

Bringing Back Arroyo Verde: Design a Creek Restoration

Learning target: I can define the criteria and constraints of a creek restoration problem precisely, evaluate competing designs against them, and justify a design by predicting how its physical changes will affect populations.

Transfer and design

About 55 min

Pairs

MS-ETS1-1 · practice

MS-ETS1-2 · practice

MS-LS2-4 · practice

engineering design

data analysis

writing

Name _____

Date _____

Period _____

Directions

You and a partner are consultants to a city council. Read the problem and the council's list, then work through the four parts in order: define the problem, study the options, evaluate them, and recommend a design. The creek, the city and the cost estimates are invented for this worksheet, but the restoration methods and the invasive plant are real. Write your own answers to Part D even though you plan together.

You will need: This worksheet, Pencil, Calculator

The problem

Arroyo Verde is a small creek that runs 1.2 kilometers through a city park in California, passing behind the houses on Maple Street in its upper half. In the 1960s it was straightened into a ditch to carry floodwater away quickly. Today **giant reed**, an invasive grass native to northern Africa and Asia that can grow taller than a two-story house, lines both banks. Giant reed uses a lot of water, crowds out native willows and cottonwoods, burns easily, and casts little shade on the water, so the creek runs warm in summer: about 22.5 °C in the pools in August. Surveys find no breeding frogs and few native birds. The council has money for a three-year project and wants a design that brings native populations back without putting the neighborhood at risk.

The council's list (not yet sorted) — 1. Pacific chorus frogs breed in the creek by the third spring. 2. The total cost is no more than \$250,000 over three years. 3. The creek should look nicer. 4. August water temperature in the pools is below 20 °C by year 5. 5. In a big storm, floodwater behind the Maple Street houses must not rise above today's level. 6. No heavy equipment works in the creek from February through August, when birds nest. 7. Giant reed covers less than 10 percent of the banks by year 3. 8. The park trail stays open except for short closures.

Part A: Define the problem

1. Sort the council's eight statements. A **criterion** describes what success looks like and can be met well or less well. A **constraint** is a limit that every acceptable design must stay within. Some statements are **too vague** to use as either.

Criterion, constraint or too vague?	Why
1. Frogs breed by the third spring	
2. Cost no more than \$250,000	
3. The creek should look nicer	
4. Pools below 20 °C by year 5	
5. No rise in flood level at Maple Street	
6. No heavy equipment February to August	
7. Giant reed under 10 percent by year 3	
8. Trail stays open	

2. Rewrite the vague statement as a precise, measurable criterion. Then explain what the council would actually count or measure to check it.

Part B: The options

A city engineer has estimated what five options would do. A **beaver dam analog** is a row of wooden posts pounded into the creek bed with willow branches woven between them. Like a beaver dam, it slows the water and backs up a pool, and it can be built with hand tools. Options can be combined if the total cost still fits the budget.

Engineer's estimates for five options (teaching dataset)

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

Option	What is done	Cost over 3 years	Flood level at Maple Street in a big storm	Still pools for breeding frogs by year 3?	August pool temperature by year 5	Giant reed on banks by year 3
A	Remove giant reed every fall for 3 years and plant native willows and cottonwoods along the whole creek	\$120,000	no change	no	19.5 °C	under 10%
B1	Build 6 beaver dam analogs along the whole creek	\$90,000	15 cm higher	yes	20.5 °C	about 70%
B2	Build 3 beaver dam analogs in the lower half only, downstream of Maple Street	\$45,000	no change	yes, in the lower half	20.5 °C (lower half)	about 70%
C	Dig a new curving channel with a wide floodplain and plant natives	\$900,000	20 cm lower	yes	18.5 °C	under 10%
D	Line the banks with rock (giant reed removed during construction)	\$80,000	no change	no	22.5 °C	under 10%

Simulated estimates for teaching. Costs and effects are invented to be realistic for a small urban creek. Today: pool temperature about 22.5 °C in August, giant reed on about 70 percent of the banks, no still pools.

Part C: Evaluate

3. The engineer did not estimate the combination A + B2. Predict its cost, its effect on the Maple Street flood level, and its August pool temperature in the lower half, and explain your temperature prediction.

4. Complete the decision matrix. First check the two constraints in the table; write 'eliminated' in the last column for any option that breaks one. Score the others: **Frogs** 2 = still pools by year 3, 0 = none. **Temperature** 2 = below 20 °C, 1 = 20 to 21 °C, 0 = above 21 °C. **Giant reed** 2 = under 10 percent, 0 = not removed. For A + B2, use your prediction from q3.

Within budget?	No rise in flood level?	Frogs (0-2)	Temperature (0-2)	Giant reed (0-2)	Total, or 'eliminated'
A					
B1					
B2					
C					
D					
A + B2 combined					

5. Which options are eliminated, and which constraint does each break? Why is it a mistake to choose an eliminated option even if it would create the best habitat?

Part D: Decide and justify

6. Write your recommendation to the council: one option or a combination that meets every constraint. Justify it with your decision matrix and with science: explain how each physical change in your design (shade, still water, removing giant reed) changes resources for living things. Say honestly which criterion your design meets least well.

7. Your design changes physical components of the creek. Predict **two** populations that should increase and **one** that might decrease, and explain each prediction through a resource that changes.

8. Plan the evidence. Name two measurements, where you would take them (include a comparison place that is not restored), and when (before and after the work). What result in year 3 would show your design is working?

9. Constraint 6 bans heavy equipment in the creek from February through August. Give a schedule for your design's work that respects it, and explain what the constraint protects.

10. Name one risk or trade-off of your design and one way to reduce it.

Constraints first, criteria second

Engineers check constraints before anything else, because a design that breaks one is not allowed no matter how good it is. Go down the 'Cost' column and cross out anything over \$250,000. Go down the 'Flood level' column and cross out anything that raises the water. Only then score what is left. For q6, try this frame: 'We recommend ___ because it stays within ___ and ___. It meets the criteria for ___ because ___ (shade, still pools, reed removal) changes ___ for ___. It meets ___ least well because ___.'

When the beavers move in

Beaver dam analogs often attract real beavers, which may then build their own dams, sometimes in places engineers did not plan. Suppose a beaver family arrives at Arroyo Verde in year 4 and starts a dam just downstream of Maple Street. Write a short plan for the council. Which criteria might the beavers help? Which constraint might they threaten? Research one method communities use to live with beavers, such as a pipe-and-fence flow device that keeps a pond from rising past a set level, and explain how it would keep the design within its constraints.