

**Chief Reader Report on Student Responses:  
2022 AP<sup>®</sup> Environmental Science Set 2  
Free-Response Questions**

• Number of Students Scored	179,957		
• Number of Readers	521		
• Score Distribution	Exam Score	N	%At
	5	16,006	8.9
	4	49,226	27.4
	3	31,557	17.5
	2	46,581	25.9
	1	36,587	20.3
• Global Mean	2.79		

The following comments on the 2022 free-response questions for AP<sup>®</sup> Environmental Science were written by the Chief Reader, Laura Hainsworth, Professor Emery & Henry College. They give an overview of each free-response question and of how students performed on the question, including typical student errors. General comments regarding the skills and content that students frequently have the most problems with are included. Some suggestions for improving student preparation in these areas are also provided. Teachers are encouraged to attend a College Board workshop to learn strategies for improving student performance in specific areas.

## Question 1

**Task:** Design an Investigation

**Topic:** Land Use in the Mississippi River Watershed/Gulf of Mexico Dead Zone

**Max Score:** 10

**Mean Score:** 3.96

### ***What were the responses to this question expected to demonstrate?***

This question focused on the broad categories of watersheds, eutrophication, and land use. Part (a) focused on land use in the Mississippi River Watershed [Topic 4.6 Watersheds, Topic 8.1 Sources of Pollution, Topic 8.2 Human Impacts on Ecosystems, and Topic 8.5 Eutrophication]. Students were expected to apply Practice 2 Visual Representations to explain how environmental concepts and processes represented visually relate to broader environmental issues. This included how land use types may relate to the movement of nutrients through a watershed and how this movement may contribute to the Gulf of Mexico dead zone [Practice 1 Concept Explanation, Topic 5.4 Impacts of Agricultural Practices, Topic 5.10 Impacts of Urbanization, Topic 8.5 Eutrophication].

In part (b) students were asked to describe how the dead zone affects marine organisms, as well as how it might affect the economies of communities along the Gulf of Mexico. Students were also expected to describe a factor that could cause the dead zone to increase during the summer months [Practice 1 Concept Explanation and Topic 8.5 Eutrophication].

In part (c) students needed to apply Practice 4 Scientific Experiments to describe and identify experimental design components, as well as provide an explanation for how the results of an investigation could be altered by the modification of the experiment from a cornfield into a large-scale concentrated animal feeding operation [Topic 5.4 Impacts of Agricultural Practices].

### ***How well did the responses address the course content related to this question? How well did the responses integrate the skills required on this question?***

- For Part (a)(i) students were asked to utilize a graphic of the continental United States displaying land use types within the Mississippi River watershed, where students used Practice 2 Visual Representations to identify the land use practice that covers the least amount of area in the Mississippi River watershed. Most students accurately made this identification of “urban” areas, although some responses incorrectly identified forests, despite large forested areas clearly shown on the diagram.
- In Part (a)(ii) students described one way that a land use practice shown in the diagram could contribute to the dead zone in the Gulf of Mexico. Many students successfully described fertilizer runoff from agricultural areas moving into streams and rivers and flowing/moving to the Gulf of Mexico and contributing to the dead zone. Often, students described pesticide runoff contributing to the dead zone in the Gulf of Mexico, but this did not earn the point because pesticides do not significantly contribute to the dead zone.
- In Part (a)(iii) students described one way that urban areas in the Mississippi River watershed could contribute to the dead zone in the Gulf of Mexico. Many students noted lawn fertilizer runoff moving over impermeable surfaces and into streams and rivers and on to the Gulf of Mexico, contributing to the dead zone.

- In part (b)(i) students were asked to describe how a dead zone affects marine organisms living in the Gulf of Mexico [Topic 8.5 Eutrophication]. Many responses successfully described that marine organisms would die or be forced to migrate due to decreased dissolved oxygen or that sunlight would be blocked by the depth of the algal mass.
- In part (b)(ii) students were asked to describe one economic effect on communities along the Gulf of Mexico that can result from the presence of the dead zone [Topic 8.2 Human Impacts on Ecosystems]. Responses that earned the point typically described a reduction in fish populations which would lead to decreased commercial fish harvest, thereby decreasing income for fishing companies/increased fish prices for consumers due to reduced supply.
- In part (b)(iii) students were asked to describe one factor that causes the area of the dead zone in the Gulf of Mexico to increase in the summer months. The most frequent responses that earned the point here described either an increase in precipitation and/or snowmelt in the summer, which would carry more fertilizer runoff from agricultural areas and lead to increased algal growth, or that warmer air temperatures in the summer would result in warmer water and a decrease in dissolved oxygen concentration because warmer water does not hold as much dissolved oxygen as cold water.
- In part (c)(i) students were asked to identify a testable hypothesis to study the effect of riparian vegetation buffers on water quality in streams in agricultural areas. Since the hypothesis shared in the student response could be rejected or not rejected, the point could be earned by stating that if riparian buffers are present, the level of nitrates/phosphates/nutrients downstream will be lower or higher or remain the same, as compared to areas without riparian buffers. Responses that did not earn the point in part (c)(i) often stated that “water quality would be better if riparian buffers were present,” which did not earn the point due to the vagueness of “water quality.”
- In part (c)(ii) students were asked to describe a control that the researchers could use in the study. Many responses accurately described “a downstream riparian area without a vegetative buffer zone” as a control. “A riparian area without a vegetative buffer zone that is located upstream” was another way a response could earn the point, as such riparian areas could also function as control sites in the study. Responses that did not earn the point in part (c)(ii) typically lacked an indication that the sites were either riparian or located near the streams, stating generally that “areas without any vegetation could be the controls.”
- Part (c)(iii) asked the student to identify one water quality test, other than measuring nitrates or phosphates, that the researchers could use in the study. Many responses earned the point in part (c)(iii) with pH, turbidity, and dissolved oxygen being the most common.
- In part (c)(iv) students were asked to explain one way that the conversion from a cornfield to a large-scale concentrated animal feeding operation could alter the results of the study. The majority of responses did not earn a point on this part of the question. The task verb “explain” calls for a response that provides information about how or why a relationship, process, pattern, position, situation, or outcome occurs. In order to earn the point in part (c)(iv), responses needed to include that water quality would decline due to a source, for example increased nutrients in runoff from a concentrated animal feeding operation, because there is animal waste in/associated with CAFOs that will move into the stream(s)/water.

**What common student misconceptions or gaps in knowledge were seen in the responses to this question?**

<i>Common Misconceptions/Knowledge Gaps</i>	<i>Responses that Demonstrate Understanding</i>
<ul style="list-style-type: none"> <li>A common misconception was that agricultural pesticides/pesticides in runoff/oil from cars lead to algal blooms; “Pesticides can runoff and travel through the Mississippi River causing an algal bloom in the Gulf of Mexico.”</li> <li>A similar misconception was that “the dead zone in the Gulf of Mexico is caused by large amounts of water being taken out of (diverted from) streams and rivers, so the reduced water volume results in an algal bloom in the Gulf of Mexico.”</li> </ul>	<ul style="list-style-type: none"> <li>“Agricultural fertilizers are used to enhance crop growth and productivity. Nutrients in fertilizers can runoff farming land into streams and rivers and travel further in a watershed, and could ultimately reach the Gulf of Mexico, resulting in a dead zone.”</li> </ul>
<ul style="list-style-type: none"> <li>A common knowledge gap was that with “higher water temperatures, the greater the dissolved oxygen content/the greater the capacity to hold dissolved oxygen.”</li> </ul>	<ul style="list-style-type: none"> <li>“As water temperature increases as a result of air temperatures increasing during the warmer summer months, there is a decrease in the dissolved oxygen concentration because warmer water does not hold as much dissolved oxygen as colder water.”</li> </ul>

**Based on your experience at the AP<sup>®</sup> Reading with student responses, what advice would you offer teachers to help them improve the student performance on the exam?**

- Starting in the first few weeks of the school year, introduce, and provide frequent student reminders throughout the year regarding the differences required by the task verbs. While “identify” requires a very short response and does not require further description or support to earn a point, “explain” requires information about how or why a relationship, process, pattern, position, situation, or outcome occurs. Students should have practice explaining concepts and answers in communicating the more detailed answer required from an “explain” task verb.
- The skills in Science Practice 2 ask students to analyze visual representations of environmental concepts and processes and in Science Practice 4 to analyze research studies that test environmental principles. The Science Practice 2 skills should be practiced often in the classroom, so students are comfortable making analyses. Visual representation analysis spotlights that are frequent (perhaps weekly), brief, and low-stress opportunities can serve as effective tools for students to strengthen these skill sets and build confidence. Many teachers find current visuals in newspapers and online sources to give students practice. Visuals include diagrams and models that illustrate environmental concepts and process.

- For Science Practice 4, students should be given opportunities to design, carry out, and analyze laboratory and field experiments that investigate environmental problems. Students should be able to identify variables, including a control, as well as identify a testable hypothesis or scientific question for an investigation. Students should also be able to provide a modification that could alter the results of a given study or to explain how a specific modification to an investigation could alter the results.
- Teachers are encouraged to continually remind students to read all parts of each free-response question carefully, including the short passage (often one or two sentences) that is often presented with the question number at the beginning, as it helps frame the questions that will follow, and may contain information that could be incorporated into a point-worthy response. This was the case with this question.

***What resources would you recommend to teachers to better prepare their students for the content and skill(s) required on this question?***

- Teachers will find sample student responses for this question on the exam information page on AP Central, along with commentary explaining why each point was or was not earned. Teachers can use these samples to better understand how the question was scored and to work with students to help practice writing correct responses.
- Teachers will find scoring guidelines for this question explaining how the question was scored on the exam information page on AP Central. Teachers can use and adapt these scoring guidelines throughout the course so that students become familiar with how their responses will be scored.
- Teachers can have students practice with the examples of FRQ 1 that have been released from the 2021 and 2022 AP Environmental Science Exams found on the exam information page on AP Central. Student samples and scoring guidelines are also available for those questions.
- Teachers can use the labs that are available in AP Classroom with their students. Each lab is designed to target specific skill development.
- In AP Classroom, teachers can access a rich collection of resources that includes formative and summative assessment items for every unit of the course.
- AP Daily videos in AP Classroom provide enriching content for every topic in AP Environmental Science. Teachers can integrate these videos into their instruction in a variety of ways to provide students with additional exposure to content throughout the course.
- AP Daily Live videos found on YouTube provide a comprehensive review of the course content for students. Teachers can assign these videos to students in the weeks leading up to the exam to reinforce content learned throughout the course.
- AP Faculty Lectures are a collection of videos available in YouTube that provide an in-depth look at specific course content from the perspective of higher education faculty at a variety of colleges and universities.
- On the AP Environmental Science Online Teacher Community there are many resources, discussions, tips, and activities that many teachers have found helpful. It is easy to sign up and teachers can search through topics of discussions from previous years.

- Teachers might consider signing up for an AP Summer Institute (APSI). An APSI is a great way to gain in-depth knowledge about the AP Environmental Science curriculum and exam. It is also a great way to network with colleagues from around the world.
- Teachers with more experience (a minimum of 3 years is required) might consider applying to be an AP Reader. The AP Reading is considered outstanding professional development by most AP teachers. Besides learning how to accurately apply AP scoring guidelines to score student responses, it is a great way to share resources and network with colleagues.

## Question 2

**Task:** Analyze an Environmental Problem and Propose a Solution

**Topic:** Habitat, Biodiversity, and Pest Control

**Max Score:** 10

**Mean Score:** 3.95

***What were the responses to this question expected to demonstrate?***

This question focused on the broad categories of competitive relationships, biodiversity, and agricultural practices. In part (a) students were asked to analyze graphical data to identify and describe patterns in interspecies relationships [Practice 5 Data Analysis and Topic 1.1 Introduction to Ecosystems].

In part (b) the prompt specifically asked for a species diversity description using the theory of biogeography [Topic 2.3 Island Biogeography, Topic 2.1 Introduction to Biodiversity].

Part (c) focused on the impact of invasive animal species and asked students to propose a solution to control pest species [Practice 7 Environmental Solutions and Topic 2.1 Introduction to Biodiversity, Topic 3.5 Population Growth and Resource Availability, Topic 9.8 Invasive Species, Topic 5.6 Pest Control Methods, and Topic 5.14 Integrated Pest Management].

In parts (d) and (e) students were asked to identify a forest provisioning ecosystem service [Practice 1 Concept Explanation and Topic 2.2 Ecosystem Services]. The next focus was on anthropogenic habitat disruption (conversion to agriculture), the impact of this disruption on species, and conservation-minded agricultural practices [Topic 2.1 Introduction to Biodiversity, Topic 4.3 Soil Composition and Properties, Topic 5.4 Impacts of Agricultural Practices, Topic 5.15 Sustainable Agricultural, and Topic 1.5 The Nitrogen Cycle].

***How well did the responses address the course content related to this question? How well did the responses integrate the skills required on this question?***

- The task verbs in the Analyze an Environmental Problem and Propose a Solution question were varied and required students to identify, describe, explain, make a claim, and justify a solution. The content ranged from ecological concepts such as biodiversity and ecosystem services to agricultural content such as soil dynamics and agricultural practices to competitive relationships such as invasive species and pest management.
- In general, the students demonstrated strong ability to analyze and interpret a graph focusing on islands with varied habitats and species. The response to part (a)(i) “The habitat type with the greatest amount of lizards are clearing and gardens,” earned a point. In addition, in part (a)(ii) students were able to analyze and describe that “The number of lizards on mongoose-present islands is less than the number of lizards on mongoose-free islands.”
- Students also were frequently able to discuss the relationships and their impacts between native and invasive species. One response to part (c)(i) described “Invasive species are generally generalist species that can adapt to a variety of environments. Because of that invasive species outcompete native species for food resources and cause the native species’ population numbers to go down.” And finally, many students were able to generate expansive and thoughtful claims of mechanisms that could control pest species and also to discuss additional benefits of their solution.

**What common student misconceptions or gaps in knowledge were seen in the responses to this question?**

<i>Common Misconceptions/Knowledge Gaps</i>	<i>Responses that Demonstrate Understanding</i>
<ul style="list-style-type: none"> <li>Responses revealed a common gap in knowledge in the topic of island biogeography. Answers to (b) often overlooked the essential characteristic of an island as being isolated, and indicated that highest species diversity would occur on islands with the most nutrients or the most rainfall.</li> </ul>	<ul style="list-style-type: none"> <li>“An island with the greatest species diversity is one that is closest to the mainland and has a large area that allows for a great number of species. Proximity to the mainland allows for species to easily migrate to the island.”</li> </ul>
<ul style="list-style-type: none"> <li>Different types of ecosystem services (Topic 2.2) are often confusing to students. This question asked for an example of a “provisioning ecosystem service provided by primary forests.” Student responses often indicated a regulating or supporting ecosystem service instead of provisioning.</li> </ul>	<ul style="list-style-type: none"> <li>“A provisioning ecosystem service provided by primary forests is wood for lumber.”</li> </ul>

**Based on your experience at the AP<sup>®</sup> Reading with student responses, what advice would you offer teachers to help them improve the student performance on the exam?**

- Remind students of the differences required by the task verbs found in the question. “Identify” requires a very short response and does not require an explanation for a point. On the other hand, students should have practice explaining concepts and answers in preparation of the more detailed answer required from an “explain” task verb.
- Encourage students to avoid the “kitchen sink” answers where they include every bit of information that is known about a topic. This leads to lists of answers with many students hoping that Readers will sort and pick through the list to find the desired response. The Scoring Guidelines are applied in such a way that only the first response in the list is scored. Students should write their strongest and best answers, rather than a list of potential answers.
- Students should avoid vague terms such as thrive, affect, control, change, and impact in their response. Directionality of answers (such as increase and decrease) should be included.
- Students should not simply repeat the prompt to generate their answer. Responses that simply repeat the prompt do not earn points. Encourage students to go beyond the prompt in their identifications, descriptions, and explanations. In part (c)(ii) many responses made a claim that “Pesticides can be applied to control pest species.” The phrase “control pest species” is found in the prompt, and this claim does not indicate how the pesticide will “control pest species” and, therefore, does not earn a point.



- This question required students to read, describe, and explain relationships among variables in a graph (Science Practice 5). These skills should be practiced often in the classroom, so students are comfortable making these interpretations and analysis. Weekly low-stress, minimal time required graph analysis can build these skill sets and student comfort levels. Many teachers find current graphs in newspapers and online sources to give students practice. Also, if the prompt indicates that students are to use the graph to answer the question, make sure they know to apply the data in the graph rather than only rely on prior content knowledge.
- The Analyze an Environmental Problem and Propose a Solution (Question 2) requires students to make a claim and justify the solution in their constructed response. Students should feel comfortable with making claims that propose a solution to an environmental problem and then justifying that claim through additional information. These can be practiced in the classroom using CED topics.
- Students should be familiar with common examples and terms within environmental science such as legume, monoculture, and predator. Vocabulary lists for each unit can help with incorporating these terms into a student’s knowledge base.

***What resources would you recommend to teachers to better prepare their students for the content and skill(s) required on this question?***

- Teachers will find sample student responses for this question on the exam information page on AP Central, along with commentary explaining why each point was or was not earned. Teachers can use these samples to better understand how the question was scored and to work with students to help practice writing correct responses.
- Teachers will find scoring guidelines for this question explaining how the question was scored on the exam information page on AP Central. Teachers can use and adapt these scoring guidelines throughout the course so that students become familiar with how their responses will be scored.
- Teachers can have students practice with the examples of FRQ 2 on the released 2021 and 2022 AP Environmental Science Exams found on the exam information page on AP Central. Student samples and scoring guidelines are also available for those questions.
- Teachers can have students practice, score, and review the examples of FRQ 2 found on the three AP Environmental Science Practice Exams that can be accessed in AP Classroom.
- In AP Classroom, teachers can access a rich collection of resources that includes formative and summative assessment items for every unit of the course.
- AP Daily videos in AP Classroom provide enriching content for every topic in AP Environmental Science. Teachers can integrate these videos into their instruction in a variety of ways to provide students with additional exposure to content throughout the course.
- AP Daily Live videos found on YouTube provide a comprehensive review of the course content for students. Teachers can assign these videos to students in the weeks leading up to the exam to reinforce content learned throughout the course.
- AP Faculty Lectures are a collection of videos available in YouTube that provide an in-depth look at specific course content from the perspective of higher education faculty at a variety of colleges and universities.

- On the AP Environmental Science Online Teacher Community there are many resources, discussions, tips, and activities that many teachers have found helpful. It is easy to sign up and teachers can search through topics of discussions from previous years.
- Teachers might consider signing up for an AP Summer Institute (APSI). An APSI is a great way to gain in-depth knowledge about the AP Environmental Science curriculum and exam. It is also a great way to network with colleagues from around the world.
- Teachers with more experience (a minimum of 3 years is required) might consider applying to be an AP Reader. The AP Reading is considered outstanding professional development by most AP teachers. Besides learning how to accurately apply AP scoring guidelines to score student responses, it is a great way to share resources and network with colleagues.

### Question 3

**Task:** Analyze an Environmental Problem and Propose a Solution doing Calculations

**Topic:** Impacts of Coal Consumption, Population, and Water Resources

**Max Score:** 10

**Mean Score:** 4.02

#### ***What were the responses to this question expected to demonstrate?***

This question focused on the broad categories of coal combustion and human population dynamics. In parts (a) and (b) students were expected to demonstrate understanding of the negative human health effects and environmental impacts of the products and byproducts of coal combustion. Students were asked to identify a human health impact related to pollutants from coal combustion. Students were then asked to describe a problem with the disposal of coal ash waste and to justify why using clay-lined pits might be a solution to some of these problems [Topic 7.1 Introduction to Air Pollution, Topic 8.2 Human Impacts on Ecosystems, Topic 9.3 Solid Waste Disposals]. Students applied Science Practice 1 Concept Explanation and Science Practice 7 Environmental Solutions to answer this section of the question.

In part (c) students were first asked to calculate a percent change in the population of Charlotte, North Carolina over a period of time. Students were also asked to calculate the doubling time of the population based on a constant growth rate. Lastly, students were asked to calculate the amount of water the city would use in a particular year using the data provided and dimensional analysis [Topic 3.8 Human Population Dynamics]. Students applied Science Practice 6 Mathematical Routines, to complete this section of the question.

Part (d) asked students to describe a realistic action that could be taken to reduce domestic outdoor water use [Science Practice 7 Environmental Solutions and Topic 5.12 Introduction to Sustainability].

#### ***How well did the responses address the course content related to this question? How well did the responses integrate the skills required on this question?***

- Students were expected to be knowledgeable about byproducts of coal production, population growth, and sustainability practices. Students also were expected to be able to set up and then evaluate basic calculations and use dimensional analysis to solve problems.
- In part (a) student responses earned a point by identifying a human health effect linked to coal. Students did not have to identify the type of pollution that caused the human health impact, therefore responses linked to particulate pollution, SO<sub>x</sub> pollution, or heavy metal pollution were all accepted such as asthma, neurological damage, birth defects, or respiratory or eye irritation.
- In part (b)(i) students earned a point for describing an environmental problem associated with coal ash disposal. Students had to identify both how the coal ash left the place where it was disposed of and describe the problem that could result. Many students described the “leaching” or “leaking” from the unlined pit resulting in contamination of groundwater or soil. Students also earned a point for describing the dry ash transported to a nearby body of water where it either increased turbidity or decreased photosynthesis. In part (b)(ii) students earned a point for justifying that because clay is “less permeable” than an unlined pit, contaminants were unable to “leach” into the nearby “soil/groundwater.”

- In the calculative part of this question, many students worked systematically and earned points. Students demonstrated the ability to calculate a percent change in part (c)(i) and calculate doubling time in part (c)(ii). In part (c)(iii) students used dimensional analysis, including proper units, to determine the total gallons of water used by the entire population of Charlotte in a given year based on data presented in the prompt. The setup point for each of these problems could be earned in multiple ways, including word expressions, and the response did not have to explicitly be on the rubric, but it had to show a correct mathematical relationship to earn a point. As the numbers came from real data, students were aided by the use of a calculator.
- In part (d) students were asked to describe one realistic action citizens could take to reduce outdoor water in times of a drought. In order for the student to earn a point they had to identify something that was both realistic, domestic, and outdoor as opposed to municipal, agricultural, or indoor. Students had to clearly demonstrate that the action they were proposing resulted in a decrease of water use. For instance, students recognized that “watering after dark or before dawn” could reduce evaporation and water use. Students also often stated a reduction in frequency of lawn watering. Students could also earn this point for an understanding of replacing lawns with either native plants that required less water, or artificial landscaping.

**What common student misconceptions or gaps in knowledge were seen in the responses to this question?**

<i>Common Misconceptions/Knowledge Gaps</i>	<i>Responses that Demonstrate Understanding</i>
<ul style="list-style-type: none"> <li>• Responses lacked a complete setup for dimensional analysis including omitting units and/or not demonstrating proper cancelling of units.</li> </ul>	<ul style="list-style-type: none"> <li>• <math>\frac{90 \text{ gallons of water}}{\text{person per day}} \times 841,611 \text{ people} \times 365 \text{ days}</math></li> <li>• <math>2.76 \times 10^{10} \text{ gallons/year}</math></li> </ul>
<ul style="list-style-type: none"> <li>• Some responses did not reflect proper rounding of numbers when using real data sets that do not always divide or multiple cleanly.</li> </ul>	<ul style="list-style-type: none"> <li>• <math>\frac{857,425 \text{ people} - 757,278 \text{ people}}{757,278 \text{ people}} \times 100</math></li> <li>• 13.22%</li> </ul>
<ul style="list-style-type: none"> <li>• Student responses revealed misconceptions about the difference between porosity and permeability in soil.</li> </ul>	<ul style="list-style-type: none"> <li>• “With clay particles being so small, it has a lower permeability compared to other soil types. This low permeability can ensure that rainwater leachate that goes through the coal ash does not infiltrate the ground water.”</li> </ul>
<ul style="list-style-type: none"> <li>• Responses confused domestic outdoor water reduction with indoor or agricultural water reduction or with reduction that came as directives from local municipalities.</li> </ul>	<ul style="list-style-type: none"> <li>• “Citizens could water their outdoor plants at night to use less water because the sun would not evaporate the water at night.”</li> </ul>

**Based on your experience at the AP<sup>®</sup> Reading with student responses, what advice would you offer teachers to help them improve the student performance on the exam?**

- Students should carefully read the question more than once and look for and underline key words. Many students calculated a correct doubling time, in part (c)(ii), but did not add it to the year given in the prompt to determine the year the population would double, so they earned neither the setup nor the answer point. Students also missed points for giving excellent examples of reduction of domestic indoor water use in part (d) as opposed to domestic outdoor water use.
- Reinforce dimensional analysis throughout the year. Require students to always show all of their work, even work they think they can do “in their head” such as multiplying a decimal percent by 100.
- Have students evaluate answers to determine if the answer they get is reasonable and to scale. Students should have number sense to look at a number and decide if their response makes sense for the question asked. Students should understand that a large city will use more than 27 gallons of water in one year. When doing math questions in class, do not just review the process, but also spend time discussing appropriate values for different units (gallons, watts, meters, etc.).
- Practice the task verbs. Students often spent time giving elaborate explanations for an identify point, and on a question that asked to describe or justify would only give a two- to three-word answer.
- Help students practice adding detail to their writing. Coal ash does more than “harm the environment” and pollutants do more than “cause lung issues.” A response needs to demonstrate a level of understanding of environmental issues appropriate for an entry level college course and should not be vague. Practice peer grading. If another student reads their response and still has questions, have the original student go back and add more detail.
- Have students practice timed free-response questions. Students should spend approximately 23 minutes per question in the free-response section. In class, have them practice their free-response questions within that time limit, so they know how to pace themselves through three questions on the exam.

**What resources would you recommend to teachers to better prepare their students for the content and skill(s) required on this question?**

- Teachers will find sample student responses for this question on the exam information page on AP Central, along with commentary explaining why each point was or was not earned. Teachers can use these samples to better understand how the question was scored and to work with students to help practice writing correct responses.
- Teachers will find scoring guidelines for this question explaining how the question was scored on the exam information page on AP Central. Teachers can use and adapt these scoring guidelines throughout the course so that students become familiar with how their responses will be scored.
- Teachers can have students practice with the examples of FRQ 3 on the released 2021 and 2022 AP Environmental Science Exams found on the exam information page on AP Central. Student samples and scoring guidelines are also available for those questions.
- Teachers can have students practice, score, and review the examples of FRQ 3 found on the three AP Environmental Science Practice Exams that can be accessed in AP Classroom.

- In AP Classroom, teachers can access a rich collection of resources that includes formative and summative assessment items for every unit of the course.
- AP Daily videos in AP Classroom provide enriching content for every topic in AP Environmental Science. Teachers can integrate these videos into their instruction in a variety of ways to provide students with additional exposure to content throughout the course.
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