

Where the Sediment Goes: Make a Layer, Then Cut a Canyon

Investigation question: When moving water erodes a pile of mixed sediment, where does each size of grain end up, how do repeated flows build layers, and what do the walls of a channel cut through those layers show?

Classroom field investigation

Groups of 4

1 session

Setup 10 · Activity 35 · Cleanup 10 min

MS-ESS2-2 · practice

MS-ESS1-4 · supports

Scientific purpose

Students run water over a mound of mixed sand, gravel and dark grounds in a tilted tray, watch erosion, transport and deposition happen, measure how far each grain size travels at slow and fast flow, build a second layer on the first, and finally cut a channel through the deposit to expose matching layers on both walls. Then they survey the schoolyard for the same features at a slightly larger scale. The investigation turns the first three rules of the lesson into things they watched happen.

Why this helps students with this chapter

Students will accept 'younger on top' as a fact long before they believe it. Watching a dark layer settle on top of a sand layer because the sand was already there, and then watching a channel slice through both and leave matching stripes on each wall, makes superposition, lateral continuity and cross-cutting into things they saw happen. The slow-versus-fast comparison adds a real measured result about how water's energy sorts grains, which they will need when they read a gravel-to-sand layer in rock.

Standards connections

MS-ESS2-2 (practice, explaining surface change by deposition and erosion by moving water at small and large scales): Students produce deposition and erosion themselves, compare slow and fast flow quantitatively, and then connect a 30-second channel in a tray and a downspout fan in the schoolyard to the Grand Canyon, which builds toward explanations of how geoscience processes change the surface at different time and spatial scales.

MS-ESS1-4 (supports, the physical basis of superposition, lateral continuity and a cutting feature being younger): A Grade 8 PE in California's sequence. Seeing a second deposit land on top of the first, and seeing a channel expose matching layers on both of its walls, gives students a physical reason to trust the rules they then use to read strata.

Roles (rotate each session)

- **Pourer:** Pours the measured water onto the mound at the agreed height and rate, using the pinhole cup for slow flow and the open cup for fast flow, and calls out when the pour starts and ends.

- **Timer and measurer:** Times each pour, then measures the length of the deposit, the farthest gravel and the layer thicknesses on the channel walls with the ruler.
- **Observer:** Watches the mound and the deposit during each pour, says aloud where grains are moving and where they stop, and uses the hand lens to check grain sizes.
- **Recorder and sketcher:** Records every measurement, sketches the tray from above after each run and draws the channel wall in cross section.

Materials

Item	Quantity	Per	Note
Shallow plastic tray about 60 by 40 cm with sides at least 8 cm high (under-bed storage box, large paint tray or a deep aluminum roasting pan)	1	group	
Damp play sand	about 2 liters	group	Damp, not wet: it holds a mound and does not blow as dust.
Coarse aquarium gravel, dark color, 3 to 6 mm	about 300 mL	group	
Dried used coffee grounds or dark craft sand	about 300 mL	group	The dark, fine second sediment. Dry the grounds fully so they do not mold.
Two 500 mL cups: one with a single 3 mm hole in the bottom (slow pour) and one plain (fast pour)	1 of each	group	
Pitcher of water, 2 L	1	group	
Two blocks or thick books to raise one end of the tray by 5 cm	2	group	
Ruler (30 cm), stopwatch or phone timer, hand lens	1 each	group	
Toothpicks to mark the mound edge and the deposit edge	6	group	
Bucket for used water, sponge and towels	1 set	group	
Recording sheet and colored pencils	1 set	student	
Broom, dustpan, mop and a sand-drying tub	1 set	class	

Estimated cost: 25 to 80 per class, mostly reusable (an estimate; A 50 lb bag of play sand is about \$6, aquarium gravel about \$8, coffee grounds are free. Trays are the main cost: under-bed boxes run about \$8 each, while aluminum roasting pans are about \$2 each. Cups, pitchers and rulers are classroom stock.)

Safety

- Water on hard floors is a slip hazard: keep the bucket under the low end of the tray, wipe spills at once, and walk, never run, with the pitcher.

- Keep sand damp to avoid dust; dry fine sand and silica dust should not be breathed. Do not blow on the tray.
- Sand and grounds never go down a sink; they clog drains. Pour used water through a cloth into the bucket and dump outside on soil or into the sand-drying tub.
- Wash hands after the activity; keep hands away from eyes while handling sand. Safety glasses are optional for the fast pour, which can splash.
- Outdoor survey: stay in the designated area, away from roads, drains and standing water; sun protection if needed.

Teacher preparation and setup

1. Dampen the sand the day before so it holds a mound without running as slurry; a 50 lb bag serves eight groups with sand to spare. Dry the coffee grounds on a tray overnight.
2. Punch a single 3 mm hole in the bottom of one cup per group with a heated nail or a drill; test that 500 mL drains in roughly 60 to 90 seconds.
3. Run the three pours yourself in one tray to learn how far the deposit spreads at your slope; adjust the slope (4 to 6 cm) so the fast pour does not reach the far end of the tray.
4. Assign half the groups slow flow and half fast flow for Run 1 so the class has both conditions to compare; or, if time allows, have each group do both in separate trays.
5. Walk the schoolyard beforehand and note two or three places where water has moved sediment: a fan of sand below a downspout, a small gully on a bare slope, layered silt at the edge of a puddle. Decide whether the survey happens as a 15-minute walk at the end of the period or as a second session.

Investigation design

Independent variable	Flow rate of the water in Run 1: slow (500 mL through a 3 mm pinhole over about 60 to 90 seconds) versus fast (500 mL poured from an open cup in about 10 seconds)
Dependent variable	Length of the deposit from the mound edge (cm) and the distance the farthest gravel traveled (cm); also the order of grain sizes from the mound outward
Controlled	Same slope (5 cm rise); Same water volume (500 mL) and pour height (about 5 cm); Same mound size and sand-to-gravel mix; Same damp sand from one supply
Trials	One Run 1 per group; four groups slow and four fast, pooled on the board. Runs 2 and 3 are done by every group with the slow cup and the open cup respectively.
Comparison	Deposit length and farthest-gravel distance for slow flow versus fast flow, and which deposit shows clearer sorting.

Student procedure

1. Set the tray on the blocks so the upper end is 5 cm higher than the lower end. At the upper end, build a mound of 2 parts damp sand to 1 part gravel, about 10 cm wide and 4 cm high, mixed evenly. Mark the mound's lower edge with two toothpicks. Leave the rest of the tray empty.

2. Run 1, erosion and deposition. The Pourer holds the assigned cup (slow pinhole or fast open) about 5 cm above the top of the mound and pours 500 mL of water onto it; the Timer records the pour time. The Observer narrates: where grains leave the mound, which path they take, where they stop. When the water drains, measure the length of the deposit from the toothpicks to its far edge and the distance to the farthest gravel. Use the hand lens to check which grain size lies nearest the mound and which farthest. Record and sketch from above.
3. Run 2, a second layer. Without disturbing the deposit, spread a 1 cm cap of coffee grounds over what is left of the mound. Pour another 500 mL the same way as Run 1. Watch where the dark grounds settle. When the water drains, note whether the dark layer lies on top of the first deposit or beneath it, measure how far it traveled, and sketch.
4. Run 3, cutting a channel. Switch to the open cup. The Pourer pours 300 mL in one narrow, steady stream onto the middle of the deposit so that the water runs as a single stream across it. Watch the stream cut a channel. When it drains, look at the two walls of the channel. If a wall has slumped, use the ruler edge to cut a clean vertical face along it.
5. Record the layers on the left wall and on the right wall of the channel, top to bottom, with each layer's material and thickness in millimeters. Note whether the layers on the two walls match. Draw a cross section of one wall.
6. Report your Run 1 numbers (deposit length, farthest gravel, pour time, flow condition) on the class board so the slow and fast groups can be compared.
7. Survey (15 minutes outdoors, or a second session). In the designated area, find one place where water has moved sediment: a fan of sand below a downspout, a tiny gully on a bare slope, or layered silt at a puddle edge. Sketch it, measure its length, and record which grain sizes are near the source and which are far. Identify which of your three runs it most resembles.
8. Answer the analysis questions individually, then compare within the group.
9. Cleanup: pour the water through a cloth into the bucket, scoop the sediment into the drying tub, wipe the tray and the floor, and return the cups and rulers.

Expected observations

- Run 1: water erodes a channel or several rills into the mound, grains move downslope in the flow, gravel stops within a few centimeters of the mound, sand spreads farther in a fan, and the finest particles travel farthest or stay suspended in the pooled water.
- Fast flow produces a longer deposit and carries gravel farther than slow flow; slow flow produces clearer sorting bands.
- Run 2: the dark grounds settle as a thin layer on top of the sand fan, extending a little farther than the sand because the grounds are lighter and finer.
- Run 3: the narrow stream cuts a channel through both layers; the walls show the dark layer over the tan sand layer on both sides, with matching thicknesses, though walls often slump and need a clean cut with the ruler.
- Survey: downspout fans show gravel or coarse sand near the pipe and finer sand at the fan's edge; gullies show a tiny channel with layered sides where the ground was layered.

Likely difficulties

- The fast pour can wash the whole deposit to the end of the tray if the slope is too steep; keep the rise at 5 cm and the pour height low.
- Channel walls slump in loose sand; teach the ruler-edge cut to expose a clean face, and read the layers immediately.
- Coffee grounds float at first and settle slowly; wait a minute before measuring Run 2.
- Groups confuse the mound (source) with the deposit (sink) in their sketches; have them label 'erosion here' and 'deposition here' before drawing anything else.
- The survey may find nothing after a dry spell; a watering can poured on a bare slope for 30 seconds makes a fan and a gully on demand.

Structured debrief

1. Pool the Run 1 numbers and compare slow with fast: fast flow carries sediment farther and carries gravel farther, because faster water has more energy and can move bigger grains; as water slows, the biggest grains drop first. Point to the sorting in every tray: gravel near, sand farther, grounds farthest.
2. Ask every group what lay on top after Run 2. The dark layer is on top in every tray because the sand deposit was already there when the grounds arrived; a new deposit can only land on what exists. That is superposition as a cause-and-effect statement, not a rule to memorize.
3. Ask about the channel walls. The layers match on both sides because they were one continuous deposit before the stream cut it (lateral continuity), and the channel is the youngest feature because it cuts both layers (cross-cutting). This is the Grand Canyon in a tray, at a scale of centimeters and seconds instead of kilometers and millions of years.
4. Connect the survey: a fan of sand below a downspout is the tray's Run 1 at a larger scale; a gully on a slope is Run 3. The same process, moving water sorting and depositing sediment, operates from a tray to a canyon, which is the heart of MS-ESS2-2.
5. Close on q9 and the limits of the model: the tray shows processes and order but not time, hardening or the enormous scale of real strata; thickness is never a clock.

Recording sheet: what students fill in

Lab 3 recording sheet: Where the sediment goes

Record what you **see** during each pour, then measure after the water drains. Keep observations (the gravel stopped 6 cm from the mound) separate from explanations (the water slowed down there).

The three runs

Run	Flow (slow or fast)	Water (mL)	Pour time (s)	Deposit length (cm)	Farthest gravel (cm)	What settled on top of what
1: erosion and deposition		500				
2: second layer (dark grounds)	slow	500				
3: channel	fast, narrow stream	300				

-  Top view of the tray after Run 2: draw the mound, the first deposit and the dark second deposit, and label where gravel, sand and grounds ended up. Below it, draw a cross section of one channel wall after Run 3, with each layer labeled and its thickness in millimeters.

Answer: Top view: the mound at the raised end with toothpick marks, a fan-shaped deposit downslope labeled gravel near the mound, sand farther, grounds farthest and on top. Cross section of a channel wall: a dark grounds band over a tan sand band (with gravel at its base nearest the mound), each labeled with a thickness in millimeters, and the channel floor at the bottom.

Why: The drawing should show sorting in the top view and superposition in the cross section.

- Mound and fan with grain sizes placed correctly
- Cross section with dark layer over sand layer and thicknesses labeled

Channel walls after Run 3 (top layer first)

Layer from top	Left wall: material	Left wall: thickness (mm)	Right wall: material	Right wall: thickness (mm)	Do they match? (yes/no)
1					
2					
3					

Schoolyard survey

Feature found	Where	Length (cm)	Grain sizes near the source	Grain sizes far from the source	Which run it resembles

1. During Run 1, where in the tray did erosion happen, where did deposition happen, and what made the grains stop moving?

Answer: Erosion happened on the mound, where the water hit and ran down it; deposition happened downslope where the flow spread out and slowed, forming a fan. Grains stopped when the water slowed enough that it no longer had the energy to carry them, biggest grains first.

Why: The key move is linking stopping to the water slowing, which is what deposition means.

- Erosion at the mound, deposition in the fan
- Grains stop because the water slows and loses energy

2. After Run 2, which deposit is on top? State the rule from the lesson that this demonstrates and explain why it could not have come out the other way.

Answer: The dark grounds deposit is on top. This demonstrates superposition: the sand deposit already existed when the grounds arrived, and a new deposit can only land on what is already there, so the newer layer must be on top. It could not come out the other way without the first layer being lifted or removed.

Why: Students should state superposition as a consequence of how deposition works, not as a rule.

- Dark layer on top
- Names superposition
- Explains that the new deposit lands on the existing surface

Analysis questions: answer key

3. The class pooled its Run 1 data (teaching dataset): slow-flow groups averaged a deposit 18 cm long with the farthest gravel at 6 cm; fast-flow groups averaged 31 cm with the farthest gravel at 14 cm. Calculate how many times farther the fast flow carried the gravel, and explain the difference in terms of the energy of the moving water.

Answer: $14 \text{ cm} \div 6 \text{ cm} \approx 2.3$, so the fast flow carried gravel about 2.3 times as far (and the deposit was $31 \div 18 \approx 1.7$ times as long). Faster-moving water has more energy, so it can keep bigger and heavier grains moving longer before it slows enough to drop them; slow water drops the gravel almost at once.

Why: Simple ratio plus the energy explanation; these are the stated teaching numbers, not real class data.

Also acceptable: Accept 'about twice as far' with the division shown, and accept 2.33.

4. In your deposit, which grain size settled nearest the mound and which farthest? If a geologist finds a rock layer that is gravel at one end and grades into fine sand at the other, what can she infer about the water that deposited it, and in which direction did it flow?

Answer: Gravel settled nearest the mound, sand farther, and the finest grounds farthest. A layer that grades from gravel to fine sand records water that was slowing in the direction of the fine grains: it had enough energy to carry gravel at the coarse end and had slowed by the fine end. The flow went from the gravel end toward the sand end.

Why: This is the sorting result read backward from the rock, the way a geologist reads a graded deposit.

- Gravel nearest, fines farthest
- Water slowing deposits coarse grains first
- Flow direction from coarse toward fine

5. Did the layers on the two walls of your channel match in order and thickness? Name the rule this demonstrates. Is the channel older or younger than the layers in its walls, and which rule says so?

Answer: Yes, both walls showed the dark layer over the sand layer with about the same thicknesses, because they were one continuous deposit before the stream cut it: the principle of lateral continuity. The channel is younger than both layers, because it cuts through them: the law of cross-cutting relationships.

Why: Two rules, each tied to the observation that demonstrates it.

- Walls match
- Lateral continuity
- Channel younger, cross-cutting relationships

6. Suppose at one spot in a tray you found a dark grounds layer underneath a sand layer, the reverse of what you expect. Give two different events that could produce this, and say what extra observation would tell them apart.

Answer: Possibility one: the grounds were deposited first at that spot and a later pour of sand covered them, so the order is correct and that spot simply records a different sequence (the rule holds). Possibility two: the deposit at that spot was disturbed after forming, for example a slump that flipped a slab or a hand that pushed sand over the grounds. To tell them apart, look for signs of disturbance: a broken or folded edge, mixed grains at the boundary, or whether the dark layer traces continuously under the sand across the tray (deposition) or ends abruptly (a slumped block).

Why: Mirrors the real question of an overturned or disturbed stack; students must propose a distinguishing observation.

- Two different causes (later deposition of sand versus disturbance after deposition)
- A specific observation that would distinguish them

7. Your channel formed in about 30 seconds; the Grand Canyon took millions of years. Name two things the tray model shows well and two things it cannot show about a real canyon cut through real strata.

Answer: Shows well: where erosion and deposition happen and why (water slowing), how grain sizes sort by water energy, that each new deposit lands on top of the last, and that a channel cuts matching layers and is younger than them. Cannot show: the time involved (seconds versus millions of years), the hardening of sediment into rock, the thickness and number of real strata, the uplift that raised the plateau so the river could cut down, and the way a real river deepens a canyon by cutting bedrock rather than loose sand.

Why: Any two sound points in each category; the time and hardening limits are the most important.

- Two valid strengths of the model
- Two valid limits, including time or hardening

8. Describe the feature you found in the schoolyard survey. Which of your three runs did it most resemble, and what evidence (grain sizes, shape, layering) supports the match?

Answer: Group-specific. A downspout fan: coarse grains near the pipe, fine sand at the edge, fan shape, resembles Run 1. A gully on a slope: a small channel with sides that may show layers, resembles Run 3. A puddle edge with layered silt: fine layers from repeated wetting, resembles Run 2's layer on layer.

Why: Credit depends on matching evidence to the run, not on which feature was found.

- Feature described with location and size
- Matched to a run with at least one piece of evidence (grain sorting, shape or layering)

9. A single storm can leave a 10 cm layer of sand in a stream bed, while a quiet lake bottom gains about 1 mm of mud per year. If you found a 10 cm sand layer and a 10 cm mud layer in a cliff, what can you say about how long each took to form? What does this tell you about using layer thickness as a clock?

Answer: The 10 cm sand layer could have formed in a single storm, in hours. The 10 cm mud layer at 1 mm per year would take about 100 years ($100 \text{ mm} \div 1 \text{ mm per year} = 100 \text{ years}$). Two layers of the same thickness can differ in formation time by a factor of thousands, so thickness cannot be used as a clock; only radiometric dates on igneous layers give time.

Why: A one-step calculation that lands the thickness-is-not-time point.

Also acceptable: Accept 'about a century' for the mud and 'a day or less' for the sand with the reasoning stated.

Individual evidence of learning

Each student submits their own run table, top-view and cross-section drawings, channel-wall table, survey entry and answers to q1 through q9. The drawings and q5 are the primary evidence for the superposition, lateral-continuity and cross-cutting targets; q3, q4 and q7 are the evidence for explaining surface change at different scales.

Assessment criteria

Criterion	Proficient looks like
Observation and measurement	All three runs recorded with times and lengths; sketches label the mound, deposit, grain sizes and the channel-wall layers with thicknesses.
Process explanation	Explains erosion at the mound, transport in the flow and deposition where the water slows, and uses water energy to explain both the slow-fast difference and the sorting of grain sizes.
Use of rules	Connects the second layer on top to superposition as a cause-and-effect result, the matching channel walls to lateral continuity, and the channel's youth to cross-cutting relationships.
Scale reasoning	Links the tray, the schoolyard feature and a real canyon as the same process at different sizes and durations, and states what the model cannot show.

Accessibility adaptations

- Let the Observer role be a narration role for students who prefer speaking; a recorded voice memo of the narration can stand in for part of the written sheet.
- Provide a pre-drawn tray outline for the top-view sketch and a cross-section template with three blank bands for the channel wall.
- Use high-contrast sediments (white sand, black gravel, dark grounds) so the layers read clearly, and allow students with low vision to read the channel wall by touch after the ruler cut.
- Pair students for the pour so that one steadies the cup and the other times; the survey can be done at a flat, accessible location such as a downspout near a paved path.

Low-cost alternative

Use a deep aluminum roasting pan or a plastic dish tub as the tray and a yogurt cup with a pinhole as the slow pourer. Sand from a school sandbox and dark soil from a garden bed replace play sand and coffee grounds. If no trays are available at all, do the whole investigation outdoors with a watering can on a bare slope: one pour for the fan, a second with dark soil on top, and a narrow pour for the channel.

Model limitations

The tray compresses millions of years into a minute and never hardens its sediment, so it shows order and process but nothing about time, compaction or cementation. The second layer is placed by hand before it is washed down, and the slope and water volume are far from the conditions of a real river, so measurements compare conditions within the tray rather than predicting real deposits. Sorting in the tray is cruder than in nature because the pour is brief. The activity has not been physically tested by the authors; the deposit lengths in q3 are a teaching dataset, not measured results, and the slope and pour volumes may need adjusting after a trial run.

Teacher notes

Keep the q3 numbers as a shared teaching dataset so every student can do the calculation even if their own tray ran badly; have them compare their group's real numbers alongside. Photograph a clean channel wall from one tray and project it next to the slide 9 canyon diagram; the matching stripes on both walls are the lesson's lateral-continuity argument in one picture.