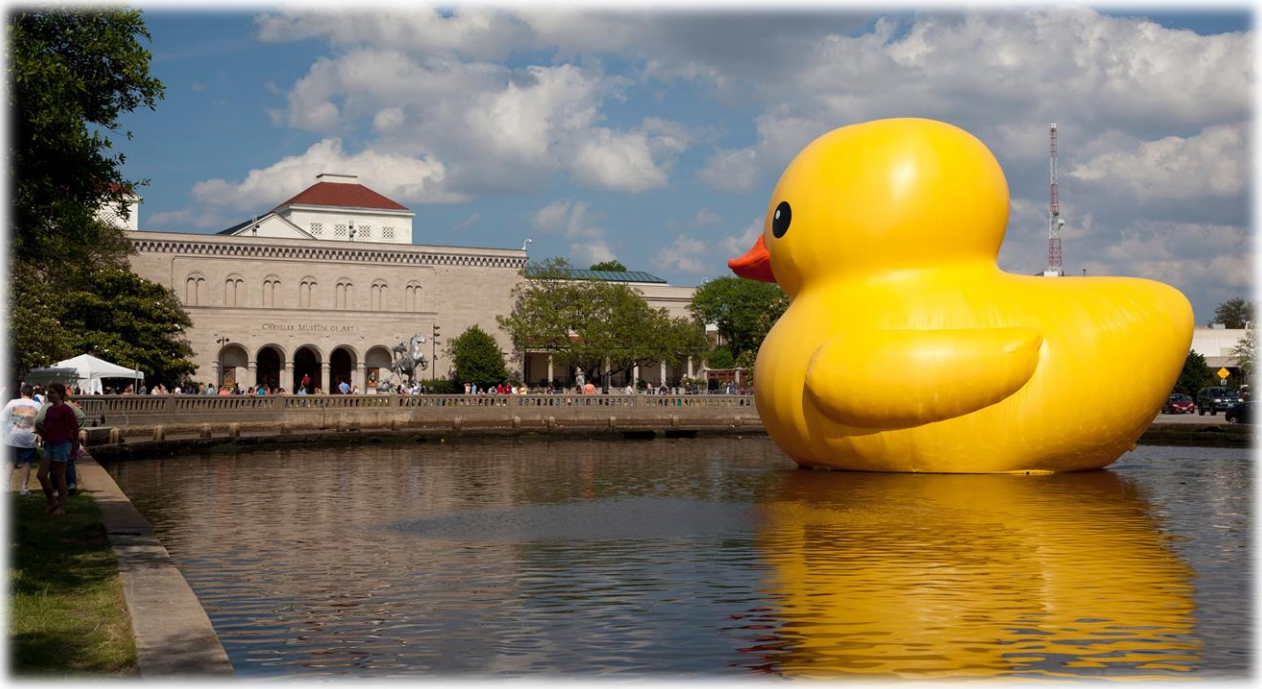
COASTAL COMMUNITY RESILIENCE CHALLENGE

TOPIC AREAS



VERSION 1.2 JUNE 5, 2018

RISE
Resilience Innovations

INTRODUCTION

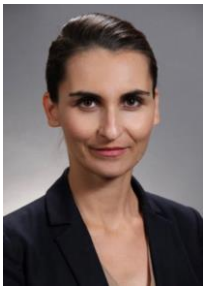
Thank you for considering participating in our Coastal Community Resilience Challenge! We appreciate your time and interest.

This document elaborates on the Challenge topics and areas in need of innovative solutions. As you review this document, please keep in mind that:

- This is a living document that will continue to be updated. Please check the Challenge website frequently or/and register your interest here and we will notify you about updates.
- If you have questions about the topics please contact us and we will point you in the right direction.
- If you are unsure whether your solution fits the Challenge topics, or if you would like to propose a solution other than those suggested, please contact us. We would love to hear from you and see how we can help.
- We will release the full criteria for the RISE Resilience Innovation Fund in summer 2018; but at a minimum, to qualify for funding you must:
    a) Be a small business (as defined by the US Small Business Administration) or a non-profit entity.
    b) Have addressed the Hampton Roads Needs section of the topic, while showing scalability and replicability globally.
    c) Have a viable and sustainable business model for growth of the business.

At the end of this document, you will find links to relevant data sets. If you need additional data please contact us and we will try to track them down!

Dr. Paul Robinson
Executive Director, RISE



Dr. Katerina Oskarsson
Chief Strategy Officer, RISE

TOPIC 1: WATER MANAGEMENT

Develop cost-effective management of ground- storm- and/or tidal water, either as affordable short-term mitigations, or low-maintenance, long-term options in urban environments with high water tables.

DESCRIPTION OF THE PROBLEM

The urban watershed management problem combines the following:

- tidal flooding overtopping seawalls
- tidal flooding tailwater in stormwater pipes producing flooding inland
- aging and undersized stormwater infrastructure limiting effective drainage
- high water table/groundwater limiting ability to store water underground
- urban environment limiting access to existing infrastructure or new infrastructure installation

WHAT IS KNOWN, AND WHAT IS ALREADY BEING DONE

Gravity-flow and pumps are commonly used in low-lying areas to manage storm- and tidal- water. However, these approaches are often not sufficient to manage the water in times of high rainfall and/or tidal surges. This leads to flooded areas taking a long time to drain, especially during recurrent rainfall and surges.

Active control systems, such as the integration of remotely actuated pumps, valves, and other equipment, are becoming attractive alternatives to optimize the performance of an entire watershed especially in low-lying coastal areas. Such control may be less costly to operate and may provide significant advantages over gravity-only management.

Flood-level maps, topography, stormwater infrastructure, elevation maps and modeling outputs from various rainfall and coastal/tidal flood assessment studies for Norfolk and some of the other Hampton Roads cities are well developed and available. Examples can be seen in many of the Data Sets provided at the end of this document.

TRADITIONAL APPROACHES THAT HAVEN'T WORKED AND WHY

The region’s low elevations combined with high water table results in weak flow through the system. This can result in tidal water backing up in the stormwater

system leading to "blue sky" flooding and very limited drainage at times of high tide.

In addition, traditional long-term coastal and stormwater infrastructure approaches are neither affordable nor adaptable to uncertainty associated with sea-level rise rates. For instance, large pump stations are often employed at outfalls, but they are very costly to build, operate, and maintain. They also may not solve the flow limitations due to undersized stormwater pipes upstream. The capital replacement cost of the pumps themselves constitute well over 50% of the infrastructure maintenance costs. This can be an unmanageable burden for a city, and an opportunity for lower cost, autonomous, technology to play a role.

Also, methods of stormwater storage in high water table environments are limited, and new approaches are required.

SUGGESTED PROJECT TOPIC AREAS

Below are several suggested project topic areas. Each topic area provides a description of the Global Need as well as the Hampton Roads Need.

Submissions do not need to be limited to the suggested project topic areas. Please contact RISE of you wish to address other topic areas.

In either case, however, to be eligible for funding from the RISE Innovation Fund, entrants **must focus on a Hampton Roads Need**, while demonstrating the ability to scale to an associated Global Need example.

Links to supporting datasets are provided at the end of this document. Entrants are encouraged to review all the datasets as often no one dataset only applies to one problem. RISE may be able to provide additional data upon request.

Project 1.1: Improved Intersection Stormwater Management

Global Need: During flash rain events and storms, transportation networks often turn, by default, into superhighways for water. Roads, intersections, underpasses and other transportation assets could do more to help affordably mitigate flooding by holding, slowing or/and channeling water in desired directions. For instance, stormwater management at intersections consist of various passive methods of capturing, storing and releasing storm water runoff: curb "bump-outs", bio swales, vegetation, pervious surface, etc. Many cities employ these methods of stormwater management to help keep intersections

and surrounding assets clear of flooding as well as for beautification, traffic calming and water quality purposes. Significant increase in efficiencies and decrease in costs will be of interest to all communities managing stormwater.

Hampton Roads Need: As part of resilience infrastructure being implemented in the Norfolk's Ohio Creek area, several intersections will be modified to increase stormwater storage, enhance nutrient removal and reduce capital as well as operations and maintenance costs over the expected 20-year life of the project. The City already has a design and budget set aside for the construction of these intersections. However, innovative solutions are sought that will meet or improve the properties in the table below.

Property	Baseline Design
Intersection and bumpout/bioswale surface geometry	Fixed – see data sets
Total cost to install	$100 - 150K
O&M cost	$3,000 - $6,000 per year
Storage capacity	At least 8,400 cf
Discharge timeframe of standing water in bump-outs, bioswales, & pervious pavement	Less than 48 hours
Street standing water (for rainfall profile in data set)	Zero
Repair & replacement period	20 - 25 years
Repair & replacement Cost	$100 - 150K

Norfolk seeks to showcase innovative solutions that would meet or preferably exceed the existing design criteria for the above properties at the intersections. Selected solutions will be implemented and showcased at up to three (3) intersections in the Ohio Creek area to demonstrate functionality.

Additional value will be placed on those designs that incorporate methods to monitor, measure and report stormwater management effectiveness over the life of the installation.

Detailed data and baseline design graphics associated with one of the intersections is posted on the RISE website (see Intersection Datasets for Project Topic Area 1.1).

Project 1.2: Interim Infrastructure Solution

Global Need: Many neighborhoods in coastal communities need flood mitigations that may take a long time to implement and require amounts of funding that most vulnerable communities cannot afford. Needed are innovative technologies and approaches for a shorter term (up to ~5 years) low-cost (~$1M) interim mitigations that would "buy time" while allowing the communities to expand them over time.

Hampton Roads Need: A ~5-year/~$1M affordable, adaptable and scalable solution to mitigate flooding in Norfolk's Hague district for a 10-year storm, and 1.5' HHMW tidal flooding. It clearly is not possible to protect the entire Hague watershed for that cost, but this topic is looking for innovations addressing threat “hotspots” in this district and developing short-term low-cost mitigations.

Project 1.3: Active Watershed Management and Control

Global Need: Many cities have aging infrastructure and cannot afford large, costly pump stations with major maintenance requirements. Needed are affordable, autonomous water management solutions that can be controlled remotely. These may consist of remotely controlled valves, multiple small pumps, and other sensor networks integrated into decision making processes.

Hampton Roads Need: Affordable active control of water management in a coastal urban watershed that would remove the need for costly pumping equipment, while effectively managing street-level flooding. Provided datasets identify land elevation, flooding maps, and infrastructure.

TOPIC 2: DATA ANALYTICS

Propose data analytics, integration, and accessibility for multiple applications to help coastal community stakeholders maintain public safety, meet logistics needs, protect property, as well as enhance quality of life among other applications.

DESCRPTION OF THE PROBLEM

To reduce the risk of living on the coast and adapt to more frequent disruptions, coastal communities should utilize data and new sensor networks to improve their ability to:

- prepare for, respond to, and recover from disruptions
- navigate in an urban environment flooded by tidal and stormwater
- navigate emergency vehicles around obstacles/impassable roadways/underpasses
- interface real-time and forecast awareness of flooding (and other environmental conditions) with new technologies in a 3-5 year time horizon (e.g., smart city data, self-driving/autonomous vehicles and traffic control, augmented/virtual reality technologies, etc.).

WHAT IS KNOWN, AND WHAT IS ALREADY BEING DONE

There are many different data sources available:

- maps/topography/roadways/other infrastructure
- weather and tidal observations and forecasts including multiple flood level sensors distributed around city, roadways, and underpasses
- Hampton Roads has also been the subject of high-fidelity tidal flood forecast technologies accounting for tides, wind, weather forecast, and bathyspheric river floor information. Highly accurate tidal forecasts have been validated up to 36 hours in advance
- traffic congestion and obstructions
- real-time granular flood level measurement and reporting around the city.

In addition, RISE is evaluating several Internet of Things (IoT) communications networks that will be established in several Norfolk locations in the middle of 2018. These networks allow low-data rate communications with sensors, actuators, etc.

TRADITIONAL APPROACHES THAT HAVEN'T WORKED AND WHY

Several problems are typically encountered in data management in an urban environment:

- Data may not be integrated into user decision-making flow, e.g., traffic guidance software may not know water depth at a given urban intersection, and may guide traffic into unsafe conditions
- Data is not integrated into actionable real-time and/or forecast guidance/information for residents, businesses, and emergency services. This impedes medium- and short-term planning and operations
- Data may not be in a form or available for use by new technologies (e.g., autonomous cars, artificial intelligence, or augmented/virtual reality, etc.).

Issues of data commonality, access, and integration are the biggest issues facing the acceptance and use of data analytics in this topic area.

SUGGESTED PROJECT TOPIC AREAS

Below are several suggested project topic areas. Each topic area provides a description of the Global Need as well as the Hampton Roads Need.

Submissions do not need to be limited to the suggested project topic areas. Please contact RISE of you wish to address other topic areas.

In either case, however, to be eligible for funding from the RISE Innovation Fund, entrants **must focus on a Hampton Roads Need**, while demonstrating the ability to scale to an associated Global Need example.

Links to supporting datasets are provided at the end of this document. Entrants are encouraged to review all the datasets as often no one dataset only applies to one problem. RISE may be able to provide additional data upon request.

Project 2.1: Data Fusion for Improved Flooding Awareness

Global Need: Operations and living in coastal communities will always be affected by the weather and tides. The global ubiquity of existing technologies (smartphones, sensors, communications) will allow these solutions to be economically replicated around the world.

Hampton Roads Need: Problems can be mitigated in many cases by better awareness and prediction. This allows people and businesses to either plan

ahead or deal with impacts tactically in a more efficient manner. Achieving these improvements will involve:

1. Identifying data sources which contain conditions observed, predicted, historical or other information. Some examples of this data are:
    a. Terrain/elevation
    b. Traffic
    c. Environment (weather, tides, ground conditions, etc.)
    d. Business activities (e.g., for ports – ship schedules, ground transportation routes and schedules)
2. Fusion of data in ways that produce increased functionality and/or combined products.
3. Use of mobile devices (and other portable/wearable technologies) in ways that engage users and provide actionable information to alleviate the impacts of disruptions. Other platforms for information display may be considered.

Project 2.2: Sensor Networks

Global Need: Many cities have embarked on establishing Internet of Things "Smart City" infrastructures and open data policies. This leads to the availability of unprecedented amount of data and information on how citizens live and operate in a city. Needed are new and innovative technologies and approaches to use these data to increase individuals' resilience.

Hampton Roads Need: Capacity of individuals and systems can be improved by smart technologies and data analytics. Hampton Roads has established itself as a "living laboratory" where innovators can get access to city infrastructure (bridges, lampposts, buildings, etc.) as well as expedited permitting. Sensors may be installed and interfacing with city infrastructure may be considered.

TOPIC 3: BUILDING VIABILITY

Maintain the viability of existing buildings facing flood risks. What are the structural or non-structural alternatives beyond traditional approaches such as costly house elevation that individual homeowners could buy? Could these approaches protect buildings for 15 - 30 years in the flood environment? Are there cost effective protections against the higher frequency, lower magnitude recurrent flooding?

DESCRPTION OF THE PROBLEM

Buildings in flood plains experience different levels of flooding. Some buildings may experience several feet of flooding and may require substantial modification to remain viable (e.g., building elevation). Other may only experience a few inches (6-8 inches) and minor modifications may be required to avoid the costs of damage.

Many buildings experience up to 8" of flooding several times per year. To avoid recurring damage and insurance claims, effective, affordable and readily deployable remedies to against this flooding are needed.

Also of concern is how these modifications are to be paid for. Are costs shared amongst home/building owners, the City, and Insurance companies (or others)? What are viable and sustainable options for funding these efforts?

Homes in Norfolk Vision 2100's "Yellow Areas" are of particular interest (see the Supporting Data Sets section at the end of this document). These areas are established neighborhoods that experience more frequent flooding. The need is for innovative technologies and approaches to help reduce flood risk and increase resilience of key infrastructure.

WHAT IS KNOWN, AND WHAT IS ALREADY BEING DONE

Relevant datasets and interactive websites showing differences in a level of flooding on cities' parcels are available in the Supporting Data Sets section at the end of this document. While a number of houses in Hampton Roads have been elevated, this option is not practical solution due to the high costs, FEMA's backlog and a high number of historic structures.

Much work has been done on assessing the cost of protecting one of the Hampton Roads Cities, Norfolk, as a whole. An approximate cost of over $1B makes this an unlikely solution barring a significant disaster.

TRADITIONAL APPROACHES THAT HAVEN'T WORKED AND WHY

Raising a house is expensive and typically reserved for extreme cases and for buildings whose value greatly exceeds the cost of raising. Costs are typically paid for by the government, the homeowner, or the insurance companies. This is not a solution that is readily applied to large numbers of homes or buildings in a city.

The high cost of raising the house is not practical for those buildings experiencing relatively small depths (e.g., 8" or less) of flooding. However, many city's housing/buildings could be protected from this lower level of flooding provided cost effective solutions were available, even if the protection was just temporary during a flood.

There are some temporary, single building, solutions available but their cost has proven to prevent widespread implementation.

SUGGESTED PROJECT TOPIC AREAS

Below are several suggested project topic areas. Each topic area provides a description of the Global Need as well as the Hampton Roads Need.

Submissions do not need to be limited to the suggested project topic areas. Please contact RISE of you wish to address other topic areas.

In either case, however, to be eligible for funding from the RISE Innovation Fund, entrants **must focus on a Hampton Roads Need**, while demonstrating the ability to scale to an associated Global Need example.

Links to supporting datasets are provided at the end of this document. Entrants are encouraged to review all the datasets as often no one dataset only applies to one problem. RISE may be able to provide additional data upon request.

Project 3.1: Protection of Established Neighborhoods

Global Need: Coastal communities have established neighborhoods that experience more frequent flooding. Needed are new and innovative technologies

and approaches to help reduce flood risk, protect homes (at least temporarily) and extend the resilience of key infrastructure.

Hampton Roads Need: Yellow areas on Norfolk Vision 2100 maps (see Data Sets links at end of this document) are established neighborhoods that experience more frequent flooding. These adaptation areas need innovative technologies and approaches to help reduce flood risk and extend the resilience of key infrastructure.

Project 3.2: Amphibious Architecture

Global Need: Despite all efforts, some parts of coastal communities may have to be abandoned due to flood risk or employ radically different architectural approaches. Amphibious architecture (i.e., "floating" buildings) have been demonstrated around the world. Of increasing interest is to apply these concepts and lessons learned on a neighborhood wide scale.

Hampton Roads Need: Despite best efforts, several sections of Hampton Roads' neighborhoods cannot be fully protected from increased flooding. Affordable solutions to adapt or rebuild these building using amphibious architecture may be designed and demonstrated.

Project 3.3: Innovative Financing

Global Need: Regardless of location in the world, coastal communities have to grapple with how to pay for resilience remedies, whether on a property-by-property basis or on a wider neighborhood- or city- wide scale. Although the relative financial responsibilities between residents and governments vary from place to place, some cost sharing may be required.

Hampton Roads Need: Hampton Roads has established hierarchies amongst city, state, and the federal governments. Work has been done in understanding the relative cost and benefits to the region of protecting the city cores, but not much has been done in understanding how to reduce the costs of mitigations (e.g., economies of scale), or sharing the costs between the government agencies, the residents, and other entities (e.g., insurance companies). Sustainable solutions are sought that can be tested and demonstrated in Hampton Roads.

TOPIC 4: RE-ESTABLISHING CRITICAL UTILITIES

Re-establish and maintain critical systems functionality to a significant defined critical urban facility. Portable systems need to be deployed within 2 hours and provide 72 hours of continuous functionality to critical services.

DESCRPTION OF THE PROBLEM/THREAT

After an acute event, vital installations need to be made functional as soon as possible to prevent further degradation in the resilience of a community. The types of facilities to be considered in this topic are:

- A 250 bed Level I trauma center hospital
- Outpatient facilities
- A major company's IT center
- A city block

Critical functionalities include:

- Electricity
- Potable water and wastewater management
- Cell phone communications
- 911 access
- Internet access

The requirement is to bring **full functionality** within 2 hours for 72 hours.

Also important is including the placement of this equipment prior to an event so that it can be deployed quickly and with minimal additional disruption.

WHAT IS KNOWN, AND WHAT IS ALREADY BEING DONE

After a hurricane, flood, or other catastrophic event, the greatest threats to people and businesses come from the inability to resume normal operations. Prompt resumption of communications, emergency services, and basic needs are essential to the region’s resilience. Economic hardships are endured if people cannot get to work, and businesses of all sizes face significant costs due to disruptions to operations. There are even threats to public safety if emergency services cannot be contacted to help those in distress.

Important institutions such as hospitals, airports, and ports are affected. Small businesses such as gas stations, hardware stores, and food service providers provide essential services. Disruptions to them could result in their going out of business.

Safety is always a prime consideration after a disruptive event when utility companies work diligently to reestablish the infrastructure. This can take several days – after Hurricane Irene (2011) some services were only restored after 5 days.

TRADITIONAL APPROACHES THAT HAVEN'T WORKED AND WHY

Electrical power is usually provided by solar power, batteries, or gas/diesel generators (or a combination of all) for limited functionality of a facility; e.g., heating or air-conditioning only parts of the space, limited internet and other communications access. While this may be acceptable for some limited operations, it may lead to greater problems subsequently; e.g., lack of air conditioning may lead to condensation damage or mold in some parts of a hospital, irregular or limited communications may hinder a city's emergency management, or a company's IT facility may be down for a period.

SUGGESTED PROJECT TOPIC AREAS

Below are several suggested project topic areas. Each topic area provides a description of the Global Need as well as the Hampton Roads Need.

Submissions do not need to be limited to the suggested project topic areas. Please contact RISE of you wish to address other topic areas.

In either case, however, to be eligible for funding from the RISE Innovation Fund, entrants **must focus on a Hampton Roads Need**, while demonstrating the ability to scale to an associated Global Need example.

Links to supporting datasets are provided at the end of this document. Entrants are encouraged to review all the datasets as often no one dataset only applies to one problem. RISE may be able to provide additional data upon request.

Project 4.1: Deployable Critical Utilities for Major Installations

Global Need: Electricity, communications (including data), and water are some of the most important elements that need to be restored after an acute event.

They can be critical in helping a city or a major industry (ports, hospitals etc.) remain stable while it recovers. Capabilities currently exist that can be installed (permanently) at installations to provide that backup, but are expensive to implement and maintain at every installation particularly when they may not be needed. Needed is a deployable integrated unit that may be pre-deployed just prior to the event and readily implemented after an event.

Hampton Roads Need: Hampton Roads is home to some of the largest ports and regional hospitals. They have the ability to function at significantly reduced capability when utilities are disrupted. There is the opportunity to develop the deployable equipment and demonstrate how they may be pre-deployed, implemented after an event, and operate continuously for 72 hours. It is important that the design in no way impedes efforts to restore permanent utilities in the area.

TOPIC 5: RECONNECTING NEIGHBORHOODS

Enhance the economic prosperity of urban neighborhoods which have been disconnected physically, economically, digitally from the rest of a thriving city. This may require changing neighborhood from low-skill/low-income, to higher income by economic and training enhancements.

DESCRPTION OF THE PROBLEM/THREAT

Urban development can often result in some low-income communities being physically cut off from the surrounding city by highways, vacant land and other barriers. This often contributes to a cycle of low skill jobs, poverty, and lack of economic prosperity for the neighborhood, residents, and the city as a whole. This situation is often exacerbated by the lack and unaffordability of basic modern services (e.g., internet broadband, and access to convenient affordable transportation).

In addition, it can be difficult to attract some of the basic businesses (e.g., food stores, gas stations, etc.) to economically disadvantaged neighborhoods.

WHAT IS KNOWN, AND WHAT IS ALREADY BEING DONE

Reconnecting communities to a city may take several approaches. Building new roads or widening existing ones is a complicated, time consuming, and expensive process, and is not a viable option for many cities. Similarly, if a highway placement is a cause of disconnection, the removal of highways is often not an option. Providing additional bus routes and frequencies can be expensive especially if ridership is low. At the same time, ride-sharing companies tend not to serve lower income neighborhoods especially during busy period when their rates increase.

TRADITIONAL APPROACHES THAT HAVEN'T WORKED AND WHY

Adding city services (e.g., roads, bus routes and frequencies) increases a city's costs and may not benefit the neighborhood residents. Bus routes have proven to be less economically sustainable in their traditional forms and building new rail lines and services can be a lengthy and costly process.

Advances in communications, ride-sharing services, and remote-working apps may counter many of the effects of the physical disconnection of a neighborhood and make living and thriving there a more viable and an economically sustainable option.

SUGGESTED PROJECT TOPIC AREAS

Below are several suggested project topic areas. Each topic area provides a description of the Global Need as well as the Hampton Roads Need.

Submissions do not need to be limited to the suggested project topic areas. Please contact RISE of you wish to address other topic areas.

In either case, however, to be eligible for funding from the RISE Innovation Fund, entrants **must focus on a Hampton Roads Need**, while demonstrating the ability to scale to an associated Global Need example.

Links to supporting datasets are provided at the end of this document. Entrants are encouraged to review all the datasets as often no one dataset only applies to one problem. RISE may be able to provide additional data upon request.

Project 5.1: Economically Sustainable Ride-Sharing System

Global Need: Traditionally cities have provided transportation services by bus, train, etc. However, the high capital and operating costs make this an expensive proposition especially for mid-size cities that may not have high ridership. This is made worse by running these services on traditional fixed schedules regardless of demand. These problems are exacerbated in those economically depressed areas or areas with a high component of low to moderate income (LMI) residents who rely on public transportation to get to/from work and to access stores. What is needed is an on-demand service using fewer and smaller vehicles - similar to current examples of on-demand transportations services. These services can be expensive and unavailable to LMI neighborhoods. They may be made more affordable by using ride-sharing, limiting drop-off/pick up points, etc.

Hampton Roads Need: Hampton Roads has several neighborhoods that have been disconnected. These neighborhoods suffer economically and are not attracting new business to increase the quality of life or economic vitality. Improved access to affordable and reliable transportation is one way to

reconnect the neighborhood. A pilot program could demonstrate how such a system would be established in these neighborhoods.

SUPPORTING DATA SETS

This section provide links to data sets that may be important to groups working on the suggested project topic areas above. Please contact RISE if you need clarification of any other the data found below. Also, if you need additional data, please let us know and we will try to track them down.

	Name	Description	Link
1	TITAN	Interactive website showing flooding level maps as well as city critical facilities	http://gisapp1.norfolk.gov/TITAN/
2	Interactive Norfolk	Interactive website showing city stormwater infrastructure, flood maps.	http://orf.maps.arcgis.com/apps/webappviewer/index.html?id=eb7164021ada45fea397d66fa84f4441
3	Lidar elevation	Elevation datasets for Norfolk.	http://vgin.maps.arcgis.com/home/item.html?id=1e964be36b454a12a69a3ad0bc1473ce
4	Lidar elevation	Elevation datasets for Norfolk in an interactive website.	http://vgin.maps.arcgis.com/apps/Viewer/index.html?appid=1e964be36b454a12a69a3ad0bc1473ce
5	Tide Gauges	Data from tidal gauges in the region.	https://waterdata.usgs.gov/va/nwis/current/?type=tide&group_key=basin_cd
6	NOAA Tide gauges	Tide gauge data	https://tidesandcurrents.noaa.gov/map/index.shtml?region=Virginia
7	Water Quality & Projects	Access to reports and data.	https://www.norfolk.gov/index.aspx?NID=3969

8	Flooding Studies	Detailed analyses and maps for tidal and stormwater flooding levels.	https://www.norfolk.gov/index.aspx?NID=3968
9	Retain Your Rain	Information on parcel-by-parcel green infrastructure.	https://www.norfolk.gov/retainyourrain
	Flood mitigation (FEMA)	FEMA flooding information sites.	https://www.norfolk.gov/index.aspx?NID=1066
10	Sandia Report	Development of an Urban Resilience Analysis Framework with Application to Norfolk, VA	http://www.sandia.gov/cities/_assets/documents/Norfolk%20Report%20SAND2016_2161.pdf
11	Emergency Ops Plans	Norfolk emergency plans.	https://www.norfolk.gov/index.aspx?NID=4064
12	Vision 2100	City vision and plan for managing and thriving in the future.	https://www.norfolk.gov/DocumentCenter/View/27768
13	Norfolk resilience zoning code	Norfolk's zoning code for building a resilient city.	https://www.norfolk.gov/DocumentCenter/View/35581