Results from a VCAPS Planning Workshop for Extreme Weather in Dauphin Island, Alabama: Final Report

Social and Environmental Research Institute

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Introduction

Like most communities along the Gulf coast, Dauphin Island repeatedly experiences severe storms and hurricanes. The island's topography and location exposes it to multiple impacts from storms. Katrina destroyed over a hundred structures on the island. Flooding from storm surges have caused significant property damage and shoreline change. Wind associated with severe storms has also taken its toll. Topographically, the island is divided into two distinct areas: the West End and the East End. The West End is essentially a long, narrow, and flat open beach. It is particularly vulnerable to washover during storms and is moving northward. A mile and a half wide breach in the West End during hurricane Katrina isolated the westerly six miles of the West End. The East End is protected by a large dune system and vegetative cover, however, it too is vulnerable to numerous effects related to storms.

To prepare itself, Dauphin Island is developing strategic approaches to mitigating future impacts. Expectations are that there will be increased exposure to extreme weather in years to come. The town faces continuing challenges to prepare for hurricanes and to recover quickly from the effects of these storms.

To better understand the impacts of extreme weather events, and especially flooding, erosion, and littoral shifts associated with extreme weather events, officials in Dauphin Island organized a workshop on December 5, 2012. With funding from the Mobile Bay National Estuary Program and with the cooperation of the town government, the Social and Environmental Research Institute (SERI) led a workshop that used a mediated modeling process called Vulnerability, Consequences, and Adaptation Planning Scenarios (VCAPS). SERI developed VCAPS with funding from the National Oceanic and Atmospheric Administration (NOAA) and MIT Sea Grant. The purpose of the workshop was to document the vulnerability of Dauphin Island to extreme weather events in a time of climate change and to identify actions that the community could undertake to increase its resilience.

Photo: West End Public Beach
Credit: T. Webler 2012

Multiple stakeholders, including town officials, local residents, and regional extension agents, participated in the workshop. The workshop began with a short presentation about predictions for regional climate change, including sea level rise and hurricanes. This was followed by a discussion of the impacts severe storms and sea level rise might have on infrastructure, commerce, public safety, and ways of life. Throughout, the focus was on how impacts may worsen due to climate change. SERI facilitated the

workshop and used concept mapping to document participants' understandings of how these weather-related hazards created damaging consequences. The results of the workshop are presented here.

Impacts of Severe Coastal Storms and Hurricanes on Dauphin Island

Dauphin Island is Alabama's only barrier island, separating the Mississippi Sound from the Gulf of Mexico. The eastern portion of the island forms the mouth of Mobile Bay. Severe coastal storms and hurricanes have repeatedly impacted the community.

Hurricanes, sea level rise, and erosion are environmental threats facing the island. According to the town's most recent hazard mitigation plan, severe storms and the flooding they bring are the top two ranked hazards (pg. 18). Between 1979-2005 there were 12 named hurricanes and tropical storms that affected the island. A major consequence of such storms is beach erosion. In some places there has been loss of shoreline, while in others the shoreline has gained, thus "moving" the island northward (littoral shift). Storm surges can overtop bulkheads and seawalls in some cases, flooding roads and buildings. Salt water can kill vegetation and damage private property and public infrastructure. Sand can be pushed inland, covering roads and intruding into buildings.

The problem of beach erosion and sand movement has been aggravated by human actions. Infrastructure, such as buildings, roads, and seawalls have disrupted the natural process of sand movement on the island. Human action is also reducing the effects of beach erosion. After each storm, the Town removes sand and reconstructs protective dunes.

Erosion has serious economic impacts. The Town loses tax revenue and has increasing cleanup costs. Private property owners and businesses face increased insurance rates, loss of property, and loss of income.

To reduce future damages and protect human lives, Dauphin Island completed a strategic plan in 2007, a hazard mitigation plan in 2009, and a draft comprehensive plan in 2012. Each made recommendations for projects and activities to reduce impacts from extreme weather now and in the future. For example, according to a participant at the workshop, the working waterfront redevelopment described in the Comprehensive Plan was conceived with sea level rise in mind.

These planning efforts are constructive and essential, yet areas of concern persist. Town leaders recognize a need to explore preparedness and mitigation of impacts associated with a changing climate.

The VCAPS Process

The VCAPS (Vulnerability and Consequences Adaptation Planning Scenarios) process is a mediated modeling approach that combines structured discussion with interactive concept mapping to create visual summaries of local knowledge about vulnerability and

Photo: Seth Tuler of SERI. Credit: T. Webler 2012

resilience. It helps government staff and stakeholders depict how a community is impacted by weather related hazards and the actions that could help reduce impacts.

A VCAPS process begins by identifying a small set of concerns or hazards that the community would like to explore. This focuses and defines the boundaries of the discussion, ensuring that the exercise is relevant to decisions. The discussion centers on one concern at a time. During the discussion, a VCAPS diagram is constructed by the research team while listening to the facilitated dialogue in the room.

Examples of weather related hazards (a partial list):

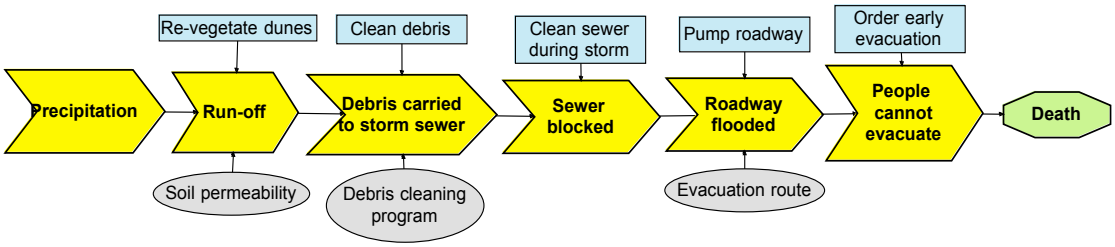
- Intense precipitation
- Storm surge
- Wind
- Increases in extreme heat
- Flooding
- Drought
- Wildfire

The participants at the workshop choose which hazards to focus upon. Groups sometime define the hazards quite broadly (e.g., super storms) or quite narrowly (e.g., coastal erosion).

After selecting the hazard, the group discusses how the hazard affects the community. Researchers listen to the discussion and construct concept maps that summarize the collective understandings. For most hazards, negative impacts come about through a chain of causes-and-effects. A facilitator guides the group to focus on one pathway at a time. As the discussion unfolds, a researcher diagrams the pathway model on the computer so that everyone can see it.

Each pathway contains a number of boxes and each box represents an "intermediary state or outcome" of the community. The pathway of intermediary outcomes ends in a consequence. A consequence is an outcome for which it is not necessary to ask the question, "Why do we care if this happens?" Consequences usually include loss of life, loss of property, health effects, or economic losses.

The figure below is a generic example of a causal chain. In it, a chain of events begins with precipitation and ends in death. The diagrams are scenarios of what *might* happen, not guarantees of what will happen. In the diagram, each yellow box represents an intermediary outcome of the system and the green octagon at the right end represents the consequence of concern.



Management actions are indicated by blue boxes along the top of the chain. They intervene to change the state of the system at specific points in the chain. This pathway can be broken by taking any of a number of actions. These are actions to change the way the community is affected. VCAPS differentiates between actions taken by private parties and actions taken by public organizations or government (at the local, county, state, or federal levels). The diagrams can include actions that are already in place or those that are proposed by the participants.

Contextual factors are the final component in the VCAPS diagram. These are specific qualities associated with an intermediary outcome or consequence that amplifies the effect of the hazard. For instance, the amount of run-off is made worse when soils have low permeability (ability to absorb water). A debris-cleaning program affects the amount of debris available to block storm sewers. A flooded roadway is a more serious problem if that roadway is an evacuation route. (For more details see Appendix B: How to Read a VCAPS Diagram.)

VCAPS in Dauphin Island

The VCAPS process in Dauphin Island was conducted during a single day workshop. Prior to the workshop staff from SERI reviewed existing Town plans (Strategic Plan of 2007, Hazard Mitigation Plan of 2009, Comprehensive Plan of 2012) and discussed history and background of Dauphin Island with Mobile Bay NEP staff and Alabama-Mississippi Sea Grant staff.

At the start of the workshop on 5 December, 2012, Catherine Janasie, Ocean and Coastal Law Fellow from the Mississippi-Alabama Sea Grant Legal Program, gave a presentation of the existing scientific understanding of climate change, including sea level rise, along the Alabama coast.

Seth Tuler then led a discussion about which weather and climate related hazards the participants would like to focus upon. The group decided to discuss severe coastal storms in combination with sea level rise. The workshop continued with discussion of past storms, but the facilitators soon brought the conversation

around to projected changes to storm severity and intensity due to climate change. It was noted that hurricane and tropical storms are expected to increase in frequency and strength in the near and long terms.

During the discussions, SERI diagrammed the causal pathways and added contextual factors and management actions to the diagrams as participants mentioned them. These diagrams were projected onto a wall in front of the participants. The remainder of this report will be a summary of those results.

The overarching concern of the group was the continual degradation of the island, from, for example, loss and movement of sand, potential for salt water intrusion, loss of vegetation and loss of habitat.

Specific management actions were identified for a range of undesirable outcomes and consequences, and the full set of actions is listed in Appendix A. Due to a lack of time in a single day workshop, this list was quite abbreviated. The management actions proposed in the workshop also do not encompass all of the actions already proposed in existing town plans (Comprehensive Plan, Hazard Mitigation Plan, Strategic Plan). Two types of management actions were identified during the workshop: 1) those that can be implemented by government (public) agencies and 2) those that can be implemented by private entities (homeowners, business owners). With more time, these lists could be more fully developed.

Because of different impacts associated with the West End and East End of the Island, issues associated with these different areas are discussed separately. VCAPS diagrams that relate to these abbreviated narratives are attached to this report.

The West End

The West End has been impacted frequently by severe storms, from both storm surge and wind. According to the most recent town hazard mitigation plan "the entire west end of the community would suffer complete wash over from a Category 1 hurricane" (pg. 29). Sea level rise is expected to exacerbate the impacts.

Photo: Protecting utilities on the West End
Credit: T. Webler 2012

Participants in the VCAPS workshop identified specific outcomes and consequences that can arise from storm surge under current and future conditions, which are shown in the West End VCAPS diagram.

Storm surge and wave actions cause both erosion and accretion. Via wave action sand can be transported over the dunes. This can cause the gain of land on the leeward side of the island, which leaves homes further from the shoreline and access to docks or boathouses more difficult. On the windward side of the island the shoreline can be eroded and land can be submerged, which can lead to the loss of property. In some cases property lots are now underwater. When rollover and washover happen, there is erosion of dune structures and vegetation, further weakening the Island, making it more susceptible to a breach or cut. A breach or cut destroys the supply of utilities, which can result in public health threats and loss of access from buried or damaged roads. Loss of land can have additional impacts. The mainland can become more exposed from loss of protection from the barrier island. Additionally, important sea turtle and bird habitat can be lost.

Direct physical damage to structures and infrastructure is another type of impact from storm surge and sea level rise. According to the 2009 Hazard Mitigation Plan, Hurricane Katrina destroyed or substantially damaged two-thirds of the structures on the West End (pg. 48); some of the damage was a result of cumulative damage from multiple hurricanes (Ivan, Dennis, and Katrina). When properties and infrastructure are damaged, various consequences can ensue, including increased costs to the Town and loss of revenues to private property owners, including rental incomes, and to the Town. The Comprehensive Plan notes that: "The west end of Dauphin Island has suffered a severe loss of land due to sand erosion during Hurricanes Ivan and Katrina. Many single family lots that were once waterfront have lost partial or complete parcels into the Gulf. Homes constructed on parcels once located in the inner platted portions of the Island's west end are finding damage at high tide as well. Many of the property owners seeking to rebuild their homes on their parcels are finding that complying with front, back, and side yard setbacks required in the zoning ordinance results with the new structure being placed too close to high tide" (pg. 37).

At the same time, the West End continues to be developed: "Most of the growth in the town continues to occur on the west end of the island, which is vulnerable to hurricanes and flooding. This area continues to be sought after by potential property owners desiring to build large homes for part-time and rental use. The west-end possesses water, sewer and electric supply infrastructure making it prime for future developments. This area generates revenue for the town through taxes, lodging taxes, sales taxes from tourism and related revenues from renters" (Hazard Mitigation Plan, pg. 46).

This trend is reflected in, and reinforced by, the Comprehensive Plan. For example, Figure 31 of the Comprehensive Plan presents a map showing complete build-out of the West End. In response to loss and gain of land that makes compliance with setbacks difficult the Comprehensive Plan proposes the following recommendation: "Research the need and support for the creation of a new residential single family zoning classification specific to houses located on the west end of the Island for the purpose

of allowing flexibility with the front, back, and side yard setbacks" (pg. 38).

During the workshop an important consequence to the Town was identified from the repeated costs to cleanup and restore infrastructure to the West End after damaging storms. This was social conflict. Repeated and rising costs to the Town and hence local residents is creating a divide among those who feel that continued occupation of vulnerable houses on the West End is not sustainable and those who own the properties and either enjoy living on the West End or who depend on the income from tourist rentals.

Photo: Flood prone area near ferry.
Credit: T. Webler 2012

While building the VCAPS diagram, the group identified some management actions that could be taken by private homeowners, businesses, or government to prevent repeated damage and reconstruction costs, reduce harm, and speed compensation and recovery. (see Table 1 of Appendix A and the West End VCAPS diagram for a full list).

Examples of actions mentioned during the workshop that could be taken by private entities include:

- Rebuilding structures;
- Move houses further back from shoreline or raise structures;
- Install generators; and
- Remove vulnerable equipment before a storm (e.g., the telephone company).

Examples of management action items that could be considered by government (public) agencies were also identified during this short workshop, including:

- Restore dune and renourish beaches and promote natural sand recruitment;
- Change dredging practices of the Mobile Ship Channel and work with the Army Corps of Engineers, State, and Port on dredging plans;
- Educate homeowners about living shorelines;
- Remove permanent structures;
- Study costs and benefits of policy options;
- Implement a lot buyout program for vulnerable West End properties;
- Repair breaches;
- Rebuild infrastructure (or decide not to rebuild or restore);
- Implement other forms of tax-generating tourism (e.g., East End rentals);
- Promote passive recreation in the West End;
- Add tax surcharge to West End properties; and
- Condemn homes on the West End to prevent rebuilding.

The group realized that some of these management actions could lead to additional consequences.

The East End

The East End is subject to impacts from severe storms, storm surge, wave action, and wind, as shown in the East End VCAPS diagram. Many, but not all, impacts have been identified in prior plans.

The outcomes and consequences from wind include direct impacts to trees, such as broken limbs and twisting. These can make trees more susceptible to damage from future storms. They also become more susceptible to damage from pests, such as pine bark beetles. Wind can cause further damage by spraying trees with salt, which can damage or kill trees.

Storm surge and wave action can lead to a number of outcomes and consequences. Sea level rise is expected to exacerbate. Participants identified the following outcomes that can arise from storm surge and wave action under current and future conditions:

- Industry can be impacted, by damage to equipment or disruption of activities;
- Sand can be transported over the dunes (rollover and washover);
- Direct physical damage to structures and infrastructure;
- Freshwater in the lake can be contaminated with salt water, which can lead to a series of ecological changes and weakening of the island over time;
- Erosion of the shoreline, which can lead to further ecological changes and weakening of the island over time;
- Inundation of boat ramps can make access to the water more difficult or costly;
- Breaching or inundation of Little Dauphin Island would expose the north side of the island to more damage from storms and infiltration of sand into the bays and marshes; and
- Blockage of Route 193 from flood waters or debris. Re-access to the island after a severe storm can be disrupted from physical blockage or from the actions of Emergency Response personnel (e.g., State Troopers). This may impede the return of local emergency response personnel as well as residents and the restoration of basic services.

Photo: Drainage ditch in the East End. Credit: T. Webler 2012

In addition to these direct outcomes, the group discussed in some detail the impacts of salt water flooding. Flooding from storm surge under possible future conditions of sea level rise can lead to:

- Damage of buildings;
- Overwhelming the capacity of the Town the stormwater system;
- Flooding of the waste water treatment plant; and
- Flooding of the ferry access road.

Efforts to control these outcomes without careful planning may end up altering the groundwater table and promoting inundation of outfall pipes. These outcomes could change the ecology of the area and lead to economic consequences.

A significant number of management actions were identified by the group. These are listed in Table 2 in Appendix A of this report and the East End VCAPS diagram. Examples included many of those proposed for the West End as well as:

- Create a breakwater to protect the working waterfront area;
- Maintain and improve drainage ditches;
- Build floating docks;
- Implement a program to speed return of essential personnel to the island;
- Improve coordination for response and recovery operations with the state and utility companies;
- Create a system for providing information to evacuated residents after a storm;
- Develop systems for retaining freshwater runoff;
- Change building codes; and
- Prepare for future infrastructure locations that are not susceptible to climate change impacts, including the waste water treatment plant.

Strategies to Prepare for Extreme Weather and Climate Change

Throughout the workshop, SERI encouraged the group to discuss management actions that could be promoted by the Town both in the near term and the long-term to increase resilience to hurricanes and severe coastal storms in a context where there are uncertainties about future conditions. At the beginning of the workshop participants asked: What can we do? What is realistic? What is already being done?

There was a desire of the group to build on existing plans when suggesting future management actions to increase resilience. The Town has already initiated many planning activities that address long term resilience, including revision to the Comprehensive Plan and a Strategic Plan. For example, the town requires 2 feet of freeboard above the requirement in the FIRM. As noted previously, according to a participant at the workshop, the working waterfront redevelopment was conceived with sea level rise in mind.

Other management actions proposed in existing plans may warrant additional consideration in light of the predictions for future weather events. For example, the Comprehensive Plan proposes the use of pervious surfaces for parking areas. During the VCAPS workshop, however, some questioned the long term effectiveness of this strategy in the context of sea level rise, which may cause the water table to rise. As another example, it was noted that the wastewater treatment plant may be vulnerable to sea level rise, as it is currently only two feet from the water, and the ground under the tanks is eroding. These factors may limit the treatment plant's lifespan or ability to accommodate additional growth.

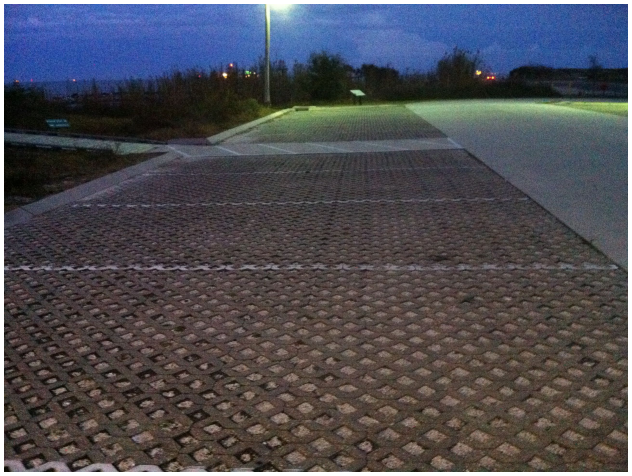


Photo: Permeable paving stones at the Estuarium on the East End. Credit: T. Webler 2012

Discussion of management actions to address the threats from extreme weather raised many potential actions. These are listed in Tables 1 and 2 of Appendix A and the diagrams, however three issues received emphasis.

First, in many situations there is a need for the Town to coordinate with other actors, including the County, State, private property owners, and private businesses. For example, participants identified the need for better sand management practices overall. This would necessitate better coordination and multi-jurisdictional planning. The Town is limited in its ability to address loss of sand because what happens on Dauphin Island is affected by the dredging of Mobile Bay channels by the Port and the Army Corps of Engineers. Another example is about the need for better coordination with state emergency responders, as it can be difficult to get essential personnel back on the island after evacuation.

Second, the complexity of the ecological system means that careful consideration needs to be given to unintended effects of management actions. For example, during the afternoon session, the group focused more on the impacts of sea level rise throughout the island. A suggestion was made that the Town develop a more aggressive stormwater management plan and a watershed management plan. Drainage could be improved by the construction of culverts and retention ponds and channeling stormwater toward the bay for oyster harvesting. Another suggestion was to find ways to funnel the water toward swamps, which would benefit habitat and help manage drought. A number of obstacles were mentioned, however, including maintenance and clearing of drainage ditches from debris and risk of spread of invasive species. Some felt that a better understanding of where stormwater drains is needed, suggesting the possibility of a study.

Photo: Sand moving on the West End.
Credit: T. Webler 2012

Third, the workshop demonstrated that the topic of what to do about the West End is high on the Town's agenda, but also very touchy. There is widespread acknowledgement that the current situation is unsustainable, yet the threats facing the West End have no easy answers. This issue ranks high in significance for a

few reasons: there are no clear ways of preventing impacts and reducing longterm and damaging changes to this part of the island, there are many competing needs and interests involved, and the issue is leading to social conflict. At the same time, there is little consensus about how to address such issues.

The group discussed options for addressing the vulnerability of the West End. There was a recognition that the Town has limited ability to prevent the repeated losses to properties on the West End. One suggestion was for the Town to do a detailed cost-benefit analysis of maintaining the West End, so that residents and local officials could better understand the long-term costs to the Town. This could help generate support for future decisions. Such a study would be consistent with the Comprehensive Plan's recommendation for the Town to research and propose a solution to inability of West End landowners to comply with zoning ordinances. Another option discussed was to slowly convert the West End to passive recreation areas (park, public beach). While more intrusive management actions were also suggested, such as creating a buy out program, preventing rebuilding, levying surcharges for services, and ceasing Town maintenance and replacement of damaged infrastructure, there was little agreement and contentious discussion about them. However, the Mayor, while stating that he was *not* advocating the abandonment of the West End and its residents, noted that the loss of the West End may be inevitable given the forces of nature and suggested that it would be appropriate for the Town to consider how the Town would be sustainable without the West End how would it have to change? how would the island survive if this happens?

Each option raises many thorny issues and faces many obstacles. Among them: To what extent should residents on the East End subsidize rebuilding of infrastructure on the West End? What are the obligations of the Town for maintaining infrastructure on the West End? What restrictions on rebuilding can the Town place on private properties on the West End? What is a reasonable long-term use of the West End that will benefit the Town while minimizing costs of maintenance? Is a buyout plan feasible and affordable or even acceptable to current property owners? Who owns "new" land from accretion on the leeward side of the West End? Is retreat possible, and how would it be accomplished? And, of course, who decides: elected officials, directly impacted property owners, all residents of the Town?

To date, the Town has not crafted a proactive approach to considering such questions about the future of the West End. Moreover, existing Town plans present a muddled approach. While the Hazard Mitigation Plan has identified the West End as highly vulnerable, the Comprehensive Plan envisions further residential build out and maintenance of this area.

Conclusion

Examination of local hazards with Town officials, interested citizens and members of the private sector can illuminate

vulnerabilities and highlight potential mitigation projects for municipalities to adopt.

VCAPS is one approach to help elicit and organize this knowledge in a format that can empower local action. The workshop discussed in this report drew upon local experience on Dauphin Island to document vulnerabilities and mitigation actions.

Dauphin Island has engaged in multiple planning processes that address hazards and vulnerabilities and strategies to prevent or mitigate their impacts. The VCAPS workshop drew on these experiences.

The workshop also revealed four ways that the Town can be more strategic in its approach to managing hazards and vulnerabilities, especially with an uncertain future resulting from climate change.

First, the VCAPS workshop provided new or additional justification for existing plan recommendations. For example, the Comprehensive Plan notes the need to "Educate the community and businesses on stewardship, low-impact development, smart growth and strategies to enhance Dauphin Island's resiliency to climate change" (pg. 58). The discussion of how more severe storms and sea level rise may exacerbate impacts shows how such actions may help. Furthermore, discussion in the Hazard Mitigation Plan to review and revise building and development codes and discussion in the Comprehensive Plan to change zoning requirements for the Central Business District and Working Waterfront may be informed by considering longer term changes that may arise from a changing climate.

Second, the VCAPS workshop discussion suggests that some recommendations in existing plans may need further attention. The recommendation to make zoning requirements on the West End more flexible to allow rebuilding on lots that are "moving" is a case in point.

Third, VCAPS helps to organize management actions in a different way than done in other reports. The Comprehensive Plan organizes management actions by thematic categories, such as land use, transportation, and Town services. The Hazard Mitigation Plan identifies mitigation actions by goal. VCAPS provides a different perspective that can be useful to planners and decision makers:

- VCAPS helps to reveal the causal connections between events and consequences, and how different kinds of management actions may be possible at different points along the "causal chain." There can be upstream actions (e.g., Town initiates a lot buy-out program) or downstream actions e.g., (homeowners re-build after homes are damaged). There are different costs and benefits associated with upstream and downstream strategies.
- Management actions performed by public entities (local, county, state government) and private entities (households, businesses, utilities) are differentiated and highlighted. This can help make apparent how

different strategies can work in concert or at cross purposes.
- The intended and possibly unintended consequences of management actions can be made explicit.

Fourth, the VCAPS workshop resulted in specific management actions that are not listed in the Comprehensive Plan, Hazard Mitigation Plan, and Strategic Plan. For example, during the VCAPS workshop it was suggested that the Town consider building retention ponds to store stormwater and collect freshwater and decentralize stormwater treatment to the subdivision scale. In addition, during the discussion about emergency response after a disaster, participants discussed the need for easing the return of essential personnel to the island through, for example, a permitting system. *We do not know if such potential actions had been identified previously and in other plans or reports because we do not have access to information about all past Town planning.*

Clearly the Town has taken many steps to address long term resilience, including the step of promoting conversations about the future, as illustrated by the VCAPS workshop. Based on our limited observations of the community and its discussions about future hazard management, we offer three recommendations for how the Town may focus future planning efforts and discussions about the future:

1. The Town should integrate existing and future plans more carefully. Actions proposed in plans should be consistent with each other and with predicted future hazards and changes. The positive and negative implications of proposed actions for long term goals of resilience should be made explicit. It is useful to ensure that the negative implications, which may not be readily apparent or difficult to measure, are fully considered. Examples include; additional costs, social conflict, changes to groundwater hydrology, increased vulnerability to some properties, and spread of invasive species (see attached diagrams for examples).

2. The Town should discuss how to prioritize management actions that can reduce future risks from hurricanes/severe storms and flooding, with an understanding of how they might change due to climate change and how they may interact in both synergistic and antagonistic ways. Attention should be given to "no regret" and "low regret" actions, as well as issues of equity.

3. The Town should adopt a more strategic, proactive, and considerate approach to discussing the future of the West End. This could include study of key issues (e.g., costs borne by town for repeated restoration of infrastructure). Alternative scenarios could be discussed, including a "stay the course" approach and "managed retreat." We make no judgments as to which would be the appropriate course of action for the Town and we fully realize how difficult such discussions will be;

however, we believe that it is important for the Town to have a considered and open discussion about options. There is evidence within the Town that this issue is contentious and divisive and may result in the emergence of a "corrosive community." Creative approaches to meeting diverse needs of individual homeowners, other residents, the Town, and the island will need to be developed.

Like other municipalities across the country, Dauphin Island will continue to experience increased exposure to extreme weather. Dauphin Island can proactively take on the adaptation challenge or it can wait for external factors that force change, such as a very severe storm hit or changes to the national flood insurance program. The national, state, county, and town systems that are in place to manage, cope, and adapt to extreme weather can be improved upon and the community will need to innovate more efficient and effective systems to prepare for storms and to restore services.

Appendix A

Management Actions for Extreme Coastal Storms in Dauphin Island, Alabama
Results from Workshop on December 5th, 2012

Table 1. Management Actions for the West End

The Table lists management actions identified during the VCAPS process, and which appear in the attached diagrams. The Table links them to the outcome or consequence they were intended to address. The Table also highlights actions that are taken by public organizations (e.g. the Town) and actions that are taken by private parties (e.g. homeowners).

Outcome or consequence being addressed	Management action	Public	Private
Sediment movement: Rollover and washover fans	Town restores dunes	X	
	Town seeks additional funds for sand renourishment	X	
Loss of elevation land	Town/county/state promote natural sand recruitment	X	
	Town works to change dredging practices of Mobile Ship Channel	X	
	Town works with Army Corps, State, Port on dredging	X	
Property (home) damage and loss	Town initiates education of homeowners about living shorelines	X	
	FEMA expands repetitive loss program	X	
	Town removes permanent structures	X	
	Town studies costs and benefits of policy options	X	
	Town implements lot buyout program	X	
	Property owners rebuild (if lot not underwater)		X
	Property owners move house further back on property		X
Loss of tax revenue, lodging taxes, county, state, town	Town promotes other forms of tax-generating tourism (e.g. East End rentals)	X	
	Town promotes passive recreation in West End	X	
	Town adds tax surcharge to West End properties	X	
Loss of sea turtle, bird habitat	Town implements revegetation program	X	
Breach or cut	Town repairs partial breaches	X	
Infrastructure lost (road, power, water)	Town rebuilds infrastructure	X	
	Town refuses to repair infrastructure	X	
	Homeowners buy/install generators		X
	Telephone company removes equipment before the storm (when under hurricane warning)		X

Social conflict over costs of West End recovery to Town	Town initiates and promotes discussions about future options	X	
Public health threat	Town shuts off water	X	
	AL Power shuts off electricity	X	
	Town condemns home	X	
Oysters decline	State closes commercial oyster beds	X	
Physical damage to structures and infrastructure	Town shuts off services	X	
	Property owner retrofits construction, including elevation, floodproofing, and roof strengthening		X
Property (home) damage and loss	Town educates homeowners about living shorelines	X	
	Town advocates for FEMA repetitive loss program expansion	X	
	Town removes permanent structures	X	
	Town studies costs and benefits of policy options	X	
	Town initiates lot buyout program	X	
	Property owners rebuild (if lot not underwater)		X
	Property owners move house further back on property		X
Loss of county, state, town tax revenue	Town promotes other forms of tax-generating tourism (e.g. East End rentals)	X	
	Town promotes passive recreation in West End	X	
	Town adds tax surcharge to West End properties	X	
Cut services / Replace lost revenue	Town initiates contingency planning for possible loss of more revenues	X	
Insurance rates go up	Town implements actions to get better FIP / CRS scores	X	

Table 2. Management Actions for the East End

The Table lists management actions identified during the VCAPS process, and which appear in the attached diagrams. The Table links them to the outcome or consequence they were intended to address. The Table also highlights actions that are taken by public organizations (e.g., the Town) and actions that are taken by private parties (e.g. homeowners).

Outcome or consequence being addressed	Management action	Public	Private
Property values decline	Town removes damaged trees	X	
Impacts to oil industry	Town coordinates with NOAA disaster preparedness center	X	
	Town/county/state get equipment in place when storm anticipated (staging, pre-positioned assets): oil containment booms, HAZMAT materials, tractors	X	
	Town continues to update hazard mitigation plan	X	
Sediment movement: Rollover and washover fans	Town restores dunes	X	
	Town seeks additional funds for sand renourishment	X	
Loss of land	Town/county/state promote natural sand recruitment	X	
	Town works to change dredging practices of Mobile Ship Channel	X	
	Town works with Army Corps, State, Port on dredging	X	
Infrastructure lost (road, power, water)	Residents buy/Install home generators		X
	Telephone company removes equipment before a storm (when under hurricane warning)		X
Town rebuilds infrastructure	Town stops repairing infrastructure	X	
Social conflict over costs of recovery to Town	Town initiates and promotes discussions about future options	X	
Public health threat	Town shuts off water	X	
	AL Power shuts off electricity	X	
	Town condemns home	X	
Property (home) damage and loss	Town educates homeowners about living shorelines	X	
	Town advocates for FEMA repetitive loss program expansion	X	
	Town removes permanent structures	X	
	Town studies costs and benefits of policy options	X	
	Town initiates lot buyout program	X	
	Property owners rebuild		X
	Property owners move house further back on property		X

Loss of sea turtle, bird habitat	Town implements revegetation program	X	
Physical damage to structures	Town shuts off services	X	
	Property owner retrofits construction, including elevation, flood proofing, and roof strengthening		X
Loss of county, state, town tax revenue	Town rebuilds properties	X	
	Town seeks ways to replace lost revenue	X	
	Town initiates contingency planning for possible loss of more revenues	X	
	Property owners rebuild properties		X
Insurance rates up	Town implements actions to get better FIP / CRS scores	X	
Docks inundated	Town builds floating docks	X	
	Property owners build floating docks		X
Invasive species move in	Property owners clean out drainage ditches		X
	Property owners keep drainage ditches vegetated		X
Little DI inundated or breached	Town revegetates	X	
	Town advocates for USFW to change policies	X	
North side of Island exposed to wave action	Town creates breakwater to protect Aloe Bay working waterfront	X	
Sand infiltration of sewer lines	Town cleans sand out of lines	X	
Route 193 flooded or blocked with debris	AL DOT elevates two parts of Rt. 193	X	
	Town clears from South	X	
	State clears from North	X	
Town employees prevented from returning (Water/Sewer Personnel)	Town seeks permits for essential personnel to ease return	X	
	Town/county/state helicopter essential personnel to island	X	
AL power not allowed onto island	Town DPW works to open causeway	X	
	Town pressures AL Power to return service	X	
Feeling helpless, Worried about homes Can't get back to island	Town talks to State, DOT and Troopers to emphasizes residents' needs	X	
	Town informs residents thru Facebook, Twitter	X	
People less likely to evacuate next time	Town clearly communicates to residents they should leave, and if they stay that emergency services are limited or absent	X	

Salt water flooding	Property owners replace impervious surfaces		X
	Property owners improve yard management		X
	Town improves drainage (open ditches)	X	
	Town builds culverts	X	
	Town builds retention ponds	X	
	Town participates in Statewide water management plan process (Statewide water task force)	X	
Ditches get clogged	Town initiates education program for homeowners to bag plant waste and keep ditches clear	X	
Invasive species move in quickly	Town sprays pesticides	X	
	Town cleans drainage ditches		
Standing water	Town installs booster pumps	X	
	Town initiates public education and outreach (social media)	X	
Mosquitoes w/ West Nile Poisonous snakes	Town and county implement health education programs	X	
Illness, death	People go to hospital		X
Freshwater sent to sea	Town retains some fresh water runoff (lots of ways to do)	X	
Land around harbor or water tower is flooded	Town raises bulkhead	X	
	Town strengthens building codes for area	X	
	Town installs pumping station (where natural drainage is not enough)	X	
	Town plans for future infrastructure locations that are climate-ready	X	
	Town works toward construction of safe harbor on west side of 193	X	
	Town constructs a roundabout	X	
Buildings damaged	Town promotes flood proofing by funneling water away from buildings	X	
	Town requires raising buildings	X	
	Town establishes new zoning so that owners can live above shops	X	
Cost of repairs	Town implements actions to get better FIP / CRS scores	X	

Stormwater inundation to sewer lines	Town decentralizes stormwater to subdivision scale	X	
	Town pipes sewage off island	X	
Capacity reached during storms	Town expands capacity of wastewater treatment plant (thru HMP?)	X	
Public health risk, Public relations issue	Town implements swimming closures		
Flooding of waste water treatment facility	Town improves protective bulkhead		
	Town distributes sandbags		
	Town upgrades plant (privatize?)		
Road to ferry underwater	Town elevates road		
	Town re-routes the road		

Appendix B

How to Read a VCAPS Diagram

The ways that weather and climate related stressors might affect a community can be described with a handful of concepts. These concepts describe aspects of consequences and vulnerabilities to them. The concepts relate to each other in a sequence of events that are causally linked, and we use the convention of showing them in a sequence that moves from left to right. At the left are the things that initiate a chain of events, which lead to concrete consequences for the community, developing to the right.

Figure B-1 shows the concepts that go into a VCAPS diagram:

- Management Concerns
- Climate Stressors
- Outcomes
- Consequences
- Contextual Factors
- Public Management Actions
- Private Management Actions
- Influence Arrows

The shapes that represent these concepts are called nodes in VUE and "building blocks" in our VCAPS terminology.

Figure B-1 also shows the general way that the concepts representing the chain flow from stressors on the left to consequences on the right. Notice how different concepts are shown with different shapes and colors. We will continue to use this particular convention in all diagrams.

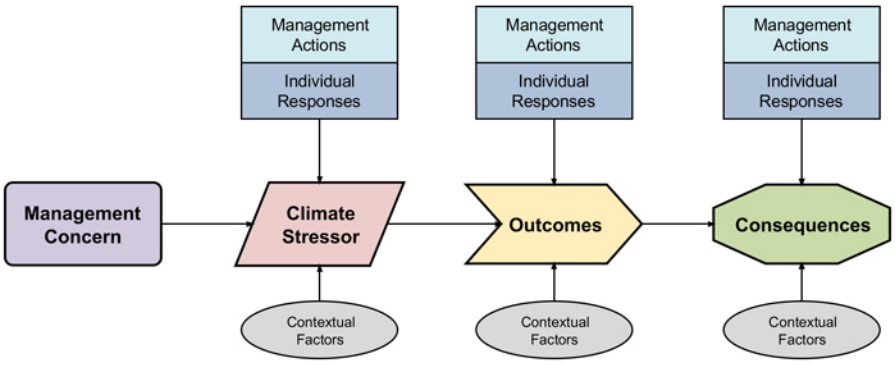


Figure B-1. Building blocks of a vulnerability-consequence diagram.

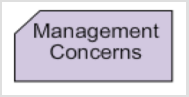
In this section, VCAPS diagram concepts (i.e. management concerns) will be **bold** and colored to correspond with the diagram colors. When examples are given for the diagram concepts, they will be *italicized*.

Management Concern

Since there are many ways that weather and climate change can impact a community, a diagram that depicts all consequences and vulnerabilities would be too complicated. To simplify things, we often begin by focusing on a specific category of **management concerns**. However, starting with a management concern is not required – it is also possible to start a diagram with a **climate stressor** (see below).

You can define a **management concern** to be whatever you want. It is a topic, or an area of focus. We suggest defining these in terms of the resource systems that you manage. For instance:

Management concern icon:



1. *Stormwater management*
2. *Wastewater management*
3. *Drinking and irrigation water management*
4. *Beach management*
5. *Shoreside infrastructure* (e.g., marinas, piers)
6. *Public health* (mosquitoes, rats, hurricanes, etc.)
7. *Building & zoning requirements* (erosion, elevation ordinances, wind shear ratings, street setbacks, etc.)
8. *Emergency management* (evacuation, fire, rescue, etc.)

Climate stressors

Each management concern can be affected by weather and **climate stressors**. These are events related to weather systems and to climate change that put some kind of stress on the community and its resource system. For instance, climate scientists are predicting that the southeastern USA will experience more rainfall in shorter time periods. We might identify this **climate stressor** as *heavy precipitation*. Heavier precipitation increases the demands on the urban drainage infrastructure. Consequently, *heavy precipitation* is a **stressor** under the management concern category *stormwater*.

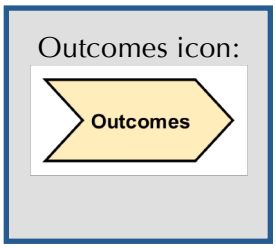
List of a few **Climate Stressors** predicted along the Southeastern US Coast:

- Accelerating sea level rise (SLR)
- Increased temperature
- More frequent heavy rain events
- More powerful hurricanes
- Higher high tides

Climate Stressor node:

Outcomes

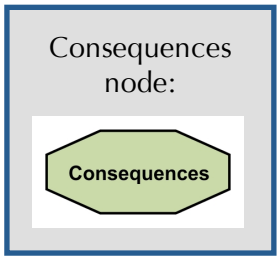
Climate stressors produce **outcomes**. These things happen in the community because of the weather or climate stressor. Specifically, they can be either processes or events that occur in social or ecological systems because of the weather or climate stressor. For example, *run-off* is an **outcome** of the stressor: *heavy precipitation*. Increased run-off also means that *more sediment will enter the stormwater system*, leading to some *drains becoming plugged*. These are more **outcomes**. The reason to distinguish among multiple outcomes is that they suggest different opportunities for intervening in the causal chain with public or private management actions (as defined below).

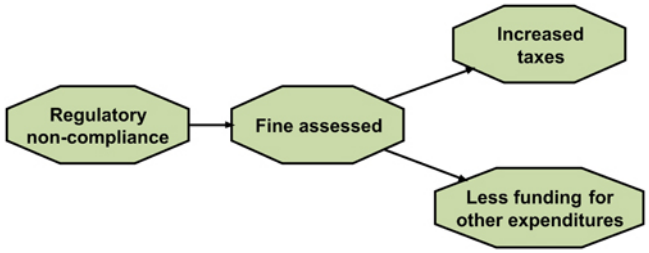


Consequences

Consequences are implications of the outcomes that affect individuals, communities, institutions, or ecosystems. Thus, they are a special kind of outcome. They reflect losses or costs to things that people care about. Examples include:

- *Death or injury*
- *Damage to structures*
- *Cost to town government*
- *Loss of income*

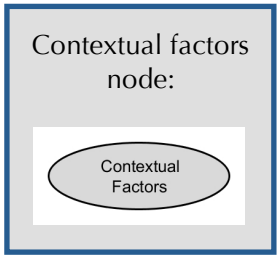


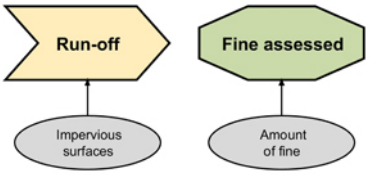


Harmful **consequences** can result from direct exposure to the event/condition or through indirect pathways, called secondary or tertiary **consequences** in this model (not shown in Figure B-1). For instance, being in non-compliance with regulations can lead to a *fine*, which is a **consequence**. This cost to the town government can mean *increased taxes* or *less funding for other expenditures*, which are subsequent **consequences**. Attention to pathways of consequences is particularly important for coastal communities where impacts have repercussions beyond coastal hazard management to long term planning for land-use, community social services, transportation, insurance, and community bond ratings. Of course, there may also be beneficial **consequences**, such as economic benefits of job creation after a hazard or revised land-use plans that improve stormwater management.

Contextual Factors

Many things in the local physical or social environment help shape the form or extent of a weather or climate stressor, outcome, or consequence. We call these **contextual factors.** They can be anything that makes a weather or climate stressor, outcome, or consequence bigger, smaller, better, worse, or simply different. For example, the size of the outcome *run-off* is determined by the *amount of impervious surface*, which is a **contextual factor**. The amount of impervious surface is a quality of the physical infrastructure and local ordinances, for example. **Contextual factors** also apply to consequences. A **contextual factor** that helps shape the consequence of a fine is the actual amount of the fine. Therefore, *amount of fine* is one **contextual factor**.

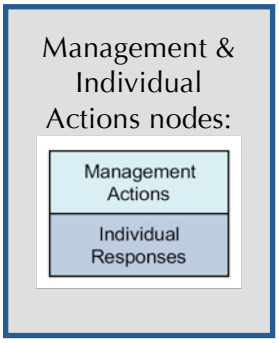


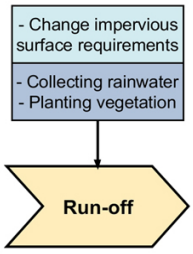


Public and Private Management Actions

Of course, leaders in a community care about all of these outcomes, and it is their job to take steps to alleviate or prevent them from happening. We refer to the actions taken by town planners, town administrators, county officials, state officials, wastewater system managers, etc. **public management actions**, and they include both proactive and reactive actions intended to prevent or mitigate weather and climate stressors, outcomes, or consequences.

Individuals, property owners, business owners, utilities, and other private entities can also take proactive or reactive actions to prevent or mitigate weather and climate stressors, outcomes, or consequences. We call these **private management actions**. These are not necessarily actions required by law. While they may be required, they can also be either spontaneous or planned actions that people take with the purpose of interrupting a chain of events that leads to an undesirable consequence.





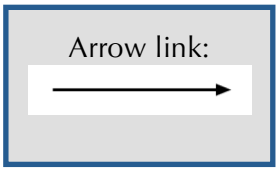
In the diagram, **public management actions** and **private management actions** appear as a node directly above a climate stressor, outcome, or consequence (with an arrow connecting the two nodes).
For example, the outcome *run-off* can be prevented or reduced by *increasing the amount of permeable surfaces*. A local ordinance that requires new development to maintain a certain amount of permeable surface is an example of a **management action**. Likewise, homeowners can make landscaping choices that minimize the outcome *run-off* by *planting certain plants, anchoring the soil, and collecting or absorbing rainwater*.

We want to emphasize that **public management actions** and **private management actions** can be made at any point along the sequence that joins climate stressors, outcomes, or consequences, as shown in Figure B-1. Those that are meant to affect a weather or climate stressor or outcome we call upstream actions, while those that are meant to affect consequences we call downstream actions. This means that there can be multiple opportunities to block or change the character of a consequence. While there are strong benefits associated with blocking the causal chain early on (i.e., upstream), there can also be significant costs to doing this. For instance, economic losses from coastal storms

can be mitigated by moving houses further from unprotected shores, but this is costly and highly controversial. Likewise, allocating too many hazard management resources at the far right side of the diagram (i.e., downstream) can also be problematic. Reimbursing people for economic damages does not adequately compensate people for all losses they might experience. In conclusion, hazard management strategies should be considered at multiple points in the causal chain.

Arrows

Arrows (referred to as "links" in VUE) connect management concerns, climate stressors, outcomes, or consequences, contextual factors, and public or private management actions. They link two elements of the diagram to represent what is being influenced.



When climate stressors, outcomes, or consequences are connected with **arrows**, the **arrows** represent cause-effect relationships. For example, sea level rise causes flooding. Erosion causes property damage.

Management actions are linked to concepts such as climate stressors, outcomes, or consequences with **arrows** to show what the actions are intended to change.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