

Designing for Climate Resiliency: A Bridge Project Linking Infrastructure, Ecology, and Ethics in an Introductory Environmental Engineering Course

Dr. Kathryn Plymesser, Montana State University - Bozeman

Dr. Plymesser holds a B.S. (Case Western Reserve University '01) and Ph.D. (MSU '14) degrees in Civil Engineering. She began her academic career at Montana State University – Billings with a teaching and research tenure-track appointment. Dr. Plymesser joined the Civil Engineering Department at Montana State University in 2016. Her research is focused in ecohydraulics and fish passage with a particular fondness for the application of hydraulic and fluid dynamic models to answer research questions in natural settings. Dr. Plymesser currently teaches Introduction to Environmental Engineering Design and Sustainability, Open Channel Hydraulics, and River Modeling.

Catherine M Kirkland, Montana State University - Bozeman

Dr. Catherine Kirkland is an assistant professor of Environmental Engineering in the Civil Engineering Department at Montana State University. In addition to her background in environmental engineering, Catherine also holds a BA in Anthropology and Sociology from Rhodes College. Her research areas include beneficial biofilms, nuclear magnetic resonance, and engineering education.

Adrienne Phillips, Montana State University - Bozeman

Dr. Adie Phillips is an associate professor in the Civil Engineering department at Montana State University. She teaches environmental engineering courses and does research in biofilms and engineering education.

Susan Gallagher, Montana State University - Bozeman

Susan Gallagher is the Education and Workforce Program Manager at the Western Transportation Institute (WTI), a transportation research center within Montana State University's College of Engineering.

Designing for Climate Resiliency: A Bridge Project Linking Infrastructure, Ecology, and Ethics in an Introductory Environmental Engineering Course

Course: EENV 102 (1st Year Environmental Engineering Course)

Assignment Type: Scaffolded, multi-week project

Duration: ~7 weeks

Student Work: Individual submissions with structured collaboration

Assignment Summary

This assignment sequence places students in a consulting role advising the City of Bozeman on a preliminary design recommendation for bridge repair, replacement, or removal on Bozeman Creek. Students must balance infrastructure needs, access, ecological health, regulatory requirements, climate uncertainty, sustainability, and stakeholder perspectives. The project emphasizes engineering judgment in an open-ended, real-world context rather than identifying a single “correct” solution.

The assignment is intentionally scaffolded through a series of short technical memoranda that build toward a final recommendation and public-facing communication deliverable.

Learning Objectives

Students who complete this assignment are able to:

- Scope an engineering problem and identify stakeholders, constraints, and project boundaries
- Identify relevant permitting and regulatory requirements for stream and bridge projects
- Use hydrologic data and climate assessments to inform design-flow recommendations
- Integrate sustainability frameworks and professional ethics into engineering decisions
- Communicate technical information to both technical and non-technical audiences

Assignment Structure

Students complete a sequence of weekly memos focused on:

1. Preliminary investigation and stakeholder analysis
2. Permitting and regulatory requirements
3. Climate change, hydrology, and design-flow selection
4. Sustainability measures and ethical considerations

The project culminates in:

- A synthesized technical report
- A brief client feedback meeting (role-played)
- A one-page informational flyer and elevator pitch for a public audience

Project 2 – Designing for Climate Resiliency

Your consulting firm has been asked to advise the City of Bozeman (COB) on a preliminary design concept for bridge repair, replacement, or removal on Bozeman Creek at East Griffin Dr. The COB needs to balance the cost of the project and need for access by local businesses and residences with the desire of local nongovernmental organization (NGO) stakeholders to preserve the aquatic ecosystem and natural river function.



Requirements and Guidelines

All homework assignments are to be written as 1 to 2-page technical memorandums (excluding the header). Please see the attached guidelines provided in the homework folder for how to effectively write a technical memo with examples.

Students may work on assignments in groups; however, each student is expected to turn in an individual assignment and are not allowed to copy one another. Students are additionally required to report any collaboration in the header of their memo. Evidence of plagiarism, including the failure to report collaboration, is grounds for disciplinary action.

Project 2 Assignments Overview

Details for each individual assignment will be provided weekly and will be due at midnight one (1) week from the date posted online.

HW 5 - Preliminary Investigation

Identify the scope of the project, stakeholders, and primary needs.

- Describe the existing bridge structure and primary issues.*
- Are there concerns for the health of Bozeman Creek? What are they and what work has been done, if any.*
- Describe the land use in the vicinity of the bridge and identify the extents of the project.*
- Who are the primary stakeholders for this project? Describe the impact of the project on these stakeholders.*

HW 6 – Permitting and Regulatory Requirements

Identify possible permitting and regulatory requirements.

- a. Which permits will be required for this project? Will this impact your recommendation? Why or why not?*
- b. Which regulations will govern the design?*

HW 7 - Climate Change and Streamflow in Montana

Explore available data and reports to determine appropriate design flows.

- a. Use streamstats to obtain design parameter estimates based on historical data.*
- b. Look for hydrologic trends in the annual average streamflow for the Gallatin River at Logan, MT using Excel.*
- c. Consult the 2017 Montana Climate Assessment and do your own research to gain an understanding of forecasted precipitation trends for Bozeman.*

HW 8 - Sustainability Measures and Ethical Considerations

Assess sustainability and ethical concerns.

- a. Review the envision framework and identify 3 items that will be important to the sustainability of your project.*
- b. Explain how the items you selected also relate to the ASCE Code of Ethics.*

HW 9 - Feedback Meeting with the Client

Get feedback on your ideas from the client.

- a. Using all the research you've conducted thus far; decide on the solution that you will recommend in your final deliverable.*
- b. Meet with the "City of Bozeman" in groups of 4-5 to get preliminary feedback on your suggestions.*

Project 2 - Final Deliverables

- a. Summarize memos 5-8 into a final report (max 5 pages excluding any references (APA format)) and figures that includes any corrections/edits recommended in earlier assignments. Ensure that the following aspects are addressed*
 - i. Scope/Background Information/Stakeholders*
 - ii. Permitting and Regulatory Requirements*
 - iii. Climate Change/Recommended Design Flow*
 - iv. Sustainability/Ethics Considerations*
 - v. Recommended Action*
- b. Prepare an informational flyer for a public meeting that describes your recommendations and be prepared to have informal 1-on-1 conversations with members of the 'public' about your design.*

Assigned: 10/15/2024

Due: 10/22/2024 at 11:59 pm

HW 5: Preliminary Investigation

Your consulting firm has been asked to advise the City of Bozeman (COB) on a preliminary design concept for bridge repair, replacement, or removal on Bozeman Creek at East Griffin Dr. The COB needs to balance the cost of the project and need for access by local businesses and residences with the desire of local nongovernmental organization (NGO) stakeholders to preserve the aquatic ecosystem and natural river function.

Start with a preliminary investigation of the bridge, creek, and surrounding area by providing the following information.

Background Information

- Describe the existing bridge structure and its primary issues. We encourage you to make a trip out to the bridge to see it in person and read through the documents that the Gallatin County Road and Bridge Department had on file for the bridge that are posted on D2L.
- Describe Bozeman Creek and its primary uses and issues. Are there concerns for the health of the creek? Have any restoration projects been completed? Are there any species of concern that live in the stream habitat?

Necessity and Project Stakeholders

- Determine the necessity of the project. Why is this task important? Who is involved (i.e. who may have a vested interest in the outcomes of this project)? Who may be affected by the outcomes of this project? What may be the impact if action is not taken?

Project Scope

- Describe the scope of the project. A project scope identifies objectives, goals, requirements, as well as boundaries, constraints and assumptions. The goal of a project scope is to clearly state the limits in which the project operates to the project stakeholders. This aims to avoid the shifting or expansion of goals which can lead to overestimates of time and capital.

How do you want to limit the extent of your project? Be sure to look at adjacent land use and ownership to help determine the possible spatial extents of the project.

NOTE: The goal of this project and assignments are to critically think about how to approach a real-world scenario from a sustainable, but practical mindset. Within reasonable boundaries (please aim to be as technically accurate as you can at this point), there is no “right” answer. This means if you can reasonably explain your answer, you will be given credit. Additionally, you may restrict or expand a project to your desire (think detailed vs broad). Feedback will be provided to help guide your thought process.

Example Formatting and Additional Guidelines:

Rubric for Homework memos

Fall 2024

Name: _____

Competency	<i>Levels of Attainment</i>				Rating
	4 Exceeds Expectations	3 Meets Expectations	2 Below Expectations	1 Unsatisfactory	
1. Technical Accuracy	The information presented was accurate	With 1-2 discrepancies, the information presented was accurate	The report contained several inaccuracies	The report contained many inaccuracies	
2. Addressing the Topic	The report contained clearly stated and well-reasoned explanations for the assigned topic.	The assigned topic was addressed with limited justification	The assigned topic was mentioned, but not reasonably addressed	The assigned topic was not addressed.	
3. Grammar and writing	The document was essentially free of errors in spelling, grammar, punctuation, or sentence structure.	The document contained 3 or fewer spelling, grammar, punctuation, or sentence structure errors	The document contained 4-10 spelling, grammar, punctuation, or sentence structure errors.	The document contained more than 10 spelling, grammar, punctuation, and sentence structure errors.	
4. Technical writing quality	The document utilized appropriate technical language and was concise and accurate.	The document was concise and accurate with few technical language errors.	The document had many instances of technical language errors or struggled with concision and accuracy.	The document failed to utilize accurate technical language and was not concise nor accurate.	
5. Citations	The report used appropriate, error-free citations	With a few exceptions the report used appropriate error-free citations.	Many citation errors were present.	Citations are improperly utilized or missing.	
Total grading on report out of 20 points possible					
Overall grade as percentage					

Assigned: 10/22/2024

Due: 10/29/2024 at 11:59 pm

HW 6: Permits and Regulations

Your consulting firm has been asked to advise the City of Bozeman (COB) on a preliminary design concept for bridge repair, replacement, or removal on Bozeman Creek at East Griffin Dr. The COB needs to balance the cost of the project and need for access by local businesses and residences with the desire of local nongovernmental organization (NGO) stakeholders to preserve the aquatic ecosystem and natural river function.

This week you will work on identifying permitting and regulatory requirements for the bridge project.

Permits and Regulations

- Create a table that lists the permits/regulations that will likely be required for the project, which agency is responsible, approximate fees, and timelines.
- Discuss the following in your memo related to your table:
 - Do you think any of the permits/regulations will influence your recommendation to the city? Why or why not?
 - What supporting documentation will be required?
- Read Chapter 4 in the Montana Stream Permitting Guide, particularly the portions that discuss bridge and culvert design. Identify at least two (2) items from the list of “Guidelines for Bridge Design” on page 4.18 that you think will be particularly important/pertinent/contentious to the project and discuss how you might approach them.

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5. Citations	The report used appropriate, error-free citations	With a few exceptions the report used appropriate error-free citations.	Many citation errors were present.	Citations are improperly utilized or missing.	
Total grading on report out of 20 points possible					
Overall grade as percentage					

Assigned: 10/31/2024

Due: 11/7/2024 at 11:59 pm

HW 7: Climate Change and Streamflow

Your consulting firm has been asked to advise the City of Bozeman (COB) on a preliminary design concept for bridge repair, replacement, or removal on Bozeman Creek at East Griffin Dr. The COB needs to balance the cost of the project and need for access by local businesses and residences with the desire of local nongovernmental organization (NGO) stakeholders to preserve the aquatic ecosystem and natural river function.

This week you will work on determining an appropriate design flow for the project.

Climate Change and Streamflow

- Use StreamStats to obtain a streamflow estimate for the 100-year (1% AEP) and 500-year (0.2% AEP) events for Bozeman Creek at the Griffin Dr. crossing.
- Using the approach from Lecture 20 investigate annual average streamflow trends near the project site.
- Consult the 2017 Montana Climate Assessment and the Fifth Annual Climate Assessment to gain an understanding of forecasted streamflow and precipitation trends for Bozeman.
- In the final paragraph of your memo, make a recommendation for the design flow that should be used for the project based on your research and analysis.

Example Formatting and Additional Guidelines:

Rubric for Homework memos

Fall 2024

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Overall grade as percentage					

Assigned: 11/7/2024

Due: 11/14/2024 at 11:59 pm

HW 8: Sustainability Measures and Ethical Considerations

Your consulting firm has been asked to advise the City of Bozeman (COB) on a preliminary design concept for bridge repair, replacement, or removal on Bozeman Creek at East Griffin Dr. The COB needs to balance the cost of the project and need for access by local businesses and residences with the desire of local nongovernmental organization (NGO) stakeholders to preserve the aquatic ecosystem and natural river function.

At this point hopefully you are narrowing in on what your recommendation will be. With that in mind, this week you will think about ethical considerations and sustainability measures related to your project.

Sustainability Measures and Ethical Considerations

- Review the Envision checklist (excel file), identify 3 items on the checklist that will be important to the sustainability of your project and discuss how you will address them.
- Explain how the items you selected from the envision framework relate to the ASCE code of ethics.

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Overall grade as percentage					

Assigned: 11/14/2024

Due: 12/6/2024 at 5:00 pm

HW 9: Feedback Meeting with the Client

Your consulting firm has been asked to advise the City of Bozeman (COB) on a preliminary design concept for bridge repair, replacement, or removal on Bozeman Creek at East Griffin Dr. The COB needs to balance the cost of the project and need for access by local businesses and residences with the desire of local nongovernmental organization (NGO) stakeholders to preserve the aquatic ecosystem and natural river function.

Its time to meet with the client! At this point you should be 90% sure about your recommendation for the project and are looking for feedback on your ideas. You should come to the meeting with questions prepared and anything you need to help you quickly convey your idea. The appointments will be 15 minutes long so if you are not prepared you may miss your chance to get feedback on your ideas.

Guidelines for Client Meeting

- You must make an appointment in person (you cannot schedule by email or over the phone) with Ms. Klockmann at the CE Office (Cobleigh 205) **before November 21st**.
- Ms. Klockmann will be attempting to schedule you a 15-minute appointment in groups of 4-5 to reduce the number of individual appointments. If there are classmates that you would like to attend the meeting with, I suggest going to the CE Office together to set up the appointment.
- **There will not be a memo required for this assignment.** When you arrive for your meeting, you will sign in on a class list, all those who have signed in for their appointment will receive full credit on this assignment.
- You have until the last day of classes (December 6th) to complete this assignment.

Example Formatting and Additional Guidelines:

Rubric for Homework memos

Fall 2024

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Total grading on report out of 20 points possible					
Overall grade as percentage					

Communicating to the Public – Final Presentation

The final presentation for Project 2 is an elevator pitch and single page informational flyer that is meant to quickly communicate your idea for the bridge project to a Bozeman community member. The elevator pitch should be no longer than 2-3 minutes and you will be asked to give this pitch several times over the course of the final exam period. Make sure you are clear about your recommendation and the justification for your decision in both your elevator pitch and flyer. I suggest the following format:

1. Introduce yourself
2. Describe the problem
3. Present and justify your solution
4. Ask if they have any questions

Please bring at least 2 copies of your flyer, one to hand in and one to use in your presentation.

	<i>Levels of Attainment</i>			
Competency	4 Exceeds Expectations	3 Meets Expectations	2 Below Expectations	1 Unsatisfactory
Audience	Presentation was appropriate for a general audience.	Presentation was appropriate for a general audience with a few exceptions.	Presentation was sometimes difficult to understand, repetitive and/or contained technical jargon.	Presentation did not consider the audience and was difficult to understand.
Addressing the prompt	The presentation included all required information: • introduction • problem description • solution with justification • Opportunity for questions	The presentation contained most of the required information	The presentation failed to adequately address the prompt and only touched on a few aspects.	The presentation did not address any of the required prompts
Delivery and Timing	Good delivery and timing, speaker was clear, prepared and professional, answered questions clearly	With a few discrepancies, speaker was clear, prepared and professional, on time, answered questions appropriately	Speaker lacked clarity in delivery, did not adhere to time constraints, struggled to answer questions clearly	Delivery was unprofessional, was significantly over time constraints, inability to answer questions

Presenter 1 Name: _____

Score: _____

Presenter 2 Name: _____

Score: _____

Presenter 3 Name: _____

Score: _____

Presenter 4 Name: _____

Score: _____

Feedback for project presentations EENV 102, Fall 2024

Presenters' Name: _____

Presentation 1 Feedback

Presentation 2 Feedback

Presentation 3 Feedback

Presentation 4 Feedback