**Human Impacts on Local Water Resources**

Developed for the Teacher Professional Learning (TPL) Workshop:

A collaboration between the Natural Resources and Education Departments at the

University of Connecticut

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| *This unit planning template was developed in alignment with Stroupe and Windschitl’s (2015) framework for* [*Ambitious Science Teaching*](http://ambitiousscienceteaching.org/) *that focuses on “1) planning a unit around a “big science idea”, 2) eliciting and activating students’ ideas about a puzzling phenomenon (for the purpose of adapting instruction), 3) helping students make sense of science activities, and 4) pressing students to construct evidence-based explanations” (p. 1). As such, each of these facets of AST are identified below.* |

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**PART 1: PLANNING A UNIT AROUND “BIG SCIENCE IDEAS”**

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| Group Member Science Area Focus Primary: High School Earth Science, Secondary: Life Science and Engineering  **Natural Systems and Natural Resource Management, Reducing Human Impacts on Natural Systems, Sustainability** |

**What core ideas do you want to teach?**

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| [**High School Disciplinary Core Idea(s) focus of Lesson**](http://ngss.nsta.org/DisciplinaryCoreIdeasTop.aspx)**:** (Identify DCI at the bullet point(s) grade band progression) [**(click here for related middle school DCI)**](https://docs.google.com/document/d/12sR5CcefcggFHFL_8_V4tfidnH7Zc2WIhtKL-Rzf1hU/edit)  **Earth Science - ESS3.C: Human Impacts on Earth Systems**   * The sustainability of human societies and the biodiversity that supports them requires responsible management of natural resources. * Scientists and engineers can make major contributions by developing technologies that produce less pollution and waste and that preclude ecosystem degradation.   **Life Science: - 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.   **Life Science - 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. * 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.   **Life Science - 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 invasivespecies, 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.   **Engineering Design - 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) |

**What are the Performance Expectations that you are working toward?**

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| [**High School Performance Expectation(s**](http://www.nextgenscience.org/)**):** [(Click here for related middle school PE’s)](https://docs.google.com/document/d/1ikHERaZLkwqStIMNWVEaArJFUQc5BXgnM50CHf8biAU/edit)  (Search by DCI)  **Earth Science: 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.*]  **Earth Science: HS-ESS3-4. Evaluate or refine a technological solution that reduces impacts of human activities on 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).]  **Life Science: 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.]  **Life Science: HS-LS2-6. Evaluate the claims, evidence, and reasoning that the complex interactions in ecosystems maintain relatively consistent numbers and types of organisms in stable conditions, but changing conditions may result in a new ecosystem.** [Clarification Statement: Examples of changes in ecosystem conditions could include modest biological or physical changes, such as moderate hunting or a seasonal flood; and extreme changes, such as volcanic eruption or sea level rise.]  **Life Science: 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.]  **Engineering Design: 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.**  **Engineering Design: 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.** |

**Why is/are this a core idea(s) in science?**

Identify the DCI in *A Framework for K-12 Science Education: Practices, Crosscutting Concepts and Core Ideas (2012)* using the following links:

Physical Science:<https://www.nap.edu/read/13165/chapter/9>

Life Science:<https://www.nap.edu/read/13165/chapter/10>

Earth and Space Science:<https://www.nap.edu/read/13165/chapter/11>

Engineering, Technology, & Applications of Science:<https://www.nap.edu/read/13165/chapter/12>

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| What does the [*Framework*](https://www.nap.edu/read/13165/chapter/1) say about the core idea(s)?  *How do humans change the planet?*  (p. 194) Humans affect the quality, availability, and distribution of Earth’s water through the modification of streams, lakes, and groundwater. Land use patterns for agriculture and ocean use patterns for fishing are affected not only by changes in population and needs but also by changes in climate or local conditions. Thus humans have become one of the most significant agents of change in the near-surface Earth system. And because all of Earth’s subsystems are interconnected, changes in one system can produce unforeseen changes in others. Some negative effects of human activities are reversible with informed and responsible management. The sustainability of human societies and of the biodiversity that supports them requires responsible management of natural resources not only to reduce existing adverse impacts but also to prevent such impacts to the extent possible. Scientists and engineers can make major contributions by developing technologies that produce less pollution and waste and that preclude ecosystem degradation.  *( P. 196)* ***By the end of grade 12.*** The sustainability of human societies and the biodiversity that supports them requires responsible management of natural resources. Scientists and engineers can make major contributions—for example, by developing technologies that produce less pollution and waste and that preclude ecosystem degradation. When the source of an environmental problem is understood and international agreement can be reached, human activities can be regulated to mitigate global impacts (e.g., acid rain and the ozone hole near Antarctica). |

**Summary:**

After reading through the specific DCI focus/foci of your unit, write a summary in your own words that describes why this is a/these are core idea(s) in science, along with what facets of this core idea(s) are most important for students to understand:

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| Summary: ([Guidance](https://drive.google.com/file/d/0Bze27OH27nfvTDl2eWRZUU9CMXM/view?usp=sharing) and [Example](https://drive.google.com/file/d/0Bze27OH27nfvbWpoVlBKcTYyb0k/view?usp=sharing) of Unpacking)  Humans impact the planet by producing pollution and waste and by changing the landscape. These changes can impact the ability of the planet’s natural systems to sustain life. Changes can also impact biodiversity. Through better understanding the planet’s natural systems for sustaining life (e.g., groundwater purification) and human impacts on these systems, we can work to develop technologies and practices to mitigate the impact of human waste, pollution, and land-use decisions that impact biodiversity. |

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**ANCHORING PHENOMENON**

**Identify a scientifically rich, complex phenomena** that will require students to use multiple principles that are central to the DCI(s) to explain (an occurrence or event that happens(ed) in the world)

[This will serve as the reason for engaging in the unit.] Resources for identifying anchoring phenomena ([What are phenomena](https://drive.google.com/file/d/0Bze27OH27nfvZ1RMNndtWWZCVlE/view?usp=sharing), [How Might I Identity a Phenomenon](https://static1.squarespace.com/static/56e316c61bbee06d13210ed6/t/583090212e69cfe8eabe413f/1479577633966/AHeuristicforPhenomena.pdf), [What are some Possible Phenomena](https://www.ngssphenomena.com/), [What are qualities of Good Phenomena?](http://researchandpractice.org/wp-content/uploads/2016/03/Anchor_Design_Problems_March2016.pdf))

* Highlighted areas throughout indicate places to modify for your own water source

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| Describe the Anchoring Phenomenon chosen to anchor the unit:  [TO BE REVISED FOR LOCAL CONTEXTS LAST DAY OF TPD] Learners will be shown aerial images of three distinctly different areas on the UConn Storrs campus (i.e., google earth images) and asked to predict the water quality and biodiversity at each site, the reasons for their predictions and explain any differences they believe will be found when comparing the three sites.  Link to: [Aerial Image of 3 sites](https://drive.google.com/open?id=0B2yfllHDY7t3MGVZMk9qamk2cjQ)  Area 1: Eagleville Brook [Google Earth](https://earth.google.com/web/@41.80749679,-72.26262714,172.33726573a,981.91593743d,35y,0h,0t,0r)  Area 2: Horsebarn Hill [Google Earth](https://earth.google.com/web/@41.81150192,-72.24313668,154.28635748a,1972.39312381d,35y,-0h,0t,0r)  Area 3: Fenton River [Google Earth](https://earth.google.com/web/@41.8336426,-72.24078074,108.54477627a,2018.13439428d,35y,-0h,0t,0r) |

**Identification of** [**Crosscutting Concept(s)**](http://www.nextgenscience.org/sites/default/files/Appendix%20G%20-%20Crosscutting%20Concepts%20FINAL%20edited%204.10.13.pdf) that can also be used to understand/explain the phenomenon: (explain this connection):

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| **Crosscutting Concepts:**  Cause and effect: Mechanism and explanation. Events have causes, sometimes simple, sometimes multifaceted. A major activity of science is investigating and explaining causal relationships and the mechanisms by which they are mediated. Such mechanisms can then be tested across given contexts and used to predict and explain events in new contexts  Patterns. Observed patterns of forms and events guide organization and classification, and they prompt questions about relationships and the factors that influence them.  Stability and change. For natural and built systems alike, conditions of stability and determinants of rates of change or evolution of a system are critical elements of study  Scale, proportion, and quantity. In considering phenomena, it is critical to recognize what is relevant at different measures of size, time, and energy and to recognize how changes in scale, proportion, or quantity affect a system’s structure or performance.  Systems and system models. Defining the system under study—specifying its boundaries and making explicit a model of that system—provides tools for understanding and testing ideas that are applicable throughout science and engineering  Structure and function. The way in which an object or living thing is shaped and its substructure determine many of its properties and functions.  Specific to this unit:  1. The cause and effect relationship between human development and the disruption of the water cycle will be explored.  2. Landscape patterns and change over time and at different scales will be examined using geospatial technology and earth science data (land cover).  3. The water resource is part of a system that include the hydrosphere, geosphere, atmosphere and biosphere. Systems occur at different scales within boundaries, but may interact with other systems and be parts of larger systems.  4. The structure and function of green infrastructure will be demonstrated in the field exercise. |

**Provide a Target Explanation of Phenomenon** [Provide a written explanation of the phenomenon, being sure to consider how the role of the identified crosscutting concept(s) you identified above as part of the explanation] (Note: the explanation should identify how science principles are coordinated to explain the occurrence or event that happened in the world) (ex. [target explanation for explaining ramps with models](https://drive.google.com/file/d/0Bze27OH27nfvQ0s3VzQ2aWRIc2s/view?usp=sharing); [target explanation of rocket launch](https://drive.google.com/file/d/0Bze27OH27nfvZ09IQWVMXzY1QU0/view?usp=sharing)):

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| **Target explanation of phenomena:**  The three systems are located geographically very close to each other, but differ in fundamental ways. Eagleville Brook is considered an urban site since much of it is surrounded by the University of Connecticut. The area has a high human impact from development and has a high level of impervious land cover. This causes precipitation to run off of paved areas such as buildings, roads and parking lots. The runoff flows into the brook carrying sediments, oil and other pollutants. The influx of chemicals into the brook decreases water quality and affects the organisms that live in the stream. This causes poor water quality and low biodiversity. The increase in runoff also lowers the amount of water infiltrating the soil, becoming purified and entering the groundwater reservoirs. Diverse *Low Impact Development* (LID) projects have been implemented in this area to reduce the adverse human impacts. These projects reduce the amount of runoff into the brook by increasing pervious surfaces. Examples include: Parking bioretention, terraced bioretention, green roofs, porous pavement, porous concrete, and rain gardens.  Roberts Brook at the Horsebarn Hill site is a brook that runs from Mirror Lake under route 195 and through agricultural pasturelands. As such, the site is a mix of urban and agricultural landscapes. This site also has a high impact from humans but in a different way from Eagleville Brook and the water quality and biodiversity is not as degraded. The runoff from precipitation flowing into the water resource carries some pollution from parts of UCONN’s campus and roads, but there is not as high a level of impervious surfaces surrounding the site. The runoff from the agricultural lands is expected to be high in nutrients such as phosphorous and nitrogen mostly from animal waste. The high nitrogen levels can cause excessive growth of aquatic plants and algae. As these decompose they use up dissolved oxygen that aquatic animals need. This can adversely affect the organisms living in the stream and decrease the biodiversity.  The final site, Fenton river off of Old Turnpike Road is a forested site and has the least adverse human impact of the three sites. There are few roads and human residences, and very little impervious land cover. There is little runoff from impervious surfaces and so the water quality and biodiversity at this site is the highest of the three. Precipitation in the forested lands infiltrates the soil, purifies and enters the groundwater reservoirs. This area is a protected forest which helps maintain its high level of ecological services such as, purification of air and water, maintaining biodiversity, soil and vegetation renewal, greenhouse gas mitigation and is aesthetically pleasing. |

**Develop a Driving Question** that will help bound the work of the unit and frame the anchoring phenomenon for the students. The question should be causal and not easily answered.

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| Driving questions:   * From looking at the aerial photos and exploring with Google Earth, what do you predict is the state of the local water resources (water quality and biodiversity) in the three chosen areas and why? * How can you determine and explain the state of these local water resources? * Why is it important to manage water resources? * What actions could be taken to protect and/or reduce adverse human impacts on the water resources in these three areas? |

**Construct an example Final Model** that you would expect your students to develop over the course of the unit. Be sure to include the components of the system, connections between those components, the “unseen” mechanisms at work, and labels. This will help you develop a template and/or conventions for the students’ models.

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| Example Final Model [[Example](https://drive.google.com/file/d/0Bze27OH27nfvcGoyYy02TVhjVjA/view?usp=sharing)]: *(insert drawing or image here)*   * Sample Model Area 1: [Eagleville Brook](https://drive.google.com/open?id=0B2yfllHDY7t3S2haM205dmpWak0) |

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| **NOTE: BELOW IS A GENERALIZABLE MODEL SCIENTISTS USED TO DEVELOP THE UNIT**  Screen Shot 2017-05-15 at 1.46.22 PM.png |

**From your Target Explanation, identify concepts within the explanation** that are central to students explaining the phenomenon [this can serve as an early ‘Gotta Have List’ that you go into the lesson considering, while also serving as a guide for identifying science activities students can engage in as part of the unit after initial modeling to work on developing more sophisticated explanations of the phenomenon] ([Example](https://drive.google.com/file/d/0Bze27OH27nfvVVNCdE5TbEMwR0k/view?usp=sharing)):

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| **Concept A:** The connection between human land-use and habitat loss and degradation of water  **Concept B:** Connections between Earth systems and relationshipto water use, water cycle disruption, and point and nonpoint pollution  **Concept C:** Humans benefit from many of the products and services of ecosystems. Human decisions and activities affect ecosystem services.  **Concept D:** Human decision making and actions, both behavioral and technological, can promote better stewardship and management |

**For each science principle identified above, choose one activity, reading, video, simulation, or investigation that will help students understand this principle** and begin to see its usefulness in explaining the anchoring phenomenon. Do this for each concept below: [possible resources: [Phet Simulations](https://phet.colorado.edu/), [NGSS Pathfinder](http://concord.org/ngss/), [National Science Digital Library](https://nsdl.oercommons.org/)]

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| **Concept A:** (to show how human land-use can lead to habitat loss and degradation):   * [Anthropocene story map tour](http://story.maps.arcgis.com/apps/MapJournal/index.html?appid=d14f53dcaf7b4542a8c9110eeabccf1c) (Optional) * [Connecticut’s Changing Landscape Story Map](http://clear3.uconn.edu/viewers/ctstory/): * [Streamstats Connecticut](https://water.usgs.gov/osw/streamstats/connecticut.html) * [Luck Isn’t Enough: the Fight for Clean Water (video)](http://nemo.uconn.edu/tools/luck_video.htm)   **Concept B:** Introduction to water cycle basics and role of land use in water resource health. Focus on Connecticut:   * Field tour in different landscapes with water sampling and analysis * [Wikiwatershed Map my Watershed](https://wikiwatershed.org/) * [Wikiwatershed Micro Site Storm Model](https://micro.app.wikiwatershed.org/)   Photos, headlines, [CT ECO](http://www.cteco.uconn.edu/) and etc. to demonstrate water degradation issues  [UConn NEMO Fact Sheet #3: Impacts of Development on Waterways](http://nemo.uconn.edu/publications/fact_sheets/nemo_fact_sheet_3_s.pdf)  **Concept C:** [Accounting for Nature’s Benefits:The Dollar Value of Ecosystem Services](https://www.ncbi.nlm.nih.gov/pmc/articles/PMC3339477/)  [Neglected biodiversity and the current extinction crisis](http://www.actionbioscience.org/biodiversity/neglected_biodiversity_and_the_current_extinction_crisis.html#.WUPHhZ2t8-M.email)  **Concept D:**  Student Low Impact Development (LID) school engineering design projects focused on water conservation, treatment or green infrastructure  Technical and Behavioral improvements:   * [Field tour of campus (LID examples);](http://uconnclear.maps.arcgis.com/apps/MapTour/index.html?appid=990a5036bb604c47af25dcd082e01ca9) * [Do It Yourself: Communities Respond to an Impervious cover TMDL](http://nemo.uconn.edu/ic-guide/index.htm) * [Eagleville Brook Impervious cover TMDL](http://clear.uconn.edu/projects/tmdl/) * [NEMO Developing a Sustainable Community](https://drive.google.com/open?id=0B2yfllHDY7t3WDJaWWtxMXl4UTA) * [NEMO Rain Garden website](http://nemo.uconn.edu/raingardens/index.htm) * [NEMO Rain Garden Smart Phone App](http://nemo.uconn.edu/tools/app/raingarden.htm) * [State of LID in CT (Story Map)](http://uconnclear.maps.arcgis.com/apps/MapJournal/index.html?appid=47a764117e33490583354e19f63337ca) * [LID Photo Gallery](http://nemo.uconn.edu/tools/LIDgallery.htm) * [National LID Atlas](http://lidmap.uconn.edu/)   Legal and Decision-making Frameworks:   * [Summary of Clean Water Act](https://www.epa.gov/laws-regulations/summary-clean-water-act) * [UConn NEMO Fact Sheet #8: They Can’t Do That, Can They? (How is Land Use Decided in Your Connecticut Town?)](http://nemo.uconn.edu/publications/fact_sheets/nemo_fact_sheet_8_s.pdf) * [Cuyahoga River Clip](https://youtu.be/tZA9OX2joUc) * [Why Rivers no Longer Burn](http://www.slate.com/articles/health_and_science/science/2012/12/clean_water_act_40th_anniversary_the_greatest_success_in_environmental_law.html) * [The Potential Big Impact of Trumps Clean Water Rollback](http://news.nationalgeographic.com/2017/03/waters-of-the-us-rule-conservation-colorado/) |

**Identify Previous Ideas and Resources** that might surface as students begin to reason about this phenomenon (use the [NGSS Disciplinary Core Idea Progressions](http://www.nextgenscience.org/sites/default/files/Appendix%20E%20-%20Progressions%20within%20NGSS%20-%20052213_0.pdf), [AAAS Science Literacy Maps](http://strandmaps.dls.ucar.edu/), and past experiences working with students around the principles (i.e., A, B, C…) above [these include ideas they may have learned previously or common ways students might think about one or more of these ideas]

**And**

**Identify Future Ideas and Resources** that learning in this unit will support. Use the [NGSS Disciplinary Core Idea Progressions](http://www.nextgenscience.org/sites/default/files/Appendix%20E%20-%20Progressions%20within%20NGSS%20-%20052213_0.pdf) and [AAAS Science Literacy Maps](http://strandmaps.dls.ucar.edu/) to identify what students will be able to learn when they have developed facility with the principles focused on in this unit:

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| Identify Previous Ideas and Reasoning:  **End of Grades 6-8:** Human activities have altered the biosphere, sometimes damaging it, although changes to environments can have different impacts for different living things. Activities and technologies can be engineered to reduce people’s impacts on Earth.  Water cycles among land, ocean, and atmosphere, and is propelled by sunlight and gravity. Density variations of sea water drive interconnected ocean currents. Water movement causes weathering and erosion, changing landscape features.  Humans depend on Earth’s land, ocean, atmosphere, and biosphere for different resources, many of which are limited or not renewable. Resources are distributed unevenly around the planet as a result of past geologic processes  Organisms and populations are dependent on their environmental interactions both with other living things and with nonliving factors, any of which can limit their growth.  Ecosystem characteristics vary over time. Disruptions to any part of an ecosystem can lead to shifts in all of its populations. The completeness or integrity of an ecosystem’s biodiversity is often used as a measure of its health.  Changes in biodiversity can influence humans’ resources and ecosystem services they rely on. |

**PART 2: ELICITING AND ACTIVATING STUDENTS’ IDEAS ABOUT A PUZZLING PHENOMENON (FOR THE PURPOSE OF ADAPTING INSTRUCTION)**

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**THE** [**TALK SCIENCE GOALS AND TALK MOVES**](https://drive.google.com/file/d/0Bze27OH27nfvWkxXOHQ2RkxsMGc/view?usp=sharing) **IS A RESOURCE FOR RESPONSIVENESS TO STUDENT THINKING THROUGHOUT THE UNIT . Additional resources are the** [**Talk Science Primer**](https://inquiryproject.terc.edu/shared/pd/TalkScience_Primer.pdf) **and the** [**Ambitious Science Teaching Discourse-Primer**](http://ambitiousscienceteaching.org/wp-content/uploads/2014/09/Discourse-Primer.pdf) **referenced next:**

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| *Eliciting students’ initial scientific hypotheses in order to plan for further instruction. The goal of this discourse is to draw out students’ understandings of a phenomenon (e.g. a bicycle rusting in the backyard) that is related to an important scientific idea (in this case chemical change or conservation of mass). After the lesson we analyze students’ ways of talking about it in order to adapt upcoming learning experiences (AST Discourse-Primer, 2015, p. 7.*) |

**Day 1:** Outline how you plan to engage students in creating/sharing their initial models that explain the anchoring phenomenon. How will you introduce the phenomenon and driving question? What is your plan for eliciting student initial models (e.g. group sizes, directions to students including some introduction to [what a model is](http://ambitiousscienceteaching.org/wp-content/uploads/2014/09/Models-and-Modeling-An-Introduction1.pdf) and what you want to be sure students do as they share their initial ideas-be sure to include where and how you will use ‘[Gotta Have Lists](https://drive.google.com/file/d/0Bze27OH27nfvSDhROUNmNnpsTm8/view?usp=sharing)’ (taken from [ambitiousscienceteaching.org](http://ambitiousscienceteaching.org)) to help focus students reasoning during this process. Include any videos, templates, webresources, etc. you might want to use. Describe how students will share their initial models with peers in small group and whole group discussions/sharing: ([Example Day 1](https://drive.google.com/file/d/0Bze27OH27nfvVEx0U2FCQXp4aVE/view?usp=sharing))

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| Outline Day 1:  **Day One – Introduction to Phenomenon**  **Learning Activities:** *Within each section below, identify the instructional grouping (whole class, small groups, pairs, individuals) you will use in each lesson segment and approximate time frames for each.*  **Initiation:** *Briefly describe how you will initiate the lesson. (Set expectations for learning; articulate to learners what they will be doing and learning in this lesson, how they will demonstrate learning, and why this is important; activate prior knowledge)*  The initiation of the lesson will be the introduction to the phenomenon (i.e., the three different sites on the UConn Campus). This should only take the first 10 minutes of class time.   * Initial discussion and sharing of ideas: [Teacher listens to students ideas, without making judgements about the ideas at this stage] The first component of the phenomenon presentation are three aerial photos of different areas on campus. When presented with the aerial photos, students should be asked What do you predict is the state of the local water resources in the three chosen areas and why? State can be described as the water quality and level of biodiversity. This will be the very beginning of eliciting student ideas.   *Through engaging with the phenomenon in this way, students are positioned to access and begin to build on their background knowledge regarding the water resources and those things that impact these resources and many of the ideas they come up with at this stage will likely make their way onto the initial Gotta Have List.*  **Lesson Development:** *Describe how you will develop the lesson, what you will do to model or guide practice, and the learning activities students will be engaged in order to gain the key knowledge and skills identified in the student learning objective(s).*  *Students will likely need to be introduced to what we mean by a scientific model (and told what is expected of them). An additional 5 minutes should be dedicated to this explanation. NSTA/NGSS resources can be used to explain, as well as providing students with a sample model (such as one of friction at a “zoomed in” level).*    After the phenomenon presentation, students will individually write initial explanations for what they think will be the state of the water resource at each site and why in their scientist notebook.  We will then transition into the body of the lesson by dividing students into small groups. The small groups will be predetermined by the teacher to meet individual student needs. The groups will consist of 3-4 students.  Once in groups, the students will be asked to brainstorm (5-7 minutes) some of their initial ideas about how they could answer this question (i.e., What do you predict is the state of the local water resources in the three chosen areas and why?). This will call upon their prior knowledge and require them to identify components that they suspect are involved, but that they’d like to know more about so that they could include them in their models. (Anticipating and eliciting students’ ideas; crafting next steps in instruction that account for students’ ideas and support students’ learning)  After the initial brainstorm, a class discussion (5-7 minutes) will be held to create the initial Gotta Have List [A list of ideas that are important to include in answers to the question about the phenomenon]. All contributions will be recorded on the board to start. Once everyone’s ideas have been shared, the class will evaluate the list and determine what they agree should be included in everyone’s initial models. (Anticipating and eliciting students’ ideas; crafting next steps in instruction that account for students’ ideas and support students’ learning)  The students will then be given 15-20 minutes constructing their initial models including elements of the Initial Gotta Have List.  After the initial models have been created, the class will circle the room as each group presents their initial model (~10 minutes).  **Closure:** Briefly describe how you will close the lesson and help students understand the purpose of the lesson. (Interact with learners to elicit evidence of student understanding of purpose(s) for learning and mastery of objectives)  The class will conclude with a group discussion of the initial models (5-7 minutes). Students will volunteer commonalities and identify elements of others’ models that they hadn’t thought of. Using students’ ideas, they will be asked what they would need to know to determine the actual states of the water resources and why they are that way. The teacher will then preview the investigations they will partake in over the next few days. (Evaluating student ideas; Crafting next steps in instruction that account for students’ ideas and support students’ learning)  **Note:** *Items in red represent where formative assessment is planned for as part of instruction. The following framework was used to think about and plan for formative assessment: (a) anticipating and eliciting students’ ideas, (b) evaluating students’ ideas, and (c) crafting next steps in instruction that account for students’ ideas and support students’ learning (Sabel, Forbes, & Zangori, 2015). As with the final unit assessment included below, the unit assessment strategy aligns well with the most recent National Research Council documents as they call on teachers to ensure that classroom assessments be an integral part of instruction that reinforces learning envisioned in the Framework and NGSS (NRC, 2017).* |

**PART 3: HELPING STUDENTS MAKE SENSE OF SCIENCE ACTIVITIES (WITH THE AIM OF USING SCIENCE PRINCIPLES BEHIND ACTIVITIES TO EXPLAIN ANCHORING PHENOMENON)**

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| *AST Discourse Strategies*  *• Making sense of data/information. The goal here is to help students recognize patterns in data, critique the quality of data, and to propose why these patterns exist. What, for example, is going on at the unobservable level that explains our observations?*  *• Connecting activities with big scientific ideas. The goal of this practice is to combine data-collection activities with readings and conversation in order to advance students’ understanding of a broader natural phenomenon. This conversation is different from the previous one, in that students are not trying to explain the outcome of an activity, but to relate the activity to a bigger science idea or puzzle that the unit is framed around. (AST Discourse-Primer, 2015, p. 7.*) |

**Day 2-10:** *(Include time needed for each activity included in Days 2-8) [use more or less days as needed for engaging students in science activities depending on what might be needed to explain the anchoring phenomenon]*

*Identify how you will ‘put on the table’ science principles (i.e., you identified above that are central to explaining the anchoring phenomenon (i.e., Principle A, B, C…) using science activities you identified for each principle above (e.g., activity, reading, video, simulation, investigation) that prioritizes students engaging in science and engineering practices to develop an understanding of the principle that will be helpful in later stages of the unit in explaining the anchoring phenomenon. Describe how you will use ‘Summary Tables [*[*1*](https://drive.google.com/file/d/0Bze27OH27nfvR0FFYkJ6UFBHZk0/view?usp=sharing)*,* [*2*](https://drive.google.com/file/d/0Bze27OH27nfvV0QweGJ4dXllMVk/view?usp=sharing)*]’ or* [*activities*](https://drive.google.com/open?id=0B-NUoj6UaD2Pc2NEVXZJSm1xTGM) *(taken from* [*ambitiousscienceteaching.org*](http://ambitiousscienceteaching.org)*) across these days/activities to help students keep a record of activities, ideas, and evidences that will be used later in the unit to revise their initial models of the anchoring phenomenon. (*[*Example Days 2-5*](https://drive.google.com/file/d/0Bze27OH27nfvVmI5RXBGRnNrMDg/view?usp=sharing)*)*

**Outline Day 2-10:**

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| **Day 2 -3**: **Determining Water Quality and Biodiversity**  [Sample Lesson Days 2 & 3](https://docs.google.com/document/d/1Cn1qhgVVj-ozJ5Den77dBozlWiaROjkCIseP4iibd1s/edit)   * Option 1: Field trip to site to make observations, collect water samples for water quality testing, and macroinvertebrate survey * Option 2: In class site photo observations (or google tour), sample water quality testing, determining key indicator macroinvertebrate species expected in each site   **Day 4-6**: **Modeling Water Flow through Ecosystems** -/water cycle basics/ water usage/water cycle disruption, Effects of different types of land cover, hydrologic soil type, agricultural activity, on runoff and water quality  [Sample Lesson Day 4 - 6](https://docs.google.com/document/d/1BK6eeeJMfiCv5Nt-m6iV32tqZ0VoyVqp9llfRPUH9Jc/edit)  **Day 7: Human Impact on Land and Water in CT -** CLEAR website and CT Changing Landscape Story Map - Students use online resources to investigate changing factors that contribute to the health of the 3 water resource sites since 1985  [Sample Lesson Day 7](https://docs.google.com/document/d/1uQ0azjYP8cXN7egv0Dld4qS79fLprCaDtvNH56dbBJA/edit#heading=h.gjdgxs)  **Day 8 & 9**: **Ecological Services**: Why is it important to manage natural resources such as land and water?  [Sample Lesson Day 8 & 9](https://docs.google.com/document/d/1H2M_VffDXjbU0jl5klmbWe4JSqEx84JvIqaLVKt0DPI/edit)  **Day 10**: **Human Decision Making**: Legislation - Clean Water Act  [Sample Lesson Day 10](https://docs.google.com/document/d/1iZSqedCDVDQ7uTzK7LaL764cKyfJ3jLHewicZSSNxoE/edit) |

**PART 4: PRESSING STUDENTS TO CONSTRUCT EVIDENCE-BASED EXPLANATIONS**

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| *AST Discourse Strategies*  *• Pressing students for evidence-based explanations. This discourse is designed to happen near the end of a unit, but elements of this conversation can also happen any time the teacher is trying to get students to talk about evidence. The goal of this discourse is to assist students in using multiple forms of evidence, gathered during a unit, to construct comprehensive explanations for a phenomenon that has been the focus of the unit.* |

In this part of the unit, students will engage in revisiting and negotiating (with the teacher) the Gotta Have List to be sure that it represents what they think should be included in the final models. Additionally, students should engage in refining their initial models by both referring to the finalized ‘Gotta Have List’ and ‘Summary Table’ that was developed across the unit. You might also consider having groups of students comment on other groups’ initial models with ‘Sticky Notes’ prior to students making final revisions to their group models (see ‘Sticky Notes [[1](https://drive.google.com/file/d/0Bze27OH27nfvcnZvdU43RWZZLVU/view?usp=sharing), [2](https://drive.google.com/file/d/0Bze27OH27nfvTl9EeFVlVFlzeWM/view?usp=sharing)]’ taken from [ambitiousscienceteaching.org](http://ambitiousscienceteaching.org)). Once students are ready to revise their models based on what they learned across the unit, be sure to identify how you will ensure that they use the Gotta Have Lists and Summary Tables as resources for supporting their final revisions. Be sure to include your complete plan for supporting student groups in revisiting their initial models (e.g. directions to students. Include any templates or resources you will use). ([Example Days 11-12](https://drive.google.com/file/d/0Bze27OH27nfvUmJBU1NGRHJ6bVk/view?usp=sharing))

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| **Day 11:** Revision of original model, discussion, and individual explanations  [Sample Lesson Day 11](https://docs.google.com/document/d/1S7B4PHhFRaOOO8808-4v4ZzvTtcVv8VZ9zhvtY3GmgY/edit#heading=h.gjdgxs)  **Day 12**: Class review of group models and building of class consensus model  [Sample Lesson Day 12](https://docs.google.com/document/d/13sfqiGPqE5Lz-jTZeWcld7irqbmoZyhWk9HHkd2oqaY/edit) |

**Construct a draft Summary Table** that includes each activity, the intended understandings from the activity, and how the activity helps develop an explanation for the anchoring phenomenon. See examples above. Adapt the table based on the number of activities in the unit.

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| **Activity**  **Include # class periods**  **(1 Class period = 45 - 50 min)** | **Patterns Observed** | **Explanation for Patterns** | **How it helps us explain the phenomenon (i.e., difference in water quality at two sites)** |
| Days 2 & 3  Field tours of sites with water sampling/ macroinvertebrate sampling **OR** In class analysis of site photos and water samples | Results specific to sites tested: Examples  \*Agricultural areas = High N & P = high algae  \*Forested areas = low N & P = low algae  \*Urban areas = high impervious areas /Low bank vegetation = high turbidity | Agricultural areas use fertilizers and pesticides which can run off into local waters  Farm animals produce manure that can go into local water resources  Forested areas provide absorption and natural pollutant processing for rainfall and surface waters.  Urban areas have high runoff into local water resources due to paved areas | Human activity in the local water resources’ immediate surroundings can affect water quality in different ways.  Examples: increasing chemicals and sediments, |
| Day 4:  Wikiwatershed modeling  Micro-site modeling:  Students look at the effects of different land types and soils on Water-cycle (precipitation, evapotranspiration, infiltration and runoff) | The more developed the land, the less water infiltrates the soil  Sands and gravelly sands have the highest rates of infiltration and clays have the lowest | Developed land has less vegetation and more paved areas. There is less area for water to infiltrate and so it runs off into local water resource.  The larger the sediment size the more spaces between which allows for infiltration | Type of land cover and hydrologic soil group affects water infiltration, runoff, and evapotranspiration and can disrupt the normal flow of water through the water cycle |
| Day 5 & 6:  Wikiwatershed Modeling  Model My Watershed:  Students model their site and test different scenarios with conservation practices | Examples:  Rain garden= decreased runoff  No Till Ag = increased infiltration  Porous paving - decreased runoff and increased filtration | The addition of different conservation practices allow for water to infiltrate the soil which decreases runoff | Decreasing runoff decreases the amounts of chemicals and sediments entering the health of the local water resources |
| Day 7:  CT Changing Landscape Story Map  StreamStats | Between 1985 and 2010, CT: Lost 6.5% of its forested land  Lost 5.3% of core forest  Lost 15% of agricultural lands  22% of land with good agricultural soils to other uses  Lost 39.5square miles of natural vegetation in streamside corridors  Gained 149 square miles of developed land  Gained 75 square miles of turf and grass land  25% of watersheds have impervious cover levels that are indicative of poor health  Connecticut’s population has grown from about 2 million in 1950 to about 3.6 million today. | Increase in population growth causes an increase in the amount of developed land. People use forest and agricultural lands to build houses and commercial areas. Developed areas have more impervious cover | Ct’s landscape changed over the 25 years from 1985 to 2010.  Overall forest cover is tied to watershed health  Inner or “core” forest areas, insulated from development and roads by surrounding forest, are known by ecologists to be important for many species of both plants and animals.  Riparian corridors are environmentally important areas that provide stream stability, pollutant removal, and critical habitat for both aquatic and terrestrial wildlife. Research indicates that forested riparian areas are an important factor in maintaining stream health, and that riparian restoration can have a positive impact on water quality. |
| Day 8 & 9: Ecosystem goods and Services | Undeveloped land has more ecosystem services than developed land | Developed land has more impervious surfaces and less habitat for a variety of wildlife - degrades ecosystem | Fenton river area has highest water quality and highest ecosystem services |
| Day 10: Legislation -  Connecticut Changing Landscape Story map  Clean Water Act | 169 Towns in CT that control land use - Wide range of patterns of new development  Water quality in large rivers, lakes and stream across the US has improved in the past 45 years | Technologies, behaviours, and laws are available to support water stewardship and management  Legislation such as the Clean Water Act has protected navigable waters from point source pollution | We can examine whether recognizable technologies and behaviors are visible that may help explain the differences in the two areas water quality and potentially make recommendations that may help with future stewardship and management in the two areas.  Non- point source pollution such as runoff has been harder to reduce through legislation aimed at water resources and must take land use into account |
| Optional: Global Impacts - Anthropocene Story Map Tour | Globally ecosystems have been stressed | Increase in human population and human activities have stressed ecosystems across the planet | More humans increase activities that degrade a variety of ecosystems that affect water resources |
| Days 10 - 15 Technological LID Research and Design Project | Specific to site and problem | Specific to site and problem Results specific to sites tested | Designs decrease the human impact on water resources by decreasing water runoff and increasing soil infiltration |

**Individual Student Evidence-Based Explanation.**  As an initial part of students summative assessment of the unit, consider asking students to develop a written evidence-based explanation of the anchoring phenomenon. In this, consider asking them to ensure they include reference to all important ideas included in the final class Gotta Have List and Summary Table. And, consider asking them to ensure they use all evidence chronicled in the rows of the summary tables (e.g., patterns and explanations for patterns) in their written explanations.

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| Plan for individual student evidence-based explanation:  For homework or in class, students will develop individual written evidence-based explanations of the anchoring phenomenon (their explanation for the differing water quality at the three sites). In this, students are asked to ensure they include reference to all important ideas included in the final class Gotta Have List and Summary Table. And, students will also be asked to ensure they use all evidence chronicled in the rows of the summary tables (e.g., patterns and explanations for patterns) are included in their written explanations. |

**PART 5: APPLYING WHAT WE LEARNED TO A REAL WORLD PROBLEM THROUGH ENGINEERING DESIGN**

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| **Day 13**: Researching Low Impact Development (LID) to protect or improve these resources  [Sample Lesson Day 13](https://docs.google.com/document/d/1pE29qmhxxvnMP9aXNBrL-ISONQfkg4CJ5YEtrF1Z9qs/edit)  **Day 14**: Initiating Design of LID project for school’s water resource  [Sample Lesson Day 14](https://docs.google.com/document/d/1ZUukocOE2UEXCOKmsVkq_M-uIsSld4w5LOJ_ciPhBxE/edit)  **Day 15**- ?: Designing solution and building prototype[optional] and Presenting  [Sample Lesson Day 15:](https://docs.google.com/document/d/1pNYWj3u8vRyl_Oqda931y3rIuC2-sI3iq-_YW7cq_-M/edit) |

**PART 6: ASSESSMENT OF STUDENT LEARNING**

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**Resource-Rubric** [EXAMPLE](https://drive.google.com/file/d/0Bze27OH27nfvd1JVLXlpNzlTRzg/view?usp=sharing) as Possible Resource for the final group or individual student evidence-based explanations. This rubric was developed by using the principles identified above that were important for explaining the anchoring phenomenon and using these as indicators for the rows. The levels of each indicator is then assessed by considering the extent to which students or groups models or explanations are useful in explaining the anchoring phenomenon using the principle of each row.

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| Rubric:  [Sample Rubric for TPL Summative Final Model Assessment](https://drive.google.com/open?id=1h7Geozk8xZwY0_tAHtB9q5fmeZnATCXlXzTRdO78pyI) |

**NGSS ASSESSMENT DEVELOPMENT TEMPLATE**

**(UNIT SUMMATIVE ASSESSMENT)**

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| *This NGSS Assessment Development Template was developed in alignment with* [*Creative Commons by the Research + Practice Collaboratory, 2016*](http://researchandpractice.org/wp-content/uploads/2016/02/StepsToDesigningaThreeDimensionalAssessment_v4.pdf)*. These five steps were designed to help teams develop assessment tasks.*   * *Step 1: Define what you will assess by analyzing relevant sections of A Framework for K-12 Science Education and crafting learning* ***claims****.* * *Step 2: Brainstorm Possible* ***Scenarios*** *for Eliciting Student Understanding.* * *Step 3: Use Task Formats to Build* ***Questions*** *to Engage Students with the Scenario.* * *Step 4: Imagine the Range of Possible* ***Student Responses*** *to the Questions.* * *Step 5: Share, Review, and Revise.* |

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**STEPS TO DESIGNING A THREE DIMENSIONAL ASSESSMENT**

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**Step 1: Define what you will assess by analyzing relevant sections of *A Framework for K-12 Science Education* and crafting learning claims.**

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| [Claim:](https://drive.google.com/open?id=0B5Sa5NkXUEdhbmZVazZVZVh4bXc) Using the original framework text, identify learning claims you want to be able to make about what students know and can do.  **Students can apply their understanding of** the interrelationship of earth’s systems (hydrosphere, geosphere, atmosphere and biosphere)  **to explain how** human activity affects the health of water resources **as they draw on knowledge from** field studies of water resources including water quality sampling, computer simulations of storm events and watersheds **and** other information from readings and investigations utilizing geospatial technologies |

**Step 2: Brainstorm Possible Scenarios for Eliciting Student Understanding**

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| [Possible Scenario](https://drive.google.com/open?id=0B5Sa5NkXUEdhTEE2NUwydnBhb28): 3D assessment tasks are multi-component tasks meaning there is one single scenario with multiple questions for students to answer relating to that scenario. These scenarios should also be based upon a new but related phenomenon. Brainstorm multiple scenarios and evaluate which is best for eliciting student understanding. Write a detailed description of the scenario and what you expect from students when approaching this scenario.  **Scenarios:** Watershed that starts in a forested area of the state, then passes through a small city and continues past agricultural lands before emptying in a bay of the ocean.   * Water resource site 1 - river flowing through an urban area with roads and commercial activity on each side. [Aerial image](https://drive.google.com/open?id=0B2yfllHDY7t3SHU4Y2F2bkN6ZmhHOWp3S19uZjlleFZtcGw4) * Water resource site 2 - river flowing through forested lands [Aerial image](https://drive.google.com/open?id=0B2yfllHDY7t3WTV1b0wwZU8yenRQZUI0a3hTY0g0SnhjelBJ) * Water resource site 3 - pond downhill from agricultural lands [Aerial Image](https://drive.google.com/open?id=0B2yfllHDY7t3WmdsZXMyQkhvSmp2MW13OElYRXExekVTTWFn)   **What is the health of this water resource and why?**   * For a new water resource site: give students an aerial map showing water resource site and watershed, and data about water quality parameters. [Water Quality Data for Site 1](https://docs.google.com/spreadsheets/d/1GBn5u2m1TwD_f9tz_9uGYA74jNspA9vtdHfbY3e4S-s/edit#gid=1046839299) * Students will decide what evidence is relevant to the health of the resource * Students will analyze the maps and data and use as evidence to make conclusions about the overall health of the water resource |

**Step 3: Use Task Formats to Build Questions to Engage Students with the Scenario**

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| [Questions (Using Task Formats)](http://researchandpractice.org/wp-content/uploads/2016/02/NGSSTaskFormats_March2016v3.pdf): Use the task formats in the Framework to help design specific questions for students to assess your claims. Keep in mind, scenarios should be accessible to all students and connect with their interests and experiences (Example [1](https://drive.google.com/file/d/0B5Sa5NkXUEdhaUp1blJ6ZE5YYlk/view)). Once you know the claim and scenario then you can go to this link and find which one of the practices matches with it.  ***NOTE: EXAMPLE QUESTIONS HAVE BEEN DESIGNED FOR EACH PRACTICE. IT MAY NOT BE NECESSARY TO USE ALL QUESTIONS.***  ***\*Select questions to create an assessment aligned with your unit objectives*** |

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| ***1. Asking Questions 3a****: Present students with a scientific phenomenon to be explained and a scientific question, then Ask students what questions we need to answer along the way to answer the scientific question, and Ask students to describe what evidence is needed to answer those questions might and how they help build toward an explanation of the phenomenon*.  **Example for Scenario 1:** Jose lives in a town that is bisected by a small river. Jose crosses a bridge over the river everyday to get to his favorite restaurant for lunch. He notices that the river has an oily sheen on the surface of that is worse some days than others. Jose wants to know what the oily sheen is and how it’s affecting the aquatic life in the river.   1. Write at least 3 questions that would need to be answered to determine the cause of the oily sheen.   ***Sample Student Response:***   * 1. ***What is the oily substance, where is it from and how is it getting into the stream?***   2. ***What is the overall water quality of the river? Is the water quality within normal parameters?***   3. ***How does the oily substance affect living things?***  1. For each question describe the evidence that would be needed to answer the question.   ***Sample Student Response***   * 1. ***Land use in watershed, stormwater management plan compliance***   2. ***Data from water quality testing of N, P, O, bacteria, macroinvertebrates sampling?***   3. ***Results from investigations into effects of substance on living things***   ***2. Developing Solutions 6A****: Present students with a textual description of a scenario of a need or desire of society and/ or the natural world, then Ask students to describe the problem, and Ask students to define the criteria and constraints for acceptable solutions to the problem.*  **Example for Scenario 2:** Due to an increase in population from a recently relocated high tech headquarters, new housing is needed in the area. A subdivision of around 50 homes is being proposed for an area of forested land bordering the river:   1. List 3 problems that the construction and maintenance of this subdivision may have on the health of the river?   ***Sample Student Response***   * 1. ***Runoff of fertilizers and pesticides from lawns into river***   2. ***Erosion of soil into river during construction***   3. ***Runoff of oil and other pollutants from impervious surfaces such as roads and driveways***  1. What are the criteria and constraints on any acceptable solutions?   ***Sample Student Response***   * 1. ***Criteria: Must keep runoff from lawns and roads from entering the river. Must minimize soil erosion during construction and keep soil out of river***   2. ***Constraints: size of lots, minimum length and width of roads and driveways, distance of roads and driveways from river, size of houses***   ***3. Developing and Using Models 4****: Present students with a textual description of an observable scientific phenomenon, then Ask students to draw and label the model components, interactions among components, and mechanisms in the model, and Ask students to write an explanation for the phenomenon, using the model as supporting evidence.*  **Example for Scenario 3:** A small pond located downhill from a farm growing vegetables has turned green, and slimy with an algal bloom. Many dead fish are floating on the top.   1. Draw and label a model of the pond **system** showing what has **caused** the algal bloom and the fish kill.    1. Include the relevant components of the **system**, the interactions between the components and the mechanism for the phenomenon.   ***Sample Student Response:***   * 1. ***Model should include:***      1. ***Relevant components in the ecosystem (farm with fertilizers, slope to pond, pond, algae, fish, bacteria, N,P, O, precipitation)***      2. ***Interactions - Precipitation causing runoff of water and fertilizers from farm into the pond.***      3. ***Uptake of N and P by plants leading to increased growth. Dead plants decaying by bacteria on the bottom. O being used up by bacteria decomposing algae. Fish not getting enough oxygen and dieing***   ***4. Constructing Explanations 5:***  *Present students with a model or representation of an observable scientific process or system, then Ask students to write a causal explanation for a relevant phenomenon using the model as supporting evidence*  **Example for Scenario 3:** Use Model above ( A small pond located downhill from a farm growing vegetables has turned green, and slimy with an algal bloom. Many dead fish are floating on the top).   1. Then write a **causal** explanation for the phenomenon referring to your model for supporting evidence.   **Sample Student Response:**   * 1. **Fertilizer from the farm containing N and P runs off during storms into the pond. The increase in N and P causing algae in the pond to grow very fast. When the algae die they sink to the bottom and decay through the action of bacteria. Bacteria use up oxygen in the chemical reactions that break down the algae into nutrients for the bacteria. The pond becomes depleted of oxygen. The fish do not have enough oxygen and suffocate.**   ***5. Planning and Carrying out Investigations 3****: Present students with a scientific phenomenon (or scientific model) to be explained and a scientific question, then Ask students to create an investigation plan to investigate the scientific phenomenon (or model), and Ask students to describe how the investigation will generate relevant patterns of evidence for answering the scientific question or for supporting the model.*  **Example for Scenario 3:**   1. Create an investigation plan to determine what is **causing** the algae to grow so abundantly in the above scenario: (a small pond located downhill from a farm growing vegetables has turned green, and slimy with an algal bloom and many dead fish are floating on the top.)   ***Sample Student Response:***   * 1. ***I would test the water in the pond for phosphate, nitrogen and oxygen and carbon dioxide ( plants need P, N, CO2 and O2 to grow) and animals need O2 to survive) to see if these nutrients were in the normal range. I would also set up collection stations to between the farm and the pond to collect water to test.***   2. ***I would set up a laboratory experiment to test the effect of each nutrient on the growth of algae and fish. I would create an aquatic environment in an aquarium where all variables would be held constant except for the one nutrient being tested (the independent variable.) I would test different concentrations of the chemical on both the fish and the algae separately to see how it affected their growth.***  1. Describe how the investigation will generate valid data to support your model   ***Sample Student Response:***   * 1. ***The investigation will generate data on the effects of the nutrients in the pond on the growth of algae and fish. The model shows that increased amounts of P and N lead to increased plant growth, but this increased plant mass also uses up O2 when the plants die and bacteria use O2 during decomposition.***   ***6. Analyzing and Interpreting Data 4:***  *Describe an investigation, the phenomenon under investigation, and recorded observations from the investigation that are directly relevant to explaining the phenomenon, then Ask students to organize the data and describe how this organization helps them to analyze the data, and Ask students to identify and describe the patterns they see in the organized data, and/or Ask students to student to describe how the patterns of evidence in the data help to explain the phenomenon.*  **Example for Scenario 1:** We have been investigating how increasing population affects land use and land cover, and how this affects the health of our water resources. The following tables have data from 1950 to 2006 on the changing population land cover in Enfield, CT (Scenario 1).  Table 1: [Enfield Land Cover and Land Cover change 1985 - 2005](https://drive.google.com/open?id=0B2yfllHDY7t3QVVuSUE1UU5hV00)  Table 2: [Enfield Population Changes 1950 -2005](https://drive.google.com/open?id=0B2yfllHDY7t3amE5SnNRSEpWWkU)   1. Organize the data so that you can determine if there are any **patterns** to help explain how population affects land use and land cover.   **Sample Student Response:**   * 1. **Various types of graphs showing changes to land cover and population increases**  1. Describe how this organization helps you analyze the data   **Sample Student Response**   * 1. **Organizing the data into graphs with information from both tables helps to see the trends in increasing population and changes in type of land cover**  1. Identify and describe the **patterns** you see in the organized data. How do the **patterns** of evidence in the data help to explain the health of the water resource?   **Sample Student Response:**   * 1. **As the population in Enfield increased, the amount of developed land increased. Before being developed, this land was agricultural and forested. This would have affected the health of the Connecticut River as the increase in developed land would increase the amount of impervious cover leading to more runoff of contaminated water into the river.**   ***7. Using Mathematics and Computational Thinking 6:***  *Present students with a large data set from an investigation, the question the data are intended to answer, and computer tools (e.g., a spreadsheet) for analyzing the data set, then Ask students to develop statistical summaries of the data set that help them answer the question about the dataset.*  **Example for Scenario 1**: What is the health of the Connecticut River at Enfield? Below is a data table of different water quality parameters recovered from a USGS gauge in the Connecticut River at Thompsonville (Enfield.) The data is from January to June of 2017 and each month is on a separate tab.   1. Analyze the data and include statistical summaries for each parameter to help determine the overall health of the river during this 6 month period. [Data Table](https://drive.google.com/open?id=0B2yfllHDY7t3bnRNOURqMnNTUEE)   ***Sample Student Response:*** [***Data Analysis Rubric***](https://drive.google.com/open?id=0B2yfllHDY7t3ZVJzX2ZoZXNoeWs)  ***8. Engaging in Argument from Evidence 2:***  *Describe a phenomenon to students, then Ask students to articulate (construct) a claim about that phenomenon, and Identify evidence that supports the claim, and Articulate the scientific principle(s) that connect each piece of evidence to the claim.*   1. Make a claim as to the health of the river and support with your data. Include the scientific principles that connect each piece of evidence to your claim.   ***Sample Student Response:*** [***Claim Evidence Reasoning Rubric***](https://drive.google.com/open?id=0B2yfllHDY7t3a0NTZXV1RGxsT3M)  ***9. Designing Solutions 1:***  *Describe or showcase a human problem, desire, or need along with design criteria and constraints, then Ask students to sketch or describe a design approach that develops a possible solution to the problem. and Ask them to explain how the relevant scientific ideas are taken into account within their design*.  **Example from Scenario 3:** Runoff from agricultural area that use fertilizers and pesticides into ponds and streams affects the health of the water resource.   1. Sketch or describe a design approach that develops a possible solution to farm runoff into ponds. 2. Explain how your design uses relevant scientific principles to solve this problem. 3. Explain how the structure of your design will help mitigate the problem   **Sample Student Response:** [**Designing Solutions Rubric**](https://drive.google.com/open?id=0B2yfllHDY7t3UzFVaGdVVDlqRE0)  **10. Obtaining, Evaluating and Communicating Information 4:**  *Present students with a set of grade-appropriate scientific literature and/or media reports related to a scientific phenomenon, then For each text, ask students to analyze and write about the validity and reliability of the information in the text (e.g., data, hypotheses, conclusions).*  **Example:** Read each article below, then synthesize the information from across the texts, and compare and contrast information across the texts to determine which are most relevant to explaining the phenomenon.  Media report 1: [Scientists work to Predict and Prevent Algae Blooms](http://ocean.si.edu/ocean-news/scientists-work-predict-and-prevent-algae-blooms)  Media report 2: [Algae known as Brown Tide creating a Murky Mess on Long Island](http://abc7ny.com/news/algae-known-as-brown-tide-creating-a-murky-mess-on-long-island/1414272/)  Media report 3: [Long Island Sees a Crisis as it Floats to the Surface](https://www.nytimes.com/2015/06/06/nyregion/long-island-sees-a-crisis-as-it-floats-to-the-surface.html?_r=0)  **Sample Student Response:** [**Generic Synthesizing Information Rubric**](https://mseffie.com/assignments/synthesis/Generic%20Synthesis%20Rubric.pdf)  [Questions (Using Cross Cutting Task Formats)](http://stemteachingtools.org/assets/landscapes/STEM-Teaching-Tool-41-Cross-Cutting-Concepts-Prompts_Nov2016.pdf): This set of prompts is intended to help teachers elicit student understanding of crosscutting concepts in the context of investigating phenomena or solving problems.  **NOTE: CROSSCUTTING CONCEPTS ARE INCORPORATED IN THE FOLLOWING TASK BASED QUESTIONS IDENTIFIED FOR THE SCIENCE AND ENGINEERING PRACTICES. ADDITIONALLY, ONLY THOSE CROSSCUTTING CONCEPTS THAT WERE DIRECTLY APPLICABLE WERE INCLUDED.**  **Cause and effect - (human land uses and disruption of water cycle; health of water resource)**  ***Incorporated in the following task based questions:***  3. Developing and Using Models  4. Constructing Explanations  5. Planning and Carrying Out Investigations  **Patterns and change over time (Land cover change)**  ***Incorporated in the following task based questions:***  6: Analyzing and Interpreting Data  **Systems**  ***Incorporated in the following task based questions:***  3. Developing and Using Models |

**STEP 7: IMAGINE THE RANGE OF POSSIBLE STUDENT RESPONSES TO THE QUESTIONS**

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| Hypothetical Student Response: (Example [1](https://drive.google.com/open?id=0B-NUoj6UaD2PUzVlN2hhN2x2NGM)): Imagining how students will respond to your prompts is an important stage in designing assessment tasks. Through thinking like a student, you will get a better sense of how your prompts might elicit their understanding developed throughout the unit.  **(See Sample Student Responses Above)**  **How can an animal and plant survive in a container that is closed to the environment?**  Revise this question so that you could test it with the following materials: CO2 sensor, pillbugs, spinach, container.  What is the effect of the type of organism on the amount of CO2 produced in a closed container?  *Or*  Evaluate and explain whether or not you could tes*t* **how an animal and plant could survive in a container that is closed to the environment***.*  This would be difficult. You can see what effect the closed container has on the plant and/or animal over a given amount of time.  Or  **How can an animal and plant survive in a container that is closed to the environment?**   * What would you predict would happen if there was only a plant in the container?  If there was only a plant in the container, there would be nothing to eat the plant so it would keep growing. If the plant was in the container by itself, it would still be able to do photosynthesis. If if was doing photosynthesis it would be making glucose that it could use as an energy source. It would also be making oxygen. Since it has both glucose and oxygen available, it would also be able to carry out respiration. So the plant could stay alive by itself in the container. * What would you predict if there was only an animal in the container?   If there was only an animal in the container there would be a couple of problems. First of all, there would be no food for the animal to eat. Initially that would probably be ok , but after a while the animal would not have energy (carbohydrates) in its body to make ATP through respiration. The other problem is that the animal needs oxygen to carry out cellular respiration. If there is no plant in the container then there will be no oxygen produced from photosynthesis. Without oxygen the animal will not be able to carry out cellular respiration to make ATP. Without this, the animal’s cells will run out of energy and the animal will die. This will probably happen before the animal starves from the lack of food. |

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