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HOW RESILIENT IS IT? THE RESILIENCE QUOTIENT ZONING ORDINANCE

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Grade Level
High School

Subject Area
Earth & Environmental Science

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Title: How Resilient Is It? The Resilience Quotient Zoning Ordinance

Focus: The Resilience Quotient (RQ) system uses zoning ordinance to address coastal resilience development issues in the city of Norfolk, Virginia. This lesson plan goes through key resilience concepts and its strategies that can promote flood risk reduction, stormwater management, and energy resilience. The activity provides several scenarios to help students understand, simulate, visualize, discuss, and practice how the Resilience Quotient works for coastal developments in the city.

Grade Level: Environmental Science and Earth Science (Oceanography); target 9th-12th grade, high school

VA Science Standards

ENV.1 and earth Science II The student will demonstrate an understanding of scientific and engineering practices by

a) asking questions and defining problems
- ask questions that arise from careful observation of phenomena and/or organisms, from examining models and theories, and/or to seek additional information; and
- define design problems that involve the development of a process or system with multiple components and criteria.

b) planning and carrying out investigations
- individually and collaboratively plan and conduct observational and experimental investigations.

c) interpreting, analyzing, and evaluating data
- construct, analyze, and interpret graphical displays of data; and
- analyze data using tools, technologies, and/or models to make valid and reliable scientific claims or determine an optimal design solution.

d) constructing and critiquing conclusions and explanations
- apply scientific ideas, principles, and/or evidence to provide an explanation of phenomena and design solutions.

e) developing and using models
- develop and/or use models to generate data to support explanations, predict phenomena, analyze systems, and/or solve problems.

f) obtaining, evaluating, and communicating information
- communicate scientific and/or technical information about phenomena in multiple formats.

ENV.8 The student will investigate and understand that Earth's resources should be conserved. Key content includes

- the trend in human consumption of energy will affect future availability of nonrenewable resources; and
- individuals can alter their own behavior to reduce their environmental impact.

ENV.9 The student will investigate and understand how human actions impact the environment. Key content includes

- advantages and disadvantages of balancing short term interests with long term welfare of society;
- individual activities and decisions can have an impact on the environment; and
- people affect their environment through the use of natural resources to include how agriculture, forestry, ranching, mining, urbanization, transportation, and commercial fishing impact the land, water, air, and organisms.

ENV.10 The student will investigate and understand that pollution and waste management affect an ecosystem. Key content includes

- pollution and resource depletion have potential environmental implications at the local and global levels. These include air and water pollution, solid waste disposal, waste water disposal, depletion of the stratospheric ozone, global warming, and land uses.

ENV.11 The student will investigate and understand that global climate change is occurring. Key content includes

- scientific evidence such as changes in average global temperature, greenhouse gases, quantities of artic and land ice, ocean temperature, ocean acidification, and sea level rise are indicators of climate change;
- there exists a relationship between global climate change and the frequency or magnitude of extreme weather events;
- sea level rise is currently affecting coastal areas of Virginia and will lead to the destruction of current habitats; and
- consequences of climate change will affect the biosphere on many levels including species migration and extinction, disease spread, and ecosystem health (e.g. bleaching corals and dying forests).

ENV.12 The student will investigate and understand that their actions as an environmentally literate citizen will play a role in environmental policies. Key content includes

- consumer choices in Virginia impact jobs, resources, pollution, and waste here and around the world;
- political, legal, social, and economic decisions may affect global and local ecosystems;
- individuals and interest groups influence public policy; and
- environmental decisions should include a cost-benefit analysis and may lead to trade-offs in conservation policy.

Ocean.8 The student will investigate and understand that weather and climate are effected by thermal properties of land and water. Key concepts include

- the ocean is a major influence on weather and climate by absorbing, storing, and moving heat; and
- local, regional, and large scale atmospheric winds have specific characteristics and predictable patterns.

Ocean.9 The student will investigate and understand that that ocean is a critical component of climate change. Key concepts include

- global mean sea level fluctuations are caused by natural and human factors;
- the ocean regulates fluctuations of Earth's average temperature over time, and
- data from a variety of studies reveal interrelationships between ocean properties and rates of climate change.

Learning Objectives

- Students will be able to explain what the Resilience Quotient system is and know the specific strategies of flood risk reduction, stormwater management, and energy resilience.
- Students will discuss and predict the effects that different strategies in the RQ system will have on the environment.
- Students will identify the costs and benefits of different interventions for different development types and use RQ to enhance community resilience.

Total Length of Time Required for the Lesson

70-90 minutes total

- 15 minutes – Introduction: Overview PowerPoint
- 30 - 40 minutes – Activity: Resilience Quotient Practice
- 5-10 minutes – Breakdown
- 15 minutes – Presentation and Discussion
- 5-10 minutes – Wrap-Up of Activity

Key Words and Vocabulary

- **Climate Change** refers to significant changes in global temperature, precipitation, wind patterns and other measures that have occurred over several decades (UCDavis, 2021).

- A **Zoning Ordinance** is a set of rules that governs how individuals can utilize land and structures in a certain region (Kenton, 2021).

- **Community Resilience** refers to a community's capacity to continue key operations, recover rapidly, and build more prosperous communities in times of disturbance (Wang et al., 2020).

- The **Resilience Quotient** is a point system, where credit is allocated for specific actions that developers and property owners can use to meet requirements in order to reduce coastal flooding risk and enhance community resilience (City of Norfolk, 2021).

- **Risk Reduction** refers to flooding risk reduction, which is decreasing the effects of floods by implementing measures within coastal areas (Kundzewicz et al., 2018).

- **Stormwater Management** is the process of reducing the rainwater runoff from impermeable surfaces, such as parking lots and rooftops. It can control channel erosion and improve water quality (Environmental Protection Agency, n.d.).

- **Energy Resilience** is about ensuring users have a stable, consistent source of energy as well as a contingency method in the case of a power outage (Jasiūnas et al., 2021).

Background Information

My name is Qiong Wang, and I am a graduate student at Virginia Tech studying disaster resilience and hazard mitigation policies. I am interested in studying hazard mitigation because it is an important component for disaster resilience. Currently, I am working with planners in the city of Norfolk, Virginia on the modifications of the Resilience Quotient (RQ) system. RQ is an innovative zoning ordinance and can help communities enhance resilience in coastal areas. I invited Yao Wang, who is a graduate student at the State University of New York College of Environmental Science and Forestry (SUNY-ESF), to produce 3D documents. Yao Wang's research interests include disaster resilience, hazard mitigation, community engagement, and floodplain management. She is also a teaching assistant at the Digital Fabrication lab, SUNY-ESF and has many experiences of utilizing laser cutters, 3D printers, CNC, and other 3D model machines and programs.

In Virginia, recurrent flooding and rising sea levels are considered the most common impact hazards (Moore and Acker, 2018). Sea levels in Virginia are rising quicker than the average global levels due to sinking land (Atkinson et al., 2013). Scientists predict the water level will rise by 0.3 to 2.5 meters by 2100 (Sub-panel, 2014). There are approximately 344,445 properties (28.9% of total) in Virginia with substantial flooding risk, and this number could increase to 389,700 (32.3% of total) by 2050 (First Street Foundation, 2020). Consequently, coastal areas of the Commonwealth should undertake efforts to reduce flood risk and better prepare for the future.

Hazard mitigation is a long-term initiative to reduce the loss of life and property. It can bring about numerous benefits. Every dollar invested in hazard mitigation can save six dollars in disaster recovery (National Institute of Building Sciences, 2017). Although hazard mitigation is a policy issue with great significance for all levels of governments, local governments bear the primary functional responsibility for hazard mitigation and community resilience (FEMA, n.d.).

In recent years, the city of Norfolk introduced higher resiliency standards and a new Resilience Quotient system. The city of Norfolk is a coastal city with 97% of developed coastal lands in Virginia and faces increasing rates of sea level rise and repetitive coastal flooding issues (Planning Webcast, 2020). Specifically, Resilience Quotient is a points-based system with three components including risk reduction, stormwater management, and energy resilience. Developers and property owners can use this system to gain resilience points to meet development requirements (Green, 2019). The current RQ system, however, is still in an initial phase of continuing modifications, both to its components and indicators, as well as to its point system so that it can provide accurate "resilience assessment" for different site conditions and development strategies. The Resilience Quotient system, if designed well, can help the city achieve its resilience goal in low-lying coastal areas.

Please see additional background in the PowerPoint associated with the lesson plan as well as the references section (for more information, see papers cited within referenced papers).

Student Handouts and Other Materials Needed

- Appendix A – Scenario handouts for groups
- Appendix B – Benefits of Resilience Quotient interventions
- Appendix C – (2D) A Master plan of the city of Norfolk (PDF file, print in A3 paper size)
- Appendix D – (2D) Illustration cards of resilient interventions for groups (print each page in letter paper size and cut each card)
- Appendix E – A Master plan of the city of Norfolk for 3D model (CAD file)
- Appendix F – 3D model development instruction
- Appendix G – GIS data for 3D model (only for teachers)
- Appendix H – GIS elevation data for Norfolk (only for teachers)

Note: both 2D and 3D files of the master plan were provided. If there is a laser cutter in your school, please use 3D files to print the plan. If not, please use 2D files to print the plan.

Materials & Supplies

- Computer and projector for accompanying PowerPoint
- Handouts listed above
- Paper and pencils/pens
- Any calculators

Teacher Preparation

Teachers need to prepare the lesson activity by printing handouts (appendix A), benefits of RQ interventions (appendix B), the master plan (appendix C or E), and illustration cards (appendix D) for the Resilience Quotient activity in advance.

Procedure

1) **Introduction – 15 minutes**

Begin with the accompanying PowerPoint to introduce the content of the Resilience Quotient system. See slides for specific notes with suggested dialog and discussion. (Slide 1—Slide 11)

2) **Activity: 30 - 40 minutes**

See slides for specific notes with suggested dialog and discussion. (Slide 12—Slide 14)

3) **Breakdown: 5 - 10 minutes**

4) **Presentation and Discussion: 15 minutes**

Please see a detailed explanation in the "Resilience Quotient Activity – Teacher's Guide" and Slide 15: summary questions. The questions were layered according to Bloom's Taxonomy.

- When each group is finished filling out their tables, they will be asked to choose one or more members to present their results.
    - The presenters should introduce the background of their group project and the required minimum resilience points.
    - The presenters should use the master plan with intervention cards to illustrate what resilient actions they selected for the project.
    - The presenters should answer the questions in the summary section of the handout.

5) Wrap-up and Assessment: 5 - 10 minutes

See slides for specific notes with suggested dialog and discussion. (Slide 16: wrap-up questions)

6) Exit Ticket

Students will need to write a short paragraph (less than 500 words) to summarize their findings for the group scenario of the Resilience Quotient system. This will allow for the individual to show their mastery of the material.

7) Optional Task

Students can also write a semi-technical paper on their findings for their group scenarios.

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Resilience Quotient Activity – Teacher's Guide

See PowerPoint Slide 12
Background and Purpose

This activity is designed to help students understand how to use the Resilience Quotient system in reality. There are three scenarios for students to simulate how developers meet the requirements after they calculate the costs and consider the benefits of interventions. The goal of this activity is for students to demonstrate what a zoning ordinance is and how the Resilience Quotient works to reduce risks and enhance community resilience.

** Please go through the whole set of instructions to see what will work best for your class in terms of student separation and equipment needed. Moreover, some information on this worksheet, such as the examples given for the activity, should not be shared with students unless absolutely essential. If a student is having trouble, then the teacher may decide whether or not to provide some of these examples.**

Materials

Each team gets a set of activity materials.

- Appendix A - Scenario handouts for groups (Resilience Quotient Compliance for Different Development Projects)
- Appendix B - Benefits of Resilience Quotient interventions
- Appendix C or E - Master plan of the city of Norfolk
- Appendix D - Illustration cards of resilient interventions
- Paper and pencils/pens
- Any calculators
    - Appendix F – 3D model development instruction
    - Appendix G – GIS data for 3D model (only for teachers)
    - Appendix H – GIS elevation data for Norfolk (only for teachers)

Note: both 2D and 3D files of the master plan were provided. If there is a laser cutter in your school, please use 3D files to print the plan. If not, please use 2D files to print the plan.

See PowerPoint Slide 13-14
Instructions of Activity

Based on the three scenarios, the class should be split into three groups (Group A, Group B, and Group C). The three scenarios are Resilience Quotient compliance for single-family development, multi-family residential development, and non-residential development. Each group will complete a full RQ compliance plan for their scenario. Each group should get a set of activity materials.

Group Title

Group A: the "Resilience Quotient Compliance for Single-Family Residential Development" Group (based on the single-family residential development scenario)
Group B: the "Resilience Quotient Compliance for Multi-Family Residential Development" Group (based on the multi-family residential development scenario)
Group C: the "Resilience Quotient Compliance for Non-Residential Development" Group (based on the non-residential development scenario)

Activity Procedure

- The groups will simulate how developers use the Resilience Quotient to conduct development projects. They will be able to pick through all the interventions in the RQ point table to determine whether their selected interventions meet the requirements. Their reasoning for why the interventions were chosen must be explained.
    - Example: the benefits of their chosen interventions for community resilience

- Each item that is selected or not in the RQ point table must be recorded on the worksheet as follows (instructions also on worksheet)

Table Sample (Group A)
Required minimum points: ____10_____

Components	Interventions	Points	Prices	Costs	Benefits	Selections
Component 1: Risk Reduction	Construct building to meet 110-mile wind load design requirements of the (Virginia Uniform Statewide Building Code) VUSBC	2.00	Engineered Wood Siding: $5 per square foot; Vinyl Siding: $3 per square foot	$8,370[1]	1.1Ba, b, and c; 1.2 A Pros a and b	√
	Elevate the ground story finished floor and all significant electrical and mechanical equipment no less than 3 feet above highest adjacent grade	2.00	$10 per square foot of the house	2,000 sq. ft x $10 = $20,000	1.1Ba, b, and c;	√
	Construct an impact-resistant (hail, tree damage) roof (do not require an anti-fungal product)	1.00	$5 per square foot			/

	Install impact (hurricane or wind) resistant windows	0.50	$50 per square foot			/
Total Points and Cost	4 points and $28,370					
Component 2: Stormwater Management	Install a green roof on at least 50% of the total roof area	2.00	$10 per square foot	(2,100 sq. ft/2) x $10 = $10,500		/
	Install a green roof on at least 25% of the total roof area	1.00	$10 per square foot			/
	Provide a rain garden to capture site-generated stormwater	1.00	$10 per square foot	300 sq. ft x $10 sq. ft=$3,000	2.2a, b, c, and d	√
	Use pervious or grass paving systems on at least 50% of parking lot and driveway area in the development	0.5	Pervious concrete: $20 per square foot; porous asphalt: $3 per square foot	(320 sq. ft/2) x $3 = $480	2.3a, b, c, and d	√
	For new tree plantings, enhance tree pits with specially engineered soils to absorb and filter runoff	0.25	$1,500 per tree			/
Total Points and Cost	3.5 points and $13,980					
Component 3: Energy Resilience	Generate no less than 75% of the electricity expected to be used by the development from on-site solar energy sources	3.00	$16,000	$16,000	3.1a, b, and c	√
	Generate no less than 25% of the electricity needed expected to be used by the development from	1.00	$5,000			/

	on-site solar energy sources					
	Install a geothermal energy heating & cooling system	1.00	$12,000			/
	Install green walls on a minimum of 200 square foot of the primary building's walls	1.00	$150 per square foot			/
Total Points and Cost	3 points and $16,000					
Combined Total Points and Cost (all components)	10.5 points and $58,350					

Note

1. Wall area: 50 feet x 10 feet x 2 + 40 feet x 10 feet x 2 = 1,800 sq. ft
   Window area: 2 feet x 3 feet x 10 = 60 sq. ft
   Roof area: 2,100 sq. ft ÷ 2 = 1,050 sq. ft
   Vinyl Siding cost: $3 x (1,800 sq. ft – 60 sq. ft + 1,050 sq. ft) = $8,370

Actions for Students in the Activity

- Select interventions
- Calculate points and costs of each intervention
- Write down benefits for the selected items
- Calculate total points and costs of interventions to meet the required minimum points
- Each group needs to choose the intervention cards for the project. It will be used for a group presentation.

See PowerPoint Slide 15
Presentation

When each group is finished filling out their tables, they will be asked to choose one or more members to present their results.

- The presenters should introduce the background of their group project and the required minimum resilience points.
- The presenters should use the master plan with intervention cards to illustrate what resilient actions they selected for the project.
- The presenters should answer the questions in the summary section of the handout. The questions were layered according to Bloom's Taxonomy.
  - Could you define zoning ordinance and the Resilience Quotient system?
  - What risks does your area have?
  - Please describe how the Resilience Quotient works to reduce risks and enhance community resilience.

- In the activity, you carried out the Resilience Quotient system for your project. How many points did you decide on earning? What is your total cost for all components?
- Please interpret your selection of interventions in each component.
  - What are the requirements for your project?
  - What are the goals of your project in risk reduction, stormwater management, and energy resilience?
  - Why did you choose those interventions?
  - Please describe the points and costs for each component and in total.
  - Which component has the most points that you selected? Why did you choose them? Please describe the short-term and long-term benefits of these interventions, both for people who are going to live in your area and for the environment.
  - What were the most expensive and cheapest interventions that you selected? Why did you choose them? What are the benefits of the intervention in the short term and long term, both for people who are going to live in your area and for the environment?
- Could you develop new interventions that are not included in the existing RQ table? If so, please provide pros and cons of the new interventions.

Wrap-up and Assessment

See slides for specific notes with suggested dialog and discussion. (Slide 16: wrap-up questions) Some possible answers are listed with each question, but these are not the only answers possible.

- Do the three groups have the same intervention items?
  - No. Since project types are different, the larger the project is, the more resilience responsibility it should have.

- What are the differences of goals among the three projects? What risks does your area have? Could these strategies be used to help?
  - Since there is a limited budget for single-family development, Group A's goal is to meet the point requirement and keep low-cost interventions. At the same time, they also need to consider the risks on the site.
  - The multi-family development group has sufficient money, and they prefer to provide more public open space for residents, so their goal is to meet the point requirement and create less risks, convenient, and comfortable community environments.
  - The industry project's goal is to have a Leadership in Energy and Environmental Design (LEED) certificate and produce less pollution in order to take social responsibility to reduce risks and make more contributions to community resilience. Leadership in Energy and Environmental Design is a green building certification program used worldwide.
  - Higher or lower flooding risk on sites should be considered.

- How do the results in Group A compare with Group B? With Group C?
  - Point amount

    - Focus components
    - Costs
    - Benefits

- What kinds of interventions have more benefits for each group in the long term? Why?
    - There is no right or wrong answer.

- What are the new interventions for each group? Are there any differences between them?
    - There is no right or wrong answer.

Exit Ticket
Students will need to write a short paragraph (less than 500 words) to summarize their findings for the group scenario of the Resilience Quotient system. This will allow for the individual to show their mastery of the material.

Optional Task
Students can also write a semi-technical paper on their findings for their group scenarios.

Appendix A
Date: _____

Member names: _____

Group A
Resilience Quotient Compliance for
Single-Family Residential Development

Objectives

- You and your team will use the materials provided to practice how developers or property owners use the point table to comply with the Resilience Quotient (RQ) standards for single-family residential development required by the city of Norfolk.
- Your single-family residential development project will demonstrate that you understand the RQ points and recognize the benefits and costs of resilient interventions and how they can promote community resilience.

General Instructions

- Your team, as a family, would like to build a house (2,000 square feet, one story, and ten windows) on site A of Norfolk, which has a standard 2-car driveway (320 square feet). The area of the roof is 2,100 square feet (sq. ft). The shape of the house is a rectangle. Its length is 50 feet, the width is 40 feet, and the height is 10 feet. Each window size is 6 sq. ft=2 feet (width) x 3 feet (height). Due to unforeseen reasons, your family has a limited budget (less than $60,000) for the home materials. We will only calculate the construction material costs in the table without the installation and maintenance costs.
- The city of Norfolk requires that a new single-family development project needs to have at least 10 points of the Resilience Quotient system. Developers or property owners need to earn at least 2 points from each of the three components; you cannot only earn 10 points from one or two components.
- Since site A is in the coastal and hurricane zone of Norfolk with a higher flooding risk, the city requires that each new single-family project must elevate the ground floor and all significant electrical and mechanical equipment no less than 3 feet above the highest adjacent grade.
- You are about to decide how many points you want to earn. You also need to consider the costs and benefits of interventions in the point table that are suitable for your home project. Your family plans to have a 300-square-foot rain garden. The cost of regular windows (not hurricane or wind resistant windows) is $25 per square foot.

Your Actions

- Fill out the table below. Carefully calculate points and costs of interventions.
- As for benefits, you only need to write down the benefits of the interventions that you selected. You need to think about the benefits in the short term and long term both for people who are going to live in your area and the environment.
- Once you have filled out the table, please stick icons of the interventions that members selected for the project on the master plan. It will be used for a group presentation.

- In the summary section, answer the questions.

Table

Required minimum points: _____

Components	Interventions	Points	Prices	Costs	Benefits	Selections
Component 1: Risk Reduction	Construct building to meet 110-mile wind load design requirements of the Virginia Uniform Statewide Building Code	2.00	Engineered Wood Siding: $5 per square foot; Vinyl Siding: $3 per square foot			
	Elevate the ground story finished floor and all significant electrical and mechanical equipment no less than 3 feet above highest adjacent grade	2.00	$10 per square foot of the house			
	Construct an impact-resistant (hail, tree damage) roof (do not require an anti-fungal product)	1.00	$5 per square foot			
	Install impact (hurricane or wind) resistant windows	0.50	$50 per square foot			
Total Points and Cost						
Component 2: Stormwater Management	Install a green roof on at least 50% of the total roof area	2.00	$10 per square foot			
	Install a green roof on at least 25% of the total roof area	1.00	$10 per square foot			
	Provide a rain garden to capture site-generated stormwater	1.00	$10 per square foot			
	Use pervious or grass paving systems on at least 50% of parking lot and driveway area in the development	0.5	Pervious concrete: $20 per square foot; porous			

			asphalt: $3 per square foot			
	For new tree plantings, enhance tree pits with specially engineered soils to absorb and filter runoff	0.25	$1,500 per tree			
Total Points and Cost						
Component 3: Energy Resilience	Generate no less than 75% of the electricity expected to be used by the development from on-site solar energy sources	3.00	$16,000			
	Generate no less than 25% of the electricity needed expected to be used by the development from on-site solar energy sources	1.00	$5,000			
	Install a geothermal energy heating & cooling system	1.00	$12,000			
	Install green walls on a minimum of 200 square foot of the primary building's walls	1.00	$150 per square foot			
Total Points and Cost						
Combined Total Points and Cost (all components)						

Summary

- ☐ Could you define zoning ordinance and the Resilience Quotient system?

- ☐ What risks does your area have?

- ☐ Please describe how the Resilience Quotient works to reduce risks and enhance community resilience.

- ☐ In the activity, you carried out the Resilience Quotient system for your project. How many points did you decide on earning? What is your total cost for all components?

- ☐ Please interpret your selection of interventions in each component.
    - What are the requirements for your project?

    - What are the goals of your project in risk reduction, stormwater management, and energy resilience?

    - Why did you choose those interventions?

    - Please describe the points and costs for each component and in total.

    - Which component had the most points that you selected? Why did you choose them? Please describe the short-term and long-term benefits of these interventions, both for people who are going to live in your area and for the environment.

    - What were the most expensive and cheapest interventions that you selected? Why did you choose them? What are the benefits of the intervention in the short term and long term, both for people who are going to live in your area and for the environment?

- ☐ Could you develop new interventions that are not included in the existing RQ table? If so, please provide pros and cons of the new interventions.

Present the Results and Discussion

Each group will have 5 minutes to show the master plan with illustration elements of intervention icons 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 intervention items?
- What were the differences of goals among the three projects? What risks does your area have? Could these strategies be used to help?
- How did the results in Group A compare with Group B? With Group C? (Points, costs, and benefits)
- What kinds of interventions have more benefits for each group in the long term? Why?
- What are the new interventions for each group? Are there any differences between them?

Exit Ticket
Students will need to write a short paragraph (less than 500 words) to summarize their findings for the group scenario of the Resilience Quotient system.

Date: _____

Member names: _____

Group B
Resilience Quotient Compliance for
Multi-Family Residential Development

Objectives

- You and your team will use the materials provided to practice how developers use the point table to comply with the Resilience Quotient (RQ) standards for multi-family residential development required by the city of Norfolk.
- Your multi-family residential development project will demonstrate that you understand the RQ points and recognize the benefits and costs of resilient interventions and how they can promote community resilience.

General Instructions

- Your team, as a developer, would like to construct a multiple dwelling project with 100 units on site B of Norfolk. The project is a building with 3 stories. One floor has 9,000 square feet (sq. ft) and 10 units per floor. The area of the roof is 10,000 sq. ft. This project has 150 parking spaces (24,000 sq. ft). The shape of the building is a rectangle. Its length is 150 feet, the width is 60 feet, and the height is 10 feet (Figure 1). Each unit has 900 sq. ft and three windows. Each window size is 6 sq. ft=2 feet (width) x 3 feet (height). Your project plans to attract buyers by conducting more public open space in order to build a healthy and cozy environment. Your company's budget is sufficient. We will only calculate the construction material costs in the table without the installation and maintenance costs.

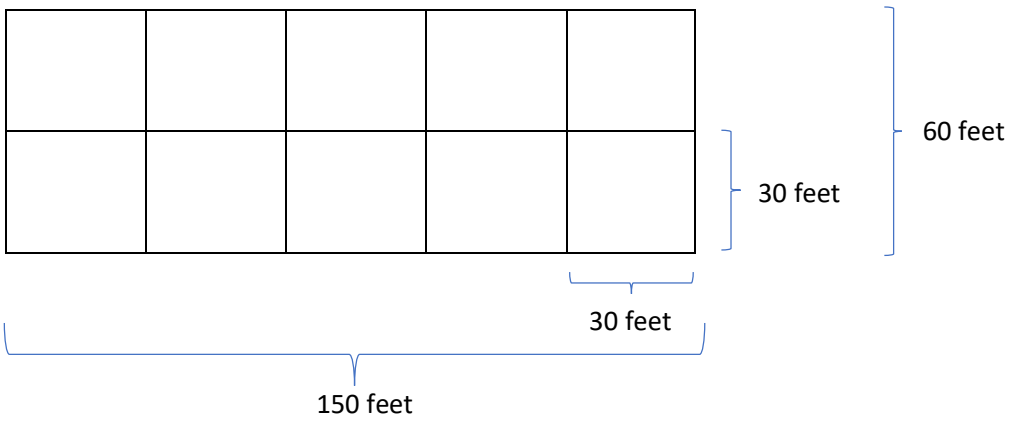

Figure 1. Plan for one floor of the apartment

- The city of Norfolk set up the minimum point requirements based on the number of dwelling units of a project.
  - 1 to 5 units: 4 points total, no less than 1 point per component.

- 6 to 29 units: 5 points total, no less than 1.5 points per component.
- 30 to 89 units: 6 points total, no less than 1.5 points per component.
- 90 to 199 units: 8 points total, no less than 2 points per component.
- 200 or more units: 10 points total, no less than 2 points per component.

- Since site B is in the coastal zone of Norfolk with a higher flooding risk, the city requires that each new multi-family project must elevate the ground floor and all significant electrical and mechanical equipment no less than 3 feet above the highest adjacent grade.
- You are about to decide how many points you want to earn. You also need to consider the costs and benefits of interventions in the point table that are suitable for your project. Your company plans to have a 5,000-square-foot rain garden on site. You also would like to do a green roof. There are four large, non-exotic trees on site.

Your Actions

- Fill out the table below. Carefully calculate points and costs of interventions.
- As for benefits, you only need to write down the benefits of the interventions that you selected. You need to think about the benefits in the short term and long term, both for people who are going to live in your area and the environment.
- Once you have filled out the table, please stick icons of the interventions that members selected for the project on the master plan. It will be used for a group presentation.
- In the summary section, answer the questions.

Table

Required minimum points: _____

Components	Interventions	Points	Prices	Costs	Benefit	Selection
Component 1: Risk Reduction	Construct building to meet 110-mile wind load design requirements of the Virginia Uniform Statewide Building Code	2.00	Engineered Wood Siding: $5 per square foot; Vinyl Siding: $3 per square foot			
	Elevate the ground story finished floor and all significant electrical and mechanical equipment no less than 3 feet above highest adjacent grade	2.00	$10 per square foot			
	Construct an impact-resistant (hail, tree damage) roof (do not	1.00	$5 per square foot			

	require an anti-fungal product)					
	Install impact (hurricane or wind) resistant windows	0.50	$50 per square foot			
Total Points and Cost						
Component 2: Stormwater Management	Install a green roof on at least 50% of the total roof area	2.00	$10 per square foot			
	Install a green roof on at least 25% of the total roof area	1.00	$10 per square foot			
	Provide a rain garden to capture site-generated stormwater	1.00	$10 per square foot			
	Use pervious or grass paving systems on at least 50% of parking lot and driveway area in the development	0.5	Pervious concrete: $20 per square foot; porous asphalt: $3 per square foot			
	Provide a fenced, centrally-located community garden space (which may be located as a rooftop garden) for residents and for urban gardening purposes at a ratio of 50 square feet per residential dwelling unit	1.00	$10 per square foot			
	For new tree plantings, enhance tree pits with specially engineered soils to absorb and filter runoff	0.25	$1,500 per tree			
	Preserve large, non-exotic trees on site (large tree defined as 20 feet or greater in height and 24 inches or	0.10 per tree preserved	$1,000 per tree per year (tree trimming cost)			

	greater diameter at breast height)					
Total Points/Cost						
Component 3: Energy Resilience	Generate no less than 75% of the electricity expected to be used by the development from on-site solar energy sources	3.00	$400,000			
	Generate no less than 25% of the electricity needed expected to be used by the development from on-site solar energy sources	1.00	$150,000			
	Install a geothermal energy heating & cooling system	1.00	$180,000			
	Install green walls on a minimum of 200 square foot of the primary building's walls	1.00	$150 per square foot			
	Provide electric vehicle (EV) level 2 charging stations, located in a parking structure or off-street parking lot, that are made available for use by residents	0.25 for every two stations	$3,500 per station			
Total Points/Cost						
Combined Total Points and Cost (all components)						

Summary

- ☐ Could you define zoning ordinance and the Resilience Quotient system?

- ☐ What risks does your area have?

- ☐ Please describe how the Resilience Quotient works to reduce risks and enhance community resilience.

- ☐ In the activity, you carried out the Resilience Quotient system for your project. How many points did you decide on earning? What is your total cost for all components?

- ☐ Please interpret your selection of interventions in each component.
    - What are the requirements for your project?

    - What are the goals of your project in risk reduction, stormwater management, and energy resilience?

    - Why did you choose those interventions?

    - Please describe the points and costs for each component and in total.

    - Which component had the most points that you selected? Why did you choose them? Please describe the short-term and long-term benefits of these interventions, both for people who are going to live in your area and for the environment.

    - What were the most expensive and cheapest interventions that you selected? Why did you choose them? What are the benefits of the intervention in the short term and long term, both for people who are going to live in your area and for the environment?

- ☐ Could you develop new interventions that are not included in the existing RQ table? If so, please provide pros and cons of the new interventions.

Present the Results and Discussion

Each group will have 5 minutes to show the master plan with illustration elements of intervention icons 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 intervention items?
- What were the differences of goals among the three projects? What risks does your area have? Could these strategies be used to help?
- How did the results in Group A compare with Group B? With Group C? (Points, costs, and benefits)
- What kinds of interventions have more benefits for each group in the long term? Why?
- What are the new interventions for each group? Are there any differences between them?

Exit Ticket
Students will need to write a short paragraph (less than 500 words) to summarize their findings for the group scenario of the Resilience Quotient system.

Date: _____

Member names: _____

Group C
Resilience Quotient Compliance for
Non-Residential Development

Objectives

- You and your team will use the materials provided to practice how developers or property owners use the point table to comply with the Resilience Quotient (RQ) standards for non-residential development required by the city of Norfolk.
- Your non-residential development project will demonstrate that you understand the RQ points and recognize the benefits and costs of resilient interventions and how they can promote community resilience.

General Instructions

- Your team, as a developer, would like to build a 30,000-square-foot warehouse on site C of Norfolk. The warehouse only has one story without windows and has 250 parking spaces (40,000 square feet). The shape of the warehouse is a rectangle. Its length is 300 feet, the width is 100 feet, and the height is 30 feet. The area of the roof is 31,000 square feet (sq. ft). Your team plans to support energy resilience and produce less greenhouse gas in order to take social responsibility to make more contributions to community resilience. Your company's budget is sufficient. We will only calculate the construction material costs in the table without the installation and maintenance costs.
- The city of Norfolk set up the minimum point requirements based on the number of areas of a project.
  - Less than 10,000 sq. ft.: 3 points total, no less than 1 point per component.
  - 10,000 to 25,000 sq. ft.: 4 points total, no less than 1.5 points per component.
  - 25,000 to 50,000 sq. ft.: 6 points total, no less than 1.5 points per component.
  - Above 50,000 sq. ft.: 10 points total, no less than 2 points per component.
- You are about to decide how many points you want to earn. You also need to consider the costs and benefits of interventions in the point table that are suitable for your project. The warehouse will have two critical facilities outside of the building. Your company plans to have a LEED certificate and plans to have a 1,000-square-foot rain garden on the ground. You also would like to do a green roof. There are four large, non-exotic trees on site. Site C is in the hurricane zone of Norfolk with a lower flooding risk. [Leadership in Energy and Environmental Design (LEED) is a green building certification program used worldwide.]

Your Actions

- Fill out the table below. Carefully calculate points and costs of interventions.
- As for benefits, you only need to write down the benefits of the interventions that you selected. You need to think about the benefits in the short term and long term, both for people who are going to live in your area and the environment.

- Once you have filled out the table, please stick icons of the interventions that members selected for the project on the master plan. It will be used for a group presentation.
- In the summary section, answer the questions.

Table

Required minimum points: _____

Components	Interventions	Points	Prices	Costs	Benefit	Selection
Component 1: Risk Reduction	Construct building to meet 110-mile wind load design requirements of the Virginia Uniform Statewide Building Code	2.00	Engineered Wood Siding: $5 per square foot; Vinyl Siding: $3 per square foot			
	If the project involves a critical facility that is intended to remain operational in the event of a flood, design the facility to be protected and operable at the water levels represented by a 0.2% annual chance (500-year) flood	0.50	$10,000 per facility			
	Elevate the ground story finished floor and all significant electrical and mechanical equipment no less than 3 feet above highest adjacent grade	2.00	$10 per square foot			
Total Points and Cost						
Component 2: Stormwater Management	Install a green roof on at least 50% of the total roof area	2.00	$10 per square foot			
	Install a green roof on at least 25% of the total roof area	1.00	$10 per square foot			

	Provide a rain garden to capture site-generated stormwater	1.00	$10 per square foot			
	Use pervious or grass paving systems on at least 50% of parking lot and driveway area in the development	0.5	Pervious concrete: $20 per square foot; porous asphalt: $3 per square foot			
	Provide a fenced, centrally-located community garden space (which may be located as a rooftop garden) for residents and for urban gardening purposes at a ratio of 50 square feet per residential dwelling unit	1.00	$10 per square foot			
	For new tree plantings, enhance tree pits with specially engineered soils to absorb and filter runoff	0.25	$1,500 per tree			
	Preserve large, non-exotic trees on site (large tree defined as 20 feet or greater in height and 24 inches or greater diameter at breast height)	0.10 per tree preserved	$1,000 per tree per year (tree trimming cost)			
Total Points/Cost						
Component 3: Energy Resilience	Generate no less than 75% of the electricity expected to be used by the development from on-site solar and/or wind energy sources	3.00	$800,000			

	Generate no less than 25% of the electricity needed expected to be used by the development from on-site solar and/or wind energy sources	1.00	$300,000			
	Install a geothermal energy heating & cooling system	1.00	$180,000			
	Install green walls on a minimum of 200 square foot of the primary building's walls	1.00	$150 per square foot			
	Provide electric vehicle (EV) level 2 charging stations, located in a parking structure or off-street parking lot, that are made available for users	0.25 for every two stations	$3,500 per station			
Total Points/Cost						
Combined Total Points and Cost (all components)						

Summary

- ☐ Could you define zoning ordinance and the Resilience Quotient system?

- ☐ What risks does your area have?

- ☐ Please describe how the Resilience Quotient works to reduce risks and enhance community resilience.

- ☐ In the activity, you carried out the Resilience Quotient system for your project. How many points did you decide on earning? What is your total cost for all components?

- ☐ Please interpret your selection of interventions in each component.
    - What are the requirements for your project?

    - What are the goals of your project in risk reduction, stormwater management, and energy resilience?

    - Why did you choose those interventions?

    - Please describe the points and costs for each component and in total.

    - Which component had the most points that you selected? Why did you choose them? Please describe the short-term and long-term benefits of these interventions, both for people who are going to live in your area and for the environment.

    - What were the most expensive and cheapest interventions that you selected? Why did you choose them? What are the benefits of the intervention in the short term and long term, both for people who are going to live in your area and for the environment?

- ☐ Could you develop new interventions that are not included in the existing RQ table? If so, please provide pros and cons of the new interventions.

Present the Results and Discussion

Each group will have 5 minutes to show the master plan with illustration elements of intervention icons 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 intervention items?
- What were the differences of goals among the three projects? What risks does your area have? Could these strategies be used to help?
- How did the results in Group A compare with Group B? With Group C? (Points, costs, and benefits)
- What kinds of interventions have more benefits for each group in the long term? Why?
- What are the new interventions for each group? Are there any differences between them?

Exit Ticket
Students will need to write a short paragraph (less than 500 words) to summarize their findings for the group scenario of the Resilience Quotient system.

Appendix B

Benefits of Resilience Quotient Interventions

Component 1: Risk Reduction

1.1 Benefits of Risk Reduction Interventions

- A. Interventions

  a. Construct a building to meet 110-mile wind load design requirements of the Virginia Uniform Statewide Building Code (VUSBC) (please use floor area to calculate).

  b. Elevate the ground floor and all significant electrical and mechanical equipment no less than 3 feet above the highest adjacent grade.

  c. Construct an impact-resistant (hail, tree damage) roof (do not require an anti-fungal product).

  d. Install impact (hurricane or wind) resistant windows.

- B. Benefits

  a. Economic Benefit
    - Reduce the financial impact of disasters, especially in terms of property damage.

  b. Social Benefits
    - Eliminate or minimize the risk of hazardous materials and substances that may be released by the project (Tina Hydropower Limited, 2017).
    - Prepare for disaster to improve community health, safety and security.
    - Encourage and provide means for adequate engagement with residents and builders.

  c. Environment Benefits
    - Apply technically and financially viable resource efficiency and pollution prevention principles and techniques that are best suited to avoid, or where avoidance is not possible, limit adverse impacts on human health and the environment (United Nations Human Settlements Program, 2021).
    - Avoid the generation of hazardous and non-hazardous waste materials.

1.2 Pros and Cons of Materials

A. Vinyl Siding

Vinyl siding is a long-lasting form of plastic that is often used on the outside of houses (Bernard, 2022).

- Pros

  a. Vinyl siding is a low-cost option and few siding materials are less expensive than vinyl siding.

  b. Vinyl siding requires less maintenance because it does not need painting. Its color is 100% homogeneous, which means the color cannot be abraded (Home Cabinet Expert, 2022).

  c. Vinyl siding lasts a long time and resists decay.

- Cons

  a. Vinyl siding is made mostly of polyvinyl chloride (PVC), and the manufacturing process produces greenhouse gases such as nitrogen oxide and carcinogens including dioxin. Another by-product of vinyl siding manufacturing is sulfur dioxide, which contributes to acid rain and smog (Home Cabinet Expert, 2022).

  b. Vinyl siding is a non-recyclable, man-made plastic that would stay indecomposable in a landfill for decades.

  c. If a house catches fire, the siding will emit lethal chemical vapors in high concentrations.

d. The US Green Building Council has rejected support for a credit specific to vinyl use, which influences builders to earn LEED points.

B. Engineered Wood Siding (EWS)
Engineered wood siding is constructed of wood fibers and durable resins (Woodtone, 2020).

- Pros
  a. EWS is less expensive than natural wood siding. It is more resistant to insects, mold and mildew than natural wood siding.
  b. EWS is easy to use, and the dust is non-toxic.
  c. The majority of EWS products are made from recycled wood and wood waste, so it is a green building material.
  d. EWS's production produces very little trash.

- Cons
  a. EWS needs ongoing painting and maintenance. Vibrance of colors can decrease over time.
  b. EWS could rot because of moisture.

Component 2: Stormwater Management
2.1 Benefits of Green Roofs
A green roof is a functioning roof for a house or other structure that uses plants instead of traditional roof coverings such as tile.

- a. With green roofs, water is stored by the substrate and then taken up by the plants from where it is returned to the atmosphere via transpiration and evaporation. In summer, green roofs can retain 70-90% of the precipitation that falls on them. In winter, green roofs can retain between 25-40% of the precipitation that falls on them (Green Roofs for Healthy Cities, n.d.).
- b. Green roofs do not only collect rainwater, but also moderate the temperature of the water and act as natural filters for any of the water that happens to run off.
- c. Green roofs minimize the amount of stormwater runoff and also delay the time at which runoff occurs, resulting in decreased stress on sewer systems at peak flow periods (Green Roofs for Healthy Cities, n.d.).
- d. Through the daily dew and evaporation cycle, plants on vertical and horizontal surfaces are able to cool cities during hot summer months and reduce the Urban Heat Island (UHI) effect. The light absorbed by vegetation would otherwise be converted into heat energy (Green Roofs for Healthy Cities, n.d.).
- e. Green roofs can also help reduce the distribution of dust and particulate matter throughout the city, as well as the production of smog. This can play a role in reducing greenhouse gas emissions and adapting urban areas to a future climate with warmer summers.

2.2 Benefits of Rain Gardens
Rain does not sink into the ground when it falls over impervious surfaces, resulting in stormwater runoff, which takes up pollution. However, when rain falls on natural areas, it is slowed down, filtered by soil and plants, and allowed to soak back into the earth. Rain gardens are functional landscaped areas designed with the purpose of capturing and filtering stormwater before it runs off into storm drains (Rain Garden Network, 2021).

- a. Pollution Control
  Rain gardens filter out sediment and other pollutants (like animal waste, brake dust, oils and

automotive chemicals) by capturing the first flush of rain (or first inch or so of rainwater runoff) which tends to contain the highest concentration of pollutants (Rain Garden Network, 2021).

- b. Flooding Protection
  By placing a rain garden, at least, 10 feet away from your home or other structures and directing rainwater runoff into the rain garden, it is possible to limit the amount of rain that runs into your basement and toward the sewer. By retaining this relatively clean water and allowing it to sink into the earth, a rain garden can prevent localized floods, replenish the local groundwater and enhance water quality.
- c. Habitat Creation
  Rain gardens should always be planted with "deep-rooted native plants". Deep-rooted plants are used to infiltrate rainwater in wet times and sense and locate water in dry times. Native plants are required for the rain garden, primarily, because they are adapted to the climate, seasons and weather and will have the best chance of survival. These plants will also attract and provide shelter and food for wildlife and support pollinators. Native plants will support a variety of birds, butterflies, beneficial insects, and other wildlife by providing diverse habitats and food supplies.
- d. Water Conservation
  Rain gardens capture and store rainwater, allowing it to slowly sink into the ground. This reduces the need to water a rain garden after it is established, allowing the garden and surrounding landscape to consume less municipal water. This decreases the need for and cost of watering your rain garden.

2.3 Benefits of Pervious or Grass Paving Systems

Pervious or grass paving systems for parking areas and other hard surfaces allow rainfall to percolate through the paving and into the ground before it runs off, while impervious pavement is the major source of stormwater runoff (Un, 2010).

- a. Pervious or grass pavement systems replenish the groundwater while reducing stormwater runoff. Permeable paving can permeate up to 70% to 80% of yearly rainfall, depending on design, paving material, soil type, and rainfall (Un, 2010).
- b. Pervious or grass paving systems can dramatically lower peak discharge rates by directing stormwater into the ground and away from the pipe-and-pond stormwater management system (Un, 2010).
- c. Grass pavers can enhance the aesthetic of a place by adding greenery to areas where there would otherwise be simply pavement (Un, 2010).
- d. Pervious or grass paving systems increase the effective developable area on a site since portions of the stormwater management system are positioned under the paved areas, and the infiltration provided by permeable paving can greatly minimize the demand for large stormwater management structures on a site (Un, 2010).

2.4 Benefits of New Tree Plantings with Engineered Soils and Native Plants

A structural soil mix, also known as an engineered or load-bearing soil, offers a promising alternative medium with a high porosity for planting in pits (Lewis, 2014).

- a. Using engineered soils to establish new tree plantings can give both room and nutrients for trees. Engineered soil can boost rooting chances in a variety of streetscape situations and meet loading standards, such as for particular cars (Lewis, 2014).
- b. Using engineered soils to grow new trees can help minimize runoff and manage stormwater. The aggregate mix has void space that accommodates runoff (Lewis, 2014).

- c. Soil, roots, and soil biota filter stormwater, which removes trace levels of harmful chemicals such as metals, organic compounds, fuels, and solvents (Lewis, 2014).

Component 3: Energy Resilience

3.1 Benefits of on-site Solar Energy Source

Solar energy is produced by transforming heat energy from the sun into electrical energy. It is also called "clean energy." The tool usually is solar panels.

- a. Generating energy that emits no greenhouse gases and reduces some forms of air pollution.
- b. Diversifying energy supply and decreasing reliance on imported fuels.
- c. Creating economic development and jobs in manufacturing, installation, and other areas.

3.2 Benefits of A Geothermal Energy Heating & Cooling System

Geothermal energy is another "clean energy" and geothermal technology uses the Earth's heat. Just a few feet below the surface, the Earth maintains a near-constant temperature (Carbon Valley Heating and Air, 2017).

- a. Green

  Geothermal heating and cooling systems are environmentally friendly. In fact, it was even named the best ecologically friendly heating and cooling system by the U.S. Environmental Protection Agency. It consumes very little electricity to move heat energy into your home. It doesn't burn fossil fuels either (Carbon Valley Heating and Air, 2017).

- b. Lower Utility Bills

  Unlike traditional heating systems, a geothermal heat pump simply moves heat from one place to another. It also requires a lot less energy to cool your home because the temperatures beneath remain a relatively constant 50 degrees Fahrenheit year-round (Carbon Valley Heating and Air, 2017).

  For those who are looking for ways to reduce their energy cost, a geothermal system would be an excellent choice. In fact, it can help save 20-50% on the cooling cost and 30-60% on the heating cost. However, a geothermal system is quite expensive. This is why a lot of homeowners are hesitant to install it in their home (Carbon Valley Heating and Air, 2017).

- c. Longevity

  The average lifespan of the Heating, Ventilation, and Air Conditioning (HVAC) system is between 13 and 15 years. Geothermal systems, on the other hand, typically last for roughly 24 years. They can even last for up to 50 years if properly cared for. They just require periodic checks and very little maintenance as compared to ordinary systems (Carbon Valley Heating and Air, 2017).

- d. Safety

  Unlike traditional heating systems, a geothermal system does not rely on fossil fuel energy. Instead, it uses free, renewable energy derived from underground. There is no risk of explosion, carbon monoxide poisoning or toxic fumes, and there are no combustion gasses. The safety of your home increases by using a geothermal HVAC system (Carbon Valley Heating and Air, 2017).

3.3 Benefits of Green Walls

The term "green walls" encompasses all forms of vegetated wall surfaces, including green facades, living walls, and retaining living walls (Ambius, n.d.).

- a. LEED Credits
  The installation of living green walls can earn buildings LEED points which, in turn, helps boost a property's value by establishing a positive perception of a structure with a lower carbon footprint (Ambius, n.d.).
- b. Improved Air Quality
  Green walls metabolize harmful toxins while releasing oxygen into the workplace air, similar to office plants but on a much larger scale (Ambius, n.d.).
- c. Energy Cost Reduction
  The interior and exterior living green walls use a mechanism called "evapotranspiration" to cool the air in the warmer summer months. The winter months see the added advantage of building insulation, thus reducing energy costs for heating the structure (Ambius, n.d.).
- d. Noise Level Reduction
  Green walls expand on this concept as vegetation 'naturally' blocks high frequency sounds while the supporting structure can help to diminish low frequency noise (Ambius, n.d.).
- e. Visual Benefits
  Green walls make a breathtaking statement by creating alluring and inviting environments. They are as equally impressive in appearance as they are purveyors of good health; the plants in the walls work as a natural air-filtration system that building occupants can enjoy (Ambius, n.d.).

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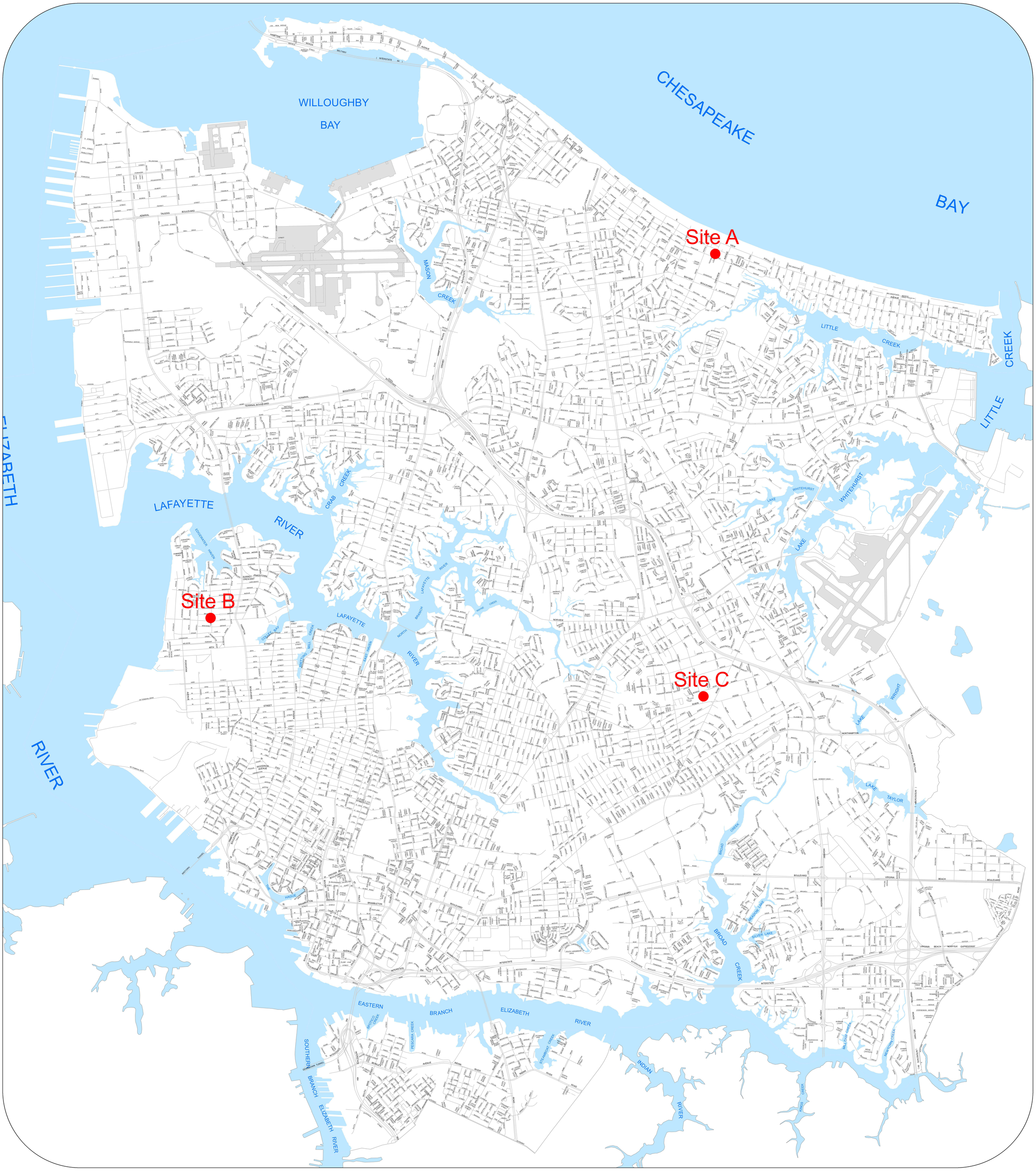
Street Map

City of Norfolk, Virginia



THE CITY OF NORFOLK

Map created by the Department of Information Technology, GIS Team;
and is intended for graphical purposes only.
Data maintained by the division of surveys and
Department of Public Works.
Date: August 2020

0 0.5 1 2 3 Miles

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W E
S

Appendix D

Point 2.00

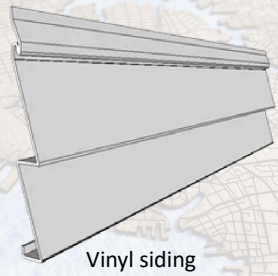
Component 1
Risk Reduction

Construct building to meet 110-mile wind load design requirements of the Virginia Uniform Statewide Building Code

Point 2.00

Point 2.00

Component 1
Risk Reduction



Construct building to meet 110-mile wind load design requirements of the Virginia Uniform Statewide Building Code

Point 2.00

Point 2.00

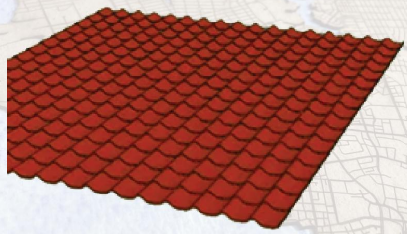
Component 1
Risk Reduction

Elevate the ground story finished floor and all significant electrical and mechanical equipment no less than 3 feet above highest adjacent grade

Point 2.00

Point 1.00

Component 1
Risk Reduction

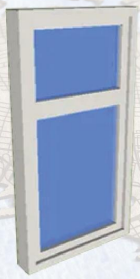


Construct an impact-resistant (hail, tree damage) roof (do not require an anti-fungal product)

Point 1.00

Point 0.50

Component 1
Risk Reduction



Install impact (hurricane or wind) resistant windows

Point 0.50

Point 0.50

Component 1
Risk Reduction

If the project involves a critical facility that is intended to remain operational in the event of a flood, design the facility to be protected and operable at the water levels represented by a 0.2% annual chance (500-year) flood.

Point 0.50

Point 2.00

Component 2
Stormwater Management

Install a green roof on at least 50% of the total roof area

Point 2.00

Point 1.00

Component 2
Stormwater Management

Install a green roof on at least 25% of the total roof area

Point 1.00

Point 1.00

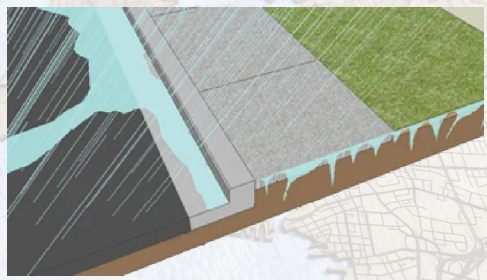
Component 2
Stormwater Management

Provide a rain garden to capture site-generated stormwater

Point 1.00

Point 0.50

Component 2
Stormwater Management



Use pervious or grass paving systems on at least 50% of parking lot and driveway area in the development

Point 0.50

Point 1.00

Component 2
Stormwater Management

Provide a fenced, centrally-located community garden space (which may be located as a rooftop garden) for residents and for urban gardening purposes at a ratio of 50 square feet per residential dwelling unit

Point 1.00

Point 0.25

Component 2
Stormwater Management

For new tree plantings, enhance tree pits with specially engineered soils to absorb and filter runoff

Point 0.25

Point 0.10

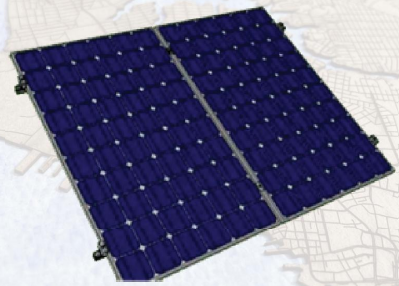
Component 2
Stormwater Management

Preserve large, non-exotic trees on site (large tree defined as 20 feet or greater in height and 24 inches or greater diameter at breast height)

Point 0.10

Point 3.00

Component 3
Energy Resilience

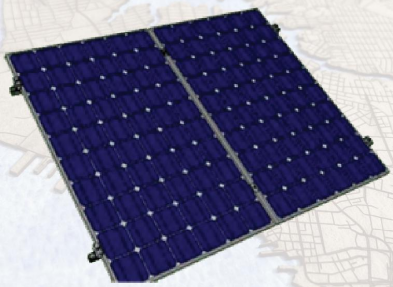


Generate no less than 75% of the electricity expected to be used by the development from on-site solar energy sources

Point 3.00

Point 1.00

Component 3
Energy Resilience

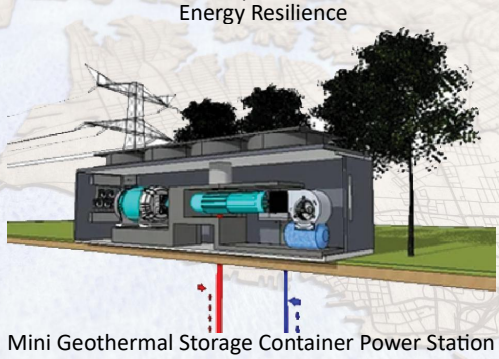


Generate no less than 25% of the electricity expected to be used by the development from on-site solar energy sources

Point 1.00

Point 1.00

Component 3
Energy Resilience



Mini Geothermal Storage Container Power Station

Install a geothermal energy heating & cooling system

Point 1.00

Point 1.00

Component 3
Energy Resilience

Install green walls on a minimum of 200 square foot of the primary building's walls

Point 1.00

Point 0.25

Component 3
Energy Resilience

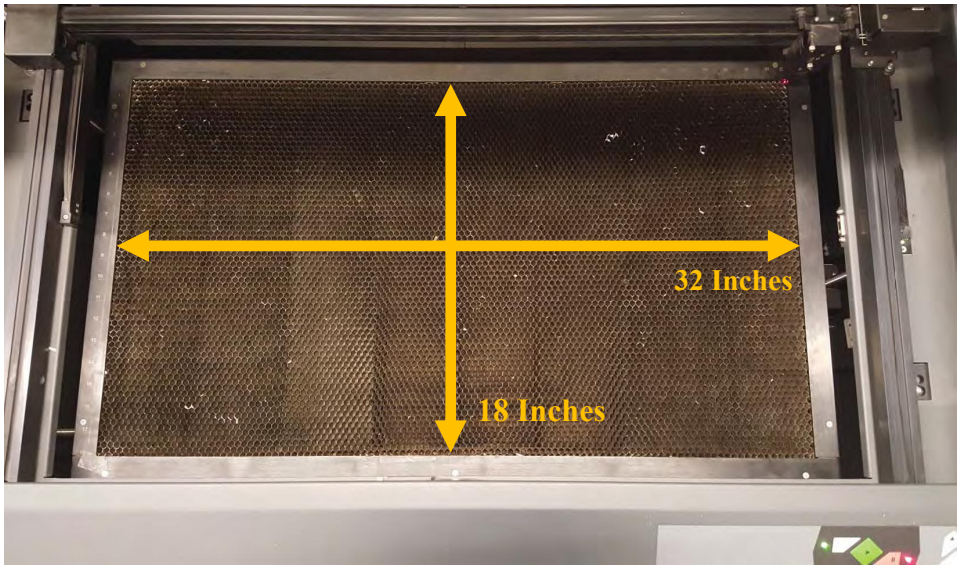
Provide electric vehicle (EV) level 2 charging stations, located in a parking structure or off-street parking lot, that are made available for use by residents

Point 0.25

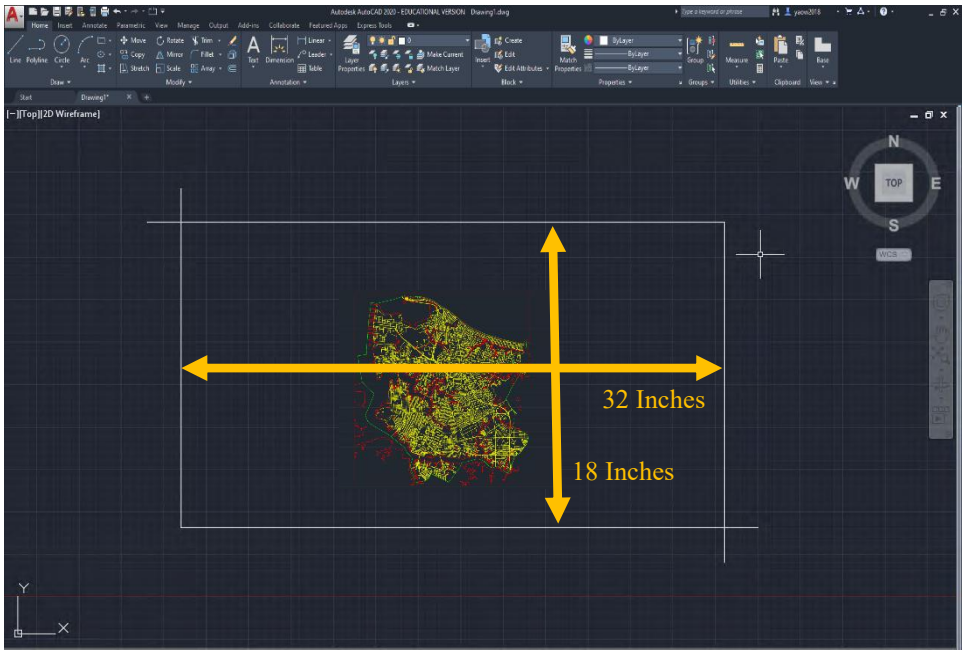
Appendix F

3D Model Development Instruction

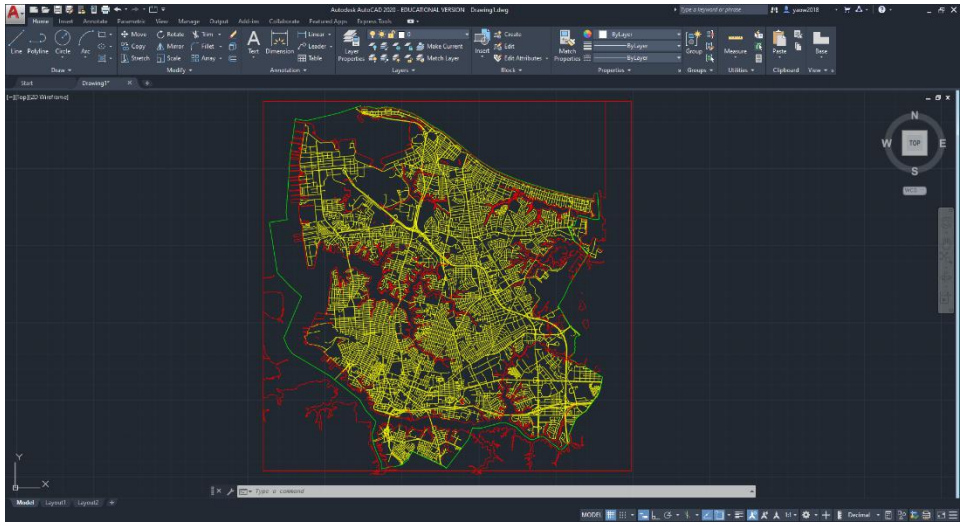
1. The bed size is 18 by 32 inches. This is the maximum “printable” area. The material should be cut down to 18 by 32 inches.



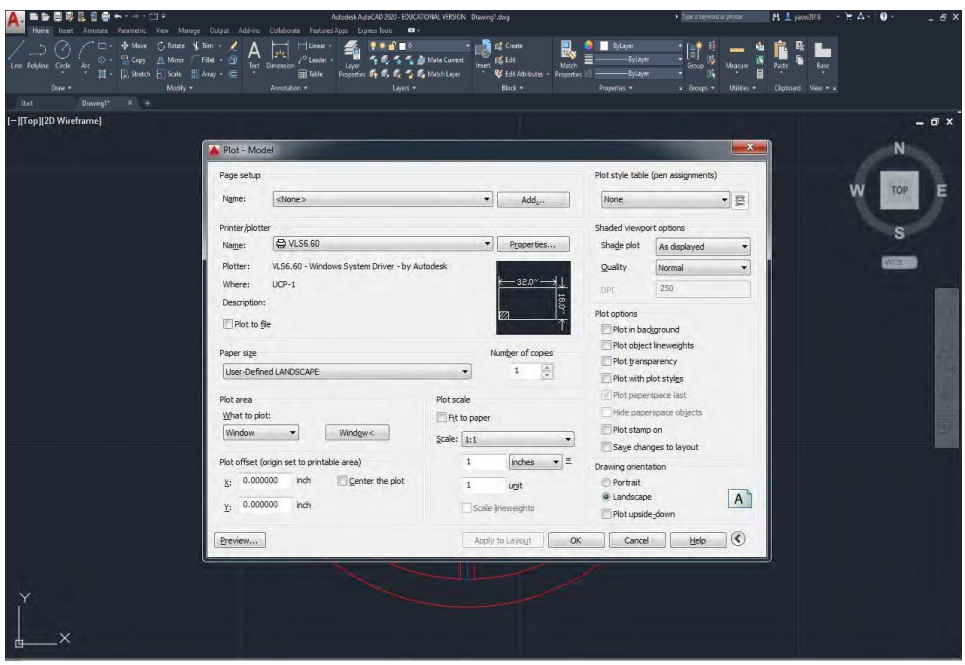
2. Scale your drawing to the size you require it to come out of the laser cutter. Draw a bounding box to help keep the printable area.



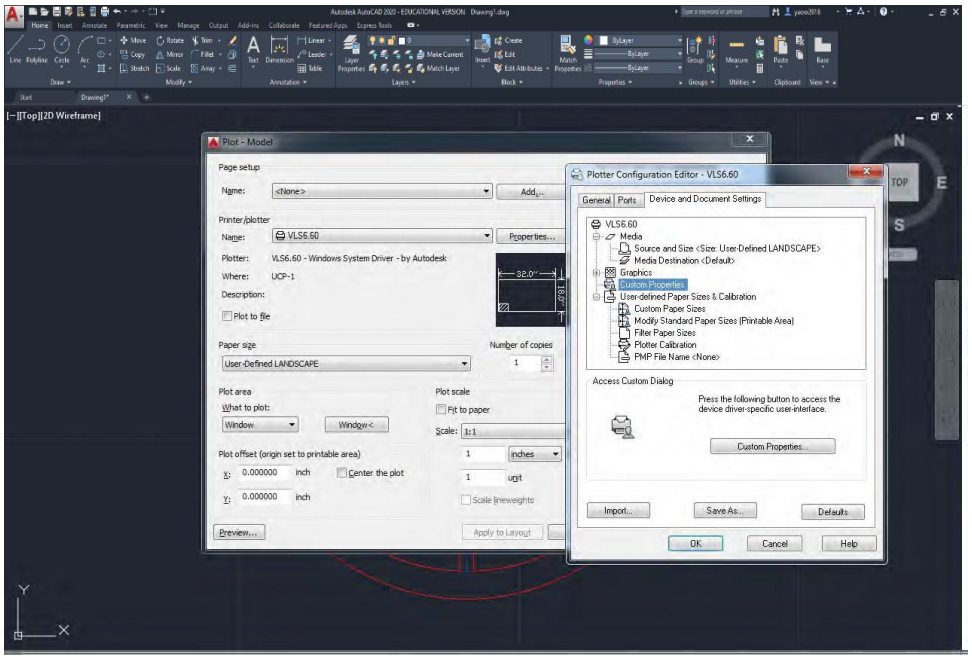
3. In this model, red is the cutting layer, yellow is the primary etching layer, and green is the secondary etching layer.



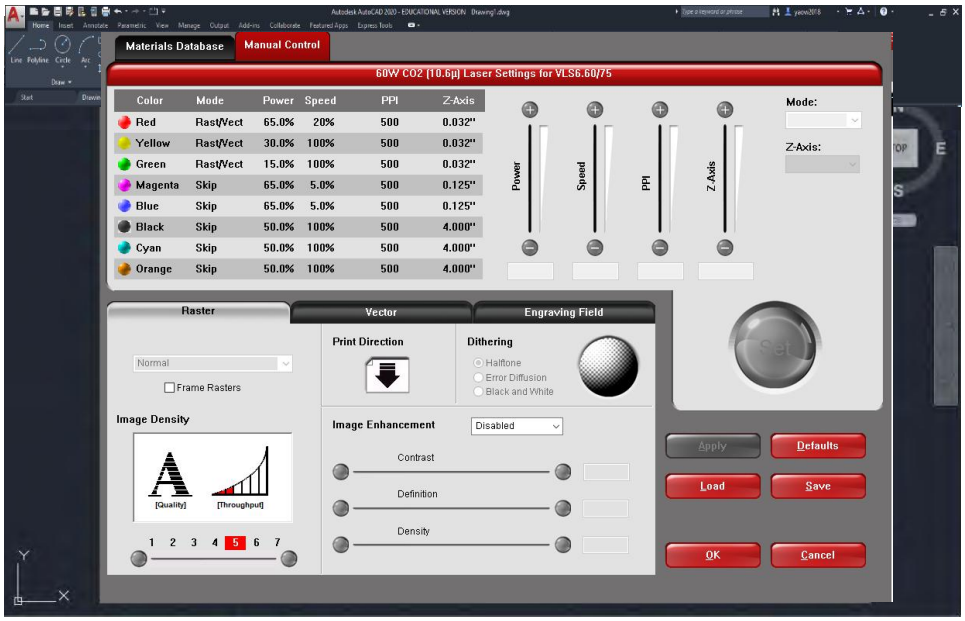
4. When the line weights and colors are set, send the linework to the UCP (Universal Control Panel) by “printing” to the VLS 6.6.



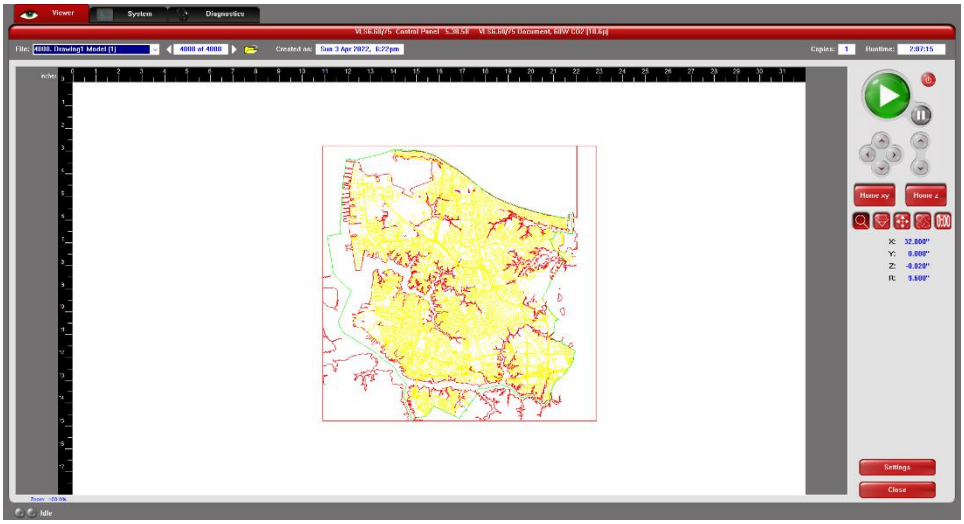
5. Select “Properties” next to the Printer/Plotter name. Select “Custom Properties” in the pop-up window that appears.



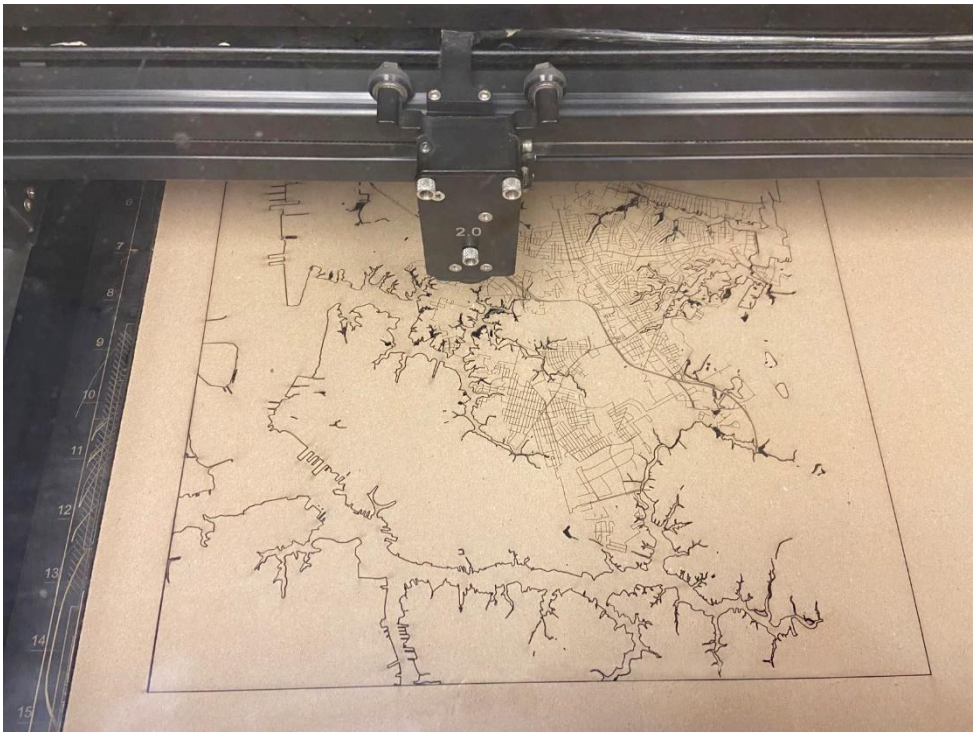
6. This is the settings interface for the UCP. Set Z-axis, power, and speed for each color.



7. Click the green button to start printing.



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



9. The final master plan is as below.

10. If you would like to have a topographic map, please find the elevation data of Norfolk in Appendix H.