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Environmental Science

SYLLABUS AND MODEL CURRICULUM

COURSE DESCRIPTION

Environmental science is a high school level course, which satisfies the **Ohio Core** science graduation requirements of **Ohio Revised Code Section 3313.603**. This section of Ohio law requires a three-unit course with inquiry-based laboratory experience that engages students in asking valid scientific questions and gathering and analyzing information.

Environmental science incorporates biology, chemistry, physics and physical geology and introduces students to key concepts, principles and theories within environmental science.

Investigations are used to understand and explain the behavior of nature in a variety of inquiry and design scenarios that incorporate scientific reasoning, analysis, communication skills and real-world applications. It should be noted that there are classroom examples in the model curriculum that can be developed to meet multiple sections of the syllabus, so one well-planned long-term project can be used to teach multiple topics.

SCIENCE INQUIRY AND APPLICATION

During the years of grades 9 through 12, all students must use the following scientific processes with appropriate **laboratory safety techniques** to construct their knowledge and understanding in all science content areas:

- Identify questions and concepts that guide scientific investigations;
- Design and conduct **scientific investigations**;
- Use technology and mathematics to improve investigations and communications;
- Formulate and revise explanations and models using logic and evidence (critical thinking);
- Recognize and analyze explanations and models; and
- Communicate and support a scientific argument.

COURSE CONTENT

The following information may be taught in any order; there is no ODE-recommended sequence.

EARTH SYSTEMS: INTERCONNECTED SPHERES OF EARTH

- Biosphere
  - Evolution and adaptation in populations
  - Biodiversity
  - Ecosystems (equilibrium, species interactions, stability)
  - Population dynamics
- Atmosphere
  - Atmospheric properties and currents
- Lithosphere
  - Geologic events and processes
- Hydrosphere
  - Oceanic currents and patterns (as they relate to climate)
  - Surface and ground water flow patterns and movement
  - Cryosphere
- Movement of matter and energy through the hydrosphere, lithosphere, atmosphere and biosphere
  - Energy transformations on global, regional and local scales
  - Biogeochemical cycles
  - Ecosystems
  - Climate and weather

EARTH'S RESOURCES

- Energy resources
  - Renewable and nonrenewable energy sources and efficiency
  - Alternate energy sources and efficiency
  - Resource availability
  - Mining and resource extraction
- Air and air pollution
  - Primary and secondary contaminants
  - Greenhouse gases
  - Clean Air Act
- Water and water pollution
  - Potable water and water quality
  - Hypoxia, eutrophication
  - Clean Water Act
  - Point source and non-point source contamination
- Soil and land
  - Desertification
  - Mass wasting and erosion
  - Sediment contamination

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- Land use and land management (including food production, agriculture and zoning)
- Solid and hazardous waste
- Wildlife and wilderness
  - Wildlife and wilderness management
    - Endangered species

GLOBAL ENVIRONMENTAL PROBLEMS AND ISSUES

- Human population
- Potable water quality, use and availability
- Climate change
- Sustainability
- Species depletion and extinction
- Air quality
- Food production and availability
- Deforestation and loss of biodiversity
- Waste management (solid and hazardous)

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BACK TO ENVIRONMENTAL SCIENCE OUTLINE

CONTENT ELABORATION: EARTH SYSTEMS

This topic builds upon both the physical science and biology courses as they relate to energy transfer and transformation, conservation of energy and matter, evolution, adaptation, biodiversity, population studies, and ecosystem composition and dynamics. In grades 6-8, geologic processes, biogeochemical cycles, climate, the composition and properties of the atmosphere, lithosphere and hydrosphere (including the hydrologic cycle) are studied.

The focus for this topic is on the connections and interactions between Earth's spheres (the hydrosphere, atmosphere, biosphere and lithosphere). Both natural and human-made interactions must be studied. This includes an understanding of causes and effects of climate, global climate (including el Niño/la Niña patterns and trends) and changes in climate through Earth's history, geologic events (e.g., a volcanic eruption or mass wasting) that impact Earth's spheres, biogeochemical cycles and patterns, the effect of abiotic and biotic factors within an ecosystem, and the understanding that each of Earth's spheres is part of the dynamic Earth system. Ground water and surface water velocities and patterns are included as the movement of water (either at the surface, in the atmosphere or beneath the surface) can be a mode of transmission of contamination. This builds upon previous hydrologic cycle studies in earlier grades. Geomorphology and topography are helpful in determining flow patterns and pathways for contamination.

The connections and interactions of energy and matter between Earth's spheres must be researched and investigated using actual data. The emphasis is on the interconnectedness of Earth's spheres and the understanding of the complex relationships between each, including both abiotic and biotic factors. One event, such as a petroleum release or a flood, can impact each sphere. Some impacts are long- term, others are short-term and most are a combination of both long- and short-term. It is important to use real, quantifiable data to study the interactions, patterns and cycles between Earth's spheres.

EXPECTATIONS FOR LEARNING: COGNITIVE DEMANDS

This section provides definitions for Ohio's science cognitive demands, which are intrinsically related to current understandings and research about how people learn. They provide a structure for teachers and assessment developers to reflect on plans for teaching science, to monitor observable evidence of student learning and to develop summative assessment of student learning of science.

VISIONS INTO PRACTICE

This section provides examples of tasks that students may perform; this includes guidance for developing classroom performance tasks. It is not an all-inclusive checklist of what should be done, but is a springboard for generating innovative ideas.

- Choose a specific location in the United States. Research and analyze the patterns of climate change throughout the geologic record, historic data (human records) and present-day data for the location. Be able to explain the interpretation and analysis of the data. Create a graphical representation of the pattern and discuss with the class.
- Research or investigate an actual environmental/geologic event (e.g., a specific release of a toxin/contaminant, hurricane, earthquake, flood, fire or landslide) and determine how each of Earth's spheres was impacted. Long-term and short-term impacts must be included. Provide scientific evidence and data to support conclusions and trace movement of contamination or energy through each sphere. Use a multimedia presentation to share findings with the class.
- Research an actual contamination event (that has quantitative data available). Use a computer-modeling program (many are available through freeware sites, fate and transport modeling) to model and predict the movement of the contamination through Earth's spheres. Develop and evaluate solutions for the cleanup, containment or reduction of the contamination. Include consequences and/or alternatives for the proposed solution. Present findings to the class or an authentic audience.
- Plan and implement an experiment or demonstration to illustrate the factors that lead to changing oceanic currents (both deep and shallow, can be 3-D or virtual). Document all steps and prepare a presentation or a poster session for the class. Defend the process and the results.
- Plan and implement an investigation to explore biomagnification or bioaccumulation within a specific Ohio ecosystem (existing public case studies can be used, such as a local Brownfields case – see resource listed below). Document the steps and process to collect or research, evaluate or test and analyze the data. Research should include the possible impact to humans. Present the process and results to the class verbally or in writing.
- Choose a specific living species. Using scientific data, trace the history of that species. Show existing, proven evolutionary relationships, environmental (both biotic and abiotic) requirements, global locations, ecosystem characteristics and sustainability predictions. Use quantifiable data to support findings and present findings to the class orally, through demonstration/explanation or a poster session.
- Plan and implement a population study of a specific area (over a period of time) or critique/analyze an existing population study. Document changes in weather, food availability and any change to the population. Prepare a scientific analysis and conclusion (in writing) for the study.
- Research or conduct a field investigation for a specific invasive species that is present in the local community or in Ohio. Examples of research questions

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include: *How did the organism get into Ohio? What is being done to control the spread of the species? What is the impact of the species on the native population?* Use quantifiable data to draw conclusions and present research results in writing or orally.

- Investigate and research the effect that climate change is having or has had on a specific living or extinct species, such as the harp seal or elkhorn coral, or on an ecosystem, such as the Great Barrier Reef or the Arctic Circle.
- Research and analyze quantifiable scientific data pertaining to food availability, reproductive requirements and changes, adaptations or population changes to draw conclusions. Students present data and conclusions to the class.

INSTRUCTIONAL STRATEGIES AND RESOURCES

This section provides additional support and information for educators. These are strategies for actively engaging students with the topic and for providing hands-on, minds-on observation and exploration of the topic, including authentic data resources for scientific inquiry, experimentation and problem-based tasks that incorporate technology and technological and engineering design. Resources selected are printed or Web-based materials that directly relate to the particular Content Statement. It is not intended to be a prescriptive list of lessons.

- The University of Maine offers a scientific case study of a specific glacier, including quantifiable data that documents measurable changes each year, at **http://climatechange.umaine.edu/Research/projects/byrdglacier.html**.
- The OSU Byrd Polar Research site offers numerous educational resources that are related to glacial geology and climate change at **http://bprc.osu.edu/**.
- The Ohio EPA provides a map of all regional Brownfields projects, a resource to provide data and documentation for local case studies involving a variety of hazardous releases into the environment and quantifiable data and monitoring data at **http://www.epa.state.oh.us/derr/SABR/brown_dtb/browndtb.aspx**.
- The North Carolina Department of Environment and Natural Resources offers basic hydrology background information, including ways to calculate ground water velocity and outlining different types of aquifers, to help in teaching about ground water at **http://www.ncwater.org/Education_and_Technical_Assistance/Ground_Water/Hydrogeology/**.
- Intellicast.com offers real-time data for the jet stream (updated daily), including velocities and patterns on an isometric map at **http://www.intellicast.com/National/Wind/JetStream.aspx**.
- The College Board provides enduring understandings recommended for AP environmental science, which can help to form discussion questions and research for this topic at **http://professionals.collegeboard.com/profdownload/cbscs-science-standards-2009.pdf**. Appendix A (page 175) of this document contains the environmental science information.
- The Digital Library for Earth Systems Education offers resources from a number of sources, such as *National Geographic*, government agencies and other scientific agencies. Resources are searchable by grade level and standards at **http://www.dlese.org/library/index.jsp**.
- NOAA provides real-time data for many of its projects and research missions at **http://www.noaa.gov/sciencemissions/bpoilspill.html**.
- The Ohio Department of Natural Resources' Project Wet offers training and resources for K-12 teachers that promote deep understanding about all aspects of water and the interconnectedness of all of Earth's spheres (Earth Systems). Training and workshop opportunities can be found at **http://www.dnr.state.oh.us/tabid/3501/Default.aspx**.
- Project Wet's *Healthy Water, Healthy People* water quality educators guide offers ideas and resources for teaching all aspects of water and water contamination issues. Ideas for field monitoring, research projects and student investigations as well as teacher training are available at **http://www.projectwet.org/water-resources-education/water-quality-education/**.
- EarthComm offers a program that uses many different strategies to reach students of all learning levels at **http://www.agiweb.org/earthcomm/**. The teaching of environmental science through relating the classroom to the real world is essential for many learners.
- The National Academy of Science provides a number of resources related to climate change and greenhouse gases at **http://nas-sites.org/americasclimatechoices/**. Some of the options include Web quests, virtual/digital learning, virtual fieldtrips and field research ideas. By providing alternate options and choices that can be completed by students at different paces, all students can benefit.

COMMON MISCONCEPTIONS

- The NSTA offers a position paper which is helpful in addressing concerns and misconceptions from students regarding evolution at **http://www.nsta.org/about/positions/evolution.aspx**.
- Students may have difficulty separating science from non-science factors as they relate to the different parts of the environment. It is important to distinguish "what is science" and therefore, what will be included in an environmental science class, especially as it relates to climate change and evolution. Identifying and understanding personal bias and ethical issues are an important step in recognizing science. Wheaton College offers *Teaching Ethical Analysis in Environmental Management Decisions: A Process-Oriented Approach* at **http://www.wheaton.edu/~/media/Files/Academics/Departments/Biology/Van Dyke files/Teachingethical.pdf**
- The EPA provides support for teachers that are teaching about climate change. To address student misconceptions regarding this issue, it is important to use real-time data and research, which can be found through the EPA at **http://www.epa.gov/students/teachers.html#epaclimate**

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- Misconceptions regarding all aspects of environmental science must be addressed through scientific data analysis, investigation and research. Discussing the conclusions and findings through a professional "gallery walk" can be a very useful way to determine possible misconceptions that exist for the class and address them. Carleton College offers a gallery walk website at **http://serc.carleton.edu/introgeo/gallerywalk/misconceptions.html**.

DIVERSE LEARNERS

Strategies for meeting the needs of all learners including **gifted students**, **English Language Learners** (ELL) and students with **disabilities** can be found at the **Ohio Department of Education site**. Resources based on the Universal Design for Learning principles are available at **www.cast.org**.

CLASSROOM PORTALS

Annenberg offers ideas about teaching high school level environmental science using an integrated Earth systems approach at **http://www.learner.org/resources/series209.html**.

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CONTENT ELABORATION: EARTH'S RESOURCES

This topic explores the availability of Earth's resources, extraction of the resources, contamination problems, remediation techniques and the storage/disposal of the resources or by-products. Conservation, protection and sustainability of Earth's resources also are included. This builds upon grades 6-8 within the Earth and Space Science strand (sections pertaining to energy and Earth's resources) and the biology and physical science (in particular chemistry and energy topics) courses at the high school level.

To understand the effects that certain contaminants may have on the environment, scientific investigations and research must be conducted on a local, national and global level. Water, air, land, and biotic field and lab sampling/testing equipment and methods must be utilized with real-world application. Quantifiable field and/or lab data must be used to analyze and draw conclusions regarding air, water or land quality. Examples of types of water-quality testing include: hydraulic conductivity, suspended and dissolved solids, dissolved oxygen, biochemical oxygen demand, temperature, pH, fecal coliform and macro-invertebrate studies. Wetland or woodland delineations and analysis, land use analysis and air monitoring (e.g., particulate matter sizes/amount) are all appropriate field study investigations. Comparative analysis of scientific field or lab data should be used to quantify the environmental quality or conditions. Local data also can be compared to national and international data.

The study of relevant, local problems can be a way to connect the classroom to the real world. Within Ohio, there are numerous environmental topics that can be investigated. Examples include wetland loss or mitigation, surface or ground water contamination (including sediment, chemical or thermal contamination), acid rain, septic system or sewage overflows/failures, landfill seepage, underground storage tank/pipe releases, deforestation, invasive species, air pollution (e.g., photochemical smog or particulate matter), soil loss/erosion or acid mine drainage.

At the advanced science level, renewable and nonrenewable energy resources topics investigate the effectiveness, risk and efficiency for differing types of energy resources at a local, state, national and global level. This builds upon grades 6-8 within both Earth and Space Science, and physical science at the high school level. Nuclear and geothermal energy are included in this topic.

Feasibility, availability, remediation and environmental cost are included in the extraction, storage, use and disposal of both abiotic and biotic resources. Environmental impact must be evaluated as it pertains to both the environmental and human risk. Examples include chemical hazards, radiation, biological hazards, toxicology and risk analysis studies. Learning about conservation and protection of the environment also requires an understanding of laws and regulations that exist to preserve resources and reduce and/or remediate contamination, but the emphasis should be on the science behind the laws and regulations.

Relating Earth's resources to a global scale and using technology to collect global resource data for comparative classroom study is recommended. In addition, it is important to connect the industry and the scientific community to the classroom to increase the depth of understanding. Critical thinking and problem-solving skills are important in evaluating resource use, management and conservation. New discoveries and research are important parts of this topic.

EXPECTATIONS FOR LEARNING: COGNITIVE DEMANDS

This section provides definitions for Ohio's science cognitive demands, which are intrinsically related to current understandings and research about how people learn. They provide a structure for teachers and assessment developers to reflect on plans for teaching science, to monitor observable evidence of student learning and to develop summative assessment of student learning of science.

VISIONS INTO PRACTICE

This section provides examples of tasks that students may perform; this includes guidance for developing classroom performance tasks. It is not an all-inclusive checklist of what should be done, but is a springboard for generating innovative ideas.

- Choose a specific environmental problem, such as the effect of herbicides in water (e.g., Atrizine), an invasive species (e.g., purple loosestrife or the Asian carp) or carbon monoxide in the atmosphere, and research the history, the scientific data before and after relevant laws were passed, and how this problem is being addressed in other countries/globally. Computer models or programs can be used to predict/analyze the problem or the movement of the contamination. Present scientific evidence and quantifiable data orally, through a poster session or in written form (scientific research paper).
- Design and conduct a field investigation that concentrates on a specific environmental problem (e.g., sediment contamination or acid mine drainage) and how the problem can be remediated. Compare results to similar communities, recommended limits, permit requirements or other published results. Analyze the data and make specific recommendations to limit, remediate, reduce or prevent the problem. Present findings to an authentic audience from the community.
- Research and document land-use planning or management in the community or at a specific location. Attend community meetings pertaining to land-use, land-management or zoning plans. Research questions should include: ***What factors are used in determining use? What data is collected and analyzed? What changes are on the horizon?*** Discuss in class.
- Take a field trip to visit the water treatment facility or watch the drilling of a water well. Document observations, including information about how water is treated prior to and after use, specific issues that may impact the source, the location of the original water source, specific tests conducted (materials and methods needed to test and how the tests are conducted, results of the tests), and the steps taken to monitor the water at the source and throughout the process (including from the facility/well into the residence). Discuss with the class.

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- Using real-time data, research the most severe environmental problems (and the root causes for the problems) that face the local community, Ohio, the United States or the world. Present evidence (quantitative data) and conclusions orally, through a poster session or in written form (scientific research paper).
- Research and collect specific data for a mass wasting or desertification event (can be present day or historical). Research questions should include: ***What factors led to the event? What was the result of the event (how was each of Earth's spheres impacted)? What data is present (analyze the data and draw conclusions)? What laws are related to the event? How can this be prevented in the future?*** Record the results graphically or in a scientific report.

INSTRUCTIONAL STRATEGIES AND RESOURCES

This section provides additional support and information for educators. These are strategies for actively engaging students with the topic and for providing hands-on, minds-on observation and exploration of the topic, including authentic data resources for scientific inquiry, experimentation and problem-based tasks that incorporate technology and technological and engineering design. Resources selected are printed or Web-based materials that directly relate to the particular Content Statement. It is not intended to be a prescriptive list of lessons.

- The U.S. Geological Survey outlines current surface water projects within the state of Ohio. Surface water-quality data (including stream gauge and volume data) can be found and used to support local field investigations. There also are links to provide historic surface and ground water data for analysis, at **http://oh.water.usgs.gov/data.htm**
- The U.S. Environmental Protection Agency offers a risk-assessment information system with specific Ohio risk assessments that can be used to provide background data or specific case studies. This information helps illustrate the types of tests that are included in a risk assessment and also provides different risk levels for specific contaminants. Find it at **http://rais.ornl.gov/tutorials/whatisra.html**
- The U.S. EPA houses online computer-modeling program for air pollutants. There also are resources and data explaining the use of computer modeling and air pollution that may be helpful in student research and investigation projects. Find it at **http://www.epa.gov/scram001/aqmindex.htm**.
- ODNR's website discusses acid mine drainage issue in Ohio. There also are specific links to Ohio watersheds (including maps of the watershed locations) that are in the abatement program and water quality data to study changes within a local area. Find it at **http://minerals.ohiodnr.gov/**
- The Ohio EPA offers a discussion about Ohio wetlands and the delineation, and qualitative analysis of Ohio wetlands at **http://www.epa.state.oh.us/portals/47/facts/ohio_wetlands.pdf**.
- The Ohio EPA outlines federal and state environmental laws at **http://www.epa.state.oh.us/Rules_and_Laws.aspx**.
- The Digital Library for Earth Systems Education offers resources from a number of sources, such as ***National Geographic***, government agencies and other scientific agencies. Grade 9-12 resources are provided at **http://www.dlese.org/library/query.do?q=&s=0&gr=02**.
- The Solid Waste Authority of Central Ohio resource section offers ideas about landfill tours, classroom and kids activities and teacher assistance and resources. **http://www.swaco.org/Education.aspx**
- ***Science News*** and ***Science Daily*** offer information highlighting science in the news that can be used for class discussions. The information is updated weekly or bi-weekly and provides references and resource sites for more in-depth discussion. Visit **http://www.sciencenews.org/** and **http://www.sciencedaily.com/**.
- NOAA provides real-time data for many of its projects and research missions at **http://www.noaa.gov/sciencemissions/bpoilspill.html**.
- For an index page for numerous environmental educational resources available through the Ohio EPA and associated agencies, visit **http://www.epa.state.oh.us/oeef/ee_resources.aspx**.
- Geology.com provides information on current events in all topic areas of geology, including resources and uses of resources, at **http://geology.com/**.
- The Ohio Department of Natural Resources provides data regarding sustainable water programs that are conducted in Ohio (monitoring programs, water quality testing information and contact information for the ODNR scientists that work in these areas) at **http://ohiodnr.com/tabid/18951/Default.aspx**.
- NSTA provides learning modules called "SciPacks" that are designed to increase teacher content knowledge through inquiry-based modules. Find a module addressing Earth's resources and humans at **http://learningcenter.nsta.org/products/scipacks.aspx**.
- The Ohio Department of Natural Resources' Project Wet offers training and resources for K-12 teachers that promote deep understanding about all aspects of water and the interconnectedness of all of Earth's spheres (Earth systems). Training and workshop opportunities can be found at **http://www.dnr.state.oh.us/tabid/3501/Default.aspx**.
- The College Board provides enduring understandings recommended for AP environmental science which can help to form discussion questions and research for this topic at **http://professionals.collegeboard.com/profdownload/cbscs-science-standards-2009.pdf**. Appendix A (page 175) of this document contains the environmental science information.
- Project Wet's ***Healthy Water, Healthy People*** water quality educators guide offers ideas and resources for teaching all aspects of water and water contamination issues. Ideas for field monitoring, research projects and student investigations as well as teacher training are available at **http://www.projectwet.org/water-resources-education/water-quality-education/**.

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Career Connection

Students will research careers related to environmental science (e.g., environmental engineer, hydrogeologist, water treatment plant operator, inspector, technician). Then, they will visit a water treatment facility and conduct career interviews to gather information about the various careers and their roles at the plant. Students will apply the information to their plan for education and training through high school and beyond.

COMMON MISCONCEPTIONS

- Common misconceptions dealing with renewable energy efficiency along with suggestions to overcome these misconceptions through exploration and investigation are available on the website of California State University, Northridge, at **http://www.csun.edu/~ml727939/coursework/690/Miha's misconception report.doc**.
- Misconceptions regarding all aspects of environmental science must be addressed through scientific data analysis, investigation and research. Discussing the conclusions and findings through a professional "gallery walk" can be a very useful way to determine possible misconceptions that exist for the class and address them. Carleton College offers a gallery walk website at **http://serc.carleton.edu/introgeo/gallerywalk/misconceptions.html**.

DIVERSE LEARNERS

Strategies for meeting the needs of all learners including **gifted students**, **English Language Learners** (ELL) and students with **disabilities** can be found at the **Ohio Department of Education site**. Resources based on the Universal Design for Learning principles are available at **www.cast.org**.

CLASSROOM PORTALS

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CONTENT ELABORATION: GLOBAL ENVIRONMENTAL PROBLEMS AND ISSUES

This topic is a culminating section that incorporates the previous topics and applies them to a global or international scale. Case studies, developing and using models, collecting and analyzing water and/or air quality data, conducting or researching population studies and methods of connecting to the real world must be emphasized for this topic. Technology can be used for comparative studies to share local data internationally so that specific, quantifiable data can be compared and used in understanding the impact of some of the environmental problems that exist on a global scale. Researching and investigating environmental factors on a global level contributes to the depth of understanding by applying the environmental science concepts to problem solving and design. Examples of global topics that can be explored include building water or air filtration models, investigating climate change data, monitoring endangered or invasive species, and studying the environmental effects of increasing human population. Researching contemporary discoveries, new technology and new discoveries can lead to improvement in environmental management.

EXPECTATIONS FOR LEARNING: COGNITIVE DEMANDS

This section provides definitions for Ohio's science cognitive demands, which are intrinsically related to current understandings and research about how people learn. They provide a structure for teachers and assessment developers to reflect on plans for teaching science, to monitor observable evidence of student learning and to develop summative assessment of student learning of science.

VISIONS INTO PRACTICE

This section provides examples of tasks that students may perform; this includes guidance for developing classroom performance tasks. It is not an all-inclusive checklist of what should be done, but is a springboard for generating innovative ideas.

- Investigate and research global human population patterns and changes over time. Example research questions include: ***What countries have marked changes in populations at present, in the past? What are the factors that affect population change? What are verifiable relationships related to population (e.g., economic indicators, education levels, laws, resource availability, environmental conditions)?*** Provide evidence and data to support conclusions. Document the research in a scientific research paper.
- Investigate and/or research (using quantifiable data and evidence) the relationship between deforestation and changing weather or, in some cases, climate, at a specific location (like the Amazon region of South America). Analyze the data and draw a conclusion based upon the analysis. Discuss the conclusion with the class.
- Plan and implement an investigation to determine the water quality of a section of a local stream. This includes researching and conducting standard water-quality tests and how to analyze the results. Compare the results to known data from a different country (with a similar setting). Compare and contrast the data and analyze the results. Example research questions include: ***What are the reasons for any statistically significant differences? What comparisons can be made about the topography or geomorphology of the location? What testing methods, materials and/or equipment are used? What are the testing dates/times/locations? What are the existing, applicable, environmental laws or requirements?*** Document all results and present to an authentic audience.
- Develop a risk assessment for a specific company. Research one particular toxin or hazardous chemical used by the company (e.g., diesel fuel) to determine possible risks and pathways to the environment and humans. The assessment should include: nature of the toxin/chemical (e.g., is the material flammable, does is react when wet), on-site use and handling (including existing safety practices) of the toxin/chemical, by-products (e.g., vapors or dilution processes), storage, transportation of the toxin/chemical, required documentation, emergency plans/guidelines, topography and geology of the area. Use a computer-modeling program (many are available through freeware sites) to model and predict the movement of the possible pathways of the toxin/chemical and recommendations of methods to contain the release of the toxin/chemical. Present the findings to the class or an authentic audience.

INSTRUCTIONAL STRATEGIES AND RESOURCES

This section provides additional support and information for educators. These are strategies for actively engaging students with the topic and for providing hands-on, minds-on observation and exploration of the topic, including authentic data resources for scientific inquiry, experimentation and problem-based tasks that incorporate technology and technological and engineering design. Resources selected are printed or Web-based materials that directly relate to the particular Content Statement. It is not intended to be a prescriptive list of lessons.

- The Ohio Department of Natural Resources provides data regarding sustainable water programs that are conducted in Ohio (monitoring programs, water quality testing information and contact information for the ODNR scientists that work in these areas) at **http://ohiodnr.com/tabid/18951/Default.aspx**.
- The U.S. Environmental Protection Agency offers a risk-assessment information system with specific Ohio risk assessments that can be used to provide background data or specific case studies. This information helps illustrate the types of tests that are included in a risk assessment and also provides different risk levels for specific contaminants. Find it at **http://rais.ornl.gov/.**
- The Ohio EPA provides guidance for ecological risk assessment, including all types of monitoring and data requirements, that can be used to provide an authentic learning experience for students. Parts of the requirements can be modified and simplified for high school students, including examples of the level of detail required to determine human risk and site evaluation. Find this information at **http://www.epa.ohio.gov/portals/30/rules/RR-031.pdf**.

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- The Environmental Protection Agency provides helpful information about conducting risk assessments at **http://www.epa.gov/risk/.**
- For information about the use of fate and transport modeling in tracing the movement of hazardous materials/contamination, including links to educational fate and transport programs and some freeware that may assist in demonstrations or small student investigations, visit **http://ceenve3.civeng.calpoly.edu/cota/enve436/fate.html**.
- The U.S. Geological Survey provides a list of free software downloads that apply directly to modeling of surface and/or groundwater at **http://water.usgs.gov/software/lists/general/**.
- *Science News* and *Science Daily* offer information highlighting science in the news that can be used for class discussions. The information is updated weekly or bi-weekly and provides references and resource sites for more in-depth discussion. Visit **http://www.sciencenews.org/** and **http://www.sciencedaily.com/**.
- NOAA provides real-time data for many of its projects and research missions at **http://www.noaa.gov/sciencemissions/bpoilspill.html**.
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- Project Wet's *Healthy Water, Healthy People* water quality educators guide offers ideas and resources for teaching all aspects of water and water contamination issues. Ideas for field monitoring, research projects and student investigations as well as teacher training are available at **http://www.projectwet.org/water-resources-education/water-quality-education/**.

COMMON MISCONCEPTIONS

- Students may have misinformation and misconceptions that pertain to climate change. To address this, it is important to provide evidence of climate change throughout Earth's history and current data to document temperature changes (surface and oceanic). Data and other resources to help with teaching climate change can be found at **http://www.epa.gov/climatechange/index.html**.
- Misconceptions regarding all aspects of environmental science must be addressed through scientific data analysis, investigation and research. Discussing the conclusions and findings through a professional "gallery walk" can be a very useful way to determine possible misconceptions that exist for the class and address them. Carleton College offers a gallery walk website at **http://serc.carleton.edu/introgeo/gallerywalk/misconceptions.html**.

DIVERSE LEARNERS

Strategies for meeting the needs of all learners including **gifted students**, **English Language Learners** (ELL) and students with **disabilities** can be found at the **Ohio Department of Education site**. Resources based on the Universal Design for Learning principles are available at **www.cast.org**.

CLASSROOM PORTALS

Annenberg offers ideas about teaching high school level environmental science using an integrated Earth systems approach at **http://www.learner.org/resources/series209.html**.