# Earth Science

## Standard E1: INQUIRY, REFLECTION, AND SOCIAL IMPLICATIONS

Students will understand the nature of science and demonstrate an ability to practice scientific reasoning by applying it to the design, execution, and evaluation of scientific investigations. Students will demonstrate their understanding that scientific knowledge is gathered through various forms of direct and indirect observations and the testing of this information by methods including, but not limited to, experimentation. They will be able to distinguish between types of scientific knowledge (e.g., hypotheses, laws, theories) and become aware of areas of active research in contrast to conclusions that are part of established scientific consensus. They will use their scientific knowledge to assess the costs, risks, and benefits of technological systems as they make personal choices and participate in public policy decisions. These insights will help them analyze the role science plays in society, technology, and potential career opportunities.

### E1.1 Scientific Inquiry

Science is a way of understanding nature. Scientific research may begin by generating new scientific questions that can be answered through replicable scientific investigations that are logically developed and conducted systematically. Scientific conclusions and explanations result from careful analysis of empirical evidence and the use of logical reasoning. Some questions in science are addressed through indirect rather than direct observation, evaluating the consistency of new evidence with results predicted by models of natural processes. Results from investigations are communicated in reports that are scrutinized through a peer review process.

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| **E1.1A** Generate new questions that can be investigated in the laboratory or field. | **Project Learning Tree Activities**<br>**Biodiversity:**<br>1. Global Invaders<br>2. Protected Areas: Issues and Analysis<br>3. Potatoes, Pesticides, and Biodiversity<br>**Municipal Solid Waste:**<br>1. The Waste Stream<br>2. Source Reduction<br>3. Recycing and Economics<br>4. Composting<br>6. Landfills<br>7. Where Does Your Garbage Go?<br>8. Success Stories and Personal Choices<br>**Places We Live:**<br>3. Mapping Your Community Through Time<br>4. Neighborhood Design<br>5. Green Space<br>6. A Vision for the Future |

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| **E1.1B** Evaluate the uncertainties or validity of scientific conclusions using an understanding of sources of measurement error, the challenges of controlling variables, accuracy of data analysis, logic of argument, logic of experimental design, and/or the dependence on underlying assumptions. | **Project Learning Tree Activities**<br>**Municipal Solid Waste:**<br>6. Landfills<br>8. Success Stories and Personal Choices |
| **E1.1C** Conduct scientific investigations using appropriate tools and techniques (e.g., selecting an instrument that measures the desired quantity—length, volume, weight, time interval, temperature—with the appropriate level of precision). | **Project Learning Tree Activities**<br>**Municipal Solid Waste:**<br>1. The Waste Stream<br>4. Composting<br>6. Landfills<br>8. Success Stories and Personal Choices |
| **E1.1D** Identify patterns in data and relate them to theoretical models. | **Project Learning Tree Activities**<br>**Municipal Solid Waste:**<br>3. Recycing and Economics<br>**Focus On Risk:**<br>3. Chances Are…Understanding Probability and Risk |
| **E1.1E** Describe a reason for a given conclusion using evidence from an investigation. | **Project Learning Tree Activities**<br>**Focus On Risk:**<br>1. What is Risk?<br>Electromagnetic Fields<br>Chlorine: Looking at Tradeoffs<br>**Places We Live:**<br>5. Green Space<br>6. A Vision for the Future<br>7. Far-Reaching Decisions<br>8. Regional Community Issues: The Ogallala Aquifer |
| **E1.1f** Predict what would happen if the variables, methods, or timing of an investigation were changed. | **Project Learning Tree Activities**<br>**Municipal Solid Waste:**<br>1. The Waste Stream<br>6. Landfills<br>8. Success Stories and Personal Choices |

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| **E1.1h** Design and conduct a systematic scientific investigation that tests a hypothesis. Draw conclusions from data presented in charts or tables. | **Project Learning Tree Activities**<br>**Municipal Solid Waste:**<br>3. Recycing and Economics<br>4. Composting<br>6. Landfills<br>8. Success Stories and Personal Choices |

**E1.2 Scientific Reflection and Social Implications**

The integrity of the scientific process depends on scientists and citizens understanding and respecting the "Nature of Science." Openness to new ideas, skepticism, and honesty are attributes required for good scientific practice. Scientists must use logical reasoning during investigation design, analysis, conclusion, and communication. Science can produce critical insights on societal problems from a personal and local scale to a global scale. Science both aids in the development of technology and provides tools for assessing the costs, risks, and benefits of technological systems. Scientific conclusions and arguments play a role in personal choice and public policy decisions. New technology and scientific discoveries have had a major influence in shaping human history. Science and technology continue to offer diverse and significant career opportunities.

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| **E1.2B** Identify and critique arguments about personal or societal issues based on scientific evidence. | **Project Learning Tree Activities**<br>**Biodiversity:**<br>1. Global Invaders<br>2. Protected Areas: Issues and Analysis<br>3. Potatoes, Pesticides, and Biodiversity<br>**Municipal Solid Waste:**<br>2. Source Reduction<br>3. Recycing and Economics<br>4. Composting<br>**Focus On Risk:**<br>1. What is Risk?<br>2. Things aren't Always What They Seem<br>4. Risk Assessment: Toold of the Trade<br>5. Communicating Risk<br>6. Weighing the Options: A Look at Tradeoffs<br>7. Decision Making: Ecological Risk, Wildfires, and Natural Hazards<br>Electromagnetic Fields<br>Chlorine: Looking at Tradeoffs<br>**Places We Live:**<br>3. Mapping Your Community Through Time<br>5. Green Space<br>6. A Vision for the Future<br>8. Regional Community Issues: The Ogallala Aquifer |

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| **E1.2C** Develop an understanding of a scientific concept by accessing information from multiple sources. Evaluate the scientific accuracy and significance of the information. | **Project Learning Tree Activities**<br>**Focus On Risk:**<br>1. What is Risk?<br>7. Decision Making: Ecological Risk, Wildfires, and Natural Hazards<br>**Places We Live:**<br>5. Green Space |
| **E1.2D** Evaluate scientific explanations in a peer review process or discussion format. | **Project Learning Tree Activities**<br>**Biodiversity:**<br>1. Global Invaders<br>2. Protected Areas: Issues and Analysis<br>**Focus On Risk:**<br>1. What is Risk?<br>2. Things aren't Always What They Seem<br>4. Risk Assessment: Tools of the Trade<br>5. Communicating Risk<br>6. Weighing the Options: A Look at Tradeoffs<br>7. Decision Making: Ecological Risk, Wildfires, and Natural Hazards<br>Electromagnetic Fields<br>**Places We Live:**<br>7. Far-Reaching Decisions<br>8. Regional Community Issues: The Ogallala Aquifer |
| **E1.2E** Evaluate the future career and occupational prospects of science fields. | **Project Learning Tree Activities**<br>**Places We Live:**<br>4. Neighborhood Design<br>8. Regional Community Issues: The Ogallala Aquifer |

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| **E1.2f** Critique solutions to problems, given criteria and scientific constraints. | **Project Learning Tree Activities**<br>**Biodiversity**<br>2. Protected Areas: Issues and Analysis<br>**Municipal Solid Waste:**<br>1. The Waste Stream<br>2. Source Reduction<br>3. Recycing and Economics<br>6. Landfills<br>7. Where Does Your Garbage Go?<br>**Focus On Risk:**<br>1. What is Risk?<br>6. Weighing the Options: A Look at Tradeoffs Electromagnetic Fields<br>**Places We Live:**<br>7. Far-Reaching Decisions<br>8. Regional Community Issues: The Ogallala Aquifer |
| **E1.2g** Identify scientific tradeoffs in design decisions and choose among alternative solutions. | **Project Learning Tree Activities**<br>**Municipal Solid Waste:**<br>1. The Waste Stream<br>2. Source Reduction<br>3. Recycing and Economics<br>**Focus On Risk:**<br>1. What is Risk?<br>2. Things aren't Always What They Seem Chlorine: Looking at Tradeoffs<br>**Places We Live:**<br>2. Community Character<br>3. Mapping Your Community Through Time<br>7. Far-Reaching Decisions<br>8. Regional Community Issues: The Ogallala Aquifer |
| **E1.2j** Apply science principles or scientific data to anticipate effects of technological design decisions. | **Project Learning Tree Activities**<br>**Municipal Solid Waste:**<br>1. The Waste Stream<br>2. Source Reduction<br>**Focus On Risk:**<br>1. What is Risk?<br>4. Risk Assessment: Tools of the Trade Electromagnetic Fields<br>**Places We Live:**<br>4. Neighborhood Design<br>5. Green Space<br>7. Far-Reaching Decisions<br>8. Regional Community Issues: The Ogallala Aquifer |

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| **E1.2k** Analyze how science and society interact from a historical, political, economic, or social perspective. | **Project Learning Tree Activities**<br>**Municipal Solid Waste:**<br>3. Recycing and Economics<br>**Focus On Risk:**<br>1. What is Risk?<br>2. Things aren't Always What They Seem<br>6. Weighing the Options: A Look at Tradeoffs<br>Chlorine: Looking at Tradeoffs<br>**Places We Live:**<br>2. Community Character<br>3. Mapping Your Community Through Time<br>4. Neighborhood Design<br>5. Green Space<br>6. A Vision for the Future<br>7. Far-Reaching Decisions<br>8. Regional Community Issues: The Ogallala Aquifer |

## STANDARD E2: EARTH SYSTEMS

Students describe the interactions within and between Earth systems. Students will explain how both fluids (water cycle) and solids (rock cycle) move within Earth systems and how these movements form and change their environment. They will describe the relationship between physical process and human activities and use this understanding to demonstrate an ability to make wise decisions about land use.

**E2.1 Earth Systems Overview**

The Earth is a system consisting of four major interacting components: geosphere (crust, mantle, and core), atmosphere (air), hydrosphere (water), and biosphere (the living part of Earth). Physical, chemical, and biological processes act within and among the four components on a wide range of time scales to continuously change Earth's crust, oceans, atmosphere, and living organisms. Earth elements move within and between the lithosphere, atmosphere, hydrosphere, and biosphere as part of geochemical cycles.

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| **E2.1C** Explain, using specific examples, how a change in one system affects other Earth systems. | **Project Learning Tree Activities**<br>**Biodiversity:**<br>1. Global Invaders<br>2. Protected Areas: Issues and Analysis<br>3. Potatoes, Pesticides, and Biodiversity |

**E2.3 Biogeochemical Cycles**

The Earth is a system containing essentially a fixed amount of each stable chemical atom or element. Most elements can exist in several different states and chemical forms; they move within and between the geosphere, atmosphere, hydrosphere, and biosphere as part of the Earth system. The movements can be slow or rapid. Elements and compounds have significant impacts on the biosphere and have important impacts on human health.

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| **E2.3b** Explain why small amounts of some chemical forms may be beneficial for life but are poisonous in large quantities (e.g., dead zone in the Gulf of Mexico, Lake Nyos in Africa, fluoride in drinking water). | **Project Learning Tree Activities**<br>**Biodiversity:**<br>3. Potatoes, Pesticides, and Biodiversity |
| **E2.3c** Explain how the nitrogen cycle is part of the Earth system. | **Project Learning Tree Activities**<br>**Municipal Solid Waste:**<br>4. Composting |

**E2.4 Resources and Human Impacts on Earth Systems**

The Earth provides resources (including minerals) that are used to sustain human affairs. The supply of nonrenewable natural resources is limited and their extraction and use can release elements and compounds into Earth systems. They affect air and water quality, ecosystems, landscapes, and may have effects on long-term climate. Plans for land use and long-term development must include an understanding of the interactions between Earth systems and human activities.

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| **E2.4A** Describe renewable and nonrenewable sources of energy for human consumption (electricity, fuels), compare their effects on the environment, and include overall costs and benefits. | **Project Learning Tree Activities**<br>**Biodiversity**<br>2. Protected Areas: Issues and Analysis<br>**Municipal Solid Waste:**<br>1. The Waste Stream<br>2. Source Reduction<br>3. Recycing and Economics<br>5. Waste-to-Energy |
| **E2.4B** Explain how the impact of human activities on the environment (e.g., deforestation, air pollution, coral reef destruction) can be understood through the analysis of interactions between the four Earth systems. | **Project Learning Tree Activities**<br>**Biodiversity:**<br>1. Global Invaders<br>2. Protected Areas: Issues and Analysis<br>3. Potatoes, Pesticides, and Biodiversity<br>**Municipal Solid Waste:**<br>1. The Waste Stream<br>2. Source Reduction<br>3. Recycing and Economics<br>5. Waste-to-Energy<br>6. Landfills<br>7. Where Does Your Garbage Go?<br>8. Success Stories and Personal Choices |
| **E2.4d** Describe the life cycle of a product, including the resources, production, packaging, transportation, disposal, and pollution. | **Project Learning Tree Activities**<br>**Biodiversity:**<br>3. Potatoes, Pesticides, and Biodiversity<br>**Municipal Solid Waste:**<br>1. The Waste Stream<br>2. Source Reduction<br>3. Recycing and Economics |

# STANDARD E4: THE FLUID EARTH

Students explain how the ocean and atmosphere move and transfer energy around the planet. They also explain how these movements affect climate and weather and how severe weather impacts society. Students explain how long term climatic changes (glaciers) have shaped the Michigan landscape. They also explain features and processes related to surface and ground- water and describe the sustainability of systems in terms of water quality and quantity.

## E4.p1 Water Cycle (prerequisite)

Water circulates through the crust and atmosphere and in oceans, rivers, glaciers, and ice caps and connects all of the Earth systems. Groundwater is a significant reservoir and source of freshwater on Earth. The recharge and movement of groundwater depends on porosity, permeability, and the shape of the water table. The movement of groundwater occurs over a long period time. Groundwater and surface water are often interconnected. (prerequisite)

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| **E4.p1B** Analyze the flow of water between the elements of a watershed, including surface features (lakes, streams, rivers, wetlands) and groundwater. (prerequisite) | **Project Learning Tree Activities**<br>**Biodiversity:**<br>3. Potatoes, Pesticides, and Biodiversity<br>**Municipal Solid Waste:**<br>6. Landfills<br>**Places We Live:**<br>8. Regional Community Issues: The Ogallala Aquifer |

## E4.1 Hydrogeology

Fresh water moves over time between the atmosphere, hydrosphere (surface water, wetlands, rivers, and glaciers), and geosphere (groundwater). Water resources are both critical to and greatly impacted by humans. Changes in water systems will impact quality, quantity, and movement of water. Natural surface water processes shape the landscape everywhere and are affected by human land use decisions.

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| **E4.1B** Explain the features and processes of groundwater systems and how the sustainability of North American aquifers has changed in recent history (e.g., the past 100 years) qualitatively using the concepts of recharge, residence time, inputs, and outputs. | **Project Learning Tree Activities**<br>**Places We Live:**<br>8. Regional Community Issues: The Ogallala Aquifer |
| **E4.1C** Explain how water quality in both groundwater and surface systems is impacted by land use decisions. | **Project Learning Tree Activities**<br>**Biodiversity:**<br>3. Potatoes, Pesticides, and Biodiversity<br>**Municipal Solid Waste:**<br>6. Landfills<br>**Places We Live:**<br>8. Regional Community Issues: The Ogallala Aquifer |

## STANDARD E5: THE EARTH IN SPACE AND TIME

Students explain theories about how the Earth and universe formed and evolved over a long period of time. Students predict how human activities may influence the climate of the future.

**E5.p1 Sky Observations (prerequisite)**

Common sky observations (such as lunar phases) can be explained by the motion of solar system objects in regular and predictable patterns. Our galaxy, observable as the Milky Way, is composed of billions of stars, some of which have planetary systems. Seasons are a result of the tilt of the rotation axis of the Earth. The motions of the moon and sun affect the phases of the moon and ocean tides. (prerequisite)

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| **E5.p1C** Explain how a light year can be used as a distance unit. (prerequisite) | **Project Learning Tree Activities**<br>**Focus On Risk:**<br>5. Communicating Risk |