NGSS STORYLINE: How do geology & human activities affect water chemistry?

Brainstorming - What do I want my students to learn about?			
Ideas for phenomena	**Anticipated Student Questions**	**Data & equipment students need to answer questions**	**SEPs, DCIs, and CCCs that the phenomena and data address**
When waters from two tributaries come together, they are very different colors. One is very orange and the other is grayish-green.  *(In this case, I want students learning* ● *how water chemistry can be affected by many different factors* ● *water at Earth's surface is connected to groundwater* ● *humans can impact and are impacted by water chemistry)*	*Where is the water coming from?* *Why would it be different colors?* *Is the water polluted?* *Is this natural or from people?* *Why does the water stay "separated"?* *Why does the orange go away downstream?* *What is all the stuff on the rocks?*	*Maps - topographic, geologic, soils* *Water Quality - water test kits* *Computers with good access to the internet* *People who work at local drinking water and wastewater treatment plants; also, environmental consultants.*	*SEPs -* ● *Asking questions that are testable and relevant* ● *Collaboratively plan an investigation to collect and analyze data to generate and test hypotheses* ● *Use tools and technology to make valid scientific claims* ● *Use mathematical/ computational thinking to describe relationships* ● *Construct an explanation using quantitative (spatial data is quantitative) information as evidence* *DCIs -* ● *Resource availability has guided the development of human society* ● *The sustainability of human societies and the biodiversity that supports them requires responsible management of natural resources* *CCCs -* ● *Empirical evidence is required to differentiate between cause and correlation and make claims about specific causes and effects.* ● *When investigating or describing a system, the boundaries and initial conditions of the system need to be defined and their inputs and outputs analyzed.* ● *Change and rates of change can be quantified over very short or very long periods of time. Some system changes are irreversible.*

Narrow down student questions to ONE driving question that can be used in all the sections (this is to preserve teacher sanity!)	
Driving Question	*How do geology and/or human activities affect water chemistry and is this a concern for people drinking the water?*

What do students already know? How do I know this?	
Where is this storyline in the sequence of learning? Pre-assessment Ideas	*This is the first unit of study in my 9th grade Earth & Space Science class. Most students had a Physical Science or Integrated science course the year before. To find out what they learned, I give a pre-assessment having them sketch out the water and rock cycles individually. Then in small groups, they work together to develop an explanation for how the two cycle are interconnected. These explanations are posted on chart paper around the room and then students participate in a gallery walk to give feedback.*

Creating the Storyline - The 5E model of instruction directs students' efforts & keeps them focused on the phenomena. (This is not a linear process.)		
	What the teacher is doing…	**What students are doing…**
Engage -	*Introduce the phenomenon*	*Record what they are observing/noticing, and what they wonder about/question*
Explore -	*Lead discussion to refine questions* *Ask students what they need* *Provide resources and instruction in how to use equipment, technology,* *Guide and support students*	*Refine questions* *Identify needed resources* *Develop a plan to collect and analyze data* *Collect and analyze data, revise plan, keep careful notes*
Explain -	*Guide and support students* *Listen for misconceptions and guide students toward more scientific explanations* *Create opportunities to share ideas amongst groups*	*Work together to compose explanations based on data and evidence* *Share explanations with other students and teacher*
Elaborate -	*Checking in with students* *Guiding and supporting students*	*Compare evidence with each other to see what kinds of similarities and differences there are* *Extend research to other places or phenomena to understand it better* *Identify the limitations of research and data collection*
Evaluate -	*Assess students' presentation*	*Present research and results* *Get and give feedback* *Demonstrate the skills gained, content learned, and make connections to the broader community of science*

Mapping it all out		
Day of Unit	**Activity**	**Notes/Rationale/etc.**

Day 1	*Take students to the stream or show a video of it if we can't go outside. Students brainstorm questions. In this case, I had students work in small groups of 3-4 students to create a list of questions. Each group picked their top three to share. I wrote them out on the board. If multiple groups had the same or similar questions, I would put stars next to them. In a class discussion, we would narrow it down to a few questions.* ***By the end of the day, I would know what stood out from all my sections. I would share these the next day.***	
Day 2	*Students find out the shared driving question and have one day to do research online. By the beginning of Day 3, they need to have outlined plan of what they want to do, resources they need, and some kind of a timeline.*	
Day 3	*Student groups share their research plan. We discuss and prioritize student ideas. For this example (which I used for 15 years), students want to know where the water is coming from. I ask lots of questions to get them to come up with the ideas of "topography" or the shape of the land and "watersheds" or areas where all the water goes into a stream.*	
Day 4-5	*Students study a topo map and ask questions. I have clay models in tubs with plexiglass for them to create topo maps. They study a topo map key and do an activity where they have to answer questions about scale, distance, elevation, and interpret a topographic profile. Some years, I have even had them go out and use tape measures and plumb bobs to make a very simple topo map of an area on campus (this adds on a few days).*	
Day 6	*We go back to our discussion from Day 3 to re-introduce the concept of a watershed. Students are given a local laminated topo map and use markers to highlight the local stream. Students then sketch out the top of the watershed on the topo map. They use a grid to figure out the area of the watershed.*	
Day 7	*Using their watershed maps, I ask students to look for anything that they think could explain what is causing the two tributaries to be so different. They will usually look for mines and other human features that would explain it. (There are no mines.) They know that the rust is from metals so I ask lots of questions to get them to come up with the idea that they need to know more about the geology of the area. I have geologic maps from the USGS but part of the area is incomplete. Weather/admin permitting, we make plans to go out to some outcrops near campus. If we can't go out, I collect rock and soil samples and bring them back for students to look at.*	
Day 8	*Field trip or sample examination. The rocks from the rusty stream are amphibolites (dark metamorphic rocks). The rocks from the lighter area are quartzo-feldspathic gneisses and pegmatites. Students determine the density of the samples and use keys to determine what kinds of rocks they are.*	
Day 9	*Students use soil test kits from the garden store to classify soils and determine soil composition.*	
Day 10	*Today is usually a workday for students to work on summarizing what they have figured out so far. They make charts, graphs and write up their ideas.*	
Day 11	*I present the video of the stream again and ask them what is in the water. At this point, they think they already know but I challenge them to show me the evidence. They haven't tested the waters yet. I ask questions until they realize they need to collect water samples and test the water chemistry. Students take some time to do some research to find out what they can test for. I have Hach water test kits from a grant from the American Chemical Society and students look through those kits to see what kinds of tests they can do.*	
Days 12-13	*Students collect and test water for a variety of chemicals.*	

Days 14-15	*Student groups make posters to present their work the following week.*	
Days 16-17	*Students present work and have some time for reflection. I ask water district people and environmental consultants to visit and give students feedback on their presentations. The adults are instructed to be very honest and ask hard questions. Afterward, students make a list that identifies the skills they need to work on and the content they didn't master. They submit this with a list of questions to me.*	