GK12: Global Watershed

Unit Title: Watershed hydrology and earth system interactions.

Subject/target grade: 8th

Unit Summary: This unit emphasizes water movement and storage as well as its interaction with other earth systems. This water-centric group of lessons was intended to complement a variety of topics commonly covered in 8th grade earth science classrooms. These lessons can be taught in series, or interspersed within broader earth science topics such as, structural geology, weather and climate, hydrology, etc.

- The first lesson (Where is the water in your watershed?) was intended to familiarize students with water cycle components and interactions. This lesson was designed to emphasize the importance of water resources to human health and well-being by connecting material with prior knowledge (basic physical, chemical and biological science content). Lesson 1 was specifically designed to introduce students to the concept of a watershed and drainage divide, which will be a recurring topic within this unit and for the remainder of the school year. No prior knowledge is needed for lesson 1, but it is likely that many students will already have basic understanding of water cycle components. Lesson 1 will likely cover 1.5 class periods

- Lesson 2 (Land use change in the Huron Creek Watershed) was intended to compliment knowledge acquired from Lesson 1. Students will be encouraged to apply their knowledge about water cycle components and interactions within the context of a watershed, and will also be encouraged to think critically about how alteration of watershed characteristics may affect water cycle components within a watershed. Students should be familiar with water cycle components and interactions within a watershed prior to Lesson 2. The instructor will need to familiarize students with general watershed characteristics such as land use and land cover. Lesson 2 is designed to cover 1 class period.

- The third lesson was developed to incorporate earth science content associated with, plate tectonics, volcanoes, and structural geology within the context of a watershed (Lake Superior basin). Lesson 3 (Whose fault is it? A geological history of why it's the Keweenaw's fault) was intended to utilize prior knowledge associated with plate tectonics and boundaries, and introduce students to structural geology concepts and terminology. Students will measure the strike and dip of exposed basalt layers in Houghton, MI, and use their experience to re-construct the geological history of the Lake Superior basin beginning 1.1 billion years ago. Students will need to be familiar with the different types of faults before beginning Lesson 3, and will be able to construct and interpret geologic cross-sections once completed. This lesson is designed to cover 3 class periods.

- The fourth lesson was developed to feature hydrometeorology terms and concepts. Lesson 4 (Plotting, analyzing and interpreting a stormflow hydrograph) was intended to introduce students to hydrographs, and encourages students to form connections between water end earth systems (atmosphere, rivers, and lithosphere). Students will become familiar with the creation and interpretation of hydrographs, and will also learn

how hydrographs can be used as a tool to promote responsible watershed development and ultimately benefit aquatic and human life. Students will use actual rainfall and stream discharge data from a nearby watershed (Trap Rock River, MI). Students will have the opportunity to think critically about their hydrographs, and be able to discuss how the duration and intensity of rainfall affects river's streamflow response. Previous knowledge associated with the water cycle, watersheds, and earth system interactions (i.e. infiltration, overland flow, soil properties) will aid student's ability to think critically about their hydrographs. A review of plotting data and an introduction to plotting a two y-axis graph may be necessary before students begin this exercise. This lesson will likely cover 2 class periods.

Michigan Content Expectations:

Content Standards Addressed:

1. E.4.1A – Compare and contrast surface water systems and groundwater in regard to the dynamics of water movement
2. E4.p1A – Describe that the water cycle includes evaporation, transpiration, condensation, precipitation, infiltration, surface runoff, groundwater and absorption.
3. E4.p1B Analyze the flow of water between the elements of a watershed, including surface features (lakes, streams, rivers, wetlands) and groundwater.
4. E2.1B Analyze the interactions between the major systems (geosphere, atmosphere, hydrosphere, biosphere) that make up the Earth.
5. E1.1D Identify patterns in data and relate them to theoretical models.
6. E1.1E Describe a reason for a given conclusion using evidence from an investigation.
7. E1.1f Predict what would happen if the variables, methods, or timing of an investigation were changed.
8. E1.2B Identify and critique arguments about personal or societal issues based on scientific evidence.
9. E2.1A Explain why the Earth is essentially a closed system in terms of matter.
10. E2.1C Explain, using specific examples, how a change in one system affects other Earth systems.
11. E2.2f Explain how elements exist in different compounds and states as they move from one reservoir to another.
12. E2.4B Explain how the impact of human activities on the environment (e.g., deforestation, air pollution, coral reef destruction) can be understood through the analysis of interactions between the four Earth systems.
13. E3.p1A Explain the origin of Michigan landforms. Describe and identify surface features using maps and satellite images.
14. E3.p3B Describe the three types of plate boundaries (divergent, convergent, and transform) and geographic features associated with them (e.g., continental rifts and mid-ocean ridges, volcanic and island arcs, deep-sea trenches, transform faults).
15. E3.3A Explain how plate tectonics accounts for the features and processes (sea floor spreading, mid-ocean ridges, subduction zones, earthquakes and volcanoes, mountain ranges) that occur on or near the Earth's surface.
16. E3.4C Describe the effects of earthquakes and volcanic eruptions on humans.
17. E4.p1B Analyze the flow of water between the elements of a watershed, including surface features

18. (lakes, streams, rivers, wetlands) and groundwater. (prerequisite)
19. E4.p3C Explain the formation of the Great Lakes.
20. E4.1C Explain how water quality in both groundwater and surface systems is impacted by land use decisions.
21. E4.3B Describe the damage resulting from, and the social impact of thunderstorms, tornadoes, hurricanes, and floods.
22. E4.3C Describe severe weather and flood safety and mitigation.
23. E4.3A Describe the various conditions of formation associated with severe weather (thunderstorms, tornadoes, hurricanes, floods, waves, and drought).

Learning Objectives:

Lesson 1

1. Students will be able to recognize water cycle components in a local watershed, and be able to describe interactions between water and earth system components.
2. Students will be able to explain how water exists in different states as it moves from one reservoir to another.
3. Students will be able to identify storage components of the water cycle, and describe the concept of water residence time
4. Students will be able to describe why (in general) groundwater is safe to drink, and recall what water quality parameter is indicative of true groundwater.
5. Students will be able to define what a watershed is, and describe a drainage divide.

Lesson 2

6. Students will be able to identify different types of land use and land cover in Huron Creek watershed.
7. Students will be able to calculate the areal extent (acres) of land cover types in the Huron Creek watershed, and determine which land cover types saw the greatest change in the past 30 years.
8. Students will be able to assess how changes to land cover may have altered water cycle components and their interactions during the past 30 years.
9. Students will be able to explain why streamflow response to a rain event would be different today than it was 30 years ago.

Lesson 3

10. Students will be able to use a compass to measure the strike and clinometer to measure the dip of an exposed rock layer.
11. Students will be able to construct a geologic cross-sectional diagram of the Lake Superior basin, and be able to define a normal and reverse thrust fault.
12. Students will be able to explain the origin of Michigan landforms in the Upper Peninsula
13. Students will be able to explain how plate tectonics, specifically divergent plate boundaries formed the Lake Superior basin.

Lesson 4

14. Students will understand the relationship between rain events and stream discharge, and be able to graph a two y-axis bar and scatter chart that contains rainfall, discharge, and time data

15. Students will be able to describe how the timing and magnitude of streamflow response relates to rainfall intensity and duration.
16. Students will be able to describe the damage resulting from severe thunderstorms and flooding.
17. Students will be able to explain how the impact of human activities on the environment affects flooding hazards.
18. Students will be able to demonstrate using specific examples, how a change in one system affects other Earth systems.
19. Students will become familiar with online data warehouses such as USGS's NWIS and NOAA-NCDC.

Table of Lessons:

Lesson Title- Brief Description	Learning Objectives	NGSS Addressed	Materials
Where is the water in your watershed? Students will learn about watersheds, identify water cycle components in a nearby watershed, and think critically about how weather & climate influence water cycle components.	Students will be able to recognize water cycle components in a local watershed, and be able to describe interactions between water and earth system components.	E.4.1A E4.p1A E2.2f E4.p1B E2.1B	Clipboard Pencil Outdoor clothing/shoes
Land Use Change in Huron Creek's Watershed. Students will identify land use cover types, calculate the area of several land use cover type, and describe how land use change during the past 30 years may have altered water cycle components and earth system interactions in Huron Creek's watershed.	Students will be able to identify land use cover types, calculate the areal extent of land use cover types in Huron Creek's watershed, and explain how changes to land use cover types during the past 30 years may have affected water cycle components and earth system interactions.	E1.1f E1.2B E2.1C E2.4B E4.1C	Pencil Calculator
Whose fault is it? A geological history of why it's the Keweenaw's fault. Students will learn how to use a compass and clinometer, and will measure the strike and dip of exposed rock layers (optional). Students will then re-create the formation of the Lake Superior basin by constructing a	Students will be able to use a compass and clinometer to measure the strike and dip of exposed rock layers, and will be able to construct a geologic cross-sectional diagram of the Lake Superior basin.	E4.p3C E3.4C E3.3A E3.p3B E3.p1A	Compass Clinometer (see lesson to make your own inexpensive clinometer) Colored pencils

series of geological cross-sections.			
Plotting, Analyzing, and Interpreting Stormflow Hydrographs. Students will construct a stormflow hydrograph, analyze their data by performing a series of calculations, and interpret their results.	Students will plot precipitation and streamflow data, and analyze their results by performing a series of calculations. Students will be able to graph a two y-axis bar and scatter chart, and compare and contrast the streamflow response to two distinct precipitation events.	E4.3A E4.3C E4.3B E2.4B E2.1C E1.1E E1.1D E2.1B	Pencil Calculator

Safety Considerations:

Lesson 1

Students will be going outside, make sure they stay together and stay off major roadways if possible. Make sure students are prepared to go outside in various weather conditions.

Lessons 2

No safety considerations other than normal classroom safety considerations

Lesson 3

Students will be going outside, make sure they stay together and stay off major roadways if possible. Make sure students are prepared to go outside in various weather conditions.

Lesson 4

No safety considerations other than normal classroom safety considerations

Evaluation Plan: *Indicates the formative and summative assessment tools that will be used and the purpose of each tool.*

Lesson 1

Students will record observations on a worksheet, and answer a few critical thinking questions. The instructor will check to see if the students filled in the worksheet correctly as a formative assessment tool to make sure they were participating during the exercise. The instructor will check answers to critical thinking questions as a summative assessment tool to gage student understanding of water interactions between earth systems. This is an introductory lesson, and is not meant to be extremely rigorous.

Lesson 2

Students will in groups to perform calculations and answer critical thinking questions about their calculations. The teacher can use their calculations as a formative assessment tool, and

their answers to critical thinking questions as a summative assessment tool to gage student understanding of watershed hydrology and earth system interaction concepts.

Lesson 3

Students will work in groups, but take turns using a compass and clinometer to measure the strike and dip of rock layers. Students will also work in groups to create 4 cross-sectional diagrams of the Lake Superior basis during the past 1.1 billion years. The instructor will use the cross-sectional diagrams as a formative and summative assessment tool to gage student understanding of lesson content. Specifically, the student's ability to depict a syncline, normal fault, and reverse thrust fault should be demonstrated.

Lesson 4

Students will construct 2 hydrographs of separate storm events. Each graph will contain 2 y-axes, and will depict rainfall and snowfall (snow water equivalent) as bar charts, and discharge data as a scatter plot. Students will then analyze the data by performing a series of calculations (rainfall intensity, duration, peak streamflow, time to peak streamflow). The instructor will use the hydrographs and calculations as a formative assessment tool (properly labeled axes, units, chart title, etc.), and the answers to the critical thinking questions as a summative assessment tools to determine the student's ability to construct a hydrograph and interpret the results.

Resources (websites):

Lesson 1

This lesson was adapted from MEECS water quality Lesson 1 (scavenger hunt)
http://www.michigan.gov/deq/0,1607,7-135-3307_3580_29678-148152--,00.html

Animation for introduction to watersheds
http://techalive.mtu.edu/meec/module01/whatiswatershed.htm

Lesson 2

Figures and data for this lesson were retrieved from the Huron Creek Watershed Management Plan: http://www.geo.mtu.edu/~asmayer/HuronCreek/HuronCreek.htm

Lesson 3

All of the links below contain useful information for instructors to read about the formation of the Lake Superior basin, and many include descriptive maps and diagrams of the Lake Superior basin geology
http://michigannature.wordpress.com/2010/07/15/the-secret-behind-the-copper-country%E2%80%99s-native-deposits/
http://www.iris.edu/hq/programs/education_and_outreach/animations/15
http://earthsci.org/education/teacher/basicgeol/deform/deform.html
http://www.minsocam.org/msa/collectors_corner/vft/mi2b.htm
http://www.nps.gov/history/history/online_books/geology/publications/pp/754-C/intro.htm

The "measuring the strike and dip of exposed basalt layers" portion of this lesson was adapted from:
http://www.geocaching.com/geocache/GC36MPG_houghton-lava-flow?guid=a7028785-e065-457e-a213-785cbc203d0f

http://mitep.mtu.edu/earth_cache/ec_houghton.php

Lesson 4

The two links below were where I acquired the data for the students to plot their hydrographs. This process is a bit tedious, and would not be a practical use of time for students to undertake during class.
http://waterdata.usgs.gov/nwis/dv?referred_module=sw&site_no=04043050

http://www.nohrsc.noaa.gov/interactive/html/graph.html?station=7199O_MADIS&w=600&h=400&o=a&uc=0&by=2012&bm=10&bd=20&bh=6&ey=2012&em=11&ed=22&eh=6&data=0&units=1&region=us

The link below contains useful information and diagrams about hydrographs
http://coecs.ou.edu/soonercity/CE3212/lessons/hydrographs.html

Brief description of how this unit relates to your graduate research. (1 page):

My graduate research and my interest in water science in general stem from the desire to understand the sources, movement, and residence times of water in different locations, compartments, and states. While my current research is specifically focused on black ash wetlands in the Upper Peninsula of Michigan, this research falls in line with my general hydrological interests associated with watershed processes, shallow groundwater resources, streams, chemistry, and soils. My PhD research is focused on estimating sources and sinks of water in small watersheds, and understanding how black ash wetland watersheds respond to disturbance. The lessons found in this unit were developed to incorporate the various elements of earth science that are both primary and secondary components of my PhD research.

The lessons found in this unit focus on interactions between water cycle components, watershed processes, hydrogeology, and earth system interactions. In Lessons 1, 2, and 4 the students identified the various locations and pathways of water in a watershed, described how water interacts with major earth systems, and analyzed how streamflow responds to precipitation inputs. The pathways, residence times, and magnitude of storage in each reservoir are precisely the types of processes that I am investigating with respect to black ash wetlands in the Upper Peninsula, and on several occasions I was able to tie in experiences and knowledge acquired from my PhD research within the scope of the class discussions.

Trying to develop a lesson that related to my research with earthquakes, volcanos, and structural geology was a bit of a stretch. However, once I finished developing Lesson 2, I realized it was not as unrelated as I originally anticipated. I often collect soil cores and commonly conduct secondary research about the geology of the watersheds where my investigations take place. These data significantly help me design my experiment and aid my interpretation of results. By constructing a geological cross-section of the Lake Superior basin the students were able to identify the location and extent of specific rock layers on the surface and beneath the surface of the Keweenaw and Lake Superior. While the scale of this lesson is much larger than my current research project, the ability to identify individual surface and subsurface rock and soil layers is quite relevant to my everyday research experiences.

Overall, the challenge of linking classroom material with my research has been extremely rewarding. There are numerous examples of how the lessons in this unit relate to my current research, and perhaps each relationship does not need to be explicitly described. I chose the examples above to exemplify the variety of ways the lessons are directly and indirectly associated with my current research. I try whenever possible to tie in applications or excerpts of knowledge gained from my current research within lectures and classroom discussion. It seems that an infrequent but regular infusion of applied research knowledge within the classroom environment is an effective way to intertwine my research activities within classroom material.