioning strategy of four questions to help students see patterns and understand the significance of their observations when carrying out a series of activities to explore a new concept.

1. What do you think will happen if ...?
2. What did you observe?
3. How can you explain your observations?
4. How are your observations in this activity like the observations you made in the last activity?

In their article, Beisenherz, Dantonio, and Richardson suggest that "one of the primary reasons that inquiry teaching doesn't work is because teachers fail to cue and sequence the thinking students must do to form concepts [by using] instructional cues, such as specific activities and core questions."

Each of the lessons in this curriculum packet contains a selection of questions for teachers to use in prompting students as they work through their learning activities. Five different kinds of questions are included as recommended by Penick, Crow, and Bonnstetter in a 1996 article in The Science Teacher magazine. They suggest a "HRASE" model for asking questions. In this model, teachers first ask easier, descriptive questions, and work towards harder questions requiring higher-level thinking. All students should be able to answer initial questions, to build up their confidence and allow them to successfully begin the path to new concept development. Each of the five question types is briefly described below.

- *History Questions*

  Ask students questions about what they have done. Even though these are descriptive questions, they should not be yes-no questions.

  Examples: What did you do? What happened? What made you think of doing that?

- *Relationships Questions*

  Ask students to compare their activities, findings, or ideas with other activities, outcomes, and students. Describing relationships leads to recognizing patterns, a major initial step in ultimately devising explanations of phenomena.

  Examples: How does this compare to (other students' outcomes or other experiments)? Where have you seen something like this before? What seems to be a common element in all your findings?

- *Application Questions*

  This requires more of the student and also reveals more of the student's depth of understanding.

  Examples: How could you use this? What problems could this solve? Where can we find other examples of this?

- *Speculation Questions*

  Students must go beyond the data and given information, to new and unusual situations. They must become creative.

  Examples: What if you (changed, eliminated, added, mixed, waited)? What would it take to prove that? If you wanted to prevent that from happening, what would you do?

- *Explanation Questions*

  Ask students to communicate an idea, process, or theory to clarify both the nature of a phenomenon and how it occurs. It can be useful to ask them to limit their vocabulary to do this, or eliminate certain words.

  Examples: How does that work? What causes that to happen? How does your explanation fit this other phenomenon?

The list of questions that is part of each lesson in this curriculum packet includes most or all of these five different levels of questions, and the questions in the lesson are arranged in order of increasing difficulty. Teachers can use the suggested questions and other similar questions to prompt students as they carry out the lesson activities.

USING AN INTERDISCIPLINARY APPROACH TO TEACHING...

For each lesson in this packet, we have listed a variety of Virginia Standards of Learning (SOL) that are supported by the various lesson activities. SOL are listed for science, social studies, language arts, math, and technology. There are sound educational advantages for using an interdisciplinary teaching approach at all grade levels. Our state and national science education standards call for science subjects to be taught in a meaningful way and related whenever possible to students' experiences. Relating science to other disciplines is a way to help students form meaningful connections between science and other subjects as well as real-life experiences. Also, and particularly in the elementary grades, it is easier to justify spending time on science field activities and projects if Standards of Learning are being met in other disciplines at the same time.

Elementary teachers who need to emphasize language arts can easily teach language skills through science. It has been said that learning science and learning language are reciprocal processes (Casteel & Isom, 1994). Also, when students are actively engaged in learning science, they have multiple opportunities for reading, writing, and communicating. Language arts skills are incorporated extensively into all our lessons. As part of the inquiry approach, students spend a lot of time discussing open questions in groups. Students also can usually produce written summaries of their investigations and make oral presentations. All of these activities relate directly to the English SOL.

Whenever it is appropriate, we have also related different lessons to SOL for social studies, math, and technology. These connections are listed at the beginning of each lesson plan. Two of the lessons, Mapping a Watershed

History (Grade 4), and Making Decisions for Water Use (Grade 7), are written primarily as social studies lessons. At the same time, these lessons also support science SOL for fourth grade and seventh grade Life Science respectively. They are truly interdisciplinary lessons.

Planning a Safe Trip...

In any science activity, the safety and well being of students is the most important priority. Teachers are ultimately responsible for their students and must follow all school and professional requirements to ensure student safety. It is not the intent in these short paragraphs to make specific safety recommendations for every situation and eventuality. Excellent resources are available on safety in science teaching and all teachers should be aware of these. Less safety information is available for science at the elementary level, but the National Science Teachers Association has produced one excellent new book (Kwan & Texley, 2002, see the end of the chapter for full information). Here we only offer a few general suggestions to help ensure that field trips and other outdoor investigations are successful, meaningful, and safe.

As a general rule, try to imagine a worst-case scenario for your activity, and then make your plans so that scenario will not occur. Before ever planning any activities, you should have communicated with parents and obtained written information of specific health problems, allergies, or other safety concerns for individual students. Parent permission forms are essential for all field trips and outdoor activities. Make sure you have enough chaperones for your trip and have followed all other school rules and procedures.

If you take students to visit a stream or beach, you should visit the site before taking the students. Ask yourself the following questions.

- Is the site appropriate for the lesson? For example, if your students will look for insect larvae in a stream, make sure the stream supports such animals.
- Is the site safe and free from natural or man-made dangers? For example, is the stream bank free of dangerous litter or poisonous plants? Be alert for any indication of animals that could bite or sting.
- Check the depth of the water, the speed of the current, and the water temperature.
- Are all aspects of the site accessible for your students with special needs?
- Is there parking and/or turn-around space for a school bus or other vehicle to be used?
- Is there access to bathrooms when needed?
- If you plan to have a meal or snack during your visit, learn if there are picnic areas and a place for students to wash their hands before eating.

If the site you are to visit is located in a local, state, or federal park, make contact with park rangers or staff as part of your planning before the trip.

- Meet the rangers or staff and discuss with them the date and time for your class visit.
- Ask if the park staff can recommend a good site for your visit. Ask if they are able to give you any assistance in planning or presenting activities to be held at the site.
- Learn if there is a visitor center, park office, or other buildings that could be part of your visit. Are there bathrooms available for students? Also, if students may need to change clothes, where can they do this?
- Find out the emergency phone number for the park so that you can share this with your school and with parents.

Make sure students are well prepared before any field trip or outdoor activity. In addition to class preparations for learning activities, students should know why and when they will take the trip, and they should know exactly what to bring with them. Parents should also be well informed by a written letter explaining the purpose of the trip, the date and times, and everything students will need to bring with them on that day. Depending on the trip, students may need to bring the following.

- Shoes and clothes to get wet and muddy.
- A change of clothes.
- Jacket, hat, gloves, and rain gear. It is often cooler on the water than it is on land.
- Long pants, not shorts. Shoes or boots, not flip flops or sandals.
- Sunscreen, sunglasses, and bug spray.
- Bagged lunch or snacks and water.
- Notebook and pencil.

On the day of a field trip or outdoor activity, make sure you review all safety rules with students and chaperones. Your safety rules might include the following.

- Stay with your group members at all times.
- Stay in the designated area, and do not go near or into the water.
- Keep your shoes on at all times to protect your feet from harm.
- Keep out of dunes and do not step on any plants.
- Do not touch any wildlife that you find or taste any water or plants.
- Learn what poison ivy and poison oak look like, and avoid these plants.
- Do not eat any food without first carefully washing your hands.

Finally, when you take students on a field trip or outdoor activity, make sure that you are well prepared yourself. Have a first aid kit with you and know how to use it. Make sure you have not overlooked any of your school requirements for field trips. You should certainly have health information for all your students with you, and contact numbers so you can quickly reach a parent or guardian in the case of any accident. Remember the most important rule: think of the worst thing that might happen and then plan accordingly.

RESOURCES...

- An Inquiry Primer. Colburn, A. (2000). *Science Scope, 23*(6), 42-44.
- Chesapeake 2000 Agreement. *www.chesapeakebay.net/agreement.htm*
- Defining Inquiry: Exploring the Many Types of Inquiry in the Science Classroom. Martin-Hansen, L. (2002). *The Science Teacher, 69*(2), 34–37.
- *Exploring Safely: A Guide for Elementary Teachers.* Kwan, T., & Texley, J. (2002). Arlington, VA: National Science Teachers Association Press.
- Questions are the Answer: A Logical Questioning Strategy for Any Topic. Penick, J. E., Crow, L. W., & Bonnstetter, R. J. (1996). *The Science Teacher, 63*(1), 26–29.
- The Learning Cycle. Barman, C. R., & Kotar, M. (1989). *Science and Children, 26* (7), 30–32.
- The Learning Cycle and Instructional Conversations. Beisenherz, P. C., Dantonio, M., & Richardson, L. (2001). *Science Scope, 24*(4), 34–38.
- Reciprocal Processes in Science and Literacy Learning. Casteel, C. P., & Isom, B. A. (1994). The Reading Teacher, 47(7), 538-545.
- *Stewardship and Meaningful Watershed Educational Experiences*. Chesapeake Bay Program Education Workgroup.(2001).