**Problem Statement:**

**How do we prepare for, respond to, and survive a disaster?**

The city of **Bothell** needs help! In the event of a natural disaster (e.g., earthquake, fire, flood, land/mudslides, and storms), power goes out, methods of communication and transportation are often lost or damaged, medical care is needed, and basic survival resources need to be maintained and distributed to those in the disaster area. Often, resources are low or have been damaged/contaminated. Your goal is to aid the community in the event of a disaster, with each group in charge of an area within the city affected by the disaster. Groups will identify two problems that can occur within a city grid, then develop a physical solution (build/repair) or a conceptual solution to a problem.

**Locally and/or Personally Relevant for Students:**

The Pacific Northwest is an area prone to multiple natural disaster types, including volcanoes, earthquakes, landslides, and fires as well as weather related disasters such as flooding, damage caused by lightning, hailstorms, and snowstorms. This problem would allow students the opportunity to learn about preparing for and surviving a natural or man-made disaster (dependant on curriculum focus). Resource management, problem solving, and a multitude of other skills can be developed while working on this problem. All students, female, minority, and other underrepresented individuals in STEM would have an opportunity to develop STEM and 21st century skills.

**Connections to career and educational pathways:**

By researching and developing solutions to either physical or conceptual problems, students will gain a better understanding of how to address problems in future careers. Students will also gain insight through research as to how people within a certain field have addressed similar problems and what careers address problems within their community.

**Conceptual Storyline:**

Each group will be responsible for providing one of the services needed for members of the community to survive a disaster. All groups will complete the following:

***BACKGROUND ACTIVITIES:***

* (LESSON 1) Introduction and discussion of catastrophic weather events using google slides presentation.
* (LESSON 2) Practice in identifying features on a map and problems that can occur in the event of a catastrophic weather event.
* (LESSON 3) Work together as a class to practice identifying criteria and constraints in a given engineering design problem. Examples include a flooded road for physical solutions and an evacuation route for a conceptual solution.

***ENGINEERING DESIGN PROCESS (PACKET OUTLINE):***

* (LESSON 3) **Step 1:*****Identify the Problem*** *The class will decide which physical or conceptual problem groups will pursue. As a class, the criteria and constraints for that problem will be identified.*
* (LESSON 4) **Step 2: *Gather Information*** *Students will research each problem identified, including historical reference information for how each problem has been addressed during a disaster.*
* (LESSON 5) **Step 3:** ***Develop a Plan*** *Students will work within the constraints of available resources to design a solution to the problem being solved by their group.*
* (LESSON 6) **Step 4: *Testing a Plan*** *Students will test their plans in a real-time disaster scenario. There will be three “trials” where the physical solution will be tested. Teacher will provide a Pugh Chart to identify the effectiveness of a conceptual solutions. Students with a conceptual solution will develop a presentation to discuss their solution.*
* (LESSON 7) **Step 5:** ***Redesign*** *Students will modify their original plan while continuing to work within allocated resources. Using the results of the previous three disaster trials for a physical solution or the Pugh Chart results for a conceptual solution, students will justify modifications based on the effectiveness of the original plan created.*
* (LESSON 7) ***Step 6: Test Again*** *Students will test their modified plans in a real-time disaster scenario. There will be three “trials” where the physical solution will be tested. Teacher will provide a Pugh Chart to identify the effectiveness of a conceptual solution.*
* (LESSON 8) ***Step 7: Reflect*** *Students will reflect on using the engineering design process to a solve a problem. Students will consider the variety of careers that are part of the engineering design process.*

**Unit Standards (NGSS, CCSS, CTE, 21st Century Skills):**

***PBL Specific Targets (NGSS):***

***Engineering Design***

* MS-ETS1-1. **Define the criteria and constraints of a design problem with sufficient precision to ensure a successful solution, taking into account relevant scientific principles and potential impacts on people and the natural environment that may limit possible solutions.**
* MS-ETS1-2. **Evaluate competing design solutions using a systematic process to determine how well they meet the criteria and constraints of the problem.**
* MS-ETS1-3. **Analyze data from tests to determine similarities and differences among several design solutions to identify the best characteristics of each that can be combined into a new solution to better meet the criteria for success.**
* MS-ETS1-4. **Develop a model to generate data for iterative testing and modification of a proposed object, tool, or process such that an optimal design can be achieved.**

***Prior Knowledge Targets (NGSS):***

***Energy Focus***

* MS-ESS3-2. Analyze and interpret data on natural hazards to forecast future catastrophic events and inform the development of technologies to mitigate their effects.
* MS-PS3-2 Develop a model to describe that when the arrangement of objects interacting at a distance changes, different amounts of potential energy are stored in the system.
* MS-PS3-3 Apply scientific principles to design, construct, and test a device that either minimizes or maximizes thermal energy transfer.\*
* MS-PS3-5 Construct, use, and present arguments to support the claim that when the kinetic energy of an object changes, energy is transferred to or from the object.
* MS-PS4-3. Waves and their Applications in Technologies for Information Transfer
* HS-ESS3-3. Evaluate competing design solutions for developing, managing, and utilizing energy and mineral resources based on cost-benefit ratios.\*

***Weather & Atmosphere Focus***

* MS-ESS2-5. Collect data to provide evidence for how the motions and complex interactions of air masses results in changes in weather conditions.
* MS-ESS2-6. Develop and use a model to describe how unequal heating and rotation of the Earth cause patterns of atmospheric and oceanic circulation that determine regional climates.
* MS-ESS3-2. Analyze and interpret data on natural hazards to forecast future catastrophic events and inform the development of technologies to mitigate their effects.
* MS-ESS3-3. Apply scientific principles to design a method for monitoring and minimizing a human impact on the environment.
* MS-ESS3-4. Construct an argument supported by evidence for how increases in human population and per-capita consumption of natural resources impact Earth's systems.

***Geology Focus***

* MS-ESS1-4. Construct a scientific explanation based on evidence from rock strata for how the geologic time scale is used to organize Earth's 4.6-billion-year-old history.
* MS-ESS2-2. Construct an explanation based on evidence for how geoscience processes have changed Earth's surface at varying time and spatial scales.
* MS-ESS2-3. Analyze and interpret data on the distribution of fossils and rocks, continental shapes, and seafloor structures to provide evidence of the past plate motions.
* MS-ESS3-2. Analyze and interpret data on natural hazards to forecast future catastrophic events and inform the development of technologies to mitigate their effects.
* MS-ESS3-3. Apply scientific principles to design a method for monitoring and minimizing a human impact on the environment.
* MS-ESS3-4. Construct an argument supported by evidence for how increases in human population and per-capita consumption of natural resources impact Earth's systems.

***Prior Knowledge Targets (CCSS):***

***Mathematics***

* (S.ID. 5, 6abc) Two Variable Distributions
* (S.MD. 6, 7; S.CP. 1-9) Independent, Conditional, Use Probability
* (S.MD. 1, 2, 3, 4, 5ab) Calculate Expected Values
* (S.IC. 5, 6) Use Data, Compare Simulations

***English Language Arts***

* [CCSS.ELA-LITERACY.RST.6-8.3](http://www.corestandards.org/ELA-Literacy/RST/6-8/3/) Follow precisely a multistep procedure when carrying out experiments, taking measurements, or performing technical tasks.
* [CCSS.ELA-LITERACY.RST.6-8.7](http://www.corestandards.org/ELA-Literacy/RST/6-8/7/) Integrate quantitative or technical information expressed in words in a text with a version of that information expressed visually (e.g., in a flowchart, diagram, model, graph, or table).
* [CCSS.ELA-LITERACY.RST.6-8.9](http://www.corestandards.org/ELA-Literacy/RST/6-8/9/) Compare and contrast the information gained from experiments, simulations, video, or multimedia sources with that gained from reading a text on the same topic.

***21st Century Skills:***

***Communication & Collaboration***

* ***Communicate Clearly***
  + Articulate thoughts and ideas effectively using oral, written and nonverbal communication skills in a variety of forms and contexts
  + Listen effectively to decipher meaning, including knowledge, values, attitudes and intentions
  + Use communication for a range of purposes (e.g. to inform, instruct, motivate and persuade)
* ***Collaborate with Others***
  + Demonstrate ability to work effectively and respectfully with diverse teams
  + Exercise flexibility and willingness to be helpful in making necessary compromises to accomplish a common goal
  + Assume shared responsibility for collaborative work, and value the individual contributions made by each team member

***Critical Thinking & Problem Solving***

* ***Reason Effectively***
  + **Use various types of reasoning (inductive, deductive, etc.) as appropriate to the situation**
* ***Use Systems Thinking***
  + **Analyze how parts of a whole interact with each other to produce overall outcomes in complex systems**
* ***Make Judgments and Decisions***
  + **Effectively analyze and evaluate evidence, arguments, claims and beliefs**
  + **Analyze and evaluate major alternative points of view**
  + **Synthesize and make connections between information and arguments**
  + **Interpret information and draw conclusions based on the best analysis**
  + **Reflect critically on learning experiences and processes**
* ***Solve Problems***
  + Identify and ask significant questions that clarify various points of view and lead to better solutions

***Creativity & Innovation***

* ***Think Creatively***
  + Use a wide range of idea creation techniques (such as brainstorming)
  + Create new and worthwhile ideas (both incremental and radical concepts)
  + Elaborate, refine, analyze and evaluate their own ideas in order to improve and maximize creative efforts
* ***Work Creatively with Others***
  + Develop, implement and communicate new ideas to others effectively
  + Be open and responsive to new and diverse perspectives; incorporate group input and feedback into the work
  + Demonstrate originality and inventiveness in work and understand the real world limits to adopting new ideas
  + View failure as an opportunity to learn; understand that creativity and innovation is a long-term, cyclical process of small successes and frequent mistakes
* ***Implement Innovations***
  + Act on creative ideas to make a tangible and useful contribution to the field in which the innovation will occur

**Table of Content/Overview of Unit**

* Lesson 1: Title: Introduction to PBL
  + Video/News reports of catastrophic events to show possible effects caused by these events.
* Lesson 2: Title: Practice with map grids & Brainstorming problems
  + Students will practice rolling locations on their local maps and identifying potential damages to structures or land features within those grids. As a class, students will decide which physical and which conceptual problem they would like to solve (may require defining “physical” vs. “conceptual” solutions).
* Lesson 3: Title: Identifying Problems, Criteria, & Constraints
  + As a class, students will decide which physical and which conceptual problem they would like to solve. Students identify the criteria and constraints for each problem (may require practice with criteria and constraints).
* Lesson 4: Title: Gather Information
  + Students will research the potential solutions to their problem One problem has a physical solution (build) and one problem has a conceptual solution (digital presentation)
* Lesson 5: Title: Develop a Plan
  + After research, students will develop a plan to solve their problems, either by budgeting a physical solution to build or a conceptual solution to analyze.
* Lesson 6: Title: Build & Test
  + Students will build their first attempt at a physical solution or analyze their conceptual solution using a PUGH chart.
* Lesson 7: Title: Redesign
  + For physical solutions, students will redesign in order to increase the effectiveness of their solution. For conceptual solutions, this will be analyzing the effectiveness of their solution using PUGH chart analysis.
* Lesson 8: Title: Reflection & Presentation
  + Students will present to the class the results of their physical solution and the revised content of their conceptual solution. Students will reflect on the engineering design process and its role in STEM and non-STEM careers.