Saving Thor Lake:

A Study of Biodiversity, Ecosystems, and Human Impact

TEACHER'S GUIDE

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Teacher Preparation	Time Required	Target Grade Range
Review Background & Scenario (10 min.) **Prepare Materials** (5 – 10 min.)	**Part 1**: 40 – 50 min. **Part 2**: 40 – 50 min.	**9th – 11th Grade**

Recommended Homework

To allow time for in-class discussion and hands-on activities, assign the following as student homework. Alternatively, these could be covered in class in an additional 30 – 45 minute session.

- Read and Analyze the Background, Scenario, and Challenge (prior to lab Part 1)
- Complete Page 1 of the Student Worksheet (prior to lab Part 1)
- Optionally, complete Part 2 Report as homework and use class time for discussion

Lab Overview

Saving Thor Lake: A Study of Biodiversity, Ecosystems, and Human Impact is an exciting hands-on activity that puts students at the center of solving an ecosystem/biodiversity crisis in a fictitious polluted lake. Students will become both scientists and engineers. As scientists, they will run tests to quantify the performance of a pollution clean-up solution. As engineers, they will compare this solution to two others and propose an optimal design.

This lab consists of two parts:

Part 1: Introduction & hands-on nitrate & phosphate testing in treated and untreated samples

Part 2: Evaluation and selection of an optimal project for maintaining Thor Lake biodiversity

Learning Outcomes

In this lab, students will learn to:

- **Describe a complex system consisting of numerous biotic and abiotic factors and consider the impact of human-related activity on the system**
- **Analyze samples quantitatively to determine the feasibility of a proposed design solution and use this evidence to make a decision**
- **Evaluate and select solutions to an environmental problem based on a range of criteria and constraints**
- **Asses an ecosystem challenge and design solutions from the perspective of scientists and engineers**

Note: Alignment to NGSS Standards described in detail on Page 17.

Challenge

You've **been hired by the National Lake Protection Agency to evaluate three different projects** for maintaining Thor Lake biodiversity - thus improving ecosystem health. Your primary goal is to prevent the loss of lake trout.

Based on their prior study, the NLPA has proposed the following projects:

1. Re-introduce young lake trout to the lake through a series of 10 stocking events over the course of 6 months. The NLPA indicates this is the least expensive approach and would result in the fastest increase in trout populations. The agency conducted simulations of this project and provided you with the data (Figure 4).

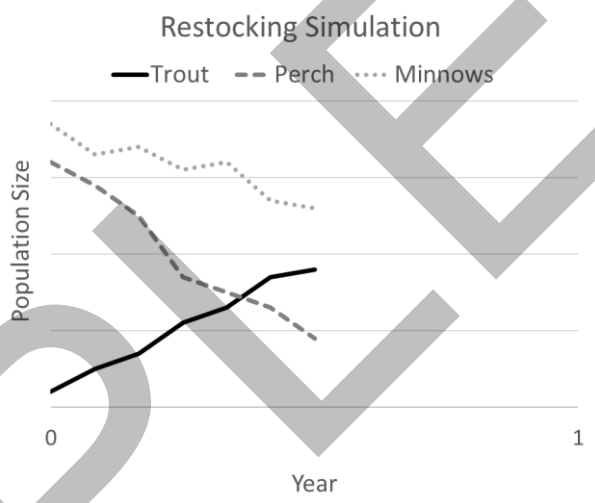


Figure 4. Projections from the NLPA on fish populations using re-stocking.

2. Collaborate with the RECON Industrial Facility to modify their water recycling system. The RECON team can return the water to the lake at a lower temperature, but they would need to offset the cost of doing so with cost reductions from the local utilities company. The NLPA estimates that this is the most expensive project due to the funding of the utilities cost reductions.

3. Contribute to a joint project with the Hill Range Water Treatment Plant. The plant has proposed adding a facility to treat lake water and return it to the lake – thus cleaning up the lake water. The process would focus on removing nitrates and phosphates from agricultural run-off which have contaminated the lake and caused **eutrophication**. The costs of this project are unknown, as the scale of the project is large.

Before you evaluate and compare the three projects, the NLPA has asked you to confirm the test results from the Hill Range Water Treatment Plant project and **answer the question: do the treated samples have Nitrate and Phosphate levels that meet the target for water quality?** You need to complete the testing and analysis and report your results to the agency.

The treatment plant has provided you with 4 samples:

- Thor Lake Initial Sample – This sample was taken directly from Thor Lake in the past month.
- 2 Treated Samples – These samples are the output of the treatment plant's new water cleanup process.
- Target Quality Sample – This is the target for water quality to be released back into Thor Lake.

To confirm their results, you will need to verify their ability to reduce Nitrate and Phosphate using the below procedure. Based on your results you should determine whether or not this project will work (be technically feasible). Then you will be able to evaluate all three projects and make your recommendation.

Background & Scenario Review

Prior to conducting this lab, students should have an understanding of Food Chains/Webs, be able to define biodiversity, and understand the basics of ecosystems. Students will be better prepared if they are also able to discuss examples of how changes to components of an ecosystem can have an impact across the whole system.

After reviewing the Background and Scenario, students should complete page 1 of the Student Worksheet prior to conducting the lab. Answers are shown below.

SOLUTIONS

Question 1

In this simplified food chain, the lake trout represents a (circle one):

Producer **Consumer**

Decomposer **Energy Source**

Answer: Consumer

Trout are the quaternary consumer in this food chain. They consume other consumers which ultimately feed on producers (algae) that get their energy from the sun.

Students should use their prior knowledge or other resources to answer this question.

Question 2

In this simplified food chain, what might happen if minnows were completely removed (circle one)?

A. Nothing, they are not important.

B. The perch population would increase because there are fewer minnows.

C. Perch populations would decline and zooplankton populations would grow.

Answer: C

Minnows are the primary food source for perch so their removal would limit the resources available for the perch. Minnows also feed on zooplankton so their removal could result in growth in the zooplankton population.

Question 3

In the population data (Figure 2), why did perch populations increase in year 3 – 5?

A. Perch are stronger fish than trout.

B. Fewer trout meant the perch were not eaten as rapidly and were thus able to increase population.

C. Zooplankton and algae populations were increasing, making more food available.

Answer: B

Trout feed on perch. Trout populations experienced a significant decline in year 2 allowing perch populations to grow. The decline in minnow populations is likely a result of perch growth.

TAKE ACTION

Depending on available time, **allow the student(s) an opportunity to present and defend their conclusion**. Encourage questions from the student(s)/class or ask some of the questions below.

***Ask Questions**:*

In a real scenario, do you think you would have collected more or fewer samples? How would this have impacted your results and conclusion? (More samples would be required in a real scenario and they may demonstrate more variability which could bring the conclusion into question)

What additional samples, data, or information could be collected to help you make a more informed conclusion? (e.g., assessment of the cost of Project 3, test data for Project 2 or analysis of agricultural run-off to confirm it as the source of contamination)

Inquiry & Exploration – Part 2: Evaluating and Selecting a Project

Students were asked to propose a project to the NLPA which they believed to be the best solution to address biodiversity and ecosystem decline. Using the Student Worksheet "NLPA Report" section, students should define the problem and the system, explain what criteria and constraints they considered, and propose their solution.

Students should complete the report section of the Student Worksheet, in class or as homework.

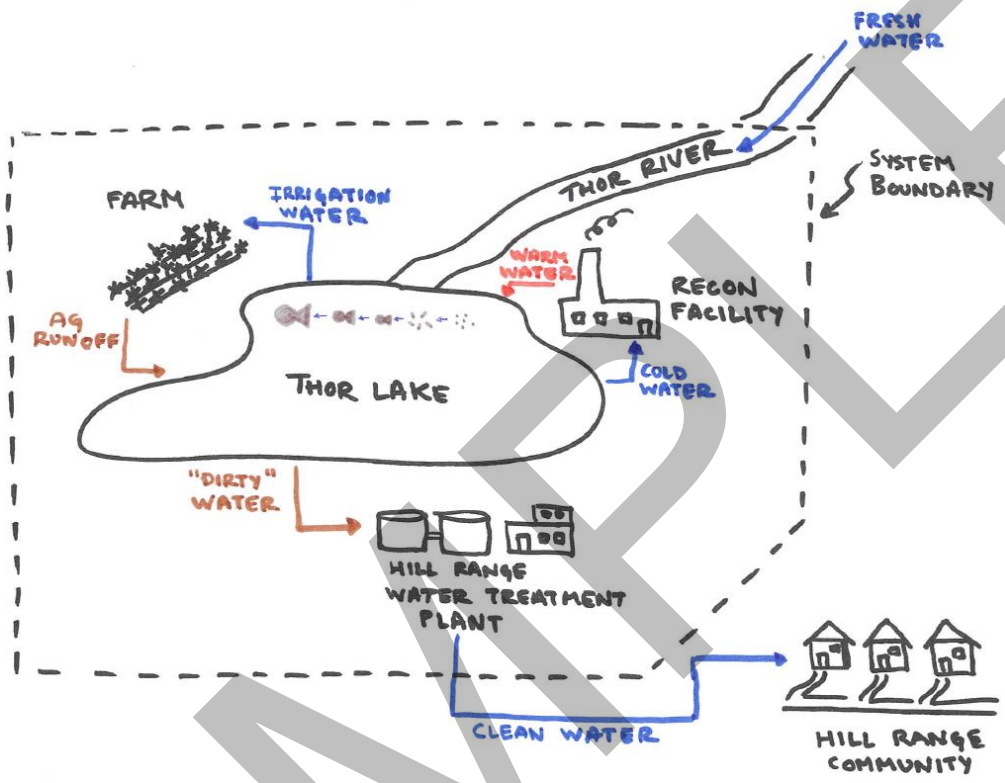
SOLUTIONS

NLPA Report 1121 – Proposed Solution to Thor Lake Biodiversity and Ecosystem Health Decline	
Name:	**Date:**
What is the problem?	
The scenario describes ecosystem decline as the issue but defines a primary goal of preventing lake trout loss. Students may indicate that lake trout loss is the problem but, this is only partially true. In this scenario, the central issue is most likely the eutrophication of the lake caused by agricultural run-off. *Advanced students may recognize eutrophication is the central problem, but note that from a societal view, loss of lake trout is considered to be the issue (it has been the focus of media attention). If this distinction is made, either answer would be acceptable.* *If students incorrectly, or only partially, identify the problem, their chosen solution may be different. Only Project #3 addresses the root cause of the ecosystem decline (eutrophication) while the others primarily address symptoms or other negatively contributing factors.*	

Draw a picture of the system

At a minimum, the system should be drawn to include the lake, the industrial facility, surrounding farms and the water treatment plant. Some students may choose to include the Hill Range community, the river, and other aspects of the Northern Watershed region inside the system boundaries.

Students may additionally show the project implemented within their system or details regarding the aquatic ecosystem (not shown in full detail below).



In order of priority, what are your criteria and constraints for selecting a solution (list at least 3 of each)?

Criteria	Constraints
Many responses are acceptable, examples include:	*Many responses are acceptable, examples include:*
Technical Feasibility – the project must work	*Cost – budgetary constraints and upkeep cost*
Safety – the project should be "safe"	*Time – implementation and execution time*
Prevent Lake Trout decline – this is a primary goal	*Side effects – what other impacts may occur?*
Long-term effectiveness – the project should solve the root problem for long term results	*Cultural, economic or social effects – the impact on the surrounding community, businesses and people*

Alignment to NGSS Metrics

This lab was designed with the Next Generation Science Standards* as its basis. These standards outline an extensive program for science education that is relevant for a wide variety of educators. While not all schools will be required to meet these standards, they enable focused and productive teaching that trains students to think and act like professional scientists and engineers.

Key Performance Expectations

HS-LS2-7: Design, evaluate, and refine a solution for reducing the impacts of human activities on the environment and biodiversity.

HS-ETS1-3: Evaluate a solution to a complex real-world problem based on prioritized criteria and trade-offs that account for a range of constraints, including cost, safety, reliability, and aesthetics, as well as possible social, cultural, and environmental impacts.

HS-ESS3-4: Evaluate or refine a technological solution that reduces impacts of human activities on natural systems.

Science & Engineering Practices	Disciplinary Core Ideas	Crosscutting Concepts
Constructing Explanations and Designing Solutions	ESS3.C Human Impacts on Earth Systems	Influence of Science, Engineering, and Technology on Society in the Natural World
Asking Questions and Defining Problems	LS2.C Ecosystem Dynamics, Functioning and Resilience	Stability and Change
Engagement in Argument from Evidence	LS4.D Biodiversity and Humans	
	ETS1.A Defining and Delimiting Engineering Problems	
	ETS1.B Developing Possible Solutions	

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