

Is the Dam Leaking? A Claim-Evidence-Reasoning Case About a Shrinking Lake

Learning target: I can use a water budget to argue, with evidence and water-cycle reasoning, what caused a lake to drop during a dry summer.

Claim, evidence, reasoning

About 45 min

Individual

MS-ESS2-4 · practice

writing

data analysis

Standards connections

MS-ESS2-4 (practice): MS-ESS2-4 is a California Grade 6 PE revisited here. Students reason about evaporation (sun-driven), inflow and outflow (gravity-driven) as parts of one system to explain a lake's water loss, which exercises the energy-and-gravity reasoning behind the water cycle model without asking them to draw the model.

Purpose: practice · **Time:** about 45 minutes · **Format:** individual

Answers with reasoning

The scenario

Mirror Lake is a small reservoir behind an earthen dam. Between June 1 and July 27, during a hot, rainless summer, the lake level fell 45 cm. At a town meeting, a resident named Mr. Okafor stood up and said: 'That dam has a crack. The lake is losing about 3 centimeters a week through it. Fix it before the lake is gone.' The water district manager, Ms. Reyes, said she would look at the numbers before spending money on repairs. Her team already measures the lake every week. Their notes and data are below.

Water district notes — 1. The lake level is read from a fixed staff gauge every Monday morning. 2. A floating evaporation pan sits in the lake so that its water is the same temperature as the lake; the pan's water loss is a good estimate of how much the lake surface loses to the air. 3. The only stream flowing in is gauged, and the water released through the dam's outlet pipe to the town is metered; both have been converted into centimeters of lake level so they can be compared with the drop. 4. No rain fell during the eight weeks. 5. The highest water temperature measured in the lake all summer was **23 °C**. 6. A diver inspected the dam face on June 3 and found no crack, but Mr. Okafor says a crack could be below the mud.

Mirror Lake weekly water budget, June 1 to July 27 (teaching dataset)

Simulated teaching dataset: the numbers are invented to be realistic, not measured.

Week	Lake level drop (cm)	Evaporation pan loss (cm)	Stream inflow (cm)	Release to town (cm)
1	6.0	4.8	1.0	2.2
2	6.4	5.1	0.9	2.2
3	6.7	5.4	0.8	2.0
4	5.6	5.3	0.7	1.0
5	5.8	4.9	0.6	1.5
6	5.3	4.6	0.6	1.2
7	4.9	4.2	0.5	1.2
8	4.4	3.8	0.5	1.1

Simulated data for teaching. All values are in centimeters of lake level. Inflow raises the lake; evaporation and releases lower it. Readings are to the nearest 0.1 cm.

Warm-up: get the numbers ready

1. Add each column for the eight weeks: total drop, total evaporation, total inflow, total release. Show the four sums.

Answer: Total drop: $6.0 + 6.4 + 6.7 + 5.6 + 5.8 + 5.3 + 4.9 + 4.4 = 45.1$ cm. Total evaporation: $4.8 + 5.1 + 5.4 + 5.3 + 4.9 + 4.6 + 4.2 + 3.8 = 38.1$ cm. Total inflow: $1.0 + 0.9 + 0.8 + 0.7 + 0.6 + 0.6 + 0.5 + 0.5 = 5.6$ cm. Total release: $2.2 + 2.2 + 2.0 + 1.0 + 1.5 + 1.2 + 1.2 + 1.1 = 12.4$ cm.

Why: Column sums; the drop total (45.1) matches the scenario's '45 cm'. Check each sum, as every later number depends on these.

Also acceptable: None; all four sums are required.

2. A water budget predicts the drop as: **evaporation + release – inflow**. Calculate the predicted drop from your totals, then subtract it from the measured total drop. How many centimeters of the drop are **not** explained by evaporation, release and inflow?

Answer: Predicted drop = $38.1 + 12.4 - 5.6 = 44.9$ cm. Measured drop – predicted drop = $45.1 - 44.9 = 0.2$ cm unexplained over eight weeks.

Why: The budget closes to within 0.2 cm, which is about the size of the gauge's reading precision (0.1 cm each on several measurements).

Also acceptable: Accept 0.2 cm; if a student's sums differ, score the method and check the arithmetic.

3. What percent of the measured drop is explained by evaporation alone? Show the division. Then calculate how many centimeters Mr. Okafor's claim ('about 3 cm a week') would add up to over eight weeks.

Answer: Evaporation share: $38.1 \div 45.1 = 0.845$, about 84 percent (85 percent if rounded up). Mr. Okafor's claim: $3 \text{ cm/week} \times 8 \text{ weeks} = 24 \text{ cm}$.

Why: Evaporation alone accounts for about five-sixths of the drop; the claimed leak would be 24 cm, which is 120 times the 0.2 cm actually unexplained.

Also acceptable: Accept 84 or 85 percent.

4. The lake never got warmer than 23 °C, yet the pan lost about 5 cm a week in June. Explain in terms of water molecules why so much water can evaporate from a lake that is nowhere near boiling.

Answer: The molecules in liquid water move at many different speeds. Even at 23 °C, the fastest-moving molecules at the lake's surface have enough energy to break free into the air as water vapor. The sun keeps supplying energy to the surface all day, so new molecules keep reaching escape speed. Boiling is not needed; boiling is when bubbles of vapor form throughout the liquid, but evaporation is a surface process that happens at every temperature.

Why: Full credit requires the spread-of-speeds idea and the surface-escape mechanism, tied to the sun's energy.

Also acceptable: Accept 'a puddle dries without boiling, and a lake is a giant puddle' as a supporting example alongside the molecular idea.

- Fastest surface molecules escape
- Sun supplies the energy
- Distinguishes evaporation (surface, any temperature) from boiling

5. Why did the evaporation loss fall from 5.4 cm in week 3 to 3.8 cm in week 8, even though it was still summer? Give one reasonable cause connected to the sun's energy or to the air.

Answer: Any one: the days were getting shorter and the sun a little lower by late July, so the lake surface received less energy each day; the air became more humid (held more vapor), which slows evaporation; the winds were calmer; or the water cooled slightly as the lake level dropped and the inflow stayed cold.

Why: Several physical causes are reasonable. The sun-energy cause is the most lesson-aligned; humidity and wind are correct too.

Also acceptable: Do not accept 'the lake had less water, so less evaporated': evaporation depends on the surface, and the surface area of a reservoir changes little over 45 cm.

- A physically reasonable cause connected to energy input or to the air's ability to take up vapor

Your argument

Answer: Claim: Mirror Lake dropped 45 cm because of evaporation, mostly, plus the water released to the town, minus the small stream inflow; the data do not support a leak of 3 cm a week. Evidence: (1) Evaporation totaled 38.1 cm, about 84 percent of the 45.1 cm drop, so most of the loss went into the air. (2) Evaporation (38.1) plus release (12.4) minus inflow (5.6) predicts a drop of 44.9 cm; the measured drop was 45.1 cm, leaving only 0.2 cm unexplained in eight weeks. (3) A 3 cm per week leak would add up to 24 cm, which is 120 times larger than the unexplained 0.2 cm; if that leak existed, the measured drop would have been about 69 cm, not 45. (4) The diver found no crack on June 3, which is consistent with the budget. (5) The pan floats in the lake at the lake's temperature, so its 38.1 cm is a fair estimate of the lake's surface loss. Reasoning: A lake is one stop in the water cycle. Energy from the sun warms the surface so that the fastest water molecules escape as invisible vapor; this happens at 23 °C because evaporation is a surface process that does not need boiling, and the hot, dry summer air could take up a lot of vapor. Gravity moves the rest: the stream carries water downhill into the lake, and the outlet pipe and gravity carry released water down to the town. Adding up everything the sun lifted out and gravity carried in and out accounts for the whole drop except 0.2 cm, which is within the precision of weekly gauge readings. A leak big enough to matter would have to show up as a large unexplained remainder, and it does not, so the evidence points to evaporation and releases, not a crack.

Why: This is the solved model response. Full credit requires a claim that names evaporation as the main cause and rejects the 3 cm/week leak, at least three numbered pieces of evidence with totals from the table and what each rules in or out, and reasoning that locates the sun's energy (evaporation) and gravity (inflow, release) in the lake system, explains below-boiling evaporation, and treats the 0.2 cm remainder as measurement precision rather than proof of a leak.

Also acceptable: A student who claims 'a tiny leak cannot be ruled out, but it is far smaller than 3 cm a week' is making a careful, correct claim and earns full credit if the evidence is there. A student who claims the dam is leaking has ignored q2 and q3; give partial credit for evidence organization only.

- Claim names evaporation (plus releases, minus inflow) and rejects the 3 cm/week leak
- At least three evidence items with numbers from the table or warm-ups
- Each evidence item states what it supports or rules out
- Reasoning places the sun's energy and gravity in the lake system
- Reasoning explains evaporation below boiling and why 0.2 cm does not prove a leak

Scoring rubric

Criterion	4 • Exemplary	3 • Proficient	2 • Developing	1 • Beginning
Claim	States the main cause (evaporation, with releases and inflow) and directly rejects the 3 cm/week leak in one clear statement.	Names evaporation as the cause but does not address the leak claim, or addresses it vaguely.	Claim names a cause not supported by the data (for example, the release alone) or is contradictory.	No claim, or a claim unrelated to the evidence.
Evidence	Three or more pieces of evidence with correct totals or percentages, each stating what it supports or rules out.	Three pieces of evidence, but one lacks a number or does not say what it rules out.	One or two pieces of evidence, or numbers copied from the table without totals or interpretation.	Evidence missing, invented, or contradicting the table.

Reasoning	Explains the sun's role in evaporation (surface molecules escaping below boiling) and gravity's role in inflow and release, and explains why a 0.2 cm remainder is within measurement precision.	Connects evaporation to the sun and inflow/release to gravity, but does not address the remainder or the below-boiling point.	Restates evidence without a mechanism, or gives the mechanism without linking it to the claim.	No reasoning, or reasoning with a science error (for example, water must boil to evaporate).
Scientific language and accuracy	Uses evaporation, water vapor, energy, gravity and water budget correctly; no errors; units on every number.	Terms mostly correct; one minor slip (for example, 'steam' for vapor) or a missing unit.	Several terms used loosely; units missing on most numbers.	Scientific language absent or consistently wrong.

Teacher notes

The dataset is simulated and built so that the water budget closes to 0.2 cm; the week 3 and week 6 drops were set 0.1 cm above the budget on purpose so that students meet a realistic, small remainder and must decide whether it means anything. Expected numbers: totals 45.1 / 38.1 / 5.6 / 12.4 cm; predicted drop 44.9 cm; unexplained 0.2 cm; evaporation share about 84 percent; leak claim 24 cm. Weekly evaporation of about 5 cm (7 mm per day) is realistic for a hot, dry Western summer. The floating pan is a simplification of how hydrologists estimate lake evaporation (real land pans need a correction factor); keep it as stated. Science to emphasize: evaporation is a surface process at any temperature (lesson pages printed 234 / PDF 270); the lake system has the sun lifting water out and gravity moving water in and out. The extension's good answer compares daytime versus nighttime drop rates, or sunny versus overcast weeks: a leak would continue at night and under clouds, evaporation would fall sharply.

Scaffold offered to students: Organize before you write

Make a two-column list on scrap paper. Left column: 'Supports a leak.' Right column: 'Does not need a leak.' Put each number from your warm-up answers into one column with a few words on why. If the right column is much longer, your claim should say the lake's drop is explained without a leak. Then write your evidence straight from the list, one sentence per item.

Extension: Design the test that would settle it

Mr. Okafor is not convinced; he says the evaporation pan might be wrong. Design a two-week test that could settle the question without draining the lake. Say what you would measure, how often, what result would support a leak and what result would rule one out. One hint: a leak through a dam does not depend on sunshine, but evaporation does. Write your plan as numbered steps with a sentence on the expected results for each possibility.