Environmental Science

INTRODUCTION AND SYLLABUS

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 three units of science. Each course should include 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.

COURSE CONTENT

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

EARTH SYSTEMS: INTERCONNECTED SPHERES OF EARTH

ENV.ES.1: Biosphere
- Evolution and adaptation in populations
- Biodiversity
- Ecosystems (equilibrium, species interactions, stability)
- Population dynamics

ENV.ES.2: Atmosphere
- Atmospheric properties and currents

ENV.ES.3: Lithosphere
- Geologic events and processes

ENV.ES.4: Hydrosphere
- Oceanic currents and patterns (as they relate to climate)
- Surface and ground water flow patterns and movement
- Cryosphere

ENV.ES.5: Movement of matter and energy through the hydrosphere, lithosphere, atmosphere and biosphere
- Energy transformation on global, regional and local scales
- Biogeochemical cycles
- Ecosystems
- Weather
- Climate

EARTH'S RESOURCES

ENV.ER.1: Energy resources
- Renewable and nonrenewable energy sources and efficiency
- Alternate energy sources and efficiency
- Resource availability
- Mining and resource extraction

ENV.ER.2: Air and air pollution
- Primary and secondary contaminants
- Greenhouse gases
- Clean Air Act

ENV.ER.3: Water and water pollution
- Potable water and water quality
- Hypoxia, eutrophication
- Clean Water Act
- Point source and non-point source contamination

ENV.ER.4: Soil and land
- Desertification
- Mass movement and erosion
- Sediment contamination
- Land use and land management (including food production, agriculture and zoning)
- Solid and hazardous waste

ENV.ER.5: Wildlife and wilderness
- Wildlife and wilderness management
  - Endangered species
- Invasive Species
- Introduced Species

ENV.GP: GLOBAL ENVIRONMENTAL PROBLEMS AND ISSUES

ENV.GP.1: Human Population
ENV.GP.2: Potable water quality, use and availability
ENV.GP.3: Climate change
ENV.GP.4: Sustainability
ENV.GP.5: Species depletion and extinction
ENV.GP.6: Air quality
ENV.GP.7: Food production and availability
ENV.GP.8: Deforestation and loss of biodiversity
ENV.GP.9: Waste management (solid and hazardous)

NATURE OF SCIENCE HIGH SCHOOL

Nature of Science
One goal of science education is to help students become scientifically literate citizens able to use science as a way of knowing about the natural and material world. All students should have sufficient understanding of scientific knowledge and scientific processes to enable them to distinguish what is science from what is not science and to make informed decisions about career choices, health maintenance, quality of life, community and other decisions that impact both themselves and others.

Categories	High School
Scientific Inquiry, Practice and Applications All students must use these 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 using a variety of methods and tools to collect empirical evidence, observing appropriate safety techniques. • Use technology and mathematics to improve investigations and communications. • Formulate and revise explanations and models using logic and scientific evidence (critical thinking). • Recognize and analyze explanations and models. • Communicate and support scientific arguments.

Science is a Way of Knowing
Science assumes the universe is a vast single system in which basic laws are consistent. Natural laws operate today as they did in the past and they will continue to do so in the future. Science is both a body of knowledge that represents a current understanding of natural systems and the processes used to refine, elaborate, revise and extend this knowledge.
	• Various science disciplines use diverse methods to obtain evidence and do not always use the same set of procedures to obtain and analyze data (i.e., there is no one scientific method).
	  ○ Make observations and look for patterns.
	  ○ Determine relevant independent variables affecting observed patterns.
	  ○ Manipulate an independent variable to affect a dependent variable.
	  ○ Conduct an experiment with controlled variables based on a question or hypothesis.
	  ○ Analyze data graphically and mathematically.
	• Science disciplines share common rules of evidence used to evaluate explanations about natural phenomenon by using empirical standards, logical arguments and peer reviews.
	  ○ Empirical standards include objectivity, reproducibility, and honest and ethical reporting of findings.
	  ○ Logical arguments should be evaluated with open-mindedness, objectivity and skepticism.
	• Science arguments are strengthened by multiple lines of evidence supporting a single explanation.
	• The various scientific disciplines have practices, methods, and modes of thinking that are used in the process of developing new science knowledge and critiquing existing knowledge.

Science is a Human Endeavor Science has been, and continues to be, advanced by individuals of various races, genders, ethnicities, languages, abilities, family backgrounds and incomes.	• Science depends on curiosity, imagination, creativity and persistence. • Individuals from different social, cultural, and ethnic backgrounds work as scientists and engineers. • Science and engineering are influenced by technological advances and society; technological advances and society are influenced by science and engineering. • Science and technology might raise ethical, social and cultural issues for which science, by itself, does not provide answers and solutions.
Scientific Knowledge is Open to Revision in Light of New Evidence Science is not static. Science is constantly changing as we acquire more knowledge.	• Science can advance through critical thinking about existing evidence. • Science includes the process of comparing patterns of evidence with current theory. • Some science knowledge pertains to probabilities or tendencies. • Science should carefully consider and evaluate anomalies (persistent outliers) in data and evidence. • Improvements in technology allow us to gather new scientific evidence.

*Adapted from Appendix H – Understanding the Scientific Enterprise: The Nature of Science in the Next Generation Science Standards

Environmental Science continued

ENV.ES: EARTH SYSTEMS: INTERCONNECTED SPHERES OF EARTH

ENV.ES.1: Biosphere
- Evolution and adaptation in populations
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- Atmospheric properties and currents

ENV.ES.3: Lithosphere
- Geologic events and processes

ENV.ES.4: Hydrosphere
- Oceanic currents and patterns (as they relate to climate)
- Surface and ground water flow patterns and movement
- Cryosphere

ENV.ES.5: Movement of matter and energy through the hydrosphere, lithosphere, atmosphere and biosphere
- Energy transformations on global, regional and local scales
- Biogeochemical cycles
- Ecosystems
- Weather
- Climate

CONTENT ELABORATION: EARTH SYSTEMS: INTERCONNECTED SPHERES OF EARTH

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. In this course, the focus is on the connections and interactions between Earth's spheres (the hydrosphere, atmosphere, biosphere and lithosphere). Both natural and anthropogenic interactions are 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., volcanic activity 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 are researched and investigated using actual data. The emphasis is on the interconnectedness of Earth's spheres and the understanding of the complex relationships between them, 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 among Earth's spheres.

EXPECTATIONS FOR LEARNING

The content in the standards needs to be taught in ways that incorporate the nature of science and engage students in scientific thought processes. Where possible, real-world data and problem- and project-based experiences should be utilized. *Ohio's Cognitive Demands* relate to current understanding and research about the ways people learn and are important aspects to the overall understanding of science concepts. Care should be taken to provide students opportunities to engage in all four types of thinking. Additionally, lessons need to be designed so that they incorporate the concepts described in the *Nature of Science*.

VISIONS INTO PRACTICE: CLASSROOM EXAMPLES

This section provides guidance for developing classroom tasks that go beyond traditional approaches to instruction. It is a springboard for generating innovative ideas to address the cognitive demands. A variety of activities are presented so that teachers can select those that best meet the needs of their students. This is not an all-inclusive checklist and is not intended to cover every aspect of the standards. **These activities are suggestions and are not mandatory.**

Designing technological/engineering solutions using science concepts	Demonstrating science knowledge	Interpreting and communicating science concepts	Recalling accurate science
ENV.ES.1: Biosphere			
Identify an instance of biomagnification or bioaccumulation within a specific ecosystem and propose possible solutions. Evaluate and critique current trends in reclaiming former industrial sites. Taking economics, government regulations and current technology into consideration, design a new method to reclaim a former brownfield in the Great Lakes Region. Research an endangered species and develop a conservation plan for the species taking into account the interests of all stakeholders. List the advantages and disadvantages of conservation.	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 for the study. Choose two accessible habitats and take a field trip. Choose a level and type of taxa (e.g., birds, insects, spiders, trees, herbaceous plants). Collect data on species diversity and abundance. Compare and contrast data using Simpson's Diversity Index or Shannon-Weiner Index to measure species diversity/abundance and compare the relative health of the two habitats.	Conduct a pond study, calculate biodiversity index and construct a sustainable food web. Research how biomagnification or bioaccumulation impacts specific Ohio ecosystems. Research should include the possible impact to humans. Present research and findings on biomagnification and bioaccumulation impacts on specific Ohio ecosystems (e.g., using "Ohio's Sportfish Consumption Advisory" published annually by the Ohio EPA). Graph survivorship curves to make judgements about environmental and health conditions in various habitats/ecosystems. Evaluate current protection and management laws pertaining to endangered species and their habitats.	Determine the carrying capacity of an ecosystem using historical or current data (e.g., Moose on Isle Royale, Kaibab Deer in Arizona).

Designing technological/engineering solutions using science concepts	Demonstrating science knowledge	Interpreting and communicating science concepts	Recalling accurate science
ENV.ES.2: Atmosphere			
		Explain the effects and causes of El Niño/La Niña weather patterns on Earth's spheres, biogeochemical cycles and biodiversity. Include regional comparisons of the effects of these events.	Complete a foldable or other manipulative on the layers of the Earth's atmosphere, complete with description and chemical composition.
ENV.ES.3: Lithosphere			
		Research and analyze an event (e.g., naturally caused [an Icelandic volcano] or anthropogenically caused [oil spills]) and make a model to demonstrate how the different spheres (e.g., atmosphere, biosphere, lithosphere, hydrosphere) are impacted. Examine human impacts on the lithosphere (e.g., hydraulic fracturing, surface mining, urbanization) and hypothesize possible consequences. Find a large tract of property for sale in your community. Using knowledge of the lithosphere through data found on United States Department of Agriculture's site, make recommendations on how this property could be used in the future. Compare soils found in various parts of the community. Use information gathered to create a soil texture map of the community.	Build a model of the layers of the Earth in order to identify and describe the components and their role in geologic events.

Designing technological/engineering solutions using science concepts	Demonstrating science knowledge	Interpreting and communicating science concepts	Recalling accurate science
ENV.ES.4: Hydrosphere			
Construct a functioning shower using only four gallons of water and household materials, which would allow someone to wash the body and hair effectively and capture the gray water produced. The shower construction should be tested to assure it meets design criteria and that it will adequately allow for a person to wash. Investigate various methods to clean up an oil spill using a model to evaluate their effectiveness. At the completion of the clean-up process, each team will assess the effectiveness, including environmental impact of the cleanup process, and make suggestions for improvement. Design methods to transport potable water to arid areas. Consider availability of materials, cost and efficiency.		Create a map of the local watershed including boundaries of adjoining watersheds. Have the map depict movement and direction of water within the watershed. Plan a demonstration to illustrate the factors that lead to changing oceanic currents (both deep and shallow). Research a water resource disaster and describe various ways the disaster has altered the ecosystem of the region. Explain the stability of that ecosystem, as well as how it has changed over time. Use Ohio EPA well water data to compare water composition of a contaminated site with groundwater from your own community.	Use a regional map to identify local water sources and their proximity to schools, neighborhoods and shopping centers. Indicate how those developments may infringe upon the health of the water sources.

Designing technological/engineering solutions using science concepts	Demonstrating science knowledge	Interpreting and communicating science concepts	Recalling accurate science
ENV.ES.5: Movement of matter and energy through the hydrosphere, lithosphere, atmosphere and biosphere			
Use quantifiable data and evidence to investigate the relationship between deforestation and changing weather or, in some cases, climate, at a specific location (e.g., the Amazon region of South America). Analyze the data and draw a conclusion based upon the analysis. Research, design, create and maintain a tabletop sustainable biosphere (e.g., eco column) using aquarium gravel, live aquatic plants and aquatic organisms (e.g., fish, ghost shrimp, Sea Monkeys ®). Use it to study nutrient cycling, limiting factors, decomposition, water quality and eutrophication.	Model and describe how toxins enter and accumulate in a food chain. Find and paraphrase laws/regulations which attempt to regulate use of potential contaminants (e.g., DDT, BPA, pharmaceuticals, lead). Research an actual environmental or geologic event (e.g., release of a toxin/contaminant, hurricane, earthquake, volcano, flood, fire, landslide) and determine how each of Earth's spheres was impacted. Include long-term and short-term impacts. Trace the movement of contamination or energy through each sphere. Provide scientific evidence and data to support conclusions. Describe the relationship between ocean surface temperature and hurricane intensity, using the NOAA database. Create a map of the most vulnerable areas and use it to identify highly populated areas that could be affected. Explore, analyze and interpret past and current climate patterns for 10 different cities around the world. Analyze differences between climate patterns. Make predictions of future patterns.	Write an article explaining the difference between climate and weather and the importance of distinguishing between the two.	

Environmental Science continued

ENV.ER: EARTH'S RESOURCES

ENV.ER.1: Energy resources
- Renewable and nonrenewable energy sources and efficiency
- Alternate energy sources and efficiency
- Resource availability
- Mining and resource extraction

ENV.ER.2: Air and air pollution
- Primary and secondary contaminants
- Greenhouse gases
- Clean Air Act

ENV.ER.3: Water and water pollution
- Potable water and water quality
- Hypoxia, eutrophication
- Clean Water Act
- Point source and non-point source contamination

ENV.ER.4: Soil and land
- Desertification
- Mass movement and erosion
- Sediment contamination
- Land use and land management (including food production, agriculture and zoning)
- Solid and hazardous waste

ENV.ER.5: Wildlife and wilderness
- Wildlife and wilderness management
    - Endangered species
- Invasive Species
- Introduced Species

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 are also included. This builds on energy and Earth's resources topics in grades 6-8 and chemistry and energy topics at the high school level.

To understand the effects that certain contaminants may have on the environment, scientific investigations and research should be conducted on a local, national and global level. Water, air, land and biotic field and lab sampling/testing equipment and methods are utilized with real-world application. Quantifiable field and/or lab data are 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 can also 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), watershed management, 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 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 is evaluated as it pertains to both environmental and human risks. 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 the existence and rationale for laws and regulations to conserve 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

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Designing technological/engineering solutions using science concepts	Demonstrating science knowledge	Interpreting and communicating science concepts	Recalling accurate science
ENV.ER.1: Energy resources			
Design an energy efficient, clean, renewable community based upon real data and models of other cities or communities. Include explanations of the benefits and consequences of various aspects of the city design. Using existing energy technologies (e.g., tidal power plants, solar panels, scrubbers) as an example, generate an alternative way to collect energy or improve an existing energy technology. Test your design.	Contact your local energy provider and conduct an energy audit of your school. Identify areas where energy can be conserved. Generate a plan to decrease energy footprint. Record energy usage in your home for a 24 to 48-hour period. With parental permission, review an electric bill for your home and identify adoptable strategies to reduce your home's energy usage.	Compose a letter to a local politician or school board outlining the need for renewable/alternative energy exploration and incorporation into your city. Include information about taxes, resources and infrastructure. Compare energy usage of the United States to energy usage of a developing nation. Parse it down to a "typical" family in America and a "typical" family in the developing country. Create a public service announcement explaining the importance of energy conservation in your community, home and school. Include methods for conservation.	Identify the primary resources used in your community for energy. Create a brochure explaining and comparing the sources. Research a widely used energy source (e.g., nuclear, oil, gas, wind, solar) and create a detailed poster discussing the pros and cons of its use.
ENV.ER.2: Air and air pollution			
Design a "city makeover" for a city near you. Your new city must promote clean air practices. Consider mass transit, industry, infrastructure, homes, education and technology.	Conduct tests for air quality in and around your school, investigate the sources of any pollutants and design a plan to remove or reduce the pollutants.	Construct a model of your home or school explaining the internal air pollutants. Determine the relationships between the pollutants and human activities in or near your home/school. Looking at air quality data (e.g., from the US EPA) outline a plan for Ohio or the Great Lake States to improve air in the next seven years. Using ice core models and/or datasets, make a graph showing how elements in the atmosphere can change over time. Interpret and extrapolate into the future.	Create a presentation on the major types and sources of air pollution. Compare the main types and illustrate ways to prevent air pollution. Design and create a poster/graphic organizer/infographic illustrating the difference between primary and secondary contaminants. Read the Clean Air Act and create a timeline demonstrating major events that led up to it and major events which occurred after it. Include results of those events.

Designing technological/engineering solutions using science concepts	Demonstrating science knowledge	Interpreting and communicating science concepts	Recalling accurate science
		Using the Clean Air Act as an example, propose an updated policy for the next 20 years, being sure to consider technology and demographics.	
ENV.ER.3: Water and water pollution			
Design and build a water filter with commonly available materials for either wastewater or drinking water, taking into account cost and efficiency. Test the water filter, analyze the data collected and brainstorm ideas on how to improve the design.	Conduct a water quality field test of various local bodies of water, and determine how the results (e.g., dissolved oxygen content, phosphates, nitrates/nitrites, pH, fecal coliform) could impact aquatic ecosystems. Identify two waterways in your area, one in a developed area and another in a natural area. Use biotic indicators and chemical tests to determine if any differences exist. Explain your findings, including ways contaminants may have moved from area to area.	Examine and report on your town's or city's water delivery system. Include where your drinking water comes from and where your waste water goes. Perform a water assessment on your home or school. Outline a water conservation plan based on the assessment. Explain where water can be conserved. Model how small changes can have large effects. Read excerpts or summaries of Rachel Carson's *Silent Spring* and create scenarios which model the effects of toxins introduced into a water system. Examine the actions that resulted from the publication of this book. Research water as a resource. Identify areas of concern and classify various sources (e.g., fresh, salt, ground, surface, glacier). Read the Clean Water Act and propose an amendment to address increases in populations and changes to ecosystems.	

Designing technological/engineering solutions using science concepts	Demonstrating science knowledge	Interpreting and communicating science concepts	Recalling accurate science
ENV.ER.4: Soil and land			
Create a plan to revitalize a brownfield site in one of the Great Lake States. Be sure to include an explanation of how it became a brownfield.	Conduct soil tests on various sites around the school or community. Determine an appropriate location for planting a community garden. Consider soil types, precipitation and yield.	Research current FDA laws pertaining to food safety for agriculture and write user-friendly versions of the laws for the public to access on the FDA website. Write a letter to a company which historically violated EPA laws outlining their violations and the impact on the environment. Deconstruct an area affected by a mass wasting, desertification or erosion event and write a detailed explanation with data. Write a "brief" for a law firm assigning responsibility for purposes of restitution and remediation.	Identify at least two examples of modern desertification. Choose one in the United States and one in another country.
ENV.ER.5: Wildlife and wilderness			
Evaluate current practices to conserve or recover native species that are currently endangered. Make assessments about the introduction of species. Identify ways that it boosts endangered species populations and potential negative impacts. Design a plan to preserve/conserve a wilderness or waterway in Ohio. Be specific and defend your rationale with data. Include biological and ecological relationships within the system.		Choose a specific living species. Using scientific data, trace the history of that species. Show existing, established evolutionary relationships, environmental (both biotic and abiotic) requirements, global locations, ecosystem characteristics and sustainability predictions. Use quantifiable data to support findings. Write a bill to be presented to state policy makers restricting, preventing or eliminating an invasive species in Ohio. Compare the biodiversity of two natural areas, including richness and distribution. Draw conclusions, including how the biodiversity is relevant toward mitigating the impact of invasive species.	Research an Ohio wilderness or water ecosystem. Identify threats to each species, including human impacts. Discuss the process of biomagnification and the ramifications if a primary consumer or a producer is removed or too many consumers or producers are introduced. Create a presentation for local stakeholders on the hazards of invasive species. Identify invasive species in the community and describe their impacts on the local food web.

Environmental Science continued

ENV.GP: GLOBAL ENVIRONMENTAL PROBLEMS AND ISSUES
ENV.GP.1: Human population
ENV.GP.2: Potable water quality, use and availability
ENV.GP.3: Climate change
ENV.GP.4: Sustainability
ENV.GP.5: Species depletion and extinction
ENV.GP.6: Air quality
ENV.GP.7: Food production and availability
ENV.GP.8: Deforestation and loss of biodiversity
ENV.GP.9: Waste management (solid and hazardous)

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 is 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, introduced or invasive species and studying the environmental effects of an increasing human population. Researching contemporary discoveries, new technology and new discoveries can lead to improvement in environmental management.

EXPECTATIONS FOR LEARNING

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Designing technological/engineering solutions using science concepts	Demonstrating science knowledge	Interpreting and communicating science concepts	Recalling accurate science
ENV.GP.1: Human population			
Work in design teams to create a plan to develop a parcel of undeveloped rural land or to revitalize an urban neighborhood that has been blighted. Solutions must address housing, transportation, business and industrial, green space and recreational land uses as well as food, water, waste and energy systems. An extension could limit funds available.	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. Use data on birth rates, death rates, life expectancy, average income and literacy rates of various countries[1] to develop a plan that could contribute to a change in the fertility and death rates.	Interpret population demographic curves, graphs or pyramids (e.g., from US Census Bureau, the UN Census, World Fact Book) and discuss differences in population growth rates among several different countries (developing vs. developed). Compare local fertility rates to national and international rates. Consider environmental and societal factors contributing to differences. Relative to resource availability and rates of consumption, assess the scope of human population growth and potential limits to its growth (e.g., Tragedy of the Commons, Hans Rosling and Gapminder Foundation)	Compare developing and developed countries, identifying the factors that separate the two types of countries.
ENV.GP.2: Potable water quality, use, and availability			
Design a water treatment system or process that can be implemented at a low cost and without the need for electricity to be used in areas that do not have access to potable water. Design and build an irrigation system that will move water at a specific rate.	Using data, research a severe water related environmental problem (and its root causes) that faces the local community, Ohio, the United States or the world. Propose ways to mitigate the problem. Test a local water source for contaminants and compare findings to the released water quality reports. If discrepancies exist, predict possible causes.	Investigate the source of various bottled water. Some brands come from municipal water supplies. Record each water source on a map. Examine the water quality report from a municipality to determine the health of the water. Investigate the effects of disinfection byproducts (DBPs) which result when chlorine and other disinfectants breakdown over time. Investigate sources of drinking water pollutants and design a plan to lower, restrict or prevent those pollutants. Conduct a water survey in your home/school. How much water do you use on a daily basis and how	Define potable water. Identify the locations of large sources of freshwater in the world and use this to explain why certain populations have little access to clean water.

Designing technological/engineering solutions using science concepts	Demonstrating science knowledge	Interpreting and communicating science concepts	Recalling accurate science
		much does it cost? Identify areas where water can be saved.	

[1]Unicef data

Designing technological/engineering solutions using science concepts	Demonstrating science knowledge	Interpreting and communicating science concepts	Recalling accurate science
ENV.GP.3: Climate change			
	Choose a specific location in the United States. Research and analyze the patterns of climate change throughout the geologic record, human historical data and present-day data for the location. Be able to explain the interpretation and analysis of the data. Analyze geoscience data and the results from global climate models to make an evidence-based forecast of the current rate of global or regional climate change and associated future impacts to Earth systems.	Research monthly average precipitation data in different areas to strengthen conclusions about periods of drought or abnormal rainfall as they relate to climate change. Compare the effects of El Niño and La Niña at two different longitudinal locations, but at the same latitude, using sea surface temperature and precipitation from real satellite data. Create a timeline of climate science and policy initiatives over the past two centuries in developing and non-developing countries. Include global data and compare different nations. Investigate the history of local habitats experiencing change (e.g., the Great Lakes). Develop position papers for and against increasing federal spending on climate change research.	Explain the correlation between historical carbon dioxide concentration data and historical global temperature data.
ENV.GP.4: Sustainability			
Redesign a city/village/town to be more sustainable. Examine concepts such as waste treatment, water resources, pollution, transportation, energy resources and maintaining biodiversity. Share recommendations and incorporate feedback to make a final proposal for the city/village/town. Research and design a sustainable lifestyle in regard to energy efficient living space and mindfully using resources, alternative transportation, dietary sources and outdoor space.		Create a pie chart displaying the breakdown of components of an individual's ecological footprint (e.g., shelter, food, energy, transportation), and construct a plan to reduce his/her carbon footprint.	Use an online ecological footprint calculator (e.g., Earth Day Network) to compare how many Earths it would take to sustain the world population for various lifestyles. Use the Tragedy of the Commons simulation activity to identify and explain potential strategies to prevent the destruction of a common resource.

Designing technological/engineering solutions using science concepts	Demonstrating science knowledge	Interpreting and communicating science concepts	Recalling accurate science
ENV.GP.5: Species depletion and extinction			
Analyze a conservation case study (e.g., osprey, bald eagle, black bears in Ohio) and write an analysis and a recommendation for solutions. Using phenological protocols, collect information on the local plants and wildlife as the seasons progress and contribute data to a local or global study. Track for comparison from year to year and location to location. Identify trends in phenological changes and design solutions to local climate impacts.		Research the effect that climate change is having or has had on a specific living or extinct species (e.g., harp seal, polar bear, dinosaur, elkhorn coral) or on an ecosystem (e.g., the Great Barrier Reef, the Arctic Circle). Create an infographic on an endangered species, including information on the organism's ecosystem and its role within the ecosystem, its value (ecologically and commercially), reasons for endangerment and possible solutions or interventions. The National Audubon Society has been collecting data on avian population and movements for over a century through the annual Christmas Bird Count. Download a dataset of the history of birds for your locality and investigate trends in the status of populations.	Research the requirements for listing a species as a species of concern, threatened or endangered on the state or federal level. Identify a species on one of these lists and research its life history, specifically the impacts leading to its decline.

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ENV.GP.6: Air quality			
Design and construct a scrubber for cleaning the sulfur emissions from burning coal. Assess how well the scrubber works by collecting calcium sulfate or sulfite to compare against a control. Identify a problem or issue with air quality in your school/community. Use real data from the EPA and develop a solution.	Investigate the effects of acid rain (with a range of pH) on seed sprouting. Conduct an investigation comparing the concentration of tropospheric ozone in various locations in the community and analyze the results to determine the cause(s) for the any differences in concentrations.	Use a case study for a city that has historically experienced air pollution (e.g., Beijing, Detroit). Analyze the situation and identify issues/actions described in the case which may be problematic. Using real-time data, research air pollution issues (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).	Illustrate the process of how acid rain is created and describe its effects on each component of the environment. Identify indoor pollutants and their sources. Explain their impacts.
ENV.GP.7: Food production and availability			
Identify the locations of food deserts in your community or surrounding areas. Write a proposal to the local government to provide that community with better food resources. Construct a plan for a sustainable garden that could provide food for your school/community. Share your plan with stakeholders.	Design and conduct an investigation to determine if a fertilizer or pesticide is toxic to an organism (e.g., radish seeds). Research food production in developing and underdeveloped nations, comparing land use vs. crop yield. Present your findings.	Research Genetically Modified Organisms used in agriculture and discuss advantages and disadvantages. Construct an energy pyramid (with a human at the top) and use data to defend or oppose the position that eating lower on the food chain is better for the environment. Using the National Geographic Website, *What the World Eats*, explore and compare the pie graphs to determine which country consumes the most/least daily calories, the most/least grains, the most/least meat, etc.	

Designing technological/engineering solutions using science concepts	Demonstrating science knowledge	Interpreting and communicating science concepts	Recalling accurate science
ENV.GP.8: Deforestation and loss of biodiversity			
Design a community of the future that demonstrates responsible practices for preservation of biodiversity and forested areas.	Use satellite mapping resources (NASA Forest Changes in Rondonia, Brazil) to investigate the connection between urbanization, population growth and deforestation. Summarize your findings.	Write a proposal for the state setting limits/regulations for housing/commercial development through the lens of biodiversity. Consider federal laws. Develop a PSA on commercial products that contribute to deforestation (e.g., palm oil) and how deforestation contributes to the loss of biodiversity. Engage in a classroom discussion on the rationale and methods to reduce the deer population in an Ohio community. Complete a graphic organizer on various tree harvesting practices (e.g., clear cutting, seed tree cutting, selective cutting, slash & burn) including a description of economic and ecological advantages and disadvantages of each.	Identify areas where urban sprawl has impacted plant, wildlife and human communities. Describe the effects on biodiversity.

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ENV.GP.9: Waste management (solid and hazardous)			
Develop a risk assessment for humans or the environment due to a toxin or hazardous chemical used by a company. The assessment should include: nature of the toxin/chemical, on-site use and handling (including existing safety practices), by-products (e.g., vapors, dilution processes), storage, transportation and emergency plans. Consider the topography and geology of the area and how these contribute to the flow of spills or leaks. Use a computer-modeling program (many are available through freeware sites) to model and predict the movement and possible pathways of the toxin/chemical. Make recommendations for containment methods. Research composting techniques. Analyze the wastes produced by the school and design an appropriate composting system to process the biodegradable waste produced. Construct and maintain a composting site on school grounds.	Conduct a landfill decomposition study over an extended period to determine the rate at which typical materials found in landfills decompose.	Collect research information on various waste management types. Compare and contrast the practices of waste management of developed and developing nations. Compare methods of at least two different nations and identify the best practices. Research the waste management issues and the root causes for the problems that face the local community, Ohio, the United States or the world. Plan and implement an investigation to explore human health issues related to the disposal of hazardous waste materials (e.g., biomagnification or bioaccumulation within a specific Ohio ecosystem). Existing public case studies can be used, such as a local Brownfields case.	Document the amount of waste a family/individual produces throughout a 24-hour period. Identify the materials that are non-recyclable and recyclable. Describe the benefits and challenges of recycling. Draw a diagram of a modern landfill and label the various components that are required or used in landfills today to prevent them from polluting the air and water.