



HOW CAN COMMUNITIES BE ENGAGED IN CLIMATE CHANGE?

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Grade Level
Advanced High School / AP / IB

Subject Area
Environmental Science,
Earth Science, Oceanography

VA SEA is a collaborative project between the Chesapeake Bay National Estuarine Research Reserve, the Virginia Institute of Marine Science's Marine Advisory Program, and Virginia Sea Grant. The VA SEA project is made possible through funding from the National Estuarine Research Reserve System Science Collaborative, which supports collaborative research that addresses coastal management problems important to the reserves. The Science Collaborative is funded by the National Oceanic and Atmospheric Administration and managed by the University of Michigan Water Center.



Appendix A

Date: _____

Member names: _____

Group A Lynnhaven Adaptation Strategy Project

Objectives

- You and your team will use the materials provided to practice how stakeholders engage in climate change adaptation planning to make decisions for Lynnhaven (the second largest watershed) in the City of Virginia Beach.
- Your Lynnhaven adaptation strategy project will demonstrate that you understand what community engagement for climate change adaptation planning is and how to conduct five phases of community engagement

General Instructions

- The inform-phase will take 10 minutes
 - Each student selects a character card at random.
 - Review the flood risks and impacts material and maps on the table.
 - Think about what flood risks and impacts your "group" character would like to address in the next 50 years and why.
 - Start with the "local resident" player and work your way clockwise. The "local resident" shares to the group the flood risks and impacts that they believe exist.
- The consult & involve & collaborate-phase will take 15 minutes.
 - Teacher gives each group a set of adaptation strategies cards.
 - The "local resident" explains their chosen strategy card or set of strategies cards to the group and highlights the benefits that the strategy brings.
 - Going clockwise, each player selects and shares for a strategy card or group of strategies cards.
 - There are four categories of adaptation strategies, including natural strategies, engineered defenses, adapted structures, and prepared communities.
 - Please select no more than 2 strategies per category.
 - Keeping in mind that the total budget is \$1,000 million.
- The empower-phase will take 15 minutes.
 - When teacher says that there are 15 minutes left, the rounds of arguing for various strategies come to an end.
 - Groups must begin to make clear decisions about a set of strategies they want to implement for their areas.
 - Place the strategy cards in the order of your preference on the board.

Your Actions

- Each student should select a character card at random.
 - Note: your group should choose "Local Resident (Coastal)" card(s).
 - If there are over four people in a group, more than one person can play local resident.
- Your team should select strategy cards.
- Your team should sort strategy cards in the desired order and glue the cards to the board.



Background

The Lynnhaven Watershed is Virginia Beach's second biggest, covering roughly 81 square miles in northern Virginia Beach. This watershed is home to a quarter of the city's citizens, a significant number of the city's businesses, and five of the city's SGAs. This essential location connects the city to the Chesapeake Bay, comprises critical municipal infrastructure and transit connections, and is home to significant military sites such as Joint Expeditionary Base Little Creek- Fort Story and Naval Air Station Oceana. Flooding in the Lynnhaven Watershed comes from either the Chesapeake Bay through Lynnhaven Inlet or Little Creek Inlet, or internally from the numerous surrounding bays and rivers.

Flood Risk Table (Adapt from Virginia Beach, 2020)

Tidal Flooding	<ul style="list-style-type: none"> High tide flooding only impacts a small amount of land today. However, residents in the Lynnhaven Watershed are familiar with tidal flooding that occurs several times a year during extreme high tides, such as during King Tides.
	<ul style="list-style-type: none"> With 1.5 feet of sea level rise, 1.5 square miles of land is anticipated to be permanently inundated during daily high tides.
	<ul style="list-style-type: none"> With 3 feet of sea level rise, An additional 2 square miles of land becomes vulnerable to permanent inundation towards mid-century.
10-Year Storm	<ul style="list-style-type: none"> A moderate storm event today impacts approximately 7 square miles of land, mostly concentrating within the low-lying neighborhoods on either side of Shore Drive, including Bay Island.
	<ul style="list-style-type: none"> With 1.5 feet of sea level rise, an additional 4 square miles of land will be impacted, with flooding reaching further south through both Thalia and London Bridge Creeks past I-264.
	<ul style="list-style-type: none"> With 3 feet of sea level rise, a 10-year storm event will result in even more extensive flooding, expanding into an additional 5 square miles of land.

Impact Table (Adapt from Virginia Beach, 2020)

Flood Exposure of Buildings

	Now	1.5 ft SLR	3 ft SLR
# Buildings	8,236	13,260	25,979
# Residents	63,568	86,661	133,129
Expected Building, Contentand Costs	\$8.77M	\$33.97M	\$129.89M

Vulnerable Critical Facilities

	Now	1.5 ft SLR	3 ft SLR
Fire Stations	2	2	5
Medical Care	0	1	2
Schools	2	6	13
Miles of Critical Roads	4.4	9.7	27

Changes in Acres of Habitat

	Now	1.5 ft SLR	3 ft SLR
Woody Wetlands	3,677	3,494	3,159
Grass Marsh	873	866	901
Tidal Flat	184	137	256
Open Water	7,072	7,607	8,291

Vulnerable Populations Exposed to Flooding

	%Today	% at 1.5 ft SLR	% at 3 ft SLR
Children (<5)	27%	37%	58%
Elderly (>65)	28%	37%	57%
Limited Income	29%	42%	62%
Disabled	29%	40%	61%

Summary

- Could you define community engagement and the phases of engagement?

- Please interpret your selection of strategies in each strategy category.
 - What are the flood risks and impacts for your area?

 - What are the goals of your area in adaptation planning?

 - Why did you choose those strategies?

 - Please describe strategies for each flood risk and impact.

 - Which strategies are your preference? Why did you choose them? Please describe the short-term and long-term benefits of these strategies, both for people who are going to live in your area and for the environment.

- Could you develop new strategies that are not included in the existing strategies cards? If so, please provide pros and cons of the new strategies.

Present the Results and Discussion

Each group will have 5 minutes to show the board and explain the results based on your answers to the questions in the summary part.

Wrap-up Questions

Let the students compare with the other two groups and ask the following questions to the students:

- Do the three groups have the same sort of strategy cards?
- How do the results in Group A compare with Group B? or With Group C?
- What are the new strategies for each group? Are there any differences among them?
- What did you find to be the most difficult part of each engagement phase?
- How did your view of adaptation planning change through playing the game?
- Did you learn anything surprising or unexpected through these engagement phases?

Exit Ticket

Students will need to write a short paragraph to summarize their findings for the three engagement phases.

Appendix B

Date: _____

Member names: _____

Group B Oceanfront Adaptation Strategy Project

Objectives

- You and your team will use the materials provided to practice how stakeholders engage in climate change adaptation planning to make decisions for Oceanfront (the smallest watershed) in the City of Virginia Beach.
- Your Oceanfront adaptation strategy project will demonstrate that you understand what community engagement for climate change adaptation planning is and how to conduct five phases of community engagement.

General Instructions

- The inform-phase will take 10 minutes
 - Each student selects a character card at random.
 - Review the flood risks and impacts material and maps on the table.
 - Think about what flood risks and impacts your “group” character would like to address in the next 50 years and why.
 - Start with the "local resident" player and work your way clockwise. The "local resident" shares to the group the flood risks and impacts that they believe exist.
- The consult & involve & collaborate-phase will take 15 minutes.
 - Teacher gives each group a set of adaptation strategies cards.
 - The "local resident" explains their chosen strategy card or set of strategies cards to the group and highlights the benefits that the strategy brings.
 - Going clockwise, each player selects and shares for a strategy card or group of strategies cards.
 - There are four categories of adaptation strategies, including natural strategies, engineered defenses, adapted structures, and prepared communities.
 - Please select no more than 2 strategies per category.
 - Keeping in mind that the total budget is \$1,000 million
- The empower-phase will take 15 minutes.
 - When teacher says that there are 15 minutes left, the rounds of arguing for various strategies come to an end.
 - Groups must begin to make clear decisions about a set of strategies they want to implement for their areas.
 - Place the strategy cards in the order of your preference on the board.

Your Actions

- Each student should select a character card at random.
 - Note: your group should choose “Local Resident (Coastal)” card(s).
 - If there are over four people in a group, more than one person can play local resident.
- Your team should select strategy cards.
- Your team should sort strategy cards in the desired order and glue the cards to the board.

Background

At 5.5 square miles, the Oceanfront is the smallest watershed in the City but provides invaluable economic growth from the tourism industry. The watershed is densely developed with both residential and commercial establishments. The City has dedicated substantial resources to improving this area in order to build upon the tourism, retail, and convention-centered business. The Oceanfront Watershed faces flood risks directly from the Atlantic Ocean (if dunes are overtopped), through Rudee Inlet, and from floodwaters from Lynnhaven Inlet coming into Linkhorn and Broad Bays.

Flood Risk Table (Adapt from Virginia Beach, 2020)

Tidal Flooding	<ul style="list-style-type: none"> With 3 feet of sea level rise, less than a square mile of land is expected to be permanently inundated during high tide. Most of this land is undeveloped.
10-Year Storm	<ul style="list-style-type: none"> During a moderate storm event, flooding originating from Little Neck Creek from the Lynnhaven can begin to enter the Oceanfront Watershed. Less than a square mile of land is impacted today.
	<ul style="list-style-type: none"> With 1.5 feet of sea level rise, flooding can reach further into the watershed and bypass Laskin Road.
	<ul style="list-style-type: none"> With 3 feet of sea level rise, a large storm event could result in even more extensive flooding, expanding into an additional 1 square mile of land and extending south to I-264.

Impact Table (Adapt from Virginia Beach, 2020)

Flood Exposure of Buildings

	Now	1.5 ft SLR	3 ft SLR
# Buildings	478	1,422	3,512
# Residents	4,744	9,641	12,953
Expected Building, Content and Costs	\$ 272,800	\$1.31M	\$8.83M

Vulnerable Critical Facilities

	Now	1.5 ft SLR	3 ft SLR
Fire Stations	0	0	1
Medical Care	0	0	1
Schools	0	1	2
Miles of Critical Roads	0.8	2.2	5.4

Changes in Acres of Habitat

	Now	1.5 ft SLR	3 ft SLR
Woody Wetlands	265	260	260
Grass Marsh	53	53	34
Tidal Flat	8	5	14
Open Water	208	223	246

Vulnerable Populations Exposed to Flooding

	%Today	% at 1.5 ft SLR	% at 3 ft SLR
Children (<5)	15%	52%	67%
Elderly (>65)	45%	61%	78%
Limited Income	16%	50%	71%
Disabled	22%	53%	74%

Summary

- Could you define community engagement and the phases of engagement?

- Please interpret your selection of strategies in each component.
 - What are the flood risks and impacts for your area?

 - What are the goals of your area in adaptation planning?

 - Why did you choose those strategies?

 - Please describe strategies for each flood risk and impact.

 - Which strategies are your preference? Why did you choose them? Please describe the short-term and long-term benefits of these strategies, both for people who are going to live in your area and for the environment.

- Could you develop new strategies that are not included in the existing strategies cards? If so, please provide pros and cons of the new strategies.

Present the Results and Discussion

Each group will have 5 minutes to show the board and explain the results based on your answers to the questions in the summary part.

Wrap-up Questions

Let the students compare with the other two groups and ask the following questions to the students:

- Do the three groups have the same sort of strategy cards?
- How do the results in Group A compare with Group B? or With Group C?
- What are the new strategies for each group? Are there any differences among them?
- What did you find to be the most difficult part of each engagement phase?
- How did your view of adaptation planning change through playing the game?
- Did you learn anything surprising or unexpected through these engagement phases?

Exit Ticket

Students will need to write a short paragraph to summarize their findings for the three engagement phases.

Appendix C

Date: _____

Member names: _____

Group C

Elizabeth River Adaptation Strategy Project

Objectives

- You and your team will use the materials provided to practice how stakeholders engage in climate change adaptation planning to make decisions for Elizabeth River (inland watershed) in the City of Virginia Beach.
- Your Elizabeth River adaptation strategy project will demonstrate that you understand what community engagement for climate change adaptation planning is and how to conduct five phases of community engagement

General Instructions

- The inform-phase will take 10 minutes
 - Each student selects a character card at random.
 - Review the flood risks and impacts material and maps on the table.
 - Think about what flood risks and impacts your “group” character would like to address in the next 50 years and why.
 - Start with the "local resident" player and work your way clockwise. The "local resident" shares to the group the flood risks and impacts that they believe exist.
- The consult & involve & collaborate-phase will take 15 minutes.
 - Teacher gives each group a set of adaptation strategies cards.
 - The "local resident" explains their chosen strategy card or set of strategies cards to the group and highlights the benefits that the strategy brings.
 - Going clockwise, each player selects and shares for a strategy card or group of strategies cards.
 - There are four categories of adaptation strategies, including natural strategies, engineered defenses, adapted structures, and prepared communities.
 - Please select no more than 2 strategies per category.
 - Keeping in mind that the total budget is \$1,000 million
- The empower-phase will take 15 minutes.
 - When teacher says that there are 15 minutes left, the rounds of arguing for various strategies come to an end.
 - Groups must begin to make clear decisions about a set of strategies they want to implement for their areas.
 - Place the strategy cards in the order of your preference on the board.

Your Actions

- Each student should select a character card at random.
 - Note: your group should choose “Local Resident (Inland)” card(s).
 - If there are over four people in a group, more than one person can play local resident.
- Your team should select strategy cards.
- Your team should sort strategy cards in the desired order and glue the cards to the board.

Background

The Elizabeth River Watershed is on the west side of the City, and shares boundaries with the cities of Norfolk and Chesapeake. There has been steady population growth in this watershed. Although land elevations in the Elizabeth River Watershed are higher than other areas in Virginia Beach increased urbanization, degradation of naturalized landscapes, and aging infrastructure contribute to flood exposure and vulnerability in this area. More than 80% of homes were built in the 1970s or earlier, leading to an older overall building stock with many homes built to lower codes or standards than in place today. The Elizabeth River provides a flood pathway from the Chesapeake Bay, through Norfolk and Chesapeake. As sea levels rise, flood pathways begin to merge with flooding driven from the North Landing River during times of southerly winds, generating more widespread flooding.

Flood Risk Table (Adapt from Virginia Beach, 2020)

Tidal Flooding	<ul style="list-style-type: none"> High tide flooding impacts a small amount of land today within the watershed. Given the relatively higher land elevations in the watershed, the growth of the future high tide floodplain is mostly constrained to the lowest lying areas directly adjacent to the river.
	<ul style="list-style-type: none"> High tide flooding with 1.5 feet of sea level rise only impacts less than half a square mile of land.
	<ul style="list-style-type: none"> With 3 feet of sea level rise, just over half a square mile of land becomes permanently inundated during high tide.
10-Year Storm	<ul style="list-style-type: none"> A moderate storm event today impacts less than a square mile of land.
	<ul style="list-style-type: none"> With 1.5 feet of sea level rise, the amount of flooding from a 10-year storm is anticipated to increase, extending into some residential areas and low-lying roadways.
	<ul style="list-style-type: none"> A moderate storm event with 3 feet of sea level rise could flood almost 2 square miles of land, representing 60% more land area flooded as compared to today.

Impact Table (Adapt from Virginia Beach, 2020)

Flood Exposure of Buildings

	Now	1.5 ft SLR	3 ft SLR
# Buildings	1,801	2,739	5,100
# Residents	9,644	13,027	26,664
Expected Building, Contentand Costs	\$843,600	\$2.86M	\$9.32M

Vulnerable Critical Facilities

	Now	1.5 ft SLR	3 ft SLR
Fire Stations	0	0	2
Schools	1	4	7
Miles of Critical Roads	0.4	0.7	2.2

Changes in Acres of Habitat

	Now	1.5 ft SLR	3 ft SLR
Woody Wetlands	369	357	383
Grass Marsh	173	174	155
Tidal Flat	20	13	35
Open Water	577	627	667

Vulnerable Populations Exposed to Flooding

	%Today	% at 1.5 ft SLR	% at 3 ft SLR
Children (<5)	13%	19%	42%
Elderly (>65)	26%	31%	55%
Limited Income	9%	13%	32%
Disabled	17%	24%	49%

Summary

- Could you define community engagement and the phases of engagement?

- Please interpret your selection of strategies in each component.
 - What are the flood risks and impacts for your area?

 - What are the goals of your area in adaptation planning?

 - Why did you choose those strategies?

 - Please describe strategies for each flood risk and impact.

 - Which strategies are your preference? Why did you choose them? Please describe the short-term and long-term benefits of these strategies, both for people who are going to live in your area and for the environment.

- Could you develop new strategies that are not included in the existing strategies cards? If so, please provide pros and cons of the new strategies.

Present the Results and Discussion

Each group will have 5 minutes to show the board and explain the results based on your answers to the questions in the summary part.

Wrap-up Questions

Let the students compare with the other two groups and ask the following questions to the students:

- Do the three groups have the same sort of strategy cards?
- How do the results in Group A compare with Group B? or With Group C?
- What are the new strategies for each group? Are there any differences among them?
- What did you find to be the most difficult part of each engagement phase?
- How did your view of adaptation planning change through playing the game?
- Did you learn anything surprising or unexpected through these engagement phases?

Exit Ticket

Students will need to write a short paragraph to summarize their findings for the three engagement phases.

Appendix B

Stakeholder Character Cards

General Instructions

- Please print three sets and laminate the cards. (Total funds=\$1,000 million)
- Please give a set for each group.
 - Note: Group A-Lynnhaven should have “Local Resident (**Coastal**)” card(s); Group B-Oceanfront should have “Local Resident (**Coastal**)” card(s); and Group C-Elizabeth River should have “Local Resident (**Inland**)” card(s)Elizabeth River
- These cards can be re-used for each class.

Group A-Lynnhaven & Group B-Oceanfront

Local Resident (Coastal)

- You have been selected to represent your community on this issue.
- Your community is a beach community.
- Members of your community enjoy living where they do because they enjoy seeing wildlife in their backyards and going to the beach.
- Your houses are near the water and your neighborhood floods during heavy storms.



\$200 million

Group C-Elizabeth River

Local Resident (Inland)

- You have been selected to represent your community on this issue.
- Your community is an inland community.
- You anticipate that as people begin to worry about sea level rise, they will be looking to move further inland.
- Members of your community enjoy living where they do because it is easy to get to the beach.



\$200 million

Government Official

- As an elected official, you work in a position of power within your local government.
- You have lived in the area for many years and plan to continue living here because you are an amateur fisherman, and you love the area.
- You have heard recent reports about the potential impact of sea level rise in your community, but you find it difficult to dedicate the necessary resources towards this issue because more immediate issues weigh you down.



\$400 million

Business Owner

- You are a born and raised resident of the area that owns a kayaking tour company.
- Recent storms have caused some damage to your business, and you are beginning to worry about the intensification of coastal dynamics in the near future.
- You also notice increasing development pressures threatening marsh areas that you like to take some of your tours through.



\$200 million

Coastal Planner

- You are not a Virginia native, but you came to this area, and you develop and manage current and long-range planning projects in collaboration with local governments and other partners.
- You also manage plan processes to ensure that agency partners are capable of providing robust public processes that include a broad spectrum of the public.



\$200 million

Appendix C

Adaptation Strategy Cards

General Instructions

- Please print three sets and laminate the cards.
- Please give a set for each group.
- These cards can be re-used for each class.

Natural Strategies

Beach and Dune Nourishment

- Replacing sand lost to erosion re-widen a beach
- Key benefits: Expand the width of beaches and increasing recreation areas; Offer enhanced protection storm events; Accelerate dune growth and habitat enhancement

\$100 million

Living Shoreline

- A protected, stabilized coastal edge made of natural materials such as plants, sand, or rock
- Key benefits: Provide erosion control; Reduce flooding during smaller storm events; Enhance habitats for wildlife and aquatic species; Improve water quality

\$25,000/acre

Land Conservation

- The long-term protection and management of unused or underused land resources, such as open space & farmland.
- Key benefits: Enhance the green infrastructure network; Provide additional recreational space for watershed residents; Relocates owners from high-risk properties

\$50,000/acre

Shellfish Reefs and Oyster Restoration

- The process of rebuilding or restoring of oyster reefs
- Key benefits: Restore habitats and species; Improve water quality; Bolster the shellfish and oyster industry/commercial and recreational fishing

\$30,000/acre

Engineered Defenses

Surge barriers or gates

- Installing physical barriers between the sea and land to prevent flooding of developed areas.
- Key benefits: Although a long-term strategy subject to significant cost and permitting hurdles, such a barrier would protect about 28,000 structures from coastal flood impacts for the assumed 3 feet sea level rise scenario.



Adapted Structures

<p><u>Building Elevation</u></p> <ul style="list-style-type: none"> Elevating existing and future structures on stilts to protect them from storm surge and flooding. Key benefits: Avoid and reduce damages to property; Maintain community relationships; Total benefits of \$1 billion; Maintain tax base <p style="text-align: right;">\$150,000</p>	<p><u>Floodplain Regulation</u></p> <ul style="list-style-type: none"> Strives to regulate safe building in flood hazard areas. Key benefits: Reduced vulnerability to flood risks for new development and substantial redevelopment; Safer long-term growth; Preservation of life and property <p style="text-align: right;">\$50,000</p>
<p><u>Resilient Roadways</u></p> <ul style="list-style-type: none"> Improving the resiliency and longevity roadways Key benefits: Reduced risks of flooded critical infrastructure assets such as roads, bridges, and highways; Increase accessibility to critical community assets; Increased safety of people and property <p style="text-align: right;">\$20,000</p>	<p><u>Shellfish Reefs and Oyster Restoration</u></p> <ul style="list-style-type: none"> Ensure long-term success and fulfilling vision of creating a better environment Key benefits: Building smarter and stronger; Reducing risks for new and current residents; Potential for reduced flood insurance costs; Decrease in flood losses to homes and businesses <p style="text-align: right;">\$30,000/acre</p>

Prepared Communities

<p><u>Business Outreach and Education</u></p> <ul style="list-style-type: none"> Provide more public education and outreach to new residents and visitors to raise awareness of flash flooding potential, as well as actions and strategies for the public to remain safe Key benefits: Reduce vulnerability of industrial and commercial businesses to flood risks <p style="text-align: right;">\$50,000</p>	<p><u>Flood Insurance Expansion</u></p> <ul style="list-style-type: none"> Covers losses directly caused by flooding. The City should focus on increasing flood insurance penetration within areas that have the highest residual risk Key benefits: Provide Community Rating System benefits for the city; Allow residents and businesses to recover faster following a flood event <p style="text-align: right;">\$50,000</p>
<p><u>Residential Community Education</u></p> <ul style="list-style-type: none"> Increase awareness and preparedness levels and help communities learn to build resilient communities Key benefits: Enhance community awareness of flood issues; Encourage a better understanding of the impact that green infrastructure plays in flood mitigation <p style="text-align: right;">\$50,000</p>	<p><u>Managed Retreat</u></p> <ul style="list-style-type: none"> Gradually moving infrastructure away from high-risk areas, primarily through the use of rolling conservation easements. Land will be acquired inland to allow for infrastructure to be rebuilt outside of highly vulnerable areas. <p style="text-align: right;">\$700 million</p>



Appendix D

Adaptation Strategy Board

General Instructions

- Team should select strategy cards (no more than 2 strategies per category).
- Team should sort strategy cards in the desired order and glue the cards to the board.

Adaptation Strategy Boards

Natural Strategy

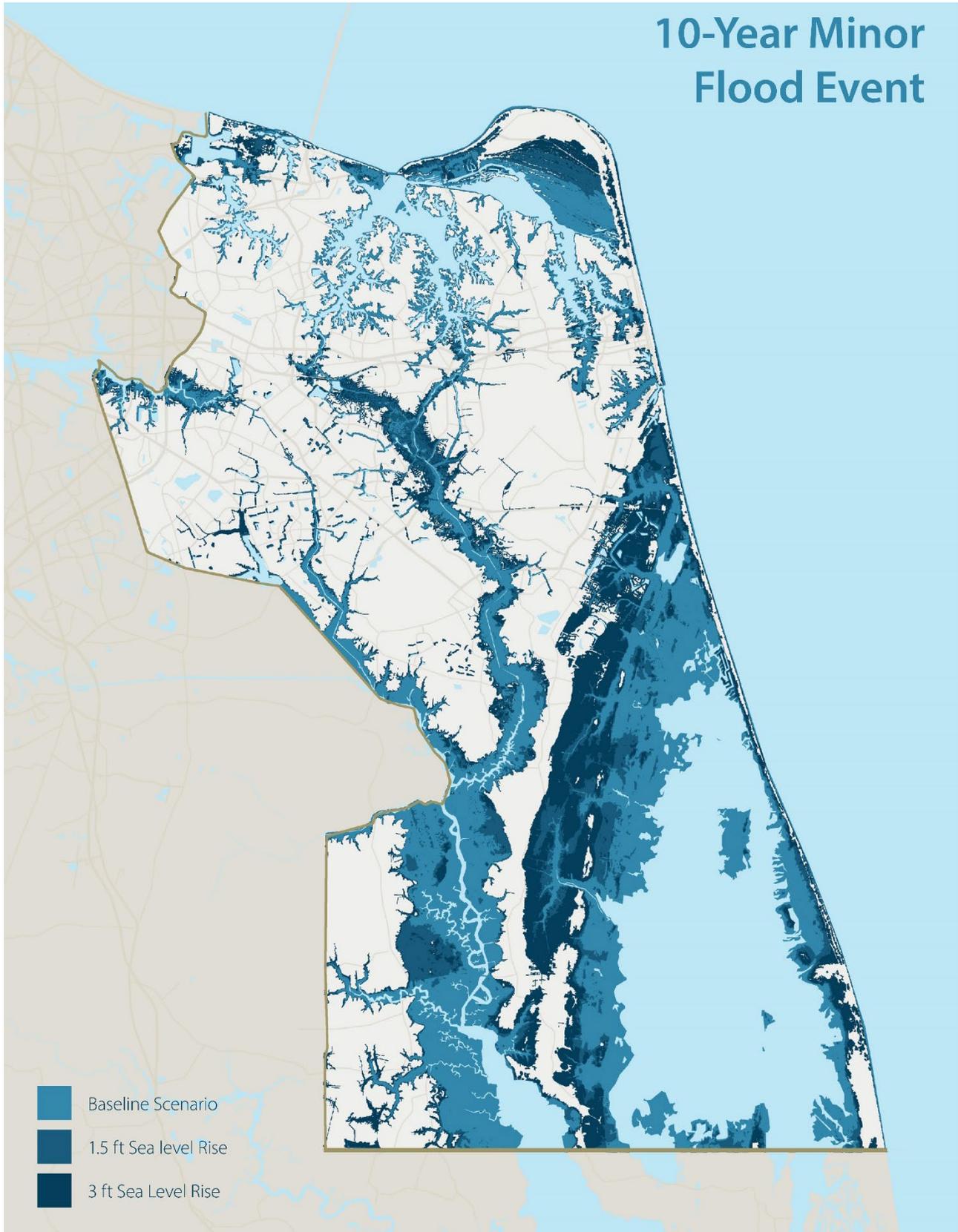
Engineered Defenses

Adapted Structures

Prepared Communities

Appendix E

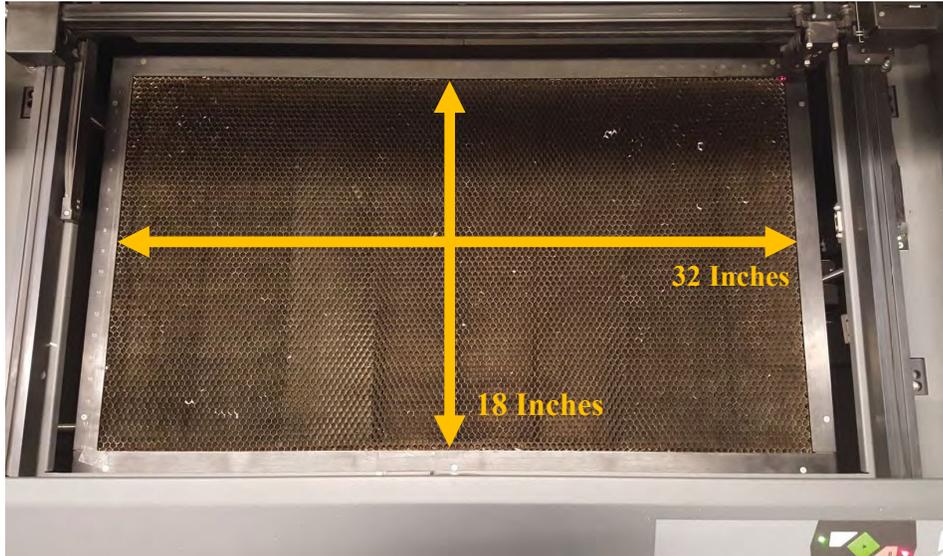
Virginia Beach Map



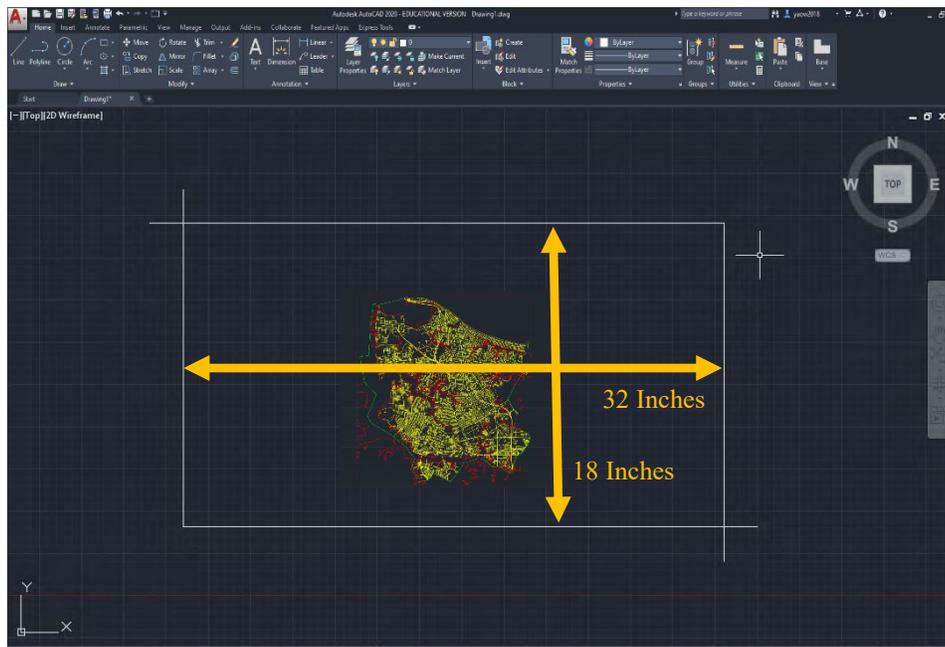
Appendix G

3D Model Development Instruction

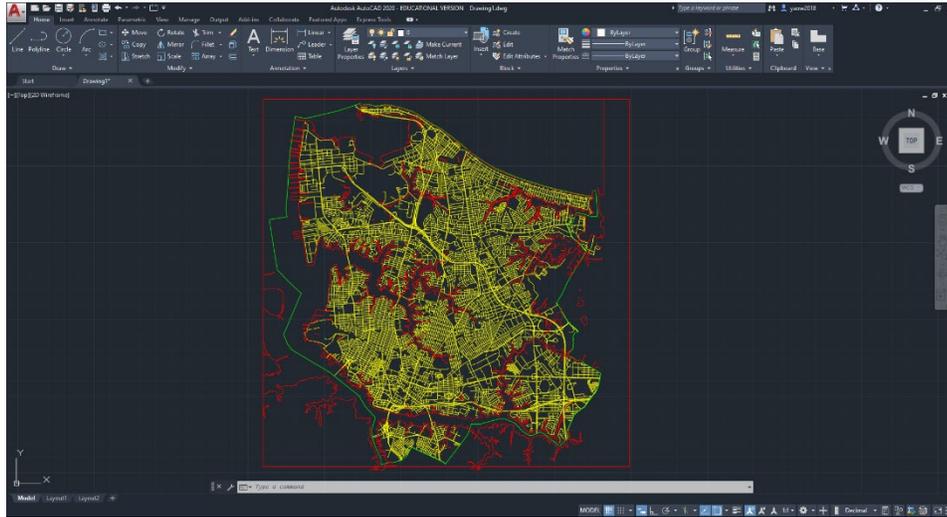
1. The bed size is 18 by 32 inches. This is the maximum “printable” area. The material should be cut down to 18 by 32 inches.



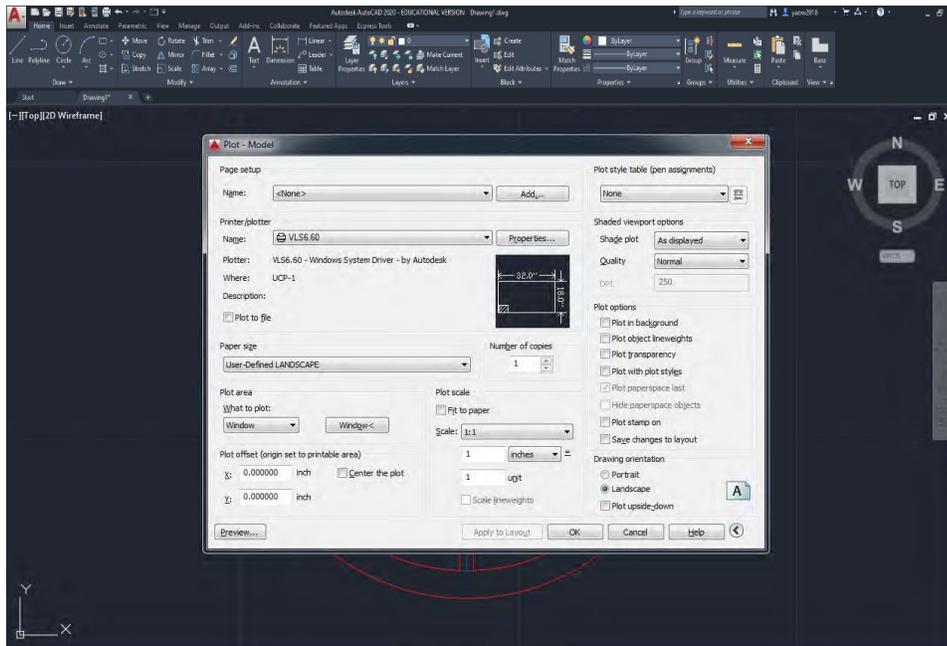
2. Scale your drawing to the size you require it to come out of the laser cutter. Draw a bounding box to help keep the printable area.



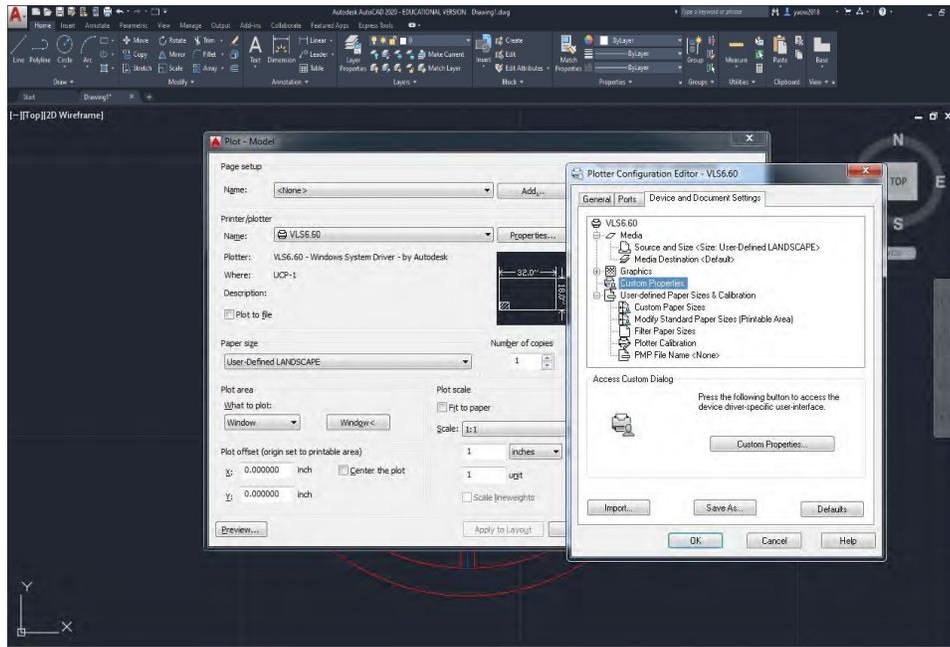
- In this model, red is the cutting layer, yellow is the primary etching layer, and green is the secondary etching layer.



- When the line weights and colors are set, send the linework to the UCP (Universal Control Panel) by “printing” to the VLS 6.6.



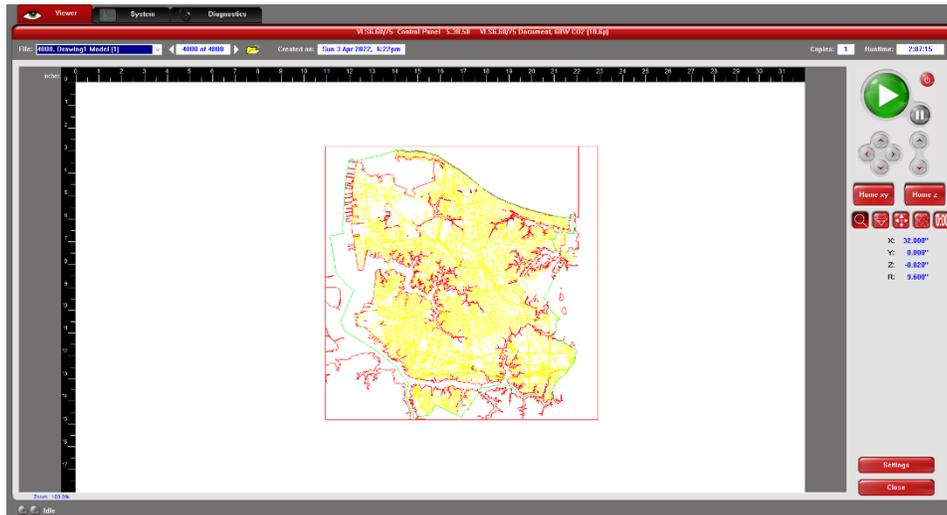
5. Select “Properties” next to the Printer/Plotter name. Select “Custom Properties” in the pop-up window that appears.



6. This is the settings interface for the UCP. Set Z-axis, power, and speed for each color.



7. Click the green button to start printing.



8. The following image shows the laser cutter working on the model.

