

MODULE 3: ORDINANCE AND POLICY SOLUTIONS

MODULE & LESSON TIMING: There are 3 lessons in Module 3. Each lesson should be able to be completed in one to two class periods, with student readings before or during.

WHAT TO EXPECT: Module 3 examines sea-level rise resilience through ordinances and policies.

- 3.1 Whose Law Is It Anyways? – levels of government ([page #3](#))
- 3.2 Community Assets at Risk - municipal decision makers ([page #16](#))
- 3.3 Flooding Pains and Dream House Gains – floodplains ([page #31](#))

TEACHER BACKGROUND RESOURCES:

Videos

- Introductory video on “Working with Natural Systems in Fairhope, Alabama” (6-minute video)
 - Alabama: <https://vimeo.com/322236377>
 - Mississippi: <https://vimeo.com/322236734>
- TED Radio Hour about sea-level rise and community impacts (13-minute video)
 - “Colette Pichon Battle: How Can We Prepare For The Next Hurricane Katrina?”: <https://www.npr.org/2021/02/26/971498925/colette-pichon-battle-how-can-we-prepare-for-the-next-hurricane-katrina>

Readings

- Informational page from the National Hurricane Center about the SLOSH model
 - Sea, Lake, and Overland Surges from Hurricanes (SLOSH): <https://www.nhc.noaa.gov/surge/slosh.php>
- Informational page with Frequently Asked Questions about ADCIRC:
 - <https://adcirc.org/home/adcirc-faq/>
- Resource to find news articles about climate change.

- Connected Coastlines is a nationwide climate reporting initiative in coastal states hosted by the Pulitzer Center: <http://connected-coastlines.pulitzercenter.org/>
- Article about how climate change is speeding gentrification in some of America's most flooding vulnerable cities.
 - "High ground, high prices": <https://www.cnn.com/interactive/2021/03/us/climate-gentrification-cnnphotos-invs/>

RECOMMENDED CURRICULUM CITATION:

Vedral, Sonia, Collini, Renee C., Miller-Way, Tina, Rellinger, Alison N., Sempier, Tracie T., Smallegan, Stephanie M., Sparks, Eric. (2021). Sea-Level Rise in the Classroom. MASGP-21-056

Curriculum developed by Northern Gulf of Mexico Sentinel Site Cooperative in collaboration with Alabama School of Mathematics and Science, Dauphin Island Sea Lab, Mississippi-Alabama Sea Grant Consortium, Mississippi State University, Smart Home America, and University of South Alabama.

Funding provided by National Academy of Sciences Gulf Research Program "Building Sea-Level Rise and Flood Resilience Capacity Through Students and Teachers" (NAS 2000009916)

3.1 Whose Law Is It Anyways?

AGE RANGE

9th—12th grade

TIME REQUIRED

60 minutes

ACTIVITY OVERVIEW

Engage: Discussion Question

Explore: Student Reading

Explain: Discussion

Elaborate: Government Research

Evaluate: Discussion

MATERIALS

Student Reading

Student Worksheet

Computers

BASED ON:

The Great State by iCivics and
Follow That Legislation by Katie
Crosby, Colleton County High
School

LESSON TOPIC: Levels of government

ACTIVITY SUMMARY: Students will explore their local type of government.

OBJECTIVES:

Students will be able to:

- Demonstrate an understanding of the structure and function of government.
- Explain the impact of state agencies and commissions on citizens' lives and property.
- Describe the role of state governments in providing services and regulating activity.

LESSON BACKGROUND: There are three major levels of government that we are going to explore to better understand who is creating the laws, policies, and ordinances that impact sea-level rise adaptation, mitigation, and resilience: local, state, and federal.

State governments work almost exactly like the U.S. federal government. There are three branches of state and federal government: an executive branch, a legislative branch, and a judicial branch. At the state level, the head of the executive branch is called the governor, for the federal government it is the President of the United States. Every state except one, Nebraska, also has a bicameral legislature, meaning that the legislature is made up of two chambers. In most states, those chambers are called the Senate and the House of Representatives. A state's judicial branch normally includes a high court, often called the Supreme Court, and a system of lower courts. These lower courts include trial courts and appeals courts. A state's three branches interact just like the three branches at the federal level. The purpose of having three branches is to balance

power so that no one branch or person becomes too powerful. The state's legislature passes laws, a state's governor can veto laws that are passed and the executive branch enforces the laws, and a state's high court has the power to decide whether state laws violate the state's constitution and to interpret how those laws should be enforced.

VOCABULARY:

Adoption	The act of accepting and entering new ordinance into the Code of Laws as a result of a majority vote in favor of the proposed ordinance.
Amendment	A change to the existing language in the ordinance.
Coastal Hazard	Physical phenomena that expose a coastal area to risk of property damage, loss of life and environmental degradation.
Coastal Resilience Index	A questionnaire for communities to assess their level of preparedness for extreme events.
Federalism	The division of powers among the local, state, and national governments.
Infiltration	The process by which water on the ground surface enters the soil.
Motion	A new idea or action.
Ordinance	An authoritative rule or law; a public injunction or regulation.
Policy	Definite course or method of action; a high-level plan embracing the general goals and acceptable procedures of a governing body.
Resilience	The capacity of a community, business, or natural environment to prevent, withstand, respond to, and recover from a disruption.

ENGAGE:

Play the "Freddy the Fish Teaches About Stormwater" video for students:

https://www.youtube.com/watch?v=jjPfLhJbdc0&feature=emb_logo (4.5 minutes).

Explain to students that as sea-level rises, the drains for stormwater might be blocked with rising seas. Ask students to brainstorm who might need to be involved in decision making to ensure stormwater systems can be adapted to sea-level rise.

EXPLORE:

Have students read the “Levels of Government” reading.

With the attention of the whole class, read a series of yes or no questions. Ask the class to answer “Yes” or “No,” alternatively students could each have a set of index cards one with “Yes” and one with “No” that they would vote with. Use each question as an opportunity to quickly discuss and follow up with additional questions about the material.

1. Do state governments have anything in common with the federal government? (Yes — they both have three branches)
2. Do state lawmakers represent citizens from a certain area of the state? (Yes — those areas are called districts)
3. Can a state governor veto bills passed by the state legislature? (Yes)
4. Does each state have its own constitution? (Yes)
5. Is a state’s legislature the only place or way laws can be adopted? (No — in many states, citizens can put laws on the ballot through the initiative process and municipalities can enact their own laws)
6. Can states always afford all the services they need to provide? (No — often they receive money from the federal government)
7. Do local governments provide any services? (Yes — schools, libraries, police, water, and many others)

Students will work on computers to research the type of government in their town or city and complete the questions below. Some of the cities along coastal Mississippi and Alabama are linked below.

Biloxi, Mississippi: <https://www.biloxi.ms.us/pdf/GMAcitycontact.pdf>

Bay Saint Louis, Mississippi: <https://www.baystlouis-ms.gov/>

Foley, Alabama: <https://cityoffoley.org/#>

Mobile, Alabama: <https://www.cityofmobile.org/government/>

Name of Town or City:

Type of local government:

Name of Mayor:

Members of the town/city council:

Time, day, and location of council meetings:

EXPLAIN:

The nation relies heavily on the economy of the Gulf coast.

Ports & Shipping – 2018 (Data from: 2018 National Economic Impact of the U.S. Coastal Port System by Martin Associates)

- \$321.1 billion in federal, state, and local tax revenues
- \$1.4 trillion in wages and local consumption
- 26% of Gross Domestic Product

Fishing – 2016 (Data from: *Fisheries Economics of the United States Volume 11* by NOAA)

- \$212 billion in sales
- 1.7 million jobs
- \$100 billion to the GDP

Culture (Data from: *State of the U.S. Ocean and Coastal Economies* by National Ocean Economics Program). Tourism & recreation accounts for:

- 28% of the coastal GDP
- 72% of coastal employment
- 41% of wages paid

Our coastal communities are valuable, but they are also vulnerable to sea-level rise. Ecosystems, communities, and economies all affect one another. So, we must give attention to all three areas to have safe and robust coastal communities, healthy natural resources, and a balanced system to ensure our communities, economies, and ecosystems can bounce back from current and future stresses. This is known as coastal community resilience.

Healthy Economy

- Working waterfronts
 - Seafood
 - Tourism
 - Ports
- Agriculture
 - Food security
- Small businesses

Healthy Environment

- Habitat protection and restoration
- Water resources
- Living resources
- Coastal planning

Healthy Society

- Education
- Public safety
 - Health
 - Physical
 - Mental
- Infrastructure
- Housing
 - Insurance

The Coastal Resilience Index

(http://masgc.org/assets/uploads/publications/662/coastal_community_resilience_index.pdf) is a questionnaire for communities to assess their level of preparedness for extreme events. This helps communities discuss and discover their coastal hazard-related vulnerabilities. It is a self-assessment tool developed by the Mississippi-Alabama Sea Grant Consortium and NOAA's Coastal

Storms Program. To complete the index, community leaders get together and use the tool to guide discussion about their community's resilience to coastal hazards. The Index provides a simple, inexpensive method for community leaders to perform a self-assessment of their community's resilience to coastal hazards, identifying weaknesses a community may want to address prior to the next hazard event and guiding community discussion. The Index is not intended for comparison between communities.

The Index uses information that is readily available and asks mainly "yes" or "no" questions. It consists of an eight-page guiding document, and includes six sections (critical facilities and infrastructure, transportation issues, community plans and agreements, mitigation measures, business plans, and social systems). The Index can be completed in less than three hours.

At the community level, local governments work with stormwater management, flood insurance, beach closures, storm surge, saltwater intrusion, hypoxic zones, harmful algal blooms, and sea-level rise. The Index is a way to identify issues such as sea-level rise that can exacerbate weaknesses where communities are not as prepared as they might need to be.

ELABORATE:

Local governments are on the frontlines of responding to sea-level rise. A number of tools are available to local governments to reduce the vulnerability of local coastal communities to flooding and sea level rise.

Zoning overlays, development setbacks, and buffer zones can be used to shift development to protect vulnerable coastal areas, accommodate rising sea levels, reduce flood risks, and lower flood insurance rates for residents and local businesses. Enacting building codes, subdivision ordinances, construction standards, and building design standards that consider future flooding frequency, depths, and extents can reduce potential damages during current and future flooding events as sea level rises.

Examples of places approaching the issue of sea-level rise through policy include using strategies of regulatory documents:

- The Comprehensive Plan
- The Code of Ordinances, mostly Building and Land Development Codes
- Stormwater Technical Standards Manual, for Public and Private
- Local Building Code Amendments
- The Transportation Technical Manual
- The Local Mitigation Strategy
- The Post-Disaster Redevelopment Plan

- The Environmental Protection Commission
- Regional Water Management District policies and guidelines

Examples of this in action from locations across the United States:

Commit to planning and permitting toward future sea level and groundwater height scenarios (comprehensive plan)

- Guarantee life-expectancy of projects
- Reduce risk for future taxpayers

Consider secondary impacts of sea-level rise (comprehensive plan)

- Hurricane storm surge and drainage issues are or will be increased
- In addition to the impact to property and structures, there are environmental and social issues to address

Mapping and inventory of susceptible infrastructure (comprehensive plan)

- Publicly owned utilities, infrastructures, and buildings
- Coastal shoreline protection

Develop flexible coastline space (comprehensive plan)

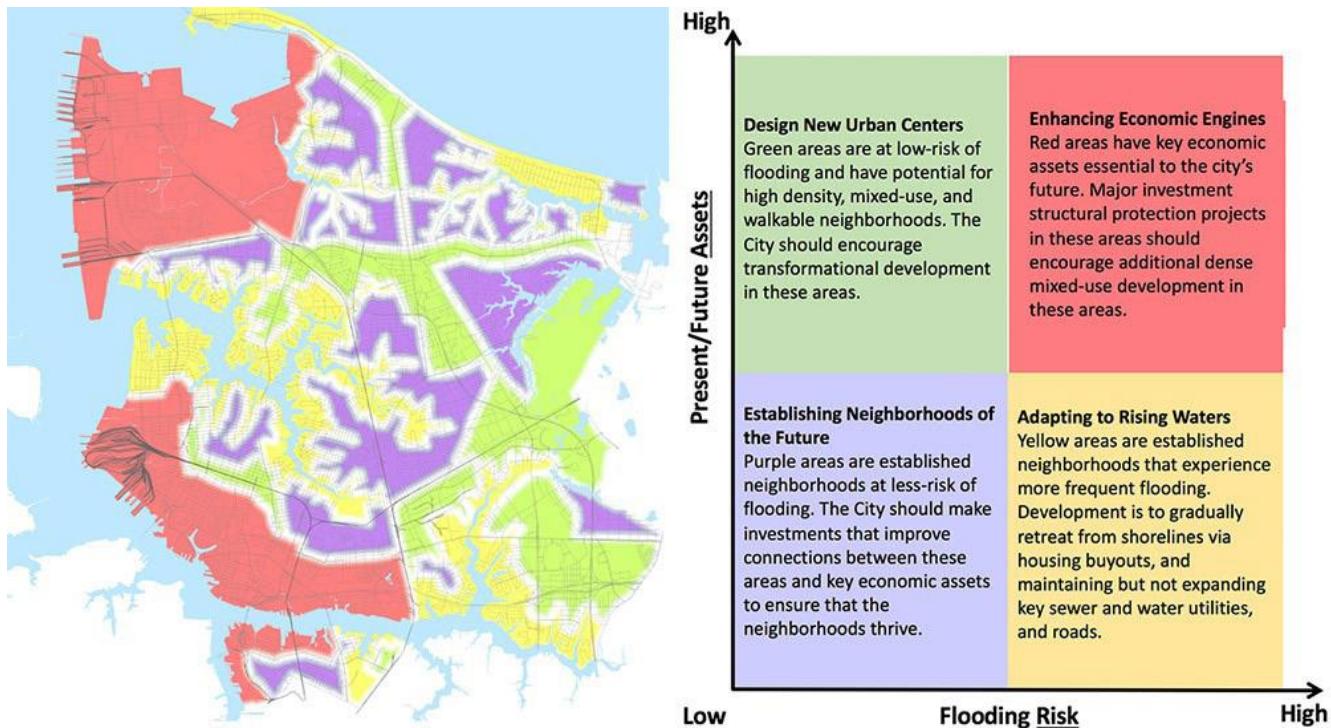
- Allows for habitat migration
- Reduces wave action and erosion
- Allows for adaptation depending on future scenarios
- Equity of coastal access
- Value to adjacent properties

Consider building height (bottom and top) (land development code, building code)

- FEMA Flood Insurance Rate Map and state building codes

Create overlay zones (land development code, comprehensive plan)

- FEMA Flood Insurance Rate Map zones
- Zones V, A, Coastal A (also a velocity zone), X
- A Protection Zone
- An Accommodation Zone
- A Managed Relocation Zone
- Can associate other stipulations, tax incentives, funding sources and disclosure policies with agreed upon planning and land development overlay zone
- Norfolk divided the city into 4 planning zones (corresponding image below)



Establish (erosion based) setbacks (land development code)

- Accommodate for future conditions
- Use historic erosion rates

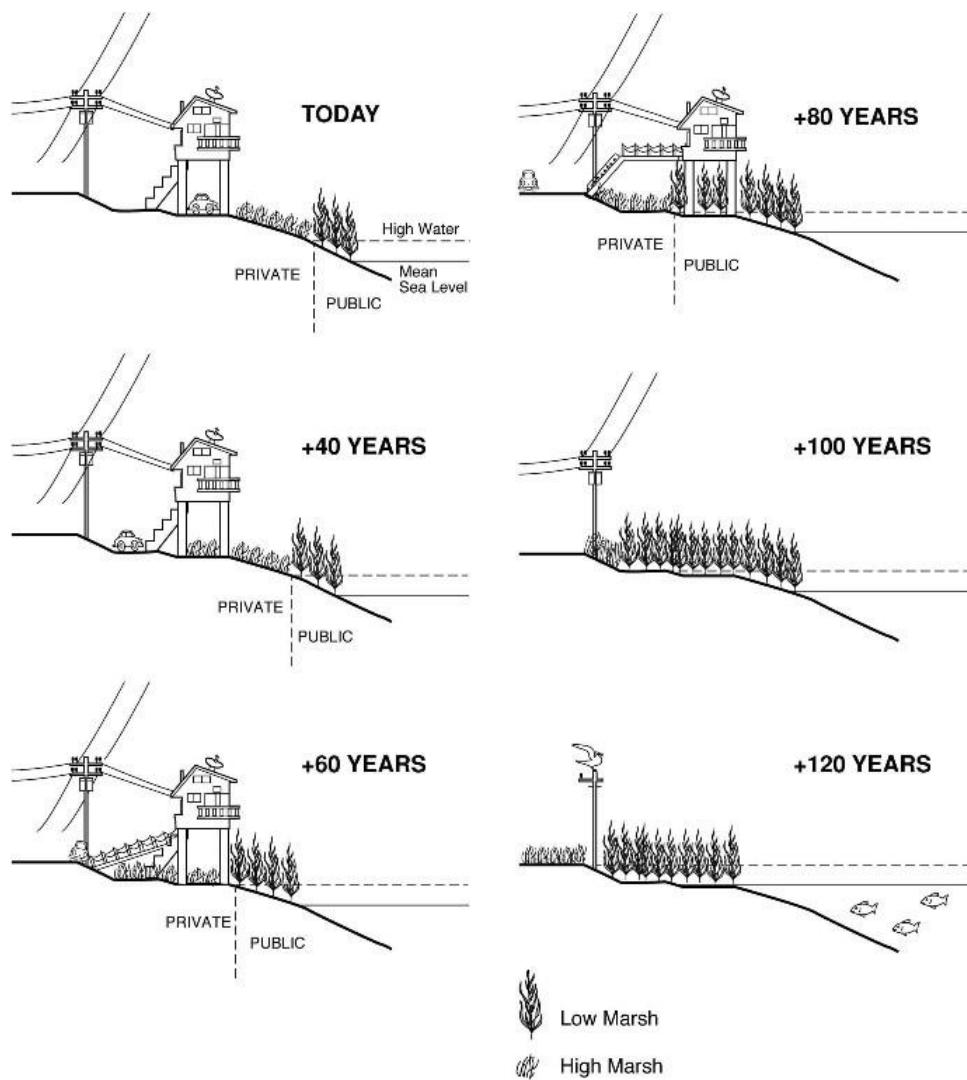
Establish sea wall standards (land development code, building code)

- Create build-to standards
- In Broward County, structures must be at least 5 feet above NAVD88 (local mean sea level). The height applies to all new or substantially repaired or rehabilitated seawalls, banks, and berms
- Sea walls must be in good repair or face fines

- Work towards the removal of sea walls to aid in habitat migration and ecosystem functionality

Options for managed relocation (land development code, comprehensive plan)

- Planning and engagement is important
- Working within property rights
- Incentivize development in non-vulnerable locations
- Rolling easements (corresponding image below)
 - Municipality purchases future land rights
 - Must allow coastline to migrate
 - Preserve for conservation or for future public access



Real estate disclosures (land development code, comprehensive plan)

- For properties that have been impacted by flooding
- If a property falls within an overlay zone, whether from FEMA or otherwise

Broward County, Policy 2.21.7 <https://www.broward.org/climate/pages/usace.aspx>

Owners must include:

"This real estate is located in a tidally influenced area. The owner may be required by county or municipal ordinance to meet minimum tidal flood barrier elevation standards during construction or substantial repair or substantial rehabilitation of seawalls, banks, berms, and similar infrastructure or when required to abate nuisance flooding."

Information adapted from the presentation "Opportunities for Regulatory Response" by Brian Cook, ASLA, PLA. Brian Cook's affiliations and contact information follows: Visiting Assistant Research Professor, Florida Center for Community Design + Research, School of Architecture + Community Design, University of South Florida email: brianraycook@usf.edu, 4202 E. Fowler Ave HMS 301, Tampa, FL 33620-8340

Students will think about the issue of storm water management and **write an initiative** that their local government could adopt to increase sea-level rise resilience.

EVALUATE:

Discuss with the class the difficulty in accessing the information and talk about what they already knew and if anything surprised them during their local government research.

STUDENT PAGE | Whose Law Is It Anyways?

Research your local government to complete the following questions.

Name of Town or City:

Type of local government:

Name of Mayor:

Members of the town/city council:

Time, day, and location of council meetings:

In low-lying localities, rising water tables, increased inundation, and increasingly high-intensity rainfall events are already impacting the function of traditional stormwater management systems and will reduce the effectiveness of some stormwater practices in the future. Many localities have traditional stormwater management systems like culverts, drainpipes, & detention basins that are already generating street flooding due to backflow of tidal waters into low-lying pipes and drainage ditches.

Green infrastructure practices like cisterns, rain gardens, bioswales, permeable pavement, green roofs, and bioswales meet water quality goals and reduce stormwater runoff, flooding, and combined sewer overflows. All system upgrades and retrofits should plan for sea-level rise adaptation by incorporating more storage and infiltration to minimize flooding. Infiltration is the return of surface water to groundwater.

Write an initiative that your local government could adopt to increase sea-level rise resilience through stormwater management.

STUDENT PAGE | Reading - Whose Law Is It Anyways?

Levels of Government

There are three major levels of government that we are going to explore to better understand who is creating the laws, policies, and ordinances that impact sea-level rise adaptation, mitigation, and resilience: local, state, and federal.

State governments work almost like the U.S. federal government. There are three branches of state and federal government: an executive branch, a legislative branch, and a judicial branch. At the state level, the head of the executive branch is called the governor, for the federal government it is the President of the United States. Every state except one also has a bicameral legislature, meaning that the legislature is made up of two chambers. In most states, those chambers are called the Senate and the House of Representatives. A state's judicial branch normally includes a high court, often called the Supreme Court, and a system of lower courts. These lower courts include trial courts and appeals courts. A state's three branches interact just like the three branches at the federal level. The purpose of having three branches is to balance power so that no one branch or person becomes too powerful. The state's legislature passes laws, a state's governor can veto laws that are passed, the executive branch enforces the laws, and a state's high court has the power to decide whether state laws violate the state's constitution and to interpret how those laws should be enforced.

Each state is divided into legislative districts that contain roughly the same number of citizens. Citizens in each district elect representatives to serve in the state legislature. That means the state legislators represent the citizens who live in their district.

The head of a state's executive branch is the state governor. The governor has the power to veto bills passed by the state's legislature. A state's executive branch also includes many departments. States usually have their own departments of education, transportation, health, and other services. These departments carry out the laws passed by the state's legislature.

Just like the U.S. has the Constitution, each state's constitution describes how the state's government must operate. In addition to the state constitution and the state legislative branch, there are usually other ways that state-wide laws can be made in a state. In many states, the initiative process allows citizens to draft laws they would like to see adopted. If citizens collect enough signatures, the law will be placed on the ballot for state citizens to vote on. The referendum process works the same way but is used to let citizens vote on a law already passed by the state legislature. No matter how a state law is adopted, the law only applies inside that state.

State governments provide many services to state citizens. These include things like police, fire safety, roads, schools, and parks. One of the biggest services is maintaining the state's infrastructure—the basic support structures that serve a geographic area, such as transportation,

communication, and power systems. These services cost money and are paid for with taxes collected from citizens. When states cannot afford to provide all the services citizens need, they use federal grants, which are sums of money designated for a certain purpose such as improving an airport or providing health care to low-income households.

Local governments, such as cities and counties, get their power from the state government. The state decides what services cities and counties are responsible for providing and what kinds of laws cities and counties are allowed to make. A municipality is a city, town, or county with a state-granted charter to make decisions. Because local governments are the closest to citizens, often they are the ones that can most easily provide services. Municipal governments provide services such as schools, libraries, police, water, and trash collection, while also regulating zoning and city ordinances. Local governments must follow both state and federal laws when providing these services and not all municipal governments have all of these powers.

Large municipalities generally follow one of three types of government: council-manager, mayor-council, and commission. In council-manager, there is a city council that oversees general administration and policy procedure. The council appoints a professional city manager for daily administrative operations and a mayor is often chosen from the council. In mayor-council the mayor is elected separately from the city council and has significant administrative and budgetary authority. The mayor will have "weak" or "strong" authority depending on the balance of political power between the mayor and the council. In commission governments, voters elect individual commissioners to a governing board where they are responsible for a specific aspect such as public works, police, or health. Though these are the three most common forms of municipal government, government structure is not always distinct with combinations of roles and authority. For example, in coastal Mississippi there are Aldermen, who are elected members of a municipal council.

State and local governments work together on topics like enforcing building codes that specify exactly how buildings must be constructed. However, local governments are often at the forefront of resilience strategies because of their local authority. An ordinance is the term for a law passed by a local government. Ordinances address local issues from sign sizes to sea-level rise resilience. The process for passing an ordinance is determined by each state.

The process for passing an ordinance starts with an idea. This idea may come from the local council, mayor, a local citizen, or be in response to state or federal actions. The idea is then introduced by the city council as a proposed ordinance. The proposed ordinance is discussed by the city council and researched by specialized committees. There is generally at least one public hearing of the proposed ordinance to provide local citizens an opportunity to comment. Once public hearings and final discussions are complete, the city council votes on the proposed ordinance. In forms of local government with a "strong" mayor, the mayor would need to approve the ordinance. The ordinance would then go into effect based on specific locality processes and details of the ordinance.

STUDENT PAGE | Whose Law Is It Anyways?

DO NOW:

What group of people are creating the laws, policies, and ordinances that impact sea-level rise adaptation, mitigation, and resilience?

EXIT TICKET:

How can you be involved in local government?

3.2 Community Assets at Risk

AGE RANGE

9th–12th grade

TIME REQUIRED

60 minutes

ACTIVITY OVERVIEW

Engage: Discussion Question

Explore: SLR 2-Pagers

Explain: Range of SLR Scenarios

Discussion

Elaborate: Community Asset Worksheet

Evaluate: Discussion Questions

MATERIALS

Community Asset Worksheet

SLR 2-Pagers

BASED ON:

Material from the NOAA

Adaptation Planning For Coastal Communities workshop.

LESSON TOPIC: Municipal decision makers

ACTIVITY SUMMARY: Students evaluate community resources and the risks those resources may face.

OBJECTIVES:

Students will be able to:

- Analyze their community assets.
- Make informed decisions for community resilience.

LESSON BACKGROUND: Sea-level rise scenarios show the range of possible outcomes.

There are three major reasons for the scenarios:

- 1) We do not know how much carbon will be in the atmosphere.
 - a. The rate of carbon emissions across the globe changes with policies put in place by different governments. Example: the Paris Agreement.
- 2) There is natural variability.
 - a. Nature is dynamic; for example, each year it is not the same temperature on August 1st. That natural “wiggle” or range must be integrated into the scenarios
- 3) Scientists are still studying the ice sheet melt.
 - a. Models used to measure the volume of ice sheets and their rate of melting is relatively new and constantly getting more accurate.

By understanding the possible outcomes of sea-level rise, communities can prepare for the future. Planning and implementing an adaptation plan is scalable and can start with a smaller project and lead to more. The integration of climate change adaptation planning into related policies and projects brings it into the mainstream.

VOCABULARY:

Assets	People, resources, ecosystems, infrastructure, and the services they provide. Assets are the tangible and intangible things people or communities value.
Built Infrastructure	Human-made buildings and structures such as bridges, roads, stormwater systems, wastewater treatment plants, buildings.
Climate Stressor	A condition, event, or trend related to climate variability and change that can exacerbate hazards or the impact of hazards.
Community Rating System (CRS)	The National Flood Insurance Program's (NFIP) Community Rating System (CRS) is a voluntary incentive program that encourages community floodplain management activities that go above and beyond standards required by the NFIP. In return citizens of that community receive flood insurance discounts.
Critical Facilities and Services	Man-made structures/improvements which, because of their function, size, service area, or uniqueness, are paramount to day-to-day function (e.g., hospitals, power plants, wastewater treatment facilities, emergency response, etc.).
Drinking Water	Water that is safe to drink or to use for food preparation without risk of health problems. Also known as 'potable water'.
Energy Infrastructure	Large-scale facilities allowing for the transport of energy (e.g., electricity, oil, and natural gas) from producer to consumer and for management and direction of energy flow.
Green and Blue Infrastructure	Plant- and water-based natural systems as infrastructure for communities (i.e., protection against flooding or improving soil, air, and water quality) in order to benefit both nature and people.
Managed Retreat	The purposeful, coordinated movement of people and buildings away from risks. At the same time, natural coastal habitat is enhanced seaward of a new line of defense. Also referred to as strategic relocation or managed realignment.

Mitigation	Processes that can reduce the amount and speed of future climate change by reducing emissions of heat-trapping gases or removing them from the atmosphere.
Natural Resources	Materials or substances that occur in nature and can be used for economic gain.
Non-climate Stressor	A change, trend, event, or action unrelated to climate that can exacerbate hazards (e.g., marine debris impacts on coastal habitats).
Probability	The likelihood of something occurring, in this case hazard events. Probabilities have traditionally been determined from the historic frequency of events. With changing climate and the introduction of non-climate stressors, the probability of hazard events also changes.
Projections	Potential future climate conditions calculated by computer-based models of the Earth system. Projections are based on sets of assumptions about the future (scenarios) that may or may not be realized.
Resilience	The capacity of a community, business, or natural environment to prevent, withstand, respond to, and recover from a disruption.
Risk	The potential total cost if something of value is damaged or lost, <u>considered together with</u> the likelihood of that loss occurring. Risk is often evaluated as the probability of a hazard occurring multiplied by the consequence that would result if it did happen.
Transportation	System (e.g., bus, roadways, subways, etc.) for moving passengers or goods from one place to another.
Uncertainty	A state of incomplete knowledge. Uncertainty about future climate arises from the complexity of the climate system and the ability of models to represent it, as well as the challenges with predicting decisions that society will make.
Utilities	Services (e.g., light, power, or water) provided by a public utility.
Vulnerability	The propensity or predisposition of assets to be adversely affected by hazards. Vulnerability encompasses exposure, sensitivity, potential impacts, and adaptive capacity.
Wastewater	Water that is adversely affected in quality by human influence (e.g., agricultural runoff, surface runoff, and most commonly sewage).

ENGAGE:

Open NOAA Sea Level Rise Viewer: <https://coast.noaa.gov/slri/>. Explore, with students, the area along the coast near your school. The slider bar with “MHHW” refers to Mean Higher High Water,

meaning that it is referencing sea-level rise impact on high tide. Some locations have blue map pins with water drops, these open photos and show simulations of sea-level rise.

Ask students who makes the choices for policies and ordinances in their town. Ask students what information would be helpful for these decision makers to have when they make plans for sea-level rise. This should set them up to explore the sea-level rise scenario projections and the days of future flooding and should call back to Module 1. *It is not necessary to have completed Module 1 for this activity.*

EXPLORE:

For this activity students will work in groups using a Sea-Level Rise 2-Pager for a local region of their choice. 2-pagers will be available with curriculum material for our local region. Students will examine their 2-pagers to familiarize themselves with the contents.

Alternative: teachers can prepare additional 2-pagers ahead of time or reference www.localSLR.org for students to view projections of sea-level rise in other locations in the U.S.

EXPLAIN:

With the class lead a discussion about what the scenario graph is showing.

Introduce the global scenario graph with multi-colored lines for future sea-level rise projections.

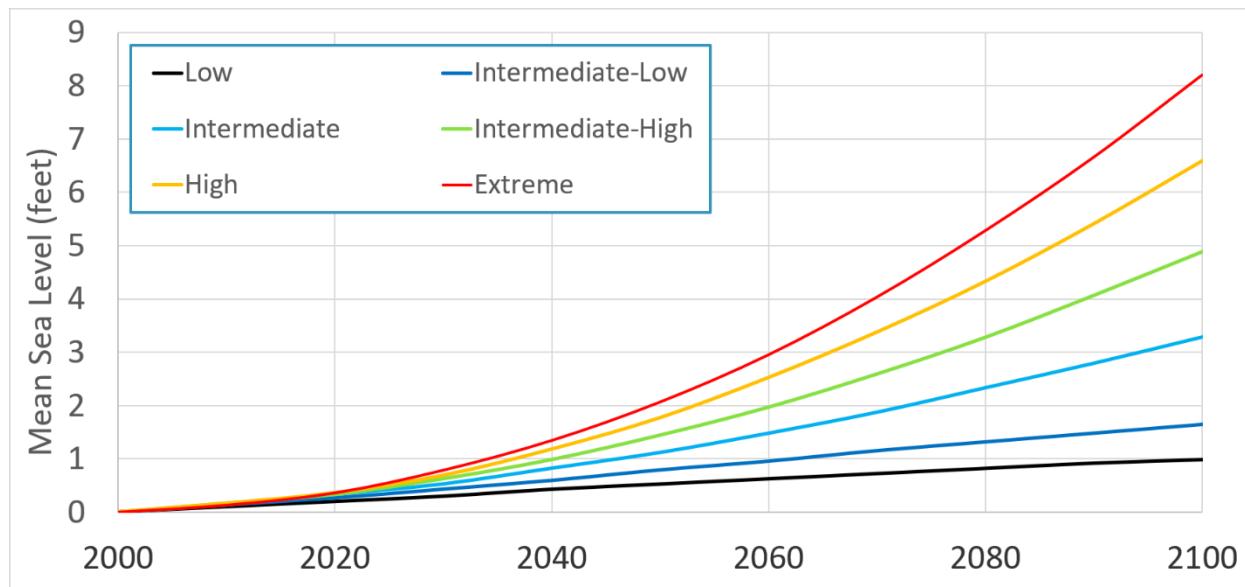


Image: global scenarios for sea-level rise. Source: Collini et al. 2018

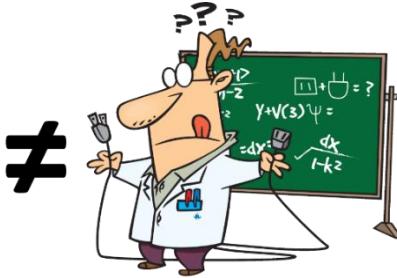
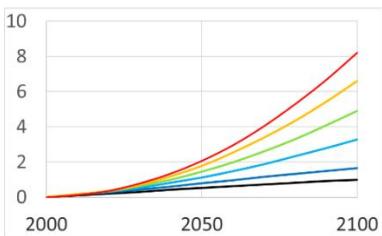


Image: Having a large range of sea-level rise scenarios does not mean that scientists do not know what they are doing. It shows the range of possible outcomes. Source: Northern Gulf of Mexico Sentinel Site Cooperative

There are three major reasons for the scenarios:

- 1) We do not know how much carbon will be in the atmosphere.
 - a. The rate of carbon emissions across the globe changes with policies put in place by different governments. Example: the Paris Agreement.
- 2) There is natural variability.
 - a. Nature is dynamic; for example each year it is not the same temperature on August 1st. That natural “wiggle” or range has to be integrated into the scenarios
- 3) Scientists are still studying the ice sheet melt.
 - a. Models used to measure the volume of ice sheets and their rate of melting is relatively new and getting more accurate constantly.

With those three reasons in mind, the graph shows the range of scientifically possible scenarios for future sea-level rise. Low scenarios follow a low-end range of natural variability and the extreme scenario follows catastrophic ice melt.

To plan for sea-level rise it is helpful to narrow down the scenarios by understanding probabilities. Looking at the scenario likelihood chart, the greater the percentage the more likely that scenario will occur based on change in carbon emissions. As you can see in the chart, the likelihood of an extreme sea-level rise scenario occurring is very low – 0.1%-0.05%.

Global Sea Level Rise Scenario	RCP8.5 no change in carbon emissions
Low	100%
Intermediate-low	96%
Intermediate	17%
Intermediate-high	1.3%
High	0.3%
Extreme	0.1%

Image: likelihood of sea-level rise scenarios. Source: modified from Collini et al, 2018

Once you understand the probability of a scenario occurring you can identify your risk tolerance. Risk tolerance is the degree of uncertainty that you are willing to accept in respect of negative impacts to your community, structures, and people. This level will change based on considerations such as the location, cost or value, function served, adaptability, and length of time.



Image: Flood risk tolerance compared to impact level. Source: Northern Gulf of Mexico Sentinel Site Cooperative

Thinking in terms of building a new structure in your community:

If you are building a new hospital, this will require a large expense, its function is critical for providing care in your community. The hospital cannot be easily moved or adapted once it is built, and you want the hospital to be present for a long time. Building a hospital has a low tolerance for risk, meaning that you have a lot put into the building, do not have the flexibility to let anything negative happen, and cannot easily move it out of harm's way. Because of these considerations, a hospital would have a low tolerance for risk. To minimize the likelihood that your hospital would be impacted by sea-level rise over the course of its life, you would want to plan to the higher sea-level rise scenarios. This does not mean that the hospital will never experience flooding, but greatly reduces the likelihood that it will flood under any of the possible sea-level rise scenarios.

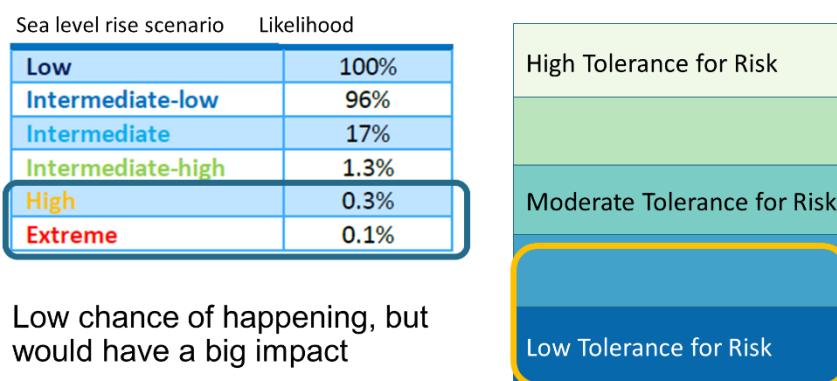


Image: Structures and areas with a low tolerance for risk should plan for high or extreme sea-level rise scenarios. Source: Northern Gulf of Mexico Sentinel Site Cooperative

If you are buying a new home there is a moderate expense required compared to something like a new power plant or hospital, it is critical for one family, other facilities are not dependent on the home, and you would want the home to be present for a mid-term length of time. Buying a home has a moderate tolerance for risk. You would not want a negative impact on the structure, but it does not support a wide community and the cost is not millions of dollars. In this case, this would be considered a moderate tolerance for risk. A person would want to plan for sea-level rise scenarios that are still less likely to occur but would not be as costly to adapt to as the higher sea-level rise scenarios.

Sea level rise scenario	Likelihood
Low	100%
Intermediate-low	96%
Intermediate	17%
Intermediate-high	1.3%
High	0.3%
Extreme	0.1%

Moderate chance of happening,
would have a moderate impact



Image: Structures or areas with a moderate tolerance for risk should plan for the intermediate or intermediate-high sea-level rise scenarios. Source: Northern Gulf of Mexico Sentinel Site Cooperative

If you are building a shed there is a minor expense, the structure does not provide a critical function, it is relatively easy to move, and it is only needed for the short-term. The shed has a high tolerance for risk, meaning that not a lot of functionality or cost would be lost if something negative occurred. In a case like this your risk tolerance is high and you would only want to plan for the amount of sea-level rise that you are certain is going to occur. The low and intermediate-low scenarios are very likely to happen.

Sea level rise scenario	Likelihood
Low	100%
Intermediate-low	96%
Intermediate	17%
Intermediate-high	1.3%
High	0.3%
Extreme	0.1%

High chance of happening,
would have a low impact

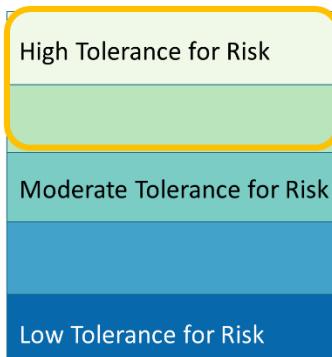


Image: Structures or areas with a high tolerance for risk should plan for the low or intermediate-low sea-level rise scenarios. Source: Northern Gulf of Mexico Sentinel Site Cooperative

The next step to narrowing down sea-level rise scenarios is to link the flood risk tolerance with probabilities.

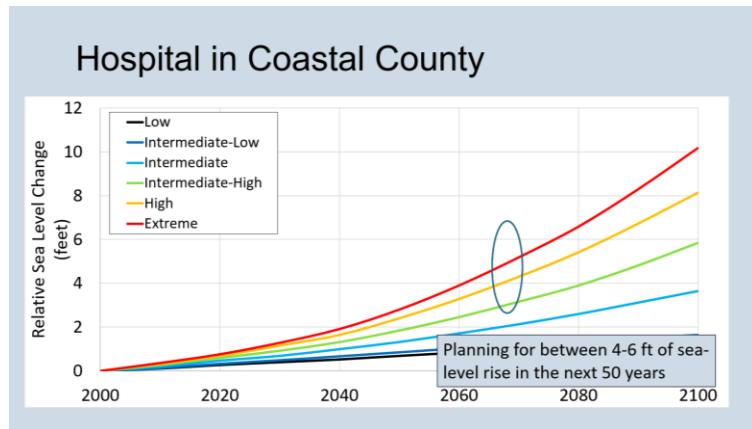


Image: Using the sea-level rise and likelihood scenarios to focus on how much sea-level rise to plan for. In this example a coastal county will build a hospital to last longer than 50 years. This structure has a low tolerance of risk, so they plan for the high or extreme scenarios. Following the x-axis to approximately 2070 (50 years in the future), then looking at the y-axis for feet of sea-level rise change on the high (yellow) and extreme (red) trend lines shows that the hospital should plan for 4-6 feet of sea-level rise. Source: Northern Gulf of Mexico Sentinel Site Cooperative.

ELABORATE:

Students will work in small groups and use the information from the sea-level rise projection graphs to work as community decision makers to plan for sea-level rise resilience. This chart is the same tool that is used by resilience professionals through the Adaptation Planning Framework. Working through this activity, models to students how professionals work through adaptation planning in our communities. In this activity students are thinking of assets as separate components. Eventually the individual assets need to be thought of in a holistic view because they fit together to create a whole community. Set up the "why" of the activity: communities have limited resources, personnel, and funding - unfortunately it is not realistic for communities to immediately upgrade all vulnerabilities. Thinking critically about all the stresses on valuable infrastructure allows resilience professionals to strategically plan the most needed resilience adaptations first.

EXTENSION:

The first chart “**Identifying Community Assets**” can be completed as a class through group discussion. Additionally, the lesson can be extended by having students complete a “Climate Issue Statement” using their responses from their assessment chart.

Climate stressors are conditions or trends that are related to climate variability and can exacerbate hazards.

- Increasing frequency and intensity of drought conditions can be a climate stressor for forests and crops. Rising sea level is another climate stressor.

Non-Climate stressors are changes or trends that are unrelated to climate but that can exacerbate hazards.

- Altering drainage patterns and replacing open land with roads and buildings are non-climate stressors for flooding hazards. Population growth along exposed coasts is another non-climate stressor.

EVALUATE:

Students complete reflection questions about the asset related to the sea-level rise projections from the first part of this activity.

How will future flooding impact your community asset?

How will the sea-level rise projections impact your asset? Is there a difference in impact between low and intermediate projections?

EXTENSION: Students present Climate Issue Statements.

STUDENT PAGE | Assets at Risk

As decision makers it is important to understand the assets that strengthen and support your community. In the following chart **list two assets in each sector and for each category**. Be as specific as possible for your community. Rather than “bridge” use “Pascagoula River High Rise Bridge.” Keep in mind that your assets might fit in more than one category.

Identifying Community Assets		
	High Value	High Consequence if Impacted
Built Infrastructure Bridges, roads, stormwater systems, wastewater treatment plants, buildings, etc. 		
Natural Resources Beaches, rivers, wetlands, parks, etc. 		
People, Commerce, and Culture Citizens, health services, historical landmarks, economy, recreation and tourism, etc. 		

Decision makers need to narrow down their focus. Choose one asset. Use the following chart to describe characteristics of the assets.

Characterizing an Asset		
Asset:		
<i>Circle the sector your selected asset belongs in</i> Built Infrastructure Natural Resources People, Commerce, and Culture   		
<i>Circle the area that best applies to your selected asset</i> Site (small) Region (medium) Extensive (large)		
Characterize Stressors		
Non-climate Stressors	Climate Stressors	Top climate Stressor Trend
<i>List all:</i>	<i>List all:</i> <i>What is the top climate stressor?</i>	<i>Is the top climate stressor already occurring?</i> Yes or No <i>Circle the expected trend of the top climate stressor?</i> Increase Decrease Stay the same

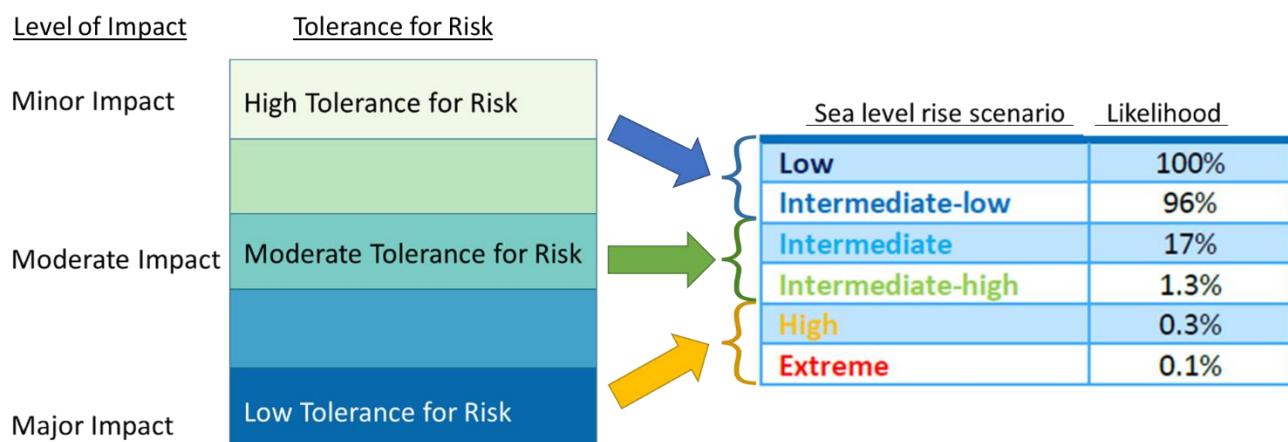
Now that you have the list of stressors to your asset, think about what consequences there may be if your asset was damaged or lost. If you think of consequences not listed write them in under “Other.” **Circle all potential consequences if your community asset is damaged or lost.**

Potential Consequences		
<i>Circle all potential consequences if your community asset is damaged or lost.</i>		
Economic	People & Society	Environmental
Movement of goods impaired	Damage to housing and displacement of people	Biodiversity or species loss
Movement of people impaired	Loss of recreation opportunities	Habitat fragmentation and/or loss
Employment centers disrupted	Residents unable to obtain key services	Loss of flood protection benefits
Disproportionate impacts on certain business sectors	Disproportionate impacts on certain community members	Water quality decline
Lost revenue	Loss of cultural or historical resources	Loss of carbon absorption function.
Increased maintenance or repair costs	Personal injury or loss of life	<i>Other:</i>
<i>Other:</i>	Overall decline in quality of life <i>Other:</i>	

If your asset is damaged the consequences will fall in a range of minor to severe impact. Think about your asset and how much relies on it functioning. **Circle the overall potential level of impact.**

Severity of Consequences	
Using the descriptions below, identify the overall potential level of impact	
Rating	Description
Minor	Financial costs to the community are possible but would be minimal. No expected loss of life, minimal decline in quality of life, and little disruption to livelihoods. Property and ecosystem damage might occur, but could be repaired without substantial cost or time.
Moderate	Some financial costs to the community are possible and would be moderate. No expected loss of life, but there could be a decline in the quality of life and some disruption to livelihoods. Recovery of property and ecosystem damage would take longer and be more costly.
Major	Large financial costs or significant inconveniences would be incurred the community. The possibility of loss of life or livelihood exists. Significant, and potentially permanent, property or ecosystem damage might occur.

Using your selected "Severity of Consequences" circle the level of impact, the tolerance for risk, and the sea-level rise scenario and likelihood you should plan for.



EXTENSION:

As a decision maker at the community level, you need to convince the other members of your community and other leaders why it is important to protect an asset from the climate change risks you have identified. Using the information you collected throughout the lesson, add them into the template below. This will be your Climate Issue Statement.

Climate Issue Statement	
<i>Tell the story of why this is important to address. Use the information from the lesson.</i>	
<i>Insert value statement for asset – why should people care is already experiencing</i>	
Asset and is susceptible to	<i>Non-climate stressor(s)</i> .
Consequences would likely be	<i>Top climate stressor</i> <i>Severity of consequences</i> ,
<i>Economic</i>	<i>people and society</i> . Therefore, we should consider strategies and actions that
<i>environmental</i>	
<i>Summarize risk tolerance approach.</i>	

STUDENT PAGE | Assets at Risk

DO NOW:

How does your local government address sea-level rise and flood resilience?

EXIT TICKET:

What are the three main reasons for sea-level rise scenarios?

3.3 Flooding Pains and Dream House Gains

AGE RANGE

9th—12th grade

TIME REQUIRED

70 minutes

ACTIVITY OVERVIEW

Engage: FEMA Floodplain Map

Explore: GOMSurge.org

Explain: Student Reading

Elaborate: Student Beach House

Evaluate: Beach House Ordinances

MATERIALS

Computers

FEMA Floodplain Map

Student Worksheet

Student Reading

LESSON TOPIC: Floodplains and ordinances

ACTIVITY SUMMARY: Students explore flooding hazards and municipal flood ordinances.

OBJECTIVES:

Students will be able to:

- Explore digital tools for viewing flood and storm surge risk.
- Identify areas along the coast that are vulnerable to sea-level rise and storm surge.
- Identify flood ordinances for buildings.

LESSON BACKGROUND:

The FEMA Flood Map Service Center:

<https://msc.fema.gov/portal/home> is the public source for flood hazard information produced to support the National Flood Insurance Program (NFIP).

FEMA identifies flood hazards on floodplain maps for community members to understand their specific risk. Special Flood Hazard Areas (SFHA) are the areas that have a 1% annual chance of a flood exceeding that depth and extent. SFHA are labeled as: Zone A, Zone AO, Zone AH, Zones A1-A30, Zone AE, Zone A99, Zone AR, Zone AR/AE, Zone AR/AO, Zone AR/A1-A30, Zone AR/A, Zone V, Zone VE, and Zones V1-V30. In the SFHA, a base flood elevation is identified to set standards of recommending building practices. The areas between the 1% annual exceedance probability flood and the 0.2% annual exceedance probability flood are moderate flood hazard areas and labeled as Zone B or Zone X (shaded). The areas outside of the special flood hazard area are at minimal flood risk and are labeled as Zone C or Zone X (unshaded).

Scientists and our governments are able to use the information available to develop models that help us prepare for the impacts of sea-level rise and flooding.

FEMA uses a model called SLOSH which stands for Sea, Lake and Overland Surges from Hurricanes (SLOSH). This model is a computerized numerical model developed by the National

Weather Service (NWS) to estimate storm surge heights resulting from historical, hypothetical, or predicted hurricanes by taking into account the atmospheric pressure, size, forward speed, and track data. These parameters are used to create a model of the wind field that drives the storm surge.

Other researchers use ADCIRC (Advanced Circulation Model) and couple it with SWAN (Simulating WAves Nearshore). ADCIRC simulates circulation and storm surge generation whereas SWAN simulates waves. When these two models are coupled, you are able to capture the complex interactions between waves and currents and the effects of both on storm surge.

SLOSH and ADCIRC+SWAN are two common models used to generate the 1% annual chance exceedance probability, sometimes known as the 100-year floodplain or the SFHA.

To make projections of sea-level rise impacts on our coastal communities, scientists use models to add in the interactions of different processes. For example, understanding how wind and waves erode sand from a coastline and change the shape allows the projection of how sea-level rise impacts might be altered with a different coastline shape. A model commonly used for this is XBeach, which simulates morphological change, including erosion and deposition, and has its own circulation and wave module. This is one of the most advanced models in terms of simulating storm impacts, and it is a high-resolution model. It can resolve processes on very small scales and it can simulate flow and sediment transport around infrastructure.

VOCABULARY:

Buildings and Structures	Structures built for permanent use (e.g., a dwelling) or that is built by putting parts together and that usually stands on its own (e.g., a house, tower, bridge, etc.).
Built Environment	Basic structures and facilities (e.g., buildings, roads, and power supplies) needed for a community.
Ordinances/Codes	Laws and regulations passed and enforced by a municipality in order to maintain safety and preserve community standards.
Planning and Land Use	Process of designing potential futures for a community, city, etc. Land use is a type of planning that is implemented through zoning, which can change management of land and lead to impactful changes.

ENGAGE:

Show students the two images of the same location on Dauphin Island, Alabama fifteen years apart. **Ask** students what might be impacting the changing shoreline. **Ask** students if they think there are any guidelines for people building their homes. What might those guidelines be? **Ask** students at which point do communities need to discuss if there is no more land for their homes. This can start a discussion about the need for managed retreat in some areas.



Image: West end of Dauphin Island, Alabama, in 2000. Yellow outline is the outline of the main land mass in 2000. The yellow arrows are pointing to houses that can be used as benchmarks for the next figure. Imagery from Google Earth. Source: Embracing the dynamics of shorelines. Eric Sparks. Mississippi-Alabama Sea Grant Consortium. Apr 04, 2018.



Image: West end of Dauphin Island, Alabama, in 2015. Yellow outline is the outline of the main land mass in 2000. The yellow arrows are pointing to houses that can be used as benchmarks

from the previous figure. Imagery from Google Earth. Source: Embracing the dynamics of shorelines. Eric Sparks. Mississippi-Alabama Sea Grant Consortium. Apr 04, 2018.

Show the video Amplified Storm Surge: Northern Gulf Sea-Level Rise (4.5 minutes): <https://vimeo.com/323815181>. This video introduces storm surge in the Northern Gulf of Mexico and introduces the tool GOMsurge.org that will be used later in the lesson.

Display the FEMA floodplain (<https://msc.fema.gov/portal/home>) map that includes the school location. Identify the zone in which the school is located.

Ask the students why is it important to understand floodplains? How could you use this map to make decisions?

EXPLORE:

Floodplain management works to mitigate coastal hazards and respond to disasters. Students will explore the features on the www.gomsurge.org website, and work through problem sets for potential future scenarios.

Students answer questions using Claim-Evidence-Reasoning. The claim is the statement that answers the question. The evidence is the data used to support the claim. The reasoning is the explanation of "why" and "how" the evidence supports the claim.

Procedure:

- 1) Students go to www.gomsurge.org and scroll down to the "Stillwater Storm Surge" section.
 - a. These images indicate 1% annual chance probability of storm surge inundation, showing the area where water pushed in by a hurricane will go. The data was developed by examining models of astronomic tide, wind and wave, and hurricane storm surge. These 1% annual chance data (commonly referred to as 100-year floodplains) were developed to assess the effects of future coastal change on storm surge under different sea-level rise scenarios.
- 2) The slider bar in the middle of the page can be moved to display two different sea-level rise projections, the Low and the Intermediate-High projections, for 1% annual chance probability of storm surge inundation in 2100. The right side of the screen displays the Intermediate-High projection of 1.2 meters, or 3.9 feet, increase of sea-level rise from 2000. The left side of the screen displays the Low projection of 0.2 meters, or 0.7 feet. Deeper water is indicated by brighter purple color.

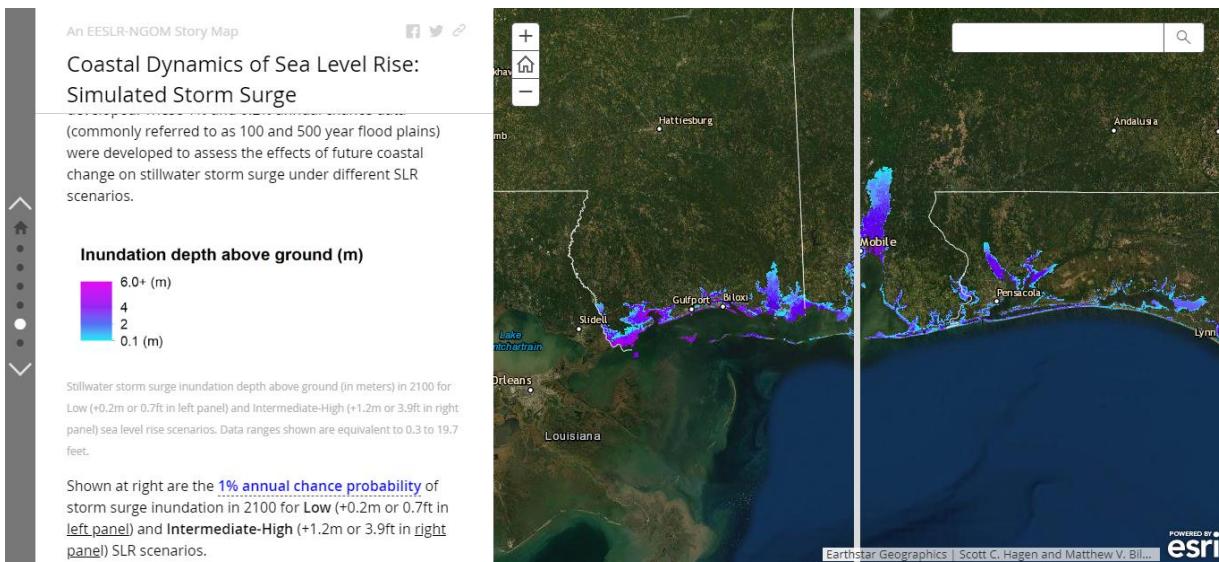


Image: a screen capture of the Stillwater Storm Surge section of gomsurge.org with the inundation depth color gradient visible. The color range is indicative of water depth in meter, lighter blue at the low end of 0.1m and brighter purple indicating water 6m and deeper. Source: www.gomsurge.org

- 3) Enter the following location into the search bar: 1815 Popps Ferry Road, Biloxi, MS. Zoom out until the colored inundation is visible. Answer the following questions about the area:
 - a. Does water reach the specific building? (marked by a blue square on the left panel).
 - b. What changes in water do you observe in the area? Does the water reach new areas? Do existing areas have deeper water?
- 4) Searching on the map find a location with a river leading to the Gulf of Mexico. Answer the following questions:
 - a. What changes in water do you observe in the river inland and the river where it meets the Gulf of Mexico?
- 5) Search the map for a location with a large city close to the coast. Answer the following questions:
 - a. What changes in water do you observe in the city compared to areas outside of the city?
- 6) Compare the differences in water inundation area and depth change from the river location to the city location. Why might you observe these differences?

EXPLAIN:

Marshes and bayous with plants are able to absorb more water than concrete. Explain that rivers can carry storm surge water farther inland, but that natural marsh and plant shorelines can help protect homes. Additionally, discuss how the floodplain is becoming larger as sea-level rises, putting more homes, businesses, and infrastructure at risk. *Connect back to Module 2 Lesson 1 about marshes if it was covered.*

Students read “100-Year Flood” reading.

ELABORATE:

Provide students with this prompt and building choices on the student worksheet.

Build your (dream) home! You are now the proud owner of property along the Gulf coast and now you get to design the home you hope to live in for many years. Your home is in the perfect location for outdoor recreation, and being close to the beach and bayous. Make a choice between the options given for each step. Once you have selected all the option make a sketch of your home.

EXTENSION: Students explore houses with different structures before taking the house quiz. Using foam board, or another water-resistant material, students cut out general models of houses: a non-elevated house, a house on stilts, an elevated house with 2 solid walls, an elevated house with 2 lattice walls, an elevated house with 4 solid walls. Recreating an activity from Module 2 Lesson 2 with the water pans, students create a shoreline with clay on one side of a plastic container and place their home one top. They then create waves in the container and compare how each house is impacted.

EVALUATE:

Communities share information with residents about how to prepare for and protect their buildings from floods. The “Flood Damage Prevention Ordinance” for Coastal Communities is an ordinance that promotes public health, safety, and general welfare to minimize losses due to floods. The provisions designated to protect public and private buildings from flood conditions are:

- (1) anything vulnerable to flooding needs be protected against flood damage at the start of construction;
- (2) uses that are dangerous to health, safety, and property, or uses that lead to increased flood height, water velocity, or erosion will be restricted or prohibited;

- (3) any filling, grading, dredging and other development which may increase flood damage or erosion are controlled;
- (4) flood barriers that are constructed and unnaturally divert flood water or increase flood hazards in other areas are prevented or regulated;
- (5) control the alteration of natural floodplains, stream channels, and natural protective barriers which are involved in the accommodation of flood waters.

Using the "Flood Damage Prevention Ordinance" for Coastal Communities the class will score their homes to how well they aligned with ordinances in place to protect against flooding damages.

Question 1 – How to elevate

Article 4 Provisions for Flood Hazard Reduction, Section A General Standards

(4) Elevated Buildings - All New construction or substantial improvements of existing structures that include ANY fully enclosed area located below the lowest floor formed by foundation and other exterior walls shall be designed so as to be an unfinished or flood resistant enclosure. The enclosure shall be designed to equalize hydrostatic flood forces on exterior walls by allowing for the automatic entry and exit of flood waters.

- (a) Designs for complying with this requirement must either be certified by a professional engineer or architect or meet the following minimum criteria:*
 - (i) Provide a minimum of two openings having a total net area of not less than one square inch for every square foot of enclosed area subject to flooding;*

What this means: All structures below base flood elevation must have at least two openings near the ground to allow water to flow through and relieve pressure from floodwater on the walls of the structure. This not only helps protect the building from being damaged but allows floodwaters to drain more quickly. It also means that structures at this level are expected to flood regularly and it should not be used as a living area or furnished as such.

Article 4 Provisions for Flood Hazard Reduction, Section F Coastal High Hazard Areas (V-Zones).

(2) All new construction and substantial improvements of existing structures shall be elevated on piles, columns, or shear walls parallel to the flow of water so that the bottom of the lowest supporting horizontal structural member (excluding pilings or columns) is located no lower than one foot above the base flood elevation level.

What this means: Walls and supports of structures must be built parallel to the flow of floodwaters so water can pass by and through them with ease. It also means that the structures must be built at least one foot above base flood elevation.

Score your home for Question 1: 2 points for raised on piles/stilts, 2 points for raised with 2 solid walls allowing ocean breeze underneath, 1 point for raised with 2 solid walls blocking ocean wind from question 1. No points for other options.

Question 2

Article 4 Provisions for Flood Hazard Reduction, Section B Specific Standards. In ALL Areas of Special Flood Hazard designated as A1-30, AE, AH, A (with estimated BFE), the following provisions are required:

(1) New construction and substantial improvements - Where base flood elevation data are available, new construction or substantial improvement of any structure or manufactured home shall have the lowest floor, including basement, elevated no lower than one foot above the base flood elevation. Should solid foundation perimeter walls be used to elevate a structure, openings sufficient to facilitate the unimpeded movements of flood waters shall be provided in accordance with standards of Article 4, Section A(4), "Elevated Buildings."

What this means: The lowest floor of any structure must be one foot above the projected height of base flood evaluation, generally the 1% annual exceedance probability. This lowers the likelihood that damage or injury will occur in the event of a flood.

Score your home for Question 2: 1 point for raised to a foot higher than the 1% annual exceedance probability from question 2. No points for other options.

Question 3

Article 4 Provisions for Flood Hazard Reduction, Section C Floodways.

(1) Floodway: Located within Areas of Special Flood Hazard established in Article 2, Section B, are areas designated as floodway. A floodway may be an extremely hazardous area due to velocity floodwaters, debris or erosion potential. In addition, the area must remain free of encroachment in order to allow for the discharge of the base flood without increased flood heights. Therefore, the following provisions shall apply:

(a) The community shall select and adopt a regulatory floodway based on the principle that the area chosen for the regulatory floodway must be designed to carry the waters of the base flood, without increasing the water surface elevation of that flood more than one foot at any point;

What this means: In communities of high risk of flood, a floodway must be designed in the area to allow floodwater to flow through and exit the community. This will reduce flooding in homes and allow water to drain from the neighborhood more efficiently.

Score your home for Question 3: 1 point for leaving the drainage ditches from question 3. No points for other options.

Question 4

Article 4 Provisions for Flood Hazard Reduction, Section D Building Standards for Streams Without Established Base Flood Elevations (Approximate A-Zones). Located within the Areas of Special Flood Hazard established in Article 2, Section B, where streams exist but no base flood data have been provided (Approximate A-Zones), the following provisions apply:

(2) No encroachments, including structures or fill material, shall be located within an area equal to the width of the stream or twenty-five feet, whichever is greater, measured from the top of the stream bank, unless certification by a registered professional engineer is provided demonstrating that such encroachment shall not result in any increase in flood levels during the occurrence of the base flood discharge.

What this means: Structures must not be built too close to streams because if the water level in the stream were to rise up to the structure, the building could block some of the water flowing down the stream. Additionally, damage to the structure could occur.

Score your home for Question 4: 1 point if you built 25 feet away from the stream in question 4. No points for other options.

Question 5

Article 4 Provisions for Flood Hazard Reduction, Section F Coastal High Hazard Areas (V-Zones). Located within the areas of special flood hazard established in Article 2, Section B, are areas designated as Coastal High Hazard areas (V-Zones). These areas have special flood hazards associated with wave action and storm surge; therefore, the following provisions shall apply:

(1) All new construction and substantial improvements of existing structures shall be located landward of the reach of the mean high tide.

What this means: No structures can be built within the area that is covered by the average high tide. They must be further inland. During storm surge, water levels can rise even higher than high tide, so this keeps buildings at a safer distance and height from storm surge.

Score your home for Question 5: 1 point if you built inland from the highest water level, and 2 points if you built behind the dunes in question 5. No points for option a.

Question 6

Article 4 Provisions for Flood Hazard Reduction, Section F Coastal High Hazard Areas (V-Zones).

(4) All pile and column foundations and the structures attached thereto shall be anchored to resist flotation, collapse, and lateral movement due to the combined effects of wind and water loads acting simultaneously on ALL building components, both (non-structural and structural). Water loading values shall equal or exceed those of the base flood. Wind loading values shall be in accordance with the most current edition of the Standard Building Code

What this means: Structures must be anchored so they do not float away or blow away during times of flood or high winds. This helps prevent people from completely losing their home.

Score your home for Question 6: 1 point if you built a house with strong foundation to resist flooding from question 6. No points for other options.

Question 7

Article 4 Provisions for Flood Hazard Reduction, Section F Coastal High Hazard Areas (V-Zones).

(6) All space below the lowest horizontal-supporting member must remain free of obstruction. Open lattice work or decorative screening may be permitted for aesthetic purposes only and must be designed to wash away in the event of abnormal wave action without causing structural damage to the supporting foundation or elevated portion of the structure. The following design specifications are allowed:

(a) No solid walls shall be allowed, and;

(b) Material shall consist of lattice or mesh screening only.

(c) If aesthetic lattice work or screening is utilized, any enclosed space shall not be used for human habitation, but shall be designed to be used only for parking of vehicles, building access, or limited storage of maintenance equipment used in connection with the premises.

What this means: The open space below an elevated building can be used for parking or storage but not for living space. Any decorative screening needs to wash away in flood water to prevent damage to the building.

Score your home for Question 7: 2 points if you elevate and use it for parking, 2 points if you decorated the piles with latticework from in question 7. No points for other options.

Question 8

Article 4 Provisions for Flood Hazard Reduction, Section F Coastal High Hazard Areas (V-Zones).

(10) There shall be no alteration of sand dunes or mangrove stands which would increase potential flood damage

What this means: Natural barriers to floodwater such as sand dunes or mangroves shall not be removed in order to build a structure if it would risk increasing damage caused by flooding. These natural structures provide a buffer for communities, protecting them from water and wind.

Score your home for Question 8: 1 point if left the dunes as they were in question 8. No points for other options.

Total your score:

If your score was between 0-3. You are a student of community ordinances.

If your score was between 4-7. Not bad – you are a potential municipal government official.

If your score was between 8-10. Excellent – you are an expert floodplain manager.

Discuss with the students what their ranking was on their dream house. Ask how might they have made changes if they knew the ordinances from the beginning?

STUDENT PAGE | Flooding Pains and Dream House Gains

Floodplain management works to mitigate coastal hazards and respond to disasters. Students will explore the features on the www.gomsurge.org website, and work through problem sets for potential future scenarios.

Procedure:

- 1) Go to www.gomsurge.org and scroll down to the "Stillwater Storm Surge" section.
 - a. These images indicate 1% annual chance probability of storm surge inundation, showing the area where water pushed in by a hurricane will go.
- 2) The slider bar in the middle of the page can be moved to display two different sea-level rise projections, the Low and the Intermediate-High projections, for 1% annual chance probability of storm surge inundation in 2100. The right side of the screen displays the Intermediate-High projection of 1.2 meters, or 3.9 feet, increase of sea-level rise from 2000. The left side of the screen displays the Low projection of 0.2 meters, or 0.7 feet. Deeper water is indicated by brighter purple color.
- 3) Enter the following location into the search bar: 1815 Popps Ferry Road, Biloxi, MS. Zoom out until the colored inundation is visible. Answer the following questions about the area:
 - a. **Does water reach the specific building?** (marked by a blue square on the left panel).
 - b. **What changes in water do you observe in the area? Does the water reach new areas? Do existing areas have deeper water?**
- 4) Searching on the map find a location with a river leading to the Gulf of Mexico. Answer the following questions:
 - a. **What changes in water do you observe in the river inland and the river where it meets the Gulf of Mexico?**
Claim (write a sentence that states what happens along the river)

Evidence (provide data that supports your claim about what happens along the river)

Reasoning (write a statement that connects your evidence to your claim about what happens along the river)

- 5) Search the map for a location with a large city close to the coast. Answer the following questions:
- a. **What changes in water do you observe in the city compare to areas outside of the city?**
Claim (write a sentence that states what happens to water in the city)

Evidence (provide data that supports your claim about what happens to water in the city)
 - Reasoning** (write a statement that connects your evidence to your claim about what happens to water in the city)
- 6) Compare the differences in water inundation area and depth change from the river location to the city location. **Why might you observe these differences?**
Claim (write a sentence that states what happens to water inundation area and depth in the city compared to the river)

Evidence (provide data that supports your claim about what happens to water inundation area and depth in the city compared to the river)

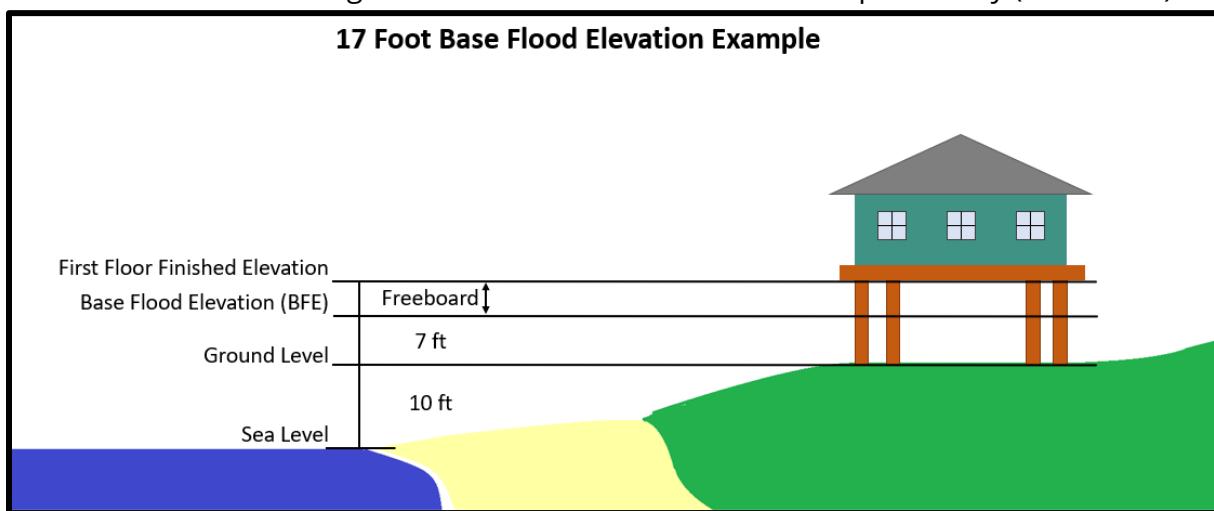
Reasoning (write a statement that connects your evidence to your claim about what happens to water inundation area and depths in the city compared to the river)

Build your (dream) home! You are now the proud owner of property along the Gulf coast and now you get to design the home you hope to live in for many years. Your home is in the perfect location for outdoor recreation, being close to the beach and bayous. Make a choice between the options given for each step. Once you have selected all the option make a sketch of your home.

1. How do you want to elevate your home, if at all?
 - a. No elevation
 - b. Raised on piles/stilts
 - c. Raised with 2 solid walls allowing ocean breeze underneath
 - d. Raised with 2 solid walls blocking ocean wind
 - e. Raised with 4 solid walls



2. How high do you want to elevate your home?
 - a. No elevation
 - b. Raised to the level of the 1% annual exceedance probability
 - c. Raised to a foot higher than the 1% annual exceedance probability (Freeboard)



3. There are drainage ditches on the road leading to your home.
 - a. You fill these in
 - b. You leave them



4. How close do you build your home to your small backyard stream?
 - a. Right next to it so you can easily access it for fishing, boating, or swimming
 - b. You want a little space, so you build 25 feet away
5. How close to the beach do you build your home?
 - a. Right at the lowest water level
 - b. Inland from the highest water level
 - c. Behind the dunes



6. You want to protect your home and belongings from floods. So you:
 - a. Build a floating house, when water level rises your house floats up and away.
 - b. Build a house with strong foundation to resist flooding impacts.
7. What do you use the underneath of your house for?
 - a. You didn't elevate so there is no underneath
 - b. You elevated and use it for parking
 - c. You elevated and set up the space as a spare bedroom
 - d. You decorated the pilings with latticework
 - e. You decorated the pilings with rustic wooden beams that also help support the overall structure



8. You can almost see the beach from your house, but there are sand dunes with beach grass in the way.
 - a. You cut an access path and build a boardwalk from your house to the beach through the dunes
 - b. You leave the dunes as they are and map out the quickest road to access the beach

Using the “Flood Damage Prevention Ordinance” for Coastal Communities your teacher will share the ordinances in place to protect against flooding damages.

Score your home for Question 1:

- 2 points for raised on piles/stilts, 2 points for raised with 2 solid walls allowing ocean breeze underneath, 1 point for raised with 2 solid walls blocking ocean wind from question 1. No points for other options.

Score your home for Question 2:

- 1 point for raised to a foot higher than the 1% annual exceedance probability from question 2. No points for other options.

Score your home for Question 3:

- 1 point for leaving the drainage ditches from question 3. No points for other options.

Score your home for Question 4:

- 1 point if you built 25 feet away from the stream in question 4. No points for other options.

Score your home for Question 5:

- 1 point if you built inland from the highest water level, and 2 points if you built behind the dunes in question 5. No points for option a.

Score your home for Question 6:

- 1 point if you built a house with strong foundation to resist flooding from question 6. No points for other options.

Score your home for Question 7:

- 2 points if you elevate and use it for parking, 2 points if you decorated the piles with latticework from in question 7. No points for other options.

Score your home for Question 8:

- 1 point if left the dunes as they were in question 8. No points for other options.

Total your score:

If your score was between 0-3: You are a student of community ordinances.

If your score was between 4-7: Not bad – you are a potential municipal government official.

If your score was between 8-10: Excellent – you are an expert floodplain manager.

STUDENT PAGE | Reading - Flooding Pains and Dream House Gains

100-Year Flood

Sea-level rise impacts ways in which water interacts with our coastal communities. With increased sea-level rise, the number of days we experience nuisance flooding increases and storm surge can travel farther inland and flood areas with deeper water. One term used to describe large flood events is the 100-year flood. Many federal, state, and local laws and ordinances are designed around the 100-year flood. To better understand this term, it is helpful to understand the history of the National Flood Insurance Program.

The National Flood Insurance Program provides flood insurance to homeowners, renters, and businesses, works at the community level to improve floodplain management regulations, and develops maps of flood hazard zones. A floodplain is a nearly flat area of land that is naturally subject to flooding. Communities use floodplain management to reduce the risk of current and future flooding by taking corrective and preventative measures to increase their resilience. In the 1960's there was widespread flooding along the Mississippi River but there was a lack of private flood insurance and the standard homeowner insurance policy does not cover flood damage. This led to large amounts of flood losses to communities and increases in federal disaster assistance needed. In response to this the United States government added the National Flood Insurance Program to be managed by the Federal Emergency Management Administration (FEMA). To designate the areas at high-risk for flooding and therefore most in need of flood insurance, the National Flood Insurance Program used the 1% annual exceedance probability (AEP) floodplain. The annual exceedance probability floodplain is a measure of chance that flooding will be at least that high/far each year. The 1% annual exceedance probability floodplain describes the areas that have a 1 in 100 chance, or 1% probability, of being flooded each year. The phrase 1-percent annual exceedance probability leads to the term 100-year flood.

The 100-year floodplain has a 1% chance of flooding every year but, like flipping a coin, you could get heads three times in a row. When you look at the risk of something in the 1% annual exceedance probability floodplain over multiple years, the risk increases. For example, there is a 26% chance a house will flood over the course of a typical 30-year mortgage. If a high school senior has lived in the same house in the 100-year floodplain for their entire life, there is a 16% chance that they would experience flooding at least once. These values (26% and 16%) are based on the probability theory that accounts for each of the mentioned years having a 1% chance of flooding. The estimates for the 1% AEP floodplain come from measurements by scientists and engineers measuring the height and flow of water. However, the accuracy of 1-percent annual exceedance probability depends on the data available, any changes in land use, river drainage, or climate change.

As our communities talk more about larger floods and increasing their protection from flooding, they may use the term 500-year flood. This corresponds to an annual exceedance probability of 0.2% or 1 in 500 chance of a flood happening each year.

With the growing need to prepare for flooding there is also the need for clear communication regarding risk. Hydrologists (the scientists that study distribution, circulation, and physical properties of water, at the United States Geological Survey) are transitioning away from the terms 100-year and 500-year flood to define floods in terms of the annual exceedance probability, such as the 1% annual exceedance probability. This helps communicate that the occurrence of a large flood does not mean that you are flood-free for the next 99 years.

FEMA identifies flood hazards on floodplain maps for community members to understand their specific risk. Special Flood Hazard Area (SFHA) is the area that will be inundated by the 1% annual exceedance probability flood. Special Flood Hazard Areas are labeled as: Zone A, Zone AO, Zone AH, Zones A1-A30, Zone AE, Zone A99, Zone AR, Zone AR/AE, Zone AR/AO, Zone AR/A1-A30, Zone AR/A, Zone V, Zone VE, and Zones V1-V30. The areas between the 1% annual exceedance probability flood and the 0.2% annual exceedance probability flood are moderate flood hazard areas and labeled as Zone B or Zone X (shaded). The areas outside of the special flood hazard area are at minimal flood risk and are labeled as Zone C or Zone X (unshaded).

Base Flood Elevations (BFEs) are the elevation to which floodwater is anticipated to rise during the 1% AEP flood for your location. The Base Flood Elevation is a regulatory requirement for the elevation and floodproofing of structures. Some states require building to at least Base Flood Elevation as defined by FEMA, but some municipalities go above and beyond and require building higher than Base Flood Elevation, known as freeboard. Federal, state, and local governments use the 1% AEP floodplain as the regulating standard for flood insurance and building codes. It can also be considered in zoning, and other policies and practices.

With our changing climate and sea-level rise coupled with changes in land use and impervious surfaces, our historic flood patterns are changing. The 1% annual exceedance probability is including a larger area and deeper water as sea levels rise. By understanding our risk, we are able to prepare our communities, homes, and businesses for current and future flooding.

Source: Robert R. Holmes, Jr. and Karen Dinicola, US Geological Survey, 100-Year Flood – It's All About Chance. April 2010. General Information Product 106

STUDENT PAGE | Flooding Pains and Dream House Gains

DO NOW:

How can you narrow down sea-level rise scenarios to focus on when starting a construction project?

EXIT TICKET:

What is a 100-year flood?