HANFORD & THE RIVER

High School Environmental Science
Produced by Columbia Riverkeeper

The Hanford Nuclear Site ("Hanford" or "Hanford Site") is the most contaminated place in the Western Hemisphere, where the United States discharged billions of gallons of radioactive waste near the banks of the Columbia River and directly into the River. Waste has contaminated the groundwater, and dozens of underground storage tanks have leaked high-level nuclear waste. Vast areas of groundwater are contaminated with nuclear and chemical waste, and, in some places, this groundwater is flowing into the Columbia River.

The 586-square-mile Hanford Site is a legacy of nuclear weapons production during World War II and the Cold War. But, nuclear activities were confined to a minor part of the site, leaving much of the site relatively undisturbed. The resulting "accidental nature" includes shrub-steppe habitat, cliff habitat, wetlands and river systems, and the most productive spawning ground for wild Chinook salmon on the main stem of the Columbia River.

The materials in this curriculum allow teachers and students to explore Hanford and the Hanford Reach of the Columbia River. This curriculum includes lesson plans, Teacher's Guides and Student Worksheets along with primary documents and supplemental materials to help facilitate student learning. The lessons permit students to analyze Hanford's history, ecology, and the risks and rewards of cleanup.

The lessons also allow students to learn about Hanford's ecology through the eyes of Hanford's threatened and endangered species. Specifically, the curriculum allows students to investigate the connection between the cleanup of Hanford and Hanford's impact on human health and the environment.

The lessons are based on an inquiry approach, which engages the students in known and unknown science concepts, has them explore and investigate, then reflect and explain their thinking and reasoning, applying and extending their new knowledge.

Teachers can use this curriculum in a variety of ways. They could use a handful of documents to supplement existing readings and lesson plans. They could also use the materials to create a new teaching unit lasting anywhere from a day to a week.

This curriculum allows students to go beyond hearing about Hanford, the shrub steppe habitat, or endangered species. Researching the species of the Hanford Reach and researching the risks and rewards of cleanup and the stakeholders, enables each student to become an investigator.

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Lesson 3: Making Environmental Decisions

	Subject Area: Environmental Science **Description:** 1 hour
Washington State Standards:	**Environmental and Sustainability Learning Standards –** Standard 3: Sustainability and Civic Responsibility
Lesson Overview:	In this lesson, students will: • Think critically about Hanford cleanup and apply the knowledge, perspective, vision and skills necessary to make personal and collective decisions and take actions that promote the long-term sustainability and cleanup of Hanford.
Learning Objectives:	At the end of this lesson students will be able to: • Evaluate the costs, risks and benefits of cleanup (Stakeholder Lesson) • Understand how cleanup choices affect the long-term health of the Columbia River and downstream communities.
Engage & Encounter	Up to this point, students have evaluated Hanford's natural resources. Students will now read about other stakeholders including Native Americans, residents, and Hanford workers. Start this lesson by having the class brainstorm a list of stakeholders. Using their understanding of the history of Hanford, radionuclides and environmental pollution, encourage students to think outside the geographic area to include those groups potentially affected by Hanford cleanup decisions. Have students look back historically to ask what was Hanford traditionally used for and will these uses return?
Explore & Investigate	Using the ***Stakeholder Description,*** students will research at least two stakeholder groups to gain a deeper understanding of the different perspectives surrounding cleanup.
Reflect	Students will prepare a ***Decision Statement*** from the perspective of their assigned stakeholder.
Apply & Extend	Students will each represent a different stakeholder. They will research the stakeholder perspective and play the role during a mock cleanup negotiation.
Assessment	Have the class reflect on the level of influence each of the stakeholders has in the decision.

	• Which of the stakeholders has the most influence? • Which stakeholders have the least influence and why? • Which stakeholders will be most affected by the cleanup decision? • Is there a relationship between the stakeholders influence and the ones that are most affected?

Teacher's Guide - Making Environmental Decisions

Students use a decision-making process to explore the complex nature of real-world environmental decisions and how they get resolved. Students will use their knowledge gained in the first lessons to identify the stakeholders and their role and impact, to map out the intended and unintended consequences from their decisions, and to negotiate a cleanup plan with other stakeholders.

Start this lesson by activating students' prior understanding about the decision-making process by asking them to think about a decision they had to make recently.

Ask:

- What was the decision about?
- How did you go about making your decision?
- What steps did you take?
- Who was involved in the process of making the decision?
- Did you seek any outside information?

Case Study

Give the students the **Case Study**: **Hanford's 300 Area Cleanup**

Ask:

- What was the reason for building the tanks at Hanford?
- What would happen to the environment if the nuclear waste storage tanks were left in place and the waste was not removed?
- What would happen to the people and animals in the area if the tanks were left in place and the waste was not removed?

Engage: Students research stakeholders. Stakeholders are individuals or groups with interests related to an issue or outcome. Every public policy decision, from funding priorities to laws, has an impact on multiple stakeholders, and thus, is frequently influenced by those stakeholders.

Ask students to brainstorm all the individuals or groups that might be involved in Hanford decisions. Explain that the individuals or groups they have identified are often called stakeholders. Some stakeholders have a strong voice, while others, such as natural resources and the physical environment, are silent and do not have a voice in the decision-making process.

Students will apply the knowledge, perspective, vision, and skills necessary to make personal and collective decisions and take actions that promote sustainability. A key aspect

of sustainability is the impact of one's decisions and actions on current and future generations. The intent of this standard is for students to apply the knowledge and experiences referred to in prior lessons by taking an active role as responsible citizens and creating positive solutions for present and future generations. Consideration of multiple perspectives allows for a wider range of possible solutions. Students should be able to envision a world that is sustainable, and articulate the changes that would be needed to achieve their vision. Necessary skills include communication, collaboration, and imagination. Desirable habits of mind include flexibility, commitment, appreciation, humor, confidence, and determination.

Write a list of identified stakeholders on the board. Explain to students that they will take on the role of one of these stakeholders and write a ***Decision Statement*** based on their knowledge and viewpoint of that stakeholder.

Explore: Divide students into small groups and assign each group two stakeholders. Using the ***Stakeholder Description,*** ask students to research at least two stakeholders to gain a deeper understanding of the different perspectives surrounding the problem. The more stakeholders they research, the better their understanding of any issues related to the problem. Students could contact Tribes, local, state and federal governments, business and industries, community groups and landowners. A list of stakeholders is provided at the end of the curriculum.

As students research the individuals and groups that are connected to Hanford, they see firsthand that most issues or problems have more than just one or two stakeholders, each of whom may have a different view point in relation to a problem and its potential solutions.

Reflect*:* Assign each student as a stakeholder representative. Students can work in groups of two or three. Have students prepare a ***Decision Statement*** from the perspective of their stakeholder. Students should develop their character's beliefs, attitudes, and point of view about the cleanup. Stress that this should go beyond what the character knows or has heard and should include identifying questions the character wants to ask about the cleanup.

Apply: Ask the students to participate in a decision-making forum. Each student will represent a stakeholder group. Give each student two minutes to present their preferred alternative as outlined in their ***Decision Statement*** and their reasoning behind it. Keep tally of the preferred alternatives and have students negotiate until more than half of the stakeholders agree on an alternative.

Debrief the final outcome. Ask:

- What were some of the roadblocks you experienced in reaching a decision?
- How did the group weigh the different consequences when making a decision?
- What compromises were made to come to an agreed alternative, i.e. did groups increase the risk to human health and the environment in order to reduce cost, or did they choose a more expensive, more complete cleanup?
- Which stakeholder had the greatest level of influence in the decision and why? Which stakeholder had the lowest level of influence?
- Why is it important for the stakeholders with the lowest level of influence to remain involved in Hanford?

- Which stakeholder will be most affected or least affected by the final decision?
- Is there a connection between the stakeholder with the most influence and the chosen outcome?

Assessment: Have the students identify the consequences of the decision. Hanford's environment is a complex system in which both biotic (living) and abiotic (nonliving) factors are interconnected. Have the students re-read the ***Case Study***. Have them illustrate the consequences in a ***Consequence Web***.

Ask:

- *Is there anything that has been missed?*
- *Which of these consequences are intended and which are unintended?*
- *Broaden your scope across state and international boundaries, what additional stakeholder groups will positively and negatively benefit from the decision?*
- *How will the decision affect future generations?*

Case Study: Hanford Tank Waste

The following case study is adapted from a real life scenario at Hanford. However, facts have been changed. This is not an actual summary of the alternatives available

The Hanford Site located within semiarid, shrub-steppe habitat in south-central Washington state. The United States government owns the Hanford Site and a government agency, the United States Department of Energy, oversees the site. Nuclear materials production and processing at Hanford released contamination to the environment, resulting in areas of contaminated soil and groundwater that pose a risk to human health and the environment.

During plutonium production, some of the most hazardous waste, including chemical and nuclear waste, was stored in underground storage tanks. Now, over 56 million gallons of Hanford waste remains in 177 underground tanks. The United States Department of Energy intends to convert most of the waste into glass logs at the Waste Treatment Plant, beginning in 2019.

Hanford's underground tanks are old and contain chemically complex waste. The tanks are buried underground, 200 to 300 feet above Hanford's groundwater, and they are located 7 to 10 miles from the Columbia River. They have already leaked more than 1 million gallons of waste into the ground. These leaks have contributed to the contamination of groundwater that flows to the Columbia River.

The United States Department of Energy recently released a Final Tank Closure Plan, outlining four alternatives for the retrieval and treatment of waste from the underground storage tanks as well as final cleanup of the underground tanks. There are four major components to the Tank Closure Plan: 1) Waste Retrieval, 2) Waste Treatment, 3) Waste Disposal, and 4) Closure of the Underground Tanks.

The four alternatives area as follows:

Alternative #1: No Action

Waste Retrieval: The United States Department of Energy will not remove any of the waste from the underground storage tanks.

Waste Treatment: They will immediately stop construction of the Waste Treatment Plant.

Waste Disposal: All of the waste will stay in the underground storage tanks.

Tank Closure: The United States Department of Energy will fill the tanks with a concrete like substance to minimize the leakage of waste and leave the tanks in place.

Cost: $4 billion

Completion date: 2021

Alternative #2: Removal & Treatment

Waste Retrieval: The United States Department of Energy will remove 99 percent of the waste from the underground storage tanks.

Case Study: Hanford Tank Waste

Waste Treatment: They will treat 50 percent of the waste in the Waste Treatment Plant.

Waste Disposal: They will store the glass logs at the Hanford Site. The remaining untreated waste will be shipped offsite.

Tank Closure: They will fill the tanks with grout to minimize any leaking of the remaining 1 percent of nuclear waste and leave the tanks in place.

Cost: $64 billion

Completion date: 2043

Alternative #3: Removal & Full Treatment

Waste Retrieval: The United States Department of Energy will remove 99 percent of the waste from the underground storage tanks.

Waste Treatment: They will treat 99 percent of the waste in the Waste Treatment Plant.

Waste Disposal: They will store the glass logs containing small of radioactive waste on site. The remaining glass logs, which contain larger amounts of radioactive waste, will be stored off site.

Tank Closure: They will fill the tanks with grout to minimize any leaking of the remaining 1 percent of nuclear waste and leave the tanks in place.

Cost: $76 billion

Completion Date: 2050

Alternative #4: Removal, Full Treatment, and Closure

Waste Retrieval: The United States Department of Energy will remove 99.9 percent of the waste from the underground storage tanks.

Waste Treatment: They will treat 100 percent of the waste at the Waste Treatment Plant.

Waste Disposal: They will not store the waste at Hanford. The Department of Energy would ship and store all of the glass logs at a special location that is designed for nuclear waste.

Tank Closure: They will remove the underground storage tanks and the contaminated soil surrounding them.

Cost: $204 billion

Completion Date: 2110

Long Term Impacts

Water Quality – Contaminants left in the soil will eventually travel deeper into the ground, into the groundwater and into the Columbia River. The following table summarizes the highest projected concentration at the Columbia River shoreline and the year, in parenthesis, that concentration will occur.

	Alternative			
Contaminant	1	2	3	4
Radionuclide (picocuries per liter)				
Tritium	502 (2050)	494 (2050)	477 (2051)	477 (2051)
Technicium-99	1,700 (2999)	418 (2317)	392 (2254)	358 (2221)
Uranium (includes -233, 234, -235, -238)	.6 (11928)	.3 (11935)	.1 (11937)	.1 (11935)
Chemical (micrograms per liter)				
Chromium	84 (4498)	74 (2079)	71 (2076)	71 (2076)
Nitrate	16,200 (2111)	17,500 (2131)	17,200 (2122)	17,400 (2146)
Total Uranium	.6 (11,931)	.2 (11,929	.1 (11938)	0

Highest projected concentration of contaminants at the Columbia River.

Human Health – Implementation of any alternative could lead to releases of radioactive and chemical waste into the environment over long periods of time. Under alternative 1, these releases would not be controlled. Under the other alternatives, releases would be controlled. A Hazard Index of less than 1 indicate little to no likelihood of adverse impact. The following table summarizes the Peak Radiation Dose at the Columbia River.

	Alternative			
	1	2	3	4
Radiation Dose at Columbia River (millirem per year)	5 (4978)	2 (2317)	1.5 (2242)	.8 (2218)
Hazard Index	2	1.5	1	.5

Peak Radiation Dose at the Columbia River.

Ecological Risk – Risk was assessed for species exposed to air and groundwater discharges. Risk index of less than 1 indicate little to no likelihood of adverse impact on the species. The following table summarizes the potential long-term impact under Plan alternatives of contaminant releases to groundwater on ecological resources. The greatest potential impacts would be on aquatic biota/salmonids (driven by chromium).

	Alternative			
Chromium	1	2	3	4
Monarch Butterfly	.2	.1	.1	.1
Chinook Salmon	2	1.8	1.8	1.6
Spotted Sandpiper	1.2	1.1	1.1	1
Bald Eagle	.4	.4	.4	.4
Deer Mouse	.2	.1	.2	.2
Coyote	1.6	.8	.8	.7
American White Pelican	.6	.6	.6	.6

Risk to aquatic and terrestrial species.

Stakeholder Description

Stakeholder Group/Name:

Web Address:

Phone Number:

Contact Name:

How is this stakeholder connected to Hanford? How has the stakeholder been affected or impacted by Hanford?

Are their cultural connections that tie the stakeholder to Hanford? Describe.

Is the stakeholder aware of Hanford? If so, does the stakeholder have any opinions about Hanford cleanup?

How might the problem affect or impact the stakeholder now or in the future?

How might the stakeholder affect or impact Hanford cleanup or possible solutions now and in the future?

Would the stakeholder like to play a role in Hanford cleanup? Would they like to share their knowledge of Hanford or help with finding a solution to pollution?

Stakeholder Description

Looking at how the stakeholder is connected to Hanford:

- *How would the stakeholder prioritize the different components of Hanford's cleanup, i.e. tank waste, v. groundwater contamination, v. burial sites?*

- *How important is it for the stakeholder to keep contamination out of the Columbia River?*

- *How important is it for this stakeholder to remove pollutants from the groundwater?*

- *How important is it for the stakeholder to prevent long-term contamination of the Hanford Site?*

What is your stakeholder's long-term vision for Hanford? Will it be used for industry, housing, wildlife, or recreation?

Additional questions for stakeholder?

Decision Statement

Name of Stakeholder Group:

As a member of the stakeholder group, how would you answer the following?

- *Whether or not you support removal of tank waste from underground storage tanks, what is your preferred alternative?*

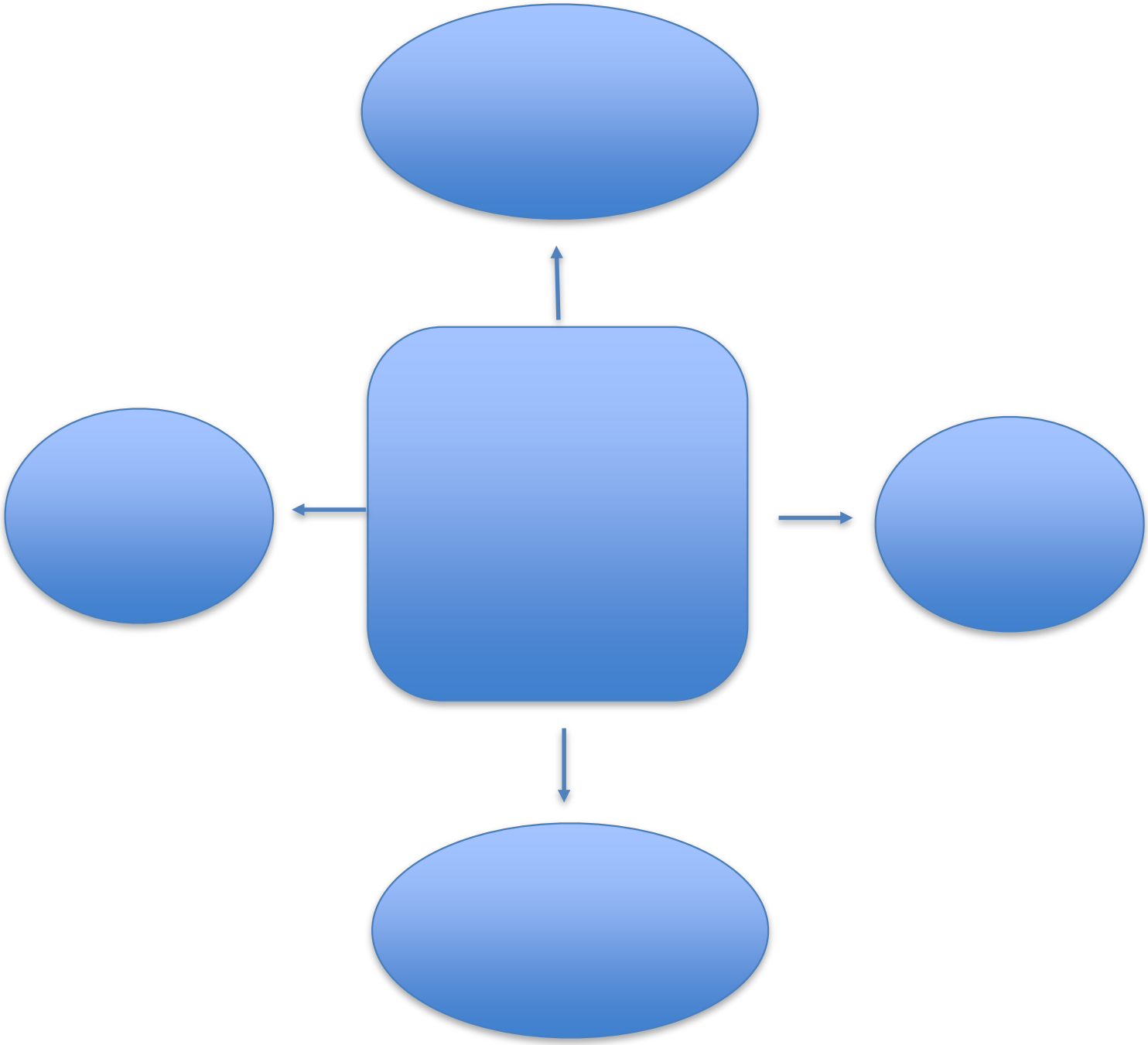
- *The reasoning for your decision, citing evidence from articles and maps you have investigated.*

- *A statement of how this decision would positively or negatively benefit human health and the environment.*

- *How you balance the risk to human health and the environment v. the cost?*

Consequence Web

Record the event you are analyzing in the center square. Then identify and record all of the consequences generated by the event. List at least four.



Additional Resources

An Overview of Hanford and Radiation Health Effects, a publication of the Hanford Health Information Network, http://web.archive.org/web/20091227062141/http://www.doh.wa.gov/Hanford/publications/overview/overview.html

The Release of Radioactive Materials from Hanford: 1944-1972, a publication of the Hanford Health Information Network, http://web.archive.org/web/20091227061941/http://www.doh.wa.gov/Hanford/publications/history/release.html

Hanford Reach National Monument, http://www.fws.gov/refuge/Hanford_Reach/

United States Department of Energy, Hanford Site, www.Hanford.gov

United States Environmental Protection Agency, Hanford Site, http://yosemite.epa.gov/r10/cleanup.nsf/sites/Hanford

Oregon Department of Energy, http://www.oregon.gov/energy/NUCSAF/Pages/index.aspx

Oregon Hanford Cleanup Board, http://www.oregon.gov/ENERGY/NUCSAF/Pages/hcb/hwboard.aspx

Columbia Riverkeeper, www.columbiariverkeeper.org

Heart of America Northwest, www.hoanw.org

Hanford Challenge, www.hanfordchallenge.org

Hanford Advisory Board, http://www.hanford.gov/page.cfm/hab

Stakeholders

Federal & State Government
National Oceanographic and Atmospheric Administration
Oregon Department of Energy
United States Department of Energy
United States Environmental Protection Agency
United States Fish & Wildlife
Washington State Department of Ecology

Local Government
Benton County
Benton-Franklin Council of Governments
City of Kennewick
City of Pasco
City of Richland
City of West Richland
Franklin County
Grant County
Yakima County

Tribes
Confederated Tribes of the Umatilla Indian Reservation
Nez Perce Tribe
Yakama Nation

Hanford Work Force
Central Washington Building Trades Council
Hanford Atomic Metal Trades Council

Local & Regional Organizations
Audubon Society
Benton-Franklin Public Health
Citizens for a Clean Eastern Washington
Columbia Riverkeeper
Hanford Challenge
Hanford Watch
Heart of America Northwest
League of Women Voters
Oregon Hanford Cleanup Board
Physicians for Social Responsibility
Richland Rod & Gun Club
Tri-Cities Industrial Development Council
Trout Unlimited