NGSS Unpacking Table		
Science & Engineering Practice (SEP)	**Disciplinary Core Idea (DCI)**	**Crosscutting Concept (CCC)**
Constructing Explanations and Designing Solutions • Apply scientific ideas, principles, and/or evidence to construct, revise and/or use an explanation for real-world phenomena, examples, or events. • Apply scientific reasoning to show why the data or evidence is adequate for the explanation or conclusion.	*LS2.D: Social Interactions and Group Behavior* • Changes in biodiversity can influence humans' resources, such as food, energy, and medicines, as well as ecosystem services that humans rely on – for example, water purification and recycling (secondary to MS-LS2-5) *ETS1.B: Developing Possible Solutions* • Sometimes parts of different solutions can be combined to create a solution that is better than any of its predecessors (MS-ETS1-3)	*Patterns* • Patterns can be used to identify cause and effect relationships. • Graphs, charts, and images can be used to identify patterns in data.
Additional Information from Appendix F: *From the Framework* – Scientists attempt to identify the claim's weaknesses and limitations. Their arguments can be based on deductions from premises, on inductive generalizations of existing patterns, or on inferences about the best possible explanation. Becoming a critical consumer of science is fostered by opportunities to use critique and evaluation to judge the merits of any scientifically based argument.	**Additional Information from Appendix E and Framework for K-12 Science Education:** LS2: Ecosystems are complex, interactive systems that include both biological communities (biotic) and physical (abiotic) components of the environment. Interactions among organisms can change both biotic and abiotic characteristics of the environment. ETS1: The creative process of developing a new design to solve a problem is a central element of engineering. This process may begin with a relatively open-ended phase during which new ideas are generated both by individuals and by group processes…Before long, the process must move to the specification of solutions that meet the criteria and constraints at hand.	**Additional Information from Appendix G:** *From the Framework* – Noticing patterns is often a first step to organizing and asking scientific questions about why and how the patterns occur. Scientists seek explanations for observed patterns and for the similarity and diversity within them. Engineers often look for and analyze patterns, too.
Brainstorm: **What are the main goals for this practice?** By grade 12, students should be able to construct a scientific argument showing how data supports a claim. Identify possible weaknesses in scientific arguments, appropriate to the students' level of knowledge, and discuss them using reasoning and evidence.	**Brainstorm:** **What are the main ideas for the DCI?** LS2: Ecosystems are dynamic…which ultimately affects the stability and resilience of the entire system. ETS1: Communicating with peers about proposed solutions is an important part of the design process, and shared ideas can lead to improved designs. By grade 12, when	**Brainstorm:** **What are the components of the CCC?** Classifications will become more detailed and closer to scientific classifications in the upper elementary grades when students should also begin to analyze patterns in rates of change. By high school, students should recognize that different patterns may be observed at each of the scales at which a system is studied.

	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.	

3-Dimensional Claim (Color-Code by Dimension):
Students will identify potential causes of pollution among NY water ecosystems of existing beef cattle production / industry practices and their effects on water quality and biodiversity to explain a solution (or combinations of solutions) that could lead to improvement in key variables by using scientific evidence to support their explanation.

Phenomenon/Design Problem:
On many beef cattle farms, there is fencing around open water sources. When a physical fence is not possible, farmers will often block access to water for their livestock with a physical barrier or grass buffer. Sources of water that do not have fencing and allow beef cattle free access to the water can easily develop algae.

Resources Available to Engage Students with Phenomenon/Design Problem (Data, Simulations, Experiments, Videos, Etc.):

- https://www.labxchange.org/library/pathway/lx-pathway:69980a09-42bf-418d-9679-f8756f2bcc6a/items/lx-pb:69980a09-42bf-418d-9679-f8756f2bcc6a:html:7bcac1df
- https://www.dec.ny.gov/docs/water_pdf/researchguide.pdf
- https://extension.wsu.edu/animalag/content/protecting-the-water-on-your-small-farm/
- https://www.youtube.com/embed/HSoHkG7bbJE?feature=oembed
- https://www.canada.ca/en/environment-climate-change/services/freshwater-quality-monitoring/publications/phosphorus-aquatic-ecosystems/chapter-1.html
- 0-how-clean-is-the-water-student.pdf (nourishthefuture.org)
- https://newyork.agclassroom.org/matrix/lesson/802/
- https://assets.savvas.com/asset_mgr/current/202131/LabSamp_MLBio.pdf
- https://lpelc.org/the-michigan-enviroimpact-tool-a-supporting-tool-to-help-farmers-in-forecasting-manure-nutrient-runoff-risk/
- https://www.usda.gov/media/blog/2017/12/13/farmers-keeping-nutrients-field-out-streams

Table 2:

- Beef lifecycle: https://www.canr.msu.edu/news/2022-msu-feedlot-educational-series
- Buffers: https://extension.wsu.edu/animalag/content/protecting-the-water-on-your-small-farm/
- Managed grazing: https://extension.sdstate.edu/impacts-drought-soil-water-forage-and-livestock-grazing-systems
- Fencing: https://www.sustainablefarms.org.au/news/benefit-cost-analysis-lends-support-for-improved-farm-dam-management/

Table 2 Additional Sources:

- https://www.usda.gov/media/blog/2017/12/13/farmers-keeping-nutrients-field-out-streams
- https://extension.missouri.edu/publications/eq681
- https://extension.sdstate.edu/impacts-drought-soil-water-forage-and-livestock-grazing-systems

- https://www.sustainablefarms.org.au/news/fencing-farm-dams-halves-methane-emissions/

Resources for Additional Consideration:

- Infographics from video - https://www.youtube.com/watch?v=TbCwZyJEb8Y
- HABs Reporting Guide - https://www.dec.ny.gov/docs/water_pdf/habsreportingguide.pdf
- Mitigating Expansion of Algal Blooms - https://pubs.acs.org/doi/10.1021/acs.est.7b05950
- Remote Pasture Water Systems - https://www.thecattlesite.com/articles/1308/remote-pasture-water-systems-for-livestock/
- Managing Water and sustainability video - https://www.oecd.org/agriculture/topics/water-and-agriculture/

Explanation for Phenomenon/Design Problem at the Grade-Appropriate Level (Color-Coded):
There are a variety of solutions being implemented by beef cattle production that include industry practices aimed toward improvement of the causes of pollution in NY water ecosystems. Scientific evidence shows that best practices include any of the following solutions to mitigate the effects of pollution due to production. Each has a unique impact on the biodiversity of a water ecosystem. Using cover crops helps soil hold onto nutrients so they are not released into the ecosystem. Managing the life cycle of beef cattle and grazing practices by using a feedlot for a portion of cattle's life cycle and reducing overgrazing helps maintain the local ecosystem. Buffers or filter strips can be used to help trap nutrients that would otherwise end up in the local water ecosystem. Fencing is a physical barrier that keeps water sources clean by blocking livestock access.

3-Dimensional Claim (Color-Coded by Dimension):
Students will identify potential causes of pollution among NY water ecosystems of existing beef cattle production / industry practices and their effects on water quality and biodiversity to explain a solution (or combinations of solutions) that could lead to improvement in key variables by using scientific evidence to support their explanation.

1	Evaluate sources of information to determine the causes of pollution that threaten biodiversity of natural resources.
2	Evaluate sources of information to determine the causes of pollution that threaten biodiversity of natural resources using data to determine patterns that exist within ecosystems.
3	Analyze data from competing design systems to support claims about the effects of natural resource

	management on sustainable biodiversity.
4	Evaluate competing design system's responsible resource management strategies based on what they effect in the environment.

Beef Barriers

Introduction:

Historically on livestock farms, such as beef cattle farms, animals were given access to open water sources. A concern that farmers have is the management of nutrients and manure that are applied to crops or created by livestock and the ways in which these might affect the ecosystem at and near their farm. As manure is produced by cattle in an area, there is the potential for algae to develop in a water source. When large amounts of algae appearing rapidly together in a group, it is known as an algal bloom. While there are many natural causes, runoff from farms and other sources can cause algae issues in local waterways as fertilizers spread on field crops can be washed away by rain and irrigation.

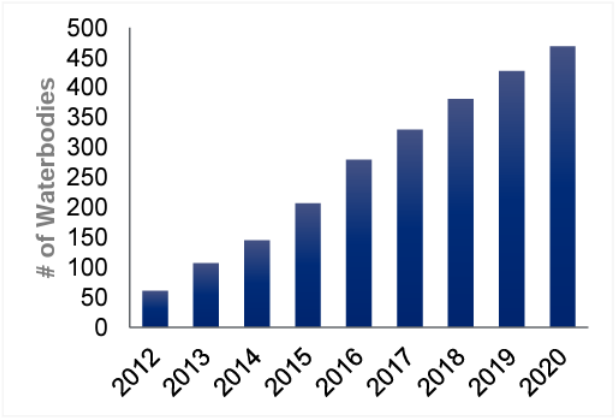
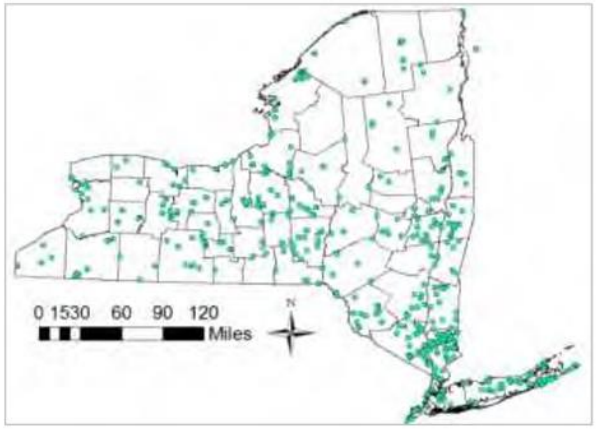
Algal blooms can have short- or long-lasting impacts on water ecosystems. Figure 1 below shows Brookmill Park Lake in Britain. Over 11 months, the lake experienced an explosive growth of algae.

Brookmill Park Lake, Britain, when there was no algal problem.
Sources/Usage: Public Domain.
Credit: Mike Quinn via Geograph U.K.

Brookmill Park Lake, Britain, when there was a severe algal problem.
Sources/Usage: Public Domain.
Credit: Mike Quinn via Geograph U.K.

Figure 1. Brookmill Park Lake

1	**PO:** Evaluate sources of information to determine the causes	**Prompt**: There are similar environmental issues in waterways throughout New York. Graph 1 below shows the number of waterbodies affected by harmful algal blooms (HABs) from 2012-2020.

	of pollution that threaten biodiversity of natural resources.	  **Graph 1. (at left) Cumulative number of waterbodies in NYS with documented HABs** **Graph 2 (at right). Cumulative map of locations of waterbodies in NYS with documented HABs, 2012-2020** **Q1.** Using Graph 1 from above, describe how waterbodies in New York have been impacted by algae since 2012. **Q2.** Using Graph 2 from above, describe any observations you notice about the locations of algal blooms in waterbodies in New York. Algal blooms can be a problem on beef cattle farms and the open water that livestock drink from, which can have a negative impact on many connected waterways. For this reason, many beef cattle farms have fencing around open water sources. When a physical fence is not possible, farmers will often block access to water for their livestock with a barrier, grass buffer, or line of trees. Examples are shown in Figures 2 and 3.

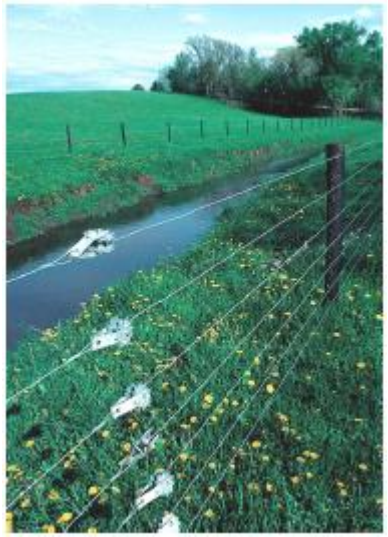


Figure 2. Fencing around stream. (Photo courtesy of USDA NRCS)

Figure 3. Trees lining a farm stream

Sources of water that do not have fencing and allow beef cattle free access to the water can easily develop algae, shown below in Figure 4.

Figure 4. Algae covered farm pond.

Q3. In what ways might a physical barrier help to prevent algal blooms in water sources on beef cattle farms?

Beef cattle farmers can help to improve water quality in their communities by managing their farms effectively.

After watching the video, Water Supply for Over 9 Million - YouTube, answer the following question:

Q4. Why is it important for beef cattle farmers to help protect the quality of the water supply?

Exemplar Student Responses

Q1.

Graph 1 shows that in 2012 there were 50 harmful algal blooms. By 2020, this number reached 500. This data shows that harmful algal blooms are significantly increasing.

Q2.

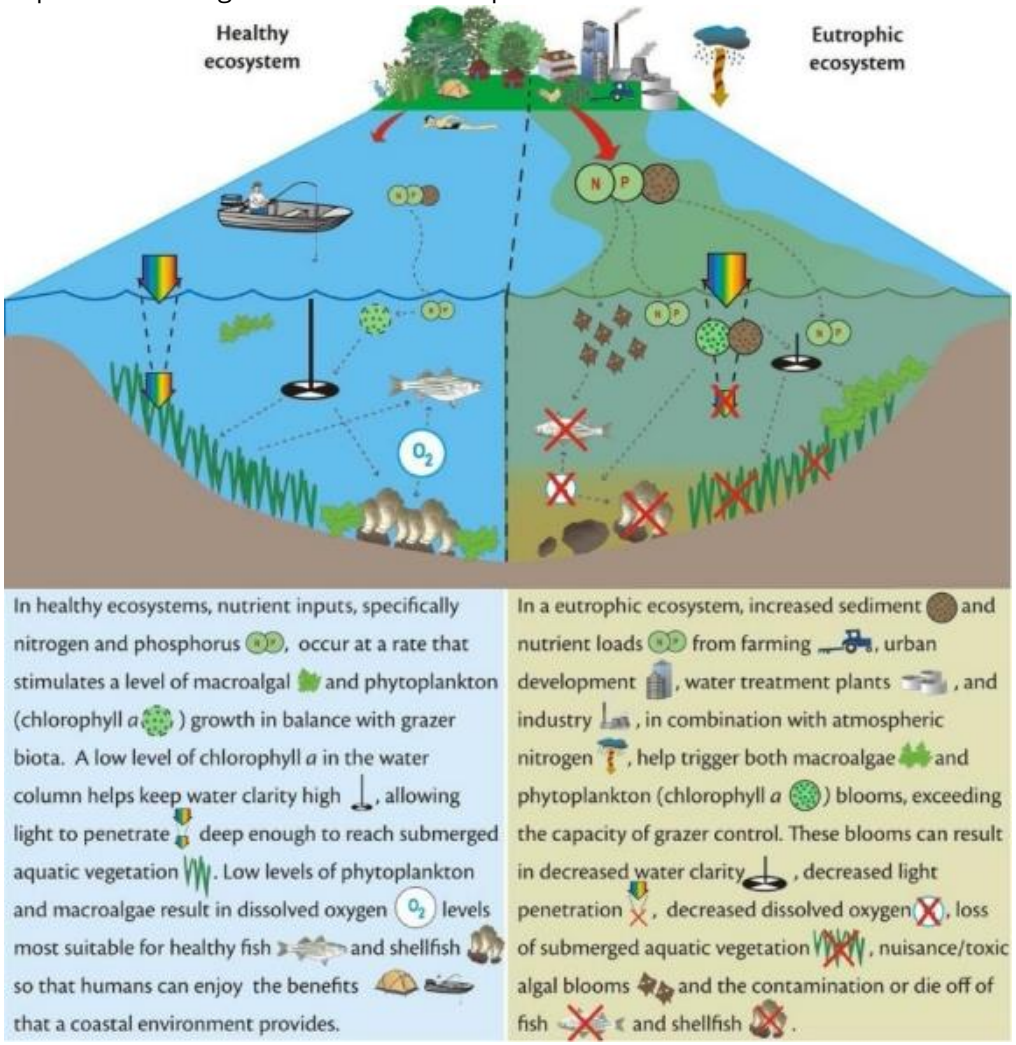
Graph 2 shows that there are harmful algal blooms occurring in most parts of the state. The southern area of New York, near New York City and Long Island appear to have the greatest concentration of harmful algal blooms in their waterbodies.

Q3.

A physical barrier might prevent harmful materials from getting into the water source. Beef cattle cannot access it to make it dirty or contaminate it in any way.

Q4.

After watching the video, beef cattle farmers need to protect the quality of the water supply so that it doesn't impact others negatively. By improving water quality, they produce a better product and prevent harmful pollutants from getting into the water ecosystem and traveling to other locations in the water.

2	**PO:** Evaluate sources of information to determine the causes of pollution that threaten biodiversity of natural resources using data to determine patterns that exist within ecosystems.	**Prompt:** **Part A:** Before we explore what beef cattle farmers do on their land, we need to understand why clean water is important. Use Figure 5 to answer the questions that follow.  **Figure 5. Conceptual diagram comparing a balanced ecosystem with one receiving excess nutrients.** **Q5.** What are some visible indicators of a healthy water ecosystem?

Q6. A eutrophic water ecosystem is unhealthy. What makes a water ecosystem unhealthy?

Q7. How can beef cattle farming impact the health of a water ecosystem?

Part B:

High amounts of nutrients like nitrogen, phosphorous, and potassium can cause algal bloom in a water ecosystem. In Data Set 1, shown below, are the results of an experiment that a student did comparing different amounts of fertilizer and seeing how much algae grew over 4 days.

Data Set 1. Average Algae Growth Compared to Amount of Fertilizer

	Average Algae Growth Counts		
Day	Control	Low Amount of Fertilizer	High Amount of Fertilizer
1	1.3	4	4
2	3.3	5.6	6.6
3	5	15	18.7
4	8.7	16	24.3

Observations from experiment:
After 4 days, the test tube that had the high amount of fertilizer was the darkest shade of green.

Q8. Using evidence from the experiment, explain the impact of nutrients on the growth of algae.

Figure 6 below shows how nutrients are related to beef cattle.

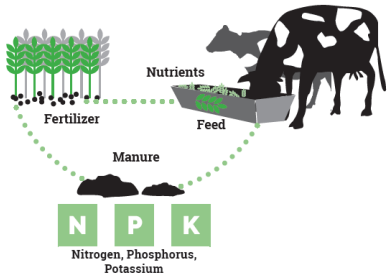


Figure 6. Manure nutrients

Q9. What is the connection of beef cattle to algae growth in open water sources on farms?

<table>
<tr><td></td><td></td><td></td></tr>
<tr><td></td><td></td><td>Exemplar Student Responses
Part A
Q5.
According to Figure 5, a healthy water ecosystem has a balance of nitrogen and phosphorous, high light penetration into the water, lower levels of algae and Chlorophyll a, dissolved oxygen to support fish, shellfish, and aquatic vegetation. All of these are key factors that support ecosystem biodiversity.

Q6.
According to Figure 5, an unhealthy water ecosystem has high levels of sediment and algal blooms, high levels of Chlorophyll a, nitrogen and phosphorus, low light penetration into the water, and less dissolved oxygen to support fish, shellfish, and aquatic vegetation. All of these are key factors that support ecosystem biodiversity and lead to unhealthy environments when they are out of balance.

Q7.
According to Figure 5, farming practices can contribute to an unhealthy balance of nutrients in a water ecosystem, having negative impacts on the key factors of healthy biodiversity of the ecosystem.

Part B
Q8.
According to Data Set 1, when there is more fertilizer present in water, it contributes to higher growth of algae over time. From day 1 to day 4 the growth of algae In the low fertilizer system, went from 4 – 16. From day 1 to day 4, the growth of algae in the high fertilizer system went from 4 - 24.3. It was reported it was also the darkest shade of green.

Q9.
According to Figure 6, cattle manure contains nitrogen, phosphorous, and potassium. Manure can be used as fertilizer to make plants grow, but it can also be absorbed into the groundwater, causing potentially harmful effects for the ecosystem and biodiversity.</td></tr>
<tr><td>3</td><td>PO:
Analyze data from competing design systems to support claims about the effects of natural resource management on sustainable</td><td>Prompt:
Solutions that limit the growth of algae in open water sources on the farm can impact the biodiversity of a water ecosystem for any water connected to it. Farmers throughout New York are part of conservation efforts to help make a positive impact. In the Chesapeake Bay region, conservation practices used by farmers in 2011 reduce the total nitrogen to rivers and streams by 44%. Phosphorous entering streams was reduced by 75% (Creech, 2021).

Table 2 below explains some potential solutions that beef cattle farmers are using.
<table>
<tr><th>Conservation Practice</th><th>What is it? What does it do?</th><th>What does it look like?</th></tr>
</table>
</td></tr>
</table>

biodiversity.

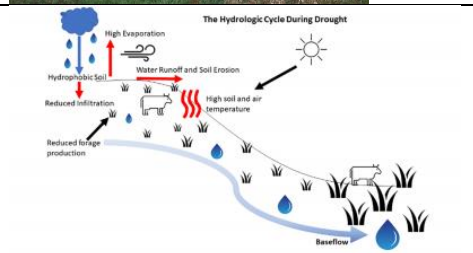
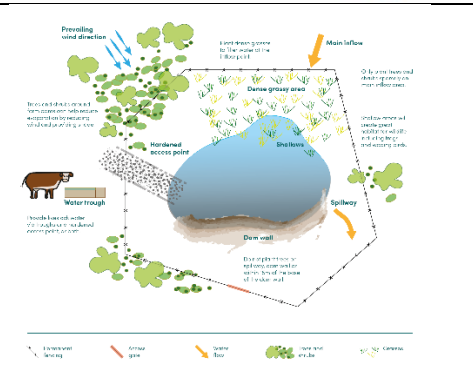
Managing the beef lifecycle	Diet grazing in the pasture consists primarily of grass forages and crop residue from grain production. Cattle may spend 4-6 months in a feedlot, where 50-85% of their diet is grain from corn and by-products. This means that it takes less time to get from birth to harvest which decreases their environmental impact	
Filter strips or vegetated / forested buffers	Buffers of trees or vegetation can mitigate nutrient pollution; remove sediment, organic matter, and pollutants from runoff and wastewater	
Managing grazing	Overgrazing can impact soil moisture, temperature, and evaporation rates. When there is little water in the soil, there is less water infiltration. This can lead to surface water runoff and increased soil loss.	
Fenced farm dams	Improves water quality for livestock consumption, provides habitat for wildlife, and secures water during droughts; draws down greenhouse gases to mitigate effects of climate change	

Table 2. Beef Cattle Farm Water Quality Solutions

Q10. Based on the evidence provided, which of the practices listed above has the greatest positive impact on biodiversity and water quality?

		Exemplar Student Response: Q10. According to Table 2, ___ practice will have the greatest positive impact on biodiversity and water quality. This is because of (data from table 2 and provides justification). **NOTE:** Student responses will need to be evaluated based on their justification and use of evidence. There is no "right answer" that identifies a specific practice as better than another, as all beef cattle production systems have unique requirements.
4	**PO:** Evaluate competing design system's responsible resource management strategies based on what they effect in the environment.	**Prompt**: Consider what practices (or combinations of practices) should be implemented to improve water quality among New York water ecosystems. **Q11.** Develop a potential solution by creating a land management plan that is economically sound and considers the environmental impacts of the beef cattle industry. Your answer should include: A potential solution 3 pieces of evidence from the task for why this solution is best for biodiversity of the environment and water ecosystems.
		Exemplar Student Response: Q11. The most effective practice(s) are ___. They will have (this specific impact) on biodiversity and water quality. This is because of (data from all prompts including justification). **NOTE:** Student responses will need to be evaluated based on their justification and use of evidence. Student responses for this prompt should highlight information from Prompts 1, 2, and 3. There is no "right answer" that identifies a specific practice as better than another, as all beef cattle production systems have unique requirements.