Unit Title: *Floods as Dynamic Events*

Subject/Target Grade: *8th Grade Science*

Unit Summary

This unit is designed to teach students about the principles behind flood generation; ultimately having them critically think about the way floods are treated when predictions for current techniques used in flood prediction. Lesson 1 begins by teaching students about the basics of discharge and solving for different components of discharge using algebra. Concurrently, the first Lesson also introduces students to a hydrograph which is an application of a time series directly related to visually displaying discharge through time, as well as how discharge can change in a stream. Lesson 2 is a transition lesson which defines a flood and explores basin properties that affect flood magnitude and generation. Students are introduced to the idea of surface runoff, and guided through the definition of different watershed properties known to affect runoff. Through the interactive PowerPoint, students are asked to weigh in on how they think each property influences surface runoff and subsequent flood magnitude. Lesson 3 is an extension of Lesson 2 in the form of a lab exercise that introduces students to soil permeability and how this property may influence runoff. Students examine the amount of water that flows through 4 different sediments in a set timeframe, estimating the permeability of each and comparing. They are asked to define soil permeability in their own terms and weigh in on how that would affect surface runoff. The final lesson is a critical thinking exercise, where students are introduced to how statistics and probability work together, and are used to predict floods. An exercise of throwing a die is designed to be a simple way to solidify the concept of flood prediction. As flood prediction utilizing probability distributions are treated in the same way as if a die were cast, the students are asked to consider this based on what they have learned about what affects flood generation and determine if this is an acceptable assumption.

*Required knowledge includes basic understanding of the water cycle, the definition of a watershed (E.ES.07.81), as well as algebraic principles (6.EE) and basic probability (7.SP).

Next Generation Science Standards

MS-ESS2 – Earth Systems

ESS2.C	*The Roles of Water in Earths Process*
	• Water continually cycles among land, ocean, and atmosphere via transpiration, evaporation, condensation and crystallization, and precipitation, as well as downhill flows on land. (MS-ESS2-4) • Water's movements—both on the land and underground—cause weathering and erosion, which change the land's surface features and create underground formations. (MS-ESS2-2)
ESS2.D	*Weather and Climate*
	• Because these patterns are so complex, weather can only be predicted probabilistically. (MS-ESS2-5)

MS-ESS3 – Earth and Human Activity

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
ESS3.B	*Natural Hazards*
	• Mapping the history of natural hazards in a region, combined with an understanding of related geologic forces can help forecast the locations and likelihoods of future events. (MS-ESS3-2)

MS-ETS1 – 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.

Learning Objectives: (written in a logical order for learning)

- Students will demonstrate knowledge of how streamflow is measured by calculating discharge given the required parameters
- Students will define floods according to USGS standards
- Students will identify a flood from a stream hydrograph and the components of a flood hydrograph
- Students will define runoff and how it is affected by urban areas, forests, the existence of water, soil and geological controls
- Students will define soil permeability
- Students will calculate soil permeability
- Students will relate soil permeability to runoff processes
- Students will relate the use of statistics to prediction using probability
- Students will demonstrate knowledge of flood prediction by comparing flood prediction to rolling dice. They will be asked if floods should be treated as independent events like rolling dice, and asked to use their previous knowledge of what affects flood magnitude to answer questions related to that concept.

Lesson Title- Brief Description	Learning Objectives	NGSS Addressed (codes)	Materials
Lesson 1: What is streamflow (Lecture + Activity) Students will be introduced to how to qualitatively and quantitatively define streamflow. They will analyze a hydrograph and be able to calculate streamflow in a river given the relevant information	• Quantitatively and qualitatively define streamflow and its components • Solve for the different components of streamflow (Q=Av) • Learn how hydrologists measure discharge • Learn how discharge varies in a stream reach	**ESS2.C** Cross Cutting Concepts • Cause and Effect	1. “What is Streamflow” PowerPoint 2. “What is Streamflow” Student Note Sheet 3. Calculator 4. Notepad
Lesson 2: What affects Flood Magnitude (Lecture + Video + Performance Task) Students will be introduced to the USGS and what they do. The definition of a flood will be given and they will be able to identify floods from hydrograph data. Simple calculations that introduce them to concepts regarding flood analysis are conducted. The lesson continues with the basin properties that affect flood magnitude and have them engage in a guided discussion on how the students think different properties affect surface runoff. Additionally, a watershed activity has them applying the concepts learned in the lesson to addressing runoff in a custom-built watershed.	• Students will define a flood according to USGS standards. • Students will define runoff and how it relates to stream discharge. • Students will identify the parts of a flood hydrograph • Students will identify components of a watershed that affect runoff • Students will assess how different components affect runoff such as forested area and urbanization, as well as climate change effects. An activity sheet will be provided that addresses these concepts as well as a watershed activity.	**ESS2.C** **ESS2.D** **ESS3.B** Cross Cutting Concepts • Cause and Effect • Systems and System Models	1. “What affects flood magnitude” PowerPoint 2. Pens/pencils 3. “What affects flood magnitude” Student Note Sheet

Lesson 3: Soil Permeability Lab (Guided Inquiry) This lesson is a laboratory exercise that guides students through defining soil permeability on their own and infer how it might influence runoff.	• Students will define soil permeability • Students will calculate permeability for 4 different “soil” types • Students will relate soil permeability’s influence on runoff	**ESS2.C** **ESS2.D** **ESS3.B** Cross Cutting Concepts • Cause and Effect • Systems and System Models	1. Soil Permeability Lab Activity Sheet (Materials Included) 2. Calculator 3. Pencils
Lesson 4: Introduction to Probability and Statistics and its role in flood prediction (High Level Task) This lesson reviews probability and statistics, guiding them through an activity that relates flood prediction to dice throwing.	• Students will be able to define probability • Students will be able to define statistics • Students will be able to relate how statistics play a role in probability • Students will probability and statistics are used in flood prediction	**MS-ESS3-2** **ESS2.C** **ESS2.D** **ESS3.B** Cross Cutting Concepts • Cause and Effect • Systems and System Models	1. “Probability and Statistics” PowerPoint 2. “Probability and Statistics” Activity Sheet 3. “Probability and Statistics” Student Note Sheet 4. Dice 5. Pen or pencil 6. Calculator

Safety Considerations:
None

Evaluation Plan:
The final activity has them draw on concepts learned in the previous Lessons to ultimately decide if floods should be treated as independent events that are drawn from a probability distribution. The final lesson (Lesson 4) takes at least 2 days to get through with accompanying lecture and activity. A final quiz with a question asked from each lesson is also provided to gauge a students' retention of the material.

Resources (websites):
http://more.mel.org/ - Michigan State Standards for Teaching
http://www.floodsmart.org – Website that details the use of hydraulic structures and the importance of flood awareness
http://water.usgs.gov/education.html - Educational resource on how the USGS monitors streamflow and why

Brief description of how this unit relates to your graduate research. (1 page):
Flood risk is an essential part of what I study. I am particularly interested in the mechanisms that affect flood response, and how they influence our assessment of flood risk. This unit will enhance my understanding of each of these mechanisms as well as the fundamentals of assessing risk by allowing me to teach these concepts to an audience that has very little prior knowledge of these matters.

Streamflow problems require core calculations that I use in many of my analyses. They are at the heart of everything I do, and using these calculations in a teaching environment allows me to attempt to hopefully stimulate interest by giving student a real world application to the use of these equations, and to reinforce my knowledge of these concepts.

The emphasis on how water is translated through the landscape is of particular importance in my work, as I believe it is a misunderstood concept in the discipline of water resources. There is a knowledge divide between flood engineers and earth scientists about what affects the timing and magnitude of floods. All will agree that the landscape plays an important role, however many of the intricacies and nuances of a landscape play a larger role than is easily captured by numerical methods. Unfortunately, these numerical methods are at the heart of statistics, therefore anything that is easily quantified is generally used regardless of the inadequacy of the measure. This unit broadly covers the concepts that I am attempting to merge in more detail in my graduate research; that the landscape impacts high (and low) flows in more complicated ways than are currently accepted and defined. The unit is an attempt to not only show the fundamentals of engineering practice, but to subtly convey how difficult it is to truly capture a process with a number (Lesson 4). This is one of the reasons I want to be able to have students visually define and describe process as well as utilize methods to quantify it; to show that it is messy, and that it is in their future to try and clean it up if they choose to do so.