

Name _____

Class Period _____

Introduction: As densely populated urban areas continue to expand, human activity is pushing out much-needed greenspaces from our community; in turn, we are also removing critical buffers that are needed to combat air and water pollution, leaving cities vulnerable to a variety of health issues and potential infrastructure damage. In August of 2017, the Greater Houston (Texas) area experienced a catastrophic flooding event, with Hurricane Harvey being designated as the wettest tropical cyclone ever recorded in US history. With many areas receiving 40" or more of rain, the rising flood waters had nowhere to go in a city covered in concrete (a barrier to natural infiltration); this caused over \$125 billion in damage, with flood waters inundating hundreds of thousands of homes and displacing more than 30,000 people. This activity explores land use in Harris County, TX, and its impact in local flooding. Students will analyze historical precipitation data, predict future flooding patterns based on past extreme weather events, and quantify potential mitigation techniques by incorporating greenspaces in urban areas.

Activity A: You will now investigate precipitation (rain) patterns for the Gulf Coast area. Students will work in pairs to plot a subset of historical precipitation from the NOAA website below:

https://www.weather.gov/hgx/climate_hou_normals_summary

Browse the data and in the above links and ask yourselves essential questions:

What kind of data am I looking at?

Where/how was this data collected?

Which numbers do I actually need to use, if I am curious about historical precipitation patterns? Monthly precipitation? Annual precipitation? What numbers DON'T I need? Why?

How could I represent these data visually, in a graph?

Think-pair-share with your partner regarding the questions above. Next, enter the above data set into Excel or Google sheets; create a scatter plot, and if possible, add a trend line. Make sure you share your plot with your instructor!

Extensional option: create 'error bars' on the data, showing the deviation from historical precipitation yearly average. You could also just add a baseline representing average rainfall.

Using your scatterplot, answer the following essential questions:

What patterns do I see in the data? What inferences can I make about future rainfall in Houston, TX? Is there a clear trend in precipitation patterns? If so, what is that trend?

What errors might there be in the data?

Activity B: Now you will analyze land use in Harris County, TX, and analyze the relationship between land use and infiltration. Working in pairs, go to: www.modelmywatershed.com

Take 5-10 minutes to 'play around' with the various options. (For instructions on how to create a project or navigate, go <https://wikiwatershed.org/help/>)

Consider the following essential questions:

How should I delineate my model's boundary type? Which boundary type best reflects the precipitation data plotted in Activity A?

What other features are being shown on this map? _____

Once you have delineated your watershed (for this exercise, county lines work best), *analyze* the various watershed characteristics. You should be able to answer the following questions:

1.) What is the primary land-use for Harris County? How many acres? What percentage? Where is this type of land use located?

2.) What types of 'open water' exist in this area? How might that impact local drainage patterns?

3.) What types of soil are present in this area? Which soil types allow for maximum infiltration? What are some potential *barriers* to infiltration?

You can now MODEL how extreme precipitation events impact infiltration. What would an extreme weather event (like Hurricane Harvey!) look like? You will consider this by modeling a '24-hr hypothetical storm event'. To select the amount of storm precipitation, you should estimate a reasonable number by reviewing 10-year storm events from the websites below:

https://www.weather.gov/hgx/pns_memorable_events2000s

https://www.weather.gov/hgx/climate_holidays_hundred

(Extensional option: students may 'deep dive' into the data, reading meteorological reports to answer the following questions: which event was costliest (in TODAY's dollars?), which event induced the highest flood waters?, which event caused the most human fatalities?)

Once you and your partner select the amount of rainfall for your 24-hour period rain event (don't forget to convert inches to cm!), you can scroll the precipitation toolbar back and forth to see how infiltration rates change during your storm event.

You should be able to answer the following essential questions:

1.) What amount of rainfall did you select for your storm event? What was the total volume of water that is accounted for as runoff? How much water was absorbed (infiltration)? How much is released as evapotranspiration?

2.) What are some land-use factors that contributed to the extreme flooding caused by Hurricane Harvey?

(For a quick simulation on land use and infiltration rates, visit :<https://runoff.modelmywatershed.org/>)

Activity C: You will now look at the eco-services provided by prairies; in particular, you will model the additional infiltration capacity of 1 acre of native Texas grasslands, and predict how additional greenspaces in urban areas can be used as a flood mitigation technique. You will quantify the amount of displaced flood waters as well as the cost-savings provided by native greenspaces.

First, you will explore the general characteristics of pocket prairies: visit the following websites for initial research.

www.tigerprairie.org

www.katyprairie.org

<https://www.nature.org/en-us/get-involved/how-to-help/places-we-protect/nash-prairie-preserve/>

<http://westsidewolfprairie.weebly.com/>

<https://www.tallgrassprairiecenter.org/>

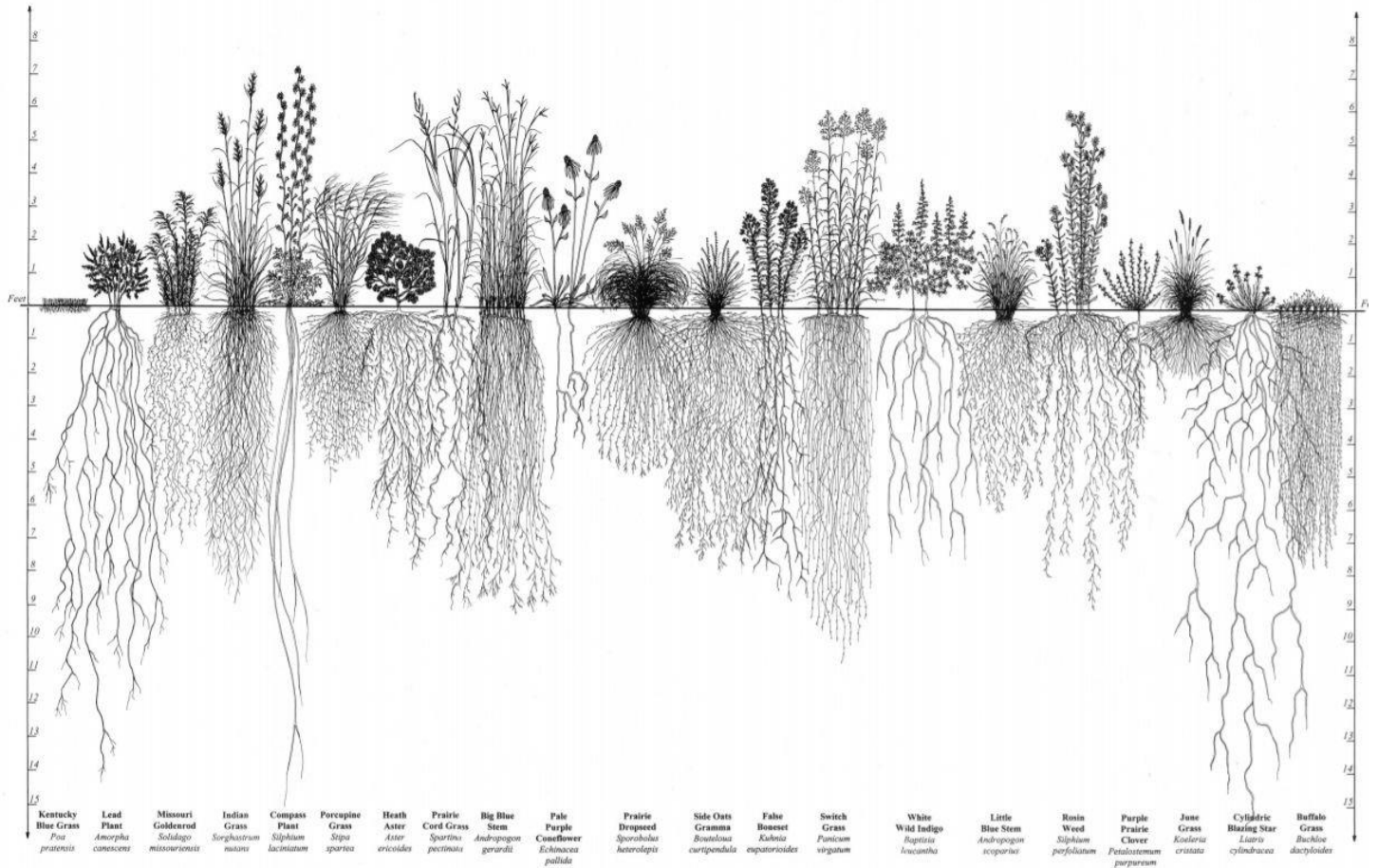
How many acres is the Tiger Prairie? _____

What types of plant species are in this prairie?

List THREE things you learned (and previously didn't know!) about prairie plants! _____

How do prairie plants impact infiltration rates? Review the following website, which outlines the various soil properties and how soil characteristics impact infiltration rates: <http://www.fao.org/3/r4082e/r4082e03.htm>

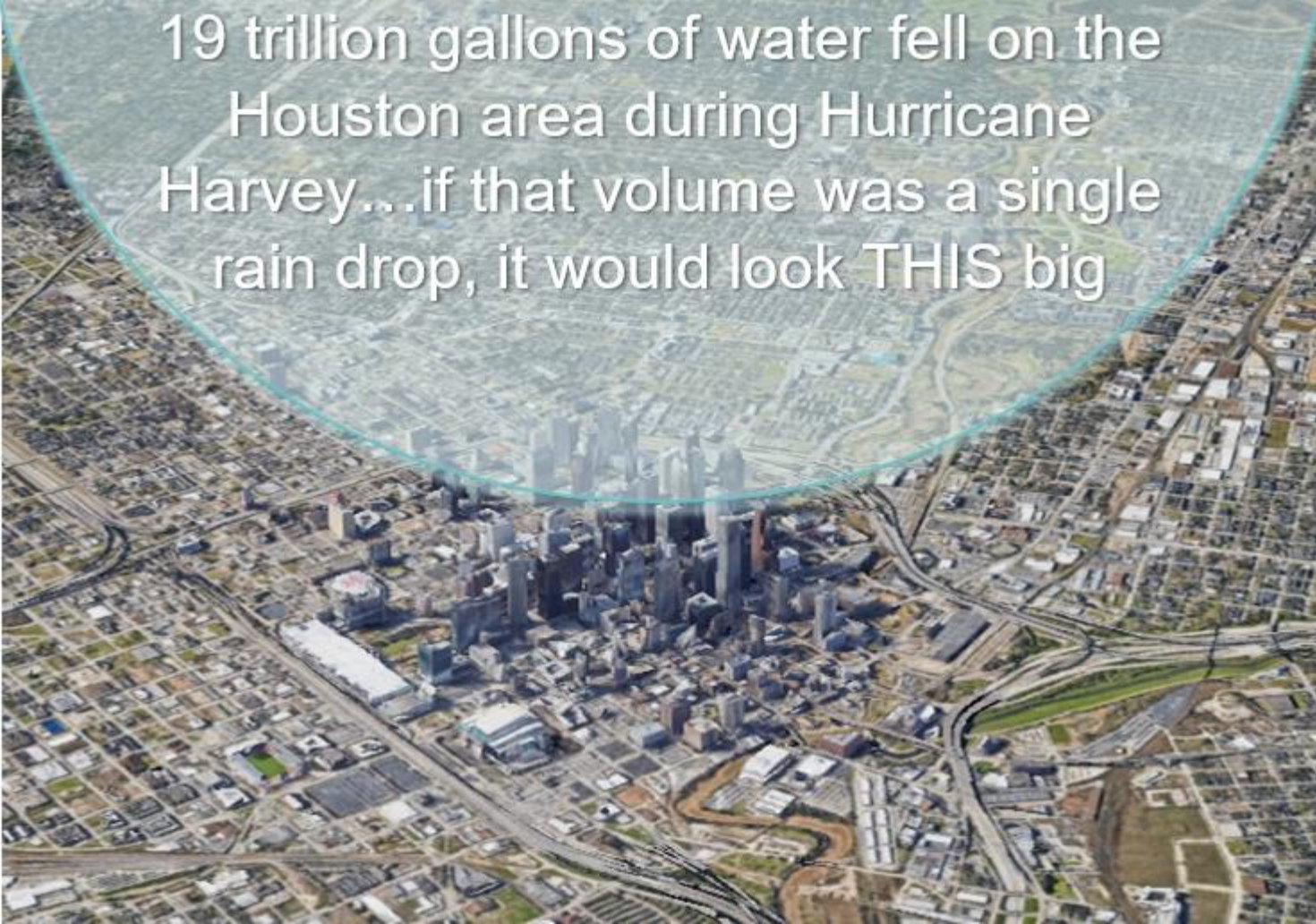
Now look at this diagram that shows the variation in root depths for various prairie plants, versus turf grass (shown as the plan on the very left of the diagram):



How might the extensive roots of prairie plants impact soil porosity and permeability? Discuss your your're your partner! _____

Now, you will return to your watershed model, and find Old Market Square, which is in downtown Houston, at the intersection of Milam Street and Congress Street (or Travis Street and Congress Street). You should convert this park into native grasslands by going to the top toolbar called 'land cover' and toggling on the grasslands option. Now create a polygon over Old Market Square. This is approximately 1 acre. (conversions: $1 \text{ km}^2 = 247 \text{ acres}$ or $4047 \text{ m}^2 = 1 \text{ acre}$). What was the NET change in the volume of water (in m^3) that was diverted from runoff into infiltration and evapotranspiration pathways? _____

- 1.) Now convert that volume to gallons ($1 \text{ m}^3 = 264 \text{ gallons}$). _____
- 2.) Study the infographic below: how many gallons of water fell on *Houston* during Hurricane Harvey? _____



19 trillion gallons of water fell on the Houston area during Hurricane Harvey...if that volume was a single rain drop, it would look THIS big

3.) How many Tiger Prairies would you need to divert 1,000,000,000 gallons of rain?

Now go to Arc GIS to view inundation maps of standing floodwaters from Hurricane Harvey:

<https://www.arcgis.com/apps/View/index.html?appid=8350c2f309bb49f8865a44cb972024c2>

Click on “1” to briefly read the background information describing how data was gathered, processed, and published in this map. Next, click on the base map gallery: toggle on/off various base maps until you find one that you feel is best for showing flood features. You may also go to:

<https://maps.woolpert.com/harvey/#c:-10650413,3468571;z:14;t:e>

Zoom into Houston until you can identify specific features; slide the image left (before) and right (after) to view the changes from before Hurricane Harvey (September 1, 2017) and after (August 31, 2017)

1.) What parts of Harris County were most impacted (most inundated)? _____

2.) Zoom in and out at various locations in Harris County: what flooding patterns do you see? Standing flood waters correspond to what natural features? And what man made features? _____

3.) Looking at the Arc GIS inundation map, identify 5 areas where you could easily install a pocket prairie! (be specific! Use latitude/longitude or cross streets!) Please list the criteria you used to select your locations. (Parks? Hardscaped areas? Areas near major streams and bayous?) _____

4.) Go back into ModelMyWatershed and draw polygons around each of your five locations; set the land use type to 'grassland'. Now add the areas of all 5 locations (hover over each polygon for size details). How many acres of prairie did you convert? Rerun your simulation. How many gallons of water did you divert? _____

Hurricane Harvey caused over \$125,000,000,000 (1.25×10^{11}) in damages. Given that the greater Houston area received nearly 19,000,000,000,000 (1.9×10^{13}) gallons of water in rainfall, means that every gallon of rainwater that fell cost Houstonians \$152. (Quick thought experiment...how much is 1 gallon of spring water at the store?) How much money could you have saved the Houston community from the water you diverted with your pocket prairies?

Activity D: You will now look at ways to incorporate native greenspaces as part of “smart growth” in urban planning.

Clearly, urban greenspaces have the potential to provide multiple ecoservices, and for the Houston area, that includes flood mitigation. If greenspaces are so valuable, why are cities not incorporating more of them? _____

How might you go about initiating change in your OWN community to create more native greenspaces?

Given the data you have just interpreted and the cost-savings you have calculated, you will create a persuasive proposal to Houston community leaders citing a location in the Greater Houston area you think should be converted to greenspace (remember, which locations have the biggest impact when converted to native prairie!). You will present your findings in CER (Claim Evidence Reasoning) format: you will create a poster that identifies your guiding question (“Where would be the ideal location for a proposed greenspace?”), your claim (“we propose installing a 1-acre pocket prairie at location x”), and to defend your claim with evidence and a solid justification. To answer the guiding question, you should consider the following factors when determining the appropriate location: soil type (permeability), hydrology (groundwater, surface water), proximity of residential or business properties, ecological resources, geology, current land use, ground slope, environment and wildlife, and laws and regulations.

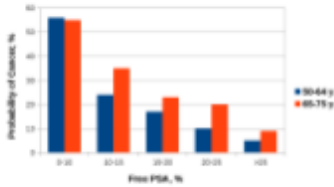
CER Poster Your poster should include all the information shown in the figure below.

The Guiding Question:

Claim: Your answer to the guiding question

Evidence:

ANALYSIS



Make a graph to or figure to show a relationship, a change over time, or a difference between groups

INTERPRETATION

This graph suggests...
This graph shows...

Explain what the analysis means

Reasoning/Justification:

These are the science concepts that are important for understanding our evidence

Explain why the evidence matters

Our evidence is based on the following assumptions

Things to remember: your EVIDENCE is a collection of facts, data, etc. that can be in the form of maps, calculations, graphs, etc. Your JUSTIFICATION is your interpretation of that evidence. It is entirely possible for two groups to use the exact same data but interpret it differently in their justifications. It is up to YOU to describe why the data defend your claim!

PART 2: GALLERY WALK You will now review your classmates' CER posters. As you are reviewing their proposed prairie sites and evidence for their choice, ask yourselves: why did they decide to focus on that site? Why did they decide that their data was important in their determination? Is that the only way to interpret the results of their analysis? How do they know that their interpretation/analysis is appropriate? What other claims did their group discuss before they decided on that one? Does seeing other groups' posters change YOUR proposed location?