Environmental Science Course Content and Process Guidelines

The Virginia Environmental Science Course Content and Process Guidelines are designed to continue the student investigations that began in grades K-8. These outcomes integrate the study of many components of our environment, including the human impact on our planet. These outcomes focus on scientific inquiry, the physical world, the living environment, resource conservation, humans' impact on the environment, and legal and civic responsibility. Instruction should focus on student data collection and analysis through laboratory experiences and field work. These should include descriptive and comparative studies as well as investigation (i.e. meaningful watershed educational experiences). It is expected that teachers will collaborate with museums, aquaria, nature centers, government agencies, associations, foundations, and private industry in efforts to engage the community, provide diverse points of view about the management of natural resources, and offer a variety of learning experiences and career education opportunities.

I. Scientific Skills and Processes

Students will identify and investigate problems scientifically and will communicate information clearly in writing, discussions, and debates. Key skills and processes include

- chemicals and equipment are used in a safe manner;
- hypotheses are formulated based on direct observations and information from scientific literature and environmental research;
- variables are defined to test hypotheses and provide evidence in constructing and critiquing explanations of phenomena;
- collection, analysis, and reporting of data in the classroom and the field using appropriate materials and technologies;
- data tables, frequency distributions, scatterplots, line plots, and histograms are constructed and interpreted;
- information is reviewed for accuracy, separating fact from opinion;
- conclusions are formed based on quantitative and qualitative data;
- questions are asked to critique the interpretation, relevance, or thoroughness of data or evidence, investigative design, and/or premise(s) of an explanation;
- ethical issues in the environmental field are researched and discussed from multiple viewpoints; and
- career opportunities in the field of environmental science are explored.

The student will demonstrate an understanding of the nature of science and scientific reasoning and logic as it applies to environmental science.

- the natural world is understandable;
- science is based on evidence – both observational and experimental;
- science is a blend of logic and innovation;
- scientific ideas are durable yet subject to change as new data are collected;
- science is a complex social endeavor; and

- scientists try to remain objective and engage in peer review to help avoid bias

The student will demonstrate an understanding of the use of mathematical reasoning and processes in environmental science. Key content includes

- error and uncertainty are inherent in any scientific study;
- experimental and theoretical probability can be calculated for dependent and independent events;
- probability is used to express the likelihood of an event happening under similar conditions; and
- statistics is a branch of mathematics used to analyze large quantities of numerical data especially for the purpose of inferring proportions in a whole from those in a representative sample.

The student will analyze current environmental issues and apply the process of engineering design in order to propose feasible solutions. Key content includes

- using engineering design is an iterative process in which science and mathematics principles are applied in the formation of a solution;
- developing and evaluating multiple solutions or designs may be appropriate for an environmental problem;
- evaluating solutions using different perspectives to include the scientific, engineering, economic, political, and social aspects of the problem; and
- choosing a solution(s) requires balancing possible positive and negative impacts of a variety of competing interests.

II. The Physical World

The student will investigate and understand the fundamentals of matter and its interactions. Key content includes

- all things are made up of atoms and elements;
- atoms and elements can interact in different ways and can be expressed as different types of chemical reactions;
- chemical processes involve energy;
- the law of conservation of energy and matter;
- water has unique properties and characteristics which plays a critical role in the environment; and
- the distribution and movement of water across the Earth affects the biosphere, hydrosphere, lithosphere, and atmosphere.

The student will investigate and understand how matter flows in the fundamental processes of Earth systems. Key content includes

- the movement of atoms and elements through the biosphere, lithosphere, hydrosphere, and atmosphere as geochemical processes to include the carbon, oxygen, nitrogen, and water cycles;

- the components, dynamics, and processes of the atmosphere, lithosphere, and hydrosphere; and
- the interrelationships among the atmosphere, geosphere, anthrosphere, and the hydrosphere.

The students will investigate and understand the major processes and systems that form Earth, including how water, living things, and rock act together to shape landforms. Key content includes

- the formation of distinctive landforms (the physical processes such as erosion, rock cycle);
- distribution of the continents (plate tectonics); and
- the comparison of how natural and human causes of changes to Earth's land surface.

III. The Living World

The student will investigate and understand that the Earth is one interconnected system to include the hierarchy and the flow of energy within an ecosystem. Key content includes

- the characteristics and components that define each of the Earth's terrestrial and aquatic biomes;
- biotic and abiotic factors in an ecosystem and how energy and matter move between these;
- the movement of energy through the living world to include food webs, food chains, trophic levels; and
- factors limiting population growth in a given area (carrying capacity).

Student will describe stability and change as it relates to both populations and ecosystems. Key content includes

- the Earth in a state of dynamic equilibrium;
- interactions between individuals (i.e. commensalism, mutualism, parasitism, predation, and competition);
- factors that determine growth rates in populations (birth, death, and migration rates);
- adaptions of organisms to the environment in terms of ecological niches and natural selection;
- the role of genetic diversity and population size in the conservation of a species;
- the natural processes of change in the environment, including examples of succession, evolution, and extinction;
- factors that influence patterns of ecological succession, including invasive species, loss of biodiversity, and catastrophic events;
- effects of change in the hydrosphere, atmosphere, geosphere, or anthrosphere on the biosphere; and
- biodiversity and co-evolution in ecosystems.

IV. Resources

The student will investigate and understand Earth's resources. Key content includes

- certain resources are nonrenewable because they are replenished at timescales of thousands to millions of years;
- environmental benefits and drawbacks of fossil fuels advantages and disadvantages of renewable resources, including solar, hydrogen fuel cells, biomass, wind, and geothermal energy;
- the benefits and drawbacks of nuclear power; and
- the benefits and drawbacks of hydroelectric power.

The student will investigate and understand conservation of Earth's resources. Key content includes

- future availability of nonrenewable resources considering the trend of human consumption of energy;
- the effects of natural and human-caused activities that either contribute to or challenge an ecologically sustainable environment;
- individuals can alter their own behavior to reduce their environmental impact; and
- changes in the availability of energy will affect society and human activities, such as transportation, agricultural systems, and manufacturing.

V. Human impact, global climate change, and civic responsibility

The student will investigate and understand the human impact on our environment. Key content includes

- Population ecology, carrying capacity, human population dynamics, impacts of population growth advantages and disadvantages of balancing short term interests with long term welfare of society;
- individual activities and decisions can have an impact on the environment;
- people impact their environment through the use of natural resources to include how agriculture, forestry, ranching, mining, urbanization, transportation, and fishing impact the land, water, air, and organisms; and
- the allocation of state and federal lands.

The student will investigate and understand pollution and waste management. Key content includes

- the effects and potential implications of pollution and resource depletion on the environment at the local and global levels to include air and water pollution, solid waste disposal, depletion of the stratospheric ozone, global warming, and land uses;
- the mechanisms of bioaccumulation and biomagnification;
- pest management; and
- methods used for remediation of land, air, and water pollution.

The student will investigate and understand global climate change. Key content includes

- the use of scientific evidence in reporting changes in average global temperature, greenhouse gases, quantities of artic and land ice, ocean temperature, ocean acidification, and sea level rise;
- the relationship of global climate change on the frequency or magnitude of extreme weather events; and
- actual and potential effects of habitat destruction, erosion, and depletion of soil fertility associated with human activities.

The student will investigate and understand civic responsibility and environmental policies. Key content includes

- consumer choices in Virginia impacts jobs, resources, pollution, and waste here and around the world;
- political, legal, social, and economic decisions may affect global and local ecosystems;
- the impact of media on public opinion and public policy;
- individuals and interest groups influence public policy;
- cost-benefit analysis and trade-offs in conservation policy; and
- compare methods used to protect the environment by local, state, national, and international governments and organizations