West Windsor-Plainsboro Regional School District
Course Title: Environmental Science
Grades: 9-12

The Mission of the West Windsor-Plainsboro Science Department

West Windsor-Plainsboro RSD

Our mission is to cultivate science learners who have the foundational knowledge to make ethical, scientifically literate decisions and the ability to apply scientific practices in order to contribute to the needs of society and a changing world.

- **Vision**

  We envision a K-12 science experience that supports and challenges every student in their science learning journey. We will:
  - *Capitalize on diversity by reaching and exciting students at all levels and interests by differentiating learning within classrooms and by offering a robust program of studies.*
  - *Emphasize authentic science and engineering practices and leverage the interdisciplinary nature of science with arts, technology, math, reading, and writing.*
  - *Integrate scientific knowledge and 21st century competencies to prepare students to make informed decisions and take action to address real world problems.*

Content Area: Science

Course & Grade Level: Environmental Science 9-12

Summary and Rationale

The first unit provides a framework for students of how life interacts with the physical and chemical Earth. The study of Environmental Science incorporates concepts from this interaction and also many cultural concepts and areas of study. Most people associate Environmental Science with either environmental activism, a movement for change in public and personal decisions driven by goals or feelings that may not be scientific, or with only systematic toxicology that does not address global issues. It is important for students who are going to spend a year studying Environmental Science to have a solid framework that places the subsequent unit goals in an overall context of rigorous science.

Students will examine the parts of an ecosystem and learn how the organisms that make up an ecosystem are interconnected. They will be able to explain how changes to organisms in an ecosystem can impact biodiversity. As a way to illustrate the change over time that Earth has experienced in the past and the scale of ecological and geological change that is currently occurring (largely due to human actions) students will explore the influence of life on Earth and Earth on life over geologic time. Within this study of geological change, students will explore decadal and epochal scale climate fluctuations and patterns. As part of this study, students will use a growing understanding of biogeochemistry to learn about geologic eras and coevolution of the abiotic and biotic components of Earth. The unit will culminate with an examination of the change of geologic eras that is currently occurring as we have moved from the Holocene to the recently recognized “Anthropocene”, an era dominated by anthropogenic changes to Earth's systems.

Recommended Pacing

6 Weeks

New Jersey Student Learning Standards for Science

Standard

CPI#	**Cumulative Progress Indicator (CPI)**
HS-ESS1-5	Evaluate evidence of the past and current movements of continental and oceanic crust and the theory of plate tectonics to explain the ages of crustal rocks. *[Clarification Statement: Emphasis is on the ability of plate tectonics to explain the ages of crustal rocks. Examples include evidence of the ages of oceanic crust increasing with distance from mid-ocean ridges (a result of plate spreading) and the ages of North American continental crust increasing with distance away from a central ancient core (a result of past plate interactions).]*
HS-ESS1-6	Apply scientific reasoning and evidence from ancient Earth materials, meteorites, and other planetary surfaces to construct an account of Earth’s formation and early history. *[Clarification Statement: Emphasis is on using available evidence within the solar system to reconstruct the early history of Earth, which formed along with the rest of the solar system 4.6 billion years ago. Examples of evidence include the absolute ages of ancient materials (obtained by radiometric dating of meteorites, moon rocks, and Earth’s oldest minerals), the sizes and compositions of solar system objects, and the impact cratering record of planetary surfaces.]*
HS-ESS2-4	Use a model to describe how variations in the flow of energy into and out of Earth’s systems result in changes in climate. *[Clarification Statement: Examples of the causes of climate change differ by timescale, over 1–10 years: large volcanic eruption, ocean circulation; 10–100s of years: changes in human activity, ocean circulation, solar output; 10–100s of thousands of years: changes to Earth's orbit and the orientation of its axis; and*

	10–100s of millions of years: long-term changes in atmospheric composition.] [Assessment Boundary: Assessment of the results of changes in climate is limited to changes in surface temperatures, precipitation patterns, glacial ice volumes, sea levels, and biosphere distribution.]
HS-ESS2-7	Construct an argument based on evidence about the simultaneous coevolution of Earth's systems and life on Earth. *[Clarification Statement: Emphasis is on the dynamic causes, effects, and feedbacks between the biosphere and Earth's other systems, whereby geoscience factors control the evolution of life, which in turn continuously alters Earth's surface. Examples include how photosynthetic life altered the atmosphere through the production of oxygen, which in turn increased weathering rates and allowed for the evolution of animal life; how microbial life on land increased the formation of soil, which in turn allowed for the evolution of land plants; or how the evolution of corals created reefs that altered patterns of erosion and deposition along coastlines and provided habitats for the evolution of new life forms.]* [Assessment Boundary: Assessment does not include a comprehensive understanding of the mechanisms of how the biosphere interacts with all of Earth's other systems.]
HS-ESS3-5	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. *[Clarification Statement: Examples of evidence, for both data and climate model outputs, are for climate changes (such as precipitation and temperature) and their associated impacts (such as on sea level, glacial ice volumes, or atmosphere and ocean composition).]* [Assessment Boundary: Assessment is limited to one example of climate change and its associated impacts.]
HS-ESS3-6	Use a computational representation to illustrate the relationships among Earth systems and how those relationships are being modified due to human activity (i.e., climate change). *[Clarification Statement: Examples of Earth systems to be considered are the hydrosphere, atmosphere, cryosphere, geosphere, and/or biosphere. An example of the far-reaching impacts from human activity is how an increase in atmospheric carbon dioxide results in an increase in photosynthetic biomass on land and an increase in ocean acidification, with resulting impacts on sea organism health and marine populations.]* [Assessment Boundary: Assessment does not include running computational representations but is limited to using the published results of scientific computational models.]
HS-LS2-2	Use mathematical representations to support and revise explanations based on evidence about factors affecting biodiversity and populations in ecosystems of different scales. *[Clarification Statement: Examples of mathematical representations include finding the average, determining trends, and using graphical comparisons of multiple sets of data.]* [Assessment Boundary: Assessment is limited to provided data.]
HS-LS2-4	Use mathematical representations to support claims for the cycling of matter and flow of energy among organisms in an ecosystem. *[Clarification Statement: Emphasis is on using a mathematical model of stored energy in biomass to describe the transfer of energy from one trophic level to another and that matter and energy are conserved as matter cycles and energy flows through ecosystems. Emphasis is on atoms and molecules such as carbon, oxygen, hydrogen and nitrogen being conserved as they move through an ecosystem.]* [Assessment Boundary: Assessment is limited to proportional reasoning to describe the cycling of matter and flow of energy.]
HS-LS2-6	Develop a quantitative model to describe the cycling of carbon among the hydrosphere,

	atmosphere, geosphere, and biosphere. *[Clarification Statement: Emphasis is on modeling biogeochemical cycles that include the cycling of carbon through the ocean, atmosphere, soil, and biosphere (including humans), providing the foundation for living organisms.]*
HS-LS4-5	Evaluate the evidence supporting claims that changes in environmental conditions may result in: (1) increases in the number of individuals of some species, (2) the emergence of new species over time, and (3) the extinction of other species. *[Clarification Statement: Emphasis is on determining cause and effect relationships for how changes to the environment such as deforestation, fishing, application of fertilizers, drought, flood, and the rate of change of the environment affect distribution or disappearance of traits in species.]* Teacher Note: Within this unit the focus of this SLO is on the relationship of various life forms found in the fossil record over geologic time and the environmental conditions within the Earth system which may have precipitated the changes in life forms.
New Jersey Student Learning Standards for English Language Arts Companion Standards	
Standard:	
CPI #	**Cumulative Progress Indicator (CPI)**
RST.9-10.8	Determine if the reasoning and evidence in a text support the author's claim or a recommendation for solving a scientific or technical problem. (HS-LS2-6)
RST.11-12.1	Cite specific textual evidence to support analysis of science and technical texts, attending to important distinctions the author makes and to any gaps or inconsistencies in the account. (HS-ESS1-5), (HS-ESS1-6), (HS-LS2-2), (HS-LS2-3), (HS-LS2-6), (HS-ESS3-5)
RST.11-12.2	Determine the central ideas or conclusions of a text; summarize complex concepts, processes, or information presented in a text by paraphrasing them in simpler but still accurate terms. (HS-ESS3-5)
RST.11-12.7	Integrate and evaluate multiple sources of information presented in diverse formats and media (e.g., quantitative data, video, multimedia) in order to address a question or solve a problem. (HS-LS2-6), (HS-ESS3-5)
RST.11-12.8	Evaluate the hypotheses, data, analysis, and conclusions in a science or technical text, verifying the data when possible and corroborating or challenging conclusions with other sources of information. (HS-ESS1-5), (HS-ESS1-6), (HS-LS2-6), (HS-LS4-5)
WHST.9-12.1	Write arguments focused on discipline-specific content. (HS-ESS1-6)
WHST.9-12.2	Write informative/explanatory texts, including the narration of historical events, scientific procedures/ experiments, or technical processes. (HS-ESS1-5), (HS-LS2-2)
WHST.9-12.1	Write arguments focused on discipline-specific content. (HS-ESS2-7)
WHST.9-12.9	Draw evidence from informational texts to support analysis, reflection, and research. (HS-LS4-5)

SL.11-12.5	Make strategic use of digital media (e.g., textual, graphical, audio, visual, and interactive elements) in presentations to enhance understanding of findings, reasoning, and evidence and to add interest. (HS-ESS2-4)
New Jersey Student Learning Standards for Career Readiness, Life Literacies and Key Skills	
CPI #	**Cumulative Progress Indicator (CPI)**
9.1.12.CFR.2	Summarize causes important to you and compare organizations you seek to support to other organizations with similar missions.
9.1.12.CFR.3	Research companies with corporate governance policies supporting the common good and human rights.
9.4.12.CI.1	Demonstrate the ability to reflect, analyze, and use creative skills and ideas (e.g., 1.1.12prof.CR3a).
9.4.12.CI.3	Investigate new challenges and opportunities for personal growth, advancement, and transition (e.g., 2.1.12.PGD.1).
9.4.12.CT.2	Explain the potential benefits of collaborating to enhance critical thinking and problem solving (e.g., 1.3E.12profCR3.a).
9.4.12.DC.7	Evaluate the influence of digital communities on the nature, content and responsibilities of careers, and other aspects of society (e.g., 6.1.12.CivicsPD.16.a).
9.4.12.DC.8	Explain how increased network connectivity and computing capabilities of everyday objects allow for innovative technological approaches to climate protection.
9.4.12.GCA.1	Collaborate with individuals to analyze a variety of potential solutions to climate change effects and determine why some solutions (e.g., political. economic, cultural) may work better than others (e.g., SL.11-12.1., HS-ETS1-1, HS-ETS1-2, HS-ETS1-4, 6.3.12.GeoGI.1, 7.1.IH.IPERS.6, 7.1.IL.IPERS.7, 8.2.12.ETW.3).
9.4.12.IML.2	Evaluate digital sources for timeliness, accuracy, perspective, credibility of the source, and relevance of information, in media, data, or other resources (e.g., NJSLSA.W8, Social Studies Practice: Gathering and Evaluating Sources.
9.4.12.IML.3	Analyze data using tools and models to make valid and reliable claims, or to determine optimal design solutions (e.g., S-ID.B.6a., 8.1.12.DA.5, 7.1.IH.IPRET.8)
9.4.12.IML.5	Evaluate, synthesize, and apply information on climate change from various sources appropriately (e.g., 2.1.12.CHSS.6, S.IC.B.4, S.IC.B.6, 8.1.12.DA.1, 6.1.12.GeoHE.14.a, 7.1.AL.PRSNT.2).
9.4.12.IML.6	Use various types of media to produce and store information on climate change for different purposes and audiences with sensitivity to cultural, gender, and age diversity (e.g., NJSLSA.SL5).
9.4.12.IML.7	Develop an argument to support a claim regarding a current workplace or societal/ethical issue such as climate change (e.g., NJSLSA.W1, 7.1.AL.PRSNT.4).
9.4.12.IML.8	Evaluate media sources for point of view, bias, and motivations (e.g., NJSLSA.R6, 7.1.AL.IPRET.6).
9.4.12.TL.4	Collaborate in online learning communities or social networks or virtual worlds to analyze and propose a resolution to a real-world problem (e.g., 7.1.AL.IPERS.6).
8.1.12.A.2	Produce and edit a multi-page digital document for a commercial or professional audience and present it to peers and/or professionals in that related area for review.
8.1.12.C.1	Develop an innovative solution to a real world problem or issue in collaboration with peers and experts, and present ideas for feedback through social media or in an online community.
8.1.12.E.1	Produce a position statement about a real world problem by developing a systematic plan of investigation with peers and experts synthesizing information from multiple sources.

8.2.12.B.4	Investigate a technology used in a given period of history, e.g., stone age, industrial revolution or information age, and identify their impact and how they may have changed to meet human needs and wants.
8.2.12.B.5	Research the historical tensions between environmental and economic considerations as driven by human needs and wants in the development of a technological product, and present the competing viewpoints to peers for review.
8.2.12.D.4	Assess the impacts of emerging technologies on developing countries.
Interdisciplinary Standards	
Standard: Math	
CPI #	**Cumulative Progress Indicator (CPI)**
MP.2	Reason abstractly and quantitatively. (HS-LS2-2), (HS-LS2-4), (HS-LS2-6), (HS-LS4-5), (HS-ESS1-5), (HS-ESS1-6), (HS-ESS2-4), (HS-ESS3-5), (HS-ESS3-6)
MP.4	Model with mathematics. (HS-LS2-1), (HS-LS2-2), (HS-LS2-4), (HS-ESS2-4), (HS-ESS3-6)
HSN-Q.A.1	Use units as a way to understand problems and to guide the solution of multi-step problems; choose and interpret units consistently in formulas; choose and interpret the scale and the origin in graphs and data displays. (HS-LS2-2), (HS-LS2-4), (HS-ESS1-5), (HS-ESS1-6), (HS-ESS2-4), (HS-ESS3-5), (HS-ESS3-6)
HSN-Q.A.2	Define appropriate quantities for the purpose of descriptive modeling. (HS-LS2-2), (HS-LS2-4), (HS-ESS1-5), (HS-ESS1-6), (HS-ESS2-4), (HS-ESS3-5), (HS-ESS3-6)
HSN-Q.A.3	Choose a level of accuracy appropriate to limitations on measurement when reporting quantities. (HS-LS2-2), (HS-LS2-4), (HS-ESS1-5), (HS-ESS1-6), (HS-ESS2-4), (HS-ESS3-5), (HS-ESS3-6)
HSS-ID.A.1	Represent data with plots on the real number line. (HS-LS2-6)
HSS-IC.A.1	Understand statistics as a process for making inferences about population parameters based on a random sample from that population. (HS-LS2-6)
HSF-IF.B.5	Relate the domain of a function to its graph and, where applicable, to the quantitative relationship it describes. (HS-ESS1-6)
HSS-IC.B.6	Evaluate reports based on data. (HS-LS2-6), (HS-ESS1-6)
Standard: Social Studies	
CPI #	**Cumulative Progress Indicator (CPI)**
Standard 6.1 U.S. History: America in the World.	All students will acquire the knowledge and skills to think analytically about how past and present interactions of people, cultures, and the environment shape the American heritage. Such knowledge and skills enable students to make informed decisions that reflect fundamental rights and core democratic values as productive citizens in local, national, and global communities.
Standard 6.2 World History: Global Studies.	All students will acquire the knowledge and skills to think analytically and systematically about how past interactions of people, cultures, and the environment affect issues across time and cultures. Such knowledge and skills enable students to make informed decisions as socially and ethically responsible world citizens in the 21st century.

Instructional Focus
Unit Enduring Understandings
● Environmental science encompasses most areas of academic study. ● The Earth is extremely old and has undergone massive changes since its formation, some of which have been directly caused by living things. ● Changes to the atmosphere, the climate, the chemistry of the oceans and the earth's surface have had profound effects on life many times in the past. ● Ozone high in the atmosphere provides an important atmospheric barrier protecting living things from ultraviolet light. ● Understanding patterns of interaction between biotic and abiotic elements of the earth that occurred in the past can help model and contextualize current patterns of change. ● All organisms transfer matter and convert energy from one form to another. Both matter and energy are necessary to build and maintain living systems. ● Changes to the living and nonliving parts of an ecosystem can have an impact on biodiversity. ● Humans are currently the primary drivers of change on the Earth. The pace of change is far faster than when other organisms influenced biogeochemical changes in the past. ● Socio-economic and geopolitical factors influence how humans experience the effects of these biogeochemical changes. ● All humans have not and will not experience the effects of these biogeochemical changes on Earth equally.
Unit Essential Questions
● Why was the development of single celled cyanobacteria so important to both the geologic and biologic evolution on Earth? ● Why were plants aquatic prior to the establishment of Earth's ozone layer? ● How does the current pace of change to the atmosphere, climate, chemistry and surface of the Earth compare to what has happened in the past? ● Why/how do geologic events cause mass extinction? ● Why did the dinosaurs go extinct? ● How do human interactions with the environment impact the biodiversity found in ecosystems? ● How has human interaction with the environment demonstrated the power of humans to be both detrimental and helpful when dealing with environmental issues? ● How have the ways that human society has interacted with the environment affected the lives of people from around the world? ● To what extent does understanding the flow of matter and energy through living systems affect personal and public policy decisions?
Content Statements
ESS1: Earth's Place in the Universe ● **ESS1.C: The History of Planet Earth -** Continental rocks, which can be older than 4 billion years, are generally much older than the rocks of the ocean floor, which are less than 200 million years old. **(HS-ESS1-5)** ● **ESS1.C: The History of Planet Earth -** Although active geologic processes, such as plate tectonics and erosion, have destroyed or altered most of the very early rock record on Earth, other objects in the solar system, such as lunar rocks, asteroids, and meteorites, have changed little over billions of years. Studying these objects can provide information about Earth's formation and early history. **(HS-ESS1-6)** **ESS2: Earth's Systems** ● **ESS2.A: Earth Materials and Systems -** The geological record shows that changes to global and regional climate can be caused by interactions among changes in the sun's energy output or Earth's orbit,

tectonic events, ocean circulation, volcanic activity, glaciers, vegetation, and human activities. These changes can occur on a variety of time scales from sudden (e.g., volcanic ash clouds) to intermediate (ice ages) to very long-term tectonic cycles. **(HS-ESS2-4)**

- **ESS2.D: Weather and Climate** - The foundation for Earth's global climate systems is the electromagnetic radiation from the sun, as well as its reflection, absorption, storage, and redistribution among the atmosphere, ocean, and land systems, and this energy's reradiation into space. **(HS-ESS2-4)**
- **ESS2.D: Weather and Climate** -Gradual atmospheric changes were due to plants and other organisms that captured carbon dioxide and released oxygen. **(HS-ESS2-7)**
- **ESS2.D: Weather and Climate** - Changes in the atmosphere due to human activity have increased carbon dioxide concentrations and thus affect climate. **(HS-ESS2-4)**
- **ESS2.E: Biogeology** - The many dynamic and delicate feedbacks between the biosphere and other Earth systems cause a continual coevolution of Earth's surface and the life that exists on it. (**HS-ESS2-7)**

ESS3: Earth and Human Activity

- **ESS2.D: Weather and Climate** - Current models predict that, although future regional climate changes will be complex and varied, average global temperatures will continue to rise. The outcomes predicted by global climate models strongly depend on the amounts of human-generated greenhouse gases added to the atmosphere each year and by the ways in which these gases are absorbed by the ocean and biosphere. **(secondary to HS-ESS3- 6)**
- **ESS3.D: Global Climate Change** - Though the magnitudes of human impacts are greater than they have ever been, so too are human abilities to model, predict, and manage current and future impacts. **(HS-ESS3-5)**
- **ESS3.D: Global Climate Change** - Through computer simulations and other studies, important discoveries are still being made about how the ocean, the atmosphere, and the biosphere interact and are modified in response to human activities. **(HS-ESS3-6)**

LS2: Ecosystems: Interactions, Energy, and Dynamics

- **LS2.A: Interdependent Relationships in Ecosystems -** Ecosystems have carrying capacities, which are limits to the numbers of organisms and populations they can support. These limits result from such factors as the availability of living and nonliving resources and from such challenges such as predation, competition, and disease. Organisms would have the capacity to produce populations of great size were it not for the fact that environments and resources are finite. This fundamental tension affects the abundance (number of individuals) of species in any given ecosystem. **(HS-LS2-2)**
- **LS2.C: Ecosystem Dynamics, Functioning, and Resilience** - A complex set of interactions within an ecosystem can keep its numbers and types of organisms relatively constant over long periods of time under stable conditions. If a modest biological or physical disturbance to an ecosystem occurs, it may return to its more or less original status (i.e., the ecosystem is resilient), as opposed to becoming a very different ecosystem. Extreme fluctuations in conditions or the size of any population, however, can challenge the functioning of ecosystems in terms of resources and habitat availability. **(HS-LS2-2) (HS-LS2-6)**
- **LS2.C: Ecosystem Dynamics, Functioning, and Resilience** - Moreover, anthropogenic changes (induced by human activity) in the environment—including habitat destruction, pollution, introduction of invasive species, overexploitation, and climate change—can disrupt an ecosystem and threaten the survival of some species. **(HS-LS2-7)**

LS4: Biological Evolution: Unity and Diversity

- **LS4.C: Adaptation -** Changes in the physical environment, whether naturally occurring or human induced, have thus contributed to the expansion of some species, the emergence of new distinct species

as populations diverge under different conditions, and the decline–and sometimes the extinction–of some species. **(HS-LS4-5)**

- **LS4.C: Adaptation -** Species become extinct because they can no longer survive and reproduce in their altered environment. If members cannot adjust to change that is too fast or drastic, the opportunity for the species' evolution is lost. **(HS-LS4-5)**
- **LS4.D: Biodiversity and Humans** - Biodiversity is increased by the formation of new species (speciation) and decreased by the loss of species (extinction). **(HS-LS2-7)**
- **LS4.D: Biodiversity and Humans** - Humans depend on the living world for the resources and other benefits provided by biodiversity. But human activity is also having adverse impacts on biodiversity through overpopulation, overexploitation, habitat destruction, pollution, introduction of invasive species, and climate change. Thus sustaining biodiversity so that ecosystem functioning and productivity are maintained is essential to supporting and enhancing life on Earth. Sustaining biodiversity also aids humanity by preserving landscapes of recreational or inspirational value. **(HS-LS2-7)**

Ability Objectives - SWBAT

General for all Units:

- Ask questions and define problems
- Develop and use models
- Plan and carry out investigations
- Analyze and interpret data
- Use mathematics and computational thinking
- Construct explanations and design solutions
- Engaging in argument from evidence
- Obtaining, evaluating and communicating information

Specific for Unit 1:

- Compare ecology, environmental science, environmental activism and sustainability. Organize areas of study or activity in appropriate categories.
- Develop an understanding of complex processes and relationships between the physical environment on Earth and the organisms that populate it.
- Use models to explain the interconnected relationships between organisms in an ecosystem.
- Use tools such as physical modeling to build a conceptual model of geological time and biogeochemical eras.
- Analyze the effect of major catastrophes, such as meteor impacts and massive volcanoes on extinctions and subsequent evolution.
- Reconstruct climate records from ice cores, sediment data, and microfossils such as temperature, precipitation, atmospheric composition, volcanic activity, and wind patterns.
- Compare the current rate of extinction to the geological background rate and to mass extinctions.
- Contrast the effects of human contributions to extinctions of other species to those of natural processes.
- Assess the benefits of biodiversity to ecosystem stability and human well being.
- Compare the population of people both regionally and globally to the population of threatened and endangered animals.

- Examine the challenges and opportunities for humans to positively influence natural systems in an effort to preserve biodiversity.
- Develop an understanding of the impact of human activities on the physical environment and the biosphere.
- Develop an understanding of the impact of global changes on the livelihood of Earth's diverse population.

Sample Performance Tasks

- Evaluate the merits and limitations of various models that illustrate the stability and change that occurs during the geologic eras. Students will use this knowledge as evidence to construct an account of Earth's formation and early history. **(HS-ESS1-5) (HS-ESS1-6) (HS-ESS2-4)**
- Present an oral and written argument based on data and evidence that illustrates the cause and effect relationship that is apparent in the simultaneous coevolution of Earth's systems and life on Earth **(HS-ESS2-7)**
- Develop and use a model based on biogeochemical cycles to explore the stability and change of the planet as the co-evolution of Earth's surface and the life that exists on it occurred. **(HS-ESS2-7) (HS-LS2-6)**
- Obtain, evaluate and communicate the cause and effect relationship that changes in environmental conditions may result in the extinction of species. **(HS-LS4-5) (HS-LS2-6) (HS-ESS3-6)**
- Analyze data from global climate models to make predictions about the current rate of global climate change and the associated future impacts to Earth's systems. **(HS-ESS3-5)**

Resources

Core Text: Environmental Science, Karen Arms, 2008, ISBN-13: 978-0-03-078136-0

Suggested Resources:

Unit 2 Title: The Human Footprint	
Content Area: Science	
Course & Grade Level: Environmental Science 9-12	
Summary and Rationale	
This unit examines the role of personal decisions on environmental issues. In this unit students will study the chemical composition of the atmosphere and the role it plays in maintaining a livable biosphere. This unit will focus on climate and the greenhouse effect and how energy production is influencing the atmosphere. Students are asked to explore how decisions about consumption and habits are made and how they influence issues of environmental concern. They will address the effect of their own personal decisions and those of other individuals on the eco-footprint of their community and society. They will compare and contrast the role of individuals and institutions. Students will develop an understanding of human population dynamics and the size of the human population. Total human impact on the environment is enormous when taking into account the size and distribution of the human population across the globe, the additive effect of unavoidable human consumption and waste, and the addition of discretionary use of nonrenewable resources. This unit will see students explore, explain, and evaluate the most potentially impactful environmental issues that human activity is influencing and that pose challenges and opportunities currently and in the coming century. They will analyze and interpret data and scientific models related to the environmental impacts of sustaining our growing population and the short-term and long-term consequences for Earth.	
Recommended Pacing	
8 Weeks	
NGSS Standards/Performance Expectations	
Standard	
CPI#	**Cumulative Progress Indicator (CPI)**
HS-ESS3-1	Construct an explanation based on evidence for how the availability of natural resources, occurrence of natural hazards, and climate change have influenced human activity. [Clarification Statement: Examples of key natural resources include access to fresh water (such as rivers, lakes, and groundwater), regions of fertile soils such as river deltas, and high concentrations of minerals and fossil fuels. Examples of natural hazards can be from interior processes (such as volcanic eruptions and earthquakes), surface processes (such as tsunamis, mass wasting and soil erosion), and severe weather (such as hurricanes, floods, and droughts). Examples of the results of changes in climate that can affect populations or drive mass migrations include changes to sea level, regional patterns of temperature and precipitation, and the types of crops and livestock that can be raised.]
HS-ESS3-2	Evaluate competing design solutions for developing, managing, and utilizing energy and mineral resources based on cost-benefit ratios. *[Clarification Statement: Emphasis is on the conservation,*

	recycling, and reuse of resources (such as minerals and metals) where possible, and on minimizing impacts where it is not. Examples include developing best practices for agricultural soil use, mining (for coal, tar sands, and oil shales), and pumping (for petroleum and natural gas). Science knowledge indicates what can happen in natural systems—not what should happen.]
HS-ESS3-3	Create a computational simulation to illustrate the relationships among management of natural resources, the sustainability of human populations, and biodiversity. *[Clarification Statement: Examples of factors that affect the management of natural resources include costs of resource extraction and waste management, per-capita consumption, and the development of new technologies. Examples of factors that affect human sustainability include agricultural efficiency, levels of conservation, and urban planning.]*
HS-ESS3-4	Evaluate or refine a technological solution that reduces impacts of human activities on climate change and other natural systems. [Clarification Statement: Examples of data on the impacts of human activities could include the quantities and types of pollutants released, changes to biomass and species diversity, or areal changes in land surface use (such as for urban development, agriculture and livestock, or surface mining). Examples for limiting future impacts could range from local efforts (such as reducing, reusing, and recycling resources) to large-scale geoengineering design solutions (such as altering global temperatures by making large changes to the atmosphere or ocean).] - In this unit, this performance expectation focuses on an overview of impacts of human activities.
HS-ESS3-6	Use a computational representation to illustrate the relationships among Earth systems and how those relationships are being modified due to human activity (i.e., climate change). [Clarification Statement: Examples of Earth systems to be considered are the hydrosphere, atmosphere, cryosphere, geosphere, and/or biosphere. An example of the far-reaching impacts from a human activity is how an increase in atmospheric carbon dioxide results in an increase in photosynthetic biomass on land and an increase in ocean acidification, with resulting impacts on sea organism health and marine populations.] [Assessment Boundary: Assessment does not include running computational representations but is limited to using the published results of scientific computational models.] - In this unit, this performance expectation focuses on an overview of modeling human impacts on natural systems.
HS-LS2-1	Use mathematical and/or computational representations to support explanations of factors that affect carrying capacity of ecosystems at different scales. *[Clarification Statement: Emphasis is on quantitative analysis and comparison of the relationships among interdependent factors including boundaries, resources, climate and competition. Examples of mathematical comparisons could include graphs, charts, histograms, and population changes gathered from simulations or historical data sets.]* [Assessment Boundary: Assessment does not include deriving mathematical equations to make comparisons.]
HS-ETS1-1	Analyze a major global challenge to specify qualitative and quantitative criteria and constraints for solutions that account for societal needs and wants.
HS-ETS1-2	Design a solution to a complex real-world problem by breaking it down into smaller, more manageable problems that can be solved through engineering.
HS-ETS1-3	Evaluate a solution to a complex real-world problem based on prioritized criteria and trade-offs that account for a range of constraints, including cost, safety, reliability, and aesthetics, as well as possible social, cultural, and environmental impacts.
HS-ETS1-4	Use a computer simulation to model the impact of proposed solutions to a complex real-world problem with numerous criteria and constraints on interactions within and between systems relevant to the problem.
New Jersey Student Learning Standards for English Language Arts Companion Standards	

Standard:	
CPI #	**Cumulative Progress Indicator (CPI)**
RST.11-12.1	Cite specific textual evidence to support analysis of science and technical texts, attending to important distinctions the author makes and to any gaps or inconsistencies in the account. (HS-ESS3-1), (HS-ESS3-2), (HS-ESS3-4), (HS-LS2-1)
RST.11-12.7	Integrate and evaluate multiple sources of information presented in diverse formats and media (e.g., quantitative data, video, multimedia) in order to address a question or solve a problem. (HS-ETS1-1), (HS-ETS1-3)
RST.11-12.8	Evaluate the hypotheses, data, analysis, and conclusions in a science or technical text, verifying the data when possible and corroborating or challenging conclusions with other sources of information. (HS-ESS3-2), (HS-ESS3-4), (HS-ETS1-1), (HS-ETS1-3)
RST.11-12.9	Synthesize information from a range of sources (e.g., texts, experiments, simulations) into a coherent understanding of a process, phenomenon, or concept, resolving conflicting information when possible. (HS-ETS1-1), (HS-ETS1-3)
WHST.9-12.2	Write informative/explanatory texts, including the narration of historical events, scientific procedures/ experiments, or technical processes. (HS-ESS3-1), (HS-LS2-1)
New Jersey Student Learning Standards for Career Readiness, Life Literacies and Key Skills	
CPI #	**Cumulative Progress Indicator (CPI)**
9.1.12.CFR.2	Summarize causes important to you and compare organizations you seek to support to other organizations with similar missions.
9.1.12.CFR.3	Research companies with corporate governance policies supporting the common good and human rights.
9.1.12.EG.3	Explain how individuals and businesses influence government policies.
9.1.12.EG.5	Relate a country's economic system of production and consumption to building personal wealth, the mindset of social comparison, and achieving societal responsibilities
9.1.12.PB.2	Prioritize financial decisions by considering alternatives and possible consequences.
9.1.12.PB.4	Explain how you would revise your budget to accommodate changing circumstances.
9.4.12.CI.1	Demonstrate the ability to reflect, analyze, and use creative skills and ideas (e.g., 1.1.12prof.CR3a).
9.4.12.CI.3	Investigate new challenges and opportunities for personal growth, advancement, and transition (e.g., 2.1.12.PGD.1).
9.4.12.CT.2	Explain the potential benefits of collaborating to enhance critical thinking and problem solving (e.g., 1.3E.12profCR3.a).
9.4.12.CT.3	Enlist input from a variety of stakeholders (e.g., community members, experts in the field) to design a service learning activity that addresses a local or global issue (e.g., environmental justice).
9.4.12.DC.7	Evaluate the influence of digital communities on the nature, content and responsibilities of careers, and other aspects of society (e.g., 6.1.12.CivicsPD.16.a).
9.4.12.DC.8	Explain how increased network connectivity and computing capabilities of everyday objects allow for innovative technological approaches to climate protection.
9.4.12.GCA.1	Collaborate with individuals to analyze a variety of potential solutions to climate change effects and determine why some solutions (e.g., political. economic, cultural) may work better than others (e.g., SL.11-12.1., HS-ETS1-1, HS-ETS1-2, HS-ETS1-4, 6.3.12.GeoGI.1, 7.1.IH.IPERS.6, 7.1.IL.IPERS.7, 8.2.12.ETW.3).

9.4.12.IML.2	Evaluate digital sources for timeliness, accuracy, perspective, credibility of the source, and relevance of information, in media, data, or other resources (e.g., NJSLSA.W8, Social Studies Practice: Gathering and Evaluating Sources.
9.4.12.IML.3	Analyze data using tools and models to make valid and reliable claims, or to determine optimal design solutions (e.g., S-ID.B.6a., 8.1.12.DA.5, 7.1.IH.IPRET.8)
9.4.12.IML.4	Assess and critique the appropriateness and impact of existing data visualizations for an intended audience (e.g., S-ID.B.6b, HS-LS2-4).
9.4.12.IML.5	Evaluate, synthesize, and apply information on climate change from various sources appropriately (e.g., 2.1.12.CHSS.6, S.IC.B.4, S.IC.B.6, 8.1.12.DA.1, 6.1.12.GeoHE.14.a, 7.1.AL.PRSNT.2).
9.4.12.IML.6	Use various types of media to produce and store information on climate change for different purposes and audiences with sensitivity to cultural, gender, and age diversity (e.g., NJSLSA.SL5).
9.4.12.IML.7	Develop an argument to support a claim regarding a current workplace or societal/ethical issue such as climate change (e.g., NJSLSA.W1, 7.1.AL.PRSNT.4).
9.4.12.IML.8	Evaluate media sources for point of view, bias, and motivations (e.g., NJSLSA.R6, 7.1.AL.IPRET.6).
9.4.12.IML.9	Analyze the decisions creators make to reveal explicit and implicit messages within information and media (e.g., 1.5.12acc.C2a, 7.1.IL.IPRET.4).
9.4.12.TL.4	Collaborate in online learning communities or social networks or virtual worlds to analyze and propose a resolution to a real-world problem (e.g., 7.1.AL.IPERS.6).
8.1.12.A.2	Produce and edit a multi-page digital document for a commercial or professional audience and present it to peers and/or professionals in that related area for review.
8.1.12.C.1	Develop an innovative solution to a real world problem or issue in collaboration with peers and experts, and present ideas for feedback through social media or in an online community.
8.1.12.E.1	Produce a position statement about a real world problem by developing a systematic plan of investigation with peers and experts synthesizing information from multiple sources.
8.2.12.A.2	Analyze a current technology and the resources used, to identify the trade-offs in terms of availability, cost, desirability and waste.
8.2.12.B.1	Research and analyze the impact of the design constraints (specifications and limits) for a product or technology driven by a cultural, social, economic or political need and publish for review.
8.2.12.B.2	Evaluate ethical considerations regarding the sustainability of environmental resources that are used for the design, creation and maintenance of a chosen product.
8.2.12.B.4	Investigate a technology used in a given period of history, e.g., stone age, industrial revolution or information age, and identify their impact and how they may have changed to meet human needs and wants.
8.2.12.B.5	Research the historical tensions between environmental and economic considerations as driven by human needs and wants in the development of a technological product, and present the competing viewpoints to peers for review.
8.2.12.C.3	Analyze a product or system for factors such as safety, reliability, economic considerations, quality control, environmental concerns, manufacturability, maintenance and repair, and human factors engineering (ergonomics).
8.2.12.D.4	Assess the impacts of emerging technologies on developing countries.
8.2.12.D.6	Synthesize data, analyze trends and draw conclusions regarding the effect of a technology on the individual, society, or the environment and publish conclusions.
Interdisciplinary Standards (fill-in Science, or SS, or Math, etc..)	
Standard: Math	
CPI #	**Cumulative Progress Indicator (CPI)**

MP.2	Reason abstractly and quantitatively. (HS-ESS3-1), (HS-ESS3-2), (HS-ESS3-3), (HS-ESS3-4), (HS-ESS3-6), (HS-ETS1-1), (HS-ETS1-3), (HS-ETS1-4)
MP.4	Model with mathematics. (HS-ESS3-3), (HS-ESS3-6), (HS-ETS1-1), (HS-ETS1-2), (HS-ETS1-3), (HS-ETS1-4)
HSN-Q.A.1	Use units as a way to understand problems and to guide the solution of multi-step problems; choose and interpret units consistently in formulas; choose and interpret the scale and the origin in graphs and data displays. (HS-ESS3-1), (HS-ESS3-4), (HS-ESS3-6)
HSN-Q.A.2	Define appropriate quantities for the purpose of descriptive modeling. (HS-ESS3-1), (HS-ESS3-4), (HS-ESS3-6)
HSN-Q.A.3	Choose a level of accuracy appropriate to limitations on measurement when reporting quantities. (HS-ESS3-1), (HS-ESS3-4), (HS-ESS3-6)
Standard: Social Studies	
CPI #	**Cumulative Progress Indicator (CPI)**
Standard 6.1 U.S. History: America in the World	All students will acquire the knowledge and skills to think analytically about how past and present interactions of people, cultures, and the environment shape the American heritage. Such knowledge and skills enable students to make informed decisions that reflect fundamental rights and core democratic values as productive citizens in local, national, and global communities.
Standard 6.2 World History: Global Studies	All students will acquire the knowledge and skills to think analytically and systematically about how past interactions of people, cultures, and the environment affect issues across time and cultures. Such knowledge and skills enable students to make informed decisions as socially and ethically responsible world citizens in the 21st century.

Instructional Focus
Unit Enduring Understandings
● The human population has grown exponentially with the help of modern technologies. ● Human decision making is driven by both logical and emotional considerations. Cost - benefit analysis with monetization is a common decision making model for those living in capitalist societies. ● Understanding decision making models as they apply to environmental issues is critical to making informed environmental decision recommendations as a scientist. ● Human activities have physical, chemical, and biological consequences for ecosystems; the magnitude of the impact depends in part on the sensitivity of the system to perturbation. ● Climate is influenced by interactions of multiple physical, chemical and biological factors, including human actions. ● The global climate is changing largely due to human influence, particularly emissions of carbon dioxide, methane and others. ● The effects of climate change are felt differently by different communities/countries/populations depending in part on socioeconomic factors and resource availability. ● Global actions with respect to climate change policies and regulations require the collaboration and support of multiple governments and organizations.
Unit Essential Questions

- What factors have allowed the human population to greatly increase?
- To what extent do human behaviors impact our planet's life support system (environment)?
- What is the greenhouse effect and how does it work?
- What are positive feedback systems and how are they influencing warming?
- What are the most pressing environmental problems that are due to human impact?
- How do people make decisions?
- How does the size of the human population influence the importance of decisions?
- What is the environmental impact of individual decisions and societal decisions?
- What actions can be taken at a personal or local level to enact positive change?
- Are the proposed changes for more sustainable resource use and disposal realistic for all communities/countries/populations?
- Are the United Nations Sustainable Development Goals attainable for all populations?

Content Statements

ESS2: Earth's Systems

- **ESS2.D: Weather and Climate -** Current models predict that, although future regional climate changes will be complex and varied, average global temperatures will continue to rise. The outcomes predicted by global climate models strongly depend on the amounts of human-generated greenhouse gases added to the atmosphere each year and by the ways in which these gases are absorbed by the ocean and biosphere. **(secondary to HS-ESS3- 6)**

ESS3: Earth and Human Activity

- **ESS3.A: Natural Resources -** Resource availability has guided the development of human society. **(HS-ESS3-1)**.
- **ESS3.B: Natural Hazards -** Natural hazards and other geologic events have shaped the course of human history; [they] have significantly altered the sizes of human populations and have driven human migrations. **(HS-ESS3-1)**
- **ESS3.C: Human Impacts on Earth Systems -** The sustainability of human societies and the biodiversity that supports them requires responsible management of natural resources. **(HS-ESS3-3)**
- **ESS3.C: Human Impacts on Earth Systems -**Scientists and engineers can make major contributions by developing technologies that produce less pollution and waste and that preclude ecosystem degradation. **(HS-ESS3-4)**
- **ESS3.D: Global Climate Change -** Through computer simulations and other studies, important discoveries are still being made about how the ocean, the atmosphere, and the biosphere interact and are modified in response to human activities. **(HS-ESS3-6)**

LS2: Ecosystems: Interactions, Energy, and Dynamics

- **LS2. A: Interdependent Relationships in Ecosystems -** Ecosystems have carrying capacities, which are limits to the numbers of organisms and populations they can support. These limits result from such factors as the availability of living and nonliving resources and from such challenges such as predation, competition, and disease. Organisms would have the capacity to produce populations of great size were it not for the fact that environments and resources are finite. This fundamental tension affects the abundance (number of individuals) of species in any given ecosystem. **(HS-LS2-1)**

ETS1: Engineering Design

- **ET S1.A.HS.1: Defining and Delimiting Engineering Problems** - Criteria and constraints also include satisfying any requirements set by society , such as taking issues of risk mitigation into account, and they should be quantified to the extent possible and stated in such a way that one can tell if a given design meets them. **(HS-ETS1-1)**

- **ET S1.A.HS.2: Defining and Delimiting Engineering Problems -** Humanity faces major global challenges today , such as the need for supplies of clean water and food or for energy sources that minimize pollution, which can be addressed through engineering. These global challenges also may have manifestations in local communities. **(HS-ETS1-1)**
- **ETS1.B: Developing Possible Solutions** When evaluating solutions, it is important to take into account a range of constraints, including cost, safety, reliability, and aesthetics, and to consider social, cultural, and environmental impacts. **(secondary to HS-ESS3- 2), (secondary HS-ESS3-4)**
- **ET S1.B.HS.1: Developing Possible Solutions -** When evaluating solutions, it is important to take into account a range of constraints, including cost, safety , reliability , and aesthetics, and to consider social, cultural, and environmental impacts. **(HS-ETS1-3)**
- **ET S1.B.HS.2: Defining and Delimiting Engineering Problems -** Both physical models and computers can be used in various ways to aid in the engineering design process. Computers are useful for a variety of purposes, such as running simulations to test different ways of solving a problem or to see which one is most efficient or economical; and in making a persuasive presentation to a client about how a given design will meet his or her needs. **(HS-ETS1-4)**
- **ET S1.C.HS.1: Optimizing the Design Solution** - Criteria may need to be broken down into simpler ones that can be approached systematically, and decisions about the priority of certain criteria over others (trade-offs) may be needed. **(HS-ETS1-2)**

Ability Objectives - SWBAT

General for all Units:

- Ask questions and define problems
- Develop and use models
- Plan and carry out investigations
- Analyze and interpret data
- Use mathematics and computational thinking
- Construct explanations and design solutions
- Engaging in argument from evidence
- Obtaining, evaluating and communicating information

Specific for Unit 2:

- Evaluate human demands on natural resources.
- Use risk assessment to evaluate environmental issues, and set priorities for decision making
- Examine some of the most pressing environmental issues in relation to their prevalence and importance at local, regional, and global scales. These include: land use and loss/degradation of habitat, invasive species, wetland loss, etc.Evaluate current solutions to environmental problems at the local, regional, and global level.
- Use principles of dynamics to explain trends in human populations over historical time and make predictions into the future.
- Explain the history of human energy consumption with particular reference to the Industrial Revolution and our increasing dependence on fossil fuels.
- Examine how the growing human population is contributing to global climate change.
- Discuss the “Tragedy of the Commons” as an example of individual decisions affecting group results and how this concept relates to environmental science.

- Relate ecosystem services to environmental commons and decisions made about private and public property.
- Use decision making models and processes including cost/benefit analysis and show ethical considerations fit into decision making.
- Argue from evidence that urbanization is either a net positive or net negative for ecological footprints of individuals and populations.
- Compare the ecological footprint of someone living in a developed versus a developing/third world country; describe the reasons why the footprint is different. Discuss needs and wants as they relate to ecological footprints.
- Develop an understanding of sustainability, and ways in which humans can reduce their impact on ecosystems and watersheds.
- Compare the greenhouse effect caused by the Earth's greenhouse gas layer to the greenhouse effect of other planets like Venus and Mercury and to that of a glass greenhouse used to grow plants.
- Analyze carbon dioxide and other greenhouse gas levels to explore the effect of industrialization and human population growth on the atmosphere.
- Contrast natural and human generated sources of methane and suggest ways to reduce human generation of this greenhouse gas.
- Use the concept of positive feedback to explore how different regions of the planet may contribute to and be affected by climate change.

Sample Performance Tasks -

- Obtain and evaluate data on the rise and fall of various human societies. Use algebraic thinking to examine the data and predict how resource availability has guided the development of human society. **(HS-ESS3-1)**
- Analyze data and use mathematical models to make a claim that resource availability is a factor that affects the carrying capacity of an ecosystem. **(HS-LS2-1)**
- Use principles of population dynamics to evaluate the claim that the rate of change modeled over short and long periods of time indicates that the human population has reached the carrying capacity determined by the availability of living and nonliving resources. **(HS-ESS3-3)**
- Engage in argument from evidence on the efficacy of systems that are designed to reduce the impacts of human activities on natural systems. **(HS-ESS3-4)**
- Design solutions for the population to produce less pollution and waste to allow for stability and positive change at local, regional, and national levels. **(HS-ESS3-4)**
- Use computer simulations, like an ecological footprint calculator, to explore the cause and effect relationships that exist when the ocean, atmosphere, and biosphere interact and how they are modified in response to human activities. **(HS-ESS3-6)**

Resources

Core Text: Environmental Science, Karen Arms, 2008, ISBN-13: 978-0-03-078136-0

Unit 3 Title: Land and Water Use	
Content Area: Science	
Course & Grade Level: Environmental Science 9-12	
Summary and Rationale	
In this unit students will study human land and water use patterns around the world. Students will be able to describe, compare and appreciate not only the reasons for regional and seasonal weather but also longer term fluctuations in climate and their effects on agriculture and freshwater supply. They will explore the effect of the angle of sunlight on climates at different latitudes and seasons. Students will be able to ask questions and define problems regarding agriculture and natural systems. Students will also focus on water use, availability, and pollution within and between these systems. They will critically analyze the sustainability of various land and water use practices and work to identify best practices for the sustainability of natural systems on a local, regional, and global scale. Freshwater is a renewable resource but one that is finite in supply. The current issues around the limits of energy availability could pale in comparison to the freshwater needs of a continually growing human population. Over the past few decades, it has been increasingly obvious that the fresh and saltwater parts of the planet are as vulnerable as, or more so than, the land and air. In this unit, students will study how our freshwater supply is replenished, current uses of freshwater, and the growing concern about the vulnerability and pollution of this essential resource. They will explore how human activity directly impacts the health of naturally occuring marine ecosystems. They will also critically analyze current policies on water use, protection, and allocation. There is a fundamental disconnect for many people between the food they eat and the land on, or water in, which it is produced. In this unit, students will also study how food is grown, processed and supplied to the consumer. They will examine the role of different farming practices, government regulations and individual decisions on the human food chain. Students will learn about the content of soils and the processes and time spans required to form different types of soil and soil nutrients. Phosphorus and nitrogen cycling are both affected by and affect humans through their involvement in food production, sewage disposal, and household and industrial chemical processes. They should leave this unit with a much greater understanding of and appreciation for food production and how food influences, and is influenced by, environmental, social, political, and economic issues.	
Recommended Pacing	
12 Weeks	
New Jersey Student Learning Standards for Science	
Standard	
CPI #	**Cumulative Progress Indicator (CPI)**
HS-ESS2-5	Plan and conduct an investigation of the properties of water and its effects on Earth materials and surface processes. *[Clarification Statement: Emphasis is on mechanical and chemical investigations with water and a variety of solid materials to provide the evidence for connections between the hydrologic cycle and system interactions commonly known as the rock cycle. Examples of mechanical investigations include stream transportation and deposition using a stream table, erosion using variations in soil moisture content, or frost wedging by the*

	expansion of water as it freezes. Examples of chemical investigations include chemical weathering and recrystallization (by testing the solubility of different materials) or melt generation (by examining how water lowers the melting temperature of most solids).]
HS-ESS2-6	Develop a quantitative model to describe the cycling of carbon among the hydrosphere, atmosphere, geosphere, and biosphere. *[Clarification Statement: Emphasis is on modeling biogeochemical cycles that include the cycling of carbon through the ocean, atmosphere, soil, and biosphere (including humans), providing the foundation for living organisms.]*
HS-ESS3-1	Construct an explanation based on evidence for how the availability of natural resources, occurrence of natural hazards, and climate change have influenced human activity. [Clarification Statement: Examples of key natural resources include access to fresh water (such as rivers, lakes, and groundwater), regions of fertile soils such as river deltas, and high concentrations of minerals and fossil fuels. Examples of natural hazards can be from interior processes (such as volcanic eruptions and earthquakes), surface processes (such as tsunamis, mass wasting and soil erosion), and severe weather (such as hurricanes, floods, and droughts). Examples of the results of changes in climate that can affect populations or drive mass migrations include changes to sea level, regional patterns of temperature and precipitation, and the types of crops and livestock that can be raised.]
HS-ESS3-2	Evaluate competing design solutions for developing, managing, and utilizing energy and mineral resources based on cost-benefit ratios*. [Clarification Statement: Emphasis is on the conservation, recycling, and reuse of resources (such as minerals and metals) where possible, and on minimizing impacts where it is not. Examples include developing best practices for agricultural soil use, mining (for coal, tar sands, and oil shales), and pumping (for petroleum and natural gas). Science knowledge indicates what can happen in natural systems—not what should happen.]* - In this unit this performance expectation focuses on the impact of agricultural practices on soil and water.
HS-ESS3-4	Evaluate or refine a technological solution that reduces impacts of human activities on climate change and other natural systems. [Clarification Statement: Examples of data on the impacts of human activities could include the quantities and types of pollutants released, changes to biomass and species diversity, or areal changes in land surface use (such as for urban development, agriculture and livestock, or surface mining). Examples for limiting future impacts could range from local efforts (such as reducing, reusing, and recycling resources) to large-scale geoengineering design solutions (such as altering global temperatures by making large changes to the atmosphere or ocean).] - In this unit this performance expectation focuses on the impact of agricultural practices on soil and water.
HS-ESS3-6	Use a computational representation to illustrate the relationships among Earth systems and how those relationships are being modified due to human activity (i.e., climate change). [Clarification Statement: Examples of Earth systems to be considered are the hydrosphere, atmosphere, cryosphere, geosphere, and/or biosphere. An example of the far-reaching impacts from a human activity is how an increase in atmospheric carbon dioxide results in an increase in photosynthetic biomass on land and an increase in ocean acidification, with resulting impacts on sea organism health and marine populations.] [Assessment Boundary: Assessment does not include running computational representations but is limited to using the published results of scientific computational models.] - In this unit this performance expectation focuses on computational analysis of the impact of management practices on soil and water.
HS-LS2-4	Use mathematical representations to support claims for the cycling of matter and flow of energy among organisms in an ecosystem.

	[Clarification Statement: Emphasis is on using a mathematical model of stored energy in biomass to describe the transfer of energy from one trophic level to another and that matter and energy are conserved as matter cycles and energy flows through ecosystems. Emphasis is on atoms and molecules such as carbon, oxygen, hydrogen and nitrogen being conserved as they move through an ecosystem.] [Assessment Boundary: Assessment is limited to proportional reasoning to describe the cycling of matter and flow of energy.]
HS-ETS1-1	Analyze a major global challenge to specify qualitative and quantitative criteria and constraints for solutions that account for societal needs and wants.
HS-ETS1-2	Design a solution to a complex real-world problem by breaking it down into smaller, more manageable problems that can be solved through engineering.
HS-ETS1-3	Evaluate a solution to a complex real-world problem based on prioritized criteria and trade-offs that account for a range of constraints, including cost, safety, reliability, and aesthetics, as well as possible social, cultural, and environmental impacts.
New Jersey Student Learning Standards for English Language Arts Companion Standards	
Standard:	
CPI #	**Cumulative Progress Indicator (CPI)**
RST.11-12.1	Cite specific textual evidence to support analysis of science and technical texts, attending to important distinctions the author makes and to any gaps or inconsistencies in the account. (HS-ESS3-1), (HS-ESS3-2), (HS-ESS3-4)
RST.11-12.7	Integrate and evaluate multiple sources of information presented in diverse formats and media e.g., quantitative data, video, multimedia) in order to address a question or solve a problem. (HS-ETS1-1), (HS-ETS1-3)
RST.11-12.8	Evaluate the hypotheses, data, analysis, and conclusions in a science or technical text, verifying the data when possible and corroborating or challenging conclusions with other sources of information. (HS-ESS3-2), (HS-ESS3-4), (HS-ETS1-1), (HS-ETS1-3)
RST.11-12.9	Synthesize information from a range of sources (e.g., texts, experiments, simulations) into a coherent understanding of a process, phenomenon, or concept, resolving conflicting information when possible. (HS-ETS1-1), (HS-ETS1-3)
WHST.9-12.2	Write informative/explanatory texts, including the narration of historical events, scientific procedures/ experiments, or technical processes. (HS-ESS3-1)
WHST.9-12.7	Conduct short as well as more sustained research projects to answer a question (including a self generated question) or solve a problem; narrow or broaden the inquiry when appropriate; synthesize multiple sources on the subject, demonstrating understanding of the subject under investigation. (HS-ESS2-5)
New Jersey Student Learning Standards for Career Readiness, Life Literacies and Key Skills	
CPI #	**Cumulative Progress Indicator (CPI)**
9.1.12.CFR.3	Research companies with corporate governance policies supporting the common good and human rights.
9.1.12.EG.3	Explain how individuals and businesses influence government policies.
9.1.12.PB.2	Prioritize financial decisions by considering alternatives and possible consequences.
9.4.12.CI.1	Demonstrate the ability to reflect, analyze, and use creative skills and ideas (e.g., 1.1.12prof.CR3a).

9.4.12.CI.3	Investigate new challenges and opportunities for personal growth, advancement, and transition (e.g., 2.1.12.PGD.1).
9.4.12.CT.2	Explain the potential benefits of collaborating to enhance critical thinking and problem solving (e.g., 1.3E.12profCR3.a).
9.4.12.CT.3	Enlist input from a variety of stakeholders (e.g., community members, experts in the field) to design a service learning activity that addresses a local or global issue (e.g., environmental justice).
9.4.12.DC.7	Evaluate the influence of digital communities on the nature, content and responsibilities of careers, and other aspects of society (e.g., 6.1.12.CivicsPD.16.a).
9.4.12.DC.8	Explain how increased network connectivity and computing capabilities of everyday objects allow for innovative technological approaches to climate protection.
9.4.12.GCA.1	Collaborate with individuals to analyze a variety of potential solutions to climate change effects and determine why some solutions (e.g., political. economic, cultural) may work better than others (e.g., SL.11-12.1., HS-ETS1-1, HS-ETS1-2, HS-ETS1-4, 6.3.12.GeoGI.1, 7.1.IH.IPERS.6, 7.1.IL.IPERS.7, 8.2.12.ETW.3).
9.4.12.IML.2	Evaluate digital sources for timeliness, accuracy, perspective, credibility of the source, and relevance of information, in media, data, or other resources (e.g., NJSLSA.W8, Social Studies Practice: Gathering and Evaluating Sources.
9.4.12.IML.3	Analyze data using tools and models to make valid and reliable claims, or to determine optimal design solutions (e.g., S-ID.B.6a., 8.1.12.DA.5, 7.1.IH.IPRET.8)
9.4.12.IML.4	Assess and critique the appropriateness and impact of existing data visualizations for an intended audience (e.g., S-ID.B.6b, HS-LS2-4).
9.4.12.IML.5	Evaluate, synthesize, and apply information on climate change from various sources appropriately (e.g., 2.1.12.CHSS.6, S.IC.B.4, S.IC.B.6, 8.1.12.DA.1, 6.1.12.GeoHE.14.a, 7.1.AL.PRSNT.2).
9.4.12.IML.6	Use various types of media to produce and store information on climate change for different purposes and audiences with sensitivity to cultural, gender, and age diversity (e.g., NJSLSA.SL5).
9.4.12.IML.7	Develop an argument to support a claim regarding a current workplace or societal/ethical issue such as climate change (e.g., NJSLSA.W1, 7.1.AL.PRSNT.4).
9.4.12.IML.8	Evaluate media sources for point of view, bias, and motivations (e.g., NJSLSA.R6, 7.1.AL.IPRET.6).
9.4.12.TL.4	Collaborate in online learning communities or social networks or virtual worlds to analyze and propose a resolution to a real-world problem (e.g., 7.1.AL.IPERS.6).
8.1.12.A.2	Produce and edit a multi-page digital document for a commercial or professional audience and present it to peers and/or professionals in that related area for review.
8.1.12.C.1	Develop an innovative solution to a real world problem or issue in collaboration with peers and experts, and present ideas for feedback through social media or in an online community.
8.1.12.E.1	Produce a position statement about a real world problem by developing a systematic plan of investigation with peers and experts synthesizing information from multiple sources.
8.2.12.A.2	Analyze a current technology and the resources used, to identify the trade-offs in terms of availability, cost, desirability and waste.
8.2.12.B.2	Evaluate ethical considerations regarding the sustainability of environmental resources that are used for the design, creation and maintenance of a chosen product.
8.2.12.B.5	Research the historical tensions between environmental and economic considerations as driven by human needs and wants in the development of a technological product, and present the competing viewpoints to peers for review.

8.2.12.C.7	Use a design process to devise a technological product or system that addresses a global problem, provide research, identify trade-offs and constraints, and document the process through drawings that include data and materials.
8.2.12.D.1	Design and create a prototype to solve a real world problem using a design process, identify constraints addressed during the creation of the prototype, identify trade-offs made, and present the solution for peer review.
8.2.12.D.4	Assess the impacts of emerging technologies on developing countries.
Interdisciplinary Standards	
Standard: Math	
CPI #	**Cumulative Progress Indicator (CPI)**
MP.2	Reason abstractly and quantitatively. (HS-ESS2-6), (HS-ESS3-1), (HS-ESS3-2), (HS-ESS3-4), (HS-ESS3-6), (HS-LS2-4), (HS-ETS1-1), (HS-ETS1-3)
MP.4	Model with mathematics. (HS-ESS2-6), (HS-ESS3-6), (HS-LS2-4), (HS-ETS1-1), (HS-ETS1-2), (HS-ETS1-3)
HSN-Q.A.1	Use units as a way to understand problems and to guide the solution of multi-step problems; choose and interpret units consistently in formulas; choose and interpret the scale and the origin in graphs and data displays. (HS-ESS2-6), (HS-ESS3-1), (HS-ESS3-4), (HS-ESS3-6), (HS-LS2-4)
HSN-Q.A.2	Define appropriate quantities for the purpose of descriptive modeling. (HS-ESS2-6), (HS-ESS3-1), (HS-ESS3-4), (HS-ESS3-6), (HS-LS2-4)
HSN-Q.A.3	Choose a level of accuracy appropriate to limitations on measurement when reporting quantities. (HS-ESS2-5), (HS-ESS2-6), (HS-ESS3-1), (HS-ESS3-4), (HS-ESS3-6), (HS-LS2-4)
Standard: Social Studies	
CPI #	**Cumulative Progress Indicator (CPI)**
Standard 6.1 U.S. History: America in the World	All students will acquire the knowledge and skills to think analytically about how past and present interactions of people, cultures, and the environment shape the American heritage. Such knowledge and skills enable students to make informed decisions that reflect fundamental rights and core democratic values as productive citizens in local, national, and global communities.
Standard 6.2 World History: Global Studies	All students will acquire the knowledge and skills to think analytically and systematically about how past interactions of people, cultures, and the environment affect issues across time and cultures. Such knowledge and skills enable students to make informed decisions as socially and ethically responsible world citizens in the 21st century.

Instructional Focus
Unit Enduring Understandings
● The human impact on ecosystems of the planet is in large part due to the production of food. ● Most food is produced in a way that is known as “conventional agriculture”. This type of food production (developed during the industrial revolution starting in the 19th century, the Green Revolution of the mid to late 20th century, and current changes brought about by genetic engineering) has greatly stressed Earth’s natural resources (such as arable soil and freshwater). ● Agriculture is dependent on availability of arable soil, fresh water, and suitable climate. Different foods are grown in areas that are best suited to their particular needs.

- Animal based food (such as meat, dairy and fish) is much more ecologically demanding than plant based foods.
- The consumption of highly processed food contributes significantly to the food demand of industrialized nations and has mostly adverse health impacts on people.
- There are alternative methods of producing food and managing farmland that may play an important role in reducing the food footprint and water consumption/pollution of societies.
- The availability of food and water in a given location will determine the amount of people that can be supported in that area.
- Changes to climate influence and require changes to the current system for producing food.
- Climate change is already influencing global weather patterns, drought and flooding, heat waves and the suitability of agricultural land for traditionally grown crops.
- The more crops are transported around the globe, the more carbon dioxide released in the atmosphere.
- Obtaining food locally or from more costly sustainable production methods may not be achievable for all members of a community.
- Water is a limited valuable resource on Earth. Water can be polluted, conserved, and treated.
- Human activity directly influences the health of aquatic ecosystems even when they are not in direct contact.
- Access to freshwater is essential to human survival.
- When too many people consume water from a shared source, the amount of water will deplete more than it can be naturally restored.
- Changes to climate affect the rate at which freshwater supplies are replenished.
- The current rate of water consumption outpaces the current rate of replenishment.
- The more carbon dioxide released by humans into the atmosphere, the more is dissolved into the ocean which causes harm to marine ecosystems through a rise in pH.
- Localized water pollution spreads and can impact locations that share this resource.
- Pollution in bodies of water can make its way into living organisms and be biomagnified through the consumption of organisms in a food chain.
- There are various ways that water can be polluted by human activity which then need to be addressed through wastewater management and cleanup.

Unit Essential Questions

- How is the food you eat produced?
- How are parts of Earth (land, air, and water) related?
- Where and why are certain areas used for food production and others not?
- What kinds of food take the most land and other resources to produce and why?
- What kind of crops can be grown in our local region?
- How do regional and seasonal weather affect both agriculture and freshwater supply?
- What should one eat that meets nutritional needs and has the least environmental impact?
- What are the best practices in food production that both produce large quantities and limit ecological damage?
- How can the availability of food and water affect population size?
- How can we best influence land use patterns to limit climate change?
- What factors contribute to the problem that our usable fresh water supply is in danger of running out?
- How does public policy influence the allocation of natural resources, such as water?
- How should water be distributed so individuals depending on it receive a fair allocation?
- How does water pollution impact organisms in an ecosystem, including humans?
- To what extent does public policy affect the pollution of freshwater resources?
- In what ways can society prevent and reduce the current amount of water pollution?
- What factors influence the replenishment and restoration of water and soil?

Content Statements

ESS2: Earth's Systems

- **ESS2.E: The Roles of Water in Earth's Surface Processes** - The abundance of liquid water on Earth's surface and its unique combination of physical and chemical properties are central to the planet's dynamics. These properties include water's exceptional capacity to absorb, store, and release large amounts of energy, transmit sunlight, expand upon freezing, dissolve and transport materials, and lower the viscosities and melting points of rocks. **(HS-ESS2-5)**
- **ESS2.D: Weather and Climate -** Changes in the atmosphere due to human activity have increased carbon dioxide concentrations and thus affect climate. **(HS-ESS2-6)**

ESS3: Earth and Human Activity

- **ESS3.A: Natural Resources -** Resource availability has guided the development of human society. **(HS-ESS3-1)**
- **ESS3.A: Natural Resources -** All forms of energy production and other resource extraction have associated economic, social, environmental, and geopolitical costs and risks as well as benefits. New technologies and social regulations can change the balance of these factors. **(HS-ESS3-2)**
- **ESS3.B: Natural Hazards -** Natural hazards and other geologic events have shaped the course of human history; [they] have significantly altered the sizes of human populations and have driven human migrations. **(HS-ESS3-1)**
- **ESS3.C: Human Impacts on Earth Systems -** Scientists and engineers can make major contributions by developing technologies that produce less pollution and waste and that preclude ecosystem degradation. **(HS-ESS3-4)**
- **ESS3.D: Global Climate Change -** Through computer simulations and other studies, important discoveries are still being made about how the ocean, the atmosphere, and the biosphere interact and are modified in response to human activities. **(HS-ESS3-6)**

LS2: Ecosystems: Interactions, Energy, and Dynamics

- **LS2.B: Cycles of Matter and Energy Transfer in Ecosystems -** Plants or algae form the lowest level of the food web. At each link upward in a food web, only a small fraction of the matter consumed at the lower level is transferred upward, to produce growth and release energy in cellular respiration at the higher level. Given this inefficiency, there are generally fewer organisms at higher levels of a food web. Some matter reacts to release energy for life functions, some matter is stored in newly made structures, and much is discarded. The chemical elements that make up the molecules of organisms pass through food webs and into and out of the atmosphere and soil, and they are combined and recombined in different ways. At each link in an ecosystem, matter and energy are conserved. **(HS-LS2-4)**

ETS1: Engineering Design

- **ET S1.A: Defining and Delimiting Engineering Problems** - Criteria and constraints also include satisfying any requirements set by society , such as taking issues of risk mitigation into account, and they should be quantified to the extent possible and stated in such a way that one can tell if a given design meets them. **(HS-ETS1-1)**
- **ET S1.A: Defining and Delimiting Engineering Problems -** Humanity faces major global challenges today , such as the need for supplies of clean water and food or for energy sources that minimize pollution, which can be addressed through engineering. These global challenges also may have manifestations in local communities. **(HS-ETS1-1)**
- **ET S1.C: Optimizing the Design Solution** - Criteria may need to be broken down into simpler ones that can be approached systematically , and decisions about the priority of certain criteria over others (trade-offs) may be needed. **(HS-ETS1-2)**
- **ET S1.B: Developing Possible Solutions -** When evaluating solutions, it is important to take into account a range of constraints, including cost, safety , reliability , and aesthetics, and to consider social, cultural, and environmental impacts. **(HS-ETS1-3), (secondary to HS-ESS3-2)**

Ability Objectives - SWBAT

General for all Units:

- Ask questions and define problems
- Develop and use models
- Plan and carry out investigations
- Analyze and interpret data
- Use mathematics and computational thinking
- Construct explanations and design solutions
- Engaging in argument from evidence
- Obtaining, evaluating and communicating information

Specific for Unit 3:

Agricultural Practices & Soil

- Examine plant growth and explain where the components of the plant come from (air, water, soil) through the lens of the biogeochemical cycles.
    - Describe the long-term and short-term phosphorus cycles and discuss how humans affect and are affected by these cycles.
    - Describe the nitrogen cycle and include the key roles of nitrogen fixing bacteria, denitrifying bacteria, legumes, and lightning.
- Describe conventional agricultural methods of growing crops and producing animal products for human consumption.
- Compare the advantages and disadvantages of the green revolution.
    - Increased yield per acre
    - Higher input of commercial fertilizer, pesticides and herbicides
    - Loss of subsistence farming
- Debate the advantages and disadvantages of genetic engineering (pesticide and herbicide resistance).
- Compare conventional and alternative methods of pest and weed control.
- Contrast how soil fertility is maintained in conventional and organic farming.
- Examine how a healthy diet can be constructed using different combinations of plant and animal based foods.
- Compare soil and climate challenges and advantages for farming in different areas of the world.
- Describe how climate challenges have brought about the necessity for change to current farming practices.
- Contrast soil formation in different climate and biome systems in terms of chemical, biological and physical weathering of parent material.
- Design a best practice set of features for preventing soil erosion and degradation on a model farm.
- Analyze how changes to weather and climate have affected soil productivity in different regions.
- Use measurements of sun angles, earth tilt, distances from the earth to the sun and other data to explore seasonal, decadal and geological patterns of variation in climate and their impact on agriculture.

- Describe, compare and appreciate not only the reasons for regional and seasonal weather but also longer term fluctuations in climate and their effects on agriculture and freshwater supply.

Water

- Explore the physical factors and processes that contribute to cycling of water (focus on transpiration and groundwater movement).
- Examine data from an ecosystem or region to explore changes in a water cycle caused by different land use patterns.
- Compare the challenges of obtaining fresh water for human use in different climatic regions (focusing on irrigation and drainage).
- Use scientific tools and techniques to evaluate the health of a local aquatic system. Infer from data the human impact on local water quality.
- Explore the ways that human activities can pollute natural water sources.
- Describe how the pyramid of energy results in biomagnification.
- Examine the danger of persistent organic pollutants in comparison to excess nutrient pollution.
- Explore the dangers of water pollution in residential areas and how local and regional governments respond to disasters (i.e. Flint, MI, Newark, NJ).
- Explore and propose different solutions for wastewater treatment and cleanup of polluted bodies of water.
- Discuss current environmental policies and regulations as they relate to freshwater use and pollution.
- Analyze the contribution of human generated carbon dioxide emissions on ocean acidity and the health of marine ecosystems.

Sample Performance Tasks -

- Analyze and interpret data on the abundance of liquid water on Earth's surface to explain the cause and effect outcomes of the overconsumption of natural water resources. **(HS-ESS2-5)**
- Construct explanations and design solutions for the causes of water pollution by developing technologies that produce less pollution and waste than can have an impact on a small or large scale. **(HS-ESS3-4)**
- Develop a model that illustrates the flow of matter that occurs during the cycling of carbon among the biosphere, atmosphere, hydrosphere and geosphere. **(HS-ESS2-6)**
- Compare and evaluate competing arguments weighing the advantages and disadvantages of genetic engineering (pesticide and herbicide resistance) as a component of the system designed to produce food as a way to address humanity's major global challenges of food availability. **(HS-ESS3-4)**
- Define problems with current technologies and social factors influencing current systems designed to produce food and develop possible solutions to address humanity's major global challenges of food availability. **(HS-ESS3-2) (HS-ETS1-3)**
- Analyze and interpret data from recent natural hazards (such as increased wildfires, more extreme droughts) to explain how recent changes in the scale, proportion, and quantity of these events influences our resource use for food production. **(HS-ESS3-2)**
- Compare and evaluate competing arguments weighing the advantages and disadvantages of freshwater allocation as a component of the system designed to produce food in locations experiencing extreme drought. **(HS-ESS2-5) (HS-ESS3-1)**
- Engage in argument from evidence how pollution in bodies of water can make its way into living organisms and cause developmental problems for those who consume it. **(HS-ESS3-6)**

Resources

Core Text: Environmental Science, Karen Arms, 2008, ISBN-13: 978-0-03-078136-0

Unit 4 Title: Resource Extraction, Use, and Disposal	
Content Area: Science	
Course & Grade Level: Environmental Science 9-12	
Summary and Rationale	
Non-renewable resources are vitally important to all societies. Throughout modern history, humans have used mineral deposits and raw materials for manufacturing as well as fossil fuels as high energy resources. In this unit, students will learn about historical and modern extraction, use, and disposal of these non-renewable resources. Discovering where the materials that make everyday products come from is important because there are many environmental issues that can occur when extracting certain materials from the Earth. There are also issues that can arise from the uses of extracted materials, such as fossil fuels. Once fossil fuels are extracted from the Earth, the burning of them for energy has major impacts on carbon dioxide levels in the atmosphere. Fossil fuels are non-renewable resources and will not be able to sustain the human need for them as a source of energy in the near future. When other existing resources need to be disposed of, there are a variety of methods that humans have invented. This has led to issues with waste management and will lead to students designing ways in which the human population can reduce waste production.	
Recommended Pacing	
6 Weeks	
New Jersey Student Learning Standards for Science	
Standard	
CPI#	**Cumulative Progress Indicator (CPI)**
HS-ESS2-2	Analyze geoscience data to make the claim that one change to Earth's surface can create feedbacks that cause changes to other Earth systems. *[Clarification Statement: Examples should include climate feedbacks, such as how an increase in greenhouse gases causes a rise in global temperatures that melts glacial ice, which reduces the amount of sunlight reflected from Earth's surface, increasing surface temperatures and further reducing the amount of ice. Examples could also be taken from other system interactions, such as how the loss of ground vegetation causes an increase in water runoff and soil erosion; how dammed rivers increase groundwater recharge, decrease sediment transport, and increase coastal erosion; or how the loss of wetlands causes a decrease in local humidity that further reduces the wetland extent.]*
HS-ESS2-6	Develop a quantitative model to describe the cycling of carbon among the hydrosphere, atmosphere, geosphere, and biosphere. *[Clarification Statement: Emphasis is on modeling biogeochemical cycles that include the cycling of carbon through the ocean, atmosphere, soil, and biosphere (including humans), providing the foundation for living organisms.]*
HS-ESS3-2	Evaluate competing design solutions for developing, managing, and utilizing energy and mineral resources based on cost-benefit ratios. *[Clarification Statement: Emphasis is on the conservation, recycling, and reuse of resources (such as minerals and metals) where possible, and on minimizing impacts where it is not. Examples include developing best practices for agricultural soil use, mining (for coal, tar sands, and oil shales), and pumping (for petroleum and natural gas). Science knowledge indicates what can happen in natural systems—not what should happen.]*

HS-ESS3-3	Create a computational simulation to illustrate the relationships among management of natural resources, the sustainability of human populations, and biodiversity. *[Clarification Statement: Examples of factors that affect the management of natural resources include costs of resource extraction and waste management, per-capita consumption, and the development of new technologies. Examples of factors that affect human sustainability include agricultural efficiency, levels of conservation, and urban planning.]* [Assessment Boundary: Assessment for computational simulations is limited to using provided multi-parameter programs or constructing simplified spreadsheet calculations.]
HS-ESS3-4	Evaluate or refine a technological solution that reduces impacts of human activities on climate change and other natural systems. [Clarification Statement: Examples of data on the impacts of human activities could include the quantities and types of pollutants released, changes to biomass and species diversity, or areal changes in land surface use (such as for urban development, agriculture and livestock, or surface mining). Examples for limiting future impacts could range from local efforts (such as reducing, reusing, and recycling resources) to large-scale geoengineering design solutions (such as altering global temperatures by making large changes to the atmosphere or ocean).] - In this unit this performance expectation focuses on the impact of mining and production of goods on the natural systems of soil, air and water.
HS-ESS3-6	Use a computational representation to illustrate the relationships among Earth systems and how those relationships are being modified due to human activity (i.e., climate change). [Clarification Statement: Examples of Earth systems to be considered are the hydrosphere, atmosphere, cryosphere, geosphere, and/or biosphere. An example of the far-reaching impacts from a human activity is how an increase in atmospheric carbon dioxide results in an increase in photosynthetic biomass on land and an increase in ocean acidification, with resulting impacts on sea organism health and marine populations.] [Assessment Boundary: Assessment does not include running computational representations but is limited to using the published results of scientific computational models.] - In this unit this performance expectation focuses on quantifying the impact of mining and production of goods on the natural systems of soil, air and water.
HS-LS2-7	Design, evaluate, and refine a solution for reducing the impacts of human activities on the environment and biodiversity. *[Clarification Statement: Examples of human activities can include urbanization, building dams, and dissemination of invasive species.]*
HS-ETS1-1	Analyze a major global challenge to specify qualitative and quantitative criteria and constraints for solutions that account for societal needs and wants.
HS-ETS1-2	Design a solution to a complex real-world problem by breaking it down into smaller, more manageable problems that can be solved through engineering.
HS-ETS1-3	Evaluate a solution to a complex real-world problem based on prioritized criteria and trade-offs that account for a range of constraints, including cost, safety, reliability, and aesthetics, as well as possible social, cultural, and environmental impacts.
New Jersey Student Learning Standards for English Language Arts Companion Standards	
Standard:	
CPI #	**Cumulative Progress Indicator (CPI)**
RST.9-10.8	Determine if the reasoning and evidence in a text support the author's claim or a recommendation for solving a scientific or technical problem. (HS-LS2-7)
RST.11-12.1	Accurately cite strong and thorough evidence from the text to support analysis of science and technical texts, attending to precise details for explanations or descriptions. (HS-ESS2-2), (HS-ESS3-2), (HS-ESS3-4)

RST.11-12.2	Determine the central ideas, themes, or conclusions of a text; summarize complex concepts, processes, or information presented in a text by paraphrasing them in simpler but still accurate terms. (HS-ESS2-2)
RST.11-12.7	Integrate and evaluate multiple sources of information presented in diverse formats and media (e.g., quantitative data, video, multimedia) in order to address a question or solve a problem. (HS-LS2-7), (HS-ETS1-1), (HS-ETS1-3)
RST.11-12.8	Evaluate the hypotheses, data, analysis, and conclusions in a science or technical text, verifying the data when possible and corroborating or challenging conclusions with other sources of information. (HS-LS2-7), (HS-ESS3-2), (HS-ETS1-1), (HS-ETS1-3)
RST.11-12.9	Synthesize information from a range of sources (e.g., texts, experiments, simulations) into a coherent understanding of a process, phenomenon, or concept, resolving conflicting information when possible. (HS-ETS1-1), (HS-ETS1-3)
WHST.9-12.7	Conduct short as well as more sustained research projects to answer a question (including a self generated question) or solve a problem; narrow or broaden the inquiry when appropriate; synthesize multiple sources on the subject, demonstrating understanding of the subject under investigation. (HS-LS2-7)
New Jersey Student Learning Standards for Career Readiness, Life Literacies and Key Skills	
CPI #	**Cumulative Progress Indicator (CPI)**
9.1.12.CFR.3	Research companies with corporate governance policies supporting the common good and human rights.
9.1.12.EG.3	Explain how individuals and businesses influence government policies.
9.1.12.EG.5	Relate a country's economic system of production and consumption to building personal wealth, the mindset of social comparison, and achieving societal responsibilities
9.1.12.EG.6	Analyze the rights and responsibilities of buyers and sellers under consumer protection laws.
9.1.12.PB.2	Prioritize financial decisions by considering alternatives and possible consequences.
9.4.12.CI.1	Demonstrate the ability to reflect, analyze, and use creative skills and ideas (e.g., 1.1.12prof.CR3a).
9.4.12.CI.3	Investigate new challenges and opportunities for personal growth, advancement, and transition (e.g., 2.1.12.PGD.1).
9.4.12.CT.2	Explain the potential benefits of collaborating to enhance critical thinking and problem solving (e.g., 1.3E.12profCR3.a).
9.4.12.CT.3	Enlist input from a variety of stakeholders (e.g., community members, experts in the field) to design a service learning activity that addresses a local or global issue (e.g., environmental justice).
9.4.12.DC.7	Evaluate the influence of digital communities on the nature, content and responsibilities of careers, and other aspects of society (e.g., 6.1.12.CivicsPD.16.a).
9.4.12.GCA.1	Collaborate with individuals to analyze a variety of potential solutions to climate change effects and determine why some solutions (e.g., political. economic, cultural) may work better than others (e.g., SL.11-12.1., HS-ETS1-1, HS-ETS1-2, HS-ETS1-4, 6.3.12.GeoGI.1, 7.1.IH.IPERS.6, 7.1.IL.IPERS.7, 8.2.12.ETW.3).
9.4.12.IML.2	Evaluate digital sources for timeliness, accuracy, perspective, credibility of the source, and relevance of information, in media, data, or other resources (e.g., NJSLSA.W8, Social Studies Practice: Gathering and Evaluating Sources.
9.4.12.IML.3	Analyze data using tools and models to make valid and reliable claims, or to determine optimal design solutions (e.g., S-ID.B.6a., 8.1.12.DA.5, 7.1.IH.IPRET.8)

9.4.12.IML.5	Evaluate, synthesize, and apply information on climate change from various sources appropriately (e.g., 2.1.12.CHSS.6, S.IC.B.4, S.IC.B.6, 8.1.12.DA.1, 6.1.12.GeoHE.14.a, 7.1.AL.PRSNT.2).
9.4.12.IML.6	Use various types of media to produce and store information on climate change for different purposes and audiences with sensitivity to cultural, gender, and age diversity (e.g., NJSLSA.SL5).
9.4.12.IML.7	Develop an argument to support a claim regarding a current workplace or societal/ethical issue such as climate change (e.g., NJSLSA.W1, 7.1.AL.PRSNT.4).
9.4.12.IML.8	Evaluate media sources for point of view, bias, and motivations (e.g., NJSLSA.R6, 7.1.AL.IPRET.6).
9.4.12.IML.9	Analyze the decisions creators make to reveal explicit and implicit messages within information and media (e.g., 1.5.12acc.C2a, 7.1.IL.IPRET.4).
9.4.12.TL.4	Collaborate in online learning communities or social networks or virtual worlds to analyze and propose a resolution to a real-world problem (e.g., 7.1.AL.IPERS.6).
8.1.12.A.2	Produce and edit a multi-page digital document for a commercial or professional audience and present it to peers and/or professionals in that related area for review.
8.1.12.C.1	Develop an innovative solution to a real world problem or issue in collaboration with peers and experts, and present ideas for feedback through social media or in an online community.
8.1.12.E.1	Produce a position statement about a real world problem by developing a systematic plan of investigation with peers and experts synthesizing information from multiple sources.
8.2.12.A.2	Analyze a current technology and the resources used, to identify the trade-offs in terms of availability, cost, desirability and waste.
8.2.12.B.1	Research and analyze the impact of the design constraints (specifications and limits) for a product or technology driven by a cultural, social, economic or political need and publish for review.
8.2.12.B.2	Evaluate ethical considerations regarding the sustainability of environmental resources that are used for the design, creation and maintenance of a chosen product.
8.2.12.B.5	Research the historical tensions between environmental and economic considerations as driven by human needs and wants in the development of a technological product, and present the competing viewpoints to peers for review.
8.2.12.C.3	Analyze a product or system for factors such as safety, reliability, economic considerations, quality control, environmental concerns, manufacturability, maintenance and repair, and human factors engineering (ergonomics).
8.2.12.D.4	Assess the impacts of emerging technologies on developing countries.
Interdisciplinary Standards	
Standard: Math	
CPI #	**Cumulative Progress Indicator (CPI)**
MP.2	Reason abstractly and quantitatively. (HS-ESS2-2), (HS-ESS2-6), (HS-ESS3-2), (HS-ESS3-3), (HS-ESS3-4), (HS-ESS3-6), (HS-LS2-7), (HS-ETS1-1), (HS-ETS1-3)
MP.4	Model with mathematics. (HS-ESS2-6), (HS-ESS3-3), (HS-ESS3-6), (HS-ETS1-1), (HS-ETS1-2), (HS-ETS1-3)
HSN-Q.A.1	Use units as a way to understand problems and to guide the solution of multi-step problems; choose and interpret units consistently in formulas; choose and interpret the scale and the origin in graphs and data displays. (HS-ESS2-2), (HS-ESS2-6), (HS-ESS3-4), (HS-ESS3-6), (HS-LS2-7)

HSN-Q.A.2	Define appropriate quantities for the purpose of descriptive modeling. (HS-ESS2-6), HS-ESS3-4), (HS-ESS3-6), (HS-LS2-7)
HSN-Q.A.3	Choose a level of accuracy appropriate to limitations on measurement when reporting quantities. (HS-ESS2-2), (HS-ESS2-6), (HS-ESS3-4), (HS-ESS3-6), (HS-LS2-7)
Standard: Social Studies	
CPI #	**Cumulative Progress Indicator (CPI)**
Standard 6.1 U.S. History: America in the World	All students will acquire the knowledge and skills to think analytically about how past and present interactions of people, cultures, and the environment shape the American heritage. Such knowledge and skills enable students to make informed decisions that reflect fundamental rights and core democratic values as productive citizens in local, national, and global communities.
Standard 6.2 World History: Global Studies	All students will acquire the knowledge and skills to think analytically and systematically about how past interactions of people, cultures, and the environment affect issues across time and cultures. Such knowledge and skills enable students to make informed decisions as socially and ethically responsible world citizens in the 21st century.

Instructional Focus
Unit Enduring Understandings
● Metal extraction, processing and use has ecological consequences that include fossil fuel use during extraction and manufacture. ● Mining for rare earth materials has environmental, social, political, and ethical consequences. ● Communities around the world are disproportionately affected by the environmental impacts of mining based on factors such as proximity to mines and prevalence of mines in their countries. ● Societal needs and wants drive the extraction of rare earth materials. ● There are major environmental impacts of mining and improper disposal at end of service. ● Fossil fuel extraction and use has environmental consequences in addition to the release of carbon dioxide including, but not limited to, spills and acid rain. ● Modern society is heavily reliant on fossil fuels. Disruptions to that supply or movements to alternative energies could have economic consequences. ● Plastics are fossil fuel based products that are processed and changed such that they cannot be melted or burned easily for disposal. Proper disposal or recycling of plastics is critical to protect terrestrial and, especially, marine environments. ● When materials reach the end of their use they are often disposed of into landfills, incineration plants, and sometimes recycling companies. ● When done properly, recycling is a more sustainable method of waste management than landfills and incinerators. ● Waste management strategies only help to organize waste that has already been produced, while waste reduction strategies will help to lower the amount of waste produced on a small and large scale. ● The long-term health effects of waste management are still not entirely understood for individuals living in close proximity to landfills and incinerators.
Unit Essential Questions
● Where do the components of a cell phone come from? How can cell phones be properly “disposed” of or recycled? ● What are the health impacts of mining practices? ● How do we get the metals that go into products we use?

- How is the extraction of resources managed? What regulations are in place for environmental protection?
- How were fossil fuels formed? How do we get each type of fossil fuel from where it is found to where we are going to use it?
- What are the environmental impacts of extracting, processing and transporting metals and fossil fuels?
- What are the environmental implications of extracting resources from protected lands?
- What are the pros and cons of approving new land for resource extraction?
- What is plastic made of and how is it produced?
- If metal is rusted and no longer useful for its original purpose does it still have any value? Why or why not?
- In what ways do humans manage waste production and what can be done to reduce it?
- What are the environmental impacts of putting waste into landfills and incineration plants?
- What are the health impacts of improper waste disposal?
- Are the proposed changes for more sustainable resource use and disposal realistic for all communities/countries/populations?

Content Statements

ESS2: Earth's Systems

- **ESS2.A: Earth Materials and Systems** - Earth's systems, being dynamic and interacting, cause feedback effects that can increase or decrease the original changes. **(HS-ESS2-2)**
- **ESS2.D: Weather and Climate -** Changes in the atmosphere due to human activity have increased carbon dioxide concentrations and thus affect climate. **(HS-ESS2- 6)**

ESS3: Earth and Human Activity

- **ESS3:A: Natural Resources -** All forms of energy production and other resource extraction have associated economic, social, environmental, and geopolitical costs and risks as well as benefits. New technologies and social regulations can change the balance of these factors. **(HS-ESS3-2)**
- **ESS3.C: Human Impacts on Earth Systems -** The sustainability of human societies and the biodiversity that supports them requires responsible management of natural resources. **(HS-ESS3-3)**
- **ESS3.C: Human Impacts on Earth Systems -** Scientists and engineers can make major contributions by developing technologies that produce less pollution and waste and that preclude ecosystem degradation. **(HS-ESS3-4)**
- **ESS3.D: Global Climate Change -** Through computer simulations and other studies, important discoveries are still being made about how the ocean, the atmosphere, and the biosphere interact and are modified in response to human activities. **(HS-ESS3-6)**

LS2: Ecosystems: Interactions, Energy, and Dynamics

- **LS2.C: Ecosystem Dynamics, Functioning, and Resilience -** Moreover, anthropogenic changes (induced by human activity) in the environment—including habitat destruction, pollution, introduction of invasive species, overexploitation, and climate change—can disrupt an ecosystem and threaten the survival of some species. **(HS-LS2-7)**
- **LS4.D: Biodiversity and Humans -** Humans depend on the living world for the resources and other benefits provided by biodiversity. But human activity is also having adverse impacts on biodiversity through overpopulation, overexploitation, habitat destruction, pollution, introduction of invasive species, and climate change. Thus sustaining biodiversity so that ecosystem functioning and productivity are maintained is essential to supporting and enhancing life on Earth. Sustaining biodiversity also aids humanity by preserving landscapes of recreational or inspirational value. **(secondary to HS-LS2-7)**

ETS1: Engineering Design

- **ET S1.A: Defining and Delimiting Engineering Problems** - Criteria and constraints also include satisfying any requirements set by society , such as taking issues of risk mitigation into account, and they should be

quantified to the extent possible and stated in such a way that one can tell if a given design meets them. **(HS-ETS1-1)**

- **ET S1.A: Defining and Delimiting Engineering Problems -** Humanity faces major global challenges today , such as the need for supplies of clean water and food or for energy sources that minimize pollution, which can be addressed through engineering. These global challenges also may have manifestations in local communities. **(HS-ETS1-1)**
- **ET S1.C: Optimizing the Design Solution** - Criteria may need to be broken down into simpler ones that can be approached systematically , and decisions about the priority of certain criteria over others (trade-offs) may be needed. **(HS-ETS1-2)**
- **ET S1.B: Developing Possible Solutions -** When evaluating solutions, it is important to take into account a range of constraints, including cost, safety , reliability , and aesthetics, and to consider social, cultural, and environmental impacts. **(HS-ETS1-3), (secondary to HS-ESS3- 2), (secondary HS-ESS3-4), (secondary to HS-LS2-7)**

Ability Objectives - SWBAT

General for all Units:

- Ask questions and define problems
- Develop and use models
- Plan and carry out investigations
- Analyze and interpret data
- Use mathematics and computational thinking
- Construct explanations and design solutions
- Engaging in argument from evidence
- Obtaining, evaluating and communicating information

Specific for Unit 4:

- Argue for a method of mining and/or refining metals that is the most ecologically and societally preferable.
- Discuss the benefits and problems associated with an increase in consumer electronics as related to the extraction and disposal of rare earth materials.
- Compare and contrast methods of mine reclamation and discuss the long term effects of these extractions.
- Explain the chemical process of fossil fuel generation and compare the energy content and structure of biological molecules and fossil fuels.
- Draw and explain the short and long term carbon cycles. Be able to relate these cycles to burning and fossil fuels.
- Compare extraction and transportation methods for different fossil fuels such as coal, oil and natural gas.
- Discuss the limitations of different fossil fuels to sustain our need for power generation as the population continues to grow.
- Choose a method for disposal of paper, plastic or metal waste and argue from evidence that it is the best method.
- Design a set of best practices for landfill construction and waste disposal.
- Compare and contrast strategies of waste management versus waste reduction.
- Analyze waste management and waste reduction systems for factors such as safety, reliability, economic considerations, quality control, and environmental concerns.
- Discuss human health challenges arising from human caused or naturally occurring chemical hazards such as radon exposure, excessive fluoride in water, lead, VOCs, etc.

- Compare the effect of plastic pollution on the health of ocean ecosystems to that of fossil fuel (oil) spills and leaks.

Sample Performance Tasks -

- Argue from evidence for a method of mining that is most ecologically and societally preferable, with an understanding that the system that is resource extraction will always have an amount of economic, social, environmental, and geopolitical costs. **(HS-ESS3-2)**
- Engage in a stakeholders debate and argue from evidence about the opening of federally protected land for resource extraction and how this relates to feedback within Earth's natural systems. **(HS-ESS2-2)**
- Plan and carry out an investigation on the structure and function of landfills to better understand the effects of improper landfill creation and management on the surrounding ecosystem. **(HS-ESS3-4)**
- Ask questions to determine relationships between production and recycling concerning energy and matter flows into, out of, and within that system as a way to evaluate technologies that produce less pollution and waste. **(HS-ESS3-4)**
- Construct explanations and design solutions for ways to manage and reduce waste production by developing technologies that produce less pollution and waste at different scales, proportions, and quantities. **(HS-ESS3-4) (HS-ETS1-2)**
- Analyze and interpret data in order to determine the cause and effect relationship between the availability and burning of fossil fuels as an energy source for human society and its impacts on the environment. **(HS-ESS3-1)**
- Plan and carry out investigations to compare and contrast current solutions for waste management, such as septic systems vs wastewater treatment plants, and determine the solutions that are the most stable or cause change to the environment. **(HS-ESS3-4)**
- Engage in argument from evidence how people who live in close proximity to incineration plants can inhale the chemicals released and cause developmental problems for those who consume it. **(HS-ESS3-6)**

Resources

Core Text: Environmental Science, Karen Arms, 2008, ISBN-13: 978-0-03-078136-0

Unit 5 Title: Alternative Energy and Climate Change Solutions	
Content Area: Science	
Course & Grade Level: Environmental Science 9-12	
Summary and Rationale	
Climate and climate change have been interwoven throughout this curriculum. The focus of this unit is on climate change solutions. Students will learn about and propose alternatives to the current ways that human society produces materials and energy. They will synthesize and apply knowledge learned throughout the school year. This includes how individuals can make changes in their everyday lives to reduce their carbon footprint including but not limited to resource use and disposal, best practices, and appropriate alternative energies. They will evaluate the effects of these possible solutions on the biodiversity of our planet as well as for diverse communities. Students will also scrutinize the large scale companies and governments that currently exist and what they can do to become carbon neutral and reduce their release of carbon dioxide into the atmosphere. There will be an exploration into alternative practices we can use to sustainably gather food and water for human society while also limiting our atmospheric and ecological effects. Students will devise alternative practices for material extraction, use, and disposal. They will emphasize the environmental impact of transitioning from fossil fuels to alternative energy options such as solar and wind for different communities. Students will also examine current national and international climate policy. At the end of this unit students will be able to construct potential solutions to our global climate change issue either at a local, regional, or global level.	
Recommended Pacing	
4 Weeks	
New Jersey Student Learning Standards for Science	
Standard	
CPI #	**Cumulative Progress Indicator (CPI)**
HS-ESS2-2	Analyze geoscience data to make the claim that one change to Earth's surface can create feedbacks that cause changes to other Earth systems. *[Clarification Statement: Examples should include climate feedbacks, such as how an increase in greenhouse gases causes a rise in global temperatures that melts glacial ice, which reduces the amount of sunlight reflected from Earth's surface, increasing surface temperatures and further reducing the amount of ice. Examples could also be taken from other system interactions, such as how the loss of ground vegetation causes an increase in water runoff and soil erosion; how dammed rivers increase groundwater recharge, decrease sediment transport, and increase coastal erosion; or how the loss of wetlands causes a decrease in local humidity that further reduces the wetland extent.]*
HS-ESS2-4	Use a model to describe how variations in the flow of energy into and out of Earth's systems result in changes in climate. *[Clarification Statement: Examples of the causes of climate change differ by timescale, over 1-10 years: large volcanic eruption, ocean circulation; 10-100s of years: changes in human activity, ocean circulation, solar output; 10-100s of thousands of years: changes to Earth's orbit and the orientation of its axis; and 10-100s of millions of years: long-term changes in atmospheric composition.]* [Assessment Boundary: Assessment of the results of changes in climate is limited to changes in surface temperatures, precipitation patterns, glacial ice volumes, sea levels, and biosphere distribution.]

HS-ESS3-1	Construct an explanation based on evidence for how the availability of natural resources, occurrence of natural hazards, and climate change have influenced human activity. [Clarification Statement: Examples of key natural resources include access to fresh water (such as rivers, lakes, and groundwater), regions of fertile soils such as river deltas, and high concentrations of minerals and fossil fuels. Examples of natural hazards can be from interior processes (such as volcanic eruptions and earthquakes), surface processes (such as tsunamis, mass wasting and soil erosion), and severe weather (such as hurricanes, floods, and droughts). Examples of the results of changes in climate that can affect populations or drive mass migrations include changes to sea level, regional patterns of temperature and precipitation, and the types of crops and livestock that can be raised.]
HS-ESS3-2	Evaluate competing design solutions for developing, managing, and utilizing energy and mineral resources based on cost-benefit ratios. *[Clarification Statement: Emphasis is on the conservation, recycling, and reuse of resources (such as minerals and metals) where possible, and on minimizing impacts where it is not. Examples include developing best practices for agricultural soil use, mining (for coal, tar sands, and oil shales), and pumping (for petroleum and natural gas). Science knowledge indicates what can happen in natural systems—not what should happen.]*
HS-ESS3-4	Evaluate or refine a technological solution that reduces impacts of human activities on climate change and other natural systems. [Clarification Statement: Examples of data on the impacts of human activities could include the quantities and types of pollutants released, changes to biomass and species diversity, or areal changes in land surface use (such as for urban development, agriculture and livestock, or surface mining). Examples for limiting future impacts could range from local efforts (such as reducing, reusing, and recycling resources) to large-scale geoengineering design solutions (such as altering global temperatures by making large changes to the atmosphere or ocean).]
HS-ESS3-5	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. *[Clarification Statement: Examples of evidence, for both data and climate model outputs, are for climate changes (such as precipitation and temperature) and their associated impacts (such as on sea level, glacial ice volumes, or atmosphere and ocean composition).]* [Assessment Boundary: Assessment is limited to one example of climate change and its associated impacts.]
HS-ESS3-6	Use a computational representation to illustrate the relationships among Earth systems and how those relationships are being modified due to human activity (i.e., climate change). [Clarification Statement: Examples of Earth systems to be considered are the hydrosphere, atmosphere, cryosphere, geosphere, and/or biosphere. An example of the far-reaching impacts from a human activity is how an increase in atmospheric carbon dioxide results in an increase in photosynthetic biomass on land and an increase in ocean acidification, with resulting impacts on sea organism health and marine populations.] [Assessment Boundary: Assessment does not include running computational representations but is limited to using the published results of scientific computational models.]
HS-PS3-3	Design, build, and refine a device that works within given constraints to convert one form of energy into another form of energy. *[Clarification Statement: Emphasis is on both qualitative and quantitative evaluations of devices. Examples of devices could include Rube Goldberg devices, wind turbines, solar cells, solar ovens, and generators. Examples of constraints could include use of renewable energy forms and efficiency.]* [Assessment Boundary: Assessment

	for quantitative evaluations is limited to total output for a given input. Assessment is limited to devices constructed with materials provided to students.]
HS-LS2-7	Design, evaluate, and refine a solution for reducing the impacts of human activities on the environment and biodiversity. *[Clarification Statement: Examples of human activities can include urbanization, building dams, and dissemination of invasive species.]*
HS-ETS1-1	Analyze a major global challenge to specify qualitative and quantitative criteria and constraints for solutions that account for societal needs and wants.
HS-ETS1-2	Design a solution to a complex real-world problem by breaking it down into smaller, more manageable problems that can be solved through engineering.
HS-ETS1-3	Evaluate a solution to a complex real-world problem based on prioritized criteria and trade-offs that account for a range of constraints, including cost, safety, reliability, and aesthetics, as well as possible social, cultural, and environmental impacts.
New Jersey Student Learning Standards for English Language Arts Companion Standards	
Standard:	
CPI #	**Cumulative Progress Indicator (CPI)**
RST.9-10.8	Determine if the reasoning and evidence in a text support the author's claim or a recommendation for solving a scientific or technical problem. (HS-LS2-7)
RST.11-12.1	Accurately cite strong and thorough evidence from the text to support analysis of science and technical texts, attending to precise details for explanations or descriptions. (HS-ESS2-2), (HS-ESS3-1), (HS-ESS3-2), (HS-ESS3-4), (HS-ESS3-5)
RST.11-12.7	Determine the central ideas, themes, or conclusions of a text; summarize complex concepts, processes, or information presented in a text by paraphrasing them in simpler but still accurate terms. (HS-ESS2-2), (HS-ESS3-5)
	Integrate and evaluate multiple sources of information presented in diverse formats and media (e.g., quantitative data, video, multimedia) in order to address a question or solve a problem. (HS-LS2-7), (HS-ESS3-5), (HS-ETS1-1), (HS-ETS1-3)
RST.11-12.8	Evaluate the hypotheses, data, analysis, and conclusions in a science or technical text, verifying the data when possible and corroborating or challenging conclusions with other sources of information. (HS-LS2-7), (HS-ESS3-2), (HS-ESS3-4), (HS-ETS1-1), (HS-ETS1-3)
RST.11-12.9	Synthesize information from a range of sources (e.g., texts, experiments, simulations) into a coherent understanding of a process, phenomenon, or concept, resolving conflicting information when possible. (HS-ETS1-1), (HS-ETS1-3)
WHST.9-12.2	Write informative/explanatory texts, including the narration of historical events, scientific procedures/ experiments, or technical processes. (HS-ESS3-1)
WHST.9-12.7	Conduct short as well as more sustained research projects to answer a question (including a self generated question) or solve a problem; narrow or broaden the inquiry when appropriate; synthesize multiple sources on the subject, demonstrating understanding of the subject under investigation. (HS-PS3-3), (HS-LS2-7)
SL.11-12.5	Make strategic use of digital media (e.g., textual, graphical, audio, visual, and interactive elements) in presentations to enhance understanding of findings, reasoning, and evidence and to add interest. (HS-ESS2-4)
New Jersey Student Learning Standards for Career Readiness, Life Literacies and Key Skills	
CPI #	**Cumulative Progress Indicator (CPI)**

9.1.12.CFR.2	Summarize causes important to you and compare organizations you seek to support to other organizations with similar missions.
9.1.12.CFR.3	Research companies with corporate governance policies supporting the common good and human rights.
9.1.12.EG.3	Explain how individuals and businesses influence government policies.
9.1.12.EG.5	Relate a country's economic system of production and consumption to building personal wealth, the mindset of social comparison, and achieving societal responsibilities
9.1.12.PB.2	Prioritize financial decisions by considering alternatives and possible consequences.
9.2.12.CAP.6	Identify transferable skills in career choices and design alternative career plans based on those skills.
9.4.12.CI.1	Demonstrate the ability to reflect, analyze, and use creative skills and ideas (e.g., 1.1.12prof.CR3a).
9.4.12.CI.2	Identify career pathways that highlight personal talents, skills, and abilities (e.g., 1.4.12prof.CR2b, 2.2.12.LF.8).
9.4.12.CI.3	Investigate new challenges and opportunities for personal growth, advancement, and transition (e.g., 2.1.12.PGD.1).
9.4.12.IML.6	Use various types of media to produce and store information on climate change for different purposes and audiences with sensitivity to cultural, gender, and age diversity (e.g., NJSLSA.SL5).
9.4.12.CT.2	Explain the potential benefits of collaborating to enhance critical thinking and problem solving (e.g., 1.3E.12profCR3.a).
9.4.12.CT.3	Enlist input from a variety of stakeholders (e.g., community members, experts in the field) to design a service learning activity that addresses a local or global issue (e.g., environmental justice).
9.4.12.DC.7	Evaluate the influence of digital communities on the nature, content and responsibilities of careers, and other aspects of society (e.g., 6.1.12.CivicsPD.16.a).
9.4.12.DC.8	Explain how increased network connectivity and computing capabilities of everyday objects allow for innovative technological approaches to climate protection.
9.4.12.GCA.1	Collaborate with individuals to analyze a variety of potential solutions to climate change effects and determine why some solutions (e.g., political. economic, cultural) may work better than others (e.g., SL.11-12.1., HS-ETS1-1, HS-ETS1-2, HS-ETS1-4, 6.3.12.GeoGI.1, 7.1.IH.IPERS.6, 7.1.IL.IPERS.7, 8.2.12.ETW.3).
9.4.12.IML.2	Evaluate digital sources for timeliness, accuracy, perspective, credibility of the source, and relevance of information, in media, data, or other resources (e.g., NJSLSA.W8, Social Studies Practice: Gathering and Evaluating Sources.
9.4.12.IML.3	Analyze data using tools and models to make valid and reliable claims, or to determine optimal design solutions (e.g., S-ID.B.6a., 8.1.12.DA.5, 7.1.IH.IPRET.8)
9.4.12.IML.4	Assess and critique the appropriateness and impact of existing data visualizations for an intended audience (e.g., S-ID.B.6b, HS-LS2-4).
9.4.12.IML.5	Evaluate, synthesize, and apply information on climate change from various sources appropriately (e.g., 2.1.12.CHSS.6, S.IC.B.4, S.IC.B.6, 8.1.12.DA.1, 6.1.12.GeoHE.14.a, 7.1.AL.PRSNT.2).
9.4.12.IML.6	Use various types of media to produce and store information on climate change for different purposes and audiences with sensitivity to cultural, gender, and age diversity (e.g., NJSLSA.SL5).
9.4.12.IML.7	Develop an argument to support a claim regarding a current workplace or societal/ethical issue such as climate change (e.g., NJSLSA.W1, 7.1.AL.PRSNT.4).

9.4.12.IML.8	Evaluate media sources for point of view, bias, and motivations (e.g., NJSLSA.R6, 7.1.AL.IPRET.6).
9.4.12.IML.9	Analyze the decisions creators make to reveal explicit and implicit messages within information and media (e.g., 1.5.12acc.C2a, 7.1.IL.IPRET.4).
9.4.12.TL.1	Assess digital tools based on features such as accessibility options, capacities, and utility for accomplishing a specified task (e.g., W.11-12.6.).
9.4.12.TL.4	Collaborate in online learning communities or social networks or virtual worlds to analyze and propose a resolution to a real-world problem (e.g., 7.1.AL.IPERS.6).
8.1.12.A.2	Produce and edit a multi-page digital document for a commercial or professional audience and present it to peers and/or professionals in that related area for review.
8.1.12.C.1	Develop an innovative solution to a real world problem or issue in collaboration with peers and experts, and present ideas for feedback through social media or in an online community.
8.1.12.E.1	Produce a position statement about a real world problem by developing a systematic plan of investigation with peers and experts synthesizing information from multiple sources.
8.2.12.A.2	Analyze a current technology and the resources used, to identify the trade-offs in terms of availability, cost, desirability and waste.
8.2.12.B.1	Research and analyze the impact of the design constraints (specifications and limits) for a product or technology driven by a cultural, social, economic or political need and publish for review.
8.2.12.B.2	Evaluate ethical considerations regarding the sustainability of environmental resources that are used for the design, creation and maintenance of a chosen product.
8.2.12.C.3	Analyze a product or system for factors such as safety, reliability, economic considerations, quality control, environmental concerns, manufacturability, maintenance and repair, and human factors engineering (ergonomics).
8.2.12.C.7	Use a design process to devise a technological product or system that addresses a global problem, provide research, identify trade-offs and constraints, and document the process through drawings that include data and materials.
8.2.12.D.1	Design and create a prototype to solve a real world problem using a design process, identify constraints addressed during the creation of the prototype, identify trade-offs made, and present the solution for peer review.
8.2.12.D.4	Assess the impacts of emerging technologies on developing countries.
8.2.12.D.6	Synthesize data, analyze trends and draw conclusions regarding the effect of a technology on the individual, society, or the environment and publish conclusions.
8.2.12.E.1	Demonstrate an understanding of the problem-solving capacity of computers in our world.
Interdisciplinary Standards	
Standard: Math	
CPI #	**Cumulative Progress Indicator (CPI)**
MP.2	Reason abstractly and quantitatively. (HS-ESS2-2), (HS-ESS2-4), (HS-ESS3-1), (HS-ESS3-2), (HS-ESS3-4), (HS-ESS3-5), (HS-ESS3-6), (HS-PS3-3), (HS-LS2-7), (HS-ETS1-1), (HS-ETS1-3)
MP.4	Model with mathematics. (HS-ESS2-4), (HS-ESS3-6), (HS-ETS1-1), (HS-ETS1-2), (HS-ETS1-3)
HSN-Q.A.1	Use units as a way to understand problems and to guide the solution of multi-step problems; choose and interpret units consistently in formulas; choose and interpret the scale and the origin in graphs and data displays. (HS-ESS2-2), (HS-ESS2-4), (HS-ESS3-1), (HS-ESS3-4), (HS-ESS3-5), (HS-ESS3-6), (HS-PS3-3), (HS-LS2-7)

HSN-Q.A.2	Define appropriate quantities for the purpose of descriptive modeling. (HS-ESS2-4), (HS-ESS3-1), (HS-ESS3-4), (HS-ESS3-5), (HS-ESS3-6), (HS-PS3-3), (HS-LS2-7)
HSN-Q.A.3	Choose a level of accuracy appropriate to limitations on measurement when reporting quantities. (HS-ESS2-2), (HS-ESS2-4), (HS-ESS3-1), (HS-ESS3-4), (HS-ESS3-5), (HS-ESS3-6), (HS-PS3-3), (HS-LS2-7)
Standard: Social Studies	
CPI #	**Cumulative Progress Indicator (CPI)**
Standard 6.1 U.S. History: America in the World	All students will acquire the knowledge and skills to think analytically about how past and present interactions of people, cultures, and the environment shape the American heritage. Such knowledge and skills enable students to make informed decisions that reflect fundamental rights and core democratic values as productive citizens in local, national, and global communities.
Standard 6.2 World History: Global Studies	All students will acquire the knowledge and skills to think analytically and systematically about how past interactions of people, cultures, and the environment affect issues across time and cultures. Such knowledge and skills enable students to make informed decisions as socially and ethically responsible world citizens in the 21st century.

Instructional Focus

Unit Enduring Understandings

- Climate is influenced by interactions of multiple physical, chemical and biological factors, including human actions.
- The global climate is changing largely due to human influence, particularly emissions of carbon dioxide, methane and other greenhouse gasses but also land use patterns such as deforestation and loss of perennial grasslands.
- Reducing the amount of carbon dioxide in the atmosphere will help stabilize the global temperature and even possibly lead to a reduction in the global temperature.
- Extreme weather (floods, droughts, more intense hurricanes, etc) are becoming more prevalent due to the rapidly changing climate.
- Society is going to have to adapt to extreme weather events (i.e. infrastructure for wildfires, droughts, hurricanes).
- Climate change is occurring at different rates in different locations. The rate of change is based on a variety of factors.
- Reducing loss of biodiversity due to climate change will lessen the impacts on global ecosystems.
- The rate at which the human population is growing will cause a dramatic increase in carbon dioxide emissions into the atmosphere unless modifications to technology are made.
- Global climate change is necessitating alternative means of food production and distribution.
- Communities around the world will need to create solutions for reduced water availability due to negative changes to water levels in their reservoirs.
- Individuals can make changes in their everyday lives to reduce their carbon footprint.
- Transitioning from a fossil fuel dependent society to alternative energy sources will greatly reduce the amount of carbon dioxide released into the atmosphere.
- Certain alternative energy options are more suitable for some locations on our planet.
    - Air pollution regulations need to be revisited and revised based on our current climate change models and current waste disposal methods.

- Individuals and corporations need to conduct a cost-benefit analysis to understand the possible unforeseen environmental impacts of alternative energy options such as material acquisition and installation locations as related to biodiversity and local ecosystems.
- Some individuals will have an easier time than others making changes in their everyday lives to reduce their ecological footprint.
- Large scale corporations and government agencies making plans to reduce their carbon output will have the largest impact on atmospheric carbon dioxide levels.

Unit Essential Questions

- How has human activity amplified the effects of the greenhouse effect?
- Why is the arctic warming twice as fast as the rest of the planet?
- What is being done to help slow and/or reduce the warming of the Earth?
- How are positive feedback systems, amplified by human activity, influencing warming?
- What are people doing that is contributing to climate change?
- How do measures taken to reduce our ecological footprints meet the mission of the Sustainable Development Goals?
- How will climate change solutions impact biodiversity?
- How are increased global temperature and decreased precipitation necessitating changes to agricultural practices?
- How can we best influence land use patterns to slow the effects of climate change?
- What is biomass and what are the benefits of using it as an alternative form of energy?
- How can communities in current drought stricken areas survive?
- How are changes to weather patterns impacting both our community and communities around the world?
- Which populations are most at risk from the effects of climate change?
- How does allocation of resources affect a community's ability to adapt to our changing climate?
- How are different countries and organizations working together to solve the climate crisis?
- What are some changes we can engineer into our electrical power generation infrastructure that can reduce its impact on climate change?
- What are some of the potential benefits & drawbacks to changing our electrical power generation infrastructure?
- What alternative energy options are best suited for our community?
- What are the limitations to transitioning society's energy use away from fossil fuels?
- What alternative energies can human society transition to that will reduce carbon dioxide output as compared to the current amount released through the burning of fossil fuels?
- How does a community implement a sustainable waste management and waste disposal system?
- What are the economic impacts of transitioning society from fossil fuels to cleaner alternatives?
- How will climate change impact career opportunities? (i.e. agriculture, energy sector, conservation, etc.)

Content Statement

ESS2: Earth's Systems

- **ESS2.A: Earth Materials and Systems** - Earth's systems, being dynamic and interacting, cause feedback effects that can increase or decrease the original changes. **(HS-ESS2-2)**
- **ESS2.A: Earth Materials and Systems** - The geological record shows that changes to global and regional climate can be caused by interactions among changes in the sun's energy output or Earth's orbit, tectonic events, ocean circulation, volcanic activity, glaciers, vegetation, and human activities. These changes can occur on a variety of time scales from sudden (e.g., volcanic ash clouds) to intermediate (ice ages) to very long-term tectonic cycles. **(HS-ESS2-4)**

ESS3: Earth and Human Activity

- **ESS3.A: Natural Resources -** Resource availability has guided the development of human society. **(HS-ESS3-1)**

- **ESS3.A: Natural Resources** - All forms of energy production and other resource extraction have associated economic, social, environmental, and geopolitical costs and risks as well as benefits. New technologies and social regulations can change the balance of these factors. **(HS-ESS3-2)**
- **ESS3.B: Natural Hazards** - Natural hazards and other geologic events have shaped the course of human history; [they] have significantly altered the sizes of human populations and have driven human migrations. **(HS-ESS3-1)**
- **ESS3.B: Natural Hazards -** All forms of energy production and other resource extraction have associated economic, social, environmental, and geopolitical costs and risks as well as benefits. New technologies and social regulations can change the balance of these factors. **(HS-ESS3-2)**
- **ESS3.C: Human Impacts on Earth Systems -** Scientists and engineers can make major contributions by developing technologies that produce less pollution and waste and that preclude ecosystem degradation. **(HS-ESS3-4)**
- **ESS3.D: Global Climate Change -** Though the magnitudes of human impacts are greater than they have ever been, so too are human abilities to model, predict, and manage current and future impacts.**(HS-ESS3-5)**
- **ESS3.D: Global Climate Change -** Through computer simulations and other studies, important discoveries are still being made about how the ocean, the atmosphere, and the biosphere interact and are modified in response to human activities. **(HS-ESS3-6)**

PS3: Energy

- **PS3.A: Definitions of Energy -** At the macroscopic scale, energy manifests itself in multiple ways, such as in motion, sound, light, and thermal energy. **(HS-PS3-3)**
- **PS3.D: Chemical Processes and Everyday Life -** Although energy cannot be destroyed, it can be converted to less useful forms—for example, to thermal energy in the surrounding environment. **(HS-PS3-3)**

LS2: Ecosystems: Interactions, Energy, and Dynamics

- **LS2.C: Ecosystem Dynamics, Functioning, and Resilience -** Moreover, anthropogenic changes (induced by human activity) in the environment—including habitat destruction, pollution, introduction of invasive species, overexploitation, and climate change—can disrupt an ecosystem and threaten the survival of some species. **(HS-LS2-7)**
- **LS4.D: Biodiversity and Humans -** Humans depend on the living world for the resources and other benefits provided by biodiversity. But human activity is also having adverse impacts on biodiversity through overpopulation, overexploitation, habitat destruction, pollution, introduction of invasive species, and climate change. Thus sustaining biodiversity so that ecosystem functioning and productivity are maintained is essential to supporting and enhancing life on Earth. Sustaining biodiversity also aids humanity by preserving landscapes of recreational or inspirational value. **(secondary to HS-LS2-7)**

ETS1: Engineering Design

- **ET S1.A: Defining and Delimiting Engineering Problems** - Criteria and constraints also include satisfying any requirements set by society , such as taking issues of risk mitigation into account, and they should be quantified to the extent possible and stated in such a way that one can tell if a given design meets them. **(HS-ETS1-1)**
- **ET S1.A: Defining and Delimiting Engineering Problems -** Humanity faces major global challenges today , such as the need for supplies of clean water and food or for energy sources that minimize pollution, which can be addressed through engineering. These global challenges also may have manifestations in local communities. **(HS-ETS1-1)**
- **ET S1.C: Optimizing the Design Solution** - Criteria may need to be broken down into simpler ones that can be approached systematically , and decisions about the priority of certain criteria over others (trade-offs) may be needed. **(HS-ETS1-2)**

- **ET S1.B: Developing Possible Solutions -** When evaluating solutions, it is important to take into account a range of constraints, including cost, safety , reliability , and aesthetics, and to consider social, cultural, and environmental impacts. **(HS-ETS1-3)**

General for all Units:

- Ask questions and define problems
- Develop and use models
- Plan and carry out investigations
- Analyze and interpret data
- Use mathematics and computational thinking
- Construct explanations and design solutions
- Engaging in argument from evidence
- Obtaining, evaluating and communicating information

Specific for Unit 5: SWBAT:

- Compare the greenhouse effect caused by Earth's greenhouse gas layer to possible technological solutions for growing crops in extreme conditions on Earth and eventually on Mars.
- Propose solutions to the current levels of atmospheric carbon dioxide and other greenhouse gases as a result of industrialization and human population growth.
- Compare and contrast the environmental impact of the Industrial Revolution of the 1880s to the current digital technological revolution.
- Contrast natural and human generated sources of methane and suggest ways to reduce human generation of this greenhouse gas.
- Draw and explain how different regions of the planet contribute to and are affected by climate change through a positive feedback model.
- Engage in argument from evidence (e.g. climate data) as to why Earth's climate will continue to get warmer unless interventions are made.
- Evaluate the pros and cons of current water allocation and distribution policies as impacted by current climate models for a variety of stakeholders.
- Propose solutions to the current contribution of human generated carbon dioxide emissions on ocean acidity and the health of marine ecosystems.
- Determine the cause and effect relationship between climate change solutions and changes to the biodiversity of Earth.
- Discuss the role of human population level changes in energy use and efficiency in addressing the energy sectors' affect on human health and environmental issues.
- Discuss the environmental shortcomings of waste disposal methods and propose solutions to lessen their impact
- Compare and contrast the extraction and transportation methods for different fossil fuels to the extraction and installation of alternative energy technology.
- Debate the merits of emerging motor vehicle power technologies such as hydrogen, electric battery, hybrid gas-electric, and turbo diesel.
- Evaluate the pros and cons of alternative energy options and their possible environmental impacts.

- Predict how the integration of alternative energy options and atmospheric carbon emissions will change the current carbon cycle if fossil fuel use is reduced.
- Compare and contrast the technology differences between fossil fuel based methods for generating electricity to low carbon technologies such as wind, solar photovoltaic, hydro, nuclear fission, biomass, and geothermal.
- Discuss the role communities play in bringing about changes to policy as it relates to the environment.
- Propose environmentally friendly and sustainable solutions for our community.

Sample Performance Tasks -

- Design solutions for current climate change issues, based on patterns from the past, by modeling, predicting, and managing current and future impacts **(HS-ESS3-5)**
- Communicate scientific and/or technical information describing an energy source that minimizes pollution in an effort to identify patterns of performance of designed systems for generating electricity. **(HS-ESS3-2)**
- Engage in argument from evidence about the pros and cons of alternative energy options as they relate to stability and change within an ecosystem. **(HS-LS2-7) (HS-ESS3-4)**
- Develop and use models of technologies that produce less pollution and waste in order to demonstrate their ability to affect stability and change in the global climate. **(HS-ESS3-4)**
- Engage in argument from evidence about how natural hazards have and will shape the course of human history at various scales. **(HS-ESS3-1)**
- Obtain information about a local incinerator and evaluate the current environmental regulations in place as they affect the systems within nearby communities. **(HS-ESS3-4)**

Resources

Core Text: Environmental Science, Karen Arms, 2008, ISBN-13: 978-0-03-078136-0