EARTH SCIENCE OVERVIEW

The academic standards and performance indicators establish the practices and core content for all Earth Science courses in South Carolina schools. The core ideas within the standards are not meant to represent an equal division of material and concepts. Therefore the number of indicators per core idea should not be expected to be equal, nor should equal numbers of performance indicators within each standard be expected.

The five core areas of the Earth Science standards include:

- Astronomy
- Earth's Geosphere
- Earth's Paleobiosphere
- Earth's Atmosphere – Weather and Climate
- Earth's Hydrosphere

The eight science and engineering practices describe how students should learn and demonstrate knowledge of the content outlined in the content standards. Engaging in these practices will help students become scientifically literate and astute consumers of scientific information. The seven core concepts (patterns; cause and effect; scale, proportion, and quantity; systems and system models; energy and matter; structure and function; and stability and change) are reinforced in the appropriate context of the core science content through hands-on instruction in the classroom.

Students should engage in scientific and engineering practices as a means to learn about the specific topics identified for the course. It is critical that educators understand the Science and Engineering Practices are ***not*** to be taught in isolation. There should ***not*** be a distinct "Inquiry" unit at the beginning of each school year. Rather, the practices need to be employed ***within the content*** for each grade level.

Teachers, schools, and districts should use these standards and indicators to make decisions concerning the structure and content of an Earth Science course. All Earth Science courses must include instruction in the practices of science and engineering, allowing students to engage in problem solving, decision making, critical thinking, and applied learning. All Earth Science courses are laboratory courses requiring a minimum of 30% hands-on investigation. Earth Science laboratories will need to be stocked with the materials and equipment necessary to complete investigations.

The academic standards and performance indicators for Earth Science should be the basis for the development of classroom and course-level assessments.

EARTH SCIENCE
SCIENCE AND ENGINEERING PRACTICES

NOTE: Scientific investigations should always be done in the context of content knowledge expected in this course. The standard describes how students should learn and demonstrate knowledge of the content outlined in the other standards.

Standard H.E.1: The student will use the science and engineering practices, including the processes and skills of scientific inquiry, to develop understandings of science content.

H.E.1A. Conceptual Understanding: The practices of science and engineering support the development of science concepts, develop the habits of mind that are necessary for scientific thinking, and allow students to engage in science in ways that are similar to those used by scientists and engineers.

Performance Indicators: Students who demonstrate this understanding can:

H.E.1A.1 Ask questions to (1) generate hypotheses for scientific investigations, (2) refine models, explanations, or designs, or (3) extend the results of investigations or challenge scientific arguments or claims.

H.E.1A.2 Develop, use, and refine models to (1) understand or represent phenomena, processes, and relationships, (2) test devices or solutions, or (3) communicate ideas to others.

H.E.1A.3 Plan and conduct controlled scientific investigations to answer questions, test hypotheses, and develop explanations: (1) formulate scientific questions and testable hypotheses based on credible scientific information, (2) identify materials, procedures, and variables, (3) use appropriate laboratory equipment, technology, and techniques to collect qualitative and quantitative data, and (4) record and represent data in an appropriate form. Use appropriate safety procedures.

H.E.1A.4 Analyze and interpret data from informational texts and data collected from investigations using a range of methods (such as tabulation, graphing, or statistical analysis) to (1) reveal patterns and construct meaning, (2) support or refute hypotheses, explanations, claims, or designs, or (3) evaluate the strength of conclusions.

H.E.1A.5 Use mathematical and computational thinking to (1) use and manipulate appropriate metric units, (2) express relationships between variables for models and investigations, or (3) use grade-level appropriate statistics to analyze data.

H.E.1A.6 Construct explanations of phenomena using (1) primary or secondary scientific evidence and models, (2) conclusions from scientific investigations, (3) predictions based on observations and measurements, or (4) data communicated in graphs, tables, or diagrams.

H.E.1A.7 Construct and analyze scientific arguments to support claims, explanations, or designs using evidence and valid reasoning from observations, data, or informational texts.

H.E.1A.8 Obtain and evaluate scientific information to (1) answer questions, (2) explain or describe phenomena, (3) develop models, (4) evaluate hypotheses, explanations, claims, or designs or (5) identify and/or fill gaps in knowledge. Communicate using the conventions and expectations of scientific writing or oral presentations by (1) evaluating grade-appropriate primary or secondary scientific literature, or (2) reporting the results of student experimental investigations.

H.E.1B. Conceptual Understanding: Technology is any modification to the natural world created to fulfill the wants and needs of humans. The engineering design process involves a series of iterative steps used to solve a problem and often leads to the development of a new or improved technology.

Performance Indicators: Students who demonstrate this understanding can:

H.E.1B.1 Construct devices or design solutions using scientific knowledge to solve specific problems or needs: (1) ask questions to identify problems or needs, (2) ask questions about the criteria and constraints of the device or solutions, (3) generate and communicate ideas for possible devices or solutions, (4) build and test devices or solutions, (5) determine if the devices or solutions solved the problem and refine the design if needed, and (6) communicate the results.

EARTH SCIENCE
ASTRONOMY

Standard H.E.2: The student will demonstrate an understanding of the structure, properties, and history of the observable universe.

H.E.2A. Conceptual Understanding: Earth is a tiny part of a vast universe that has developed over a huge expanse of time. At the center of Earth's solar system is one local star, the Sun. It is just one of a vast number of stars in the Milky Way Galaxy, which is just one of a vast number of galaxies in the observable universe. The study of the light spectra and brightness of stars is used to identify compositional elements of stars, their movements, and their distances from Earth. Nearly all observable matter in the universe formed and continues to form within the cores of stars. The universe began with a period of extreme and rapid expansion and has been expanding ever since.

Performance Indicators: Students who demonstrate this understanding can:

H.E.2A.1 Construct explanations for how gravity and motion affect the formation and shapes of galaxies (including the Milky Way Galaxy).

H.E.2A.2 Use the Hertzsprung-Russell diagram to classify stars and explain the life cycles of stars (including the Sun).

H.E.2A.3 Construct explanations for how elements are formed using evidence from nuclear fusion occurring within stars and/or supernova explosions.

H.E.2A.4 Construct and analyze scientific arguments to support claims about the origin of the universe (including the red shift of light from distant galaxies, the measured composition of stars and nonstellar gases, and the cosmic background radiation).

H.E.2A.5 Obtain and evaluate information to describe how the use of x-ray, gamma-ray, radio, and visual (reflecting, refracting, and catadioptric) telescopes and computer modeling have increased the understanding of the universe.

H.E.2B. Conceptual Understanding: The solar system consists of the Sun and a collection of objects of varying sizes and conditions – including planets and their moons – that have predictable patterns of movement. These patterns can be explained by gravitational forces and conservation laws, and in turn explains many large-scale phenomena observed on Earth. Kepler's laws describe common features of the motions of orbiting objects, including their elliptical paths around the Sun. The solar system appears to have formed from a disk of dust and gas, drawn together by gravity.

Performance Indicators: Students who demonstrate this understanding can:

H.E.2B.1 Analyze and interpret data to compare the properties of Earth and other planets (including composition, density, surface expression of tectonics, climate, and conditions necessary for life).

H.E.2B.2 Obtain, evaluate, and communicate information about the properties and features of the moon to support claims that it is unique among other moons in the solar system in its effects on the planet it orbits.

H.E.2B.3 Use mathematical and computational thinking to explain the motion of an orbiting object in the solar system.

H.E.2B.4 Construct explanations for how the solar system was formed.

EARTH SCIENCE
EARTH'S GEOSPHERE

Standard H.E.3: The student will demonstrate an understanding of the internal and external dynamics of Earth's geosphere.

H.E.3A. Conceptual Understanding: Evidence indicates Earth's interior is divided into a solid inner core, a liquid outer core, a solid (but flowing) mantle and solid crust. Although the crust is solid, it is in constant motion and is recycled through time. Plate tectonics is the unifying theory that explains the past and current movements of the rocks at Earth's surface and provides a coherent account of its geological history. Weathering (physical and chemical) and soil formation are a result of the interactions of Earth's geosphere, hydrosphere, and atmosphere. All forms of resource extraction and land use have associated economic, social, environmental, and geopolitical costs, risks, and benefits. Natural hazards and other geological events have shaped the course of human history.

Performance Indicators: Students who demonstrate this understanding can:

H.E.3A.1 Analyze and interpret data to explain the differentiation of Earth's internal structure using (1) the production of internal heat from the radioactive decay of unstable isotopes, (2) gravitational energy, (3) data from seismic waves, and (4) Earth's magnetic field.

H.E.3A.2 Analyze and interpret data from ocean topography, correlation of rock assemblages, the fossil record, the role of convection current, and the action at plate boundaries to explain the theory of plate tectonics.

H.E.3A.3 Construct explanations of how forces cause crustal changes as evidenced in sea floor spreading, earthquake activity, volcanic eruptions, and mountain building using evidence of tectonic environments (such as mid-ocean ridges and subduction zones).

H.E.3A.4 Use mathematical and computational thinking to analyze seismic graphs to (1) triangulate the location of an earthquake's epicenter and magnitude, and (2) describe the correlation between frequency and magnitude of an earthquake.

H.E.3A.5 Analyze and interpret data to describe the physical and chemical properties of minerals and rocks and classify each based on the properties and environment in which they were formed.

H.E.3A.6 Develop and use models to explain how various rock formations on the surface of Earth result from geologic processes (including weathering, erosion, deposition, and glaciation).

H.E.3A.7 Plan and conduct controlled scientific investigations to determine the factors that affect the rate of weathering.

H.E.3A.8 Analyze and interpret data of soil from different locations to compare the major physical components of soil (such as the amounts of sand, silt, clay, and humus) as evidence of Earth processes in that region producing each type of soil.

H.E.3B. Conceptual Understanding: The sustainability of human societies and the biodiversity that supports them requires responsible management of natural resources. Human transformation of the natural environment can contribute to the frequency and intensity of some natural hazards.

Performance Indicators: Students who demonstrate this understanding can:

H.E.3B.1 Obtain and communicate information to explain how the formation, availability, and use of ores and fossil fuels impact the environment.

H.E.3B.2 Construct scientific arguments to support claims that responsible management of natural resources is necessary for the sustainability of human societies and the biodiversity that supports them.

H.E.3B.3 Analyze and interpret data to explain how natural hazards and other geologic events have shaped the course of human history.

H.E.3B.4 Obtain and evaluate available data on a current controversy regarding human activities which may affect the frequency, intensity, or consequences of natural hazards.

H.E.3B.5 Define problems caused by the impacts of locally significant natural hazards and design possible devices or solutions to reduce the impacts of such natural hazards on human activities.

EARTH SCIENCE
EARTH'S PALEOBIOSPHERE

Standard H.E.4: The student will demonstrate an understanding of the dynamic relationship between Earth's conditions over geologic time and the diversity of organisms.

H.E.4A. Conceptual Understanding: Living things have changed the makeup of Earth's geosphere, hydrosphere, and atmosphere over geological time. Organisms ranging from bacteria to human beings may contribute to the global carbon cycle. They may influence the global climate by modifying the chemical makeup of the atmosphere. As Earth changes, life on Earth adapts and evolves to those changes. Just as life influences components of the Earth System, changes in the Earth System influences life.

Performance Indicators: Students who demonstrate this understanding can:

H.E.4A.1 Construct scientific arguments to support claims that the physical conditions of Earth enable the planet to support carbon-based life.

H.E.4A.2 Construct explanations for how various life forms have altered the geosphere, hydrosphere and atmosphere over geological time.

H.E.4A.3 Construct explanations of how changes to Earth's surface are related to changes in the complexity and diversity of life using evidence from the geologic time scale.

H.E.4A.4 Obtain and evaluate evidence from rock and fossil records and ice core samples to support claims that Earth's environmental conditions have changed over time.

H.E.4A.5 Develop and use models of various dating methods (including index fossils, ordering of rock layers, and radiometric dating) to estimate geologic time.

H.E.4A.6 Use mathematical and computational thinking to calculate the age of Earth materials using isotope ratios (actual or simulated).

H.E.4A.7 Develop and use models to predict the effects of an environmental change (such as the changing life forms, tectonic change, or human activity) on global carbon cycling.

EARTH SCIENCE
EARTH'S ATMOSPHERE – WEATHER AND CLIMATE

Standard H.E.5: The student will demonstrate an understanding of the dynamics of Earth's atmosphere.

H.E.5A. Conceptual Understanding: Weather is the condition of the atmosphere at a particular location at a particular time. Weather is primarily determined by the angle and amount (time) of sunlight. Climate is the general weather conditions over a long period of time and is influenced by many factors.

Performance Indicators: Students who demonstrate this understanding can:

H.E.5A.1 Develop and use models to describe the thermal structures (including the changes in air temperature due to changing altitude in the lower troposphere), the gaseous composition, and the location of the layers of Earth's atmosphere.

H.E.5A.2 Develop and use models to predict and explain how the angle of solar incidence and Earth's axial tilt impact (1) the length of daylight, (2) the atmospheric filtration, (3) the distribution of sunlight in any location, and (4) seasonal changes.

H.E.5A.3 Analyze and interpret data to predict local and national weather conditions on the basis of the relationship among the movement of air masses, pressure systems, and frontal boundaries.

H.E.5A.4 Analyze and interpret data of pressure differences, the direction of winds, and areas of uneven heating to explain how convection determines local wind patterns (including land/sea breezes, mountain/valley breezes, Chinook winds, and monsoons).

H.E.5A.5 Construct explanations for the formation of severe weather conditions (including tornadoes, hurricanes, thunderstorms, and blizzards) using evidence from temperature, pressure and moisture conditions.

H.E.5A.6 Develop and use models to exemplify how climate is driven by global circulation patterns.

H.E.5A.7 Construct scientific arguments to support claims of past changes in climate caused by various factors (such as changes in the atmosphere, variations in solar output, Earth's orbit, changes in the orientation of Earth's axis of rotation, or changes in the biosphere).

H.E.5A.8 Analyze scientific arguments regarding the nature of the relationship between human activities and climate change.

EARTH SCIENCE
EARTH'S HYDROSPHERE

Standard H.E.6: The student will demonstrate an understanding of Earth's freshwater and ocean systems.

H.E.6A. Conceptual Understanding: Water is an essential resource on Earth. Organisms (including humans) on Earth depend on water for life. Its unique physical and chemical properties are important to the dynamics of Earth systems. Multiple factors affect the quality, availability, and distribution of Earth's water.

Performance Indicators: Students who demonstrate this understanding can:

H.E.6A.1 Analyze and interpret data to describe and compare the physical and chemical properties of saltwater and freshwater.

H.E.6A.2 Obtain and communicate information to explain how location, movement, and energy transfers are involved in making water available for use on Earth's surface (including lakes, surface-water drainage basins, freshwater wetlands, and groundwater zones).

H.E.6A.3 Plan and conduct controlled scientific investigations to determine how a change in stream flow might affect areas of erosion and deposition of a meandering alluvial stream.

H.E.6A.4 Analyze and interpret data of a local drainage basin to predict how changes caused by human activity and other factors influence the hydrology of the basin and amount of water available for use in the ecosystem.

H.E.6A.5 Analyze and interpret data to describe how the quality of the water in drainage basins is influenced by natural and human factors (such as land use, domestic and industrial waste, weather/climate conditions, topography of the river channel, pollution, or flooding).

H.E.6A.6 Develop and use models to explain how groundwater processes affect limestone formations leading to the formation of caves and karst topography.

H.E.6A.7 Obtain and communicate information to explain how the convection of ocean water due to temperature and density influence the circulation of oceans.

H.E.6A.8 Develop and use models to describe how waves and currents interact with the ocean shore.

H.E.6A.9 Ask questions about the designs of devices used to control and prevent coastal erosion and flooding and evaluate the designs in terms of the advantages and disadvantages required for solving the problems.