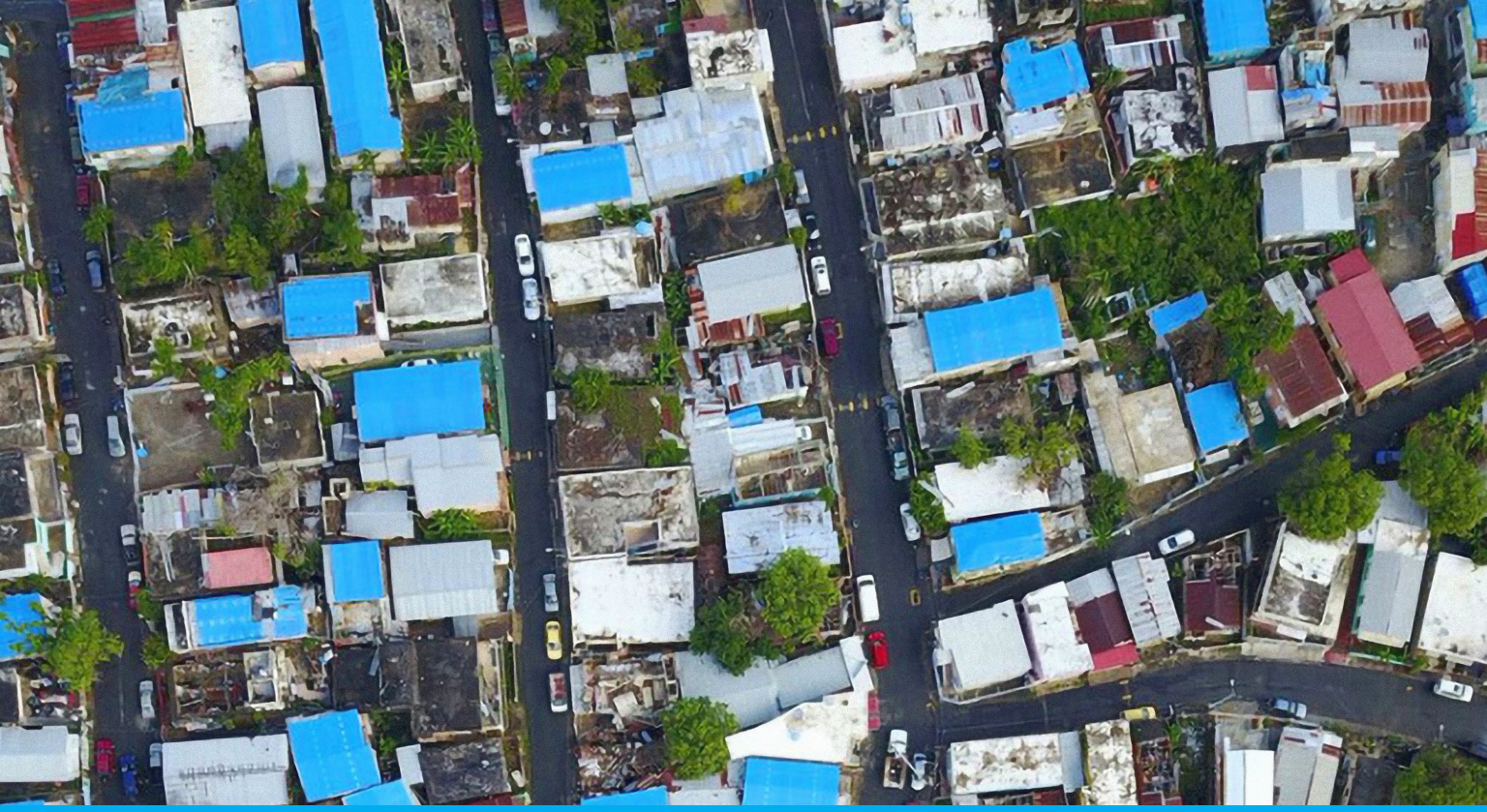

KEEP SAFE

A GUIDE FOR RESILIENT HOUSING DESIGN IN ISLAND COMMUNITIES

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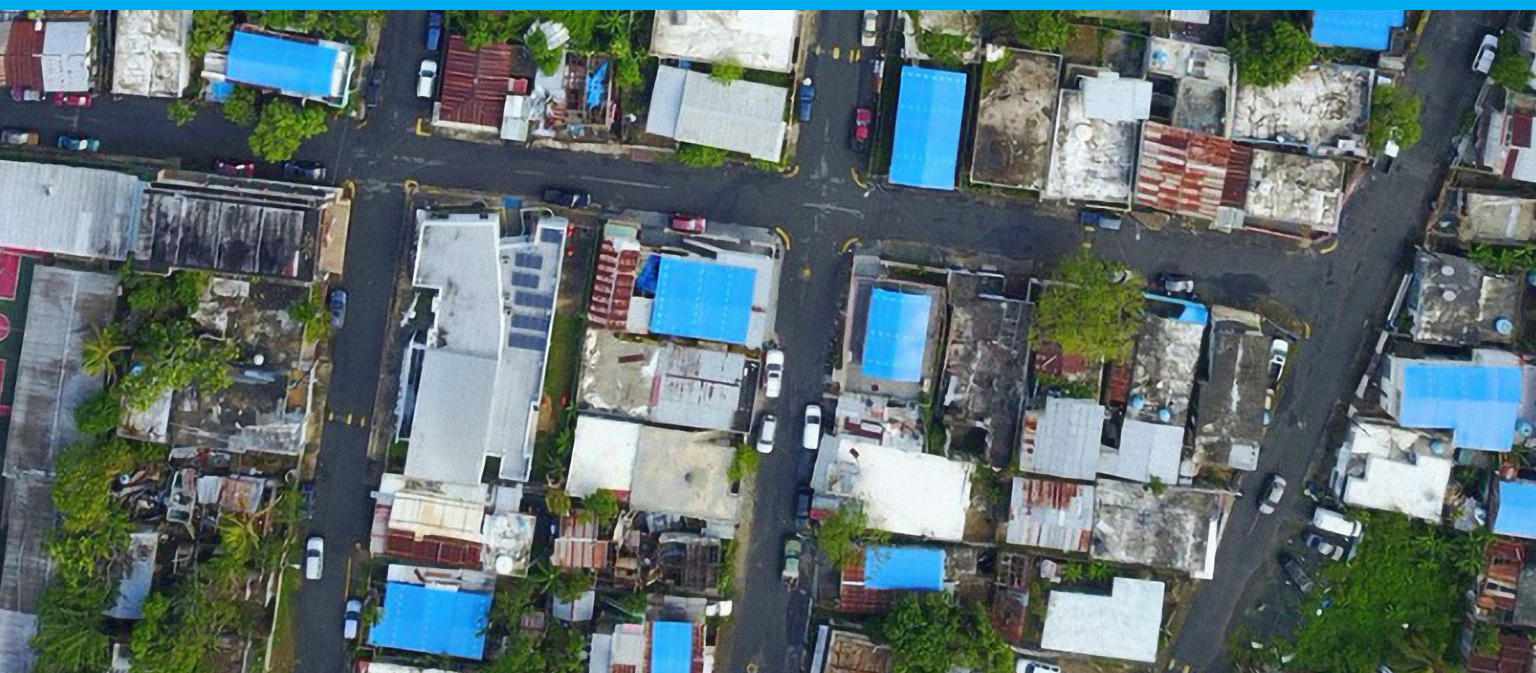



PABLO MARVEL, RESILIENT POWER PUERTO RICO

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A GUIDE FOR RESILIENT HOUSING DESIGN IN ISLAND COMMUNITIES

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This guide is dedicated to the unsung heroes of disaster recovery and rebuilding – women of courage who are community builders and are passing on their resilient values to future generations. Thank you for teaching us how to protect and care for the places we call home.

DISCLAIMER

Disclaimer for KEEP SAFE: A Guide for Resilient Housing Design in Island Communities

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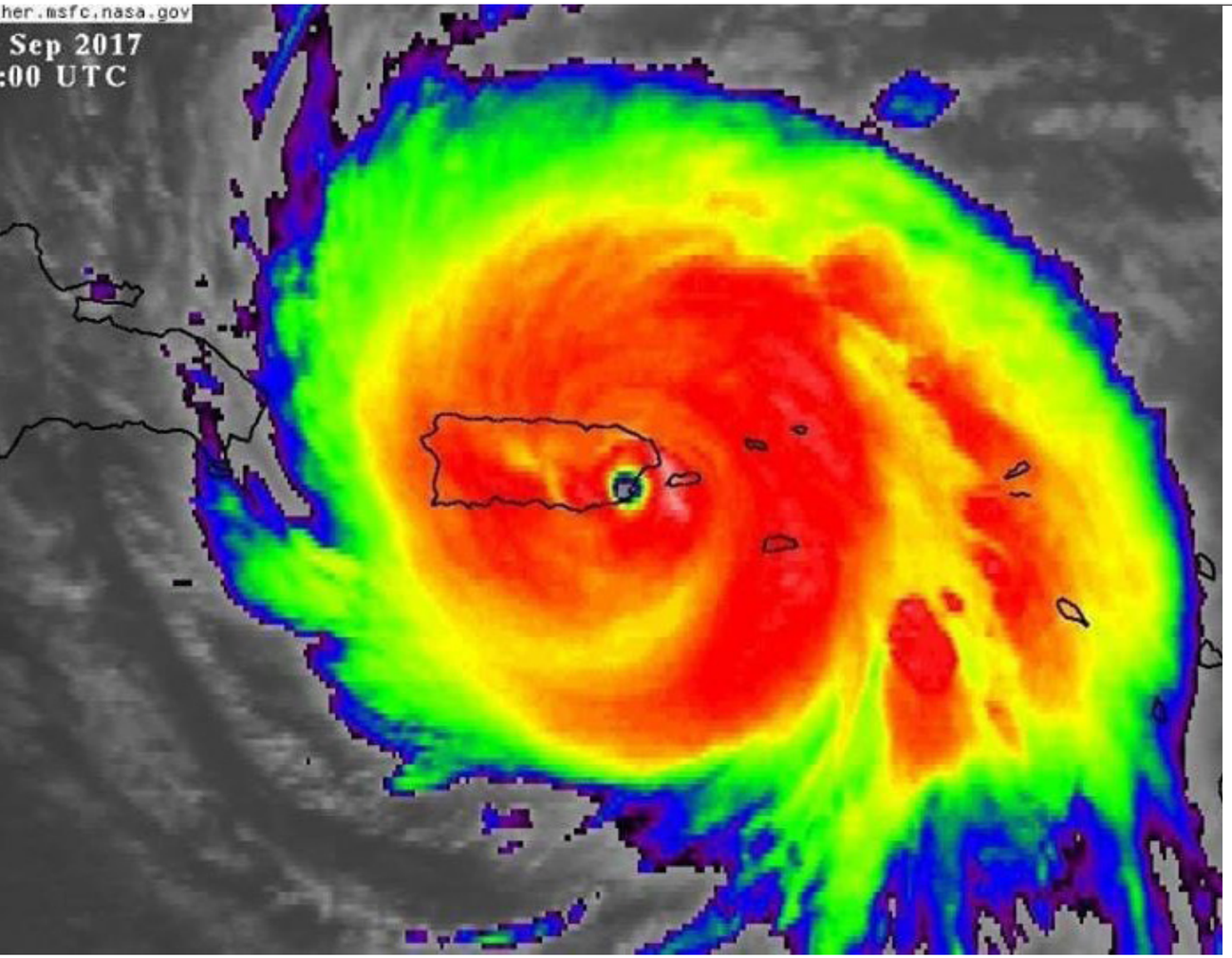
LETTER FROM ADA MONZÓN





In 2017, Hurricane Irma's and Hurricane Maria's passage through the Caribbean brought several challenges, but also a valuable lesson on the importance of togetherness, safe housing, and building community resilience. This document is inspired by and directed to all Puerto Ricans, and it summarizes strategies developed and tested for resiliency in the face of these catastrophic natural disasters.

We faced the most difficult experience of our lifetime with these devastating hurricanes, but we pulled together through hard work, the collaboration of many organizations, and government efforts. We are known for our warm hospitality and diversity, but we know Mother Nature is changing around us, testing our emotional strength to withstand the harshest conditions. No matter where we live, our profession or level of expertise, we need to face the challenges climate change brings with courage and resilience.

Governments, universities, businesses, professional institutions and communities need to be committed to education and building a safer and stronger Puerto Rico. Decision makers in housing need to make housing facilities more resilient and able to harness natural resources in order to stave off risks from natural hazards. Hurricanes are natural events, and Category 4 and 5 hurricanes are more frequent globally due to climate change, but these disasters are related to the actions people and communities take. We need to consider scientific knowledge to build safer communities. Now, there are unprecedented opportunities to create resilient communities, and to protect life and property.

Hurricane Maria has had devastating effects on every system that supports day-to-day life: power and water systems, communications, economic development, education, food supply, health care, social services, transportation, and more. Rebuilding after Maria will take a long time and needs to be based around strong communities.

Education is our best way to empower communities so that they can take control of and shape their future. Housing—the cornerstone of healthy communities—is essential and should be as much about improving the quality of life for people as building homes. We are all hopeful, and we look forward to building a safer future as a weather-ready nation.

— Ada Monzón

KEEP SAFE

A RESILIENT HOME



A LESSON IN RESILIENCE

By Ricardo Alvarez-Diaz - Architect

In the early morning hours of September 20, 2017, I found myself locked inside my apartment in San Juan with my wife and three daughters. This was not the first time we had experienced a hurricane in Puerto Rico, and that might be why we decided to stay on the island and brave out the storm. The roar of the sea, the hiss of the wind and the intense rain that hammered against our glass windows, foreshadowed one of the most devastating hurricanes of the past century. For hours, my only defense was to hug my terrified daughters, and hold on to my wife, to lessen the anxiety and fear I felt as a direct result of the general lack of preparedness we faced during this catastrophic event.

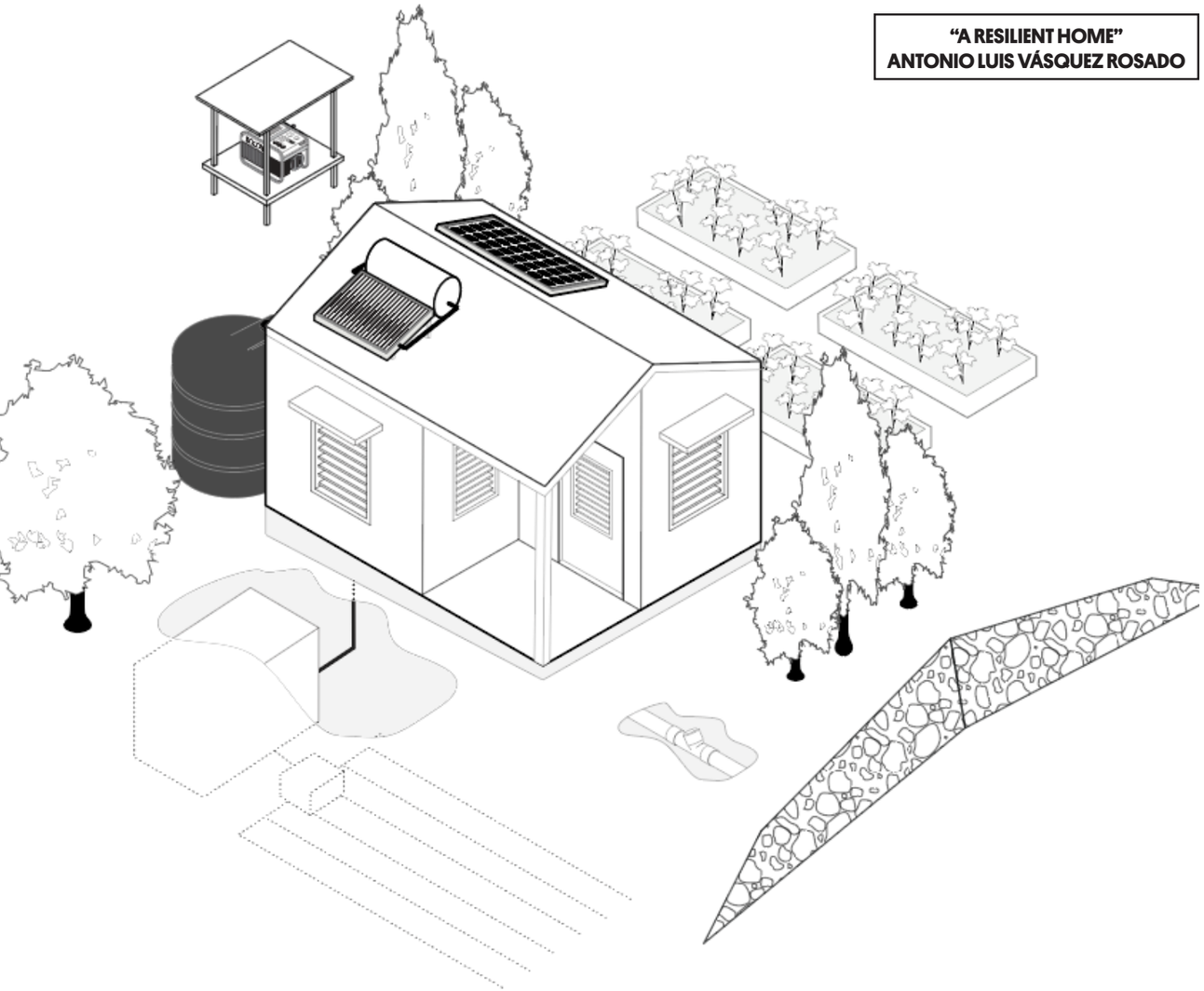
Both Hurricanes Irma and Maria, which hit land in the Virgin Islands, Puerto Rico, and later on the mainland in the United States, caused the loss of thousands of lives, separated families, weakened infrastructure, destroyed the environment, and caused billions of dollars in property damage. However, the biggest challenge of these climatic disasters in Puerto Rico and the Virgin Islands was what happened afterwards. The situation was truly dire. We could not communicate with the outside world nor even amongst ourselves. We could not work. We could not buy anything. There was no water. There was no light. And all was due to the fact that we had had not mapped out our resilience strategies beforehand.

But what is resilience? The term comes from the Latin “resiliere” which means durability, elasticity, or the ability to recover with speed after a great difficulty. In 2017, WE learned that rebuilding after a natural disaster of this magnitude is much more than simply raising up damaged or destroyed structures. Indeed, natural disasters offer up opportunities to employ better construction techniques, to utilize new construction materials, and to implement new strategies of resistant and sustainable design that better meet the needs of the people before, during, and after such catastrophes. We learned how important it is to support each other as human beings through our shared communities and citizen collaboration and education.

This manual was born from that desire. So, we can educate both working professionals and the general public on how to be better prepared for the next disaster. Thus armed, we will rise again with greater impetus, flexibility, and ease—to not only survive, this time, but to thrive.



A COMMITMENT TO SAFE AFFORDABLE HOUSING



"A RESILIENT HOME"
ANTONIO LUIS VÁSQUEZ ROSADO

Two months after Hurricane Maria, my Enterprise colleagues and I visited Puerto Rico and the U.S. Virgin Islands to identify how we could support the recovery. We had been doing work in Puerto Rico for nearly twenty years, so while we did not yet know how we could support long-term rebuilding, we felt urgently that we must. After our team strategized and packed emergency supplies to give to partners in the San Juan area, Ponce, Caguas, Mayaguez and St. Croix, we walked the dark streets of Old San Juan, sparingly lit with generators whose hums were a deafening reminder of the impact of Hurricane Maria.

As we navigated from location to location, under the direction of Michelle Sugden Castillo, across Puerto Rico and the USVI, we saw electrical lines down all around us, fallen trees and debris. But what struck us most deeply was the devastation Maria had unleashed on people's homes. And yet despite all that had occurred, we saw community leaders who had risen up to provide resources and deliver water, hot meals and replacements for damaged items. We saw the strength and fortitude of communities that, though impacted, were never defeated. We saw people working together to support one another during the most trying of times.

We were moved to create a resource to enable people to build back stronger, so that when tens of billions of dollars of federal aid arrived, the money could be used to protect residents from future harm. And as you will see, we wanted to provide ideas for rebuilding homes that take advantage of natural solutions to existing challenges, like using plantings to fight erosion.

This book is a tribute to the resiliency of the people impacted by the storms.

This rebuilding manual was created collaboratively with the input of more than 100 people in Puerto Rico, the USVI and on the mainland, many of whom provided their expertise while managing the rebuilding of their own homes.

I would especially like to recognize and thank the manual's creator and greatest champion, Laurie Schoeman, without whom it would not exist.

I want to also recognize Erika Ruiz, who leads all of Enterprise's recovery work in Puerto Rico; Patrick Jordan and Jelani Newton, who leads Enterprise's recovery work in the USVI; and Marion McFadden, who leads Enterprise's recovery and resilience work nationwide.

Special thanks to The New York Community Trust, Hurricane Relief Fund and U.S. Caribbean Strong Relief Fund at The Miami Foundation, and Unidos por Puerto Rico for their generous support which made this guide possible.

This guide represents one of our key contributions toward a resilient future for Puerto Rico, the USVI and other island communities working to protect housing from risks of natural hazards.

— Laurel Blatchford, President,
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The production team on Keep Safe includes experts from a range of generations, disciplines and communities who had the courage and fortitude to commit to this project and work tirelessly to bring Keep Safe into existence.



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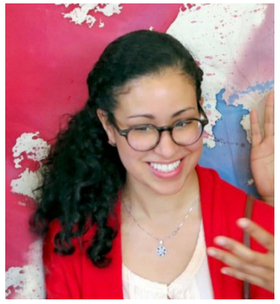

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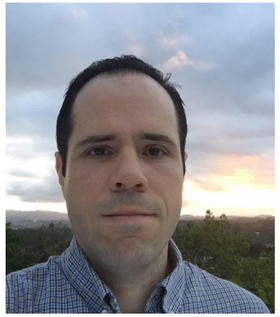

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KEEP SAFE

FEBRUARY 1ST, 2018: FIRST WEEK OF SPRING SEMESTER AT THE UNIVERSITY OF PUERTO RICO ARCHITECTURE SCHOOL WHICH HAD BEEN DELAYED DUE TO HURRICANE MARIA.

STUDENT TESTIMONIALS FROM PROFESSOR ANNA GEORAS' PROFESSIONAL EXPERIENCE INTERNSHIP (IXP) WHICH PROVIDES STUDENTS WITH PROFESSIONAL EXPERIENCE IN ARCHITECTURE.



April 17 Convening of Partners at BPPR Centro Europa Santurce, San Juan Puerto Rico

WHY WE MADE KEEP SAFE

This guide started with an idea: that homeowners and building owners needed tools to inform the redevelopment and rehabilitation of their homes and housing after Hurricane Maria. Over the course of the year following Maria, over 200 experts from across Puerto Rico and mainland United States came together to conceive, develop and design a guide with the purpose of helping vulnerable home and residential building owners rebuild smarter and stronger so that homes—particularly affordable homes—will be able to withstand the variety of hazards by which Puerto Rico, the U.S. Virgin Islands (USVI), and shared island communities are afflicted.

Hurricane Maria reminded the world of the fragility of almost all of Puerto Rico's major infrastructure, including its economy, power and water systems, transportation routes, building stock, healthcare system, poverty levels, social support for vulnerable people, food supply, and more. The storm's aftermath also reminded the world of the strength of Puerto Rico's communities and the progress people can make working together under a common purpose. In times of crisis, housing that depends less on the island's fragile infrastructure (known as passive adaptability) can help sustain communities and meet their basic needs for safe shelter, clean water, and food. It is clear that people's way of life and work must change while building and caring for one another so that the inevitable extreme events of the future are less harmful. No matter who you are or where you live, this manual was designed to help you prepare for the weather ahead.

This guide will allow you to learn what specific conditions in Puerto Rico make buildings and people vulnerable to disaster. It will also help you to identify the best ways to adapt a home or residential facility as well as everyday practices to the perils of climate change. You don't need financial reserves or construction expertise to make changes that protect you and the people you love from disaster. Whether you plan to build a new house or want to retrofit the one you live in now, you will find strategies that reap multiple benefits of your investment.

This guide was produced as part of the Enterprise Community Partners' Climate Strong Islands Initiative (CSII), which is an effort to make Puerto Rico, the USVI, and Florida Keys' long-term recovery more equitable after Hurricanes Irma and Maria—particularly for low-income families—by helping residents safeguard against future natural hazards. Through CSII, we are working with local and national partners to help communities affected by Hurricanes Irma and Maria in three main ways: increasing their resilience, strengthening the organizations serving those places, and accelerating the recovery of infrastructural, social, and economic institutions.

We welcome you to read this guide either in sections or in whole and to share it with your community. Rebuilding with resilience safeguards homes, lives, and communities. Rebuilding safeguards the future of Puerto Rico.

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COMMUNITY LEADERSHIP

IS THIS GUIDE FOR ME?

Homeowner or Building Owner

As the owner of your home, be it a townhouse or a detached building, you wield the power to make decisions regarding your structure's resiliency. You can choose to make major, permanent changes to your site and home to ensure safety before, during, and after a natural disaster.

Community leader

The community regards you as their representative. Your communication and organizational skills enable you to serve as a liaison between governmental/external efforts during times of distress. By taking on a leadership role to bring your community together in the face of an emergency, you are catalyzing a collaborative effort towards resiliency that can persist long after the disaster hits.

Tenant

Renting at a multifamily building may limit the actions you can take in terms of fortifying your home against natural disasters because you have limited ability to determine how the building is prepared but you can still provide the authority with suggestions and key information found in this guide to improve your home.

Administrator

You may be an administrator of a housing program or are able to determine how to regulate a housing facility or home. This guide can help you determine ways to safeguard the building from hazards or set up a program to fund or support housing resilience.

Property Operator

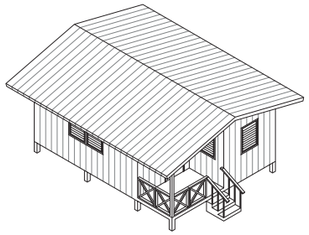
You are the legal owner of a property which you rent out and you are responsible for ensuring it is safe and has emergency plans in place. Your tenants can certainly engage in some of the preventive and prescriptive measures included in this guide.

Construction Professional

As an architect, engineer, contractor, master builder, inspector, or other professional in the construction industry, the information included in the main corpus of this guide may seem basic to you. However, it is becoming increasingly important to bear these principles in mind.

TYPE OF HOME AND COMMUNITY CONFIGURATION

TYPE OF HOME

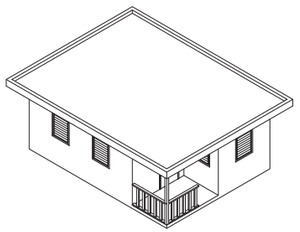


NAME

WOODEN DETACHED

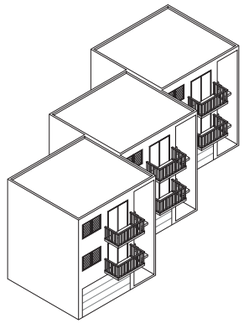
DESCRIPTION

- Wooden Structure
- Can have Zinc roof



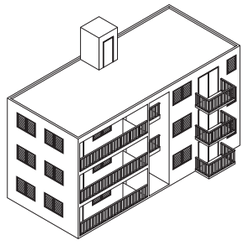
CONCRETE DETACHED

- Concrete/Block and rebar structure
- 1-2 stories



TOWN HOUSES

- “Medianera” or shared wall
- One owner per vertical unit

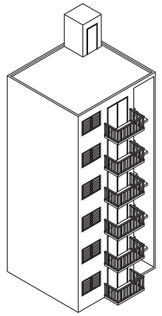


NAME

WALK-UP

DESCRIPTION

- Multiple owner
- Up to 3 floors from ground



HIGH RISE CONDOMINIUM

- Multiple Owner
- 3 floors and up
- Administrator oversees big decisions
- Requires elevators

TYPE OF COMMUNITY



NAME

INFORMAL COMMUNITY

DESCRIPTION

- Area of mixed use
- Uncertain property limits
- Organic growth
- Some units are only accessible via alleyways
- Limited outdoor space (private)



URBAN LOTIFICATION

- Defined lots
- Planned growth
- Formal roads
- Many units share walls
- Area of mixed use



URBANIZATION

- Defined lots with dedicated outdoor space
- Homogeneous building typologies
- Can be gated

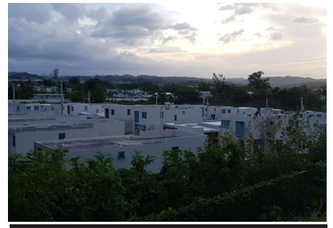


NAME

FINCA

DESCRIPTION

- Irregular topography
- Lotification size and form varies
- Dispersed lotification



INDEPENDENT MEGA-LOT

- Strictly defined lot
- Defined areas for parking or outdoor spaces

NAVIGATING THE GUIDE

How you prepare for and respond to risks from extreme weather and natural hazards will vary. The strategies applicable to you and the way you implement them will depend on your construction knowledge, your home's typology, and its location. We encourage everyone to familiarize themselves thoroughly with this entire document, but you can also read the strategies most applicable to your site.

Keep Safe was designed specifically for Puerto Rico's climate, culture, and architecture and contains general guidelines to achieve maximum resiliency. As you read, we encourage you to think about how to adapt the strategy for your home and specific needs.

Some strategies are not instantly achievable or rewarding; they might require months of planning and saving and, in some cases, they might take years to produce results. Do not get discouraged or frustrated; instead, develop a plan to achieve your strategy.

For each step of the way, we encourage you to reach out to design or construction professionals for help in customizing a strategy to your needs and ensuring compliance with the latest building codes. Use this guide to prepare for the meeting, ask the appropriate questions, and ensure you are not being taken advantage of during the process.

what specifically applies to you, and providing you with all the options at a glance. While we use a step-by-step approach to explain each concept, the manual's success relies on the actions you take after reading it to achieve resiliency.

We encourage you to use this guide as a workbook. Fill out the checkboxes, underline, circle, draw, take notes from other sources, and customize the guide for yourself as you see fit.

This document has been designed to help you take the most effective actions to keep your home safe from disaster. It offers an overview of hazards, risks, and vulnerabilities that will help you understand the greatest challenges of your region and how they affect your home. This includes a catalog of strategies revealing opportunities to create everyday benefits as you mitigate your biggest risks, ways to strengthen your community so the effects of a disaster are lessened for everyone, simple ways to take the first steps, and resources to support you as you move forward. For a comprehensive understanding, you should read it cover-to-cover, but each section is kept brief so that you can select a concise collection of the elements most important to you. The strategies, modeled like a catalog, give you the option of focusing on what specifically applies to you, while providing you with all the options at a glance. While we use a step-by-step approach to explain each concept, the manual's success relies on the actions you take after reading.

We encourage you to use this guide as a workbook. Fill out the checkboxes, underline, circle, draw, take notes from other sources, and customize the guide for yourself as you see fit.

The main sections present the complex and interconnected challenges of adapting to climate change in five parts:

- Overview of Natural Hazard Vulnerabilities in Puerto Rico explains the principles behind climate change mitigation and profiles natural hazards that present the greatest risks to housing and residents.
- Strategies for Resilience contains 28 strategies that utilize straightforward language and diagrams to present what you need to know about the technical aspects of each strategy.
- Each strategy comprises of an introduction to a particular challenge, a description and function of what the strategy entails, how it works, and of ways to apply said strategy through actions to increase resilience. While all the strategies are interrelated to some degree, a list of supporting strategies refers you to the most closely related material, while the listed resources will direct you to more detailed information. Where relevant, there are tips on operations and maintenance, approximate costs, and additional benefits. Finally, different case studies will be shown to illustrate implementation.

The Strategies are organized by chapters as follows:

- A Safer Site
- Building Protection
- Passive Habitability
- Water Management
- Energy
- Emergency Preparedness
- Community
- Putting it Together will help you implement plans for implementing strategies.
- Community Engagement holds strategies to encourage community preparedness. Homeowners and housing owners can not achieve resiliency without community strength. This chapter also shows how communities in Puerto Rico can build upon the networks that arose after Hurricane Maria to be ready for the next disaster and grow more connected every day.
- Putting it Together
- Additional Resources at the end of the book will direct you to resources that offer more information.
- Appendix offers additional specific information.

DIRECTORY OF SYMBOLS & ICONS

Costs of Variety of Strategies will be estimates and tiered in this range. All costs are only estimates, the following variables will need to be considered when pricing out scope and strategies including:

- Cost of Materials and including escalation for harder to procure supplies
- Cost of Labor and including escalation for federally funded projects
- Timing of implementation
- Complexity of project and experience of contractor, the more experienced the contractor the more savings there can potentially be.

Cost Ranges

$	$0 – $6,000 **
$$	$6,000 – $12,000
$$$	$12,000 – $20,000
$$$$	$21,000+

**Majority of projects over 6K will require a permit

CALL OUT BOXES / DEFINITIONS

HAZARD

An event that can potentially be dangerous or harmful depending on varying degrees of intensity and severity. There can be 'natural' hazards (i.e. flooding, earthquakes, tsunamis, high winds and extreme temperatures) and 'technological' hazards (i.e. terrorist attacks, oil spills, chemical explosions).

DISASTER

A hazard event which disrupts the normal daily activity of a society. Disaster impacts are not just the result of hazards, but they are also the product of social, political, and economic situations.

VULNERABILITY

Characteristics of a person or group and their situation that influence their capacity to anticipate, cope with, resist, and recover from the impact of a hazard.

RISK

A hazard multiplied by vulnerability (both social and physical) and lessened by mitigation and capacity to cope or adapt. Disasters are characterized as the interaction between a hazard and the degree of vulnerability experienced by citizens.

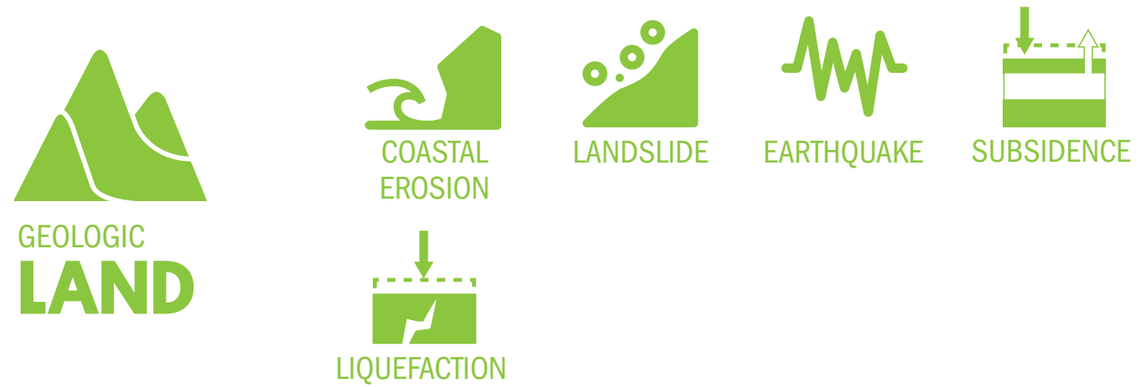
MITIGATION

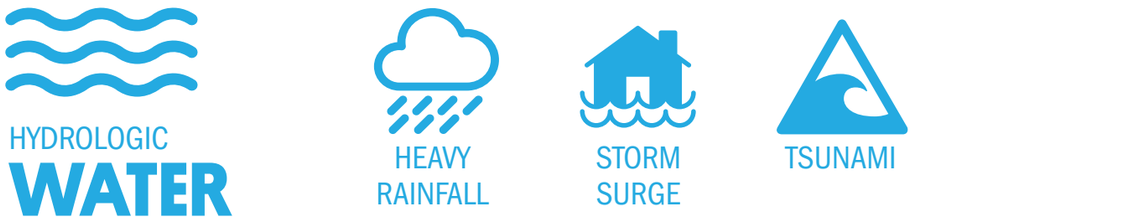
Is the effort to reduce loss of life and property by lessening the impact of disasters.

ADAPTATION

The adjustment in natural or human systems in response to current natural hazards and actual or expected climate change impacts. Actions taken to help communities and ecosystems moderate, cope with, or take advantage of actual or expected changes in weather and climate conditions







HAZARDS AND STRATEGIES

DISCLAIMER

This wayfinding map was created to illustrate the interconnectedness of the book's resilience strategies to stated risks. Consult building professionals when determining how each strategy can reduce risk to a variety of hazards.

HIGH WINDS	DROUGHT	FIRE	EXTREME TEMPERATURE	HEAVY RAINFALL	STORM SURGE	TSUNAMI	COASTAL EROSION	LANDSLIDE	EARTHQUAKE	SUBSIDENCE	LIQUEFACTION			
●	●	●	●	●	●	●	●	●	●	●	●	**Strategy 1:** Reinforce Your Site	Page 68	$-$$$
●	●	●	●	●	●	●	●	●	●	●	●	**Strategy 3:** Plant an Edible Garden	Page 96	$
●	●	●	●	●	●	●	●	●	●	●	●	**Strategy 4:** Assess the Priorities for Your Home or Building Structural Condition Prior to Event	Page 138	$
●	●	●	●	●	●	●	●	●	●	●	●	**Strategy 15:** Reduce your Energy Use	Page 262	$-$$
●	●	●	●	●	●	●	●	●	●	●	●	**Strategy 16:** Integrate Solar Electricity	Page 272	$-$$$$
●	●	●	●	●	●	●	●	●	●	●	●	**Strategy 17:** Integrate Solar Thermal Energy	Page 290	$$-$$$
●	●	●	●	●	●	●	●	●	●	●	●	**Strategy 18:** Install Energy Backup	Page 298	$$-$$$
●	●	●	●	●	●	●	●	●	●	●	●	**Strategy 19:** Reduce your Water Consumption	Page 320	$
●	●	●	●	●	●	●	●	●	●	●	●	**Strategy 23:** Develop a Household Emergency Plan	Page 373	$
●	●	●	●	●	●	●	●	●	●	●	●	**Strategy 24:** Choose a Space to Keep Your Family Safe	Page 392	$
●	●	●	●	●	●	●	●	●	●	●	●	**Strategy 25:** Respond + Begin Household Recovery	Page 398	$
●	●	●	●	●	●	●	●	●	●	●	●	**Strategy 26:** Develop a Community Plan	Page 420	$
●	●	●	●	●	●	●	●	●	●	●	●	**Strategy 27:** Identify + Prepare Safe Community Shelter	Page 426	$-$$
●	●	●	●	●	●	●	●	●	●	●	●	**Strategy 28:** Inspiring Post-Disaster Planning for Community	Page 434	$-$$

HIGH WINDS	DROUGHT	FIRE	EXTREME TEMPERATURE	HEAVY RAINFALL	STORM SURGE	EARTHQUAKE			
○	●	●	●	●	●	●	**Strategy 2:** Reinforce Site with Vegetation	Page 78	$
●	○	○	○	●	●	●	**Strategy 5:** Build a Strong Foundation	Page 142	$$
●	○	○	○	●	●	●	**Strategy 6:** Build Stronger Walls	Page 154	$-$$
●	○	○	○	●	●	●	**Strategy 7:** Build a Sturdy Roof	Page 170	$$-$$$$
●	○	○	○	●	●	●	**Strategy 8:** Anchor, Seal and Protect Building Openings	Page 184	$-$$
○	○	○	○	●	●	○	**Strategy 9:** Flood Proof Home	Page 204	$-$$$
○	○	○	●	○	○	○	**Strategy 10:** Reduce Thermal Heat Gain	Page 216	$-$$$
○	○	○	●	●	●	○	**Strategy 11:** Increase Home Ventilation	Page 224	$-$$
○	○	○	●	○	○	○	**Strategy 12:** Benefit from Natural Light	Page 230	$-$$
○	●	○	○	●	●	●	**Strategy 14:** Manage Pests	Page 244	$-$$
○	●	●	○	●	●	●	**Strategy 20:** Collect and Use Rainwater	Page 330	$-$$
○	●	○	○	○	●	●	**Strategy 21:** Improve Septic Waste Disposal System	Page 346	$$-$$$
○	○	○	○	○	●	○	**Strategy 22:** Prevent Wastewater Backflow In Homes	Page 356	$

CHOOSING HEALTHIER MATERIALS



A healthy material is one that introduces little to no harm to the user. Carefully choosing the types of materials used for a home is therefore critical to the health of its occupants. A growing number of scientists warn that chemical exposure to existing building materials has negative health impacts ranging from the development or exacerbation of asthma to effects on brain development and disruption of the endocrine system.

In Puerto Rico, climate conditions like heat, high sun, and flooding affect how a material stands over time. If materials contain certain toxins, these can be emitted from building products under normal conditions. A common example is that ‘new carpet smell’ which comes from the off-gassing of carpet adhesive.

Heat and humidity cause materials to break down more quickly, increasing toxin exposure. The impact of such exposure varies and is magnified for children based on their behavior and stage of development.

Most people assume that the materials we use in our building products are composed of chemicals that have been tested and approved as safe for human health by the US Government, but this is not the case. Tens of thousands of chemicals remain untested, and yet they are used in everyday products. Federal restrictions against toxic chemicals in products are rare and often limited in their scope. Even known hazardous substances like asbestos and lead are still allowed in many items, including building materials. These are known as chemicals of concern.

Residents, manufacturers, construction workers, and waste disposal workers may be exposed to these toxins throughout the product lifecycle. Even emissions from manufacturing facilities impact those nearby and can contaminate the broader environment. When manufacturing facilities are damaged during extreme events, additional contamination of soil, air, and water can occur.

What You Need to Know

- When choosing materials for your home, it is important to avoid materials that contain chemicals of concern.
- By making informed choices, we can reduce chemical exposure in our buildings, in our communities, and in our homes. Informed choice begins with transparency about product content. When we know what is in these products, we can compare and assess alternatives, and make informed choices to avoid chemicals of concern where possible.
- Our choices influence a huge international market, providing incentives for manufacturers to reduce the use of chemicals of concern and create healthier products that meet our needs at prices we can afford.



LEAVE NO TRACE: SUPPORTING A CIRCULAR ECONOMY

Puerto Rico's Solid Waste Authority estimated that Hurricane Maria generated nearly 6.2 million cubic yards (or 43 football stadiums filled eight feet high) of waste and debris. With limited landfill capacity, soccer fields and other sites were transformed into temporary dumps.

This is a common concern following any major event. Waste and debris need to be properly managed to minimize landfill use and maximize recycling where possible.

Not all waste and debris is easily repurposed. Contaminated materials pose health hazards and must be handled with care. Household Hazardous Waste [HHW] refers to those materials that might combust, are corrosive, or are toxic. These require special care in disposal, as does moldy or contaminated debris. The EPA notes that materials that remain wet for 48 hours or more may need to be discarded as they will likely become a source of mold growth.

For disposal or potential recycling/composting, the EPA recommends separation of waste and debris into five groups: household garbage, construction debris, vegetation debris, white goods [such as appliances] and electronics. The practice of careful sorting to reduce landfill waste also relates to the concept of Circular Economy.

The Circular Economy "aims to redefine growth, focusing on positive society-wide benefits. It entails gradually decoupling economic activity from the consumption of finite resources, and designing waste out of the system. Underpinned by a transition to renewable energy sources, the circular model builds economic, natural, and social capital." The Circular Economy has three core principals: to eliminate waste and pollution through design, recycle products and materials, and rebuild natural systems.

The concept is simple: waste less, spend less, and save more.

Much of Puerto Rico's solid waste ends up in one of the island's 29 landfills, most of which do not comply with Commonwealth and federal landfill requirements and were at capacity before Maria. Many are located in areas at risk from earthquakes and flooding. While Law 70 (1992), the Solid Waste Reduction and Recycling Law of Puerto Rico, makes it mandatory that individuals, state agencies, and public corporations that generate recyclable waste categorize them as part of a recycling program, only around 10% of waste is recycled, according to the Solid Waste Authority (Autoridad de Desperdicios Sólidos, [ADS]).

What You Need to Know

- Sorting waste properly increases the likelihood of reuse.
- Recycling materials saves money, helps the environment, creates jobs, and boosts the economy.
- Repurposing building materials reduces waste and enables others to improve their homes at a reduced cost.
- Choosing non-toxic materials for rebuilding or home maintenance reduces the entry of toxins into homes and waste streams and lessens negative health impacts.



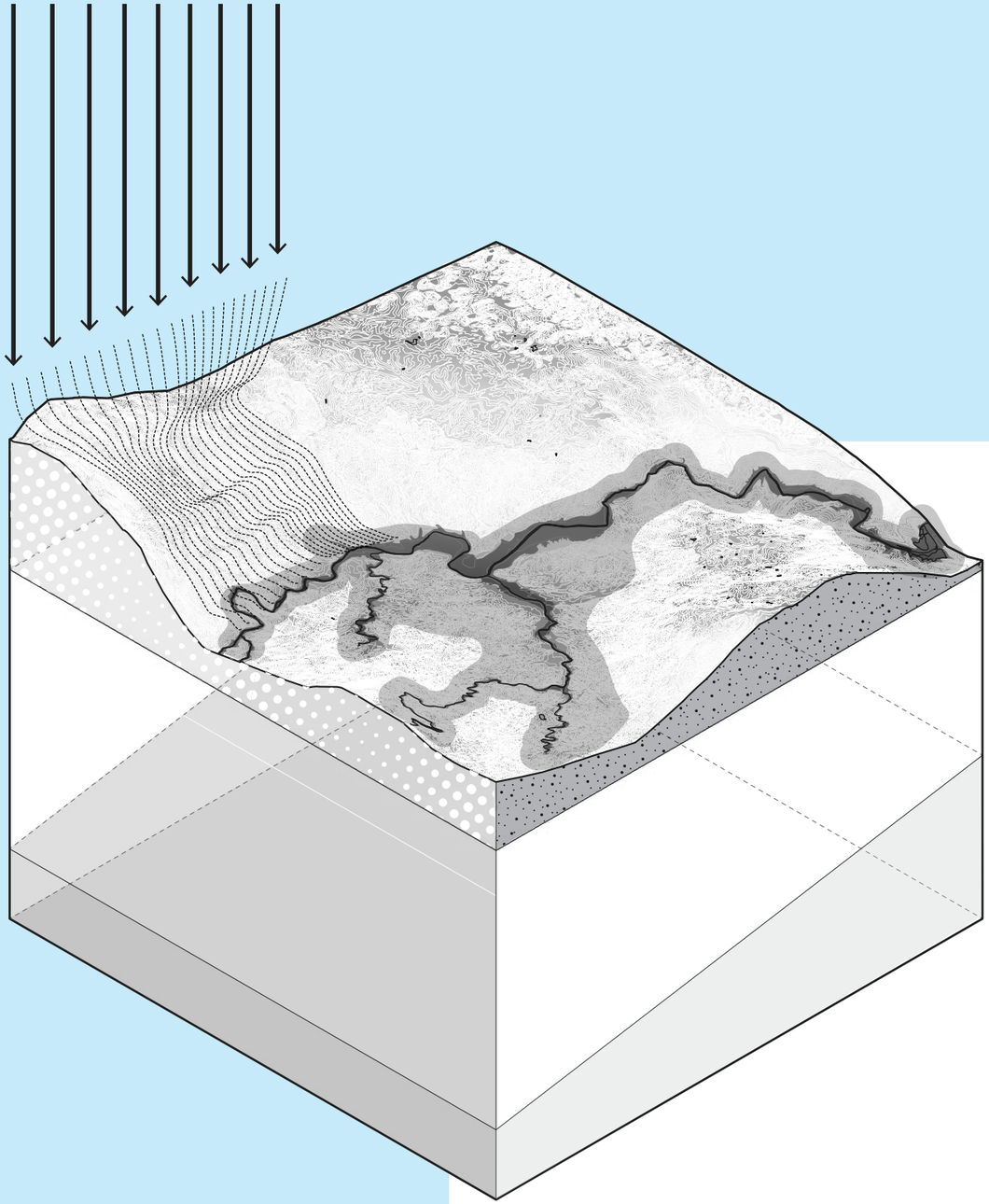
RECOGNIZING COMMUNITY LEADERSHIP BY LUCILLA MARVEL

“The house is the place where both planning and community development impact upon the family and individual, be it in the urban or rural area. Housing represents the micro-setting and end result of planning’s macro-scope and plans. It is a truism that a home is more than a house; a home is more than four walls. Planning for housing must therefore take into account more than the physical structure and spatial requirements; it should consider the social, economic and psychological needs of the individuals and families who will occupy the housing. And housing must be considered within the community context.

It is also a truism that communities know their needs and conditions better than anyone else and this enabled them to be the first responders and, sometimes for months, the only responders to the vast and devastating emergencies caused by Hurricanes Irma and Maria. Throughout the island there are countless examples of community leaders and unsung heroes who continue to work and find ways to survive and improve their communities, seeking information and knowledge that will facilitate their participation in the recuperation and rebuilding of their homes and surroundings. They want to be protagonists and beneficiaries of the longer-range mitigation process as well, working towards a vision of social justice for all.”

This statement from Listen to What They Say: Planning and Community Development in Puerto Rico sets the framework for a participatory planning process where residents and members of different communities are an essential and vital part of the process in all its phases.





INTRODUCTION

ADDITIONAL RESOURCES AT:
WWW.ENTERPRISECOMMUNITY.ORG/SOLUTIONS-AND-INNOVATION/DISASTER-RECOVERY-AND-REBUILDING/KEEPSAFE

INTRODUCTION TO PUERTO RICO'S HAZARDS AND RISKS

DIAGRAMS AND MAPS BY LARISA OVALLES PAULINO

Hurricane Maria underscored Puerto Rico's fragile built environment and the need to rethink reconstruction for millions of homes and hundreds of communities. Puerto Rico currently faces earthquakes, landslides, liquefaction, extreme heat, and flooding caused by increased rainfall, tsunamis, sea level rise, and storm surge. Familiarizing yourself with these hazards will help your home, family, and community prepare for future events. This section focuses on understanding these hazards and provides resources to determine the safest strategies for protecting your site against environmental risks.

Climate change projections must be considered when planning for future risks and when making long-term decisions, so that people and communities will be better prepared for future disasters. The consequences of extreme events due to climate change will become more severe over time according to the predictions of the National Climate Assessment,[1] and will lead to economic impacts and increased stress on communities. Future projected risks include:

- Puerto Rico is located near the subduction zone between the North American and Caribbean tectonic plates and along the path of a highly active hurricane zone which exposes the island to multiple hazards including landslides and tsunamis.
- Puerto Rico is expected to warm faster than the global average, with increases in both mean and extreme temperatures.[2]
- Changes in precipitation patterns and temperatures will bring more frequent extreme rainfall events, but rainfall is also projected to decrease in the wet season with more increased drought and fire risk.[3] The eastern region is expected to experience the greatest decline in precipitation in the following decades, followed by the central mountainous region.[4]
- Rising sea levels will erode coastlines, particularly in the Western part of the island around Rincon.[5]
- More frequent and intense storms will compound the impacts of sea level rise, increasing the magnitude of storm surges, but also will contribute to coastal erosion and receding shorelines.

In the 1950s, rapid and unplanned urbanization led to the occupation of vulnerable locations, the destruction of ecosystems, including forest and wetlands, creation of unequal access to water and other services, and encouraged unsafe building practices, which affected the capacity of housing and communities to withstand impacts from natural hazards. This compromised the natural and native ecosystems that had adapted to and protected the land from natural hazards for millennia: areas of the island, that could support site drainage, are now covered with impervious surfaces like concrete that creates flooding rather than aquifer recharge. The continued development in hazardous locations, in combination with the increasing changes in climate and the inability to afford compliance with building code, will only exacerbate household and communities' already existing socio-economic vulnerabilities.

Housing location combined with other vulnerabilities like income, age and health status contribute to a person's exposure to risk. Structures located in the coast are prone to flooding and coastal erosion, high wind gusts challenge the implementation of building codes in the island, while mountainside communities, especially those close to river beds, are impacted by water reservoir overflow and dangerous runoffs. In addition, much of Puerto Rico's infrastructure is located in coastal areas, including drinking water and sanitary pipelines,pump stations, wastewater treatment and power plants and associated distribution systems were impacted by Maria and affect the habitability of housing and quality of people's lives.

IDENTIFYING HAZARD TYPES

Each home, whether single family or located in a multifamily building, needs to be fortified against the direct impact of predicted hazards as well as the cascade of effects that occur in the wake of natural hazard events such as damaged electrical systems or blocked roads. Identification and classification of existing and anticipated hazards is an essential first step in working toward a safer and more resilient home and community, and the primary step toward implementation of safer strategies.

The protection of a home always needs to be considered in the context of its location within the environment because the same hazard may manifest itself differently in the mountains, valleys, and coastal regions of Puerto Rico. In the central mountainous regions, with their sloping hills and in combination with development patterns, landslide hazards are a growing concern. Coastal zones face increased risks of flooding, storm surges, and coastal erosion. At the regional scale, strategic land use planning and land use policy can help improve resilience against these hazards and mitigate disaster risks.

Building to current codes is the first and most important step toward creating a resilient home, but that alone is not enough to withstand the impact from events, which can damage systems such as utilities, roads, and other infrastructure that support homes and communities. Therefore, it is crucial to have alternatives in place to support affected homes when those systems are not available. The strategies in this guide seek to help mitigate these impacts while strengthening and ultimately preserving homes.

This section will focus specifically on the different types of natural **hazards** common to Puerto Rico that are caused by major disaster events, such as tropical cyclones and earthquakes. For the purpose of this guide, hazards will be grouped into three main categories: **Air (Atmospheric), Water (Hydrologic), and Land (Geologic)**. Communities often face more than one type of hazard as well as unique challenges based on their social, economic, and physical vulnerabilities, exposing them to different levels of risks:



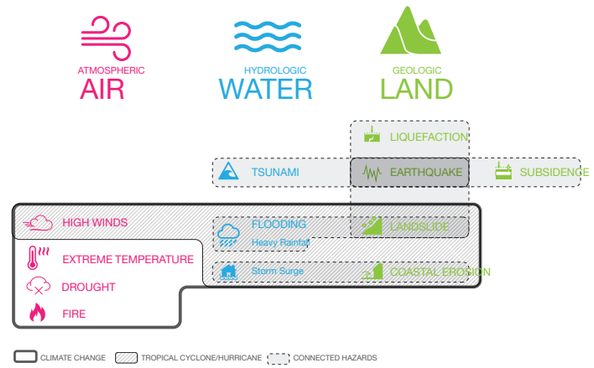
Air (Atmospheric) focuses on the effects of rising atmospheric temperatures, which leads to higher wind speeds driving more powerful tropical cyclones and extreme heat, in turn creating the conditions for drought and wildfires.



Water (Hydrologic) covers the consequences of sea level rise, storm surges, and altered precipitation that lead to both flooding and drought.6



Land (Geologic) covers the consequences of land movement including earthquakes and the movement of land resulting from compaction, which leads to liquefaction, erosion, landslides, and subsidence.



ATMOSPHERIC AIR

AIR (ATMOSPHERIC)

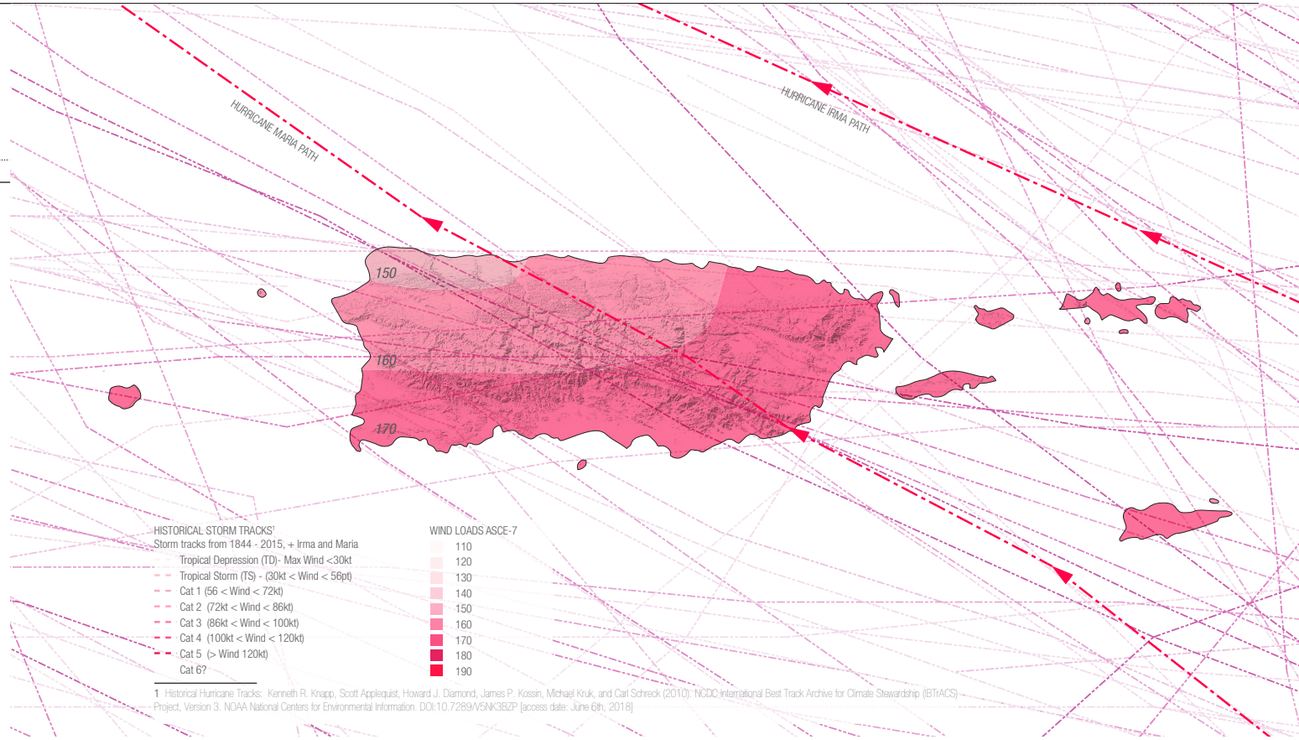
HIGH WINDS

High winds are one of the main hazards caused by tropical cyclones, or “hurricanes,” in addition to flooding caused by storm surge and heavy precipitation. The highest wind speeds are near the center of the storm, or “eye,” so the wider the storm, the more places are hit by the highest winds. Tropical cyclones usually arise during “hurricane season,” from June 1st to November 30th, because they require a surface water temperature of at least 82 degrees Fahrenheit.

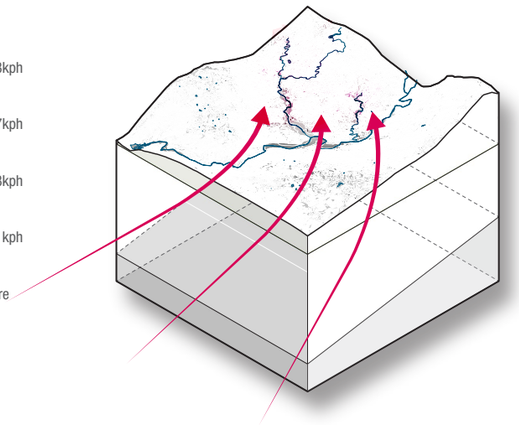
Wind speeds are used to classify events: tropical depressions (up to 38 mph), tropical storms (39-73 mph) and hurricanes (74 mph or higher), which are further divided into categories (‘Cats’): Cat 1 (75-95 mph), Cat 2 (95-110 mph), Cat 3 (111-129 mph), Cat 4 (130-156 mph), and Cat 5 (157 mph or higher).7

Exposure to high wind risks can vary depending on location, terrain, and other geophysical conditions. Open terrain has more potential for wind damage, but densely populated areas have the potential for more windborne debris.

- Soil in mountain areas can be destabilized, when high winds rip up trees and plants and precipitation saturates the ground.
- High winds cause damaged canopies, dead trees, and broken branches that in combination with other factors, such as drought and high temperatures, and increased fire risk.



1 Historical Hurricane Tracks: Kenneth R. Knapp, Scott Applequist, Howard J. Diamond, James P. Kossin, Michael Kruk, and Carl Schreck (2010): NCDC International Best Track Archive for Climate Stewardship (IBTrACS) Project, Version 3. NOAA National Centers for Environmental Information. DOI:10.7289/V5NK3BZP [access date: June 6th, 2018]





IMPACTS TO HOMES

There are over 1 million housing units in coastal areas, and few have been fortified to withstand high winds, extreme rain or storm surge resulting from cyclones and hurricanes. Storm surge is propelled ashore by hurricane winds and will reach more properties as sea levels rise.

High Winds:

- High wind pressures and wind-driven rain cause fragile power lines to collapse, uproot trees, and lift debris and vegetation.
- High winds produce a large amount of debris that can perforate buildings. This brings wind-driven rain into the building, furthering water damage and allowing wind pressure to increase inside the house leading to structural damage.
- High winds destroy roofs, walls, windows, structural systems, and foundations.
- Driving rain damages windows and doors and lifts roofs from the inside.
- Flying debris turns unsecured objects, even large trees, into projectiles.
- High winds result in damage to foundations and overall structures, backed up sewage systems, shorts in electrical systems, ruptured containers of pollutants, and mold on surfaces and structures.

ATMOSPHERIC AIR

AIR (ATMOSPHERIC)

DROUGHTS

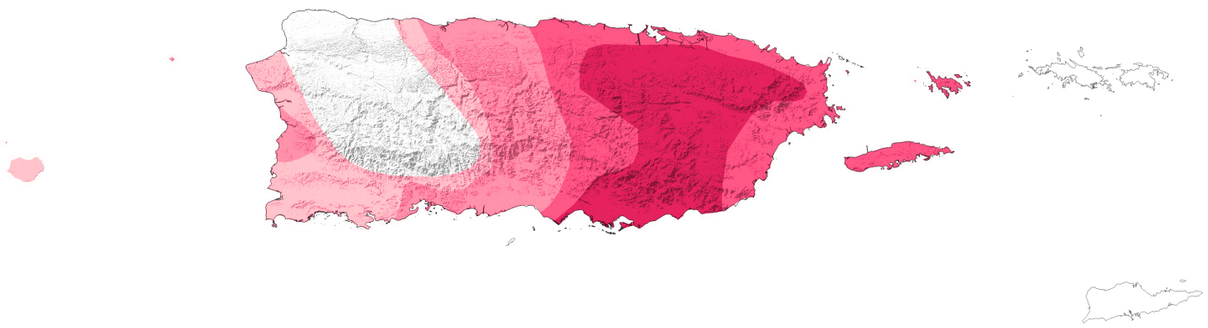
Droughts are caused by decreased precipitation, resulting in water shortage and related economic, environmental, and social impacts. It is likely that droughts will continue to intensify for the island as temperatures increase and precipitation decreases, with more frequent dry days. Dry season in Puerto Rico primarily runs from December to April, preceding the hurricane season. When drought occurs, underground aquifers are not replenished, lowering the water table. Lowering the groundwater table dries out the soil above it. When soil dries out, it causes the land to sink, leading to "subsidence" and instability.

- Drought affects vegetation in all regional locations and leads to food insecurity.
- Drought threatens the water supply, imperiling crops and people.
- Lowland moist forests dry out from drought or tree canopy loss from cyclones and become fuel for fires.

Impacts to Homes

- Droughts may reduce streamflows, lower lake and reservoir levels, deplete soil moisture and aquifer reserves, and diminish groundwater reserves, limiting potable water supplies for homes.
- Droughts limit water for farms and gardens.
- Dry vegetation increases fire risk, creating wind-blown embers, which are the main causes for the majority of structures that ignite in wildfires. Embers can be carried more than a mile through the wind, according to the National Fire Protection Association (NFPA).

Many homes are in areas adjacent to dense vegetation, referred to as the "Wildland Urban Fire Interface," and are susceptible to fires and conditions determined by type and distribution of vegetation, the flammability of structures in the area, density of settlement, weather patterns, topography, hydrology, and road construction.



August 25, 2015 Drought[1]
- None
- D0 (Abnormally Dry)
- D1 (Moderate Drought)
- D2 (Severe Drought)
- D3 (Extreme Drought)
- D4 (Exceptional Drought)

1 Drought Monitor by including the National Drought Mitigation Center (NDMC), the U.S. Department of Agriculture (USDA) and the National Oceanic and Atmospheric Administration (NOAA) http://droughtmonitor.unl.edu/Data/GISData.aspx

EXTREME HEAT

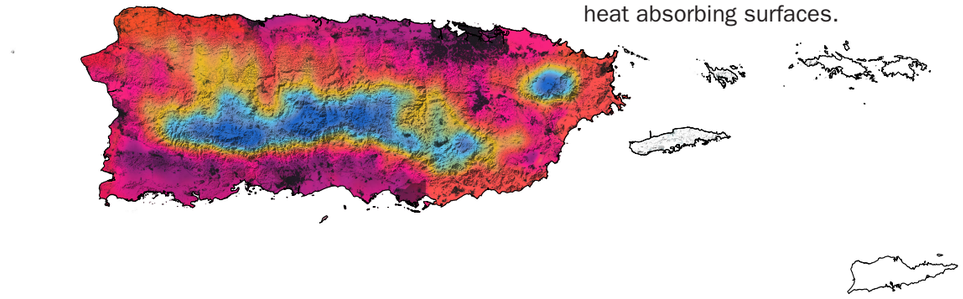
Extreme heat is a combination of increased temperature, high humidity, and evaporation that reaches 10 degrees or more above the average high for the region. Puerto Rico's annual temperature (81 degrees Fahrenheit) has increased by over 1.5 degrees Fahrenheit since 1950. There will be more days of extreme heat and an annual temperature rise of 9.5 degrees by 2100.

Heat related illnesses are exacerbated by stagnant atmospheric conditions and poor air quality, making people who live in urban areas more vulnerable to the effects of prolonged heat waves than those living in rural areas. Extreme heat can also affect communities by increasing demand for more ventilation and cooling in buildings and dependence on electrical power. Increase in average temperatures can limit the time people spend outside, while also releasing more air pollutants, leading to poorer air quality and increased thermal stress on residents.

Impacts to Homes

Heat can affect housing significantly, especially since the modern home is dependent on mechanical cooling systems to keep occupants comfortable. Dark surfaces, common in developed areas, absorb heat from the sun and then radiate it out, creating hotter localized zones. Health risks grow for everyone; the longer the heat lasts, it is especially dangerous for vulnerable populations such as seniors, anyone with compromised health, asthma or other respiratory issues, children, and pets. Impacts to housing include:

- Increased demand for mechanical cooling systems, taxing the power grid and leading to blackouts.
- Increased demand for water, taxing the water supply.
- Increased health risks due to higher constant temperatures and hotter air, which can lead to cardiac and respiratory problems.
- "Urban Heat Island" effect: urban communities are exposed to higher temperatures compared to rural and vegetated areas due to the amount of heat absorbing surfaces.



MAXIMUM ANNUAL AIR TEMPERATURE 2017[1]
- 30
- 28
- 26
- 24

LAND CLASSIFICATION MAP: PUERTO RICO LAND USE PLAN 2015 [2]
- High and Low Density Urban Areas

1 PRM NOAA-CREST program with the UPRM CASA project, University of Puerto Rico, Mayaguez Campus. http://academic.uprm.edu/hdc/GOES-PRWEB_ANNUAL_RESULTS/2017/
2 Puerto Rico Planning Board, November 2015 ----- Junta de Planificación de Puerto Rico, Noviembre de 2015.

HYDROLOGIC WATER

WATER (HYDROLOGIC)

FLOODING

Flooding is an overflow of water that submerges areas that are usually dry. There are hundreds of water bodies in Puerto Rico, many of which are prone to overflowing their boundaries.

Flooding damages in Puerto Rico continue to escalate due to changing weather, bringing more rainstorms and greater sea level rise. Due to Puerto Rico's rapid urbanization over past decades, watersheds are now covered with impervious surfaces (asphalt, concrete and roofing) that prevent infiltration of rainfall into the soil, thus disrupting the water cycle. The Puerto Rico Planning Board, together with FEMA, estimates that 252,748 structures throughout the island face the risk of flooding. Excessive rainfall coupled with housing located in flood plains, unpaved roads, and steep slopes exacerbates erosion rates and has adverse effects on reservoir capacity, water quality, and nearshore marine habitats.

Heavy rainfall and extreme storms also trigger frequent landslides. Puerto Rico is highly susceptible to landslides due to its mountainous terrain, especially in rural areas where vulnerable construction on hills and slopes is more common.

There are several types of flooding and exposure will differ depending on the location. Types of flooding include:

- Inland flooding which can occur through downpours over a short period of time or during extended periods of rain. Inland flooding or "urban flooding" can be caused by infrastructure failure (e.g. when sewer lines get clogged) or extreme precipitation.
- Flash flooding which builds up quickly, often in urban areas, where there are impervious surfaces or sewer systems that prevent water from draining.
- Riverine flooding that occurs when rivers overflow due to precipitation, runoff from higher areas, and if near the coast, storm surge, coastal, and tidal flooding. Riverine flooding causes erosion of riverbanks, fills reservoirs and other infrastructure with silt, and prevents sufficient water from being both stored and distributed. Valleys are hit hardest by inland and riverine flooding from rain, which can cause landslides from unstable terrain.
- Tidal flooding that can result from normal tidal variations of sea levels. As seas rise, tidal variations will push further inland.
- Coastal flooding and "storm surge" which is the inundation of coastland, primarily due to storm surge in coastal areas. Storm surge, known in Spanish as marejadas ciclónicas, is a rise in water levels generated by a storm, over and above the predicted astronomical tides. This rise in water levels can cause extreme flooding in coastal areas, particularly when storm surge coincides with normal high tide, resulting in storm tides reaching up to 20 feet or more in some cases. Sea level rise will continue to amplify the impacts associated with coastal hazards, including storm surge.
- Coastal erosion is loss of coastland when waves and currents remove sand from the beach. Coastal zones experience the highest and strongest direct storm surge and resulting flooding and erosion.
- Storm Surge flooding:
  - Scours the ground and homes with wave action, often ripping the ground level of buildings apart, causing more damage than wind or flooding alone.
  - High-energy wave action may cause shorelines to recede inland and sites to disappear.

Flooding can lead to:

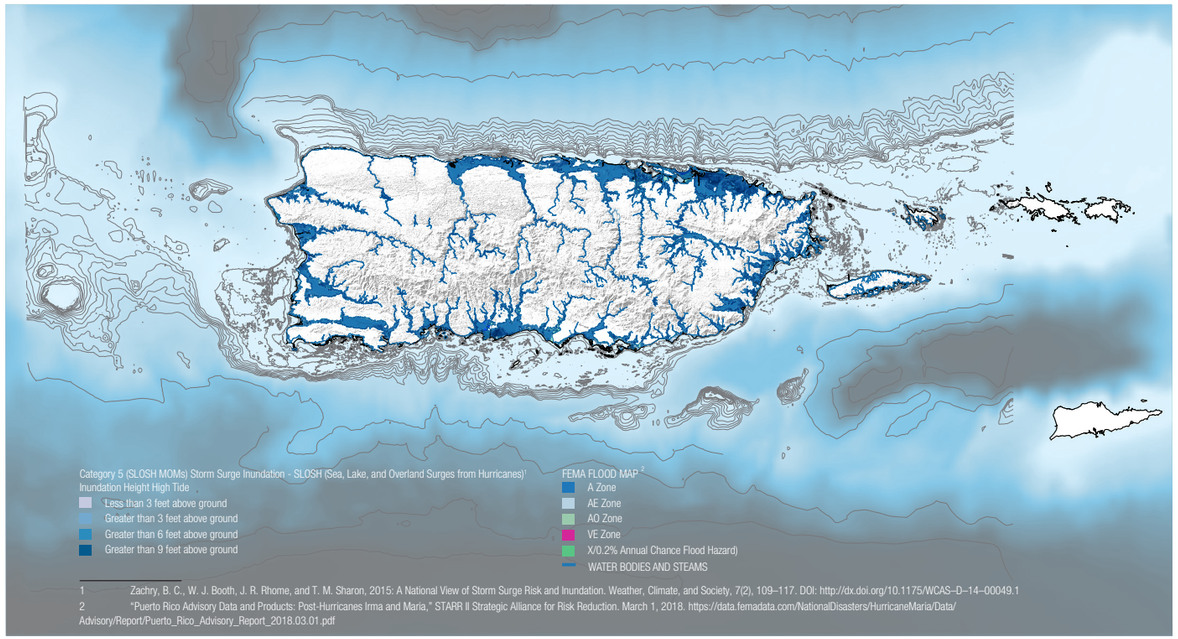
- Health problems from exposure to polluted floodwater
- Standing water that exposes residents to vector-borne diseases
- Breached infrastructure such as dams and levees, which cause further damage
- Damage to structural systems in wood-frame buildings
- Damage to electrical and plumbing systems
- Loss of interior finishes and home contents
- Growth of toxic mold
- Release of hazardous household chemicals or fuels
- Erosion of landscape around homes

Impacts to Homes

Models predict that Puerto Rico's total coastal land area will shrink by 3.6% by 2100 and create substantial issues for all property owners. Over 92% of coastal municipalities recorded a loss of their shoreline, which translates into loss of community land for housing, associated infrastructure, and local economy, leaving coastal properties even more vulnerable to future disasters.



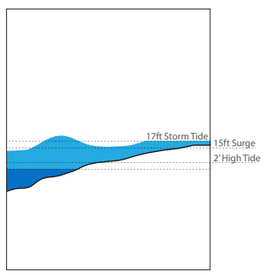
WATER (HYDROLOGIC)

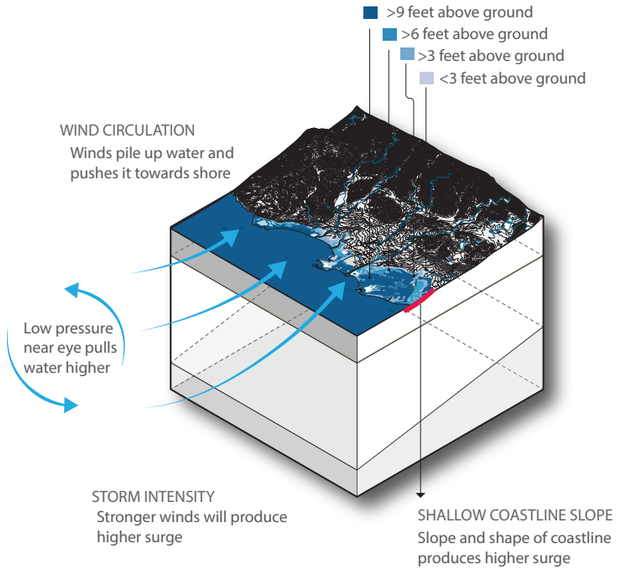


1 Zachry, B. C., W. J. Booth, J. R. Rhome, and T. M. Sharon, 2015: A National View of Storm Surge Risk and Inundation. Weather, Climate, and Society, 7(2), 109–117. DOI: http://dx.doi.org/10.1175/WCAS–D–14–00049.1

2 "Puerto Rico Advisory Data and Products: Post-Hurricanes Irma and Maria," STARR II Strategic Alliance for Risk Reduction. March 1, 2018. https://data.femadata.com/NationalDisasters/HurricaneMaria/Data/Advisory/Report/Puerto_Rico_Advisory_Report_2018.03.01.pdf

FEMA creates flood maps with boundaries of risk. Find out what zone you live in to understand your flood risk: https://msc.fema.gov/portal/searchDefining FEMA Flood Zones



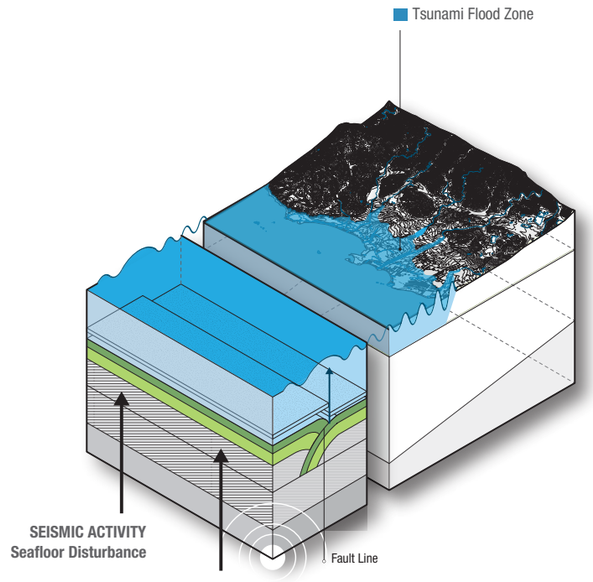


LAND (GEOLOGIC)

EARTHQUAKES

Earthquakes are caused by the release of energy accumulated within or along the edges of the earth's tectonic plates where seismic waves radiate around the origin epicenter and cause the ground to shake. Earthquakes are sometimes followed by tsunamis and land-deformation processes such as liquefaction, landslides and subsidence:

- **Liquefaction**: causes water pressures to increase in the soil sediment and the sand grains to lose contact with each other, making the sediment flow like a liquid. Most liquefaction occurs in areas that have been artificially filled. About 45%, of the San Juan metropolitan area is constructed on coastal plains and former wetlands, making it highly vulnerable to liquefaction.
- **Landslides**: A landslide is a downward slope movement of rock or soil (or both), occurring on the surface of rupture. Landslides, triggered by earthquakes or heavy rainfall, often happen without warning and move very quickly.
- **Land subsidence**: is the gradual settling and compaction or sudden sinking of the earth's surface.
- A **Tsunami** is a series of ocean waves generated by sudden displacements and disturbances of the sea floor, such as earthquakes, underwater landslides or volcanic eruption-sometimes thousands of miles away from the source. Tsunamis cannot be predicted, giving people less warning time to evacuate and prepare. There are few strategies to mitigate against tsunami impact, most of risk reduction relies on preparedness and evacuation.



LAND (GEOLOGIC)

IMPACTS TO HOMES

- Earthquakes increase ground instability and frequently cause buildings to collapse from structural and other property damage. The greatest damage occurs when buildings are located on unconsolidated sedimentary rock, especially when it is saturated with water or when groundwater is high. Structures of unreinforced masonry are at great risk and vulnerable to smaller quakes than buildings built to current seismic codes (2018 International Building Code).
- Subsidence
  - Leaves foundations less secure
  - Increases risk of flooding in low-lying areas
  - Increases the rate of sea level rise because the ground is lower and may also allow for higher water tables and coastal surges
- Landslides
  - Topple homes built on unstable soil, burying anything they fall upon
  - Disrupt road access and prevent emergency crews from providing rescue, provisions, or repairs
  - Prolong danger after rains and earthquakes, when unstable conditions exist but are not visible
- Earthquake-induced tsunamis
  - Destroy buildings and infrastructure with high-energy wave action
  - Spread debris over large areas
  - Cause dramatic coastal erosion
  - Bring with them debris that magnifies the damage to structures in its path

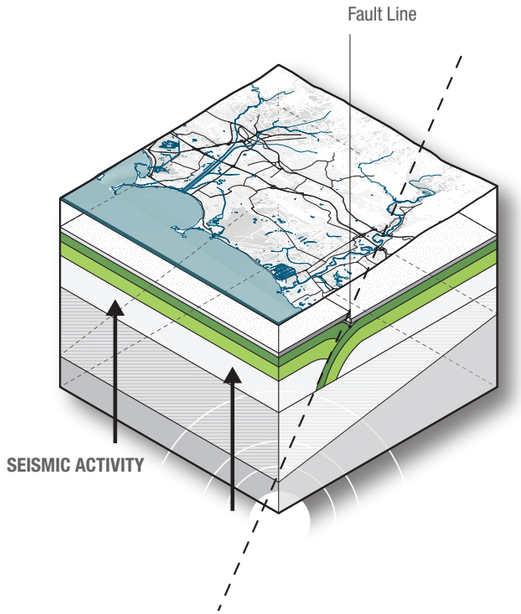
- **After any seismic event, land may not be safe to rebuild on. Get homes inspected to ensure structural safety.**

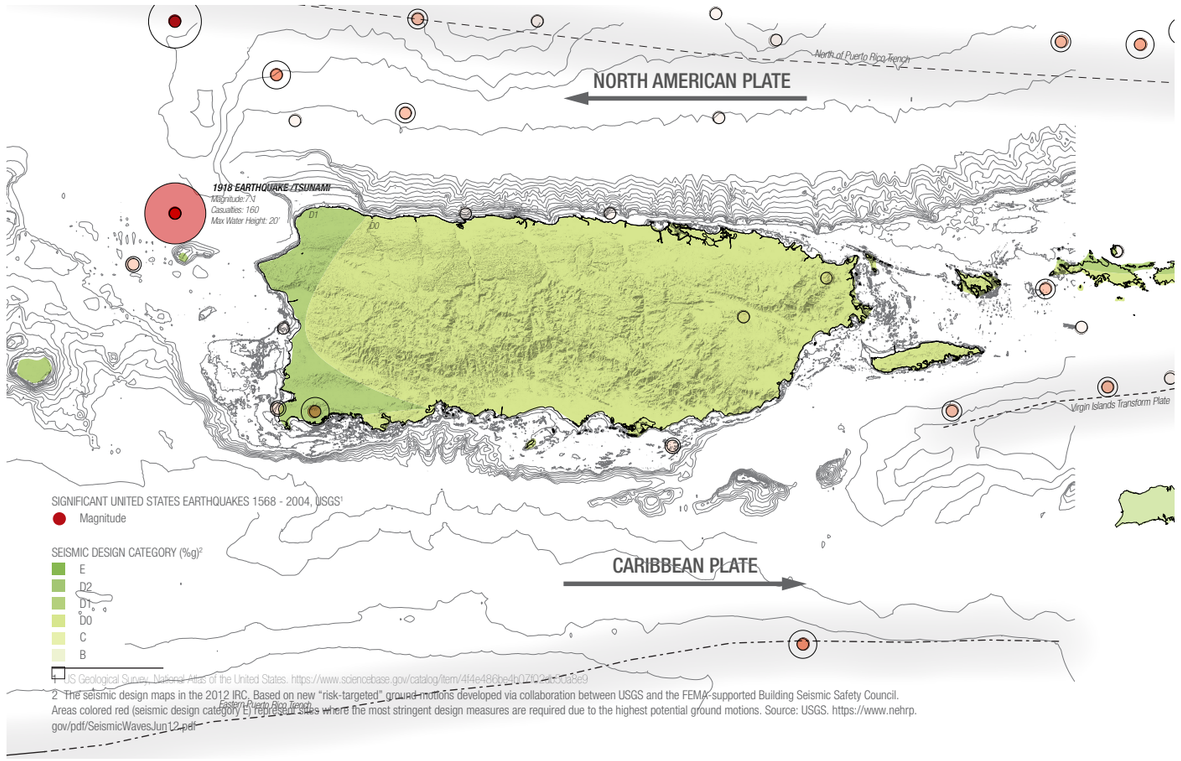
Fact: There are few land areas or islands to block a tsunami generated near the Puerto Rico Trench from entering the Atlantic Ocean. At the larger scale, certain land management strategies can be applied. For example, wave energy from tsunamis may be reduced 75% if the waves pass through 200 meters of mangroves. . It has also been found that 1.5km belt of mangrove may be able to reduce a wave one meter high (Mazda et al. 1997).



THE PUERTO RICO TRENCH

The Puerto Rico Trench is the deepest part of the Atlantic Ocean and the Caribbean Sea at just over 8,600 meters (5.3 miles). The Puerto Rico Trench marks the boundary between two tectonic plates, the North American and Caribbean plates. The North American Plate moves west-southwest relative to the Caribbean Plate and subducts (slides) beneath it. The Puerto Rico Seismic Network detected 3,947 earthquakes in 2016.





1 US Geological Survey, National Atlas of the United States. https://www.sciencebase.gov/catalog/item/4f4e486be4b07f02db3da8e9
2 The seismic design maps in the 2012 IRC. Based on new "risk-targeted" ground motions developed via collaboration between USGS and the FEMA-supported Building Seismic Safety Council. Areas colored red (seismic design category E) represent sites where the most stringent design measures are required due to the highest potential ground motions. Source: USGS. https://www.nehrp.gov/pdf/SeismicWaves.Jun12.pdf

HISTORY OF DISASTERS IN PUERTO RICO

It cannot be emphasized enough that awareness and education build resilience and help prepare for and reduce the impact of future hazards. In most cases, lessons learned through past disasters have been the main catalysts for advancing change and knowledge, both in the general population and in public policy. A combination of environmental, economic, social, cultural, and political factors allow events like Hurricanes Irma and Maria to inflict additional damage, affecting the Puerto Rican economy, environment, and society. Understanding the socio-economic and political context of a disaster builds a comprehensive view of the impact it has on the island at the time and what can be done moving forward.

It is important to examine disastrous events in the past to understand how devastating natural hazards can be on Puerto Rican communities. Land use patterns and the development of the built environment are critical towards determining risk exposure, but socio-political and economic processes also influence inequitable exposure to hazards and unequal access to protection. The following comparative retrospective examines the lessons learned from eight main historic events and provides a better understanding of the current and future disaster landscape of the island, especially in how these events have led to changes at different scales—from how people and communities prepare and respond to disasters to how they have triggered changes in policy at different levels of government. These events highlight how people see, understand, and remember risks, serving as a map of Puerto Rico's collective memory regarding natural disasters.



1899 THE SAN CIRIACO HURRICANE

The San Ciriaco Hurricane happened in 1899, just as Puerto Rico was transitioning from Spanish to American control, influencing hurricane response and contributing to the poverty, political instability, and lack of comprehensive relief at the time. It was considered the deadliest natural disaster in Puerto Rico's history, surpassed recently by Hurricane Maria. More than 3,300 people died in the floods and 25% of the population were left homeless. Twenty-eight consecutive days of rain were recorded and winds reached 100 mph. Most of the cultivated crops were destroyed, including more than half of the sugar crops, but the coffee plantations in the mountains were the most impacted. This lead to severe social and economic difficulties in Puerto Rico for years to come. The storm surge that entered the area of Humacao reached at least 15 feet in height, reaching one mile inland. **This event established disaster relief processes on the island under US military protocols. The new Weather Bureau was established to collect detailed information.**

1918 SAN FERMÍN EARTHQUAKE AND TSUNAMI

The epicenter of this earthquake was located about 35 km from Aguadilla on the northwest coast of the archipelago. It measured 7.1 ML on the Richter scale and was followed by a tsunami five minutes later where waves reached a height of 20 feet. San Fermín caused the most damage in Mayagüez and neighboring cities, resulting in 116 casualties, over $4 million in damages, and leaving more than 10,000 people homeless. River currents from backflowing estuaries demolished bridge foundations resulting in collapsing infrastructure, severed underwater telegraph cables, disrupted communication systems, and triggered mudslides. Most of the property damage was located in Aguada and Añasco, where a lot of the masonry, brick buildings, and structures with little reinforcement were damaged. Liquefaction was observed during the earthquake as well as cracks in the low lying grounds, especially in the cane fields in western Puerto Rico. **A Special Earthquake Commission was established after the event, and continues to monitor the probability of major earthquakes today.** Their 1919 Technical Reports gave general recommendations for seismic resistant buildings. Other important documents were produced as a consequence of the 1918 event, including recommendations by the U.S. Army Corps of Engineers and the Commissioner of the Interior to revise the Building Regulations in Puerto Rico.

1985 LANDSLIDE OF MAMEYES

The landslide occurred during extreme rainfall from Tropical Storm Isabel, which produced 70 mm of rain in an hour and triggered a rock-block slide that destroyed most of the Mameyes residential area northwest of Ponce. Other contributing factors in the slide included sewage saturating the ground in the densely populated hillside neighborhood and a leaking water pipe at the top of the landslide. The Mameyes landslide destroyed/damaged over 200 homes and killed at least 129 people, which resulted in the largest death toll from a single landslide in North American history. The event highlighted Puerto Rico's housing shortage and the need for more low-cost housing. After the landslide, the Governor ordered a study of the informal communities located in "high-risk areas" where people would be notified of the risks and given assistance to move elsewhere. **The Isabel storm floods and landslides of 1985 prompted federal agencies to make comprehensive evaluations (Federal Interagency flood hazard mitigation team response report for Puerto Rico, 1985) and also generated demands for landslide study and policy changes, including zoning.**

1986 FIRE AT DUPONT PLAZA HOTEL

The Dupont Plaza Hotel in San Juan suffered a major fire on December 31st of 1986. This building was located at the central Ashford Avenue in the Condado area, one of the most exclusive tourist areas in the capital city. The fire was started by three members of the Unión de Tronquistas of Puerto Rico. In the fire, the basement, lobby, and casino were destroyed in the flames and a total of 97 citizens died; another 140 were injured. More than 165 people had to be rescued from the rooftop of the hotel and transported to the nearest beach. It took almost 6 hours for firemen to extinguish the fire. **This event at the Dupont Plaza hotel exposed the lack of equipment and readiness for fires.** After the tragedy, legislation was passed to require that public and private multipurpose buildings have automatic sprinklers and smoke detectors.

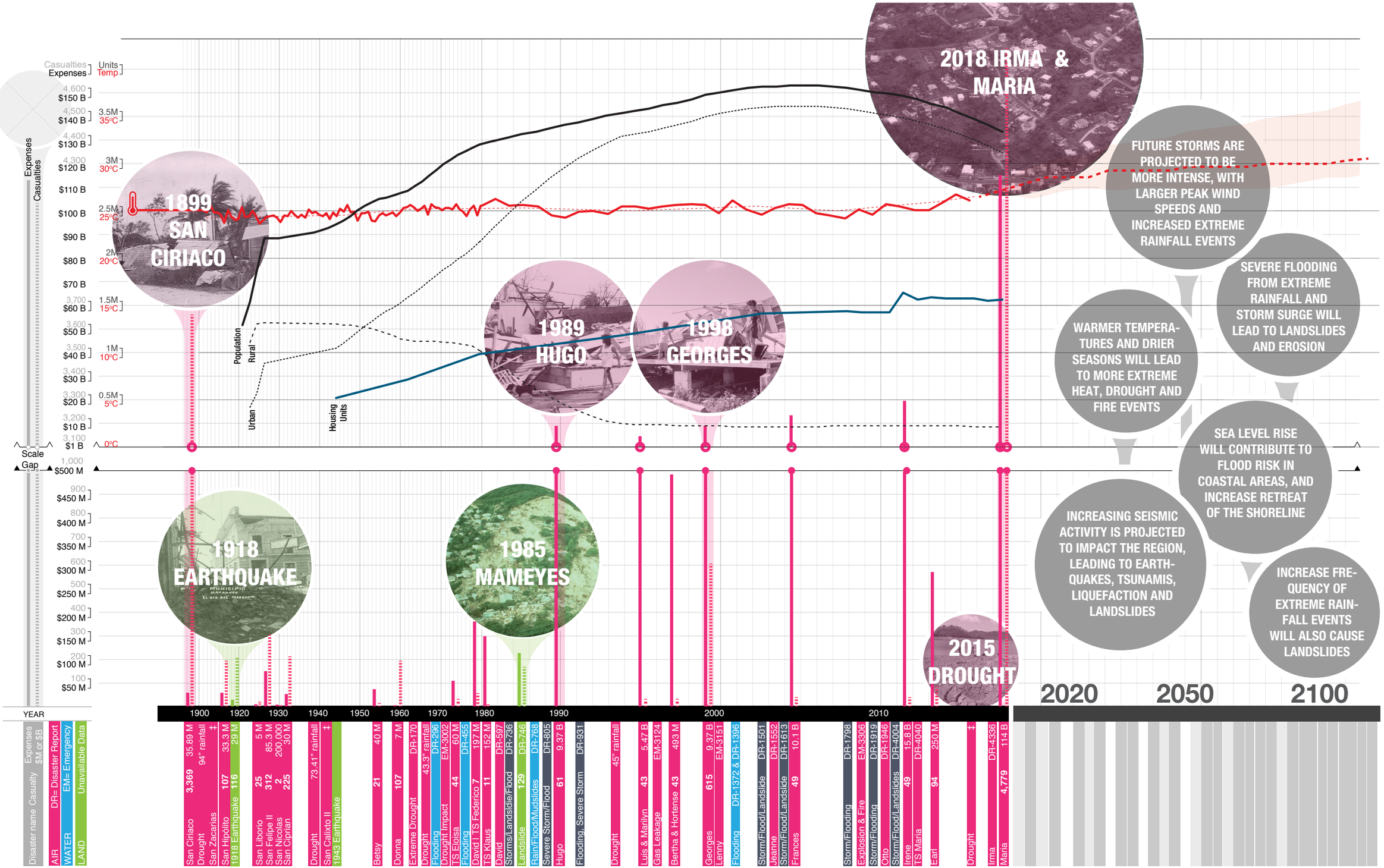


DIAGRAMA POR JEAN CARLOS VEGA-DIAZ AND LARISA OVALLES PAULINO

HISTORY OF DISASTERS IN PUERTO RICO

1989 HURRICANE HUGO

Hurricane Hugo made landfall in Puerto Rico on the southeast coast as a strong Category 3 Hurricane. Until 2016, Hugo was catalogued as the most intense tropical cyclone, claiming 24 casualties in South Carolina and 34 fatalities in the Caribbean, including Guadeloupe, St. Croix, and Puerto Rico. With a total cost of 9 billion, it was the most harmful hurricane to make landfall in the US at the time. The storm also triggered landslides in eastern Puerto Rico, which led to guidelines determining landslide risks based on slope hazard evaluations. **After Hugo, a hurricane storm tide atlas was published for the affected eastern municipalities of Yabucoa, Humacao, Fajardo, Naguabo, Ceiba, Luquillo and Rio Grande (Post, 1994), and an evaluation of the Puerto Rican experience regarding the NOAA storm surge model (SLOSH) managing coastal hazards. Post-Hugo, federal preparedness documents targeted hurricane-resistant building guidelines (FEMA, 1989).**

1998 HURRICANE GEORGES

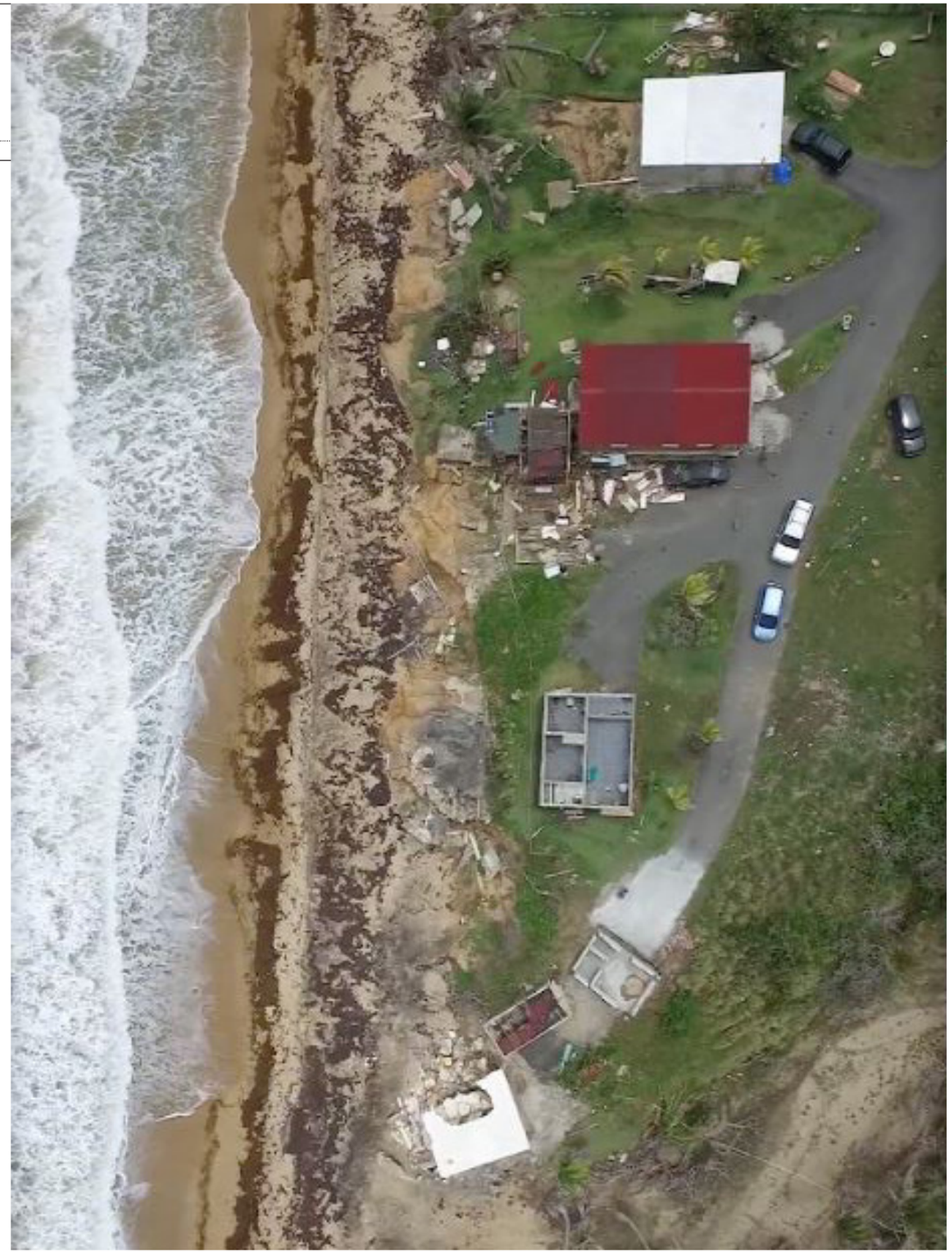
Georges reached Category 4, causing 8 casualties and around $2 billion in losses. It caused the most damage to the agricultural sector, losing 75% of the coffee crops and 95% of the plantain and banana crops. A total of 28,005 homes were destroyed and 72,605 were damaged. By 1998, Puerto Rico was following a combination of local Codes and Permits (ARPE) standards and the Uniform Building Code standards for designs able to withstand 125 mph winds in residential structures. In 1999, the Puerto Rico Emergency Management Agency (PREMA) was created. Post-Georges, federal construction guidelines addressed one and two family dwellings in hurricane and seismic zones. **US and Puerto Rican officials prepared a plan that forbid rebuilding in areas that were risk-prone or in need of assessment. With the failure and collapse of significant Puerto Rican structures, Hurricane Georges' impact on the built environment set a building code optimization precedent.**

2014-2016 DROUGHT

The drought experienced from 2014 to 2016 was the worst in the Caribbean in at least 66 years. The National Drought Mitigation Center (NDMC) declared extreme and severe droughts in Puerto Rico. By 2015, more than 1.5 million people were affected by the drought. Summer water and ice deliveries were rationed and available in public places. Some areas would have water available every 24 hours up to 48 days. The drought dried up pastures and resulted in falling milk production as well as declining mango and plantain crops. The farming and tourism sectors suffered the greatest economic loss. **As drought is now considered one of the greatest threats to Puerto Rico, food security is becoming a preparedness priority.**

2017 HURRICANE MARIA

With loss estimates of over $90 million, Hurricane Maria was one of the most costly disasters in United States history. It also emerged as one of the deadliest on record. **The death toll attributed to Maria was 64 right after the storm, but this was ultimately raised to around 3,000. A new modelling method was developed to include people whose lives were shortened by the stress of the storm. The true costs of vulnerability can now be reflected more accurately.**



FERNANDO ABRUÑA

Fernando Abruña holds a Bachelor's in Architecture and the Master of Architecture from the Rhode Island School of Design and Pratt Institute of Technology respectively. He completed a non-traditional Doctor of Design Science Degree in 1977 at the age of 25 as an apprentice to Richard Buckminster Fuller from the International College in California. Dr. Abruña is a licensed, practicing architect, a retired professor of the School of Architecture, University of Puerto Rico, and Fellow of the American Institute of Architects. He is also the Founding and Past President of the U.S. Green Building Council, Caribbean Chapter, and the publicly recognized authority in Sustainable Design in Puerto Rico.

Abruña is the author of local best-selling green design and construction books including Fresco Gratis (touching upon the subject of passive cooling systems) and ¡Casas! (which was published by the Institute of Puerto Rican Culture). He is the Founder and 1st Director of the Sustainable Design Studio at the School of Architecture, University of Puerto Rico. Abruña practices his profession with his wife, Architect Margaret Musgrave, a Color Consultant and a licensed Green Realtor in charge of Interior Architecture for the firm. Abruña & Musgrave, Architects' office is located in a two-hundred-year-old building in the historic city of San Juan, Puerto Rico.



Fernando Abruña 2/18/2019

What inspired you to initially invest in this movement for design and construction?

Before studying architecture, I was majoring in psychology. I remember walking with a friend at the University of Puerto Rico when I saw a tree casting its shadow against a street gutter. I saw this beautiful and contrasting conjunction between natural and man-made systems: the gutter as an expression of technology and the flickering shadow of the leaves of the tree so beautiful, moving with the wind against the sunlight. This was an epiphany, I said to myself this is something special and important. I told my friend "let's go back to the library, I would like to see some catalogues on architecture schools". There, I looked at a few catalogues and the one that caught my interest was Rhode Island School of Design's (RIDS) catalogue. I eventually graduated from RISD where I did my research on natural ventilation; the school was so interested in the idea that they supported my building of a wind tunnel and a room to conduct my research. My first book, Fresco Gratis, was written in 1980 and based on this research. Then I went on to demonstrate and manifest those ideas in the world through design, building, publications, and education.

The word 'resilience' comes from the structural principle of a material coming back to its original condition once a load is taken off. People come up with new definitions every day. The way I define it is as how a living space is designed to survive catastrophic (including climatic) events through 'Feasible Redundancy.' Redundancy in systems makes for better resiliency in the built environment since it allows you to survive. If a first system fails, a second system comes into play. If the second system also fails, a third system takes its place. The challenge, as I see it, is how to make this redundancy economically and socially feasible and hence the term 'Feasible Redundancy.'

Resiliency depends hugely on maintenance; more important than the concepts of sustainability and resiliency is MAINTENANCE, especially in Puerto Rico where the catastrophic force of Hurricane Maria greatly impacted systems that did not have the benefit of appropriate maintenance in place. Whenever a system is designed, its maintenance needs to be planned for and carried out. Recurring funds and user involvement to assure maintenance are essential for resiliency and sustainability to function properly.

What challenges did you encounter as you created these models?

When I started working on these ideas within the design and construction industry, energy, materials, and resources were cheaper. Energy was so cheap that people would not consider natural ventilation, daylighting, and passive strategies because it was relatively cheap to do it the wrong way. The Oil Embargo of 1973 caused, in my view, a technological and cultural shift where people began to appreciate nature, sustainability, and resilience as potential solutions to the challenges brought about by the built environment and its effect on nature. In the beginning, it was the forces of counterculture that brought this discussion to the forefront. I became a tree hugger; I knew cutting down trees was not a trivial issue because of the inherent benefits that come from having them around. I knew it was wrong, but I could not justify it with rational arguments. My approach was visceral. Later on, corporate institutions started adopting these ideas and started assessing the impact of the systems and attributing scientific metrics to the work to measure that impact. The challenge at that time, when I began doing this, was that the metrics were not there. Now, with scientific metrics, you can argue not to cut a tree because it will, for example, cost you more for air conditioning, water retention, etc.

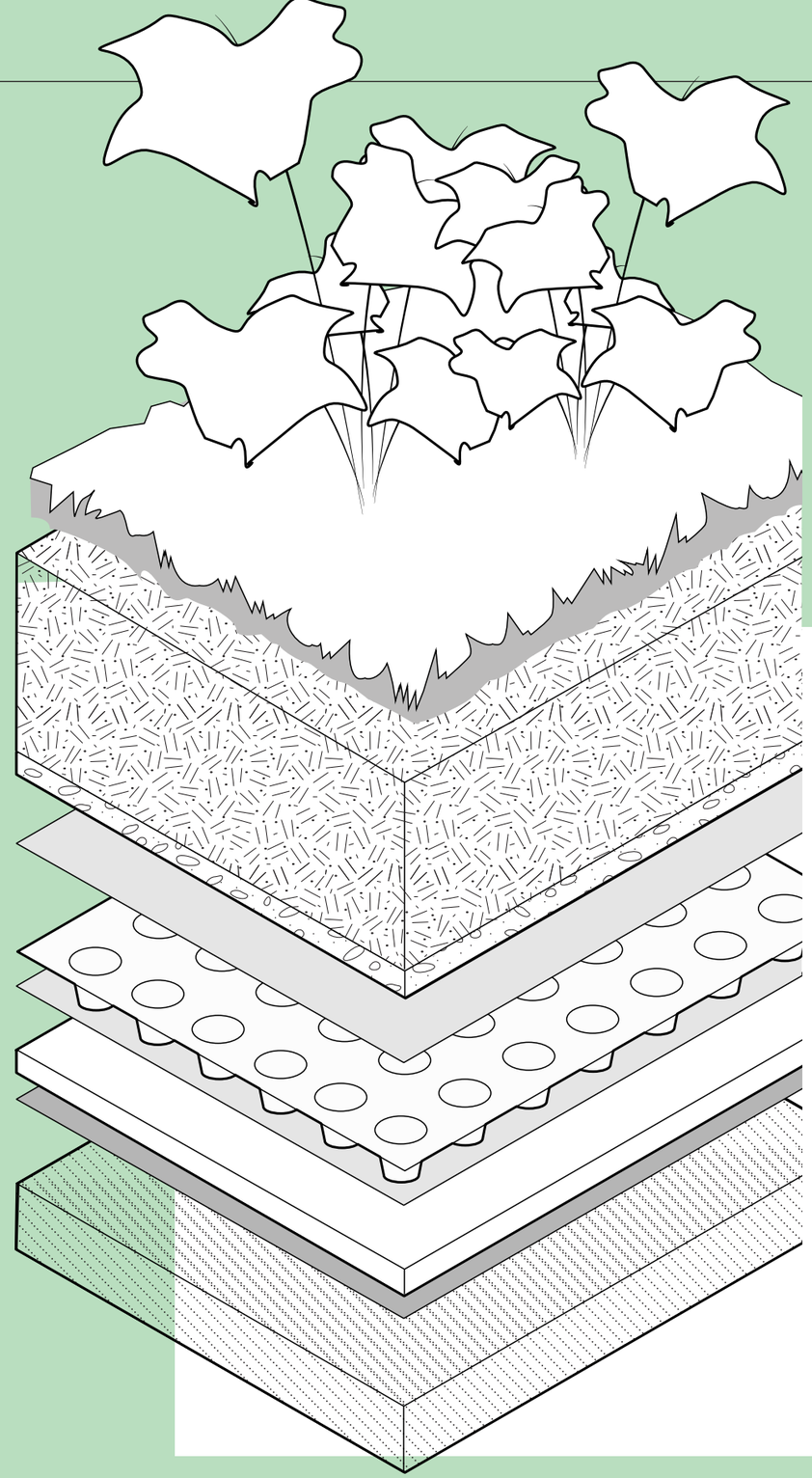
Another challenge is the risk factor and which communities are going to be on the front line in climate change and its consequent displacements. The place where you are born is such a significant piece of your own soul. Some communities face more challenges than others depending on their resources. The costs of things are skyrocketing. Building in flood prone areas is going to be costlier than going to a new place. But if we talk about the relocation of communities, we need to talk about well-off communities like Ocean Park as well as economically challenged and depressed communities like those bordering the Martín Pena Channel. If you are going to talk about relocating communities, you need to do it across the board and not just the communities with lower incomes, which are typically the more exposed and vulnerable communities. There cannot be any exceptions. The same relocation argument is happening and will continue to rise at a global scale. Imagine a foreigner, say from Switzerland, building an argument for all Puerto Ricans to move from the island because we are in the annual path of hurricanes, it makes some sense…but would all Puerto Ricans agree with this idea? Vulnerable communities also face the same challenge in flood prone areas. It is a difficult issue that needs more discussion. Ultimately, Nature will make the final decision, if we, as a society, cannot come to an equitable agreement between us all.

What lessons have you learned from Maria and what do we need to invest in?

The government issued recovery funds that need to be well-managed. There seems to be a speed frenzy as to how to spend this money. We need to move slower in order to make sure we spend it correctly, in the right places, and above all making maintenance the priority in that plan. The eyes of the world are on Puerto Rico. What we do will be carefully observed and studied by many other communities around the world. Puerto Rico is now living the future, which other regions in the world will be facing in theirs.

CHAPTER

1



A SAFER SITE: SITE FORTIFICATION STRATEGIES

Fortify your site against extreme natural hazard risks.

TYPES OF STRATEGIES LISTED IN THIS SECTION

STRATEGY #

STRATEGY NAME/TITLE

DESCRIPTION

01	02	03
REINFORCE SITE WITH INFRASTRUCTURE	**REINFORCE SITE WITH VEGETATION**	**PLANT AN EDIBLE GARDEN**
Risks threatening a site like flooding and fire can be mitigated by designing green and gray infrastructure to work together. Green and gray infrastructure help manage risks from storm water, support heat reduction, manage drought, enhance air quality, and create recreational spaces. This strategy focuses on how to choose infrastructure elements that best suit your site.	This strategy describes the properties of soil, elevation, and plant types that are necessary for vegetation to serve as a protective element.	After a natural disaster strikes, primary resources, including food, can become scarce. This strategy focuses on how conscientious use of vegetation can offer a local back-up food resource and a year-round supply of food.
$-$$$	$	$

Climate change adaptation presents many opportunities to approach building and living in Puerto Rico more holistically; we need to lighten the load on existing power and water infrastructure systems, better integrate what is built with surrounding ecosystems, use resources and manage waste more sustainably, and provide better support for vulnerable populations. Addressing regional risks in this light broadens the options for fortifying your site against disaster. Adaptation also requires new collaborations, and case studies of projects and partnerships throughout the islands are included here for reference and inspiration.

Especially for islands in the Caribbean, geographical isolation compounds water and food security issues. Managing water—whether related to precipitation, flooding, stormwater runoff, storm surge, coastal erosion or subsidence—is the first step toward protecting your home from damage. Combining green and gray infrastructure features is an effective way to do this. Beyond your site, resilient infrastructure recharges aquifers, prevents subsidence, reduces vulnerability of the landscape and agricultural lands to drought, and reduces ambient temperatures.

While green infrastructure refers to projects that draw from nature to achieve desired results, gray infrastructure utilizes man-made, constructed infrastructure like pipes, sewers and sewage treatment works, ditches, dikes, and dams to manage risks of flooding.

This section presents a series of strategies that integrate green and gray infrastructure, including how to reinforce your site through appropriate hardscape and plantings, choose and plant vegetation that is suited to climate variability, and cultivate your own source of food and medicine through an edible garden.



STRATEGY

01 REINFORCE SITE WITH INFRASTRUCTURE

$-$$$

Risks threatening a site like flooding and fire can be mitigated by designing green and gray infrastructure to work together. Green and gray infrastructure help manage risks from storm water, support heat reduction, manage drought, enhance air quality, and create recreational spaces.

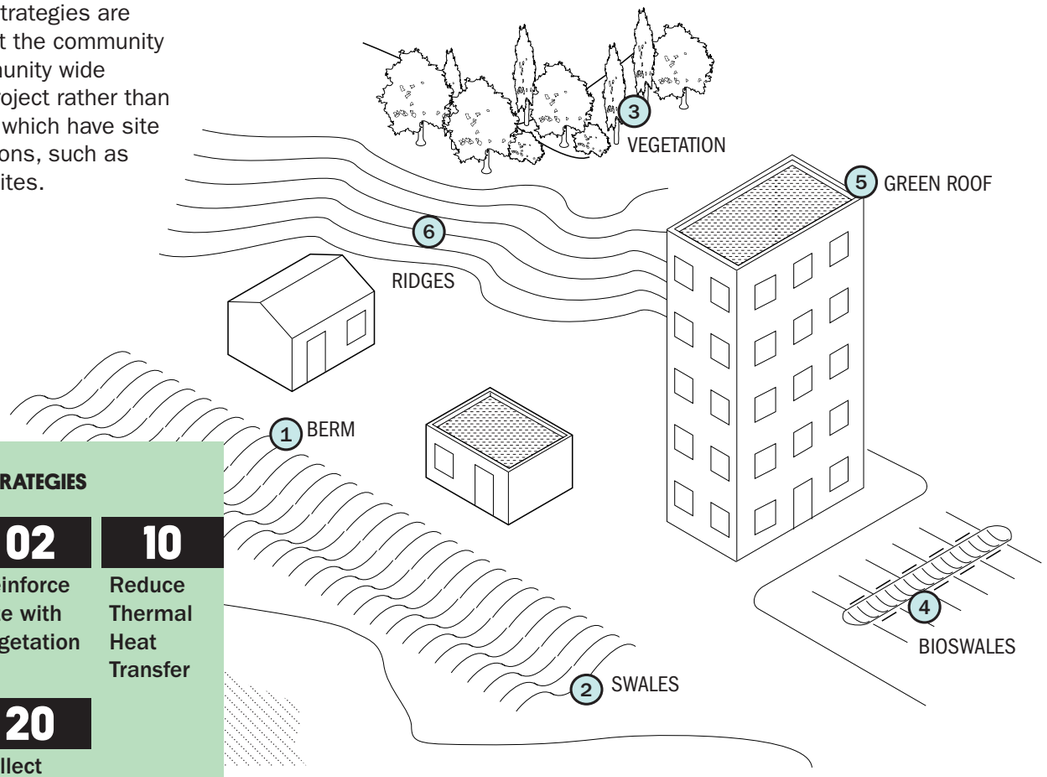
This strategy focuses on how to choose infrastructure elements that best suit your site.

Strategy in Action

1. *Site Housing in a Safe Location*
2. *Implement Green Infrastructure on Site*
3. *Implement Gray Infrastructure on Site*

WHAT YOU NEED TO KNOW

Many of these strategies are best deployed at the community level as a community wide infrastructure project rather than individual sites, which have site and size limitations, such as sister housing sites.

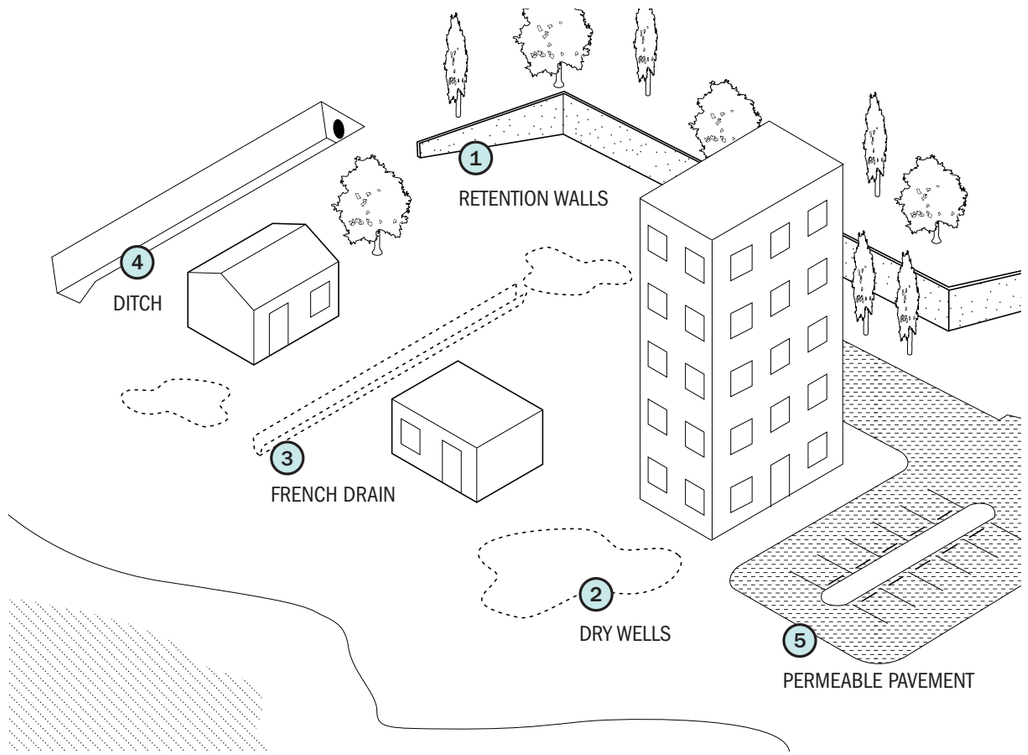


SUPPORTING STRATEGIES

01 Reinforce Site	**02** Reinforce Site with Vegetation	**10** Reduce Thermal Heat Transfer
15 Reduce Your Energy Use	**20** Collect and Use Rainwater	

STEP 1 - SITE HOUSING IN A SAFE LOCATION

- For New Construction, Site Housing in a Safe Location
- Don't site your house or facility in a floodplain or floodway as determined by FEMA: https://msc.fema.gov/portal/home
- Be careful not to site housing in an area prone to landslides. Consult with the resources listed below for a description of historical landslides.
- Ensure drainage paths go from the roof, down the wall, away from the house and the site, and into the street gutters to avoid dumping water onto your neighbor's site.
- Avoid locating your home or building in a very arid area without bringing water to the site to keep foliage from drying out and becoming “tinder.”
- Avoid locating your home, building, or associated infrastructure in coastal areas.



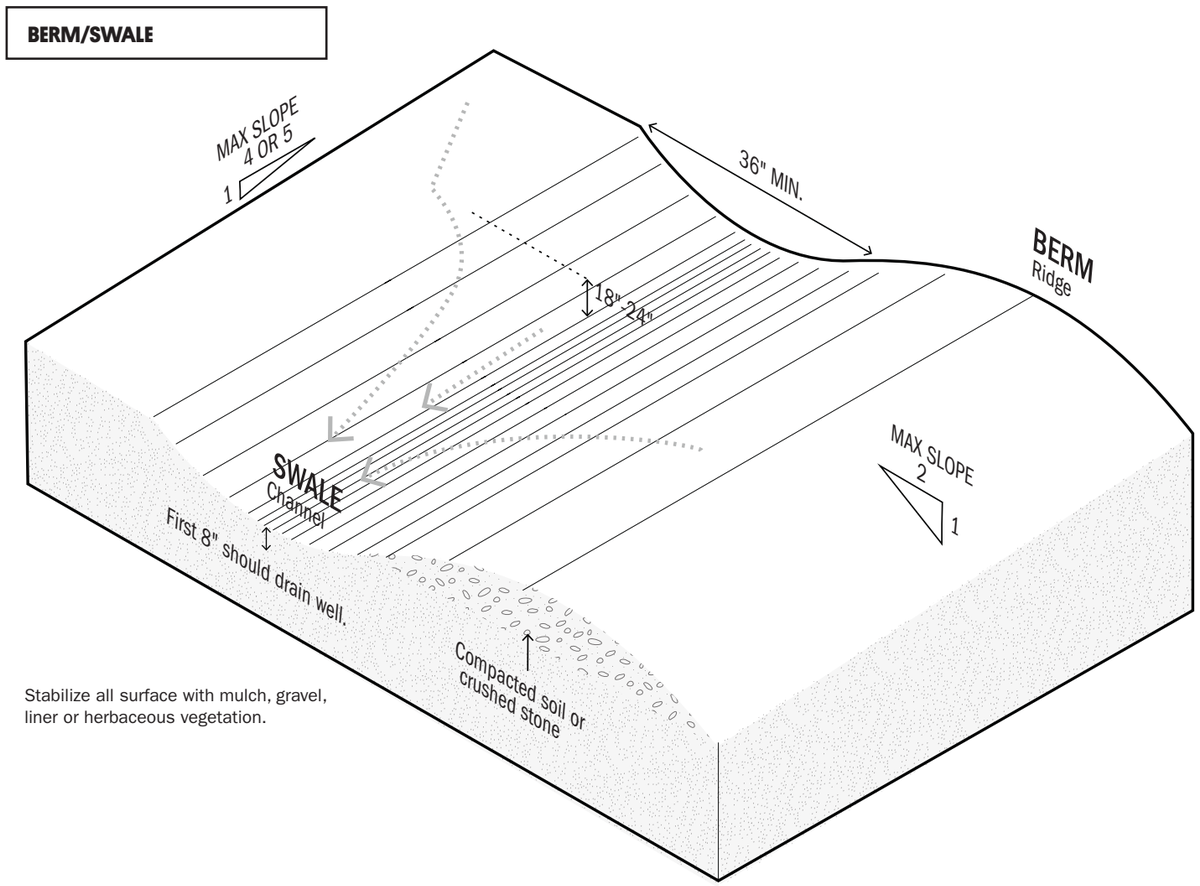
STRATEGY

01 REINFORCE SITE WITH INFRASTRUCTURE

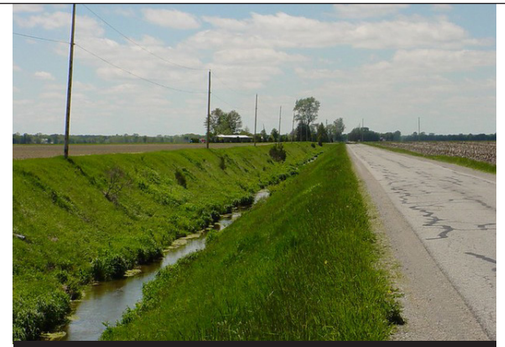
STEP 2 - IMPLEMENT GREEN INFRASTRUCTURE ON SITE

- Consult a contractor, civil engineer, agronomist, or the Agricultural Extension Service (SEA, by its Spanish acronym) to design green infrastructure systems as outlined below.
- Be cautious when choosing where to deposit water. If water is contaminated with debris, do not deposit into a lake, river, or sea.

BERM/SWALE



Stabilize all surface with mulch, gravel, liner or herbaceous vegetation.



A. BERMS

Berms are compacted earth or gravel ridges that slow water headed downslope from rain, riverine flooding, or storm surge in coastal areas and reduce erosion. Berms offer opportunities for other activities as well; frequently termed ‘berms with benefits,’ they create walking paths, exercise, picnic or meditation areas, and places for children to play.

NATURAL HAZARDS IT PREVENTS

- Landslides
- Flooding
- Erosion
- Storm Surge

WHAT YOU NEED TO KNOW

- The slope ratio of a berm should be around 1:4 or 1:5 and should be 18”-24” high. The purpose of the slope is to drain and direct. water.
- Pile compacted soil or washed stone parallel to ditch, opposite the water flow, at a maximum slope of 1:2.
- In most cases, herbaceous vegetation will help in stabilizing the berms.



B. SWALES

Swales are shallow channels with gently sloped sides that manage water runoff, filter pollutants, and increase rainwater filtration by directing water to a garden with adequate drainage (rain garden) or a buried dry well. It can also absorb water through the soil on site and protect natural waterways. A swale may be either natural or human created. Artificial swales are often infiltration basins.

NATURAL HAZARDS IT PREVENTS

- Landslides
- Flooding
- Erosion
- Storm Surge

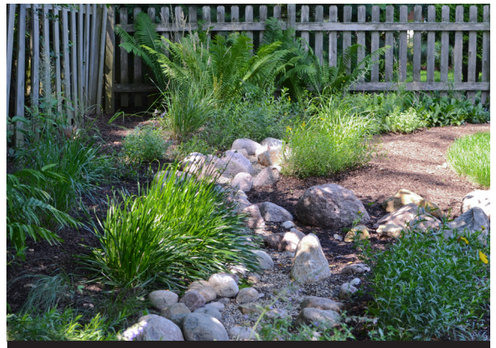
WHAT YOU NEED TO KNOW

- Dig the channel with sloped slides and a small slope in the direction of water runoff.
- The sides of the swale should flare so they extend out 3” to 4” more than they are tall, and the first 8” of soil should drain well.

STRATEGY 01

REINFORCE SITE WITH INFRASTRUCTURE

STEP 2 - IMPLEMENT GREEN INFRASTRUCTURE ON SITE



C. BIOSWALES/RAIN GARDENS

Bioswales/Rain Gardens receive water and filter it through different substrate layers and vegetation and help to absorb rainwater. They can be engineered to manage a specific amount of rainfall.

NATURAL HAZARDS IT PREVENTS

- Flooding
- Storm Surge

WHAT YOU NEED TO KNOW

- A bioswale consists of:
- Vegetation layer on slope
- Mulch & top soil
- Geotextile fabric
- Trench with perforated pipe



D. BOULDERS

Boulders (also known as rip rap) are large pieces of rock that can be placed strategically to steer water, hold earth, or even act as wave-barriers (“rompeolas”) and mitigate erosion.

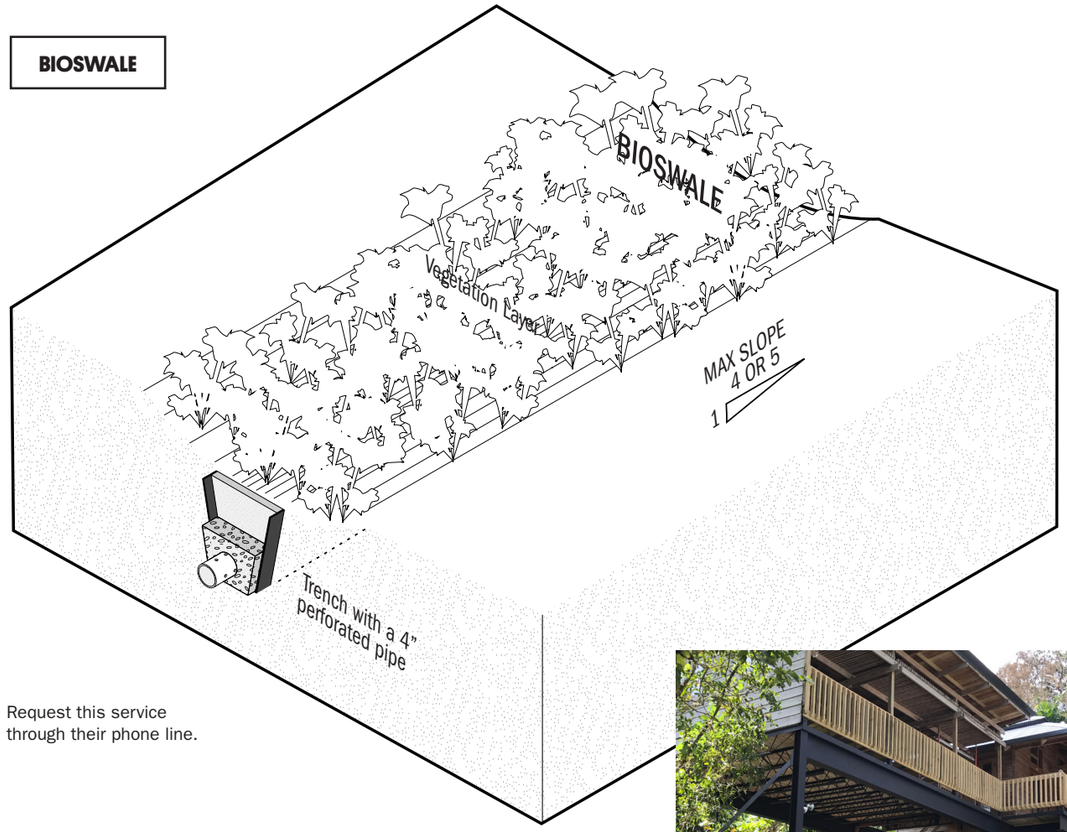
NATURAL HAZARDS IT PREVENTS

- Flooding
- Storm Surge

WHAT YOU NEED TO KNOW

- Shores: Boulders can be implemented in shores to reduce erosion or at the foot of a slope to give it structure and avoid mudslides in fields.
- They generally come in 3 sizes:
- Small – 4”-5”: good at preventing erosion and weed growth
- Medium – 6”-9”: prevents erosion, discourages walking traffic
- Large – 9” and up: absorbs wave energy more efficiently, prevents erosion on critical areas.
- Concrete rubble from demolitions can be repurposed for this.

BIOSWALE



Request this service through their phone line.



E. VEGETATION

Plants help anchor soil systems, which prevents earth movement while mitigating flooding damage. Superficial roots stabilize the top soil while deep and lateral roots fortify deeper layers.

NATURAL HAZARDS IT PREVENTS

- Flooding
- Heat
- Fire
- Erosion
- Storm Surge

WHAT YOU NEED TO KNOW

- Identify a location for planting: the area should be separated from structures, aerial and terrestrial electric lines, water lines, and septic tanks.
- Select trees that do not damage structures or break easily with strong winds. Consider size, roots, flowering, fruits, and watering. See Strategy 11.
- Remove tree canopies that grow past the electric cables. Trees near electric lines should only be handled by the Electrical Authority of Puerto Rico (AEE, by its Spanish acronym).

STRATEGY 01

REINFORCE SITE WITH INFRASTRUCTURE

STEP 2 - IMPLEMENT GREEN INFRASTRUCTURE ON SITE



F. GREENROOF

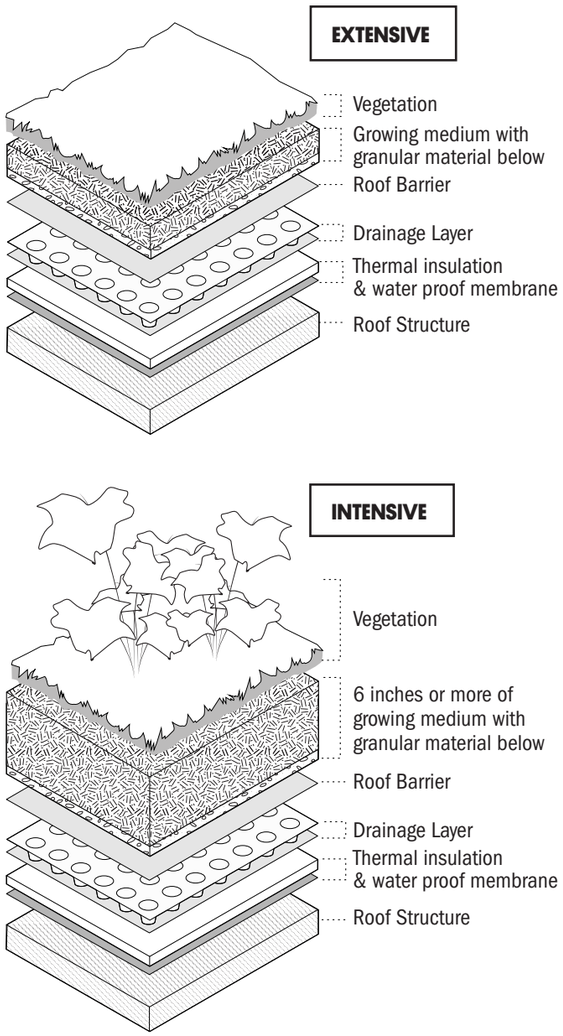
Roofs that are partially or totally covered with soil and a growing medium, planted over a waterproofing membrane. Ask an architect or structural engineer if your roof can support the added weight of soil, plants, and the water green roofs retain.

NATURAL HAZARDS IT PREVENTS

- Heat

WHAT YOU NEED TO KNOW

- Roofs that are partially or completely covered with vegetation and a growing medium can help mitigate excessive heat gain and manage storm water.





G. RIDGES

Boulders (also known as rip rap) are large pieces of rock that can be placed strategically to steer water, hold earth, or even act as wave-barriers (“rompeolas”) and mitigate erosion.

NATURAL HAZARDS IT PREVENTS

- Flooding
- Storm Surge

WHAT YOU NEED TO KNOW

- Shores: Boulders can be implemented in shores to reduce erosion or at the foot of a slope to give it structure and avoid mudslides in fields.
- They generally come in 3 sizes:
- Small – 4”-5”: good at preventing erosion and weed growth
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- Large – 9” and up: absorbs wave energy more efficiently, prevents erosion on critical areas.
- Concrete rubble from demolitions can be repurposed for this.



H. FIRE-WISE HOUSING

Strategically place plants and objects near home or property that are rated as not flammable.

NATURAL HAZARDS IT PREVENTS

- Fire

WHAT YOU NEED TO KNOW

- Remove dry vegetation from around and between dwellings.
- Avoid building in areas where access for emergency vehicles may be challenging, such as in flood-prone areas.
- Avoid building on steep hillsides, where fire may spread rapidly upwards.



I. DUNES

Coastal dunes typically consist of sand mounds that can range from a few feet to several dozen feet in height and may have vegetation as part of their composition. Coastal dunes are not static: they change in size, shape, and location depending on the time of year or impacts associated with storms and coastal wave events. The main benefit dunes provide is protection against coastal hazards, as well as providing sand for beach replenishment in times of need.

NATURAL HAZARDS IT PREVENTS

- Landslides

WHAT YOU NEED TO KNOW

- To build a dune, the most efficient way is to incorporate simple structures or vegetation that will serve as filters for retaining sand. In the case of structures (like wooden pallets or screens), they will need to be relocated as the dune increases in size, while the vegetation will grow with the dune to occupy the new space. In general, the best way to promote a healthy dune system is to avoid interfering with them or removing vegetation already in place.

STRATEGY 01

REINFORCE SITE WITH INFRASTRUCTURE

STEP 3 - IMPLEMENT GREY INFRASTRUCTURE ON SITE

- Consult a contractor, civil engineer, agronomist or the Agricultural Extension Service (SEA, by its Spanish acronym) to design gray infrastructure systems as outlined below.
- Be cautious when choosing where to deposit water. If water is contaminated with debris, do not deposit into a lake, river, or sea.
- Gray infrastructure may require special permits and a larger and more specialized professional team, can be more costly, and can be disruptive to the site if not properly designed and built.



RETAINING WALLS

Retaining walls are permanent barriers that prevent water from infiltrating the site. They are designed to contain the weight of the terrain on a steep slope that otherwise would collapse. Without a retaining wall, extreme rain might destabilize the exposed terrain and cause a landslide. These structures are beneficial in areas where erosion is inevitable or where critical infrastructure needs to be protected.

NATURAL HAZARDS IT PREVENTS

- Flooding
- Landslides
- Erosion
- Heat

WHAT YOU NEED TO KNOW

- Built with reinforced concrete.
- Usually shaped as an inverted T.
- On the side of the terrain being stabilized, use a drain along the wall to keep water away from the structure.
- The drain consists of a PVC pipe surrounded by gravel and fabric that filters dirt and debris out.



DRY WELLS

Dry wells are underground tanks, usually made of concrete, that store water to percolate or drain slowly to another site or sewer. Their design is similar to a pool.

NATURAL HAZARDS IT PREVENTS

- Flooding
- Erosion

WHAT YOU NEED TO KNOW

- A simple dry well is a 4”-6” deep and 3’ diameter pit filled with gravel or aggregate covered with topsoil.



FRENCH DRAIN

A French Drain system slowly drains surface water and can consist of a PVC tube with holes, different grades of rock or similar materials that allow percolation of water through the soil and out to a desired area.

NATURAL HAZARDS IT PREVENTS

- Flooding
- Erosion

WHAT YOU NEED TO KNOW

- Perforate a PVC tube and place into a trench.
- Surround the tube with gravel and then cover with a permeable fabric.
- Direct water to a sewer, dry well, or other method of disposal.



DITCH

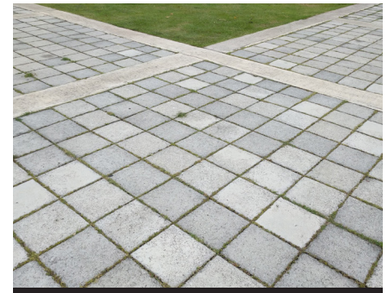
Ditches are channels that are used to redirect water flow. Historically, common practice has been to “re-canalize” or “re-channel” rivers to avoid flooding but in recent years communities are adapting to “living with water,” rather than channeling it off site, by allowing water to flow through sites.

NATURAL HAZARDS IT PREVENTS

- Flooding
- Erosion

WHAT YOU NEED TO KNOW

- A simple dry well is a 4”-6” deep and 3’ diameter pit filled with gravel or aggregate covered with topsoil.



PERMEABLE SURFACES

Permeable surfaces consist of a paver, porous concrete, or other flooring system that allows water to pass through and percolate slowly into the soil, instead of solid pavement that reduces the area of the terrain that naturally percolates water.

- Usually made of asphalt, concrete, or planted surfaces.
- Areas with permeable pavement are usually utilized as an amenity for non-essential services like recreation.

NATURAL HAZARDS IT PREVENTS

- Flooding
- Heat

WHAT YOU NEED TO KNOW

- For pavers, the terrain is flattened and prepared prior to placement.
- The porous pavement or surface material is poured in place like regular concrete. Its porosity is a result of the permeable slab-like surface.
- If pavement needs to bear “loads” such as vehicles, it will need to be validated for load bearing capacity in advance of placement.

OPERATIONS AND MAINTENANCE TIPS

- Permeable surfaces used for parking, driving, or walking require periodic cleaning and inspection for weed growth on pavers or walls not designed to have vegetation.
- Keep a fire line on your site to prevent fire from encroaching on your site.
- Keep a clean site to keep hazards at bay.
- Keep draining systems free of debris.

STRATEGY

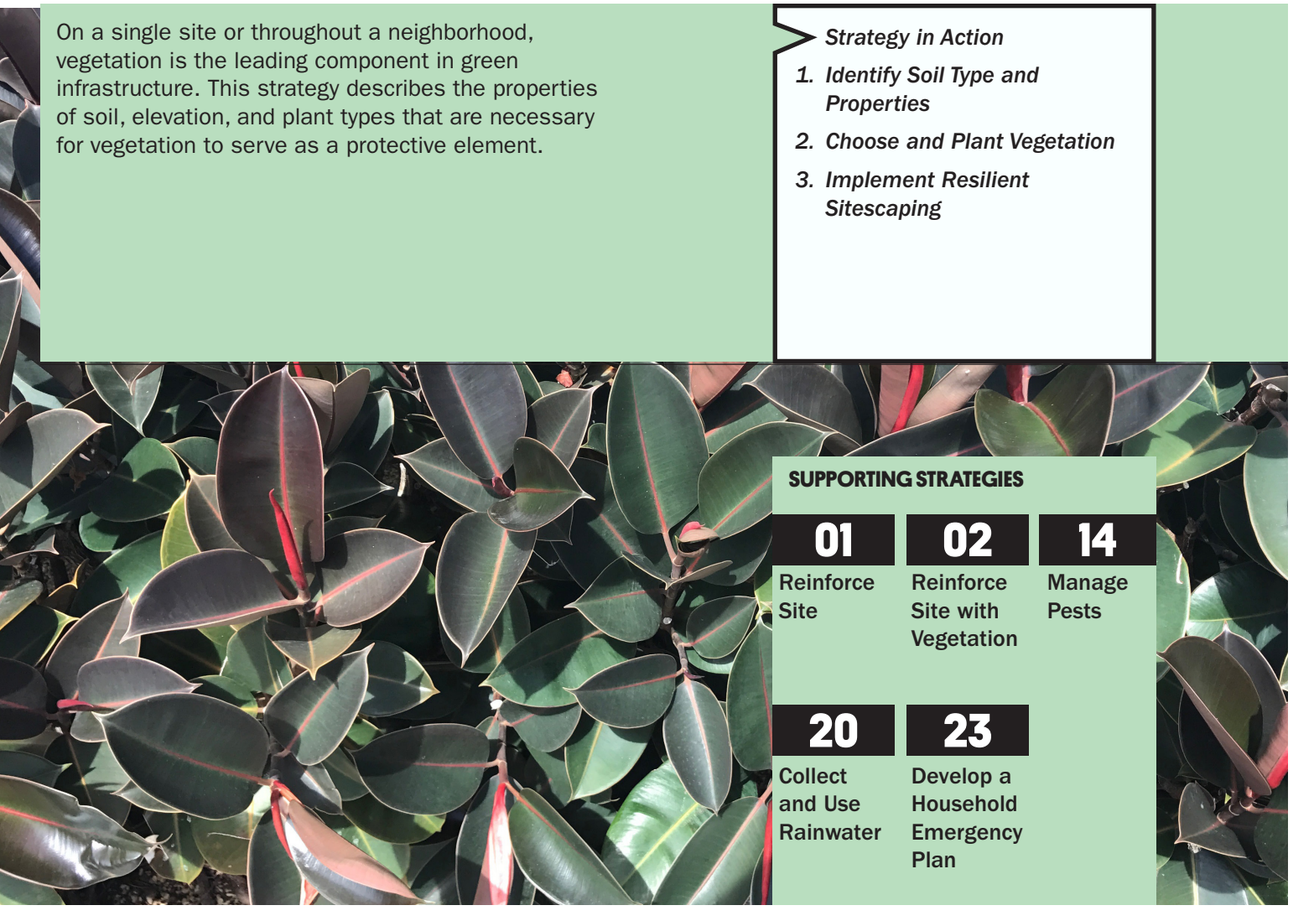
02 REINFORCE SITE WITH VEGETATION

$

On a single site or throughout a neighborhood, vegetation is the leading component in green infrastructure. This strategy describes the properties of soil, elevation, and plant types that are necessary for vegetation to serve as a protective element.

Strategy in Action

1. *Identify Soil Type and Properties*
2. *Choose and Plant Vegetation*
3. *Implement Resilient Sitescaping*



SUPPORTING STRATEGIES

01	02	14
Reinforce Site	Reinforce Site with Vegetation	Manage Pests
20	**23**	
Collect and Use Rainwater	Develop a Household Emergency Plan	

WHAT YOU NEED TO KNOW

The success of vegetation depends on:

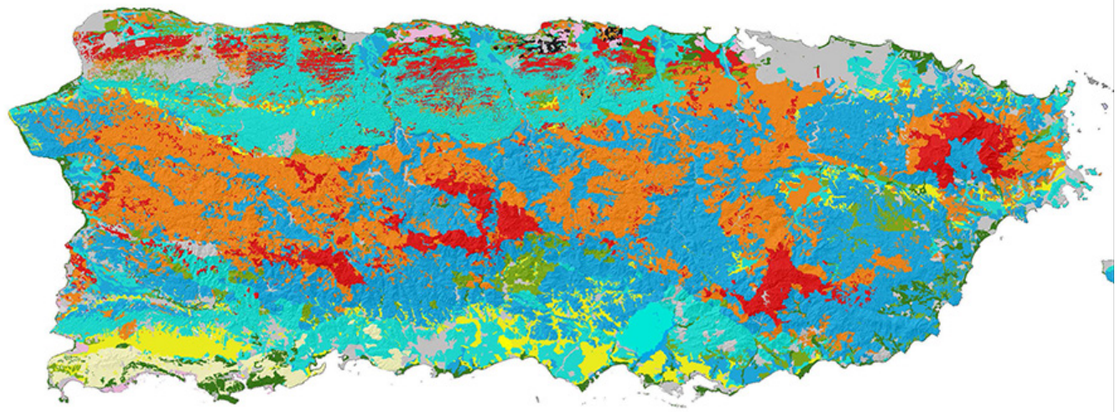
- Appropriateness of plant for soil type
- Health of plants and plant properties
- Maintenance and care
- Available light

Benefits of vegetation include:

- Soil stabilization
- Restoration of local ecosystems
- Creation of recreational spaces
- Shading and wind break
- Air and water quality enhancement
- Potential source of food or medicine (see Strategy 3: Plant an Edible Garden)

STEP 1 - IDENTIFY SOIL TYPE AND PROPERTIES

Soil Orders of Puerto Rico



SOURCE: USDA NATURAL RESOURCES CONSERVATION SERVICE

A. TYPE

There are several factors that determine the type of soil in an area: composition, climate, topography, plant activity, and minerals. The consistency of the soil can be classified as silt, sand, or clay. Sandy soil is found in rivers and beaches and is very loose and easy to work with, but has few of the nutrients that a plant may need. Silt is fertile and easy to work with. Clay has small particles and is very heavy when wet, making it difficult to work with. The combination of the three soil types—that is very fertile—is known as loam.

LEGEND

- **Alfisols**: semi-arid to humid areas
- **Aridisols**: arid or semi-arid climate
- **Entisols**: unconsolidated sediment or rock
- **Histosol**: organic materials
- **Inceptisols**: more developed unconsolidated sediment or rock
- **Miscellaneous**: Areas of human altered soil and non-soil areas
- **Mollisol**: semi-arid to semi-humid areas, typically under a grassland cover.
- **Oxisols**: tropical rain forest
- **Spodosols**: typical soils of coniferous or boreal forests
- **Ultisols**: product of continuous weathering of minerals in a humid, temperate climate
- **Vertisol**: high content of expansive clay minerals

STRATEGY

02 REINFORCE SITE WITH VEGETATION

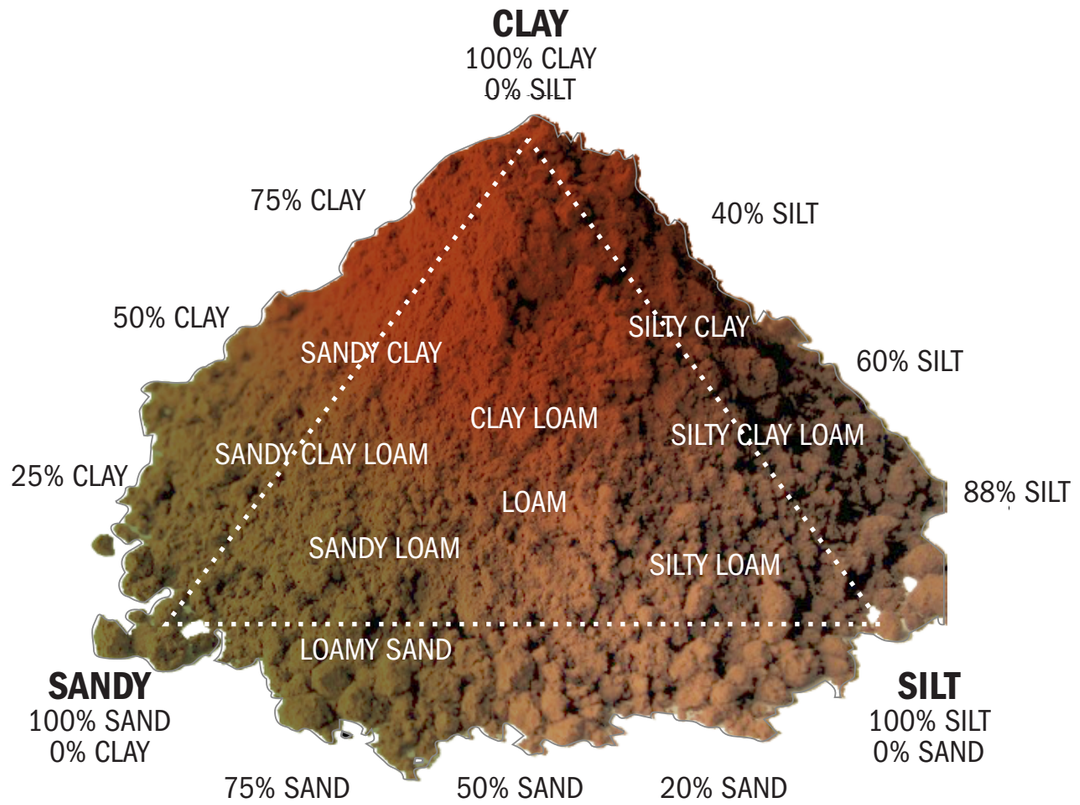
STEP 1 - IDENTIFY SOIL TYPE AND PROPERTIES

IDENTIFY TYPE OF SOIL BY REGION

The consistency of soils naturally occurs as a mixture of the different kinds, as illustrated to the right.

The soils in Puerto Rico are variable and are classified as different types or diverse series depending on their localization within Puerto Rico. The soils that have similar characteristics conform a series. The most prominent series were classified in 11 groups. The two principal groups are in the mountainous and humid regions and the coastal valleys. The set of these series is known as the association, named after the areas in which they were identified. In the mountainous humid area, the associations include Tanamá-San Sebastián, Humatas-Los Guineos-Alonso, and Pellejas-Lirio-Ingenio; these are clay-like and loamy.





B. PROPERTIES

Properties of soil will vary based on location in the island, the relationship to coastal and water resources, altitude, and the proximity to developed communities. It's important to pay attention to the following elements as soil is selected.

- **Salinity**: A measure of the concentration of salts in water or soil.
- **PH Balance**: Measures the acidity or alkalinity of water or soil. The scale of PH is logarithmic and goes from 0 to 14. A PH of 7 is considered neutral.
- **Contamination**: Laboratory tests can be performed to detect contaminants in the composition of the soil.
- **Subsoil**: The layer just below the topsoil, which has less organic matter in its composition.

STRATEGY 02

REINFORCE SITE WITH VEGETATION

STEP 2 - CHOOSE AND PLANT VEGETATION

Native trees are those that are part of the natural landscape of Puerto Rico. Native trees are better at sustaining the local climate and may also have more capacity to survive extreme events like Hurricanes Irma and Maria.

- Choose vegetation based on your results from the chart above, the landscape available, and your intended purpose.
- Consult with agronomists, gardeners, or municipality agriculture experts about uses, recommendations, maintenance, and the resistance of trees under hurricane winds.
- Before covering an entire area with plants, test a small section and ensure that the plant is growing well without damaging the soil. If the test is not successful, move the plant to a different location or try another plant.
- Although they provide shade, it is best not to plant medium to big trees at a distance where they can fall on a home if toppled by hurricane winds. Nearby trees can also increase the humidity inside the home and can encourage mold growth.



STEP 2 - CHOOSE AND PLANT VEGETATION

- Plant trees in places that match its preferred conditions so that they won't need excessive care, like watering or adding nutrients. Consider the use compost to fertilize.
- Consult an arborist or an agronomist in case the tree has signs of a disease or insects. Consider the use of natural insecticides.
- Consider the use of natural insecticides.



SEASHORE DROPSEED
SPOROBOLUS VIRGINICUS



SALT HAY
SPARTINA PATENS



STRONGBARK
BOURRERIA SUCCULENTA

DESCRIPTION	A spreading perennial with green or purple flowers. Grows from 10 to 50 cm (4 to 20 inches).	Grass grown from 1 to 5 feet tall solitary or in small clumps.	Small to medium tree with green leaves arranged alternately, and it has fruit that goes from orange to red when ripe.
SOIL CONDITIONS REQUIRED	■ Soil Type: Sandy (stable dunes) ■ Salinity: High	■ Soil Type: Sandy ■ Growns on low dunes or sand flats ■ Salinity: High	■ Soil Type: Occurs in sand with a limestone substrate ■ Salinity: Moderately tolerant to salt ■ pH: High
BENEFITS	■ Dune stabilization ■ Provides habitat for animal species.	■ Dune stabilization ■ Provides habitat for animal species	■ Attracts pollinators and provides food for birds.

STRATEGY 02

REINFORCE SITE WITH VEGETATION

STEP 2 - CHOOSE AND PLANT VEGETATION



BEACH BEAN
CANAVALIA MARITIMA

DESCRIPTION

A perennial herb with a trailing or climbing stem

SOIL CONDITIONS REQUIRED

- Soil Type: Sandy Grows along coasts and edges of coastal bushland
- Salinity: High

BENEFITS

- Dune stabilization
- Provides habitat for animal species
- Can form a symbiotic relation with bacteria in the soil that enriches the soil.



SEA GRAPE
COCCOLOBA UVIFERA

DESCRIPTION

Medium tree that grows on the coasts. The tree has big rounded leaves and produces edible fruits.

SOIL CONDITIONS REQUIRED

- Soil Type: Sandy
- Salinity: High

BENEFITS

- Can be used as a hedge and wind breaker and shadig system.
- Tolerates drought.



ALLIGATOR WEED
ALTERNANTHERA PHILOXEROIDES

DESCRIPTION

Aquatic (freshwater). Often forms tangled masses in water. Good in shallow ponds, depressions, and ditches with fresh water.

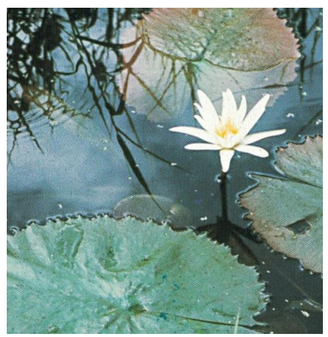
Considered invasive.

SOIL CONDITIONS REQUIRED

- Soil Type: Water (damp soil)

BENEFITS

- Can be used to stabilize soil and sites.
- Considered invasive and must be restrained to control its growth.



WATER LILY
NYMPHAEA AMPLA

DESCRIPTION

Aquatic (freshwater) plant that floats with a submerged root. Flowers are white and diurnal.

SOIL CONDITIONS REQUIRED

- Soil Type: Water (damp soil)
- Salinity: Freshwater

BENEFITS/ RISKS MITIGATED

- Provides habitat for animal species.
- Can be invasive.



WATER HYSSOP
BACOPA MONNIERI

DESCRIPTION

Aquatic (freshwater) succulent with leaves and small white or light blue flower.

SOIL CONDITIONS REQUIRED

- Soil Type: Water

BENEFITS/ RISKS MITIGATED

- Provides nesting and food for birds.



SOUTHERN CATTAIL
TYPHADOMINGENCIS

DESCRIPTION

Forms extensive colonies. Grows in rivers, beside lakes and herbaceous marshes.

SOIL CONDITIONS REQUIRED

- Soil Type: Water (damp soil)
- Salinity: Freshwater

BENEFITS/ RISKS MITIGATED

- Provides habitat and nesting sites for birds.
- Can be invasive.

STRATEGY 02

REINFORCE SITE WITH VEGETATION

STEP 2 - CHOOSE AND PLANT VEGETATION



BLACK OLIVE TREE
BUCIDA BUCERA

DESCRIPTION

A medium to large tree which can grow up to 100 feet.

SOIL CONDITIONS REQUIRED

- Soil Type: Can grow almost all over the island, in both humid and dry soils.

BENEFITS

- It can be planted to embellish and to provide shade. It is a large tree, so care must be taken when planting it near structures.



WHITE CEDAR
ABEBUIA HETEROPHYLLA

DESCRIPTION

A medium tree that can reach 60 feet. Its flowers are pink and tubular. Its delicate white seeds can be dispersed by the wind.

SOIL CONDITIONS REQUIRED

- Soil Type: The tree grows in the woods along the island.

BENEFITS

- It can grow in almost any type of soil and can be used for embellishment for parks.



ROYAL PALM TREE
RYSTONEA REGIA

DESCRIPTION

A palm tree that can reach 30 meters in height and has a distinctive sheath on the upper part of its foliage.

SOIL CONDITIONS REQUIRED

- Soil Type:
- Can grow in dry and humid soils.
- Common in the humid mountains.

BENEFITS

- Decorative; its fruit is an important source of food for birds and insects.
- Dry leaves that fall from the tree can be dangerous for cars and people.



ROYAL POINCIANA
DELONIX REGIA

DESCRIPTION

A medium tree distinctive for its showy red flowers and umbrella-like canopy.

SOIL CONDITIONS REQUIRED

- Soil Type: Will grow in almost any soil but needs good drainage, will tolerate drought.
- Salinity: Will tolerate salt.

BENEFITS

- Care must be taken when planting near homes because the root system will damage foundations or anything near it that is underground.



MANILA PALM
ADONIDIA MERRILLII

DESCRIPTION

A palm tree that can reach 20 feet high. Its fruit is distinctive and is important for bird species.

SOIL CONDITIONS REQUIRED

- Soil Type: Fertile soils with good drainage.

BENEFITS

- Used for embellishment and its fruit is an important source of food for bird.



JUNGLE GERANIUM
IXORA COCCINEA

DESCRIPTION

A shrub with very dense foliage, showy red flowers, and dark purple fruit. Its flowers attract bees and birds.

SOIL CONDITIONS REQUIRED

- Needs full sun but can tolerate some shade.

BENEFITS

- Can be used as a hedge.

STRATEGY 02

REINFORCE SITE WITH VEGETATION

STEP 2 - CHOOSE AND PLANT VEGETATION



NARRA
PTEROCARPUS INDICUS

DESCRIPTION

A large tree with many long branches, yellow flowers, and a distinctive round wing seed.

SOIL CONDITIONS REQUIRED

- Soil Type: Can be found in various types of soils, from sandy loams to clay.
- Salinity: Tolerates moderate levels of salt in the soil.

BENEFITS/ RISKS MITIGATED

- A nitrogen-fixing tree, it has been recommended for use in agroforestry systems and as a shade tree for coffee and other crops



TEA
AMYRIS ELEMIFERA

DESCRIPTION

Grows from a shrub to a small tree up to 6 meters in height. The leaves are aromatic when crushed. It has white flowers and bears fruit.

SOIL CONDITIONS REQUIRED

- Soil Type: Grows well in sandy soils and limestone soils. Can also grow in moist terrains with good drainage.
- Can be found in the Guanica Dry Forest.

BENEFITS/ RISKS MITIGATED

- Its fruit is a source of food for birds.
- The tree is very resinous, and its wood can be used as a torch.



WEST INDIAN SATINWOOD
ZANTHOXYLUM FLAVUM

DESCRIPTION

Grows from a shrub to a small tree up to 11 meters in height. The leaves are aromatic when crushed and its flowers are a greenish white color.

SOIL CONDITIONS REQUIRED

- Soil Type: Can grow in a sandy terrain and limestone.
- Can be found in the Guanica Dry Forest.

BENEFITS/ RISKS MITIGATED

- Its flowers attract pollinators (insects and bees).



MANGROVES

DESCRIPTION

- Also known: Button Mangrove, White Alling, Black Mangrove, Red Mangrove, White Mangrove
- Mangroves can survive on the threshold of water and terrain on the coast but are not limited to it.

SOIL CONDITIONS REQUIRED

- Soil Type: Water (damp soil) and sand in coastlines and estuaries
- Salinity: High
- Can also be found in estuarine waters.

BENEFITS/ RISKS MITIGATED

- Mangroves are known as nature's filters; the reason they have a distinctively sour smell is precisely because they cycle pollutants out of the water. Because of their high tolerance for varying levels of salinity and strong root systems, they are fantastic to use as natural sea walls or rompeolas against wave surges and for any type of shore suffering from erosion.



BLACKRODWOOD
EUGENIA BIFLORA

DESCRIPTION

Small to medium tree with green leaves of

1 - 2 cm and small white flowers. Gives small fruit that is red or black when ripe.

SOIL CONDITIONS REQUIRED

- Soil Type: Can be found in the coastal valleys, limestone substrate, and in the mountains.

BENEFITS/ RISKS MITIGATED

- Provides fruit for birds.



SERRETTE GUAVE
EUGENIA DOMINGENSIS

DESCRIPTION

- Small to medium tree with green leaves and white small flowers. Gives small round fruit which is red when ripe.

SOIL CONDITIONS REQUIRED

- Soil Type: Can be found in mountains, humid mountains, and coastal valleys.

BENEFITS/ RISKS MITIGATED

- Provides fruit for birds.

STRATEGY

02 REINFORCE SITE WITH VEGETATION

STEP 2 - CHOOSE AND PLANT VEGETATION

OPERATIONS AND MAINTENANCE TIPS

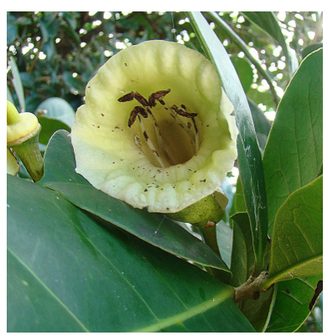
- Plant trees in places that match its preferred conditions so that they won't need excessive care, like watering or adding nutrients. Consider the use compost to fertilize.
- Consult an arborist or an agronomist in case the tree has signs of a disease or insects.
- Consider the use of natural insecticides.



WEST INDIAN BAY TREE
PIMENTA RACEMOSA



MAGA
THESPESIA GRANDIFLORA



BLACK CALABASH
AMPHITECNA LATIFOLIA



FIDDLEWOOD
CITHAREXYLUM FRUTICOSUM



MARICAO
BYRSONIMA SPICATA

DESCRIPTION	Small to medium tree with aromatic leaves.	A small to medium tree with large green leaves and a red to dark red flower.	Small to medium tree can reach 30 feet with a variable spread.a narrow crown, is moderately dense and of irregular form. Gives yellow flowers and green fruit.	A small to medium tree with extended top, irregular foliage and white flowers. It gives abundant fruit.	A medium tree with green leaves, though some are red, and others are yellow. The Maricao has yellow flowers and gives fruit irregularly through the year.
SOIL CONDITIONS REQUIRED	■ Soil Type: Can be found on hillsides but can grow in somewhat humid areas	■ Soil Type: Grows best in limestone hillsides and alluvial bottom between the hills. ■ Can grow in full sun and some shade.	■ Soil Type: The soil found in the coastal line. ■ Needs open space and good sun.	■ Soil Type: Can tolerate humid and somewhat dry soils.	■ Soil Type: Does not tolerate humid soils. ■ Needs good sun
BENEFITS	■ Its leaves are used to make an infusion with rubbing alcohol to relieve muscular pain (alcoholado).	■ Attracts pollinators and can be used for shade and embellishment in parks.	■ This upright, densely-foliated, evergreen can provide site shading and stabilization. Provides food for birds.		
BENEFITS/ RISKS MITIGATED				■ Provides food for birds and attracts bees.	■ Provides food to pollinators, including bats and birds.

STRATEGY 02

REINFORCE SITE WITH VEGETATION

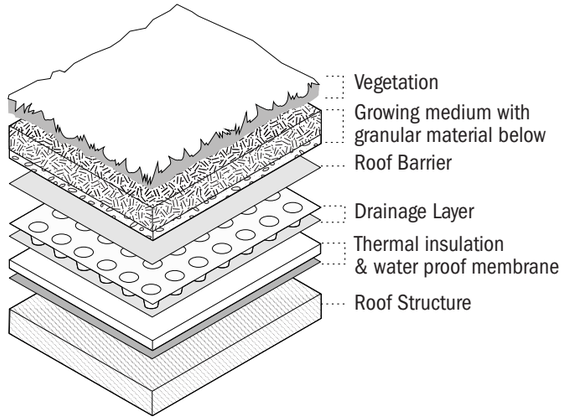
STEP 3 - IMPLEMENT RESILIENT SITE SCAPING

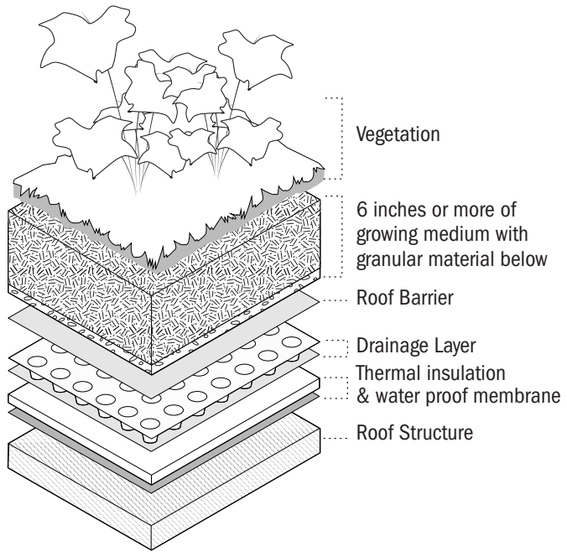
When planting vegetation that will need a minimum of care and maintenance, it's better to choose local vegetation, the ones that grows better within the conditions of the place where they will be planted.

A. GREEN ROOFS

- Roofs that are partially or completely covered with vegetation and a growing medium mitigate excessive heat gain and manage stormwater.
- Green roofs are classified according to the depth of soil or growing medium, which determines species it can support.
- A green roof consists of several layers including a membrane to protect the roof from water leakage, soil layers, a drainage layer and vegetation.
- Consult with building professionals to identify the load a roof can sustain with plantings, water and materials.
- Verify that roof vegetation is watered to prevent building flammability and maintain ability for roof habitat and benefits. This may require water pumped to the roof.







EXTENSIVE

- Does not require an irrigation system (thin soil layer).
- Recommended vegetation: succulents, cacti
- Pros: minimal maintenance required,
- Relatively inexpensive
- Cons: limited choice of plants, cannot grow vegetative species

INTENSIVE

- Requires irrigation systems (thicker soil layer).
- Recommended vegetation: virtually any plant or tree whose root system will not grow deeper than growing medium (generally less than 6 inches).
- Pros: can incorporate a greater variety of vegetation
- Cons: greater weight loading on roof, higher cost

STRATEGY

02 REINFORCE SITE WITH VEGETATION

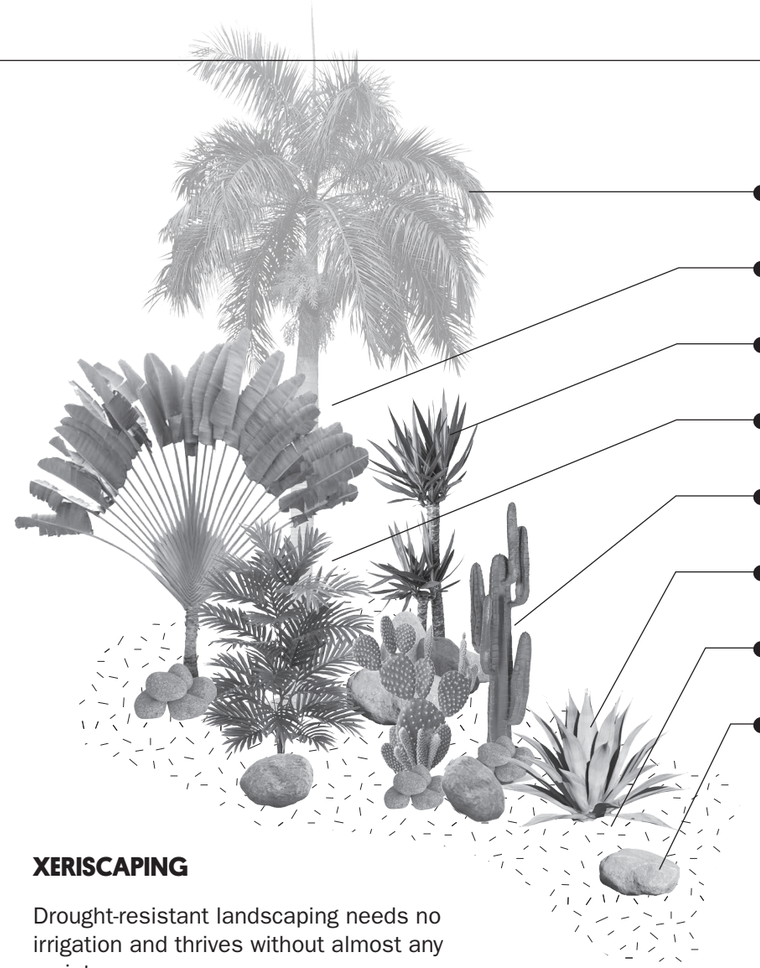
STEP 3 - IMPLEMENT RESILIENT SITE SCAPING

B. XERISCAPING

- A type of garden that requires little supplemental water. Creates breeze for areas that are very hot and do not receive much rain, such as Southern Puerto Rico.







XERISCAPING

Drought-resistant landscaping needs no irrigation and thrives without almost any maintenance.

OPERATIONS AND MAINTENANCE TIPS

- The height of a tree must not be longer than its distance to a structure so that the tree won't fall over said structure in case high winds overthrow it. Planting trees near homes also has the disadvantage of possibly damaging the structure of the home or damaging plumbing or service lines.
- Trim dead branches so that they won't turn into projectiles. Consider trimming all tree branches so that they won't exert resistance to the winds and survive hurricane winds. Trimming trees may require the work of a professional and the use of a crane or a bucket crane truck.
- Do not trim any branches by any near electrical lines. Call the authorities for that purpose whenever you see branches growing near or towards the lines. Do not plant trees near electrical lines.
- To cut a tree, obtain a permit from the Department of Natural and Environmental Resources (DRNA, by its Spanish acronym).

STRATEGY

03 PLANT AN EDIBLE GARDEN

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REMEMBER

An Edible Garden is a Critical Part of a Resilient Home. Domestic gardens are affordable and easily manageable. They allow you to grow your own food and medicines and reduce supermarket costs. You can incorporate specific herbs to help ward off insects, specific plants to control thermal heat gain (see Strategy 14 Manage Pests), and redirect wind for better natural ventilation (see Strategy 11 Increase Ventilation).

After a natural disaster strikes, primary resources, including food, can become scarce. This strategy focuses on how conscientious use of vegetation can offer a local back-up food resource and a year-round supply of food. Additionally, it provides a range of other benefits like exercise, community building and cost savings. Another positive aspect is the consideration of growing medicinal plants which can improve the health of residents and the community.

Strategy in Action

1. Plan Your Garden

2. Plant Your Garden

WHAT YOU NEED TO KNOW

Importance of Edible Vegetation

Edible Vegetation promotes resilient communities by:
- Removing air pollutants
- Providing shade
- Fortifying the soil
- Supplying food
- Supplying homeopathic medicine
- Creating community bonding opportunities

Preparing the soil for growing food is a critical first step to any gardening activity.

Thoughtful design of the layout for your garden will determine its success. Optimal growing conditions include flat surfaces where the appropriate sun light ratio is available to the crops. However, don't let this deter you from trying to work on sloped surfaces or areas with a shade. While sloped surfaces will pose challenges of soil erosion and nutrient mobility, plenty of techniques exist to help you make use of any terrain available to you. Additionally, building your garden with enough plant variety will allow you to maximize its growing potential, even with varying access to sunshine in your garden.



SUPPORTING STRATEGIES

01 Reinforce Site

02 Reinforce Site with Vegetation

14 Manage Pests

20 Collect and Use Rainwater

23 Develop a Household Emergency Plan

STEP 1 - PLAN YOUR GARDEN

A. EVALUATE THE GROWING CONDITIONS OF YOUR FUTURE GARDEN

A successful garden will be supplied with healthy soil, plenty of sunshine, and water. Garden planning is all about allocating these resources.

Sun: If your plot is surrounded by large trees and/or structures, your future garden may suffer from sun deprivation. As a fundamental source of energy for plants, sunlight must be optimized. If your conditions allow, prioritize your garden location to south-facing areas with as much sun exposure as your land area allows.

Soil: Healthy soil may already be available in your plot. This is soil that is nutrient-dense, has good drainage, and is on a terrain that is relatively flat to avoid erosion. Sometimes, these conditions cannot be met. Use alternatives, such as container gardening with hydroponics, to persist with your gardening goals. Your Agricultural Extension Service (SEA, by its Spanish acronym) can conduct soil health testing and help you identify soil health and safety parameters.

Water: Your garden must be watered regularly. Adequate garden planning will help you devise a source of irrigation water that minimizes added costs and provides clean water to your garden. Consider ways in which you can collect and store rainwater (such as rain barrels). Check that your water source is always safe by monitoring water quality.

B. DETERMINE WHICH FOODS ARE MOST SUITABLE FOR YOUR GARDEN

Growing your own food allows you to choose among multiple fruit and vegetable varieties, which gives you the opportunity to try many new foods and flavors. Choosing the right variety of plants to grow will require consideration of your garden's capabilities (space limitations; access to resources like sun, soil, and water; and growing methods). Consider the following list of plants that are generally suitable for growing conditions in Puerto Rico. Choose among those which may thrive in the local conditions of your site and with the growing system you choose. Consider the amount of space available for the plants to grow. To decide on the proper space, consider the general rule of thumb which establishes that a plant will grow as big as it roots.



STRATEGY 03

PLANT AN EDIBLE GARDEN

Plant cycle | Shaded | Direct sun | Harvest cycle | Water once a week | Water 2-3 times a week | Water regularly

STEP 1 - PLAN YOUR GARDEN

VEGETATION FOR FOOD: TREES



COCONUT / PALM TREES

Plant cycle: 12 months — Fruits after 6-10 years, after flowering



CITRUS

Plant cycle: 6-8 months — Fruits after 3-6 years



PAPAYA

Plant cycle: 9-11 months — Fruits after 7-11 months



BANANA/PLANTAIN TREES

Plant cycle: 9 months — Fruit after 1 year

VEGETATION FOR FOOD: SHRUBS AND VINES



PUMPKINS

Plant cycle: 3-4 months



AVOCADOS

Plant cycle: 12 months



EGGPLANT

Plant cycle: 3-6 months



PANA / BREADFRUIT

Plant cycle: 12 months — Fruit after 5 years

STRATEGY 03

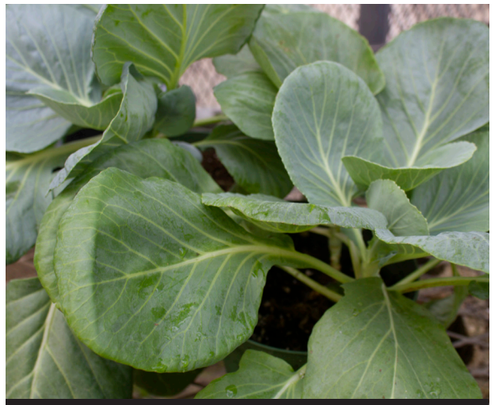
PLANT AN EDIBLE GARDEN

REMEMBER

An alternative for growing edible gardens at home with limited yard space is to establish a community garden in a park and allow community members' access to plots in the garden. Check that the soil is not contaminated. A list of resources on community gardens is included below.

STEP 1 - PLANT YOUR GARDEN

VEGETATION FOR FOOD: ROOT VEGETABLES



LETTUCE/CABBAGE FAMILY



PEPPER SPECIES

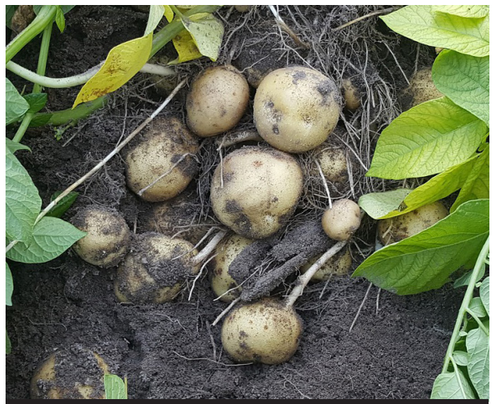


ONION/GREEN ONIONS - PLANT IN SHALLOW SOIL



SPINACH

Vegetable after 3 months



POTATOES/YAUTÍA/ÑAME/OTHER LOCAL TUBERS



TOMATOES



SWEET POTATO/YAM SPECIES



CARROTS

STRATEGY 03

PLANT AN EDIBLE GARDEN

DISCLAIMER

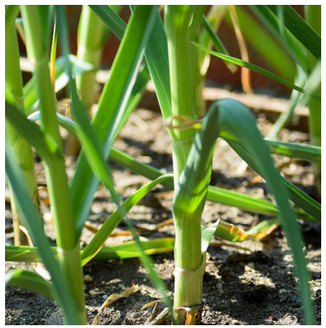
Consult with a medical professional before consuming these plants. Some plants might interact with certain medicines or may not be recommended for some diseases.

STEP 1 - PLANT YOUR GARDEN

MEDICINAL PLANTS

Medicinal plants can be used in a variety of ways:

- As tea, which is usually an infusion of Camellia sinensis, an evergreen shrub native to East Asia.
- As an infusion, which is prepared by pouring hot water over leaves, flowers, fruits or bark of plants commonly used for this purpose.
- As oil. Plant-based oils are extracted by different methods suitable for the part of the plant containing the oil. Some methods include cold pressing, distillation, and solvent extraction.
- As tincture, an extract of a plant dissolved in ethyl alcohol. Tinctures are ingested.
- The following plants, common in Puerto Rico, have been known for their medicinal properties. Given that most of these are herbs or small plants, they are all great alternatives for container gardening.



GARLIC

HOW IT GROWS

Bulb or tuber

HOW TO USE

It is used to prevent blood clots and cerebral aging. It aids digestion and prevents flatulence. It is also used as a mosquito repellent.

When eaten raw, it releases antiseptic properties.



BASIL

HOW IT GROWS

Plant or herb

HOW TO USE

Basil is commonly consumed for stomach problems such as spasms, loss of appetite, intestinal gas, diarrhea, and constipation.

It is also used in teas, infusions, baths, and botanical massage oils.



YELLOWCRESS OR WATERCRESS LEAVES

Plant

Watercress boasts many important vitamins and minerals, including over 100% of the recommended daily intake (RDI) for vitamin K. Watercress is extremely high in antioxidants which may help prevent chronic diseases, such as diabetes, cancer and heart disease. Add to salads and green juices/smoothies.



CINNAMON BARK

Tree [bark]

Has antibacterial, anti-inflammatory, and antioxidant properties. Cinnamon lowers blood glucose levels in patients with type 2 diabetes. Use in teas, add to jarabes or homemade cough syrups made with honey and lemon, suck on a single clove raw, and include it in botanical oils for the skin.

STRATEGY 03

PLANT AN EDIBLE GARDEN

STEP 1 - PLANT YOUR GARDEN

MEDICINAL PLANTS



ONION

HOW IT GROWS

Bulb or tuber

HOW TO USE

The possible health benefits of consuming onions include mood improvement, and healthy skin and hair. Use in food preparation.

Add to jarabes or homemade cough syrups made with honey and lemon.



CITRUS FRUITS [LEMON, ORANGE, LIME, GRAPEFRUIT]

HOW IT GROWS

Fruit shrub or tree

HOW TO USE

These fruits work as antidepressants (mood lifters). They have antiseptic properties; they can be used to clean and as stain removers. Add to teas, infusions, botanical massage oils, aromatherapy, alcoholates or alcoholados. Drinking their juice and eating these fruits releases some beneficial properties.



MARIGOLD FLOWERS OR CALÉNDULA

HOW IT GROWS

Flowering plant

HOW TO USE

Supports new tissue growth during wound healing process and decreases swelling in the mouth and throat.

Use this flower for your tea, make it into an infusion, and use in baths.



CLOVE

HOW IT GROWS

Flowering Plant

HOW TO USE

Clove oil contains a chemical called eugenol that may help decrease pain and fight infections, but more research is needed.

Use it to make tea, add it to jarabes or cough syrups made with honey and lemon, suck on a single clove raw, and use it in botanical oils for the skin, alcoholates or alcoholados



EUCALYPTUS LEAVES

HOW IT GROWS

Tree

HOW TO USE

Might be able to break up mucus in people with asthma. Eucalyptus oil contains chemicals that might help pain and inflammation.

Use these leaves for teas, infusions, green juices/smoothies, baths, botanical massage oils and ungüentos or medicinal ointments.



GINGER

HOW IT GROWS

Root

HOW TO USE

May help relieve or prevent nausea and vomiting. Some studies show that ginger may help nausea caused by chemotherapy.

Use in teas, infusions, green juices/smoothies, baths, botanical massage oils and ungüentos or medicinal ointments, compresses, condiments, alcoholates or alcoholados.

STRATEGY 03

PLANT AN EDIBLE GARDEN

STEP 1 - PLANT YOUR GARDEN

MEDICINAL PLANTS



LEMONGRASS

HOW IT GROWS

Plant/Herb

HOW TO USE

Lemongrass is an insect repellent, it helps to treat anxiety, gastrointestinal problems, and induces sleep.

Use for teas, juices and green smoothies, baths, and essential oils for your skin.



"MALAGUETA" OR WEST INDIAN BAY TREE LEAVES

HOW IT GROWS

Woodsy Shrub/tree

HOW TO USE

These leaves help treat muscle pain and work as a natural insect repellent.

Use in baths, botanical massage oils and ungüentos or medicinal ointments, compresses, and alcoholates or alcoholados.



MARJORAM

HOW IT GROWS

Plant/Herb

HOW TO USE

Marjoram is commonly used to relieve symptoms such as runny nose or cough, as well as to treat colds, infections, and various digestive problems. However, there is no clear scientific evidence to support these or any other uses.

Use in teas, infusions, green juices/smoothies, baths, botanical massage oils and ungüentos or medicinal ointments, alcoholates or alcoholados, and compresses. It is also included in condiments, in vinaigrettes, and is added raw in salads.



LEMON BALM OR "TORONJIL"

HOW IT GROWS

Plant or herb

HOW TO USE

Lemon balm is used for digestive problems, including upset stomach, bloating, flatulence, vomiting, and colic. Many people believe lemon balm is calming, so they take it to treat anxiety, sleep problems, and restlessness. It is used in infusions, green juices/smoothies, baths, botanical massage oils, ungüentos or medicinal ointments, and compresses. It is also used in condiments, vinaigrettes, and added raw in salads. Lemon balm is proven to treat herpes simplex virus 1 and 2.



MINT

HOW IT GROWS

Plant or herb

HOW TO USE

Mint oil is used topically for tension headaches.

Mint is also used in tea blends, infusions, green juices/smoothies, baths, botanical massage oils, ungüentos or medicinal ointments, compresses, condiments, and even in home cleaning products.



NIM OR NEEM

HOW IT GROWS

Tree

HOW TO USE

Used in traditional medicine for skin conditions and for stomach ailments. It is also used as a disinfectant against pests and parasites. The oil is used to get rid of pests in agriculture.

Neem leaves are used in capsules. Additionally, oil is extracted from its seeds and is used as a curative massage oil.

STRATEGY 03

PLANT AN EDIBLE GARDEN

STEP 1 - PLANT YOUR GARDEN

MEDICINAL PLANTS



OREGANO

HOW IT GROWS

Plant or herb

HOW TO USE

Oregano is taken orally for respiratory tract disorders such as cough, asthma, allergies, croup, and bronchitis; it is also taken orally to treat stomach disorders such as heartburn, bloating, and parasites. Oregano oil is used for skin conditions including acne, athlete's foot, dandruff, canker sores, warts, wounds, ringworm, rosacea, and psoriasis; it is also used to treat insect and spider bites, gum disease, toothaches, muscle and joint pain, and varicose veins. Oregano oil is also applied to the skin as an insect repellent.

It is included in tea blends, broths, condiments, baths, botanical massage oils, ungüentos or medicinal ointments, compresses, jarabes or homemade cough syrups, alcoholates or alcoholados, and even in home cleaning products.



BLACK PEPPER [SEEDS OR FRUITS]

HOW IT GROWS

Flowering Vine

HOW TO USE

Black pepper might help fight germs (microbes) and increases the flow of digestive juices. Black pepper is applied as a natural topical pain reliever.

It is also used as a condiment, is chewed raw or included in tea blends. It can be included in baths, botanical massage oils, ungüentos or medicinal ointments, and alcoholates or alcoholados.



BUSHY LIPPIA [LEAVES]

HOW IT GROWS

Flowering Plant

HOW TO USE

This plant is a mint but its ingestion can prove toxic for the liver.

It is used in teas, infusions, green juices/smoothies, baths, botanical massage oils, ungüentos or ointments, compresses, and alcoholates or alcoholados.



ROSEMARY LEAVES

HOW IT GROWS

Plant, can grow to become a bush.

HOW TO USE

Rosemary is used for digestive problems, including heartburn, flatulence, and loss of appetite. Rosemary is also applied to the skin for preventing and treating baldness. It treats circulation problems as well.

It serves as a condiment, tea, aromatherapy essential oil, massage oils, and ungüentos or ointment.



BLUE/MEXICAN ELDERBERRY LEAVES AND FLOWERS

HOW IT GROWS

Bush, can grow to become a tree

HOW TO USE

Reduces cold and flu symptoms. While berries are rich in nutrients, raw elderberries are inedible and must be properly cooked before they can be ingested. Use elderberries to make teas, jarabes or cough syrups, green juices and smoothies, baths, and alcoholates or alcoholados.



ALOE VERA OR "SÁBILA"

HOW IT GROWS

Thick-leafed plant

HOW TO USE

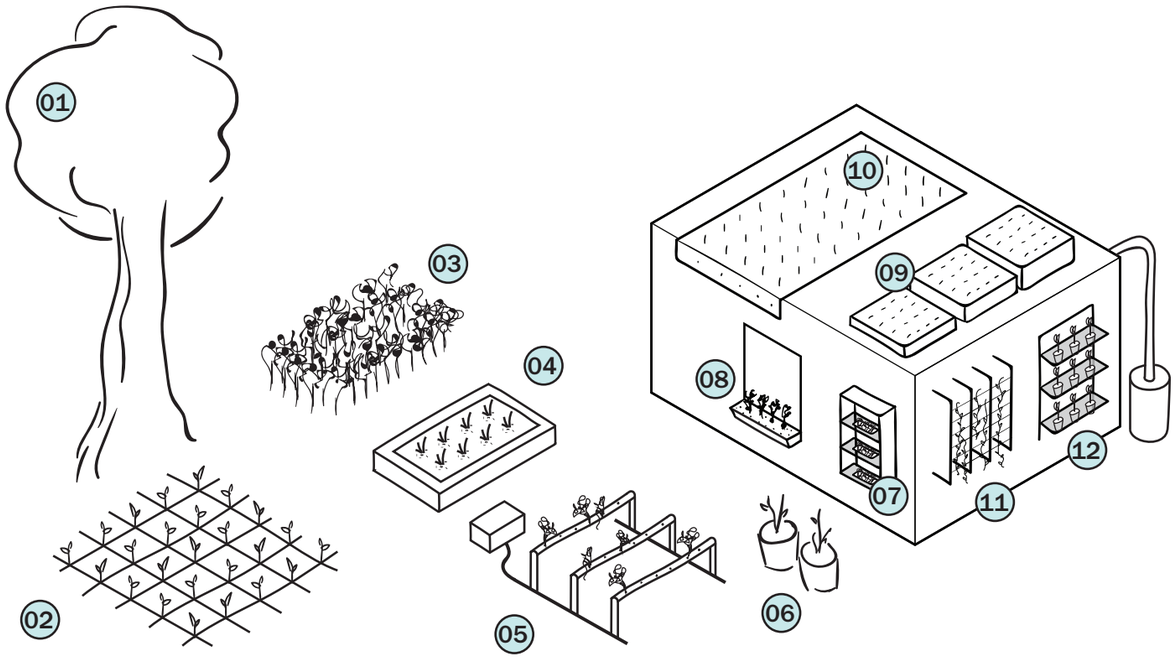
Helpful for minor burns, aloe vera gel should not be confused with aloe juice or aloe latex, both of which contain potent laxative substances. You can harvest its "crystal", the slimy and transparent flesh interior, by carefully skinning each leaf with a knife. Use in infusions, green juices/smoothies, jarabes or homemade cough syrups, compresses, and other applications.

STRATEGY

03 PLANT AN EDIBLE GARDEN

STEP 2 - CHOOSE AMONG GROWING METHODS

Based on the conditions of your garden—available land, layout, soil quality, and budget—you may choose to use soil as the growing medium for your plants or a water-based medium that delivers nutrients to plants grown in hydroponic systems. This section includes information to consider when determining the growing method for your garden.



01 Fruit Trees
02 Direct Soil Gardening
03 Fruit or Herb Bushes
04 Raised Bed Planter
05 Hydroponic System (Ground or Roof)
06 Planters
07 Window Green House
08 Window Sill Planters
09 Extensive System / Trays vary in depth
10 Intensive System / Built into roof depth
11 Light Mesh for Climbing Species
12 Shelve or Pocket System

SOIL PLANTING $

- This method utilizes nutrients available in the soil to grow food or herbs.
- A vertical garden is a technique used to grow plants in soil or on a medium vertically, using a trellis, fence, wall or similar surface with soil at the bottom.

LOCATION

- Outdoors (single family house with yard, multifamily housing with community garden, exterior walls, and balconies)
- Indoors (herbs and microgreens in greenhouses

PROS

- Grows a wide range of native species.
- Provides site shading.
- Helps control pests on site.
- Helps manage stormwater and drainage.
- Can be linked to a home's graywater system.
- Absorbs soil nutrients.

CONS

- Prone to insect infestation, mold growth, and contaminants in the soil and water.





HYDROPONIC PLANTING $

- This method uses mineral nutrient solutions in a water solvent on mediums such as perlite, Rockwool, clay pellets, peat moss, or vermiculite to grow plants without soil. Because this method is employed indoors, it requires artificial sources of UV rays (sunlight).

LOCATION

- Indoors (greenhouses)
- Outdoors on a covered structure (terraces or balconies)

PROS

- Yields a quantity of leafy greens (like basil, cilantro and arugula) that is three times more than a traditional soil system can provide.
- Grows in indoor and outdoor conditions. Gardener has more control over crop exposure to light, insects and natural elements if grown indoors.
- Enables experimentation with different crops throughout the year.
- Enables food production in areas where soil is contaminated.

CONS

- Requires higher initial investment.
- Ongoing utility cost related to lighting and pumps.
- Prone to pest infestation (aphids) and powdery mildew.
- Water needs a specific pH balance.Requires nutrients to be imported from the garden.
- Needs electricity to power up motor, lights, and fans.
- The system needs added nutrients.







STEP 3 - GROWING STYLES

If you choose to use soil as your growing method, there are various styles of gardening among which you can choose from and adapt to your land and resource availability.

PLANTERS

Planters can be any type of container that holds soil for plant growth. They come in various materials, shapes and sizes.

LOCATION

- Indoors
- Outdoors (ground, walls, roofs)

PROS

- Grows in indoor and outdoor conditions.
- Works in a variety of configurations, including vertical.
- Alternative if ground soil is contaminated or infertile.
- Can run with an automatic drop water system.
- Can be moved around which is helpful in gardens with limited sunshine access
- Nutrients and water are retained longer, so there is less leaching.
- Simplified pest control as these will be localized (if they appear).

CONS

- Will limit a plant's growth particularly trees
- Grows a limited range of native species due to limited root growth in containers.





STEP 3 - GROWING STYLES



VERTICAL

Plants, particularly vines, can be placed vertically and trellised along a wall. Growing plants vertically maximizes space use, making it an ideal alternative for growing edible plants indoors (herbs, microgreens, lettuces).

LOCATION

- Indoors
- Outdoors (ground, walls, roofs)

PROS

- Grows in indoor and outdoor conditions.
- Works in a variety of configurations.
- Can run with an automatic drop water system.
- Grows a limited range of native species.will limit a plant's growth particularly trees
- Grows a limited range of native species due to limited root growth in containers.

CONS

- Grows a limited range of native species.





GROUND $

This method provides the most versatility in terms of plants that can be grown. Root vegetables and tubers, for example, may do better directly in the soil. Additionally, growing foods directly from the soil supports shading of property and improves the soil's structural stability (decreases the risk of runoff during flooding).

LOCATION

- Outdoors

PROS

- Grows outdoor.
- Works in a variety of configurations.
- Can run with an automatic drip water system.
- Benefits from intra-species soil biodiversity.

CONS

- If soil is contaminated, ground growth is impossible.

OPERATIONS AND MAINTENANCE TIPS

- Test the soil for contaminants prior to planting. Ensure your planting terrain is contaminant-free so that harvested goods are safe. Send samples to laboratory to check soil health.
- Monitor the health of your plants. Pay attention to how your plants react to weather changes as well as insects, heat, and water changes.
- Monitor your water. If your plants are drying out, you might want to increase water diet. Consider automating irrigation with a time release pump to ensure delivery of water per schedule.
- Watch out for pests. Minimize use of pesticides by enlisting Integrated Pest Management (IPM) to manage pests. IPM is a system for managing pest problems using a range of safe and least-toxic methods. This system is a sustainable alternative to using traditional toxic-laden pesticides and agrochemicals commonly introduced to Puerto Rico since the 1940's and onward.
- Protect your garden from atmospheric events. Trim tree branches; store any tool, equipment or machinery; and pick up any debris that can affect the garden.
- Remove climbing plants from the fences and secure any structure that could be affected by strong winds. Include crops that can survive hurricane winds, like root vegetables.
- Collect your harvest before the storm and check that you are covered during and immediately after the event.

STRATEGY 03

PLANT AN EDIBLE GARDEN

STEP 4 - BUILD YOUR GARDEN

A. IDENTIFY YOUR PLOT AND POTENTIAL LAYOUT

If Planting directly in the soil:

- Although we are often limited in terms of available plots for gardening, seek to design your layout such that you maximize south-facing exposure such that your plants can benefit from maximum sunshine in the mornings.
- Elements that could limit sunshine exposure include: large trees, walls, and surrounding buildings.
- Parts of your plot that are exposed to shadows are great for seed starting (seedlings) and shade plants.
- As is described in the next sections, the type of soil in which you will be planting should be considered when determining if a slope is beneficial for your garden. If your plot tends to have high amounts of clay, you may benefit from locating your plot along a slight slope such that drainage is facilitated.
- You may create a narrow (1”W by 10”L) ditch on the highest point of your garden to control the speed of the water that runs down the profile of your plot.
- Although less relevant in urban settings, make sure there is a barrier between your garden plot and any large animals such as dogs, cats, rats, or chickens. These can physically alter your garden and/or introduce unwanted pathogens.

Planting in containers, outside:

- Your criteria for locating planting containers outside should be very similar to the ones outlined for in-soil planting.
- Containers will give you additional benefits: Your garden can be spaced out to maximize sun availability, you will have better control of your soil health (moisture, and nutrient mobility), it will be easier to control for pests as these will be localized (if they occur).
- Containers, however, will limit a plant’s growth extent. Managing drainage properly will also vary based on container type and may require some initial trial-and-error.

Vertical Gardens:

- If building in a greenhouse consider ventilation and circulation of air, siting of greenhouse to take advantage of full sun so you don’t need to provide lighting.
- Ensure the greenhouse can withstand strong winds, fires and flooding like any other structure.
- Manage the pest problems through IPM to reduce chemical pollutants from entering the air inside the greenhouse

B. SCHEDULE OF PLANTS: ANNUAL OR PERENNIAL PLANTS

- Annuals are plants that have just one growing cycle. Perennials grow and multiply for three-plus years. The avid gardener should prepare to create a garden that is in continual bloom by the using both annuals and perennials. If growing food, emphasis should be placed on repeat plantings. Tomatoes plantings on a continuous basis, for example.
- A tactic linked to biodiversity, is to design garden with crops that have differing harvest times. By staggering the times throughout the year when crops ripen, you not only ensure a supply of fruit and vegetables for your kitchen for longer than a single growing season, you avoid exposure to an insect population bloom decimating your entire harvest.

TIP: ENCOURAGE BIO-DIVERSITY!

- Annuals are plants that have just one growing cycle. Perennials grow and multiply for three or more years. The avid gardener should prepare to create a garden that is in continual bloom by using both annuals and perennials. If growing food, focus on repeat plantings (for example, tomato plantings on a continuous basis).
- Another tactic, which is also linked to biodiversity, is to design a garden with crops that have differing harvest times. By staggering the times throughout the year when crops ripen, you not only ensure a supply of fruit and vegetables for longer than a single growing season, but also avoid exposure to an insect population boom that could decimate your entire harvest.
- Hydroponics or greenhouse grown plants offer more variety regarding scheduling plants throughout the year.

COMMON PROBLEMS WITH PLANTS



Yellowing:
Lack of light or the pot is too small



Root Rot:
Too much water



Spindly Stems:
Lack of light or fertilizer



Leaves falling:
Could be due to any of the following: the pot is too small, lack of humidity, too much fertilizer, excessive heat, excessive water, lack of water or insufficient light.

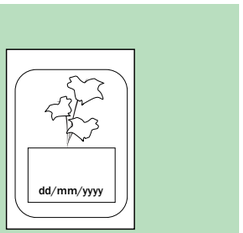
STRATEGY

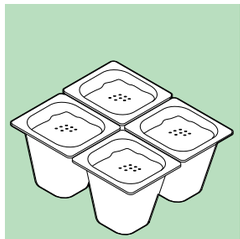
03 PLANT AN EDIBLE GARDEN

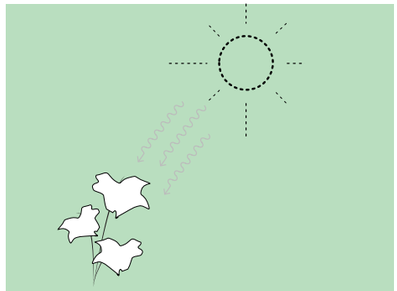
Soil-Based Systems

STEP 4 - BUILD YOUR GARDEN

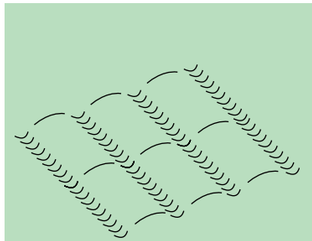
C. BEGIN THE PLANTING PROCESS

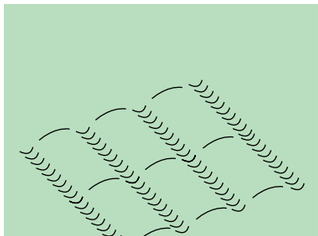


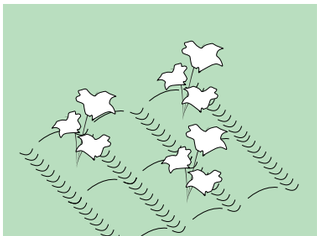




STEP	1	2	3
DESCRIPTION	■ Buy seeds at a store or at a seed sharing community. Store in a dry and dark place. ■ You can begin your garden by sprouting seeds or by getting plant seedlings or cuttings, from a local nursery or neighbor, that have already grown to 6 inches or more.	■ Plant seeds in a shallow, perforated planter, also known as a seed starter.	■ Choose your planting location according to plant requirements. Pay attention to the: ■ Type of soil ■ Available sunlight or shade ■ Identify closest source of water
TIP	■ Track the date the seeds were planted. ■ Purchase heirloom seeds: these are passed down from generation to generation and are not genetically modified. A good place to buy them is Seed Savers Exchange. For more information, visit www.seedsavers.org/ ■ Prepare the soil, especially if its sandy or loamy: Sandy loam leaks organic material and improves with organic mulch and compost that can be prepared on site.	■ Do not plant your seeds in too deep! A good rule of thumb is to place them less deep than their own width. ■ An egg carton can double as a seed starter planter.	■ You will need about 6 to 9 inches deep of good quality soil for best results. ■ Although you are often limited in terms of available plots for gardening, design your layout in such a way that you maximize south-facing exposure so that your plants benefit from maximum sunshine in the mornings. ■ Elements that could limit sunshine exposure include large trees, walls, and surrounding buildings. ■ The parts of your plot that are exposed to shadows are great for seedlings and shade plants. ■ Lay out the garden toward the sun for maximum light. Avoid laying out the garden in depressions where water may accumulate, hillsides subject to a lot of water runoff, and where trees, shrubs and buildings would shade site. ■ Site your garden in flat land if possible. If not flat, then lay it out in terrace land to create flat surfacing.







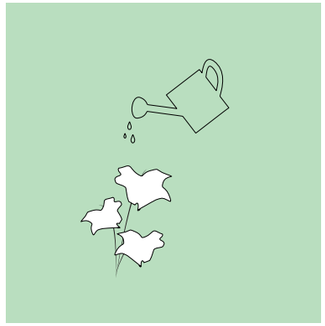
STEP	4	5	6
DESCRIPTION	■ Know your soil and prepare it: – Remove all weeds – Till to oxygenate the soil.	■ Prepare your soil with nutrients ■ Add organic nutrients if necessary.	■ Once they reach a height of 6-8 inches, transplant your seedlings from the seed starter to the site.
TIP	■ Plant directly into your soil if it is dark and has good drainage. ■ You will need to determine type of soil in which you will be planting to determine drainage capacity of soil. If your plot has high amounts of clay, you may benefit from relocating your plot along a slight slope to facilitate draining. ■ Create a narrow (1” W by 10” L) ditch on the highest point of your garden to control the speed of the water that runs down your plot. ■ Although less relevant in urban settings, check if there is a barrier between your garden plot and any large animals such as dogs, cats, rats, or chickens. These can physically alter your garden and/or introduce unwanted pathogens.	■ If soil is too loamy, water and nutrients will wash out of the soil. Keep soil healthy for nutrient retention. ■ If it the soil is too dry, you may need to add nutrients to it by mixing it with potting mix and peat moss.	■ Move roots carefully and protect them from sun or damage with a cloth. ■ Place gently in a dug-out hole, and pat and water with care so as not to overwater.

STRATEGY

03 PLANT AN EDIBLE GARDEN

STEP 4 - BUILD YOUR GARDEN

Soil-Based Systems







STEP	7	8	9
DESCRIPTION	■ Water plants according to its species' needs.	■ Continue to add nutrients to soil as needed.	■ Till between crop cycles to oxygenate soil
TIP	■ Healthy plants are more resilient to pests. Check that the soil is healthy, that its fertility is maintained, and that soil temperature is kept relatively stable with mulch. Preserve organic matter in the soil to hold soil moisture and diminish water stress in plants. ■ Watch out for any plagues or pests. Increase your plants immunity by maintaining healthy balance of water, liight and well aerated soil which supports the variety of bacteria, protozoa, fungi and algae that supports the root zone around your plant and your plants immunity to disease.	■ You can add a natural fertilizer, like homemade compost, up to once a month. ■ Keep track of the rain so you do not saturate the plants with water.	■ Keep track of the rain so you do not saturate the plants with water.



C. BEGIN THE PLANTING PROCESS

Hydroponic Gardening

- a. Hydroponics is a method of growing plants without soil by using mineral nutrient solutions in a water solvent.
- b. The nutrients used in hydroponic systems can come from an array of different sources; these can include, but are not limited to, byproduct from fish waste, duck manure, or purchased chemical fertilizers.
- c. Growing medium can be a range of substrates. Each substrate has pros and cons ranging from cost to weight. Most common types are:
  - Rockwool (spun wool substrate)
  - Lava rock
  - Clay pebbles
  - Coco coir (made from coconut husks)
  - Peat moss
- d. For all techniques, hydroponic reservoirs are built of plastic, but other materials have been used, including concrete, glass, metal, vegetable solids, and wood. Containers should exclude light to prevent algae and fungal growth in the nutrient solution.
- e. With hydroponic farming, there are two types of watering systems: continuous flow or static. In continuous flow systems, water needs continuous circulation through the system and this requires a pump; nutrients are delivered to the system in a continuous method. In a static system, water does not circulate continuously and nutrients are delivered to the system.

STRATEGY 03

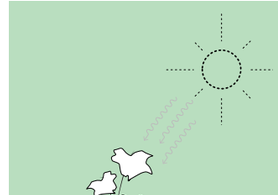
PLANT AN EDIBLE GARDEN

STEP 4 - BUILD YOUR GARDEN

TYPES OF HYDRO SYSTEMS

PLANT NAME	NUTRIENT FILM TECHNIQUE (NFT)	AQUAPONICS	WICKING
			
HOW IT GROWS	A solution with nutrients is recirculated through channels where the plants grow. The roots are not completely submerged in water.	It works as a combination of raising both fish and vege-tables or aquaculture and hydroponics.	Nutrients and water are led to the plant by capillary action from a container with the mixture.



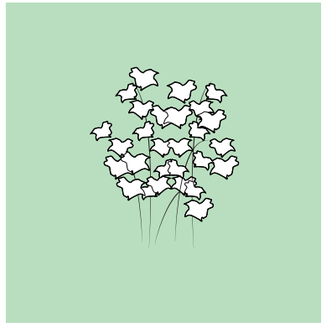
STEP	1	2	3
			
DESCRIPTION	■ Identify your budget for equipment as well as greenhouse assembly.	■ Identify site location and whether you will be growing indoors or outdoors.	■ Identify plants (and if you also want to support aquaponics system with fish)
TIP	■ Consider cutting costs by fabricating your own containers and channels for the growing systems.	■ Consider a site with the following resources: ■ Access to electricity for lighting, fans or pumps. ■ Access to full sunlight (and if there is not enough sunlight, lighting must be supplemented) ■ Access to full ventilation for stem and plant growth. ■ Access to potable water, which can come from a well or domestic plumbing. ■ Access to drainage when discharging tanks. This can be a slope or site design that can utilize and manage water. ■ When growing indoors, you will need to supplement natural light with artificial light. ■ If you are building a greenhouse, consider air circulation and the greenhouse site to take advantage of full sun availability and remove the need to provide lighting. ■ Verify that the greenhouse can withstand strong winds, fires and flooding just like you would with any other structure.	■ Consider vine crops, like tomatoes, that can be vertically grown in areas of smaller size. ■ Consider fast growing or “bolting” herbs that can be quickly cycled through the system as well as highly valuable herbs for bartering, taking to market or that are well-preserved.

STRATEGY 03

PLANT AN EDIBLE GARDEN

STEP 4 - BUILD YOUR GARDEN

Hydroponic Gardening



STEP 4

DESCRIPTION

- Choose growing substrate

TIP

- Always allow the substrate to drain in between watering times since this invites new and oxygen-rich air inside. Confirm that whichever hydroponic substrate you choose does not contain too much salt or elements that are harmful to plants and/or people.
- Rockwool (spun wool substrate)
- Lava rock
- Clay pebbles
- Coco coir (made from coconut husks)
- Peat moss



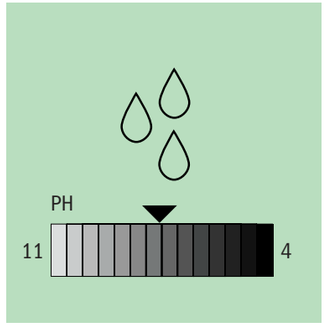
STEP 5

DESCRIPTION

- Types of Nutrients

TIP

- Growers can buy a 'pre-mixed' nutrient solution which simply needs to be diluted (for liquid concentrates) or dissolved in water before use. There are problems that can, and often do, arise with deficiencies of one or more of the nutrient elements. Common problems in-clude: (1) low nutrient strength, resulting in insufficient nutrients for the plants in general; and (2) The nutrient formula you are using may not be completely bal-anced, and one (or more of the elements) may be defi-cient. If growing fish, you will need to ensure they have enough food available, in addition to plant roots.



STEP 6

DESCRIPTION

- Water and pH level maintenance

TIP

- Ensure that there is a source of potable water on site.
- Ensuring correct pH levels in the water of the plants keeps them healthy in a hydroponic gar-den because it affects how plants “uptake nu-trients”. The pH level is a measure of the acid / alkaline balance of the water in your hydropon-ic system, also known as the nutrient solution. An incorrect pH level will reduce or completely lock out the amount of nutrients a plant can ab-sorb and eventually destroy it. A pH of 7 is neu-tral and most plants prefer a neutral pH, alt-hough some plants do better within a certain pH range.



STEP MAINTENANCE

TIP

- As you add nutrients to your garden, you may notice an increase or decrease in the pH level of the soil or water in your garden.

*If you are growing fish, their waste product will in-crease pH level. Therefore, monitor the pH level to en-sure fish survival.



HARVEST!

- Utilize integrated pest management (IPM) for all crops. This is a method used to manage pests without pesticides or harmful chemicals (See Strategy 14 Manage Pests).
- Purchase nutrients from organic sources.



THREE USEFUL HOME REMEDIES FROM YOUR GARDEN

Jarabe or “Cough Syrup”

- Crystal from two aloe vera stalks/leaves
- 1/2 raw yellow/white onion
- 2/3 Cup of lemon juice
- Honey [choose unfiltered for maximum benefit]

Blend all of these ingredients together and let mixture rest until foam that forms on the surface is gone. Drink before meals and before bed. Yields enough for 1 adult, 4 doses [1 day].

Hand Sanitizer

- ½ part “alcoholado” infused with “Malagueta”
- to do this, take 1 bottle of “alcoholado”, empty ¼ part and fill up with malagueta to the brim. Leave to infuse at a cool, dry place and use whenever needed.
- ½ part water

Put in a spray bottle and use as a sanitizer for your body and around the house.

Juices/Teas to alleviate chikungunya, dengue and zika virus symptoms

[anti-inflammatory properties]

- Blend 1 papaya tree leaf [without central vein] with 4 to 6 ounces of water. Drink 2 ounces at a time, at least 4 times a day until symptoms recede.
- Freshly pressed orange juice fortified with aloe vera and honey. Drink liberally.
- Green mango tea made by boiling peel and flesh together with cinnamon bark and West indian bay tree seeds. Drink at least 4 times a day until symptoms recede.

ORGANIC SEEDS/ECOLOGICAL

- Place: Desde Mi Huerto, Department of Food (Trastalleres), Freshmart (Hato Rey)
- Contact: Raúl Rosado raul@desdemihuerto.com

- Place: Estación Experimental de Lajas
- Cost: They make donations to groups. From communities
- Contact: Bryan Brunner 787-889-1530 / 787-372-1269 brbrunner@yahoo.com

COMPOST

- Place: Vivo Recycling
- Cost: $20.00 the meter of compost
- Contact: They have a compost plant in Caguas that serves one meter of compost for $20.00 and you have to pick it up: carr #1, km 32.3 Caguas, 00725
- www.vivopr.com 787-258-1870

Place: University of Puerto Rico, by the ROTC parking

- Cost: Free if you demonstrate it is not for lucrative activity, and they will offer a permit for one year
- Contact: Wilfredo Febres (supervisor) 787-504-6747
- Rafael Hernández (supervisor) 787-447-1748
- Miguel Grajirenes (digger) 787-455-5184
- Georgie Villanueva (bobcat) 787-306-8036

SEMILLAS ORGÁNICAS/ ECOLÓGICAS

- Place: Johnny Seeds (Internet)
- Contact: www.johnnyseeds.com

VERMICOMPOST (WORMS) FOR FORTIFYING SOIL

- Contact:Roberto Morales 787-602-6202
- Myrna Ramos 787-396-0640

HUERTO URBANO

- Place: Jardin Botanico, UPR-Rio Piedras
- Cost: Free
- Contact: This is the facebook page of the garden manager- he is a great resource to the community and welcomes anyone who wants to learn hands-on. Trained agronomist: https://www.facebook.com

AGRICULTURE EXTENSION SERVICE

- Place: Various: San Juan, Mayaguez, Aguadilla
- Cost: Free
- Contact: https://www.facebook.com/pages/Servicio-De-Extension-Agricola-UPR/571551529678835

LA JAQUITA BAYA / COMEDERÍA



Interviewee: Xavier Pacheco; Jaquita Baya, Miramar

Description: Puerto Rican chef Xavier Pacheco announced the closing of the Jaquita Baya Restaurant in Miramar, after seven years of showcasing the local cuisine with his own brand of creative cooking based on the farm-to-table approach. This happens as a direct result of the challenges brought by the impact of Hurricane Maria to the current economic situation. Jaquita Baya closed its doors to the public during this difficult period. However, in the months that followed Maria, Pacheco enabled the space to help his team of workers.

INTERVIEW

In the aftermath of hurricane Maria, I witnessed the needs of the people around me and decided to take action. The immediate response was to adjust to the new reality we faced; I had to learn how to navigate the situation as a businessman (especially how to avoid capitalizing on it), and determine how we could do our part to help the people around us. Another response that was expected from our sector was to provide food at a low cost.

In the future, I think I would hit the streets more and establish stronger partnerships to help me to take food to other places, while also sustaining my business and helping my employees, who are my immediate community. From this situation, we definitely learned that we need to look for ways in which local restaurants can provide support during the recovery process while simultaneously maintaining their operations. In this way, we help others, be it by providing food or by becoming employers for those who, for one reason or another, lost their jobs. So we are looking for alternatives as we work towards this goal.

Lessons Learned

As a result of Hurricane Maria, there were experiences that demonstrate effective practices of community wisdom and civic leadership.





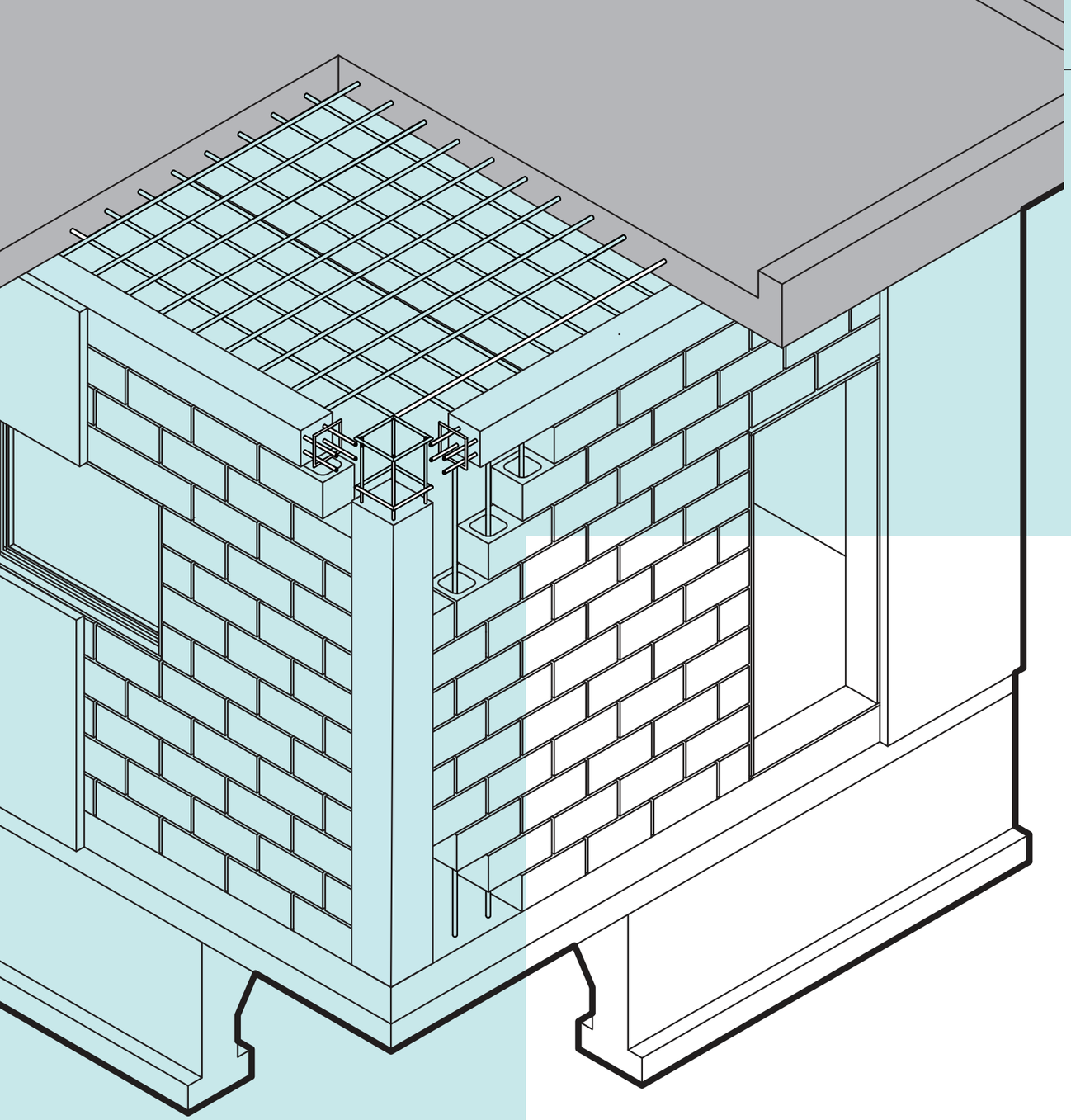
CENTRO DE ADIESTRAMIENTO PARA PERSONAS CON IMPEDIMENTOS (CAPI, INC.), AIBONITO

Description: CAPI is a non-profit organization located in the municipality of Aibonito. Its mission is to promote and provide employment opportunities through different modalities to help people with significant disabilities.

Vision and Mission: The Training Center for People with Impaired, Inc. provides services to support the development of people with disabilities to improve the quality of life of people with disabilities in Aibonito and surrounding towns. Services include employment, life management and business development employment placement for youth with disabilities, visual services and home care for the elderly, as well as training in hydroponic agricultural systems and transition services for students from 14 to 21 years old, among others.







CHAPTER

2

BUILDING PROTECTION

This chapter focuses on strategies that strengthen housing facilities from natural hazards like wind and seismic risk.

TYPES OF STRATEGIES LISTED IN THIS SECTION

STRATEGY #	04	05	06	07	08	09
STRATEGY NAME/TITLE	ASSESS THE PRIORITIES FOR YOUR HOME OR BUILDING'S STRUCTURAL CONDITION PRIOR TO EVENT	BUILD A STRONG FOUNDATION	BUILD STRONGER WALLS	BUILD A STURDY ROOF	ANCHOR, SEAL AND PROTECT BUILDING OPENINGS	FLOOD PROOF HOME
DESCRIPTION	Frequent monitoring and regular maintenance of your home will prevent small problems from becoming big ones in a disaster. This strategy focuses on how to identify your home's vulnerabilities and prioritize maintenance and repairs.	A strong building starts with the foundation, meaning the way it is anchored to the ground. This strategy focuses on what makes a foundation strong.	Strong walls enable the foundation and roof to function together as a resilient structural system. This strategy focuses on how to design strong walls for your home.	A roof shelters you from rain and sunlight throughout the year, and should be strong enough to withstand disasters. This strategy focuses on how to design a strong roof for your home.	A house has many openings, including entry doors, windows, skylights, and garages as well as vents. Properly anchored and sealed openings protect a home from natural disasters. This strategy focuses on protecting your home by appropriately selecting and securing openings.	This strategy focuses on ways to floodproof a home to minimize water damage. See the Resources section below to check your home's vulnerability to coastal flooding.
	$	$$	$-$$	$$-$$$$	$-$$	$-$$$

STRATEGIES TO REDUCE BUILDING VULNERABILITY TO NATURAL HAZARDS

FEMA found that 357,492 homes were damaged to some degree by Hurricane Maria, which comprises approximately 23% of the island's housing stock. Damage is categorized from "affected" to "destroyed." Even "minor damage" means that people may need to move out, and a home with "major damage" is unsafe to live in, possibly for months or even longer.

For retrofits as well as new construction, investing in mitigation measures before the next natural disaster can protect lives, reduce operating costs on an ongoing basis, save money on repair and rebuilding, and lessen the odds that relocation will be necessary. In 2017, the National Institute of Building Sciences (NIBS) estimated that every $1 invested in mitigation saves $4 in recovery costs for single buildings; mitigation at the community level saves $6 for every $1 spent. Upholding codes and standards are a key to achieving these returns, and Puerto Rico now requires compliance with the International Code Council's 2018 International Codes.

Each home has particular vulnerabilities based on its structure as well as its site. This chapter explains how to assess and identify building elements that benefit most from mitigation measures. Understanding what makes the foundation, walls, and roof of your home strong, and how to anchor openings and evaluate floodproofing options that can help you devise an overall approach to protect your home while addressing multiple hazards at once.

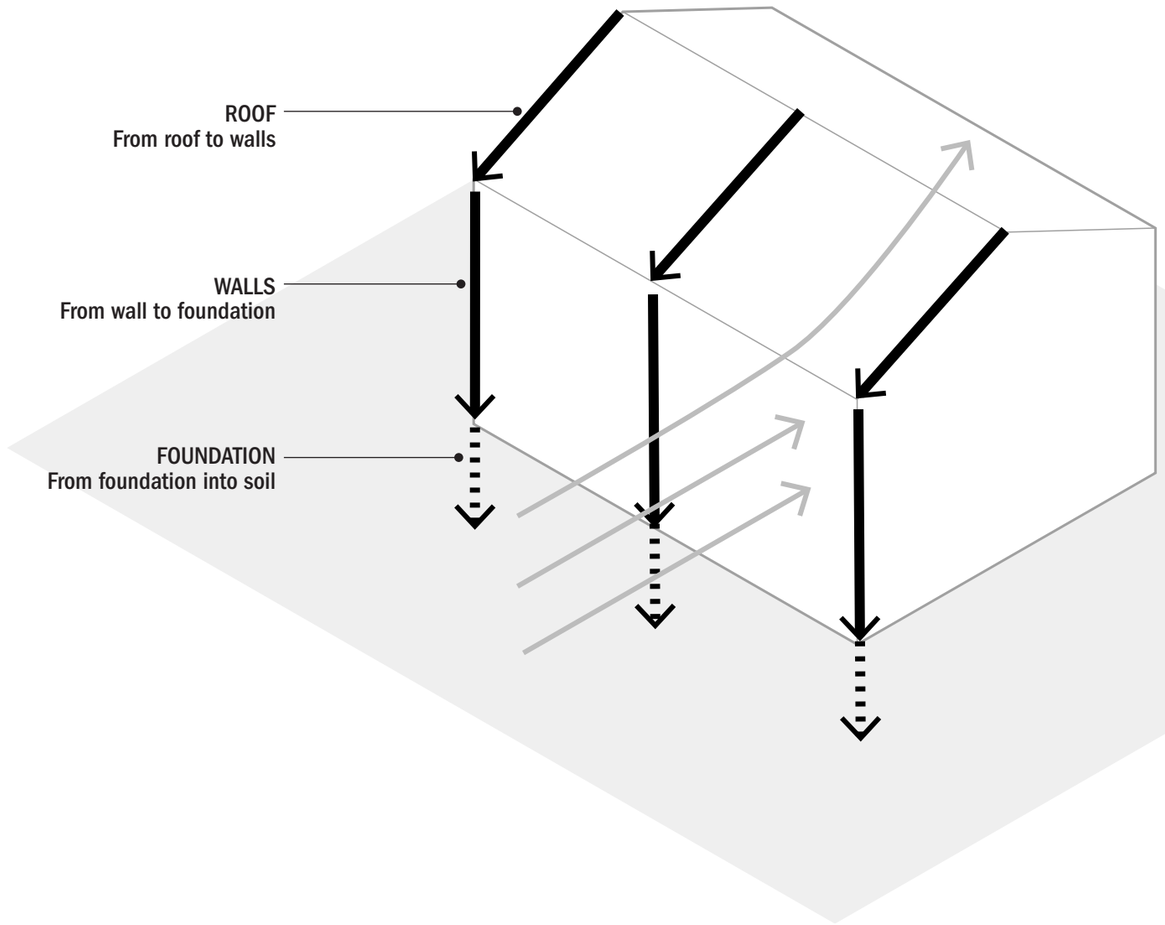
The foundation, the structural system beneath the walls and roof, the envelope (the walls, roof, windows, doors, and everything else that separates inside from outside), and the mechanical systems are tied together in a "continuous load path," which acts like a chain that holds building elements together. Maintaining a continuous load path means no single element must bear the forces of the event by itself. This is the key principle in ensuring that housing can withstand threats that originate above ground, such as a cyclone, or below, such as an earthquake.

INTRODUCTION

Protection Glossary of Terms

- **Anchor bolts:** a bolt is a fastener that is usually used with a nut, for connecting two or more parts. The anchor bolts are usually placed inside the concrete mix before hardening, in a way that the threaded part of the bolt remains outside where an element will be connected to it. Anchoring bolts can be used to connect the wood sill plates of a wood frame. Anchor bolts, in combination with an expansion, can be used after the concrete has hardened by making a drill hole; the expansion will anchor the bolt to the hole in the concrete.
- **Metal ties:** steel elements that substitute the use of nails directly into wood to connect them. These steel elements are placed over two or more pieces of wood to be united and are then fastened using screws, bolts, or nails, as specified. Tie-downs come in different shapes and are used for different purposes in home construction.
- **Fasteners:** all kinds of mechanical elements used to join elements, like timbers of steel columns, and that can later be removed. Nails, screws, and bolts are examples of fasteners.

CONTINOUS LOAD PATH



As hurricanes gain strength, structures must be able to withstand greater wind force.

There are four ways in which wind can affect your home's structure:

- Uplift (wind flows over the roof of the home that create a lifting effect).
- Racking (wind exerts horizontal pressure that can cause the home to tilt).
- Sliding (wind exerts horizontal pressure which can cause home to slide off its foundation).
- Overturning (when the home is unable to rack or slide, wind can cause the walls to rotate off the foundation).

STRATEGY

04 ASSESS THE PRIORITIES FOR YOUR HOME OR BUILDING'S STRUCTURAL CONDITION PRIOR TO EVENT

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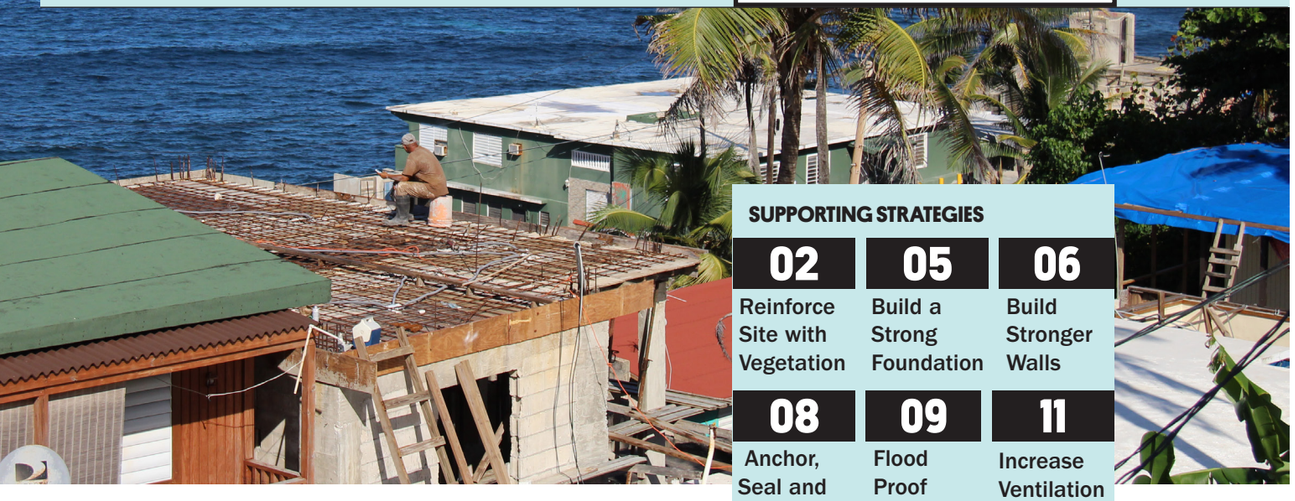
The condition and strength of a home's structure depends on continuous monitoring and frequent maintenance. This strategy focuses on how to evaluate a structure by identifying points of weakness and implementing solutions. Consult with a building professional (can be a contractor, engineer, or architect) to get the most thorough inspection possible.

Strategy in Action

1. Inspect Your Home

A. By Type

B. By Vulnerability



Daguao Naguabo
Centro Comunitario

WHAT YOU NEED TO KNOW

- Homes can suffer structural damage due to natural disasters, lack of maintenance, and normal wear and tear.
- Inspect your home or building (interior and exterior) at least once a year.
- Keep the chart below in a safe location to share with a design or engineering professional.

SUPPORTING STRATEGIES

02 Reinforce Site with Vegetation

05 Build a Strong Foundation

06 Build Stronger Walls

08 Anchor, Seal and Protect Building Openings

09 Flood Proof Home

11 Increase Ventilation

13 Control Moisture and Mold

14 Manage Pests

22 Prevent Wastewater Backflow in Homes

23 Develop a Household Emergency Plan

DISCLAIMER

This is a guidance framework only and not intended to be a complete engineering inspection tool. A licensed engineering professional should be consulted to carry out a comprehensive engineering investigation.

Ensure foundation is compliant with code: 2018 IRC and IBC (as adopted by the PRBC) structural provisions and ASCE 7-16 and ASCE 24-24 (adopted by reference to IBC and IRC).

ANNUAL INSPECTION CHART

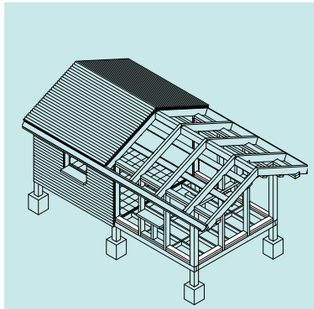
DATE	INSPECTED BY	INTERIOR NOTES	EXTERIOR NOTES
..... /..... /2019	.....	.....	.....
..... /..... /2020	.....	.....	.....
..... /..... /2021	.....	.....	.....
..... /..... /2022	.....	.....	.....
..... /..... /2023	.....	.....	.....
..... /..... /2024	.....	.....	.....
..... /..... /2025	.....	.....	.....
..... /..... /2026	.....	.....	.....
..... /..... /2027	.....	.....	.....

STRATEGY 04

ASSESS THE PRIORITIES FOR YOUR HOME OR BUILDING'S STRUCTURAL CONDITION PRIOR TO EVENT

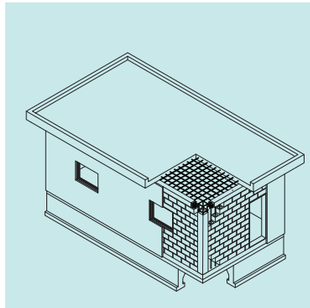
STEP 1 - INSPECT YOUR HOME

A. BY TYPE Each type of construction has its own particular vulnerabilities. Watch out for the following signs of deterioration.



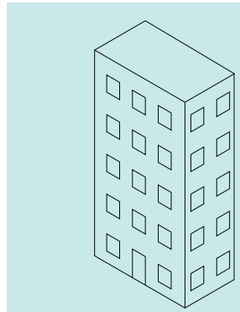
SINGLE FAMILY WOOD

- Termite damage
- Humidity
- Rusted joints
- Roof membrane cracks
- Lack of roof sealants
- Rusted or loose nails and/or screws



SINGLE FAMILY CONCRETE

- Cracks and fissures
- Exposed interior rebar and corrosion
- Loose or rusted joints
- Appropriate and good condition in fastening of windows and doors or other apertures



MULTIFAMILY

- Central cores and the maintenance rooms
- Cracks and fissures
- Humidity
- Exposed interior rebar and corrosion
- Rusted joints
- Weak balconies
- Failing roof sealants
- Appropriate and good condition in fastening of windows and doors or other apertures

OPERATIONS AND MAINTENANCE TIPS

- Inspect your facility annually for variety of vulnerabilities.
- Establish a routine to maintain building systems and repair cracks and fissures.
- Regularly paint the home to keep structure safe.
- Eliminate any electrical systems that could come into contact with water.
- Eliminate any gas related hazard-leaks or loose tanks.

B. BY WEAKNESS The best way to maintain a building is to understand each vulnerability and implement the solution that best targets it.

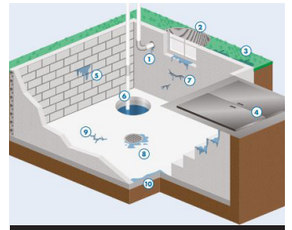


TERMITES

Eat organic material and weaken strength of wood. Includes porches, soil near foundations and trees.

SOLUTION

- Regularly inspect all wood components in your home for small, pin-sized holes and/or sawdust mounds.
- Check porches, wooden columns and beams, doors and cabinetry.
- Call a professional to exterminate termites.



CRACKS AND FISSURES

Allow water and air to enter the building, leading to larger cracks and fissures and more structural damage.

SOLUTION

- Inspect regularly home structure, soil condition and corroded rusts, as they can all cause cracks, particularly after natural disasters.
- Fix immediately as they can cause permanent damage to the home.
- Avoid using nails, instead drill holes on the wall prior to inserting the screw. Use expansion for screws on concrete surfaces unless using tabcon.



CORROSION

Salt residue in the air and interaction between different metals lead to weak joints.

Check anchorage, nails and screws, specially those around structure joints - the place one member meets another, like a column meeting a beam.

SOLUTION

- Regularly apply waterproof sealants to metal components and substitute any corroded screws/plates.

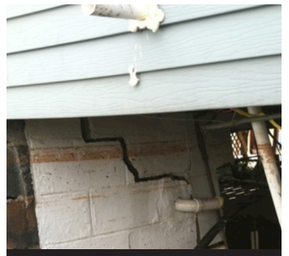


HUMIDITY

Allows moisture to enter the building, leading to mold and structural damage.

SOLUTION

- Inspect home structure, regularly particularly after natural disasters.
- See Strategy 10 to measure humidity in your home.



EXPOSED STRUCTURAL COMPONENTS

If finishes tear off, they can expose the building structure to the elements. Contact with water or salt in air can cause rebar to corrode and deteriorate.

Inspect beams, columns and foundation for exposed rebar.

SOLUTION

- Call a professional to fix the problem and reinforce the structure.

DEFERRED MAINTENANCE



Lack of building and systems maintenance can permanently damage the structure.

Electrical cables should be checked for exposed wires that can end up in short-circuits and fire. Also verify breakers for burnt-out fuses. Go to Strategy 20 for more info on electrical Systems.

Leaks at potable water, A/C and sewage lines can expose structural elements to humidity and deterioration. Go to St. 16 for more info on checking for leaks.

Overgrown trees and bushes can pose damage to a building's structure. A tall tree with overturned/rotten roots can be easily uprooted by wind and fall over a roof. Untrimmed bushes can attract pests that might debilitate columns, beams and foundation.

Gas leaks can be extremely dangerous. An old gas tank is more likely to have a loose valve.

SOLUTION

- Regularly paint to reduce material deterioration.
- Cut vegetation that can damage the structure.
- Eliminate electrical systems that could potentially create flammability concerns for the building.
- Hire a licensed electrician/ plumber to solve any issues regarding power lines, water systems and gas.

STRATEGY

05 BUILD A STRONG FOUNDATION

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DISCLAIMER

Consult with licensed building professionals to design and build a foundation. Stay in touch with the design professionals that designed and constructed your home's foundation as an important resource when it is time for maintenance.

Ensure foundation is compliant with 2018 International Code Council codes - IBC and IRC (as adopted by the PRBC) - and structural provisions and ASCE 7-16 and ASCE 24-14.

A strong building starts with the foundation, meaning the way it is anchored to the ground. This strategy focuses on what makes a foundation strong.

Strategy in Action

1.Foundation Design Principles

2. Establish the Type of Foundation

3. Design the Foundation

4. Choose Flooring

WHAT YOU NEED TO KNOW

A foundation is the base of a home. It holds walls and roofs, and maintains a continuous load path by transferring the loads from the structure into the layers of soil below.

The International Code Council Code (I-Codes) and the building standards of the National Flood Insurance Program (NFIP) require that a foundation must be designed prevent:

- **Floatation**
- **Collapse**
- **Lateral movement**

To accomplish this, a foundation must:

- Resist lateral and uplift loads from floods, high winds, and earthquakes.
- Be protected against flood-borne and wind-borne debris impacts.
- Be resistant to erosion and scour that can undermine the foundation.

The components of a strong foundation are:

- Strong, flood-damage-resistant, and decay-resistant materials (reinforced concrete or preservative treated wood).
- Elements sized for appropriate structure loads and local soil conditions.
- Proper connections and anchors to transfer loads between the foundation and the rest of the structure.

Consider the following when designing the foundation:

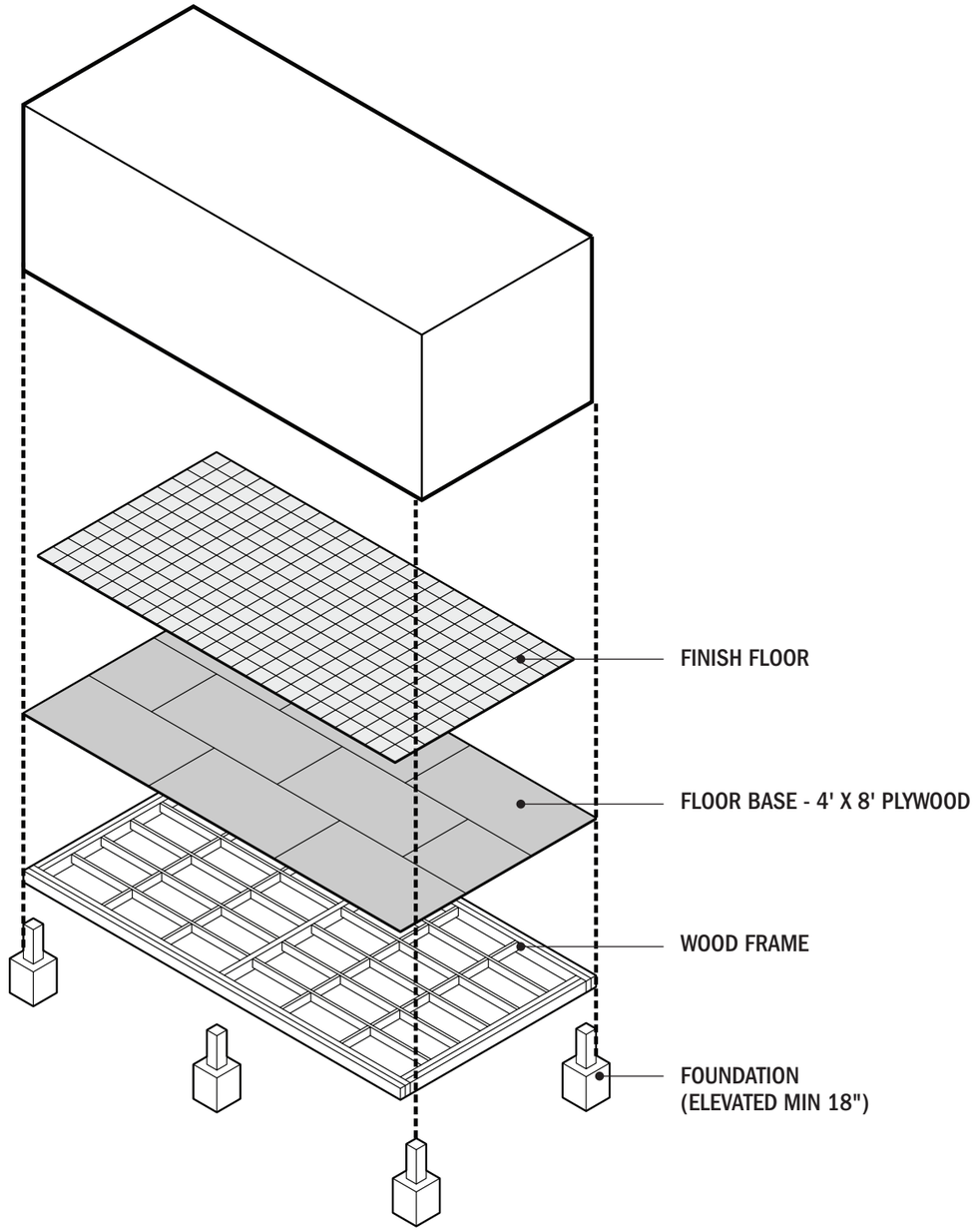
- Its own weight and of persons and equipment to be inside or on the roof.
- Design wind speed.
- Seismic design category.
- Flood Zone – See Strategy 01: Reinforce Site.
- Soil type – Bearing capacity and level of compaction.
- Water table – How much water is beneath the supporting soil.
- Budget

Foundations often fail due to:

- Weak structural connections to the walls or floors above them.
- Improper concrete mixture, inadequate and/or exposed rebar in concrete foundations. (Inadequate design of concrete foundations can lead to cracking and fragments dangerously breaking off during a storm or seismic event).
- Decay and incorrect footing connections in timber foundations
- Soil that is not appropriately prepared which includes compacting and proper sizing of footings for structural support.

SUPPORTING STRATEGIES

04 Assess the Priorities for Your Home or Building	**01** Reinforce Site with Infrastructure	**06** Build Strong Walls
07 Build a Sturdy Roof	**09** Flood Proof Home	**25** Establish Family Emergency Plan



STRATEGY

05 BUILD A STRONG FOUNDATION

STEP 1 - FOUNDATION DESIGN PRINCIPLES



Cracked Foundation



Failed foundation due to weak structural connections

Stuart Adams FEMA



Failed foundation due to inappropriate concrete mix



Failed foundation due to inappropriate soil



Anchor bolts, tie-downs and fasteners must be flood-damage and corrosion-resistant. Use stainless steel, especially near the coastline, or galvanized steel.



Although wood is often cheaper, concrete is superior to wood foundations, as it is more resistant to humidity, wind, fire and termites.



Install french drains around draining docks to collect and drain out excess water that reaches the foundation through the soil. French drains are perforated PVC pipes that are buried over a fine mesh and covered with gravel. For more info on French Drains, please refer to Strategy 1: Reinforce Site.



Use sewers or dry wells to collect excess runoff/rainwater. Avoid draining on hillsides and cut/filled areas to minimize erosion. For more info on siting and surface stormwater management, go to Strategy 01: Reinforce Site.



Refer to IBC 1805.4.2 Foundation Drain - “Where a drain tile or perforated pipe is used, the invert of the pipe or tile shall not be higher than the floor elevation. The top of joints or the top of perforations shall be protected with an approved filter membrane material. The pipe or tile shall be placed on not less than 2 inches of gravel or crushed stone complying with Section 1805.4.1, and shall be covered with not less than 6 inches of the same material.”

STRATEGY

05 BUILD A STRONG FOUNDATION

DISCLAIMER

Consult with licensed building professionals to design and build a foundation. Stay in touch with the design professionals that designed and constructed your home's foundation as an important resource when it is time for maintenance.

Ensure foundation is compliant with 2018 International Code Council codes - IBC and IRC (as adopted by the PRBC) - and structural provisions and ASCE 7-16 and ASCE 24-14.

STEP 2 - ESTABLISH THE TYPE OF FOUNDATION

Ask an engineer what is the best type of foundation for your home. The foundation depends on site and structural needs.

Foundation Styles in Coastal Areas

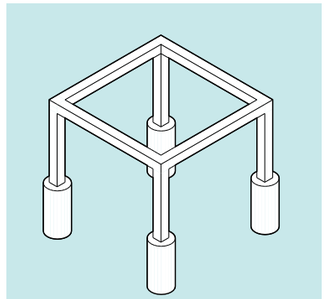
STYLE	ZONE V	COASTAL A ZONE (UMWA)	ZONE A
Open/deep	Acceptable	Acceptable	Acceptable
Open/shallow	Not permitted	Acceptable	Acceptable
Closed/shallow	Not permitted	Not Recommended	Acceptable
Closed/deep	Not permitted	Not Recommended	Acceptable

A. SITE ASSESSMENT



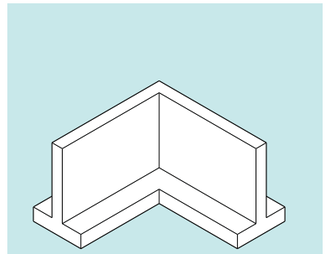
- Ground investigation should be done before determining foundation. A qualified professional tests the composition and capacity of soil to resist seismic force and flood.
- A strong foundation should be "locked" - which means it must not allow lateral movement. Bracing may be needed depending on soil quality, presence of bedrock, water table height, and other local topographical features. Approach will also vary from single to multi-story building, which is why it is crucial to consult with both a soil and construction professional.

B. STRUCTURAL NEEDS



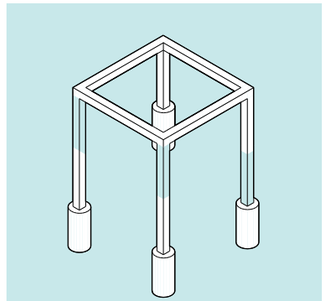
SHALLOW

- Used when the structural loads are low and the surface soil layer is strong in terms of bearing capacity.
- Embedment of shallow foundations typically 3' below the finished grade level [the soil/land surface].
- Shallow foundations such as grade slabs and crawlspace wall footings transfer the load to shallow soil layers.



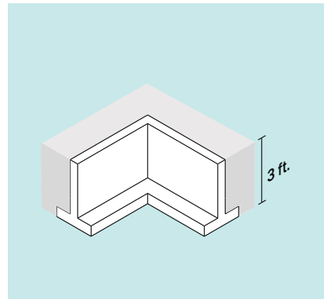
DEEP

- Used when the structural loads are bigger, or when the surface soil bearing capacity is insufficient.
- Typically used in muddy soils, sites vulnerable to erosion, or flood zones.
- Used for multifamily buildings.
- Deep foundations such as piles transfer the load to deeper soil layers or down to bedrock.



OPEN

- Allows water to pass through, minimizing the chance of water collecting in unwanted areas.
- Reduces the lateral flood loads the foundation must resists.
- Less prone to damage from flood debris, because debris is less likely to get trapped.



CLOSED

- Does not allow water to pass through, which can create an obstruction to flow.
- Creates larger obstructions to moving floodwater, increasing the level of scour.
- Typically constructed using perimeter walls.

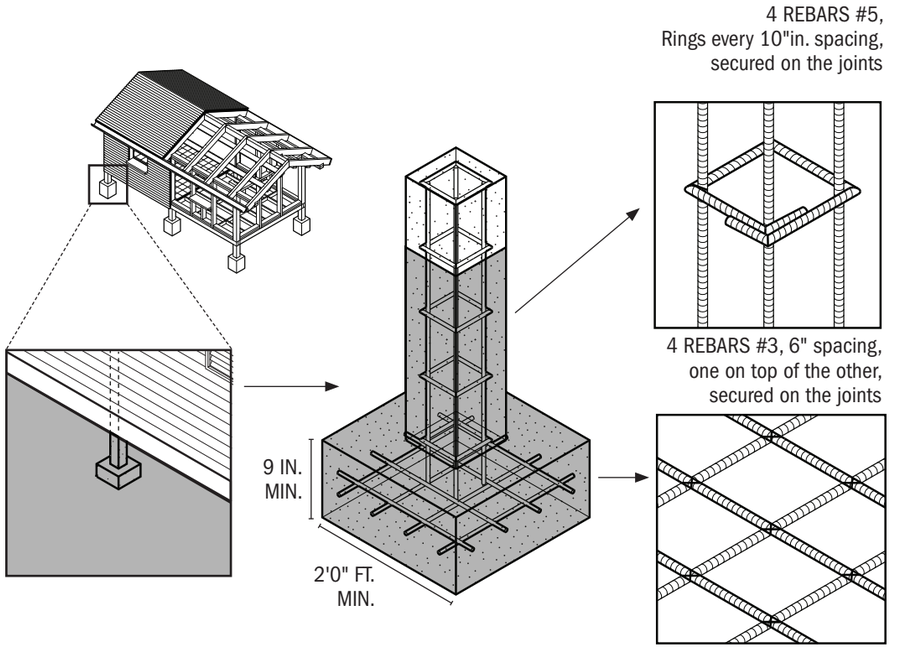
C. MAINTENANCE NEEDS

- Have a qualified professional inspect the foundation (joints, site grading drainage and landscaping) once a year. Regular inspections by a professional increases the probability that your home will withstand a natural disaster.
- Paint the wood and exposed steel with corrosion- and mold-resistant paint and primer once a year so air and salt do not corrode it.
- Choose "treated wood" at lumber yard whenever possible.
- Seal wood with polyurethane, copper naphthenate, sanding sealer or other waterproof sealant annually after the rainy season. Be sure to seal the ends and any areas where the wood has been notched or bored.
- Follow manufacturer recommendations when using sealants and dispose of sealants responsibly.

STRATEGY

05 BUILD A STRONG FOUNDATION

COLUMNS – OPEN/SHALLOW OR DEEP



PROS

- Elevates the house.
- Complies with wet floodproofing requirements.
- Reduces flood loads on structure.

CONS

- Vulnerable to erosion and flood loads.
- Undersized or shallow piles are vulnerable to erosion, fracture or overturning.
- Masonry piers prone to water intrusion in humid and wind-driven rain environments.



Columns, also called piers, are made of reinforced concrete and rest on footings.

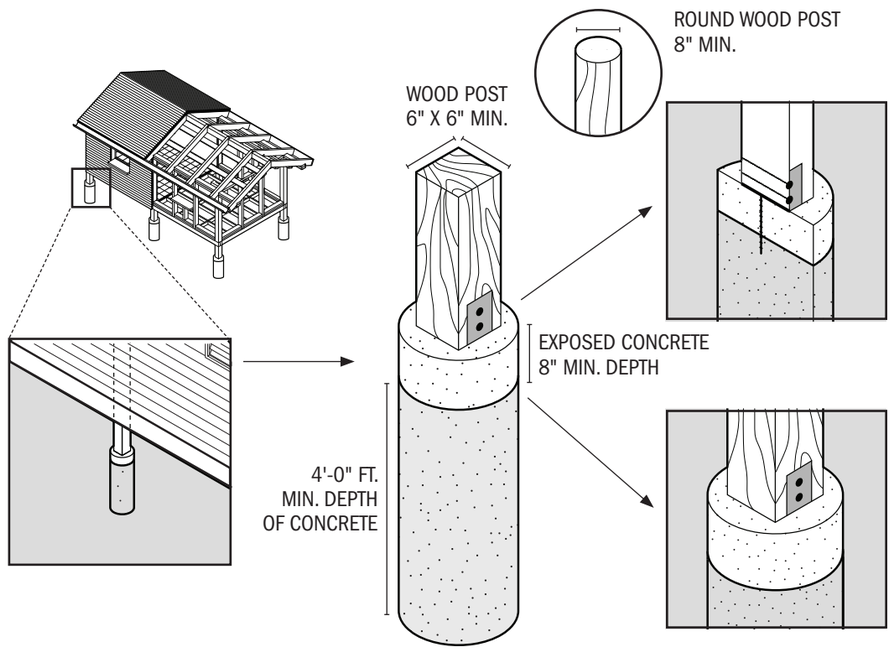
- Typically used in coastal zones further back from the shoreline.
- The embedment depth of the footings depends on the soil capacity.
- Provide at least 3” of concrete cover for the rebar to minimize corrosion risk.
- Properly size and reinforce the footing at the base of each pier.
- Provide a robust connection with continuous rebar between the footing and the pier to prevent separation or failure.
- If you use grade beams to provide additional stability, ensure they comply with floodproofing requirements and are properly connected.
- Use corrosion-resistant and durable fasteners for connections.
- Maintain proper edge distance so fasteners do not fail.
- Ensure that water does not collect bellow beam structures - this can cause subsidence and foundation settlement - similar to sinking through quicksand.

STEP 3 - DESIGN THE FOUNDATION

The type, size and layout of foundation depends on soil’s capacity and the amount of weight or force the building will exert on it.

Consult a professional engineer to determine appropriate soil conditions.

POSTS / PILES – OPEN/DEEP



PROS

- Elevates the house.
- Complies with wet flood-proofing requirements.
- Reduces flood loads on structure.

CONS

- Undersized posts are vulnerable to fracture.
- Improperly braced columns can fail under high loads.



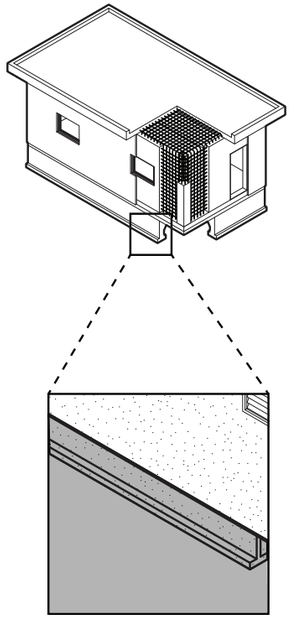
Round or square structures made of concrete or wood embedded in the ground.

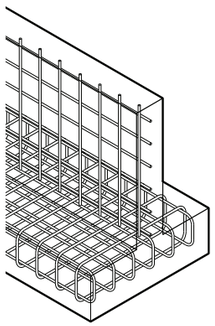
- Typically used in coastal zones, specifically near the shoreline.
- Install bracing, such as knee braces or diagonal bracing, to support the posts.
- Install grade beams or bracing to resist lateral loads.
- Orient bracing parallel to the direction of any potential floating or wind-driven debris to minimize impact.
- Use corrosion-resistant and durable fasteners for connections to the posts.
- Make sure fasteners are not placed too close to the edge as they may fail or pull out under applied loads.
- Treat wood to minimize decay.
- Common post failures include-deterioration of wood, inadequate bracing, undersized piles, and inadequate embedment. Embedment refers to the way the footing - or lowest point of the foundation - anchors to the soil.

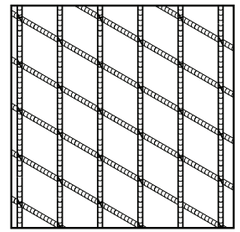
STRATEGY 05

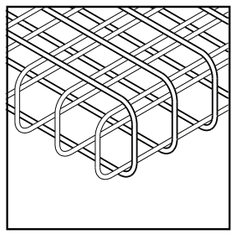
BUILD A STRONG FOUNDATION

WALL – CLOSED/SHALLOW









PROS

- Increases resistance of structure to earthquake.

CONS

- Not recommended in coastal flood zones because walls obstruct flood flow.



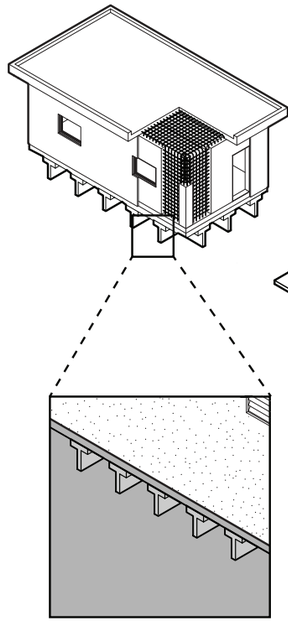
- Use in areas exposed to shallow flooding and low risk of erosion and wave surge.
- Use adequate rebar sizing and spacing.
- Masonry walls should be fully grouted and have rebar.
- Typically used in one-story single family homes.
- Not recommended for coastal areas.
- Continuous walls are made of reinforced concrete or masonry that sit on footings embedded in the ground.
- Provide robust connections between the foundation walls and the floor diaphragm to maintain a lateral load path.
- Structural walls in the first floor should sit directly above foundation walls and have tie-downs and anchor bolts.
- Use continuous and/or lapped rebar in all connections or joints to minimize chance of failure.

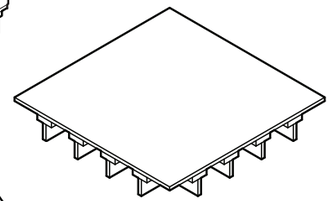
STEP 3 - DESIGN THE FOUNDATION

The type, size and layout of foundation depends on soil's capacity and the amount of weight or force the building will exert on it.

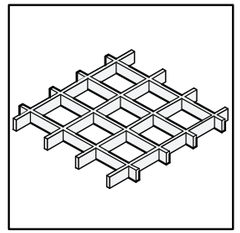
Consult a professional engineer to determine appropriate soil conditions.

GRADE SLABS – CLOSED/SHALLOW





CONCRETE GRID BASE



4 REBARS #3, 6" IN. SPACING, ONE ON TOP OF THE OTHER, SECURED ON THE JOINTS

PROS

- Increases resistance of structure to earthquake
- Increases resistance to uplift and overturning.

CONS

- Not recommended in coastal flood zones because walls obstruct flood flow.



- Mat foundations are continuous slabs of reinforced concrete that sit on grade.
- Typically used in non-coastal areas or terrains with higher scour resistance.
- Can function as a base for the finished floor and should be reinforced with a grid of rebars.
- Provide adequate connections between the structural walls and the slab foundation.



STRATEGY

05 BUILD A STRONG FOUNDATION

WOOD



INSTALL THE FLOOR

FINISH FLOOR

Tiles and polished concrete are most common in Puerto Rico. Do not use vinyl because it is bad fot the environment and occupants due to off-gassing of chemicals.

FLOOR BASE

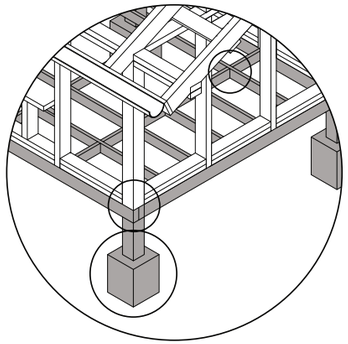
3/4” thick 4’ × 8’ Plywood Panels. Center on the frame below. Place the panels parallel to the main beams offset them from each other for stronger quality.

WOOD FRAME

Build beforehand so wood panels can be easily fastened. The grid consists of a series of main beams and secondary beams. Use spaces compatible with 4’ × 8’ nominal wood panels.

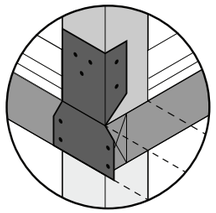
FOUNDATION

Elevated min 18” above the DFE to prevent rotting. See Stragegy 09 Flood Proof Home.

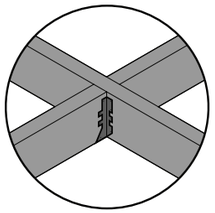


INSTALLATION DETAILS

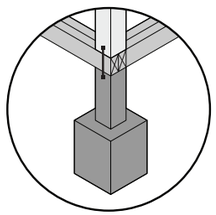
FOUNDATION DETAIL



FOUNDATION FRAME DETAIL



CONNECTION TO FOUNDATION



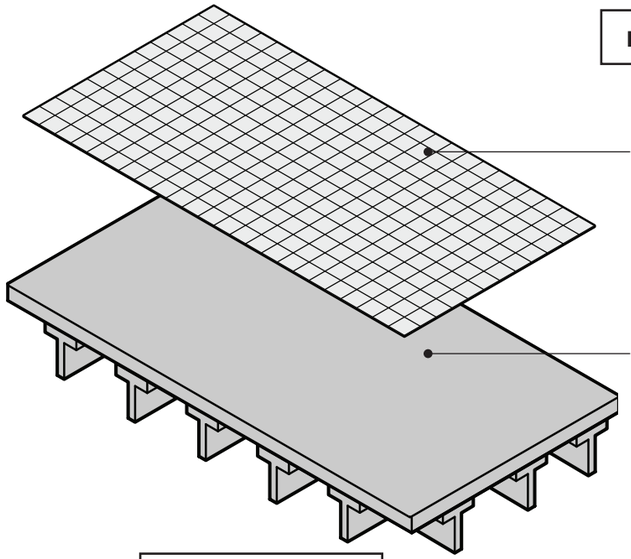
STEP 4 - CHOOSE FLOORING

Consult a structural engineer to determine the appropriate elements size for the flooring.

- A resilient floor system withstands the loads on the building without yielding or losing continuity. Having an interruption in the flooring system can exert unwanted pressure and potentiate the floor falling through.
- The foundation and the floor achieve a continuous load path by using appropriate clips, straps and hold downs whenever a wood member encounters another.
- Complement a strong foundation and flooring system with shear walls and a strong roof to transfer shear loads - the weight of the building and whatever is inside it down - safely.
- Use rated and tested materials.
- The bottom of the lowest structural member supporting the lowest habitable floor should be located above the DFE (Design Flood Elevation). See Strategy 08: Anchor, Seal and Protect Building Openings.

CONCRETE





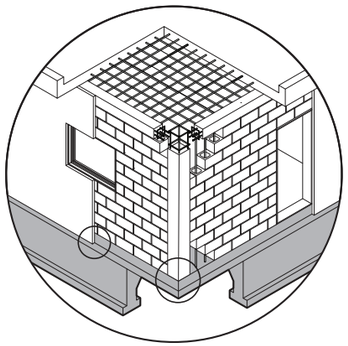
INSTALL THE FLOOR

FINISH FLOOR

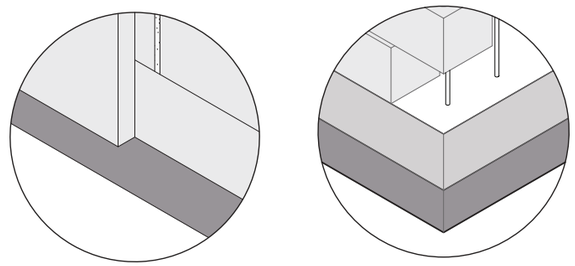
Tiles and polished concrete are most common in Puerto Rico. Do not use vinyl because it is bad fot the environment and occupants due to off-gassing of chemicals.

MAT FOUNDATION

Can serve as concrete floor base or, if treated, can serve as the floor.



INSTALLATION DETAILS



STRATEGY

06 BUILD STRONGER WALLS

$-$$

DISCLAIMER

Consult with licensed building professionals to design and build walls. Stay in touch with the design professionals that designed and constructed your home's walls as an important resource when it is time for maintenance.

Ensure foundation is compliant with 2018 International Code Council codes IBC and IRC (as adopted by the PRBC), and structural provisions, and ASCE 7-16 and ASCE 24-14 (adopted by reference to IBC and IRC).

Strong walls enable the foundation and roof to function together as a resilient structural system. This strategy focuses on how to design strong walls for your home.

Strategy in Action

1. *Wall Design Principles*
2. *Establish the Type of Wall*
3. *Select Wall Materials*
4. *Design the Wall System*

WHAT YOU NEED TO KNOW

A wall is part of the structural system and delineates a home and its interior spaces. It is held by the foundation, it supports the roof, and maintains a continuous load path by allowing the roof loads to reach the foundation.

A wall:

- Supports the roof and transmits vertical (gravity) and lateral (environmental) loads to the foundation.
- Helps air circulate around the home.
- Protects the home from wind, flood, and earthquake loads.

A wall must:

- Be properly anchored to resist wind and seismic loads.
- Have drainage to prevent rainwater ponding, particularly in low-sloped roofs.
- Be leak-free and crack-free, since any holes may compromise its structural integrity.

The components of a strong wall are:

- Framing or the skeleton.
- Strong connections to the structural system or the joints.
- Multiple layers, including insulation, to maintain a regular interior temperature.
- Interior and exterior finishes to shield the structure.
- Openings. (See Strategy 08)

Consider the following when designing the walls:

- Wind.
- Seismic Design Category.
- Flood forces - hydrostatic, hydrodynamic, debris, breaking waves.
- Openings - size and number.
- Strength of the foundation.
- Roof weight.
- Anchoring system for a natural disaster.
- Budget.
- Weight supporting including equipment and people on the roof.

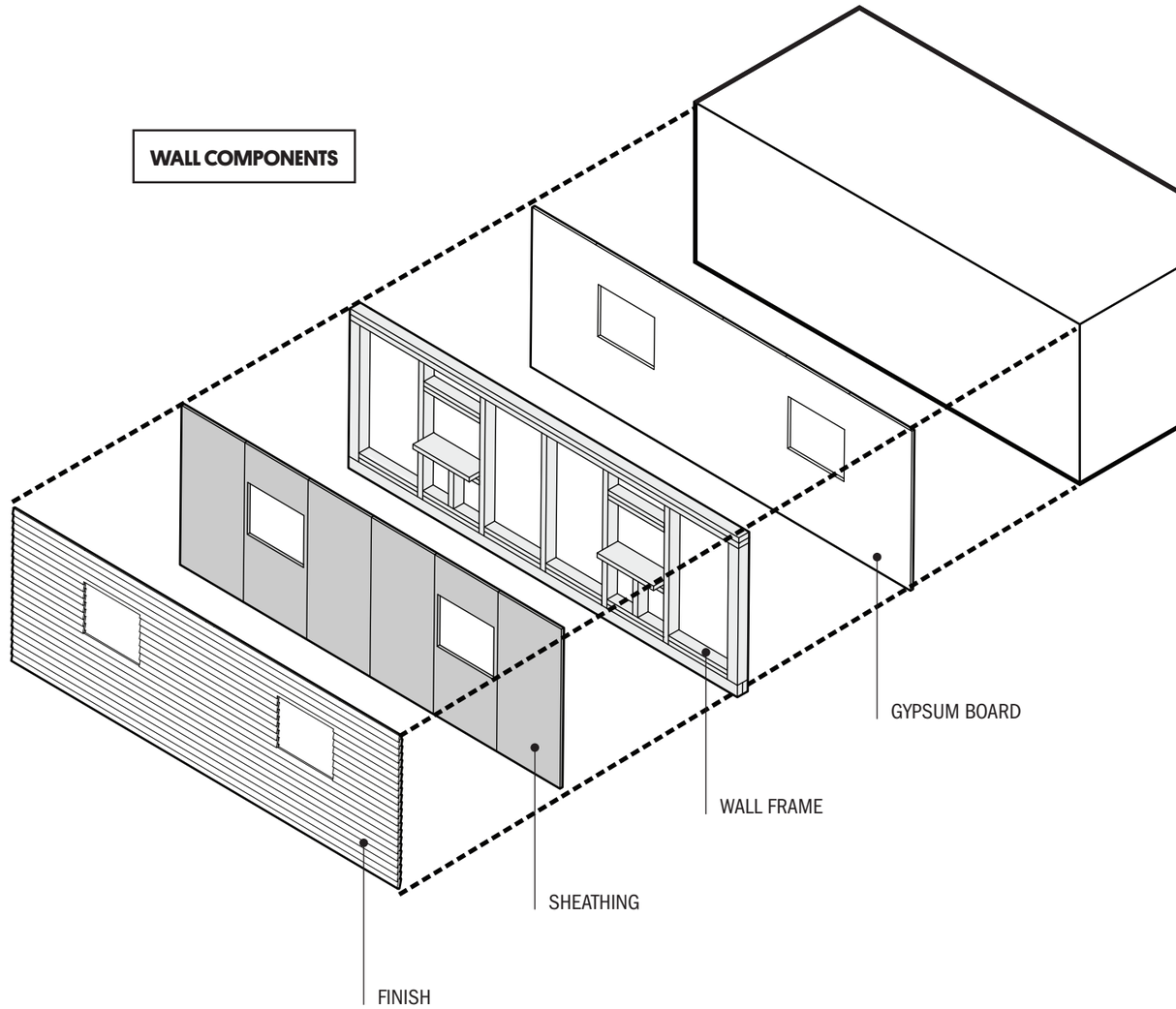
ESTIMATED COST

$	Wood frame with panels $ per sq. ft.
$$	Concrete columns with fill-in walls $ per sq. ft.
$$	Cast-in-place concrete with blocks $ per sq. ft.

SUPPORTING STRATEGIES

05 Build a Strong Foundation	07 Build a Sturdy Roof	08 Anchor, Seal, and Protect Building Openings
11 Increase Home Ventilation	12 Benefit from Natural Light	23 Develop a Household Emergency Plan

WALL COMPONENTS

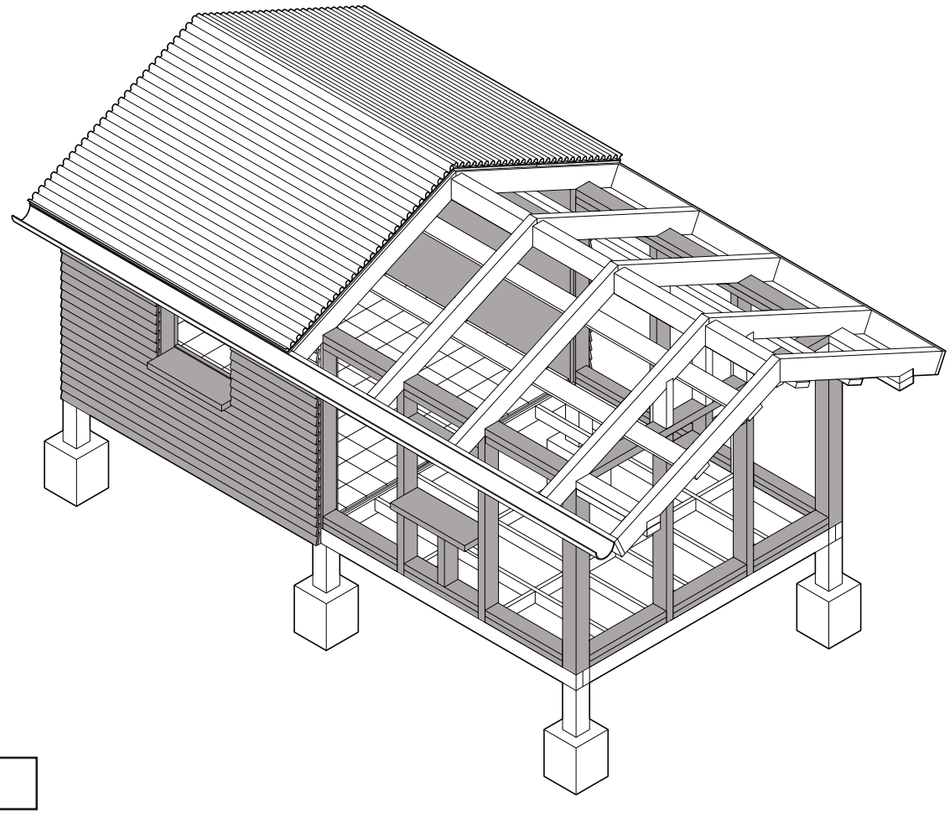


STRATEGY

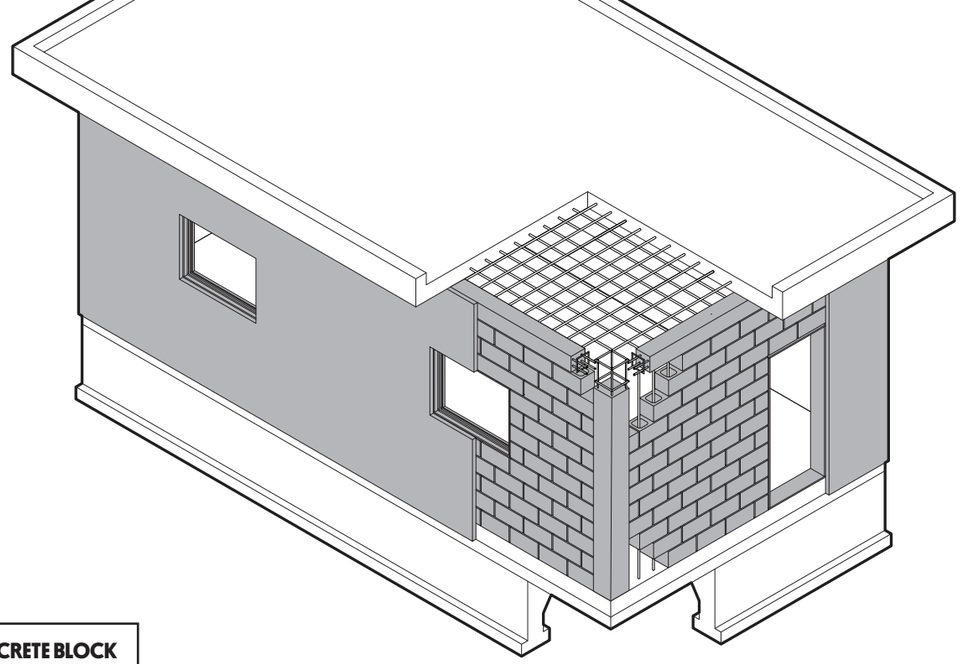
06 BUILD STRONGER WALLS

STEP 1 - WALL DESIGN PRINCIPLES

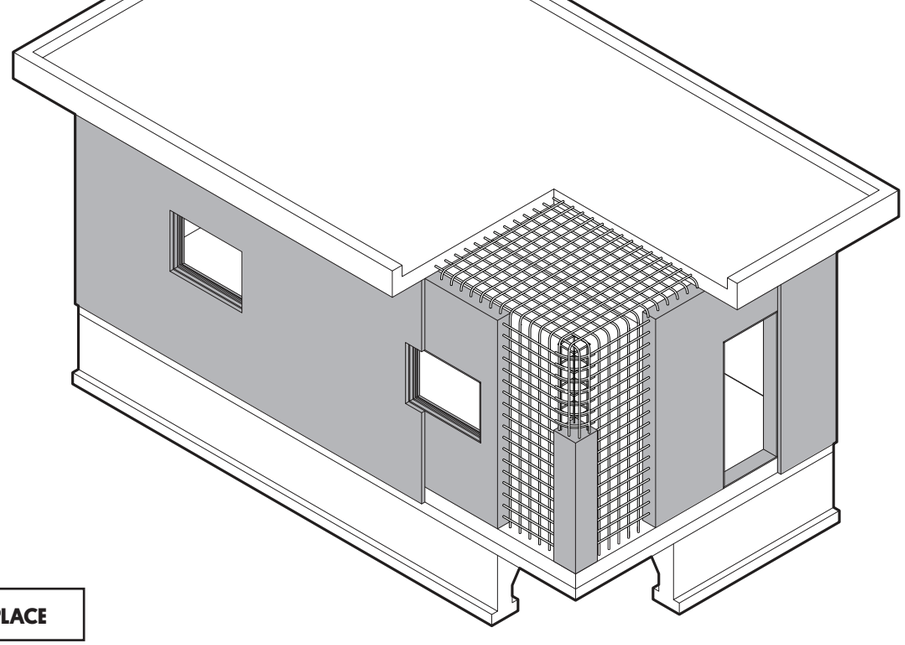
- Maintaining a continuous load path is like a chain that holds a home together from the roof to the foundation. A continuous load path is critical during an earthquake or hurricane because it holds a home together when ground forces or high winds try to pull it apart. Maintain a continuous load path by using vertical reinforcement, from the foundation to the roof, through the structural walls.
- Anchor interior partition walls into the structural frame for stability.



WOOD



CONCRETE BLOCK



CAST IN PLACE

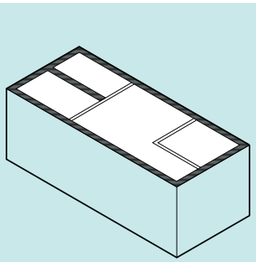
STRATEGY

06 BUILD STRONGER WALLS

STEP 2 - ESTABLISH THE TYPE OF WALL

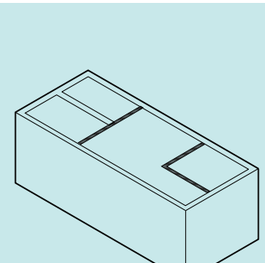
Ask an engineer what is the best type of wall for your home.

STRUCTURAL WALLS



- Mainly exterior walls (interior in some cases).
- Vertically continuous from foundation to roof through all floors.
- Part of the continuous load path.
- Support foundation and roof.
- Support the home under vertical forces, like gravity loads.
- Transfer lateral loads through the house and into the foundation.
- Frame into beams.
- In multi-family buildings, Rear walls and can be placed between units as fire walls.

NON-STRUCTURAL WALLS (PARTITION WALLS)



- Interior walls.
- Not vertically continuous between floors.
- Not part of the continuous load path.
- Do not support any structure.
- Provide insulation and privacy.

STEP 3 - SELECT WALL MATERIALS

Ask an engineer what are the best wall materials for your home.



WOOD FRAME – STRUCTURAL

A structural system of wood rafters, trusses, floor joists, wall studs, columns, and beams that create a structure and framework for applied interior and exterior finished surfaces.



CONCRETE - STRUCTURAL

A mixture of aggregate (usually sand, gravel) along with cement and water. Poured concrete is cast into forms on the building site. Reinforcing steel bars, or rebars, provide concrete with structural strength.



CONCRETE BLOCKS – NON-STRUCTURAL

Also called concrete masonry units (CMUs), they are large, hollow units often filled with grout and rebar that create non-structural walls.



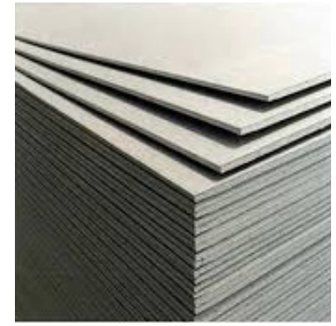
PLYWOOD PANELS – NON-STRUCTURAL

Thin sheets of wood layered and glued together to create various standardized thickness and grades used for different applications like formwork for concrete, paneling and finishes. These also serve for boarding up openings in case of a hurricane.



GYPSUM BOARD – NON-STRUCTURAL

Typically made of metal, finished with joint compound sanded between layers until the surface is smooth and ready for paint. Mostly used as interior partitions and dropped ceiling features.



FIBER CEMENT BOARDS (PLYCEM)-NON STRUCTURAL

Thin tiles or sheets made of cement that are reinforced with glass fibers. These come in different sizes, mixtures and consistencies.

STRATEGY

06 BUILD STRONGER WALLS

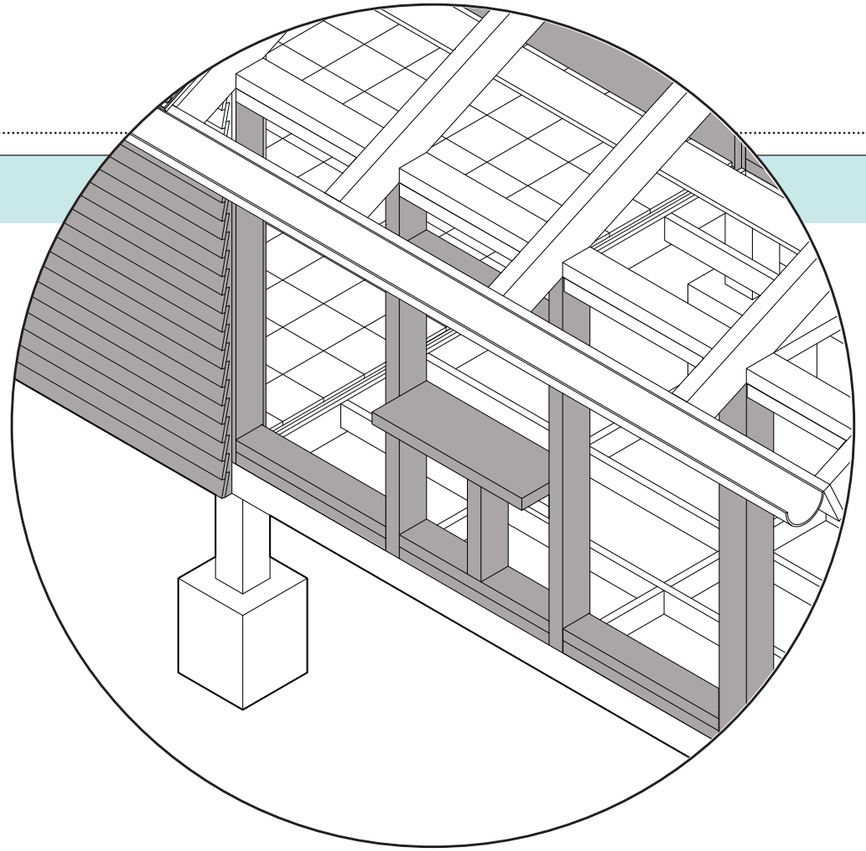
STEP 4 - DESIGN THE WALL SYSTEM

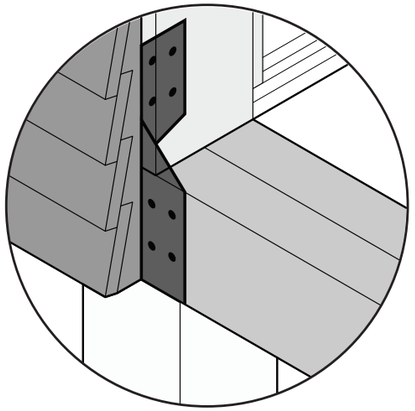
Ask an engineer how to design a resilient and strong wall system.

A. WOOD FRAME

- Wood frame construction consists of a structural frame of beam and columns or stud-frame walls that maintain a direct and continuous load path from the roof down to the foundation.
- Wood frame construction typically uses treated lumber with nominal dimensions or measurements (2 ft. x 4 ft.).
- A double layer of lumber, known as the top plate, sits on top of the wood studs. This piece anchors the roof to the wall construction. See Strategy 07 for more information.
- Space wall studs at 16 in. on center or less sit on an additional double layer of lumber known as the bottom or sill plate.
- Horizontal beams can be added for extra support. Use pressure-treated wood 12 in. above the Base Flood Elevation (BFE). Use moisture resistant panel screws below the beams so they can be easily cleaned and replaced.
- To expand an existing concrete home with wood frame construction, consult a licensed design professional to confirm proper anchorage techniques and ensure a continuous load path.







CONNECTION TO FOUNDATION

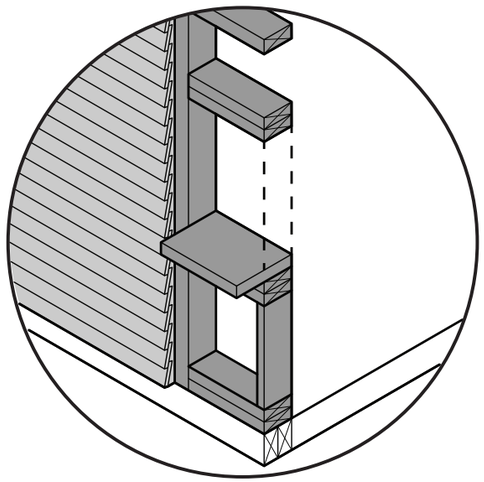
- The sill plate anchors the entire wall system to the foundation using anchors and straps. Nuts and washers are used to tighten the anchor bolts, and holes must be drilled in the lumber before installing the anchors.
- Stud-frame walls and columns rest directly on the sill plate attached to the foundation using anchors and hold down ties.
- Corner columns require (3) 2’x 4’members on each side attatched to bolts and washers. The corner columns are attached to the foundation.

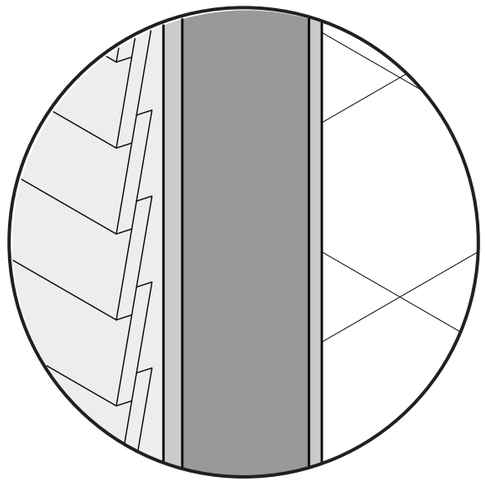
STRATEGY

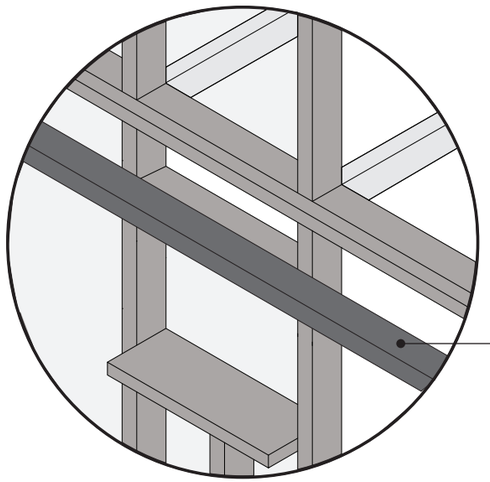
06

BUILD STRONGER WALLS

STEP 4 - DESIGN THE WALL SYSTEM







FRAMING AROUND OPENINGS

- Double vertical “jack trim” and horizontal “header” and “sill” members are recommended on all sides, typically 2 ft. x 4 ft.
- Framing members around the openings are connected using metal plates or angles and fasteners. The fasteners are typically either bolts or lag screws. There is a variety of fasteners in the marketplace. Consult with the manufacturer to determine the appropriate fastener, size, frequency, and fastening pattern for the home.
- Refer to Strategy 08 for anchorage, sealing, and protection methods.
- See Strategy 12 and 11 for placing openings for proper ventilation and natural light.

CONNECTION BETWEEN EXTERIOR AND INTERIOR WALLS

- If interior structural walls are required for heavy lateral loads (i.e. seismic forces), tie them to the structural system correctly. They require special connections to the exterior structural walls and floor diaphragms.

CONNECTION BETWEEN STORIES

- Structural walls should be vertically continuous from the foundation to the roof.
- In multi-story homes, higher floors may have wood framing.
- The roof of a concrete home can be used as a slab-on-grade floor for the wood frame on the second story.
- Anchor wood floors into the structural walls using anchor bolts.
- The second story walls sit directly above the floor joists. They connect to the bottom wall plate and floor joist using nails, fasteners and metal plates/angles, or manufactured connections.
- Exterior and interior structural walls align directly above the first-floor structural walls.
- Use metal straps to reinforce floor-to-foundation connections.
- Ensure vertical members (studs/columns) are properly connected to the horizontal members (top and bottom plates).

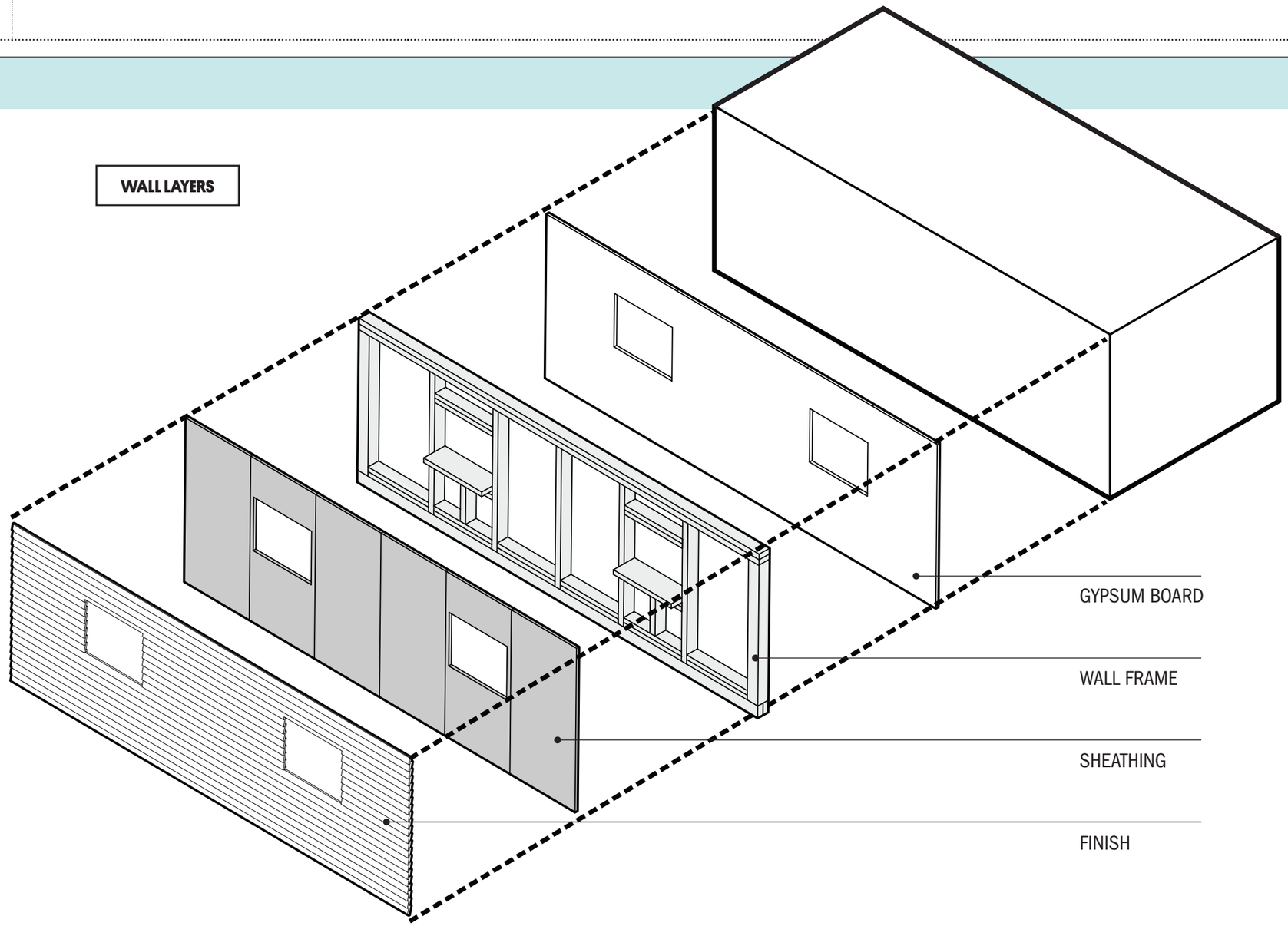
STRATEGY

06 BUILD STRONGER WALLS

STEP 4 - DESIGN THE WALL SYSTEM

FINISHING

- Use flood damage-resistant materials below the anticipated design flood level. Refer to FEMA Technical Building 2 (FEMA TB-2) for requirements in flood zones.
- Place insulation inside the frame between the studs to keep interior temperature stable, despite outside temperature.
- Sheathing, typically plywood, is attached to the wood studs and joists using 6d or 8d common nails.
- Every panel must align with a wood stud, plate, or blocking for proper installation.
- A 4 ft. x 8 ft. panel is recommended to span the wall studs.
- Leave a minimum ½ in. vertical gap between sheathing panels to account for shrinkage of the supporting wood member.
- Exterior wall sheathing, like stucco plastering, can be used as a base for finishes.
- Plywood panels in structural walls should be 5/16 in. thick minimum and CD grade.
- Gypsum board used in structural walls should be ½ in. thick minimum.

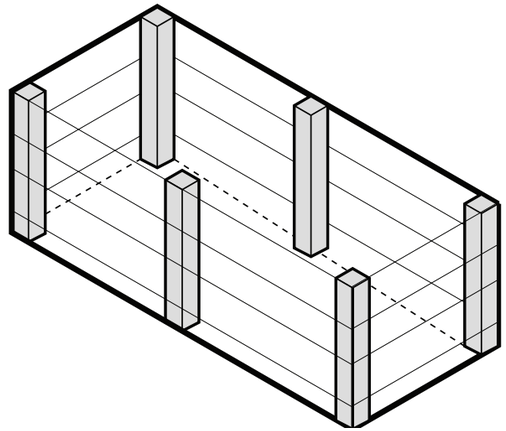


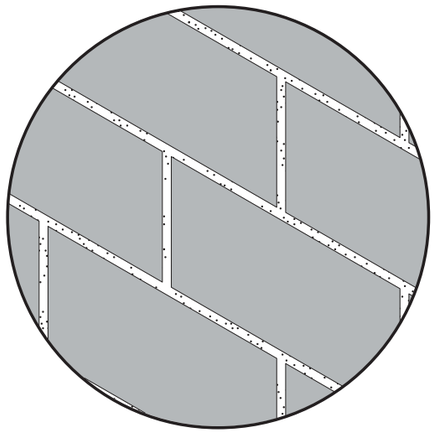
STRATEGY

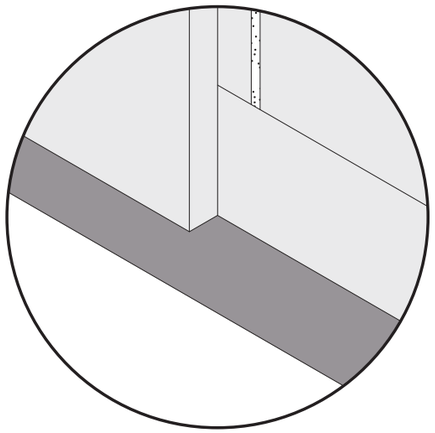
06 BUILD STRONGER WALLS

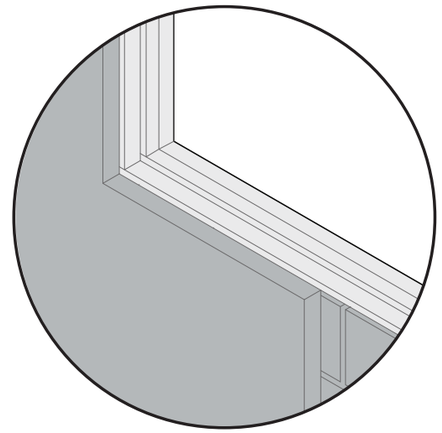
STEP 4 - DESIGN THE WALL SYSTEM

B. CONCRETE









POURED CONCRETE

- Pour concrete directly into engineered formwork with rebar laid into the forms.
- Formwork is a mold, typically made from plywood panels, that frame the wall's final thickness.
- Use ties to maintain the distance while pouring and curing.
- The process consists of: Build the formwork, pour the concrete and sample for testing, wait for the concrete to cure and verify strength test results, dismantle the formwork.
- The process is slower to erect than a wood frame or concrete frame with infill walls.

CONCRETE FRAME WITH INFILL WALLS

- Design a poured concrete frame as outlined above.
- Design a structural grid of rebar that connects columns.
- Columns must be directly above the foundation in order to transfer the load properly.
- Columns and beams have vertical and horizontal rebar to transfer gravity and lateral loads, including wind and seismic loads, into the foundation.
- Use concrete blocks to fill the gaps between the structural grid columns.
- Grout and place rebar in block cell at required spacing.
- Add joint reinforcement and horizontal rebar for lateral loads.
- Tie infill walls to the structural concrete frame.

CONNECTION TO FOUNDATION

- This system can only be anchored to a concrete foundation.
- The foundation should have dowels embedded in the dry mixture extending into the wall, prior to pouring the concrete.
- Reinforcing steel embedded in the foundation, called dowels, are the primary connection between the walls and the foundation. They should match the spacing and size of the wall rebar. See Strategy 05.
- Dowels should extend into the foundation and match the spacing and size of rebar. Typical spacing is 8 in. or 16 in. on center to match the concrete block rebar and size, depending on the structural design. Refer to Strategy 05 for information regarding foundations.
- Ensure there is adequate lap between the dowel and wall rebar to transfer forces into the foundation. The length of lap required depends on the size and type of dowel.
- Provide a minimum of 3 in. of concrete cover on all sides of the dowels.

FRAMING AROUND OPENINGS

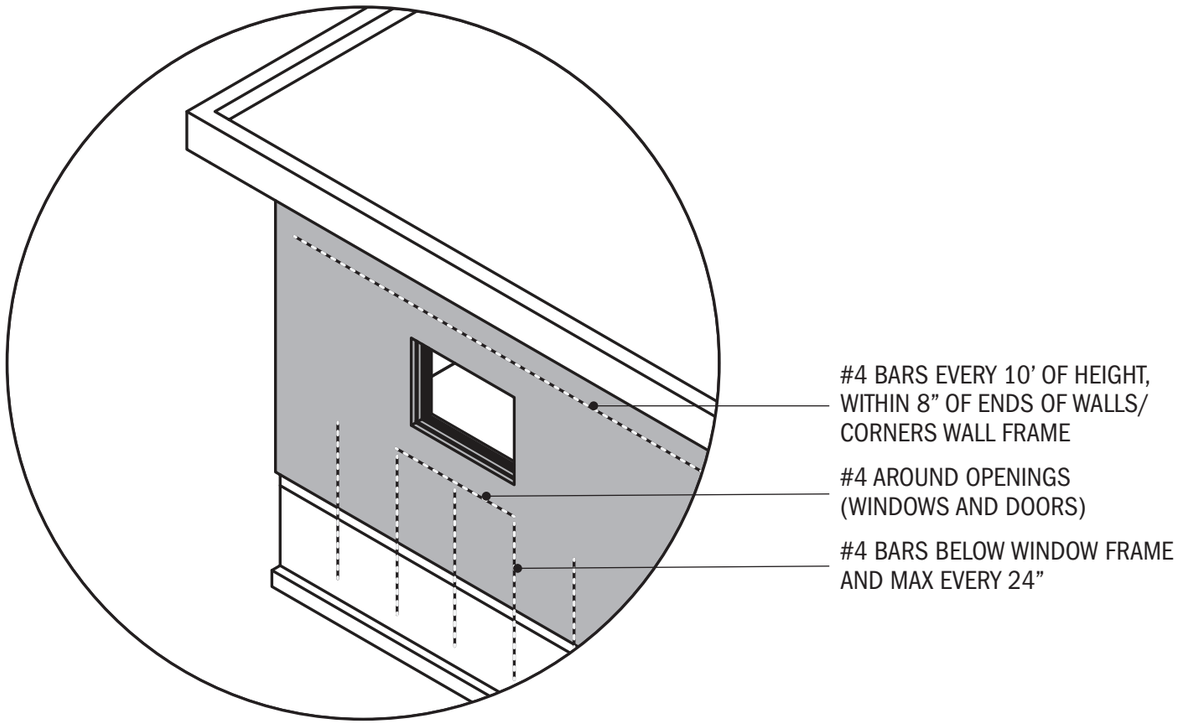
- The building code requires rebar around openings on all sides in structural walls.
- Additional horizontal rebar is required above and below the opening, called a lintel beam. Horizontal rebar should extend beyond the opening in both directions.
- Rebar size and spacing is dependent on the strength required. The building code requires a minimum of No. 4 size rebar (½ in. diameter), spaced at a maximum of 24 in. on center, but this will depend on the structural design.
- For concrete frame with infill walls, a poured concrete frame should be built for wall openings.

STRATEGY

06 BUILD STRONGER WALLS

STEP 4 - DESIGN THE WALL SYSTEM

FRAMING AROUND OPENINGS



CONNECTION BETWEEN EXTERIOR AND INTERIOR WALLS

- Anchor interior partition walls into the frame for stability.
- Maintain a continuous load path by ensuring vertical reinforcement is continuous from the foundation to the roof in structural walls.
- Additional horizontal rebar, called a lintel beam is required and must be continuous on all exterior walls and interior structural walls.
- Ensure there is an adequate lap when transitioning between rebars.

CONNECTION BETWEEN STORIES

- Structural walls should be vertically continuous from the foundation to the roof.
- In multi-story homes, higher floors may have wood framing.
- Anchor wood floors into the structural walls using embedded anchor bolts.

FINISHING

- Latex paint and ceramic tiles are the best type of material to withstand flooding and protect the structure.
- Use manufacturer instructions to prepare the wall before applying.
- Anchor exterior finishes, like tiles, using wall ties.
- In addition to floodproofing requirements, waterproofing is recommended on exterior wall and slab surfaces.

OPERATIONS AND MAINTENANCE

Use the appropriate length of framing members.

Wood expands and contracts under different environmental conditions, such as humidity. Tighten wood fasteners after wood members contract. Anchor bolt nuts should be finger-tight plus a ¼ to ½ turn with a hand wrench. Do not over-torque the anchors.

There are different types of protective coatings for wood fasteners, including screws and nails. Select appropriate protective coatings to prevent rusting of the fasteners.

Corrosion and humidity affect the structural integrity of a house no matter the distance from the coast. Establish a habit of inspecting your walls for signs of humidity and corrosion damage. Pay close attention to the structural walls and its joint connections.

Watch out for deep cracks in the structural walls. If these appear, contact a professional engineer or architect immediately.

Structural walls should not be altered or removed in future remodels without inspection and approval by a registered design professional. Mark structural walls so that they are not altered or removed.

STRATEGY

07 BUILD A STURDY ROOF

$$-$$$$

DISCLAIMER

Consult with licensed building professionals to design and build a strong roof. Stay in touch with the design professionals that designed and constructed your home's roof as an important resource when it is time for maintenance. Ensure openings are compliant with current codes including the2018 IBC and IRC (as adopted by the PRBC) structural provisions and ASCE 7-16 and ASCE 24-14, and certified by the American Society for Testing and Materials (ASTM) as needed for wind-resistance.

A roof shelters you from rain and sunlight throughout the year, and should be strong enough to withstand natural hazard events and disasters. This strategy focuses on how to design a strong roof for your home.

Strategy in Action

1. Roof Design Principles

2. Establish the Type of Roof

3. Design the roof system

WHAT YOU NEED TO KNOW

A roof is part of the Main Wind Force Resisting System (MWFRS). It is held by the walls and the foundation, and maintains a continuous load path by transferring wind loads from wind-facing walls into parallel structural walls on the sides, and down to the foundation.

A roof:

- Protects the home from rain.
- Protects the home from wind loads.

A roof must:

- Be properly anchored to resist wind loads and hold solar panels or other equipment.
- Have drainage to prevent rainwater ponding, particularly in low-sloped roofs.
- Be leak-free and crack-free, as any holes may compromise its structural integrity.

The components of a strong roof are:

- Framing, or the trusses or joists.
- Roof deck, or the envelope.
- Strong connections to the structural system, or the joints.
-

- One or more impermeable layers, including waterproofing membrane, to keep water out of the building and provide insulation.
- Sealed chases to accommodate for future installations of PV panels. Any perforation done to a galvanized material after installation can damage the coating, and result in corrosion and cracking.

Consider the following when designing the roof:

- Wind.
- Seismic design category
- Rain.
- Strength of walls and foundations.
- Anchoring system for a natural disaster.
- Budget.

The most common failures in concrete roof construction are due to:

- inappropriate concrete mix.
- inadequate rebar connections.
- lack of drainage.
- loss of rebar strength due to corrosion.

The most common failures in wood roof construction are due to:

- Inadequate fasteners on roof decking or coverings.
- Inadequate connections between roof and wall frame.
- Lack of continuous load path through structure.
- Strength loss in corroded anchors and ties.

SUPPORTING STRATEGIES

04 Assess the Priorities for Your Home or Building

05 Build a Strong Foundation

06 Build Stronger Walls

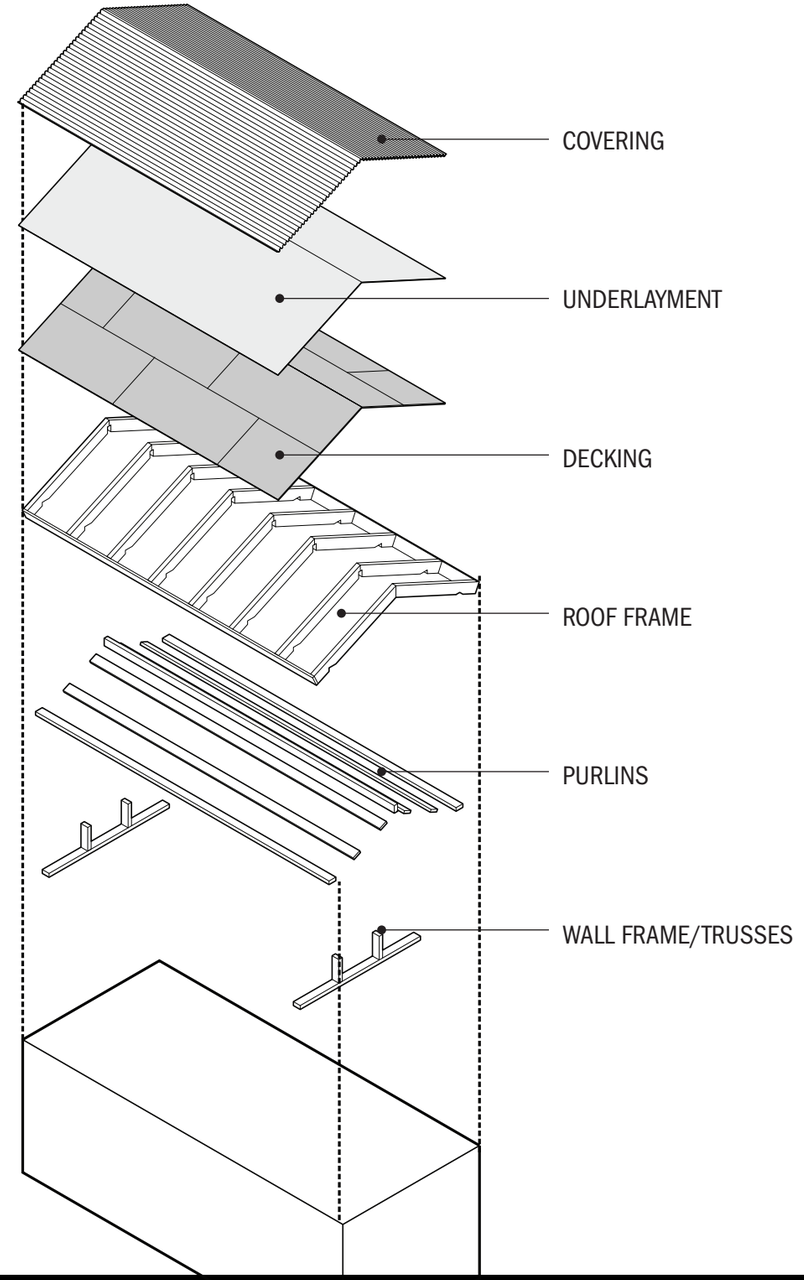
14 Manage Pests

17 Collect + Use Rainwater

19 Prevent Wastewater Backflow in Homes

21 Integrate Solar Energy Systems

25 Develop a Household Emergency Plan



STRATEGY

07

BUILD A STURDY ROOF

CORRECT WOOD ROOF



FAILED WOOD ROOF



CORRECT CONCRETE ROOF



FAILED CONCRETE ROOF



CORRECT WOOD ROOF



FAILED WOOD ROOF



CORRECT CONCRETE ROOF



FAILED CONCRETE ROOF



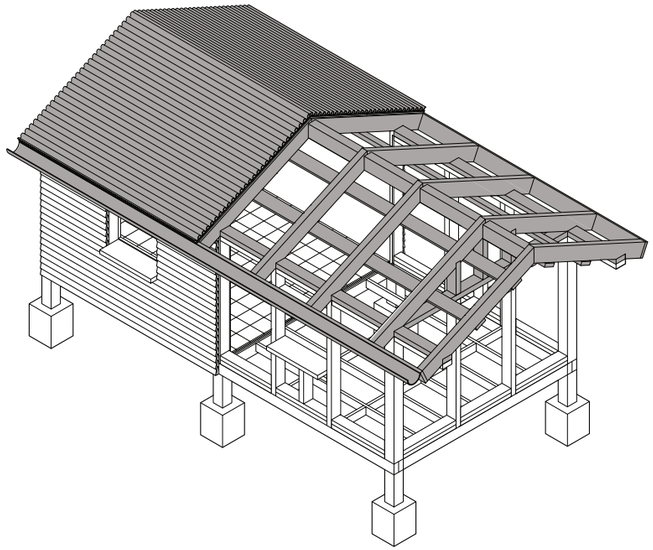
STRATEGY

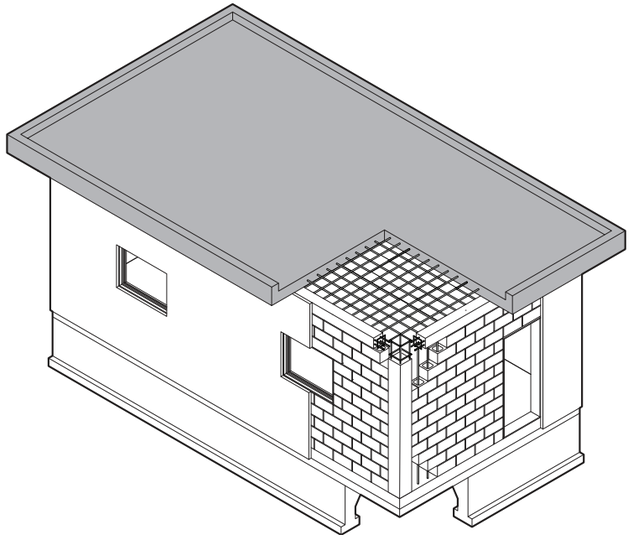
07 BUILD A STURDY ROOF

STEP 1 - ROOF DESIGN PRINCIPLES

Build a drainage system in the roof to prevent rainwater ponding and potential damage during a storm.

- Anchor any equipment mounted on the roof, like solar panels or utilities, to resist wind loads.
- A multi-layer roof (including water barrier or membrane) prevents water leaks, insulates the building, and better protects the building core.
- The roof's slope should be a maximum of 1:2 (1 foot of height for every 2 feet of length).
- Do not add openings on roofs, as this increases the risk of wind damage and leaks. If openings (i.e. skylights) are installed, additional framing members, typical double members, are required on all sides of the opening and they should be designed to resist wind-borne debris impact.
- Antennas, solar hot water heaters, cisterns/ tanks, solar panels or any other equipment should be securely anchored or removed during a natural disaster to prevent damage to the equipment and the roof. See Strategy 25: Develop a Household Emergency Plan.
- Any balcony or garage roof should be designed and constructed apart from the main roof to prevent the main roof to be damaged





STEP 2 - ESTABLISH THE TYPE OF ROOF

- Ask an engineer what is the best type of roof for your home.
- The roof's slope should be a maximum of 1:2 (1 foot of height for every 2 feet of length).





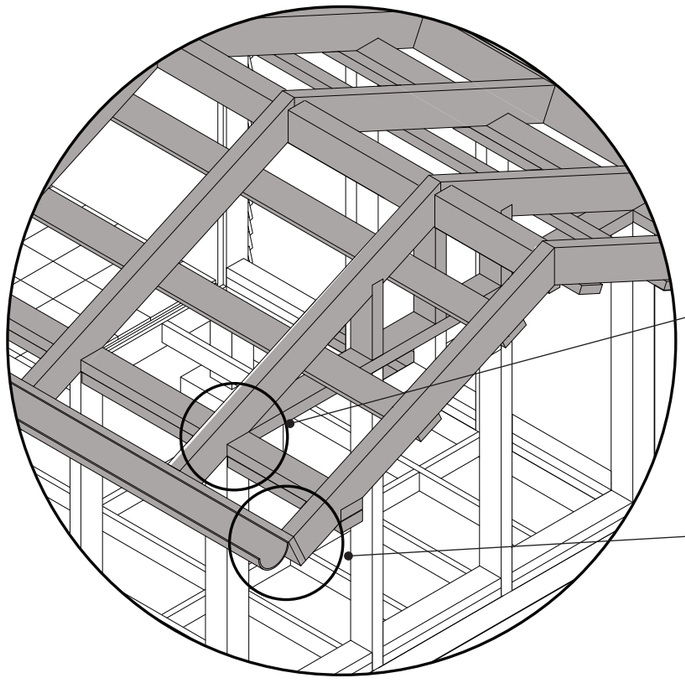
TYPE	HIPPED ROOF	FLAT OR LOW-SLOPED ROOF
DESCRIPTION	A structural system of wood rafters, trusses, floor joists, wall studs, columns, and beams that create a structure and framework for applied interior and exterior finished surfaces.	■ Usually build of concrete ■ Drains prone to be blocked by debris. Drains should b designed properly and checked after a climatological event to prevent pooling sinc could cause roof to collapse. Exercise caution and safety when going to the roof. ■ Prone to punctures from windblown debris or rainwater ponding. ■ Prone to pooling water if not drained appropriately.

STRATEGY

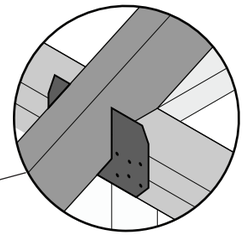
07 BUILD A STURDY ROOF

STEP 2 - ESTABLISH THE TYPE OF ROOF

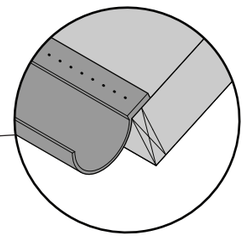
A. WOOD



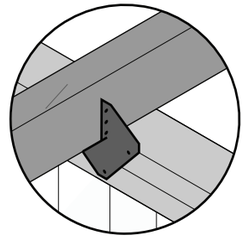
ROOF TO FRAME DETAIL



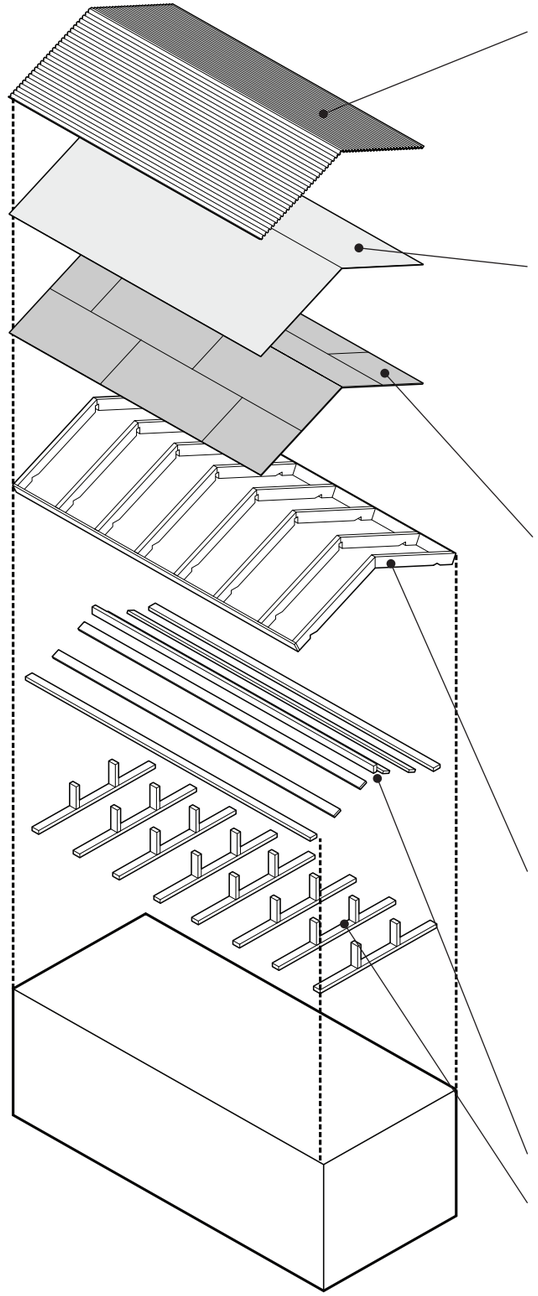
GUTTER DETAIL



FLAT ROOF - ROOF TO FRAME DETAIL



- The roof overhangs (eaves) should not extend more than 18 in. from the exterior wall to reduce risk of roof uplift failure.
- Covered patios and balconies should have their own independent roof structure, in case it gets damaged or is uplifted it does not damage the home roof structure.
- The size and spacing of roof framing members depends on the height and span.
- Roofs with longer spans or larger loads require thicker framing members and stronger trusses.
- Multi-story buildings have higher wind loads and require stronger roofs.



COVERING

Roof's first line of defense against wind,rain, flying debris.

- Zinc is the most common and resilient type of covering.
- Asphalt and concrete/clay tiles are not recommended because the do not protect the roof.
- Anchor zinc panels with #10 or #12 screws of the same material of the metal roof and with rubber washer. Seal screas with rubber seal to prevent water leaks.
- Overlap with 3 channels on each side and anchor with at least 6" extending from the union of the panels.

UNDERLAYMENT

Insulation and waterproofing layers

- Waterproofing layer - prevents leaks.
- Self-adhering polymer modified bitumen membrane, placed on the roof deck.
- Self-adhering polymer modified bitumen flashing tape, placed on all decking panel joints.
- 30 lb. felt tar paper membrane, button cap fastner 9 O.C. edge, 12 in. in O.C. field.
- Insulation layer - keeps moisture from entering the decking.
- Rigid layer, placed on top of the decking.

DECKING

Makes the frame rigid so it can transfer loads to exterior walls

- 4' × 8' 5/8" thick plywood panels.
- Use screws, ring-shack, or screw-shank nails in the corner regions and along the roof perimeter for wind resistance.
- The panels must be longer than 24" anywhere on the roof, and longer than 48" at rake edge (the sloped sides of a gable end).
- A panel "H" clip spaced between framing and member attachments. Spray closed-cell polyurethane foam adhesive on the underside of the decking at all framing and joints attachments to prevent moisture and humidity from damaging the wood.
- Offset plywood panels and screw to the truss beams with 3-3 1/2" wood screws.

ROOF FRAME

Provides structural support for the roof

- Use metal ties to link the structural walls as part of the continuous load path.
- At the top of the roof, rafters frame into a ridge board. Ridge board must be at least 1" thick. Rafters are typically nominal lumber spaced at 16" o.c.
- Collar ties are located below the ridge board and hold rafters together. They mus be at least 1" × 4" and spaced no more than 4" o.c. These are key components to resist uplift forces from wind.
- Provide ridge straps at each connection between the ridge board and rafters before installing decking.

PURLINS

WALL FRAME/TRUSSES

- Use rafter ties at every rafter to connect the walls to the roof to maintain a continuous load path.

STRATEGY

07

BUILD A STURDY ROOF

STEP 2 - ESTABLISH THE TYPE OF ROOF



HURRICANE TIES DETAIL



INSTALLATION DETAILS



INSTALLATION DETAILS



INSTALLATION DETAILS

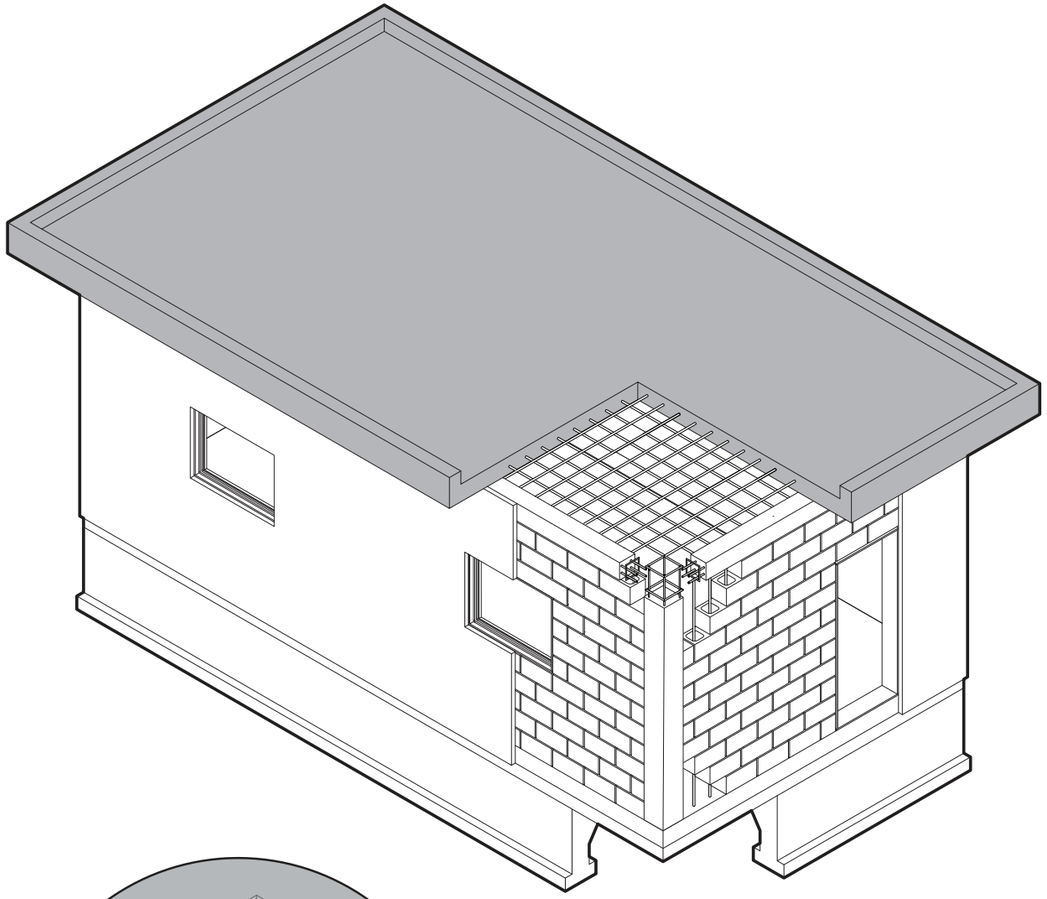
STRATEGY

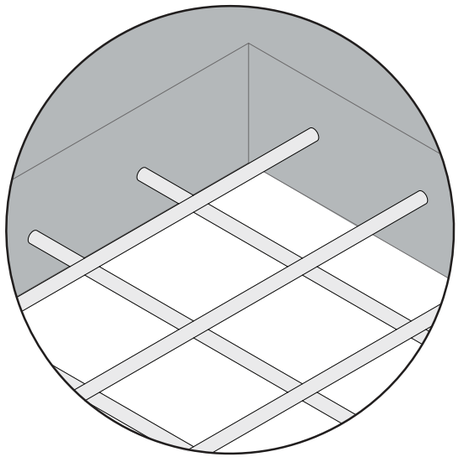
07 BUILD A STURDY ROOF

STEP 2 - ESTABLISH THE TYPE OF ROOF

B. CONCRETE

- With adequate design and construction techniques, concrete roofs perform well structurally during wind and wind-driven rain events, but should specifically be engineered to withstand seismic events or they can contribute to catastrophic failure.
- Consult a professional engineer for all retrofit and design of concrete roofs.
- Beams should have an inch of height for every foot it projects horizontally.
- If you notice any anomalies or that structure does not meet above standard, contact a professional engineer for an evaluation on your building.
- Keep in mind the following considerations when working with a professional engineer.
- Formwork is required to pour the concrete and let it cure. Form ties, secured in place with fasteners, hold formwork together during pour and curing. It's important that concrete cures completely to achieve its full strength and should be tested to ensure strength is achieved.
- Reinforcing steel, or rebar, provides strength to a concrete system. Rebar should be coated to be corrosion-resistant. Provide at least 2-3 in. of concrete cover to ensure rainwater and environmental pollutants don't corrode the rebar.
- Roofs need to be sized appropriately taking into account the rebar, the required concrete depths, electrical conduits and plumbing.
- Concrete strength is dependent on the size and spacing of spacing of rebar. Rebar should be continuous and two-way in slabs and also have temperature rebar.
- Connections between the wood roof system and supporting wall system is critical for the strength of a roof and overall resilience of the house. Embed dowels into structural walls and provide adequate anchors and hurricane ties. Refer to Strategy 6 for additional information about structural walls.
- There are three types of concrete roof systems:
  - Two way flat plate
  - Flat beam and slab
  - Inverted beam





STRATEGY

07 BUILD A STURDY ROOF

STEP 2 - ESTABLISH THE TYPE OF ROOF

OPERATIONS AND MAINTENANCE

If you see cracks, rot or insect damage in the wood roof framing, replace the entire member. DO NOT replace it with a smaller piece of lumber.

Watch for termites. Preserve and treat your wood to prevent it from rotting.

If you see any cracks, splits, tears, punctures in the waterproofing membrane or other exterior roof components, patch or replace component in accordance with above best practices.

Periodically inspect drains and downspouts, especially before and after a storm, to ensure they are clear of debris and are free flowing.

Corrosion and humidity affect the structure and fasteners of a roof no matter the distance from the coast, use stainless steel fasteners wherever possible (especially at roof edges and corners).

Inspect rooftop equipment (including water tanks) and mechanical components to ensure tie downs and other fasteners are maintained.

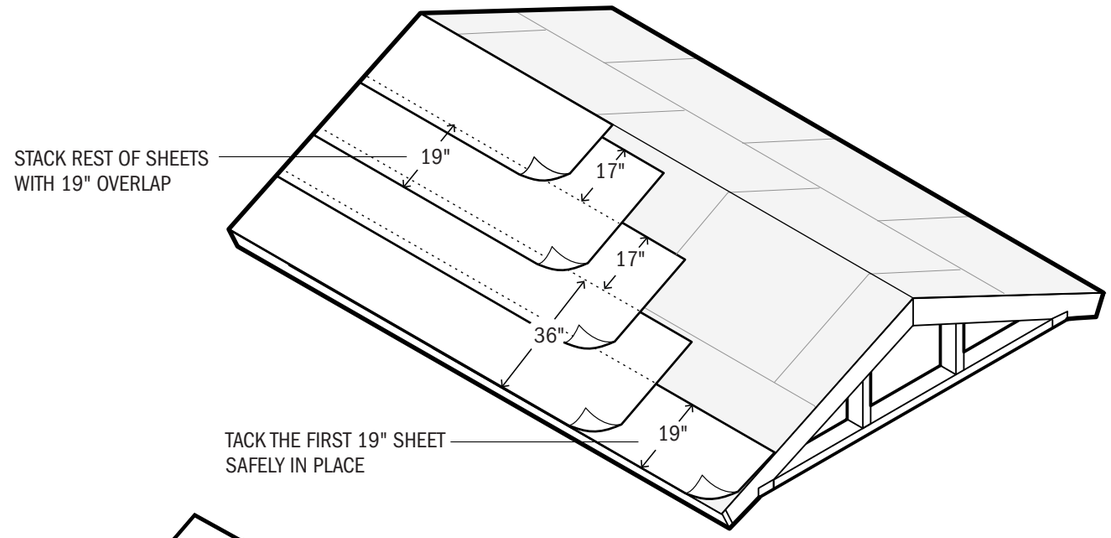
Make sure the roof can withstand the weight of the equipment or water tank, which make cause the roof to collapse and cause fatalities.

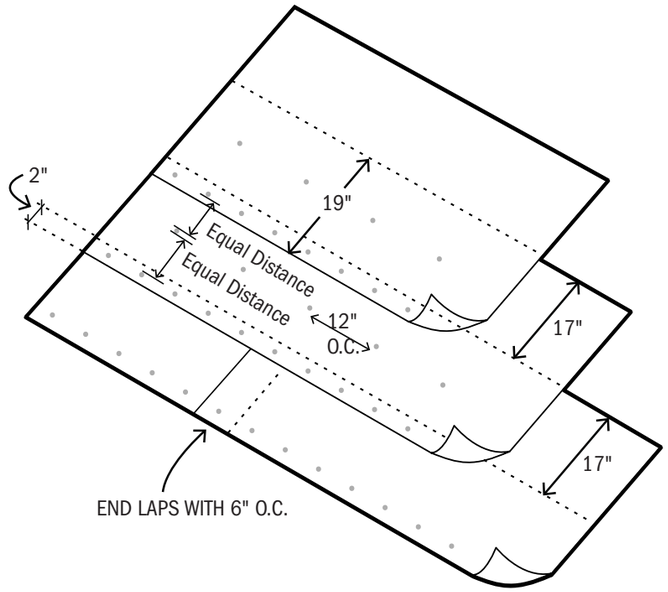
WATERPROOFING





- Waterproof the roof to ensure that water does not damage the concrete roof structure and/or leak into the structure.
- Integrate waterproofing concepts into the concrete mix. Using the wrong proportions of a mix, particularly high percentage of aggregate, can result in an excessively porous surface that leads to waterlogging.
- Use a sealant or continuous membrane on the exterior of the roof.
- Terminate waterproofing at all edges and transitions to guard against wind uplift. Gaps in waterproofing or excess material might catch in high winds and lead to progressive roof system failures.
- Apply the protection layers following a 2% slope in direction to roof drainage (see Strategy 20: Collect and use Rainwater) to ensure rainwater doesn't pool. Rainwater pooling is a serious hazard: not only does it lead to leaks, but pooling water can increase the weight on the roof, potentially compromising its structural integrity.





STRATEGY

08 ANCHOR, SEAL & PROTECT OPENINGS

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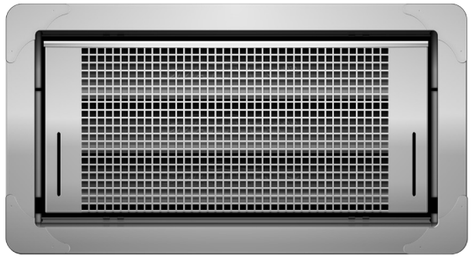
DISCLAIMER

Consult with licensed building professionals to design and build openings. Stay in touch with the design professionals that designed and constructed your home's openings as an important resource when it is time for maintenance. Ensure openings are compliant with current codes including the2018 IBC and IRC (as adopted by the PRBC) structural provisions and ASCE 7-16 and ASCE 24-14, and certified by the American Society for Testing and Materials (ASTM) as needed for wind-resistance.

A house has many openings, including entry doors, windows, skylights, and garages as well as vents. Properly anchored and sealed openings protect a home from natural disasters. This strategy focuses on protecting your home by appropriately selecting and securing openings.



Smart Vent

DESCRIPTION AND FUNCTION

An **opening** is a door, window, skylight, vent, or other aperture in the house's exterior envelope that provides controlled access/egress or regulates the flow of air and protects the home's occupants from weather, pests and/or pollutants. Openings also help maintain the temperature and humidity levels within the home.

Openings must meet the following design requirements:

- Be protected against breaching.
- Comply with floodproofing requirements for openings in flood zones. See Strategy 09.
- New glazed doors, windows and skylights in newly-constructed homes must be manufactured to resist wind pressures and wind-borne debris.

Consider the following when choosing and placing the openings:

- Risks exposure from wind and wind-driven rain.
- Balancing comfort and aesthetics with risk tolerance.
- Life cycle costs – includes initial installation costs and long-term maintenance.

Why openings fail

- incorrect anchorage can make even strongest doors/windows/skylight fly off.
- cracks or improper sealing through which water can seep.
- not protected against projectiles at high-wind scenarios.

SUPPORTING STRATEGIES

- 06 Build Stronger Walls
- 10 Control Thermal Heat Transfer
- 11 Increase Ventilation
- 12 Benefit from Natural Light
- 13 Control Moisture and Mold
- 14 Manage Pests
- 25 Respond + Begin Household Recovery



CORRECT OPENING

Smart Vent



CORRECT OPENING



FAILED OPENING = INAPPROPRIATE ANCHORAGE



FAILED OPENING = OPEN OPENING

STRATEGY

08 ANCHOR, SEAL & PROTECT OPENINGS

STEP 1 - TYPES AND EFFECTIVENESS OF OPENINGS

See Strategy 11 to understand how to select windows to maximize ventilation.

- Fixed assemblies are generally more resistant to wind and rain than operable assemblies. However, they provide limited ventilation and are vulnerable to pressure failure.

A. WINDOWS

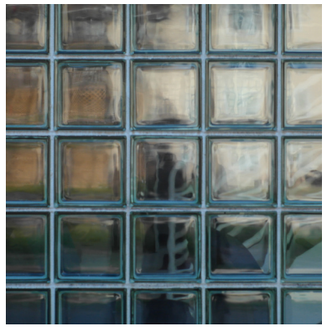
IN-PLACE PROTECTION



IN PLACE PROTECTION WINDOWS







	FIXED, IMPACT-RESISTANT GLAZING	ALUMINUM JALOUSIE WINDOW	GLASS BLOCKS
PROS	■ Code Compliant and can withstand wind load. ■ May reduce a home's energy consumption. ■ No manual deployment required (passive).	■ Common in Puerto Rico. ■ Allows daylight and ventilation, maintains privacy. ■ Flood damage-resistant material	■ Inexpensive ■ Allows daylight and maintains privacy. ■ Flood damage-resistant material. ■ No manual deployment required (passive).
CONS	■ Expensive	■ Allowed by code, but is vulnerable to wind-borne debris so it must be protected by wind resistant panel. ■ Does not comply with the energy code. ■ Vulnerable to wind-driven rain entry.	■ Sealed element - Cannot be opened.

STRATEGY

08 ANCHOR, SEAL & PROTECT OPENINGS

STEP 1 - TYPES AND EFFECTIVENESS OF OPENINGS

A. WINDOWS

NO PROTECTION







GLASS JALOUSIE

PROS

- Very common in Puerto Rico.
- Allows daylight and ventilation.
- Flood damage-resistant material .

CONS

- Vulnerable to wind-borne debris damage and wind-driven rain entry.

CASEMENT

- Very common in Puerto Rico.
- Allows daylight and ventilation.

- Vulnerable to wind-borne debris damage and potential wind-driven rain entry.

STRATEGY

08 ANCHOR, SEAL & PROTECT OPENINGS

STEP 1 - TYPES AND EFFECTIVENESS OF OPENINGS

B. DOORS

IN-PLACE PROTECTION



FIXED, IMPACT-RESISTANT

PROS

Flood doors and barriers must comply with floodproofing requirements. See Strategy 09.

CONS

Are vulnerable to rain water entering the inside with the wind action.

Are costlier compared to non-impact resistant doors.



GLASS PANEL SLIDING DOORS

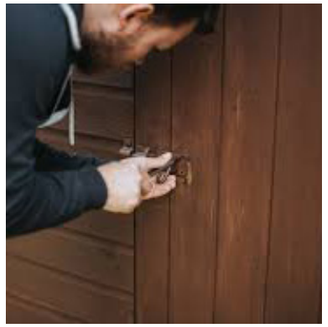
PROS

- Offer views to the outside, and natural lighting.

CONS

- When used, the inside may need additional protection from the sun's rays
- If not impact resistant, these are vulnerable and may have to be protected with shutters or other in the event of a hurricane and may be vulnerable to burglary.

NO BUILT-IN PROTECTION



SINGLE-LEAF WOOD

PROS

- Can be made impact resistant.
- Have aesthetic attributes.

CONS

- If not treated properly, are vulnerable to the sun and humidity.



DOUBLE LEAF WOOD

PROS

- Can be made impact resistant.
- They take less space when opening.

CONS

- More expensive than single leaf.
- Need to be secure between the two leaves compared to the single leaf that are secure to the wall Vulnerable to wind pressure and wind-borne debris failure as well as wind-driven rain entry in gaps between the door and door framing.
- Requires glazing protection.



BIFOLD

PROS

- Can open up a space to the outside to the exterior.
- They are usually not recommended since they might lose its balance or form by the action of gravity and use.

CONS

- Vulnerable to wind pressure and wind-borne debris failure as well as wind-driven rain entry in gaps between the door and door framing.
- Requires glazing protection.



PIVOTING

PROS

- The use of pivot doors is usually motivated by aesthetics
- Can be made of different materials

CONS

- Expensive
- Vulnerable to wind pressure and wind-borne debris failure as well as wind-driven rain entry in gaps between the door and door framing.
- Requires glazing protection.

STRATEGY

08 ANCHOR, SEAL & PROTECT OPENINGS

STEP 1 - TYPES AND EFFECTIVENESS OF OPENINGS

C. GARAGE DOORS



PROS

- Can be found in a variety of sizes and materials.

CONS

- Ensure doors and openings in garage doors are wind-resistant and have been tested for positive and negative pressures.
- Single two-car garage doors are more vulnerable to wind failure than one-car garage doors unless they are braced prior to the storm (active).

D. SKYLIGHTS



PROS

- Allow daylights in spaces that are far from exterior walls.
- Some skylights can open to allow for additional ventilation.

CONS

- Rooftop skylights can increase vulnerability of wind and wind-driven rain entry into the home, leading to potential structure and contents damage.

E. VENTS



Smart Vent

PROS

- No manual deployment required.
- HIghly effective at protecting structure.
- Can lower insurance as a wet flood proofing technique.
- Must be designed and installed to prevent water damage or leakage.

CONS

- Flood doors and barriers must comply with floodproofing requirements. See Strategy 09.

OPERATIONS AND MAINTENANCE

- Inspect seals and framing of windows, vents and doors annually for signs of wear or separation.
- Watch out for corrosion, clean immediately and replace corroded elements if necessary. The use of corrosion-resistant connectors, fasteners and surface materials will reduce this risk.
- Timber openings must be inspected annually for signs of rot or insect damage. If damage cannot be repaired using painting or sealing, replace damaged timber with new timber or decay-resistant materials.

STRATEGY

08 ANCHOR, SEAL & PROTECT OPENINGS

STEP 2 - ANCHOR OPENINGS

- Even hurricane-rated openings can fail if they are not properly anchored to the structural framing (not just the surrounding exterior sheathing).
- Use corrosion-resistant hardware and fasteners.
- If the openings contains glass, ensure the system complies with the appropriate ASTM requirements and specified design thickness.



WOOD FRAMING



DO'S

- Galvanized wood screws

DONT'S

- Nails or Staples

CONCRETE



DO'S

- Galvanized Concrete or Lag screws

DONT'S

- Nails

STRATEGY

08 ANCHOR, SEAL & PROTECT OPENINGS

STEP 3 - SEAL OPENINGS

▷ Fill any cracks, crevices or penetrations around its perimeter and at interfaces between the opening and the supporting wall to prevent intrusion of water and leaks from wind-driven rain.

A. SEALANTS



SEALANT JOINTS

- Prevents water entering between frame and wall.
- Removable stop, sealant, and backer rod.
- Sealants should be waterproof/ marine rated



WEATHERSTRIPPING

- Prevents water from entering through the opening.
- Examples include door drips,neoprene seals.

B. DOORS AND FLASHING

VESTIBULE

- Provide additional surface for weather-stripping and to trap water before it enters the main structure.

OUT-SWINGING DOORS

- Place weatherstripping on the interior side of the door to minimize decay.

PAN FLASHING

- Prevents water from seeping underneath the door.



STRATEGY

08 ANCHOR, SEAL & PROTECT OPENINGS

STEP 4 - PROTECT EXTERIOR OPENINGS



IN PLACE AUTOMATIC METAL ROLL SHUTTER

COST

$$

SPECIFICATIONS

- Look for label that indicates it is compliant with ASTM standards (ASTM E1996m 2017)
- Anchor to the wall, not to the opening frame.

PROS

- Permanent solution.
- Resistant to wind and debris impact.
- Easily open and close from inside the home.

CONS

- Active mitigation
- Requires mechanical maintenance.
- Must be properly secured. Misalignment on tracks can lead to structural damage.
- No obstructions (i.e. window air conditioning units).
- Ensure it can be raised manually, in case of a power outage.



TEMPORARY PLYWOOD PANELS

COST

$

SPECIFICATIONS

- Must be at least 7/16 in. thick and preservative-treated.
- Anchor to the wall, not to the opening frame.

PROS

- Quick assembly.
- Can be anchored to window frame or bracket frame mounted on the wall.

CONS

- Active mitigation.
- Temporary solution.
- Not permitted on structures with roofs more than 33 ft or with wind speeds greater than 130 mph.
- Properly anchor to wall to prevent blow-off.



ALUMINUM OR POLYCARBONATE PANELS

COST

$-$$

SPECIFICATIONS

- Panels must overlap and be fastened together
- Anchor to the wall, not to the opening frame.

PROS

- Best value for cost and durability.
- Easy to store.

CONS

- Active mitigation.
- Temporary solution.
- Difficult to install on upper levels.
- Need two rails permanently installed on the opening perimeter.

MANUAL ACCORDION

COST

$-$$

SPECIFICATIONS

- System similar to metal roll shutters, except they are opened and closed on the sides of the opening.
- -Anchor to the wall, not to the opening frame.

PROS

- In place, ready to close.

CONS

- Active mitigation.
- Must be closed manually from the outside.
- Difficult to access on higher levels.



STRATEGY

08 ANCHOR, SEAL & PROTECT OPENINGS

STEP 5 - OPENING FAILURE

CRACKS OR INAPPROPRIATE SEALING

Allows wind and wind-driven rain to enter a house, damaging the building envelope and creating potential wind pressure failure.

OPENING COVER FAILURE

If air comes in but cannot escape, it exerts additional pressure on the interior of the structure that can lead to structural damage and failure of openings.

PAN FLASHING

Failure to close openings or implement opening protection systems allow significant wind and wind-driven rain to enter and damage the structure. Unsecured objects and materials (furniture, wall finishes, electrical equipment) may also be at risk of being damaged by wind pressures or pulled out through the opening.

INAPPROPRIATE ANCHORAGE

Full detachment of openings from the supporting wall can lead to wind and wind-driven rain damage and associated damages and losses.



FAILED OPENING



TIGHT OPENING

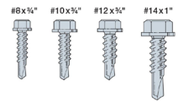


STRATEGY

08 ANCHOR, SEAL & PROTECT OPENINGS

ANCHORAGE SYSTEMS

NAME	IMAGE	FUNCTION	USES
WEDGE ANCHOR		Fastening structural steel, handrails, signs, racks, equipment and formwork bracing	Solar water heater and other equipmen
SLEEVE ANCHOR		Fastening in solid concrete and masonry	Solar water heater and other equipment
DROP-IN ANCHOR		Internally threaded drop-in expansion anchors for use in flush-mount applications. Requires a setting tool.	Solar water heater and other equipment
STRIKE ANCHOR		Inserted into pre-drilled hole, the strike center pin to expands.	Solar water heater and other equipment
LAG SHIELD		Lag screw is inserted to expand shield.	Solar water heater and other equipment
CHEMICAL ANCHORING		Pre-drilled hole is filled with concrete adhesive.	Solar water heater
ANCHOR FASTENERS		Anchor wood to concrete	Connect wood sill plates to concrete foundation
CONCRETE AND MASONRY SCREW		Anchor opening elements (i.e. windows)	Fastening windows Permanent metal shutters

NAME	IMAGE	FUNCTION	USES
HURRICANE TIE		Tie roof truss to wood wall frame	Wood roof truss
TRUSS CONNECTOR PLATES		Tie roof truss components together	Wood roof truss
STUD PLATE TIES		Tie from foundation to wood columns	Wood columns
STRAP TIES		Tie from foundation to wood columns	Wood columns
FASTENERS		Fasteners for metal ties	Metal ties
COMMON STAINLESS STEEL NAIL		Nails for metal ties when indicated	Metal ties
WOOD SCREWS		Wood to wood screw	Wood panel shutters

STRATEGY

09 FLOODPROOF YOUR HOME

$-$$$

If your home or building is located in designated floodplain as noted by FEMA along the coast which experience storm surge with breaking waves during or along a river that may overflow during heavy rains, you should understand how flood water can affect your structure so that you can mitigate the risks, damages and costs associated with flooding. This strategy focuses on ways to floodproof a home to minimize water damage. See the Resources section below to check your home's vulnerability to coastal flooding.



DISCLAIMER

Consult licensed building professionals to determine the best floodproofing strategy for your home. Stay in touch with the design professionals that designed and constructed your system as an important resource when it is time for maintenance.

FEMA does NOT recognize dry floodproofing as an acceptable strategy for residential structures. The building code requires buildings with residential occupancy to be wet floodproofed.

Ensure floodproofing is compliant with code: IBC (as adopted by the PRBC) structural provisions and ASCE 7, with materials certified by the American Society for Testing and Materials (ASTM) against high winds and flooding.

WHAT YOU NEED TO KNOW

Floodproofing prevents water from entering and damaging the home and critical mechanical, electrical and plumbing systems. There are two types of floodproofing:

Wet floodproofing – Mitigates water damage to the home by allowing water to freely flow up to the DFE and allows unoccupied portions of a building to be flooded that are modified using flood damage-resistant materials and relocating key equipment and contents, reducing damages and losses.

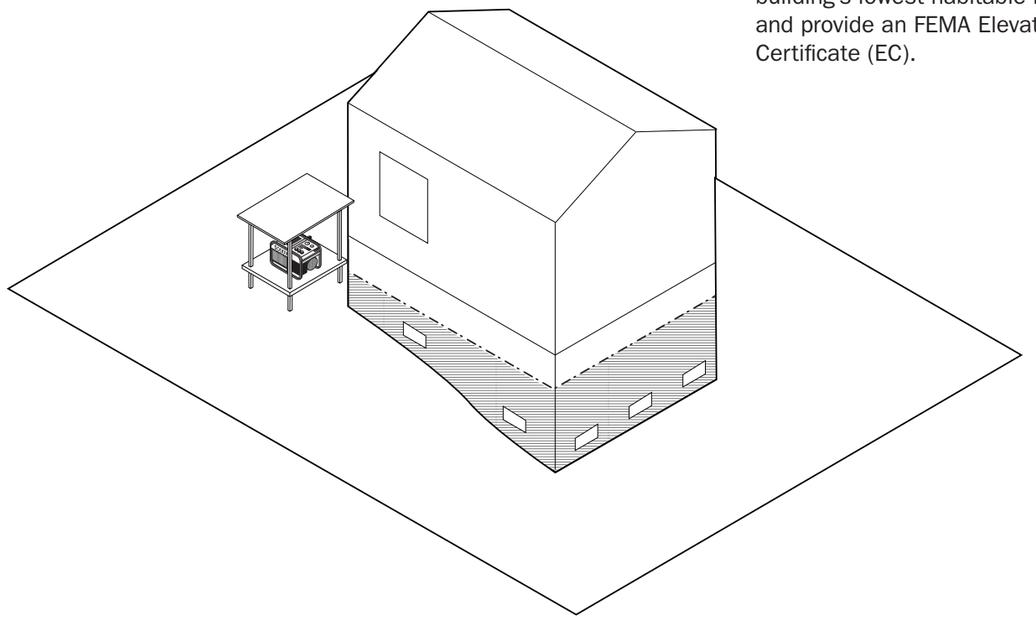
Dry floodproofing – Mitigates water from entering the home through its watertight structure. Use only in non-habitable commercial spaces of concrete multi-family buildings. Remember that dry floodproofing is active mitigation and subject to failure. It is an expensive option.

- **Active** – Requires human intervention for removable elements to be deployed before a natural disaster.
- **Passive** – Fixtures and systems are automatically integrated into the structure, so they do not need to be deployed before a natural disaster.

Design Flood Elevation (DFE) is the level at which a building should be floodproofed. A building's DFE is calculated based on FEMA's Base Flood Elevation (BFE) plus an additional amount as a safety buffer which is called "freeboard" and is indicated in the 2018 building code (2' or more)

The BFE is provided in the FEMA Flood Insurance Rate Maps (FIRMs), which includes wave effects. These maps do not take into account future sea-level rise from climate change. See "Resources."

Hire a surveyor who will identify the building's lowest habitable level and provide an FEMA Elevation Certificate (EC).



OPERATIONS AND MAINTENANCE

Clearly label breakaway walls and critical components.

Regularly inspect outdoor fixtures for signs of rust and corrosion, and areas below the DFE for leaks, seepage and cracks.

Prior to an expected flood, items used or stored in flood-prone basements or ground-floor spaces should be moved out of the building or to higher floors in advance of a flood. These include vehicles, mechanical equipment, furniture, area rugs, personal belongings, cleaning supplies and toxic chemicals.

After a flood, it's important to clean areas where the floodwaters, debris, and scour have occurred, as these could pose serious safety and health risks to occupants. *If wastewater has flooded home its important to take special precautions when cleanup and consider hiring a professional with safety equipment to protect against disease.

In coastal and tidal riverine areas, corrosion of metals caused by salt water inundation may be a problem. Periodic maintenance of key components and fasteners is important for the overall health of the building.

ESTIMATING COSTS

Costs are dependent on variables including location, materials, type of construction, and risk exposure, that all contribute to real cost estimating valve.

SUPPORTING STRATEGIES

01 Reinforce Site

02 Reinforce Site with Vegetation

03 Plant an Edible Garden

05 Build a Strong Foundation

13 Control Moisture and Mold

22 Prevent Wastewater Backflow in Homes

25 Establish Household Emergency Plan

STRATEGY

09 FLOODPROOF YOUR HOME

WET FLOODPROOF HOME

Design with the understanding that the portion of the building below the DFE will flood.



1. REPURPOSE ALL FLOORS BELOW THE DFE

DESCRIPTION

- Floors located below the DFE can be used for storage, vehicle access or parking.
- Walls prone to contact with floodwater must be designed with flood openings or to break away under flood loads.
- Refer to FEMA technical bulletin TB-9 for information regarding breakaway walls.
- Note that walls must be certified as breakaway walls.



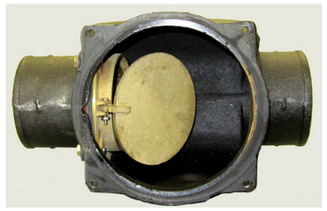
2. ELEVATE CRITICAL SYSTEMS

- Elevate interior and exterior systems like mechanical air handling, electrical, and plumbing at least 1 foot above the DFE to ensure their function during and immediately after a flood.
- Prevent direct contact with flood water and minimize/avoid damage.
- If relocating systems is not possible, they must:
  - be designed and installed to prevent water from entering or accumulating within the components.
  - resist hydrostatic, hydrodynamic and debris impact loads.



3. INSTALL FLOOD VENTS AND/ OR FLOOD OPENINGS IN WALLS

- This will allow water to pass through perimeter walls and throughout the wet floodproofed areas.
- Locate openings below the BFE
- Bottom of openings are 1 ft or less above the ground level.
- Locate at least 2 openings on different walls of each enclosed area. If there are multiple enclosed areas, each area should have flood openings.
- 1 sq. inch of flood openings are needed for every 1 sq. foot of enclosed area.
- Openings should have a width and a length of at least 3 inches.
- Any louvers, screens, or covers on flood openings must allow automatic flow of floodwater in and out of the area.
- Doors and windows without installed openings do not count.



4. PROVIDE BACKWATER VALVES FOR WATER, SANITARY AND STORMWATER SYSTEMS

DESCRIPTION

- Backwater valves prevent wastewater from entering into the home's plumbing system and flooding the house. Refer to Strategy 19 for more information.
- Harden pipes up to DFE to reduce pressure on pipes if there backlow occurs.



5. ELEVATE, SECURE, OR TIE DOWN TANKS

- Includes fuel and water tanks
- If they cannot be elevated above the DFE, secure and properly tie down.
- Ensure they are empty to avoid leaks and contamination.



6. USE FLOOD DAMAGE-RESISTANT MATERIALS UP TO THE DFE

- Use stainless steel connectors and fastening systems.
- Materials must withstand direct and prolonged contact with water with flood water for 72 hours.
- The FEMA Technical Bulletin 2 (TB 2) of Flood Damage-Resistant Materials Requirements of 2008, approves only class 5 (highly resistant that can withstand exposure to water in movement) and class 4 (resistant but less durable under water in movement).
- Some class 5 materials include: concrete block, marine grade plywood, glass blocks, polyurethane formed in place and steel with waterproof adhesives.

- Install detachable mold- and moisture-resistant cladding at the bottom four feet using corrosion resistant screws.
- Design and build interior walls to vent/breath so cladding does not need to be removed for wall to dry
- Build cabinets off the floor above the flood line

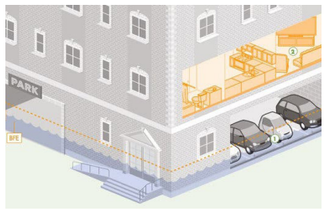
- Other acceptable materials per TB2 include:
  - Cement Board,
  - Concrete,
  - Non paper faced GWB,
  - Marine grade plywood,
  - Preservative treated lumber,
  - Plastic lumber,
  - Fiberglass,
  - Stone
  - Steel (painted/coated), closed cell insulation,

STRATEGY

09 FLOODPROOF YOUR HOME

DRY FLOODPROOF HOME

In a residential building, **dry floodproofing can only be used in non-habitable spaces**, e.g. lobbies, building manager office, utility rooms, retail, storage, etc. and is only permissible when the facility has a lowest floor commercial use.







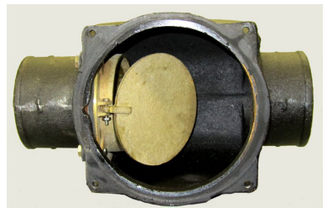
DESCRIPTION

1. Design the structure to withstand hydrostatic, hydrodynamic and debris impact loads associated with the DFE and determined by a structural engineer.

2. Seal all cracks and openings (except for flood vents or openings) below the DFE.

3. Install backwater control plugs in floor drains.







DESCRIPTION

4. Use waterproof covers for vents, louvers located under the DFE and install them before a natural disaster.

5. Permanently seal floor drains

5. Install sewer backwater valves.

6. Cap house trap to prevent water from flowing into the home if main sewer is backed up.

6. Install a sump pump at the lowest point of the home.









DESCRIPTION

7. Protect electrical equipment that cannot be relocated with waterproof enclosures.

8. Permanently replace first floor doors with flood doors and install removable flood gates over entryways.

9. Install waterproof hatch doors on sidewalk hatches.







DESCRIPTION

10. All power sockets must be at least 18 in above the floor or projected flood level. Prevent damage to the circuits from flood water.

10. Use a trench drain at the base of the stairs to reduce seepage from a non-protected hatch.

Bailey House

WILLIAM KEEGAN FOUNDER, PRESIDENT HEART 9/11

Description: The Healing Emergency Aid Response Team 9/11 (HEART 9/11) is a team of first responders including the FDNY, NYPD, and NYC Building Trades. The group came together in the aftermath of September 11, 2001 in New York City. The mission of HEART 9/11 is to immediately respond to natural and man-made disasters, rebuild community centers in hard-hit areas to meet community needs, and help communities recover by building resiliency for families and individuals. In Puerto Rico, HEART 9/11 worked on an initiative launched by New York Governor Andrew Cuomo, called NY Stands with Puerto Rico. The initiative, launched in April 2018, helped repair and rebuild approximately 90 homes in Orocovis.

A highly decorated Lieutenant and a 20-year veteran of the Port Authority Police Department, Bill Keegan was Night Operations Commander of the NYC World Trade Center Rescue/Recovery Teams, and awarded the highest medal for the WTC 9/11 response effort. In 2007, William Keegan founded HEART 9/11 (Healing Emergency Aid Response Team) – a non-profit disaster response organization comprised of police, fire, union construction workers, 9/11 surviving families and those who share our belief that we can help ourselves by helping others.

INTERVIEW

What led you to come to Puerto Rico? What challenges did you face? What happened?

We knew the pain that we had been through on 9/11. You wake up one morning and there is bright sunshine and within hours your world is turned upside down. We thought that, with our skills and expertise, we could make a difference for the people of Puerto Rico. We responded to Texas and Hurricane Harvey and had been in the Keys because of Hurricane Irma, so we thought we would be up to the task because other organizations had been stretched so thin prior to the hurricane the week before. We knew our level of expertise would go a long way in helping to organize recovery response in Puerto Rico. Many of the people that work in the trades, from the police officers to the firefighters, come from Puerto Rican descent, and they were anxious to get back to their homeland and families and bring them comfort and supplies. In the end, they wanted to bring them a sense of home by transferring their skills and knowledge to the people of Puerto Rico, so they can help rebuild themselves.

What challenges did you face?

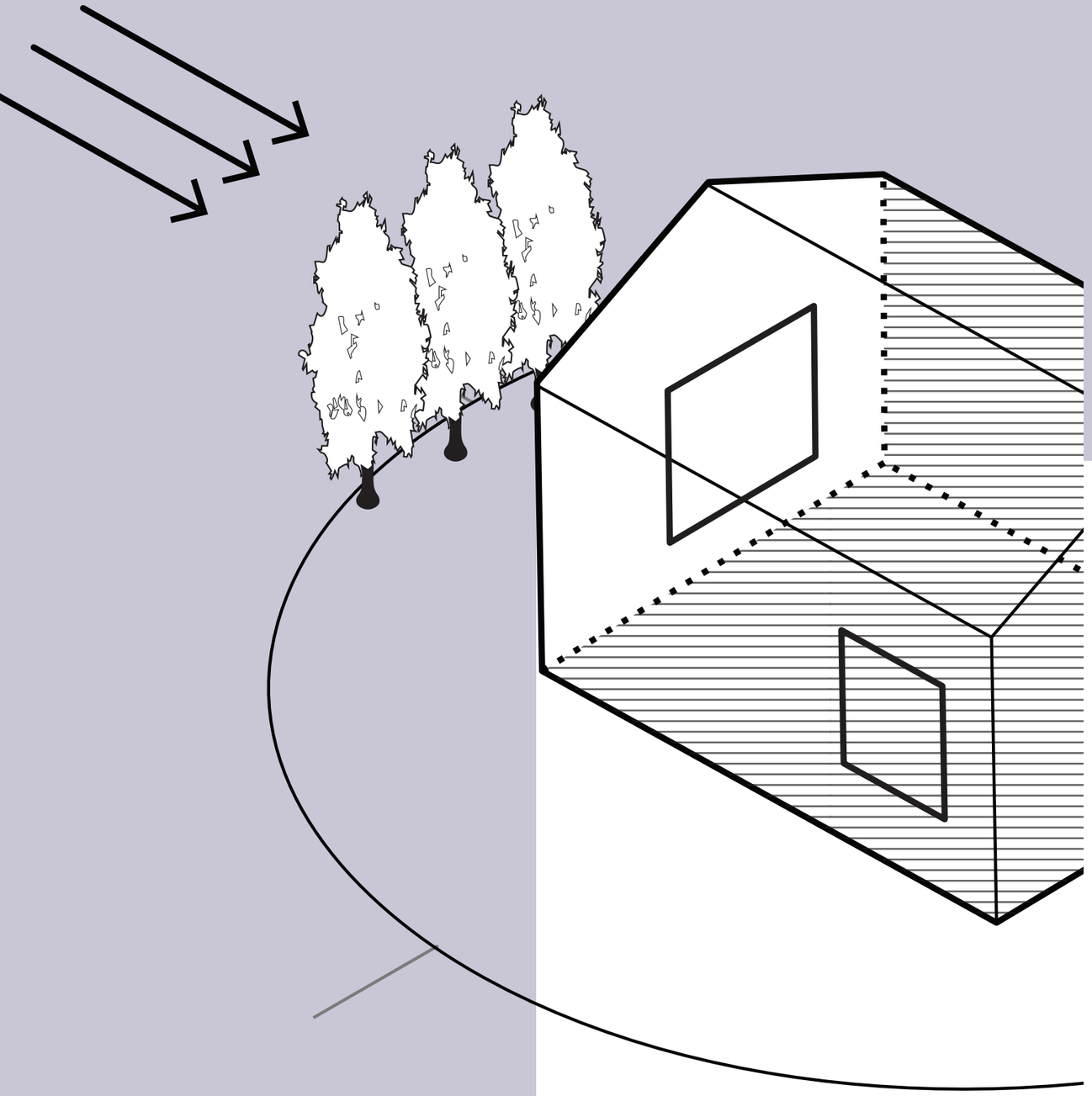
The first one was a combination of obvious difficulties like lack of fuel, water, and medical supplies proved greater as you moved away from the island's coast lines. There were logistical challenges of ships and other planes bringing in supplies. There wasn't any power, so we had to have generators in place in our own supply chain of food and water.

The second challenge was entering communities that were unable or had no experience with networking and organizing themselves to respond to the magnitude of the disaster. First, what we needed to do was help them organize. Then, we had to demonstrate that if they partnered with the community boards, neighborhoods, pastors, and churches, they could get something done quickly. The level of our expertise with real union carpenters that know how to frame and put sheet metal in showed the community repeatedly that we were able to get the work done—and provide real tangible results—not just being people promising someday. Literally, men and women with toolbelts on, putting people's homes back together, and putting roofs back on. The community was going around the streets and collecting the sheet metal that was blown off their roofs and bringing it to HEART 9/11 members to install and at least have a roof over their heads.

Working with communities is critical to help you prioritize the most vulnerable households. Our teams were able to provide medical support and enable people to obtain medical attention. We became a holistic response group that gave people advice on how to make homes safe, helping take down trees, and clearing roads.

CHAPTER

3



PASSIVE HABITABILITY

Strategies that improve a housing facility's ability to maintain habitable conditions in the event of extended power loss or in the event of hazardous conditions related to natural hazards.

PASSIVE HABITABILITY 03

INTRODUCTION

This chapter introduces the concept of “passive habitability,” or how building components and ways of operating them can help households survive during an extended outage of municipal energy, water or gas systems. Passive survivability is a holistic concept: a building’s structure, energy system, water system and immediate surroundings all work together so that people can live “off the grid.” Some techniques of passive survivability are useful for new construction, such as shaping a house in relation to the sun and prevailing breezes in order to keep the interior temperature comfortable with little or no power. Other methods of managing your current home on an everyday basis, such as optimizing air flow and natural light, can reduce your dependence on electricity for cooling and lighting. This is especially important as the number of hot nights on the island rises, increasing the need for 24-hour cooling.

TYPES OF STRATEGIES LISTED IN THIS SECTION

STRATEGY #	10	11	12	13	14
STRATEGY NAME/TITLE	REDUCE THERMAL HEAT TRANSFER	INCREASE VENTILATION	BENEFIT FROM NATURAL LIGHT	CONTROL MOISTURE AND MOLD	MANAGE PESTS
DESCRIPTION	This strategy focuses on slowing down heat transfer to reduce dependence on cooling systemsand maintain a habitable indoor temperature, year round after a storm or during power outages.	This strategy shows how using mechanical-free or “passive” ventilation actions can promote air movement through and within a building to maintain a comfortable indoor temperature without electricity.	Natural light improves a home’s quality and comfort by efficiently illuminating interior spaces while lowering the overall energy consumption. Increasing natural light or daylighting a room can provide light to occupants when electricity is unavailable. This strategy shows you how to increase natural light.	This strategy focuses on mold prevention by eliminating sources of moisture.	This strategy focuses on actions that individual homeowners or communities can take towards preventing and mitigating pests in a way that promotes non-toxic solutions to manage specific pest problems, referred to as Integrated Pest Management (IPM).
	$$	$$$	$	$$$	$

This chapter explains the principles of what makes a home heat up (“thermal heat transfer”), and how manage sunlight and air currents to keep it as comfortable as possible with minimal use of electricity. Incorporating passive survivability strategies into the way you live now will reduce your energy bill and protect residents in hazardous conditions, like extreme heat or long power outages.

Staying cool, safe air, a pest-free environment and nutritious food are essential to good health. Ways to reduce common health hazards and increase food security are also addressed in this chapter.

STRATEGY

10 REDUCE THERMAL HEAT TRANSFER

$$

Materials and orientation of homes on a site impact the indoor temperature of a living space. Reflective surfaces and shading prevent heat gain directly from sun while insulation slows heat transfer from the outside building surfaces through walls and roof toward the cooler interior environment. In Puerto Rico's tropical climate, depending less on mechanical systems to cool a space reduces energy costs and increases day-long and year-round space comfort. This strategy focuses on slowing down heat transfer to reduce dependence on cooling systems and maintain a habitable indoor temperature, year-round, after a storm, or during power outages.

Strategy in Action

1. Orient Home to Reduce Heat Gain

2. Provide Cool Roots

3. Shade the Home

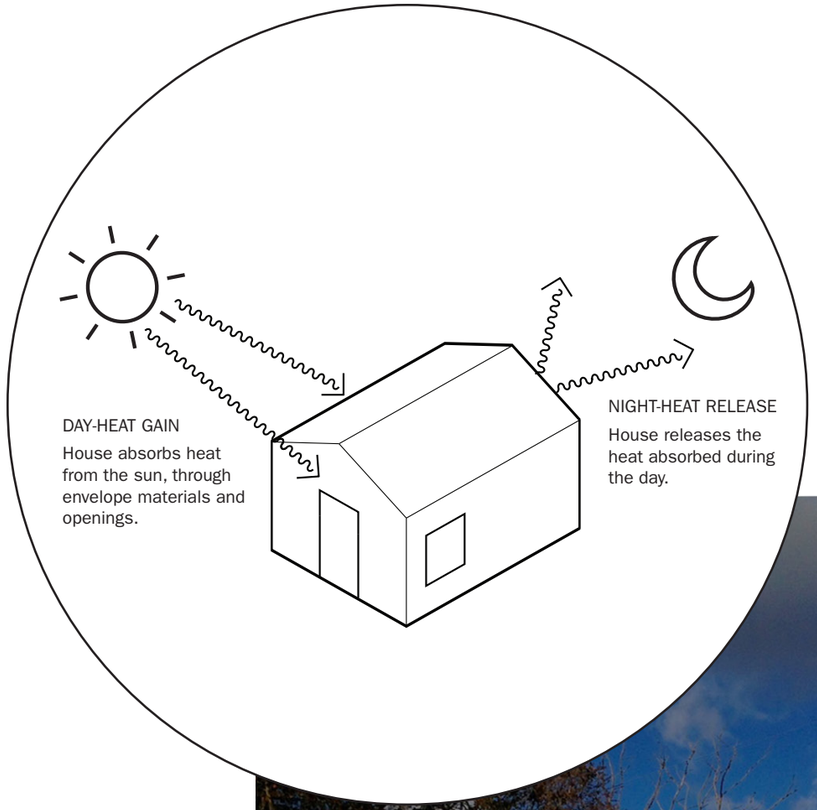
4. Enhance Windows

5. Choose Thermally Efficient Materials

6. Build to Code

WHAT YOU NEED TO KNOW

- Thermal heat gain is how much sunlight raises indoor temperature and is determined by:
- Materials – The characteristics of the exterior materials, particularly the ability to reflect sunlight and resist heat transfer.
- Orientation - Direction of building facade determines how much sunlight enters a spac.
- Construction - Cracks and gaps on walls or roof allows air to enter a home
- Ventilation - Changes temperature as outdoor and indoor air come into contact. See Strategy 13.
- Outdoor conditions - the sunlight, temperature and wind at the home site.
- Elevation – The mountain region is colder than the valley or the coast.
- Time of Day - Homes gain heat during the day and release it at night. Daytime to nighttime temperature differences will be smaller near sea level and higher at higher elevations.
- Elevated Outdoor temperatures-A home heats up when outdoor temperatures rise and/or surfaces become hot from sunlight.




FERNANDO ABRUNA

SUPPORTING STRATEGIES

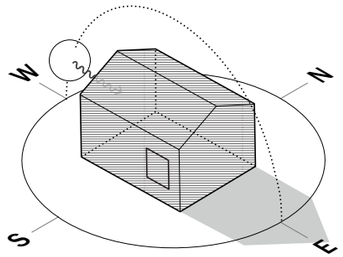
02	07	13	14
Fortify your Site with Green Infrastructure	Anchor, Seal and Protect Openings	Benefit from Cross Ventilation	Benefit from Natural Light

STRATEGY

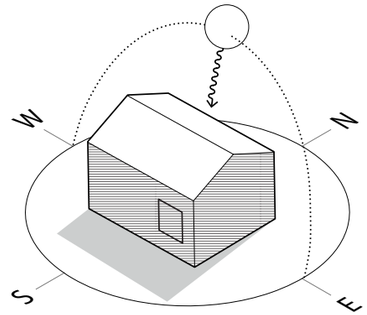
10 REDUCE THERMAL HEAT TRANSFER

STEP 1 - ORIENT HOME TO REDUCE HEAT GAIN

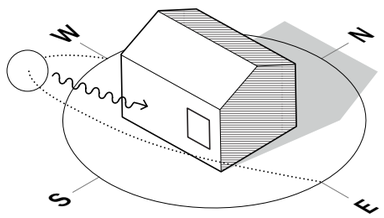
- The critical facades for heat gain are east, south, and west. Lower sun angles on the east and west sides of a building mean greater heat gain for east and west facing windows and walls. To minimize morning and afternoon heating, orient a building such that the longer sides (typically having more windows) face north/south, and the narrower sides (with less windows) face east/west. See Strategy 11 for more on orientation of windows.
- Ensure that building façades are protected against direct sunlight (see Strategy in Action items #2 and #3 below). South facing façades also receive significant direct sunlight; roof overhangs can effectively shade south facing windows and walls.



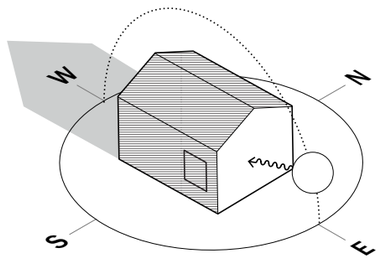
WEST
In the afternoon, the West façade receives direct sunlight.



NORTH
Throughout the day, the North façade receives indirect sunlight.



SOUTH
Throughout the day, the South façade receives direct sunlight – from low in the sky in winter to high angle in summer.



EAST
In the morning, the East façade receives direct sunlight.

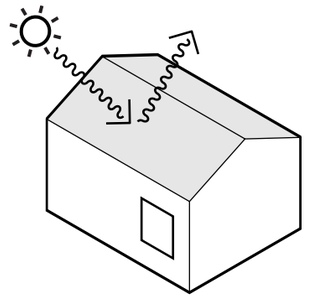
STEP 2 - PROVIDE COOL ROOFS



- White or light colored roof surfaces that are highly reflective are recommended because they reflect heat from sunlight and prevent heat from entering a home and heating it up, while dark roofs absorbs sunlight which can heat up the home and surrounding site. Look for roof products or coatings with an aged solar reflectance greater than or equal to 0.55 which means that 55% of the heat is reflected away from the home keeping it cooler.

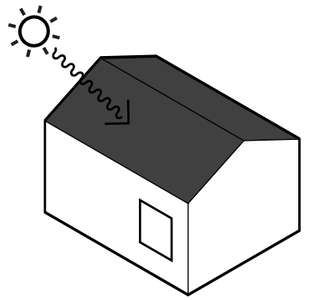
- Provide roof or ceiling insulation of at least R-30.

LIGHT COLOR ✓



Light colors reflet most of the sunlight, thus they absorb little and do not heat up the space.

DARK COLOR ✕



Dark colors absorb most of the sunlight, thus they reflect little and do heat up the space.

For painting your roof, loof for Energy Star roofing products: these products reflect the sunlight and reduce the amount of heat transferred to the interior of the space.

STRATEGY

10

REDUCE THERMAL HEAT TRANSFER

STEP 3 - SHADE THE HOME

Use vegetation and add architectural features to provide shade and prevent the Sun's heat from entering the home.

- The foliage of the tree provides the most shade. Ensure that the tree's height and location will cast shade on the right surface, at the desired time of the day.
- Keep a considerable distance between vegetation and the home to avoid damage during strong winds. The distance from the tree to the house should exceed the tree's height.

OPERATIONS AND MAINTENANCE TIPS

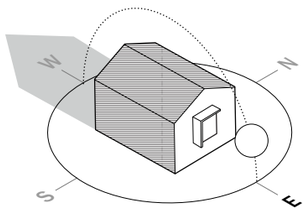
- Ensure roof overhangs, windows, and shading devices can withstand hurricane winds. Inspect them for for loose anchors or other parts, rust and corrosion. Repair as necessary.
- Trim trees regularly to prevent damage from loose limbs.
- Remove awnings that do not provide sun protection and can possibly become projectiles.

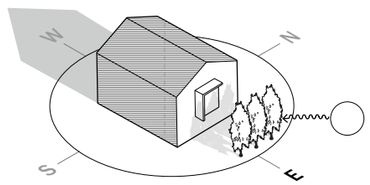


PEREZ HACIENDA LAS LUNAS, CAGUAS

EAST

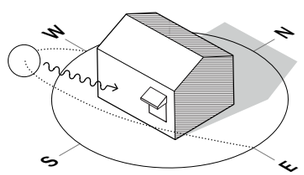
- Vertical and horizontal Shading around an east-facing window provide shading for late morning.
- Plant tall shrubs or short trees on the East side to reduce morning direct.

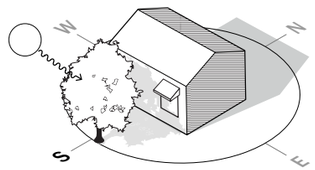




SOUTH

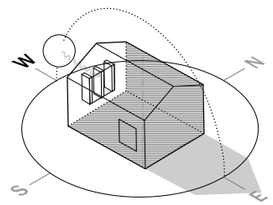
- Horizontal shading over a single south-facing window provides good shading year round. Porches, overhangs, and awnings provide similar effect, see examples below in #4.
- Plant tall trees on the South side to reduce day-long direct sunlight. Awnings or shaded porch can also serve this purpose.

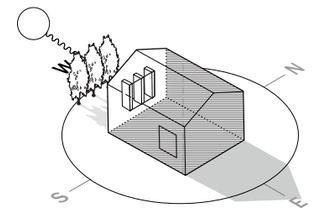




WEST

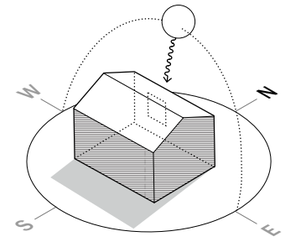
- Vertically and horizontally shade west facing windows to block afternoon sun.
- Plant tall shrubs or short trees on West side to reduce afternoon direct sunlight.

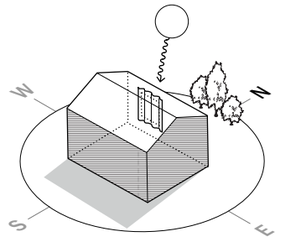




NORTH

- Interior shade for glare control or if window is an accordian "miami" style curtain, close them slightly.
- Plant light greenery on the North side for glare control, if necessary.





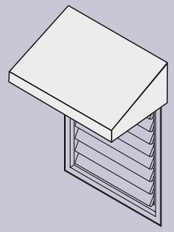
STRATEGY

10 REDUCE THERMAL HEAT TRANSFER

STEP 4 - ENHANCE WINDOWS

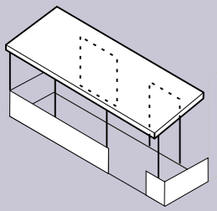
Add architectural features or enhance windows to provide shade and reduce thermal heat gain.

PERMANENT

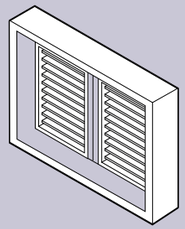


OVERHANGS ON WINDOWS

Must be well casted to avoid cracks.

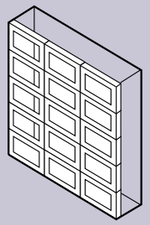


OVERHANGS ON PORCH



CONCRETE FRAMES

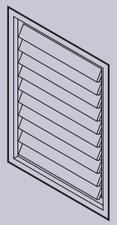
Must be well cast to avoid cracks



BRISE-SOLEILS

Provides shade while letting daylight through.

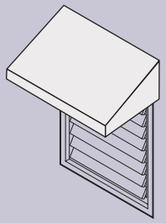
Available in metal or concrete



JALOUSIE WINDOWS

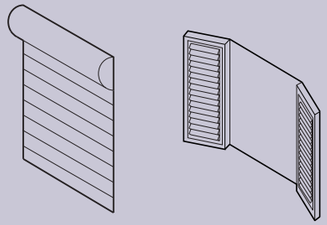
Allow light and ventilation while protecting opening during a storm.

REMOVABLE

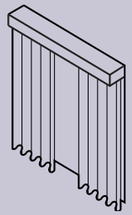


AWNINGS OR BAHAMA

- Available in canvas, wood or metal.
- Operable ones can be deployed as necessary in response to the sun.
- Anchor well to avoid breakage or detachment.



RETRACTABLE OR INTERIOR

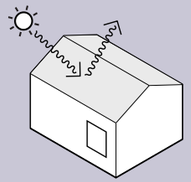


CURTAINS

Can reduce solar heat gain and provide light level control and glare control

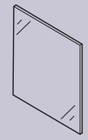
STEP 5 - CHOOSE THERMALLY EFFICIENT MATERIALS

- Cover south, east, and west facing glass windows, glass doors or skylights with a tinted film to keep visibility to the outside, but reduce heat gain. For new construction and alternatively for existing homes, replace unshaded south, east and west facing glass windows, glass doors or skylights with newer windows that have a solar heat gain coefficient (SHGC) of 0.40 or lower. Low SHGC windows help minimize solar heat gain into the home.
- Look for roof products or coatings with an aged solar reflectance greater than or equal to 0.55 and insulate roofs to at least R-30.
- Select white or light colored paint for unshaded walls and insulate walls to at least R-4.



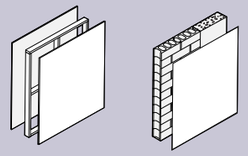
ROOFS

- Roof aged solar reflectance >= 0.55
- Insulate to at least R-30.
- Consider radiant barriers.



GLASS WINDOWS, GLASS DOORS AND SKYLIGHTS

- Window film or low solar heat gain coefficient (SHGC) products for unshaded glass.



WALLS

- White or light colored exterior paints.
- Insulate exterior mass walls to at least R-4 and exterior frame walls to at least R-13.
- Consider radiant barriers.

STEP 6 - BUILD TO CODE

- Code compliance is required in Puerto Rico.
- Energy codes provide “one-stop shopping” for the minimum cost-effective building efficiency standards.
- Consider exceeding code levels where costs are low.
- Energy code compliant buildings are typically more comfortable than those not built to code.
- It is significantly less expensive to improve energy efficiency in new construction than in a retrofit.

STRATEGY

11 INCREASE VENTILATION

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As outside air moves through a space, it affects both the temperature and the moisture content of air inside. Ventilation –replacing indoor air with outdoor air without the use of mechanical fans– reduces moisture, equalizes air temperature and humidity, and cools our bodies as it evaporates sweat. Even humid air moving quickly across our skin will make us feel cooler, so increasing the speed and volume of air exchanged between the inside and outside of a space makes the environment feel more comfortable.

This strategy shows how using mechanical free or "passive" ventilation actions can promote air movement through and within a building to maintain a comfortable indoor temperature without use of electricity. The key to managing ventilation is making the most of prevailing winds received by Puerto Rico, which are affected by local conditions such as topography and adjacent buildings.

Strategy in Action

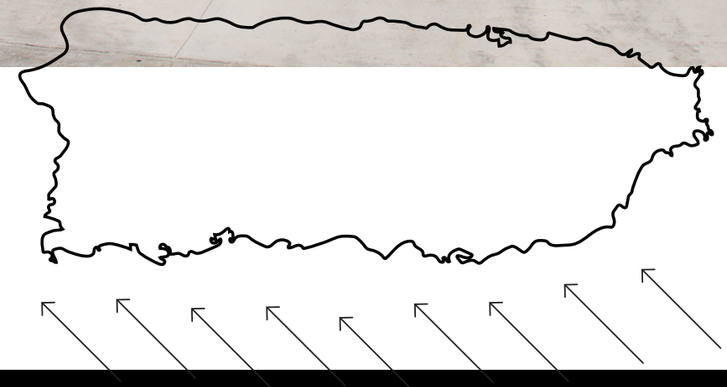
1. *Place Openings in the Building to Maximize Air Movement*
   a. Cross Ventilation
2. *Orient Your Home to Increase Natural Ventilation*
3. *Use Vegetation to Ventilate Your Space*
4. *Install Wind Chases and Vents*

WHAT YOU NEED TO KNOW

- Creating clear paths for air to flow through the home encourages passive ventilation.
- Passive ventilation relies on air currents generated by prevailing breezes, adjacent buildings and terrain and differences in temperature between spaces.
- Window and door placement, size and operation affect ventilation rate and effectiveness.
- Cross-ventilation refers to the concept of placing window and door openings to allow air to move into and out of a space or the whole house.
- Island Location – Puerto Rico is exposed to Caribbean Trade Winds, which determine the predominant wind direction (North-South).



Villas de Trujillo



SUPPORTING STRATEGIES

02	08	13	10	12
Reinforce Site with Vegetation	Anchor, Seal and Protect Openings	Mold and moisture control	Reduce Thermal Heat Transfer	Benefit from Natural Light

STRATEGY

11

INCREASE VENTILATION

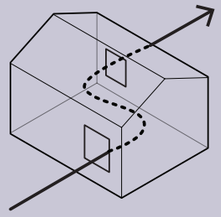
STEP 1 - PLACE OPENINGS IN THE BUILDING TO MAXIMIZE AIR MOVEMENT

- Cross Ventilation means that outside air moves into and out of a house in response to air pressure differences in such a way that air flow is induced in a large portion of the house or space.

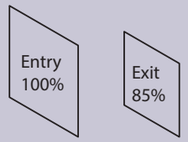
OPERATIONS AND MAINTENANCE TIPS

- Reposition furniture that blocks air flow.
- Make opening and closing windows easy.
- For jalousie, awning, and casement windows, replace broken window cranks and lubricate cranks periodically when you notice they do not fully extend the window.
- Trim landscaping away from windows.

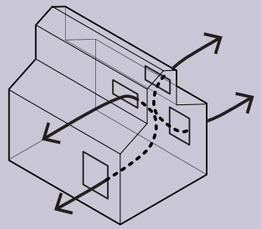
PROS



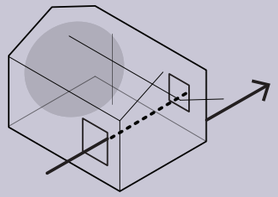
Maximize the amount of space that the air circulates through by misaligning windows.



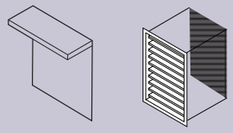
Exit openings should be slightly smaller than entry openings to increase wind acceleration and maximize flow. Partially closing exit windows enhances air flow.



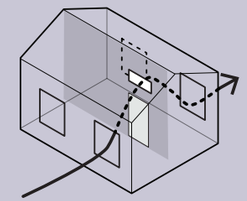
Install windows or openings near ceilings to drive hot air up and out.



Maximize constant flow by having parallel windows. Keep in mind that this will only ventilate the area that the wind passes through. NOT the best advice. Contradicts figure above. Wind tunnel effect. Ill-advised because it won't provide any mixing.

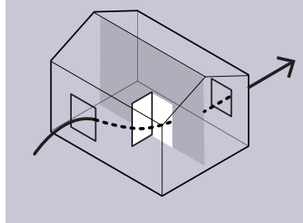


Protect Openings from rain and pests, by installing overhangs and screens. (See Strategy 12 | Reduce Thermal Heat Gain and Strategy 15| Manage Pests)Health improvement from controlling pests is a high priority because it impacts the health of residents.

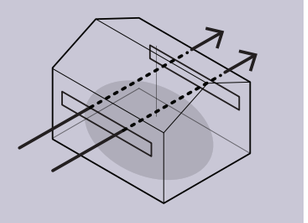


If walls and doors block the air path, implement openings in walls, louvered doors and transoms so air can go through.

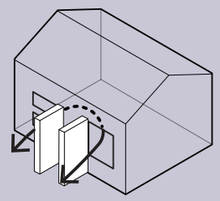
CONS



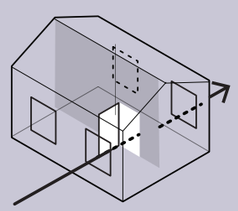
Cross Ventilation requires a minimum of two openings per room but If rooms have only one window, open the room's door and windows in other rooms so air travels through the house.



Place windows near occupants to maximize comfort provided by wind.



Cross ventilation between windows on the same wall can be induced with wing walls.

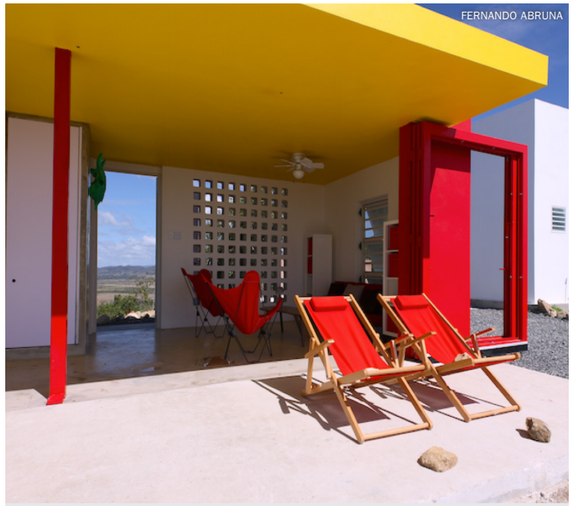


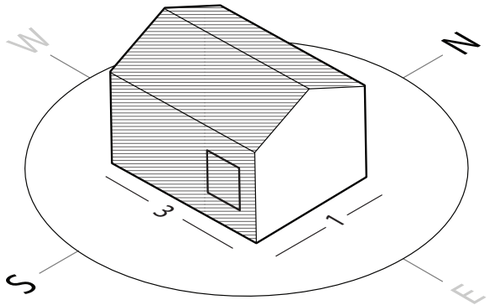
Ensure interior walls do not disrupt air flow.

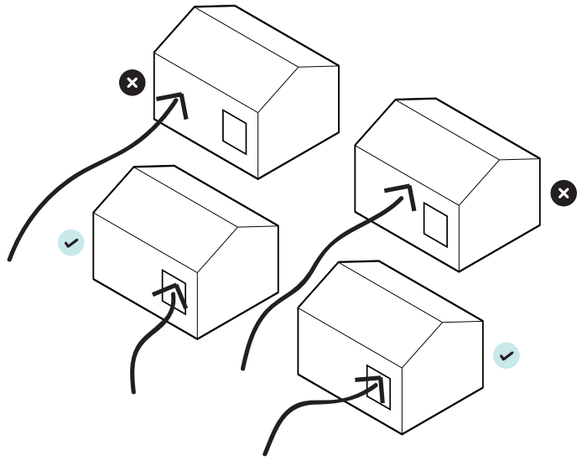
STRATEGY

11 INCREASE VENTILATION

STEP 2 - ORIENT YOUR HOME TO INCREASE NATURAL VENTILATION





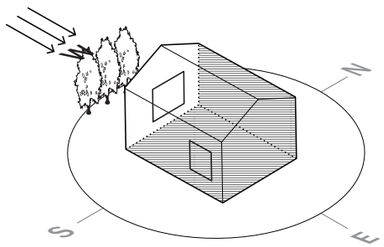


- Orienting a house or housing facility will impact ventilation in addition to capturing solar gain and controlling water.
- When determining how to orient your home as a new construction, or if you are substantially retrofitting a home, orient the longest facade and place windows north or south to capture prevailing winds.
- The ideal proportion for maximizing passive systems is 1:3
- When building a new structure or an addition, ensure there is adequate distance from adjacencies. Discuss this with a building professional.

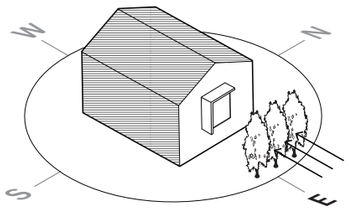
STEP 3 - UTILIZE VEGETATION TO VENTILATE YOUR SPACE



- Plant trees to direct breeze towards the house and openings.
- Do not plant trees very close together because foliage can work as a massive horizontal wall through which wind cannot permeate.
- Keep a distance between trees and the building to avoid damage during strong winds. The distance from the tree to the house should exceed the tree's height.



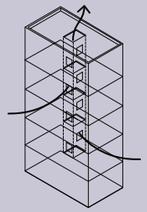
West



East

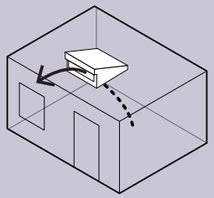
STEP 4 - INSTALL WIND CHASES AND VENTS

Hot air moves up. Installing towers or channels that allow hot air to exit the building cools a space.



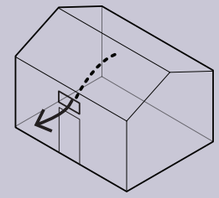
VENT TOWER

A continuous space throughout floors, such as staircases or a central atrium, can captures hot air from individual units and expels it upwards. For the technique to work, ensure each unit has an appropriate entry that allows wind to move.



WIND CHASES

An opening near the cusp of the ceiling that allows hot air to exit the space, thus reducing the temperature inside.



TRANSOM WINDOWS

An opening above the doors that allows hot air to exist space thus reducing temperature inside.

STRATEGY

12 BENEFIT FROM NATURAL LIGHT

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Natural light improves the quality and comfort of homes by efficiently illuminating interior spaces while lowering the overall energy consumption. Increasing natural light or 'daylighting' a room can provide light to occupants when electricity is not available. Windows and doors bring in light, but they can also make a space too bright or too hot. While placement and size of windows and doors is an important aspect of new construction, modifying shading on existing buildings can make the most of daylight while reducing temperature rise indoors. See Strategy 10 Reduce Thermal Heat Transfer.

Strategy in Action

Orient Your Home to Maximize Natural Light

2. Control Natural Light

A. Vegetation

B. zWindow Size

3. Choose Your Shutters

4. Create Light Shelves

5. Create Skylights

WHAT YOU NEED TO KNOW

- Daylighting is the utilization of sunlight to illuminate interior spaces.
- The lighting quality in your home is determined by:
  - **Adjacencies**: nearby structures, such as terraces or your neighbor's home, as well as vegetation, impact how much natural light goes into your house.
  - **Building Openings**: mechanisms, such as windows, doors, or skylights, that allow natural light in.



OPERATIONS AND MAINTENANCE TIPS

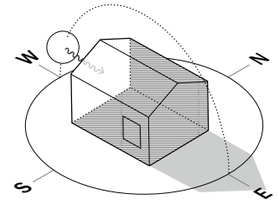
- Trim plants on ongoing basis.
- Check anchorage at shutter systems. Check for rust in metal elements and joints.
- Wipe windows and glass to reduce glare from grease and exposure to dirt and dust which can impede visibility.
- Ensure windows and penetrations into building appropriately water sealed to prevent water intrusion and pests.
- Orient new Units of Housing to take advantage of Light.
- Locate Vegetation Location to manage light exposure
- Size Windows to take advantage of light.
- Create Light Shelves and use Skylights to Open up Spaces to Light.

SUPPORTING STRATEGIES

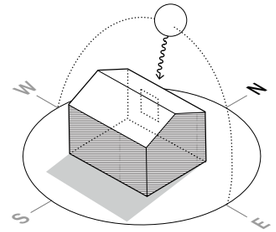
02	08	12	13
Reinforce Site with Vegetation	Anchor, Seal and Protect Openings	Benefit from Natural Light	Control Moisture and Mold

STEP 1 - CHOOSE THERMALLY EFFICIENT MATERIALS

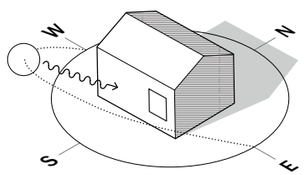
- The critical facades for sunlight are the ones located to the east, west and south. Orient a building in a way that the longer side faces north/south, and the narrower side faces east/west.
- Remember that the ideal proportion for maximizing passive systems is 1:3.
- Ensure that building facades are protected against direct sunlight.
- Remember that the ideal proportion for maximizing passive systems is 1:3.
- Ensure that building façades are protected against direct sunlight.



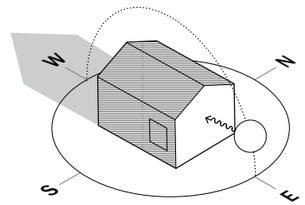
WEST
- In the afternoon, the West façade receives direct sunlight.
- Place your porch on the West side if you intend on using it in the afternoon.



NORTH
Throughout the day, the North façade receives indirect sunlight.



SOUTH
Throughout the day, the South façade receives direct sunlight.



EAST
- In the morning, the East façade receives direct sunlight.
- Place your porch on the East side if you intend to use it in the morning.

STRATEGY

12 BENEFIT FROM NATURAL LIGHT

STEP 2 - CONTROL NATURAL LIGHT

A. VEGETATION

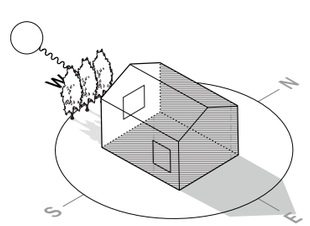
- Trees reduce direct sunlight.
- The foliage of the tree will provide the most shade. Ensure that the tree's height relates to the opening you wish to protect.
- Keep a distance between the greenery and the building to avoid damage during strong winds. The distance from the tree to the house should exceed the tree's height.



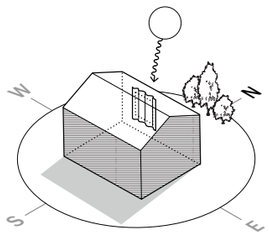
B. WINDOW SIZE

Size your windows according to sun exposure in the home.

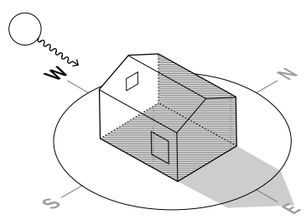




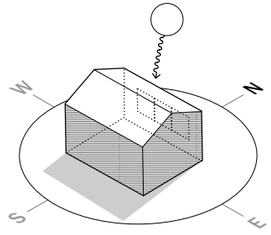
WEST
Plant tall trees on the West side to reduce afternoon direct sunlight.



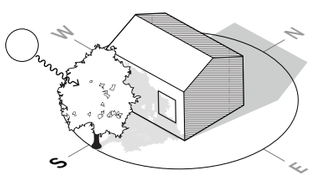
NORTH
Plant light greenery on the North side for glare control, if necessary.



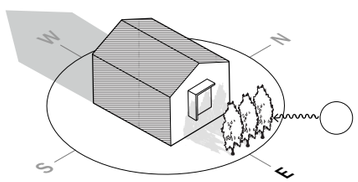
WEST
Minimize the quantity and size of openings in this façade. Since it is exposed to direct sunlight in the afternoon, it will increase heat gain.



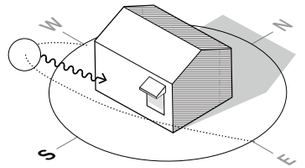
NORTH
Maximize the quantity and size of openings in this façade. Near sunrise and sunset in the summer, the North facade can briefly receive direct sun, but the energy impact is low. In May, June and July, the sun can be slightly north of directly overhead but with the slightest overhang it will miss the north facade.



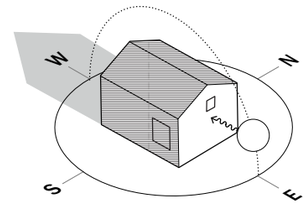
SOUTH
Plant tall bushes on the South side to reduce day-long direct sunlight.



EAST
Plant tall trees on the East side to reduce morning direct sunlight.



SOUTH
Shade openings, since they are constantly exposed to sunlight.



EAST
Minimize the quantity and size of openings in this façade. Since it is exposed to direct sunlight in the morning, it will increase heat gain.

STRATEGY 12

BENEFIT FROM NATURAL LIGHT

STEP 3 - CHOOSE YOUR SHUTTERS

- Choose a product that is rated to be hurricane proofed.
- Choose a product with following attributes for shades and curtains:
  - Higher RS (Solar Reflectance) values mean lighter colors reflect more heat away
  - Higher VLT (Visible Light Transmission) values mean more daylight is allowed to pass through
- The most common types of shutters are jalousie windows.
- If suitable for your building, lockable, exterior shutters anchored into a concrete frame will withstand an extreme weather event better than shutters anchored to a wood frame.
- Choose your shutter materials based on your available budget, durability and availability.

SHUTTER STYLES



VERTICAL

- Vertical oblique: Protects against sunlight entering from a horizontal direction, but not from above.



HORIZONTAL

- Solid horizontal: It's minimal geometry makes it structurally sound, but it only offers 50% of sun protection.
- Movable horizontal devices: Provides full protection from the sun when completely open, and offers space to isolate heat between the shutter and the outside surface. Operable systems are recommended.



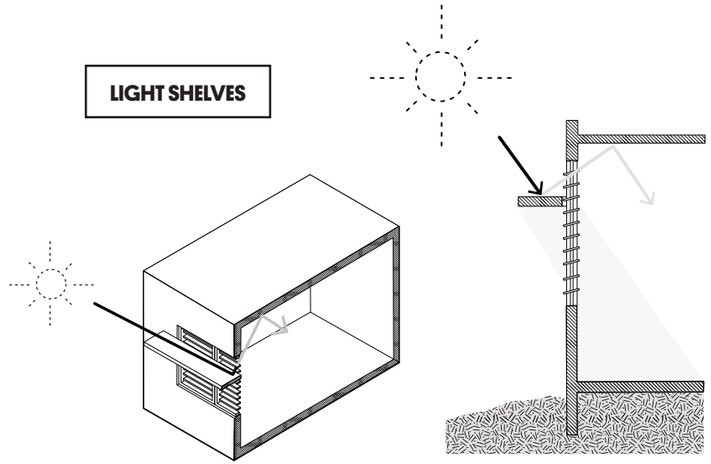
MIXED

- Movable horizontal louvers: Protects opening from direct sunlight coming in from all directions.
- Movable louvers: Allows the user to open during the part of day where the sun is not directly hitting each façade. Operable systems are recommended.

STEP 4 - CREATE LIGHT SHELVES

- A horizontal unit installed in the interior of a space that:
  - Blocks direct light from entering the home
  - Redirects light to the ceiling to illuminate interiors indirectly.
- Some systems in the market are operable and protect from high winds when shut.

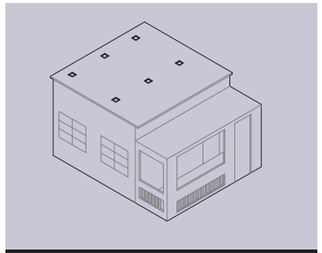




STEP 5 - CREATE SKYLIGHTS

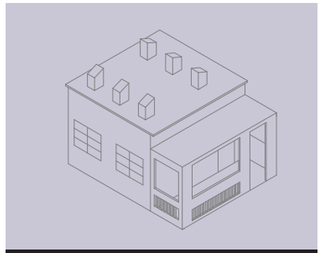
Skylights are openings in the roof that help illuminate spaces that are not contiguous to the building's façade.





ORNAMENTAL GLASS BLOCK

$ Lets in diffused light



SKYLIGHT TOWERS

$$$ Lets light in and filters out radiation. They can be customized to your home.

STRATEGY

13 CONTROL MOISTURE AND MOLD

$-$$

Mold is a fungus that compromises indoor air quality and the material integrity of windows, doors, foundations, walls, roofs, and interior finishes. Even small amounts of mold pose health threats to people who are immunocompromised or have respiratory conditions such as asthma. Mold thrives in moist and humid environments. Flooding, heat, humidity, and precipitation are perfect conditions for mold development, while porous materials are the perfect medium for its growth. This strategy focuses on mold prevention by eliminating sources of moisture.

Strategy in Action

1. *Inspect Your Home*
   a. *Check for Water Leaks to Prevent Mold*
   b. *What to Look for*
2. *Reduce Sources of Moisture*
   a. *Floods*
   b. *Leaks*
   c. *Condensation*

WHAT YOU NEED TO KNOW

- Mold development is propelled by:
  - **Amount of moisture**: Mold needs water to grow. Controlling moisture levels on exterior home surfaces and in indoor spaces reduces the potential for mold growth. Even though spores are present year-round, higher than usual temperatures, sudden temperature changes, humidity, and moisture accelerate their growth by dissolving the nutrients present in materials. Moisture occurs through:
  - **Precipitation:** rain enters a home through holes and cracks in the roof or walls.
  - **Humidity:** moisture occurs through condensation (when moist warm air meets cold surfaces) or though spills and plumbing leaks. It can also occur from cooking or bathing.
  - **Floods:** water enters a home through the ground. In other words, water filters through floor structure, foundation, and soil.
- The high moisture content that precedes mold growth can seriously compromise home components before mold appears.
- **Type of materials:** A material's chemical characteristics and how much moisture it can absorb make it nutrient rich in substrates that feed mold.
- Natural ventilation and daylight keep spaces dry and less prone to mold. See Strategy 11 and Strategy 12 for information on ventilation and how to benefit from natural light.

SUPPORTING STRATEGIES

11	12	26
Increase Ventilation	Benefit from Natural Light	Begin Household Recovery

REMEMBER

- Hire a professional mold remediation professional!
- The United States Environmental Protection Agency (EPA) and Centers for Disease Control (CDC) recommend hiring trained mold remediation professionals if mold growth covers more than 100 square feet (a 10 ft. by 10 ft. area).
- Inappropriate treatment can spread fungi to other surfaces and into the air, thus worsening the situation.
- Inform the hired professional of any water leaks, flood incidents, and/or previous moisture problems.
- "Ensure that the moisture problems have been resolved as part of the remediation process, otherwise the mold is likely to return."
- Reasons for hiring a professional mold inspector:
  - The inspector will recognize the different types of mold.
  - The inspector will find mold in places you might not think there is mold.
  - The inspector will bring industrial equipment, like moisture meters, to find all hidden mold growth without disturbing your home.
  - The inspector will know the best way to contain and remove large colonies of mold without spreading spores (also known as mycotoxins).



STRATEGY 13

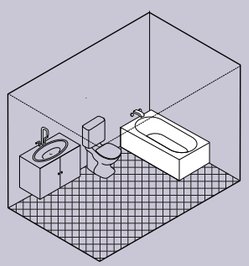
CONTROL MOISTURE AND MOLD

STEP 1 - INSPECT YOUR HOME

If you suspect you have mold, hire a mold inspector (see inset).

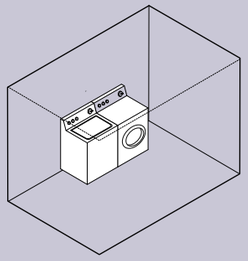
- **Olfactory Inspection**: Not all mold species are visible. Musty/moldy smell is an accurate indicator of the presence of mold.
- **Visual Inspection**: Look for changes on color and/or texture on the surface of the materials. Molds show usually as dark sets of rounded spots, although they can take other shapes and colors. Note however that not all stains caused by humidity are always mold. Molds are often confused with efflorescence, discolorations and substance infiltrations.
- **Moisture Inspection**: Look for evidence of water intrusion such as drip lines, water marks, mildew, and bubbled paint. Determine the source of the water and take action to eliminate or control it. Use a moisture meter to monitor your space and find concealed mold and water damage. A moisture content above 14% indicate that your space is humid enough to develop mold.

A. CHECK FOR WATER LEAKS TO PREVENT MOLD



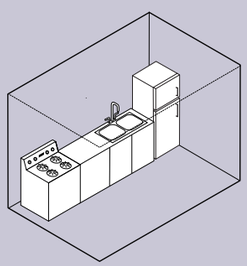
BATHROOM

Clean toilet bowl, tiles, and sink regularly to prevent mold growth.



LAUNDRY ROOM

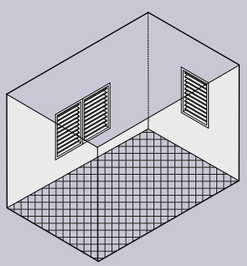
Pay close attention to the area behind and under the washer.



KITCHEN

Pay close attention to sinks and fridges, checking also their backs and underneath areas.

- Check cabinets' interior regularly.
- Keep dry the backsplash and/or any other surface prone to condensate moisture coming from cooking and/or boiling.

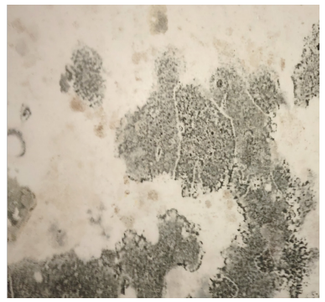


SURFACES

- Identify condensation in openings, walls, or ceilings, both inside and outside.
- Identify condensation in areas that generate sudden temperature changes, such as kitchen backsplashes and surfaces nearby air-conditioning (AC) units.
- Inspect areas that regularly flood or are prone to flooding.
- Inspect any plumbing connections under the sink or to an ice-maker.



B. WHAT TO LOOK FOR



MOLD

WHAT IT IS

A superficial growth produced by a fungus.

WHERE IT DEVELOPS

Nutrient rich and moist materials like wood or concrete such as lumber, plywood, and paper facing of drywall and batt insulation. Even dusty surfaces since dust is a mold food.

HOW TO PREVENT IT

See Strategies in the following pages.



EFFLORESCENCE

WHAT IT IS

Efflorescence is the deposit of salt in the surface of a porous material. It manifests itself like a white coating.

WHERE IT DEVELOPS

Materials composed of soluble ingredients, which disintegrate in the presence of salt, such as concrete.

HOW TO PREVENT IT

Apply a hydrophobic sealant to prevent water absorption.



RUST STAINS

WHAT IT IS

A discolored spot on a particular surface.

WHERE IT DEVELOPS

Concrete walls or ceilings, because of rebar rusting.

HOW TO PREVENT IT

Contact a contractor and/or specialist to provide advice regarding potential required repairing of the impacted/damaged area

STRATEGY 13

CONTROL MOISTURE AND MOLD

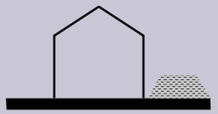
STEP 2 - REDUCE SOURCES OF MOISTURE AND KEEP THE BUILDING DRY

Floods, stormwater, and humid air are sources of water which bring about moisture. Identify the source to protect your home and keep it mold-free.

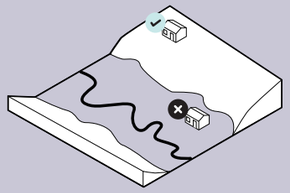


A. FLOODING

A temporary condition of partial or complete inundation of normally dry land areas.







HOW TO PREVENT IT

- Refer to Strategy 9 on Flood Proofing Structure.
- Use sandbags or other flood proofing methods to prevent flood water from entering the house.

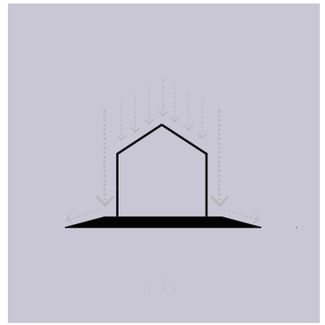
- Cover the roof with a waterproof membrane to reduce rainwater intrusion. See Strategy 07 | Assemble a Sturdier Roof.
- Install an interior foundation drainage system.

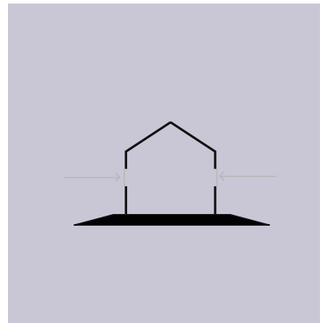
- For new construction, build your home above the floodplain.

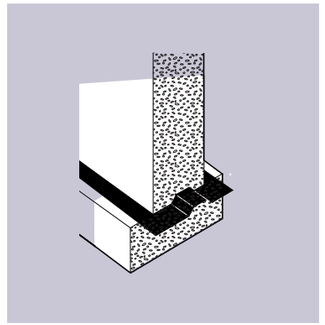
B. LEAKS

Cracks in roofs, ceilings, or walls allow entrance of moisture.









HOW TO PREVENT IT

- Flash and seal penetrations into roof and walls for plumbing and electrical.
- Place container underneath the leak while you seal it. Empty container at least daily to reduce indoor humidity.
- Ensure the home's drainage is working properly.
- Keep drainage paths clear.
- Drain rain to ground from foundations and crawl spaces by establishing capillary breaks to separate the ground from the structure.
- Eliminate low spots of roofs, standing water seeps into porous materials to ceiling.

- Avoid interior finishes that are vapor flow retarders.
- Seal or flash leaks on your doors or windows. See Strategy 08 | Anchor, Seal + Protect Openings.

- For new construction ensure there is a capillary break, like a vapor barrier is placed below a concrete slab before pouring the concrete.

STRATEGY 13

CONTROL MOISTURE AND MOLD

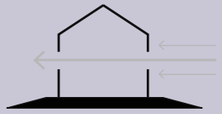
STEP 2 - REDUCE MOISTURE AND KEEP THE BUILDING DRY

OPERATIONS AND MAINTENANCE TIPS

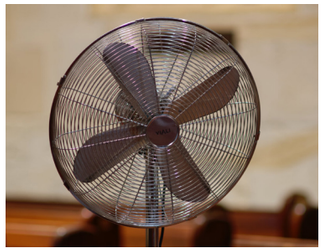
- In areas with regularly high temperatures and high humidity, inspect regularly for leaks and verify drainage takes water away from house (see Safe Site).
- Check plumbing connections to verify there are no drips. Include ice maker lines and washing machine hose connections in your inspection.
- Keep ceiling and exhaust fans clean and in good condition to maintain air flow.
- Ensure that drainage paths are maintained going from the roof, down the wall, away from the house, and away from the site, into the street gutters to avoid dumping water onto your neighbor's site.
- Maintain drainage by cleaning gutters, removing debris off the roof, evening out the surface of the roof to prevent ponding, keeping landscaping next to the foundation below finish floor level.

C. CONDENSATION

- Occurs when moist air encounters a cold surface, and turns into water.
- Condensation may hide inside or behind household materials.







HOW TO PREVENT IT

- Naturally or mechanically ventilate your home specifically areas with high humidity kitchen, bathroom & laundry. See Strategy 13 | Increase Home Ventilation.
- Dry condensed water from AC promptly. Avoid having AC air blowing on glass or metal surfaces such as windows.
- Use a dehumidifier to reduce moisture level and make sure to empty it regularly. For continuous dehumidifier use, connect a condensate line to drain water outdoors or to another drain. A small portable dehumidifier may not be sufficient by itself to remove all necessary moisture in a space that is not air conditioned.
- Indoor air circulation: mechanical fans can also even out interior humidity and force air out of building



D. MATERIAL

Porous materials absorb and retain moisture. Wall paper, gypsum board, wood, paint/primers that are not treated with antimicrobial agents, lumber, plywood, paper facing of drywall, batt insulation, and dusty surfaces since dust is a mold food.

Use materials without cellulose and other natural fibers to deprive mold of food and limit growth.







HOW TO PREVENT IT

- Remove materials that have been wet for more than 48 hours.
- No vinyl flooring, 6 mil poly under slabs, footers, and on bare earth crawl space floors.
- Recommended material is concrete floors or a surface finish such as terrazzo or stained concrete.
- Use 6 mil poly under slabs, footers, and on bare earth crawl space floors.
- Use waterproof materials or sealers so when water retreats, it is easy to clean and repair.



STRATEGY

14 MANAGE PESTS

$-$$

Pests are organisms that transmit disease. Under the right conditions, they can reproduce quickly and cause an epidemic. Pests create waste that can impact health of housing occupants by impacting air quality, leaving waste and biting occupants. Pest-transmitted disease like ZIKA impact the health of communities leading to a public health crisis. This strategy focuses on actions that individual homeowners or communities can take towards preventing and mitigating pests in a way that promotes non toxic solutions to managing pests–referred to as Integrated Pest Management.

Strategy in Action

1. *Protect against Flying Pests*
2. *Protect Against Crawling Pests*

WHAT YOU NEED TO KNOW

- Pest growth and spread is determined by disruptions to their habitats:
  - Natural events
  - Hurricanes
  - Earthquakes
  - Heavy rains
  - Soil Movement

SIGNS OF PESTS

- Droppings around food packages, in drawers or cupboards and under the sink.
- Musty smell
- Signs of nests built out of shredded paper, fabric or dried plant matter.
- Signs of chewing on food packaging and in the walls and on furniture
- Black or brown streaks on the walls between packages and furniture (rodents like to squeeze through tight spaces)
- Holes chewed through walls and floors that create entry points into the home.

SUPPORTING STRATEGIES

03	05	08	29
Plant and Edible Garden	Build a Stronger Foundation	Anchor, Seal and Protect Openings	Inspiring Post-Disaster Planning for Community

STEP 1. PROTECT AGAINST FLYING PESTS





THEY CARRY

MOSQUITOES	FLIES
■ Yellow fever ■ Dengue ■ MalariaZika ■ Chikungunya	■ Typhoid fever ■ Cholera ■ Dysentery

WEAR PROTECTIVE CLOTHING AND REPELLENT

Some protection is offered by protective clothing such as long-sleeved shirts, head nets, collars, and hats.

Repellents are only partially effective against swarms of biting midges. When choosing repellants, look for products that are DEET-free and effective at repelling a wide range of mosquitoes, ticks, and other bugs. Be careful when using repellents since they can irritate eyes and in intense doses may induce neurological damage.

Alternatives include Picardin, referred to as “Icaridin” which is a synthetic compound derivative ofcompounds found in black pepper. Studies show that it performs as well as DEET. The repellent is so effective, the World Health Organization recommends Icaridin, alongside DEET and another repellent called IR3535, as one of the best choices for preventing mosquito bites that can lead to disease.

The oil of lemon eucalyptus is a natural insect repellent. The oil of this Australian plant is refined into a substance known as PMD, which can be an effective aid to ward off mosquitoes and can be found in several brands of repellent.



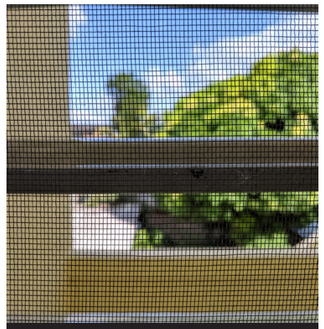
OPERATIONS AND MAINTENANCE TIPS

- Ensure wood is treated to prevent termites.
- Inspect window and door screens for holes since pets can break the mesh with their claws and beaks.
- Maintain a sufficient supply of your preferred insect repellent.
- Call an expert or pest control service to fumigate the home at a time when no residents or pets are inside.
- For multi-family buildings, develop standard pest management protocols and best practices for preventative maintenance, occupancy turnovers, and storage spaces.
- Place food in a pest proof container.

STRATEGY

14 MANAGE PESTS

REMEDIES AGAINST FLYING PESTS



INSTALL WINDOW SCREENS

Install a metal mesh screen so flying pests cannot access the interior of your home, especially at nighttime.



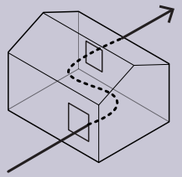
REMOVE STILL WATER

Stagnant water attracts flying pests. Drain flower pots, garbage cans, or street holes. If you cannot remove the water, cover with a lid.



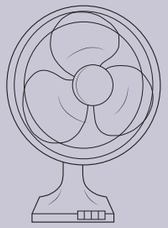
PLANT AN HERB GARDEN

-Plant lemon, basil, lemon balm, lavender, and peppermint which are traditionally used to ward off flying pests.



PASSIVE VENTILATION

- Use passive ventilation systems to push pests out of your home and prevent them from coming in.
- See Strategy 11 Increase Ventilation for more information.



ACTIVE VENTILATION

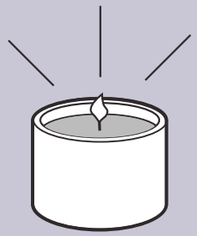
Low energy fans can divert flying pests from entering your home or approaching you.



MOSQUITO LAMPS

UV mosquito lamps can be used to repel mosquitoes from a site, your deck, or patio. These devices use butane heaters or candles to warm up pads containing the insecticide allethrin which is the same chemical used in most mosquito coils.

The products claim to offer up to 15 feet of odorless bug protection, but their effectiveness drops when there's a breeze.



CITRONELLA-BASED CANDLES OR LAMPS

This citronella candle can be effective at creating a perimeter around outdoor areas to keep mosquitoes away. It can somewhat help ward off mosquitoes because the smoke from candles or lamps can confuse the bugs and prevent them from smelling you. It is often combined with other essential oils such as lemongrass and spearmint. For maximum benefit, it is best to combine this method with other stated methods.

Mosquito coils: Like citronella candles, mosquito coils produce a smoke that confuses mosquitoes. The coils contain the insecticide allethrin.

Bees are not Pests!

The greatest contribution of bees and other pollinators is the pollination of nearly three quarters of the plants that produce 90% of the world's food. A third of the world's food production depends on bees. This means that every third spoonful of food depends on pollination (i.e., fruit, vegetables, seeds, nuts, and oil seeds). Bees are vital for the preservation of ecological balance and biodiversity in nature.

Bees also act as indicators of the state of the environment. Their presence, absence, or quantity tells us when something is happening with the environment and that appropriate action is needed. Climate change and the use of pesticides causes some flowers to bloom earlier or later than usual, leaving bees with fewer food sources at the start of the season. Also, bees suffer habitat loss from development and the lack of bee-friendly flowers.



STRATEGY 14

MANAGE PESTS

STEP 2. PROTECT AGAINST CRAWLING PESTS



CENTIPEDE

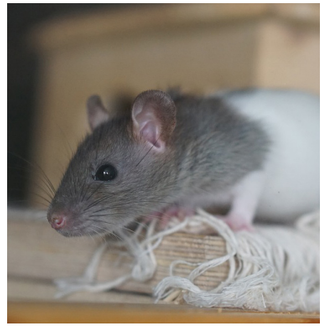
THEY CARRY

- Venomous bite that can cause anaphylactic shock



COCKROACHES

- Can contaminate food and carry Salmonella



RODENTS

- Carry Leptospirosis, Typhoid fever, Cholera, Dysentery.



IGUANAS

THEY CARRY

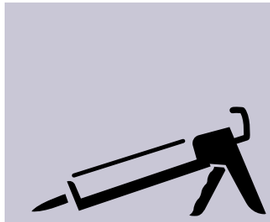
- Destroy gardens, crops and native species.

REMEDIES AGAINST CRAWLING PESTS



CONTROL VEGETATION GROWTH

- Ensure vegetation is maintained and trimmed to prevent crawling pests from creating a colony.
- Protect trees and plants by wrapping chicken wire barriers around the trunk.



SEAL OPENINGS

- Seal all wall, floor and joint small holes with steel wool and low VOC caulk. For holes greater than ¼" use rodent and corrosion proof screens (stainless steel or copper) or cement.
- See Appendix for locations.



INSTALL RODENT BAIT STATIONS

- Install a rodent bait station, a child and pet friendly box that traps rodents in a safe and humane way.
- Works indoors or outdoors.
- Use as directed by manufacturer.

STRATEGY

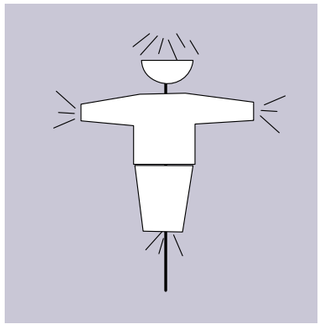
14 MANAGE PESTS

REMEDIES FOR CRAWLING PESTS



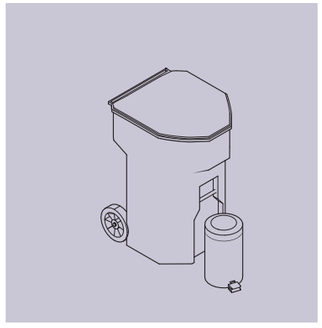
ELEVATE YOUR HOME

- Elevate your home min. 3’ from the ground.
- Maintain a gap between entry and stairs to avoid pests from crawling inside.
- (See Strategy 05 | Build a Stronger Foundation)



USE SCARECROWS/PLASTIC BAGS

- Iguanas are startled easily by sounds and movement. Place a scarecrow or a plastic bag in your backyard to scare them off.



USE PEST PROOF TRASH RECEPTACLES



CASA AUSENTE. FERNANDO ABRUÑA



FERNANDO ABRUÑA

PROGRAMA DE EDUCACIÓN COMUNAL DE ENTREGA Y SERVICIOS (PECES, INC.)

Interviewees: Jose J. Oquendo y Carlos A. Vazquez; PECES, Inc.

Description: Programa de Educación Comunal de Entrega y Servicios (PECES, Inc.) provides prevention, education, and professional training services for communities in Puerto Rico. Its mission is to promote educational, economic, and social development throughout the southeast area of the island. After Hurricane Maria, PECES, Inc. formed an alliance with GlobalGiving in an effort to help the Punta Santiago community in Humacao, to repair and rebuild 100 homes, whose residents, a year after the disaster, have been unable to repair. PECES also works to promote the local economy by hiring local builders and contractors for repairs and appraisals. Moreover, whenever possible, the program buys all the necessary materials through local companies. In July of 2018, PECES reported that their services had helped a total of 28,874 families, 18 municipalities, and 40 communities, with the support of about 565 volunteers.

INTERVIEW

PECES, Inc. is a non-profit organization that focuses its efforts on the municipalities in Puerto Rico's eastern region, from Canovanas to Maunabo, as well as the island municipality of Vieques. We are currently also serving the island's mountain municipalities of Barranquitas and Aibonito. PECES' main objective is to promote education. Bearing this in mind, we provide an alternative educational setting for students who haven't been able to obtain a continuous education. Our alternative school has been operating for 25 years, and we receive around 200 students every year. Another one of our initiatives is focused on the community's economic development, as a way to eradicate poverty by holding solidarity economy as a pillar for growth. An example of this initiative is the Punta Santiago Natural Reserve. In this project, we paired the conservation of natural resources and assets with the community's economic growth through the small shops we have established there for visitors and eco-tourists. Since our organization is located in Punta Santiago, we thought we knew and were aware of everything that happens in the area. Nonetheless, we came to realize that this just wasn't the case. Maria helped us identify the main needs of our community. For example, even though residents had no food, the home was seen as the foremost priority because people here literally didn't have a roof over their heads. Maria came to redefine this process, the way we approach immediate response, and what we take into account when a disaster hits.

For one of our first response efforts, we all gathered as an organization and began visiting every single home in the community to let neighbors know what was happening, and they in turn kept others informed as well. It basically became a communication chain and we started developing small "clusters" of information. The documentation of all events through social media proved useful for us as well. This also helped put Punta Santiago in the public eye.

If we had to share something about our own experiences, I believe that the hardest challenges we faced were:

1. Upholding transparency and prioritizing ethics during the process. We follow a well-structured work flow, but we knew we were all going through the same situation on different levels and under particular circumstances. So, to protect our image as an organization as well as our team, we worked hard to organize and document the delivery of purchases, water, and materials. We documented everything in case somebody questioned our integrity; that way, we had the information available to show donors, residents, and whoever requested proof that the aid supplies had been distributed among members of the community, not PECES staff.

2. How to give ourselves some space (as a team) to process the situation before working with and for the community. As I mentioned beforehand, we all experienced this event in different ways and had additional family-related concerns that came up as we worked as an organization within the community. Therefore, before working with the community, we equipped our team with the space and tools (such as access to psychologists) to receive emotional support and be able to carry on with their duties.

3. Prioritizing the community's needs.

4. How to distribute all aid supplies received and manage disaster capitalism. It became very hard for us to deal with this matter because, thanks to everything we documented on social media about what was happening in Punta Santiago, we were able to obtain financial aid and donations of food, provisions, etc. However, there were always companies and/or celebrities visiting us to promote their product or image. We noticed this was the case when they showed up with production teams, cameras, music, among other things. We always got people who came to help because they truly wanted to, but others came just for the publicity.





PLENITUD, LAS MARIAS

For more information, visit
https://www.plenitudpr.org/

Description: Plenitud is a non-profit organization located in the municipality of Las Marias that provides agricultural education and sustainability services. Part of its mission is to inspire the immediate community to embrace more sustainable practices and a culture of service. This project was launched in 2008 and was incorporated as an organization in 2010. Afterwards, in 2011, Plenitud established its 15-acre farm in Las Marias.

INTERVIEW

Since the idea to develop Plenitud was born, we were already getting ready for a scenario where climate change and the system's instability could affect us. Consequently, we began a project to collect rainwater to use for compost, crops, food, and cooking, among other things. We have 2 tanks (5,000 gallons each) that enabled us to help the community. Additionally, we had bought food in bulk prior to the hurricane, such as grains, rice, some spices, which we stored in large buckets.



After the hurricane, we first tried to clear the path to leave the farm. Once we did this, we sent people with first-aid kits and gallons of water to check up on our neighbors who live in the surrounding areas. Afterwards, we took a walk to identify which roads were closed off and which ones could serve as fast and easy access. We then started clearing the roads that provided the most direct access to the main roads. We also participated in multi-sectoral gatherings coordinated by the municipality as part of their community outreach efforts. The goal was to provide health services, food, and clothes for people in different communities.

Just as it was for everyone, communication was one of our biggest challenges. However, we have walkie talkies, which we use to communicate with each other in the farm. We use them because the farm spans 15 acres and we sometimes work well into the night. Maria helped us realize how important these are to stay in contact with one another. Another challenge related to the lack of communication was that, at the time, we had 5 student volunteers that had come from the United States and had to spend the hurricane here. Although we were at ease because we had collected water and had bought and stored sufficient food, those first days were hard, because we wanted to be able to tell the parents of these students that they were all right.

I think that the main lesson we learned was that, at times like these, collaboration between different sectors is important. We also witnessed the importance of religious leaders and churches. The people who go to church are usually the ones who know where other neighbors live, whether it's the little old lady that lives alone, the single mother, the bedridden old man, etc. At least here, in Las Marias, there are no well-known community leaders, so in this case, the churches have become that community liaison.

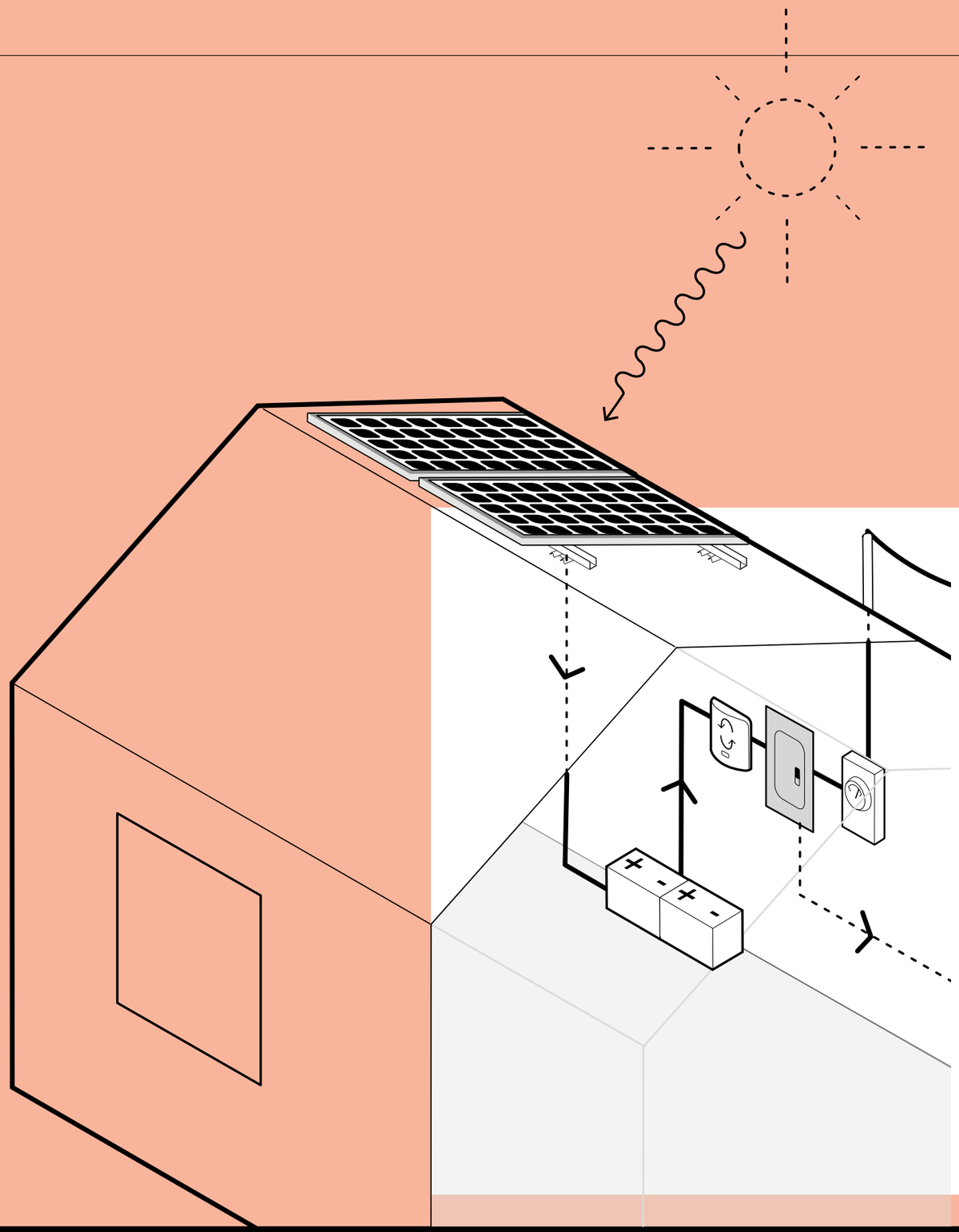


PABLO MARVEL
BUENA VISTA COMMUNITY CENTER SANTURCE
RESILIENT POWER PUERTO RICO

SCOTT LAHN
EL COQUI COMMUNITY CENTER
RESILIENT POWER PUERTO RICO

CHAPTER

4



ENERGY GENERATION + BACKUP

Strategies that provide critical needs for power when a facility loses power or other services

TYPES OF STRATEGIES LISTED IN THIS SECTION

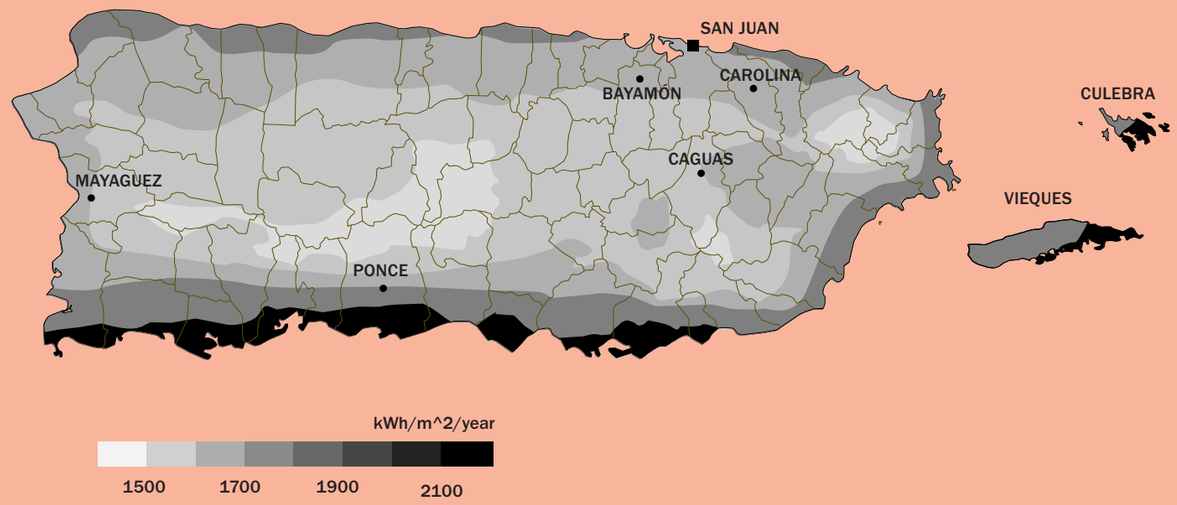
STRATEGY #	15	16	17	18
STRATEGY NAME/TITLE	REDUCE YOUR ENERGY USE	INTEGRATE SOLAR ELECTRICITY	INTEGRATE SOLAR THERMAL ENERGY	INSTALL ENERGY BACKUP
DESCRIPTION	The first step to reduce energy consumption is to know how much we are consuming, and think through which uses are critical. Installing energy-efficient fixtures and complementing your electric systems with passive strategies will further help reducing your energy consumption while making sure to supply your most important needs during an emergency.	This strategy focuses on explaining the basics of how to evaluate a home's potential for solar energy use as well as, and the basics of how to harness its possibilities.	Solar thermal systems use the heat from the sun to heat water as opposed to solar photovoltaic (PV) which uses solar energy to energize a home. This system allows it to depend less on electric water heating and reduce costs. This strategy focuses on explaining how the system works, how to purchase it, and how to install it.	Backup energy systems offer homes the ability to power essential equipment when the electrical grid is not available. This strategy focuses on explaining how to choose a generator and how to install it.
	$-$$	$-$$$	$-$$$$	$$-$$$

The majority of electrical power in Puerto Rico is produced, transmitted, distributed, and sold by a single source: the Puerto Rico Electric Power Authority (PREPA)/Autoridad de Energía Eléctrica Puerto Rico (AEEPR, by its Spanish acronym). When PREPA's power plants (largely fueled by natural gas and imported oil) and power lines were completely disabled by Hurricane Maria, millions of people suddenly went without the conveniences of modern life (electricity, refrigeration, and Internet service). Water distribution became impossible when pumps lost power. The situation became life-threatening for people whose medical care depended on electrical devices. Seniors and others who needed air-conditioned spaces suffered from heat-related illnesses. Best estimates indicate that the death toll in Puerto Rico grew by a factor of approximately 1700% in the three months following Maria's landfall, partly because of the lack of electricity, potable water, and limited access to medical facilities and healthcare.

For years, it has been common knowledge that both equipment and purchasing sources of electricity need to be diversified. Hurricane Maria accelerated the development of new options for homes and communities that are both greener (not dependent on fossil fuels) and more resilient. A growing, alternative energy industry is making renewable technology, such as solar panels and solar thermal systems, available to more people, and is working towards localizing distribution through micro-grids. While emergency generators remain a good support for short-term power loss, new energy systems can provide long-term value.

Along with these technological solutions, the way to scale down dependence on electrical suppliers is to reduce daily energy consumption patterns in your home. This chapter explains how to live using less power, how to evaluate alternative energy systems for year-round use, and how to manage a backup system to get through an emergency.

HORIZONTAL SOLAR IRRADIATION IN PUERTO RICO



STRATEGY

15 REDUCE YOUR ENERGY USE

$-$$

Many homes depend on generators on a frequent basis. Energy efficiency is of critical importance if you need backup power, if limited grid power exists, or if you decide to have the home solar energy powered. In addition to surviving power loss, reducing energy consumption will also save households money. This strategy focuses on identifying easy ways to conserve and use energy efficiently to save on home energy bills and reduce the cost of any renewables, battery, or generators.

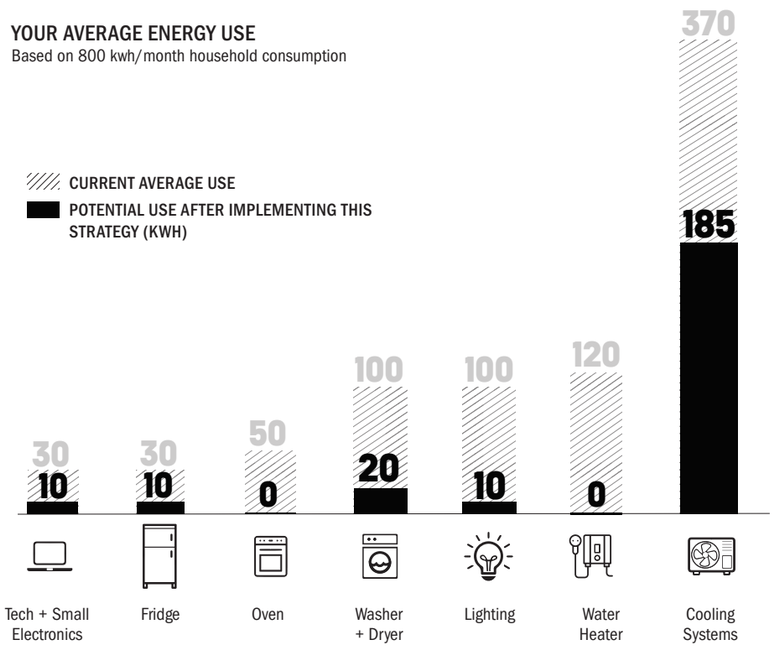
Strategy in Action

1. *Identify Your Electric Energy Consumption*
2. *Install Energy Efficient Equipment and Fixtures*
3. *Establish Critical Loads*
4. *Implement Passive Strategies*
5. *Conserve Energy*

WHAT YOU NEED TO KNOW

- A typical home in Puerto Rico consumes between 500 and 1,000 kWh per month.
- This strategy will allow you to reduce your energy consumption by more than 70%.
- Once your energy consumption is lowered, the next step is estimating total home energy use as well as critical power energy use. This information is important for determining energy budgets and making decisions regarding renewable energy systems, batteries, or generators.

YOUR AVERAGE ENERGY USE
Based on 800 kwh/month household consumption



STEP 1 - IDENTIFY YOUR ELECTRIC ENERGY CONSUMPTION

Use your electric energy bill to understand your monthly consumption. Plug the result in the equation below to know your yearly consumption.

UNITS	POWER (W)	KILOWATT-HOUR (KWH)	VOLTAGE (V)
DESCRIPTION	The amount of energy used over a period of time. It is measured in watts.	A unit that equals 1000 watts in one hour. The AEE charges you per kWh.	Voltage is the pressure from an electrical circuit's power source that pushes charged electrons (current) through a conducting loop or circuit, enabling them to do work such as illuminating a light. In brief, voltage = pressure, and it is measured in volts (V).



SUPPORTING STRATEGIES

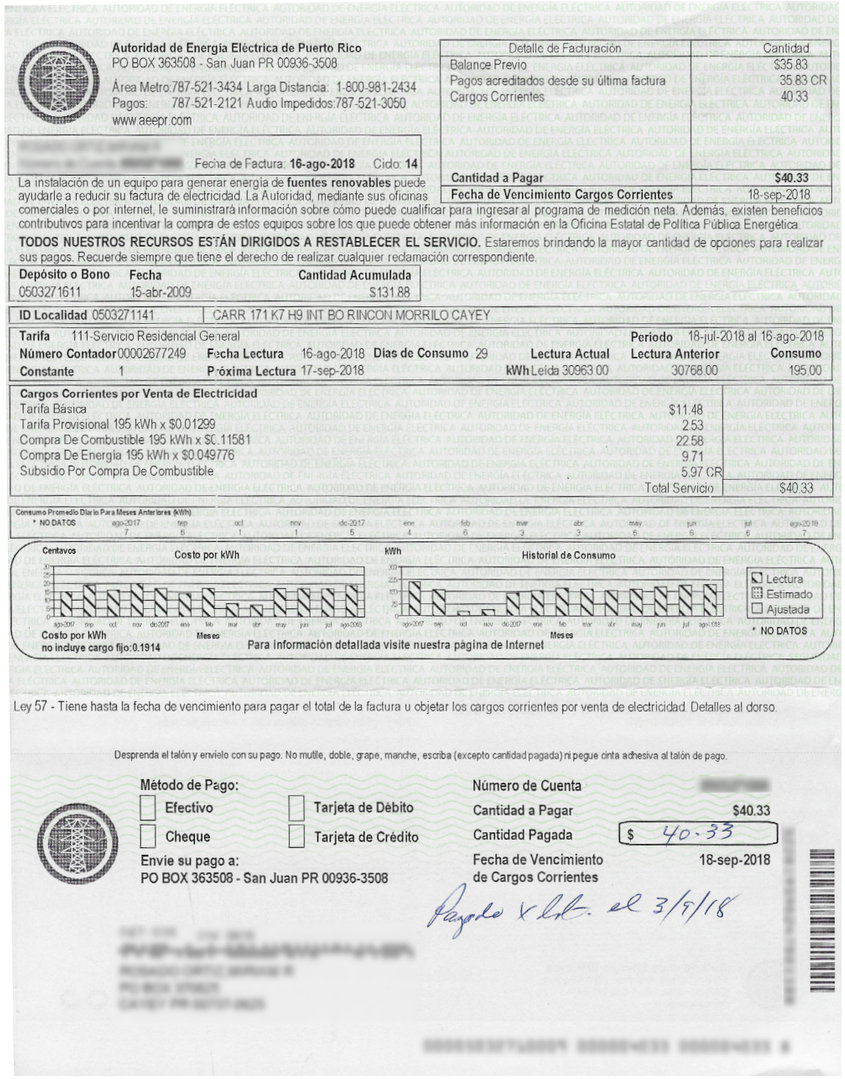
10	11	12
Reduce Heat Transfer	Increase Ventilation	Benefit from Natural Light

STRATEGY 15

REDUCE YOUR ENERGY USE

STEP 1 - IDENTIFY YOUR ELECTRIC ENERGY CONSUMPTION

PAPER BILL



Autoridad de Energía Eléctrica de Puerto Rico
PO BOX 363508 - San Juan PR 00936-3508
Área Metro:787-521-3434 Larga Distancia: 1-800-981-2434
Pagos: 787-521-2121 Audio Impedidos:787-521-3050
www.aeepr.com

[redacted] Fecha de Factura: **16-ago-2018** Ciclo: **14**

Detalle de Facturación	Cantidad
Balance Previo	$35.83
Pagos acreditados desde su última factura	35.83 CR
Cargos Corrientes	40.33
Cantidad a Pagar	**$40.33**
Fecha de Vencimiento Cargos Corrientes	18-sep-2018

La instalación de un equipo para generar energía de **fuentes renovables** puede ayudarle a reducir su factura de electricidad. La Autoridad, mediante sus oficinas comerciales o por internet, le suministrará información sobre cómo puede cualificar para ingresar al programa de medición neta. Además, existen beneficios contributivos para incentivar la compra de estos equipos sobre los que puede obtener más información en la Oficina Estatal de Política Pública Energética.

TODOS NUESTROS RECURSOS ESTÁN DIRIGIDOS A RESTABLECER EL SERVICIO. Estaremos brindando la mayor cantidad de opciones para realizar sus pagos. Recuerde siempre que tiene el derecho de realizar cualquier reclamación correspondiente.

Depósito o Bono	Fecha	Cantidad Acumulada
0503271611	15-abr-2009	$131.88

ID Localidad 0503271141 CARR 171 K7 H9 INT BO RINCON MORRILO CAYEY

Tarifa 111-Servicio Residencial General
Número Contador 00002677249 **Fecha Lectura** 16-ago-2018 **Días de Consumo** 29 **Lectura Actual** kWh Leída 30963.00 **Periodo** 18-jul-2018 al 16-ago-2018
Constante 1 **Próxima Lectura** 17-sep-2018 **Lectura Anterior** 30768.00 **Consumo** 195.00

Cargos Corrientes por Venta de Electricidad

Tarifa Básica	$11.48
Tarifa Provisional 195 kWh x $0.01299	2.53
Compra De Combustible 195 kWh x $0.11581	22.58
Compra De Energía 195 kWh x $0.049776	9.71
Subsidio Por Compra De Combustible	5.97 CR
Total Servicio	$40.33

Consumo Promedio Diario Para Meses Anteriores (kWh)
* NO DATOS ago-2017 7 sep 6 oct 1 nov 1 dic-2017 5 ene 4 feb 6 mar 3 abr 3 may 6 jun 6 jul 6 ago-2018 7

Centavos — Costo por kWh — Meses
Costo por kWh no incluye cargo fijo:0.1914

kWh — Historial de Consumo — Meses
Lectura / Estimado / Ajustada
* NO DATOS

Para información detallada visite nuestra página de Internet

Ley 57 - Tiene hasta la fecha de vencimiento para pagar el total de la factura u objetar los cargos corrientes por venta de electricidad. Detalles al dorso.

Desprenda el talón y envíelo con su pago. No mutile, doble, grape, manche, escriba (excepto cantidad pagada) ni pegue cinta adhesiva al talón de pago.

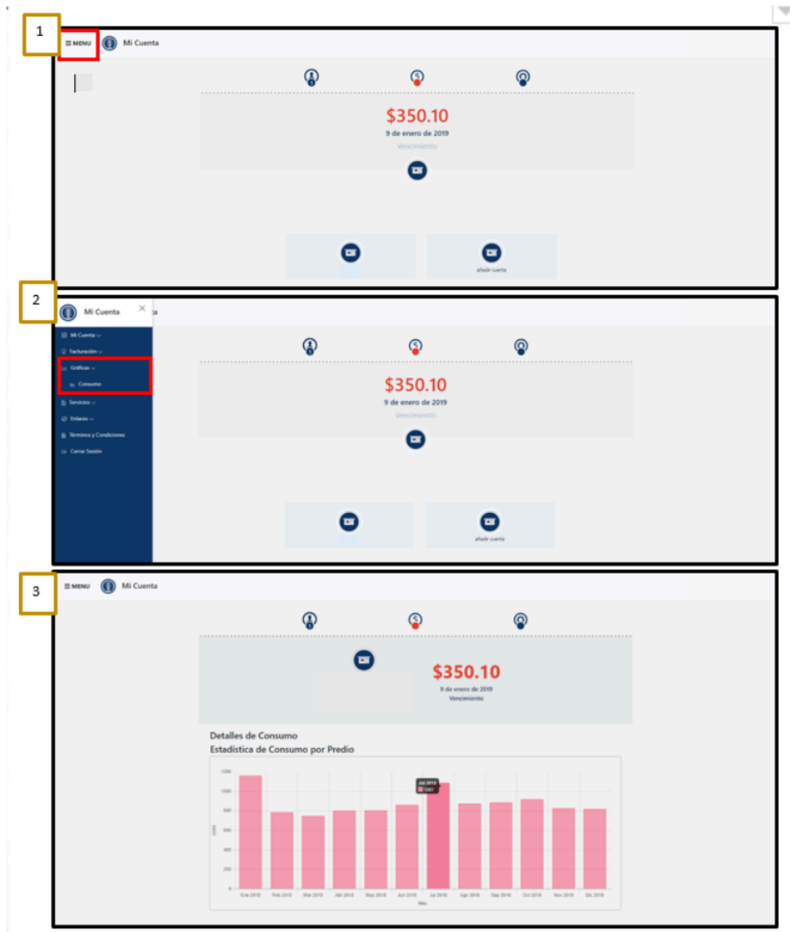
Método de Pago:
☐ Efectivo ☐ Tarjeta de Débito
☐ Cheque ☐ Tarjeta de Crédito

Envíe su pago a:
PO BOX 363508 - San Juan PR 00936-3508

Número de Cuenta [redacted]
Cantidad a Pagar $40.33
Cantidad Pagada $ 40.33
Fecha de Vencimiento de Cargos Corrientes 18-sep-2018

Pagada x Int. el 3/9/18

E-BILL



UNITS	POWER (W)	KILOWATT-HOUR (KWH)	VOLTAGE (V)
DESCRIPTION	The amount of energy used over a period of time. It is measured in watts.	A unit that equals 1000 watts in one hour. The AEE charges you per kWh.	The amount of energy stored and available for use. Most appliances use 110/120V lines, but others need 220V. These typically have a double breaker (fusibles guaretos).

STRATEGY 15

REDUCE YOUR ENERGY USE

STEP 2 - INSTALL ENERGY EFFICIENT EQUIPMENT AND FIXTURES

- Replace old standard fixtures and appliances for more efficient new models.
- Use products that have an Energy Star label. These use up to 70-90% less energy than the regular models, while producing up to 70% less heat, which indirectly reduces the cooling system energy consumption. For more information, visit https://www.energystar.gov/.
- Properly install fixtures and appliances to avoid short circuits. When necessary, hire a professional.

LIGHTING

- Choose task-specific lighting to reduce lighting excess.
- Energy Star certified LED bulbs are the most cost-effective. They use 10% of the energy regular bulbs use, and last 25 times longer.
- In a multi-family building, consider automatic lighting controls, like occupancy sensors, to significantly reduce energy use.

WATER HEATER

- Insulate hot water pipes and storage tanks to lower heat loss and use 10-20% less energy in heating.
- Tankless and/or solar water heaters use 10% of the energy electric water heaters use.
- Design new plumbing layout to minimize water loss through hot water delivery.
- Consider a solar water heater and refer to Strategy 17 for more information on solar thermal systems.

COOLING SYSTEM – FAN

- Ceiling fans help cool a space.
- Use counter-clockwise spin during the summer to drive the warm air upwards, and counter-clockwise spin during the winter to drive the warm air downwards.
- Size equipment in accordance with the Air Conditioning Contractors of America Manuals J, S, or ASHRAE.

COOLING SYSTEM – AC

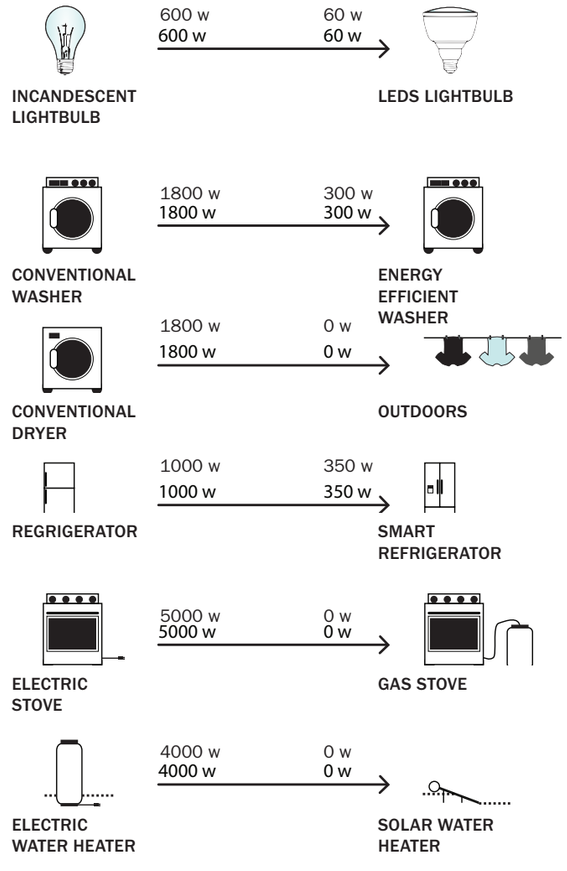
- Locate AC within the building envelope to reduce thermal loss.
- Replace AC filters once a month.
- Replace system with an energy efficient one.

DETERMINE YOUR POTENTIAL ANNUAL ENERGY CONSUMPTION

- Identify which fixtures you can exchange and your current fixtures, and determine their wattage.
- Estimate the number of hours used daily. Some items, like the refrigerator, are used 24 hours a day.

  _____ (w) x _____/ hours per day 1000 = _____ kw per hour for 1 appliance

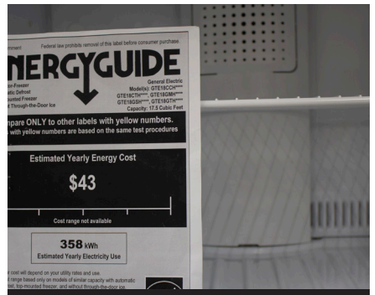
- _____ (kwh for 1 appliance) x _____ days used in a month = _____ kw consumed per month
- Add the results from the above formulas to calculate your monthly energy consumption.
- Calculate your annual energy consumption.
  _____ (kw per month) x 12 = _____ Potential Annual energy consumption





ENERGY EFFICIENT LIGHTBULBS


ENERGY EFFICIENT WASHER



ENERGY EFFICIENT REFRIGERATOR


GAS STOVE

STRATEGY

15 REDUCE YOUR ENERGY USE

REMEMBER

Take advantage of sunlight hours to complete tasks that will need a light during the night.

STEP 3 - ESTABLISH CRITICAL LOADS

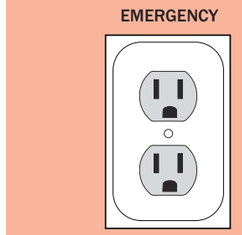
- Critical load refers to the collective load of home equipment that should remain on consistently in order to safely inhabit the space (e.g., refrigerators and medical devices.)
- Produce at least the critical load needed to withstand an emergency.
- Use Chart 2 to determine the critical load that you need to produce using an alternative energy system.



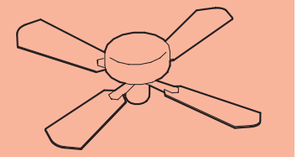
CRITICAL LOADS SINGLE FAMILY



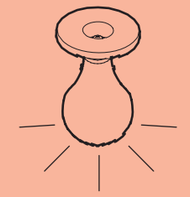
CRITICAL LOADS MULTI FAMILY



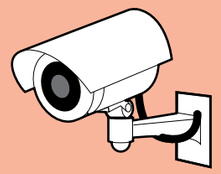
EMERGENCY OUTLETS



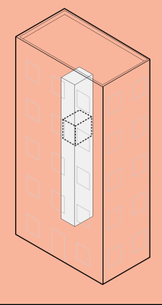
COOLING (FANS)



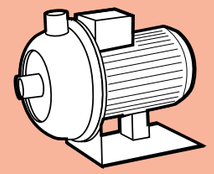
ESSENTIAL LIGHTING



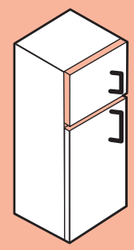
SECURITY SYSTEMS



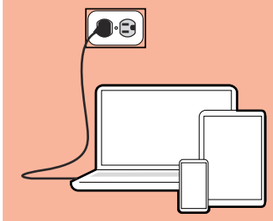
ELEVATOR



WATER PUMPS



REFRIGERATION FOR MEDICAL SUPPLIES



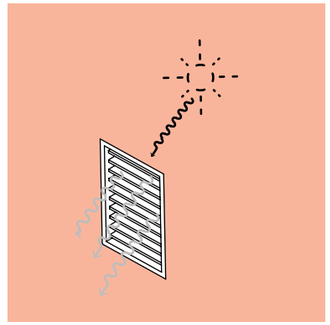
TECH HUB

STRATEGY

15 REDUCE YOUR ENERGY USE

STEP 4 - IMPLEMENT PASSIVE STRATEGIES THAT DON'T NEED ELECTRICITY

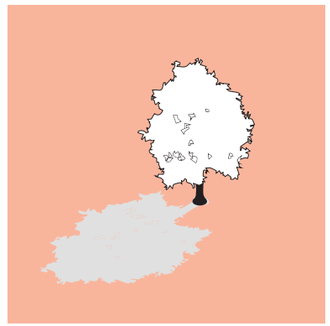
Design and operation choices can help reduce energy use. See Strategies on Passive Habitability for more information.



CREATING MORE DAYLIGHT

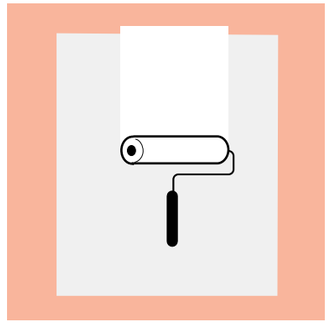
SEE STRATEGY: 12 - Benefit from Natural Light

IMAGE



NAME: **PLANTING VEGETATION**

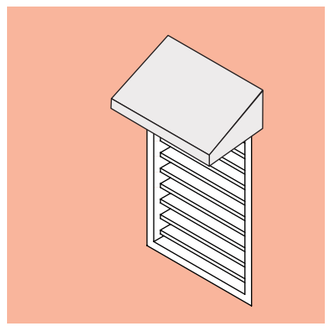
SEE STRATEGY: 02 | Reinforce Site with Vegetation



USING LIGHT INTERIOR COLORS

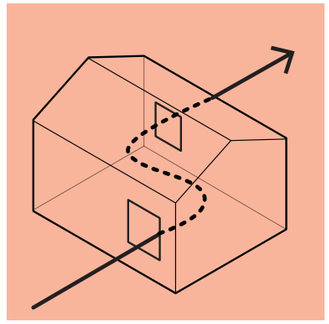
SEE STRATEGY: 10 - Reduce Heat Transfer

IMAGE



NAME: **SHADE**

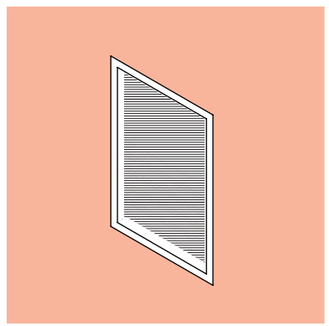
SEE STRATEGY: Strategy 10: Reduce Thermal Height Gain



USING NATURAL VENTILATION

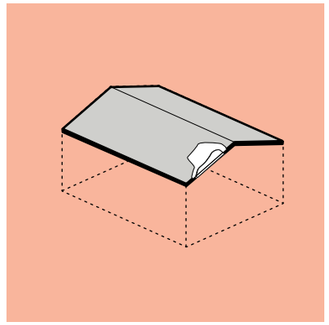
SEE STRATEGY: 11 - Increase Ventilation

IMAGE



NAME: **WINDOW FILMS**

SEE STRATEGY: Strategy 10: Reduce Thermal Heat Gain



ROOF

10 | Reduce Heat Transfer

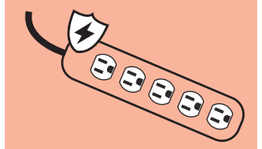
STEP 5 - CONSERVE ENERGY

ENERGY STAR

Look for the Energy Star label on new devices. Products tagged with this logo use half the energy of standard models.



Turn off electronic equipment when not in use.



Invest in advanced power strips. These will prevent electronics from drawing excessive energy and protect them from surge damages.



Unplug devices when fully charged or not in use. Just by being plugged-in, these become "vampire charges," adding up to 10% of your home energy use! Leaving devices unplugged will reduce energy use and prolong the device's battery life.

OPERATIONS AND MAINTENANCE TIPS

- Clean or replace air-conditioning (AC) unit filters once a month.
- If your cooling system has been in use for more than 15 years, replace it with an energy efficient system.

STRATEGY

16 INTEGRATE SOLAR ELECTRICITY

$-$$$

Successful installations of photovoltaic (PV) panels across Puerto Rico are increasing. PV panels provide some portion, if not all, of a home's energy needs, while making it less dependent on the system. This strategy focuses on explaining the basics of how to evaluate a home's potential for solar energy use as well as the basics of how to harness its possibilities.

Strategy in Action

1. Identify Power Needs

2. Identify the Appropriate PV System Configuration

3. Install the System

4. Connect the Residential System to an Inverter

5. Connect the System to Batteries

WHAT YOU NEED TO KNOW

- A photovoltaic module (PV), also known as a "solar panel," is a technology that converts sunlight into electrical energy. There are three different PV modules available, which vary in material composition, internal structure as well as cost. Photovoltaic modules vary in size mainly due to the number of solar cells connected in series. Generally, 60-cell and 72-cell modules are commonly found in residential and larger commercial installations.
- Monocrystalline: these are cells made out of silicon that are formed into bars and cut into wafers. Typically, they are of a dark black hue color with even texture (high efficiency, leads PV market).
- Polycrystalline: cells that are made out of silicone fragments and are melted together to form the wafers. They are slightly less efficient but can be cost effective. This is the recommended and most common type in Puerto Rico.
- Thin layer or thin film: cells made out of a translucent material that maximizes light and visibility but is not as efficient. It is also more expensive.
- PV arrays are composed of multiple modules made up of two layers of semiconductor material with opposite charges. When sunlight hits their surface, it knocks electrons loose, makes them move through the layers, and creates a current (see below).
- PV arrays are connected in series referred to as "strings."
- For autonomous systems, some PV systems inverters include charge controllers which redirects power from the PV or power authority to charge the batteries.

SUPPORTING STRATEGIES

10 Reduce Thermal Heat Transfer

11 Increase Ventilation

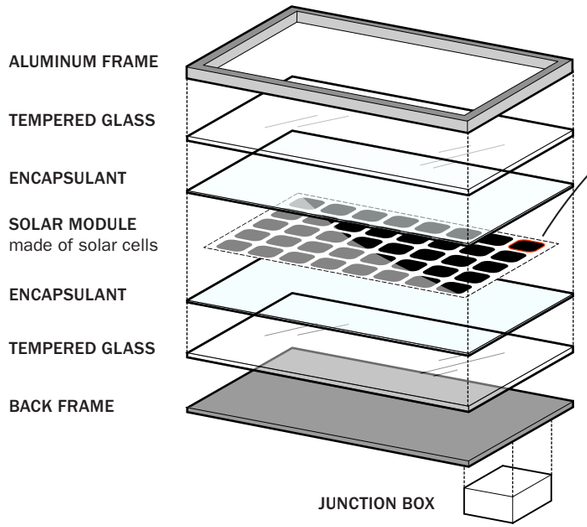
12 Benefit from Natural Light

15 Reduce Your Energy Use

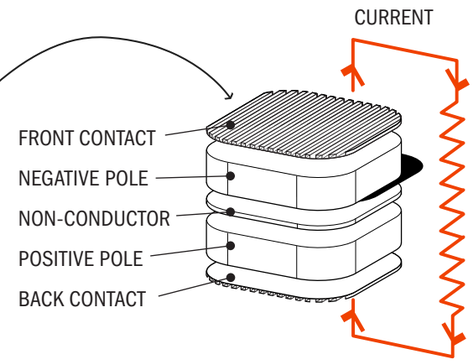
18 Install Energy Backup

- An inverter is a device that takes stored energy and converts it from direct current (DC) to alternating current (AC), which is the type of frequency used by most fixtures and appliances.
- Arrays can be connected to a battery pack to store energy if the grid is not available.
- If switching completely to solar energy is not an option, at least use solar modules as backup power by installing a small array only to power critical loads.
- A grid-tie inverter converts direct current (DC) from PV modules to alternating current (AC) and voltage levels compatible to the utility grid (synchronized to 60 hertz).
- A stand-alone inverter converts stored energy in batteries, electrically transforming direct current (DC) to alternating current (AC).
- Power conditioning units are intelligent units that monitor charge, usage, and supplement difference with stored energy while simultaneously charging from the grid. These can be used in interconnected and bimodal systems.

PHOTOVOLTAIC PANEL



SOLAR CELL



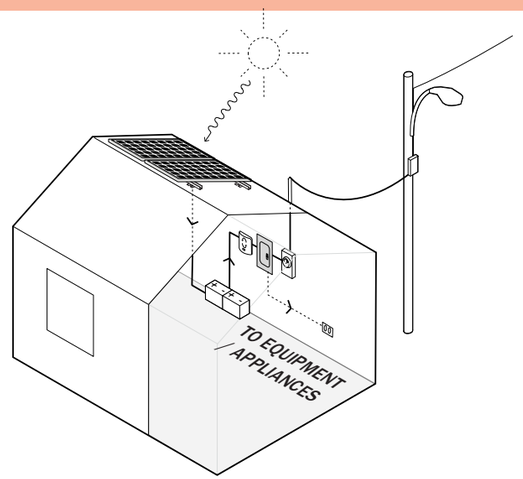
Solar cells are composed of two layers of semi-conductor material with opposite charges. Sunlight hitting the surface of a cell knocks electrons loose, which then travel through a circuit from one layer to the other, providing a flow of electricity.

STRATEGY 16

INTEGRATE SOLAR ELECTRICITY

STEP 1 - IDENTIFY POWER NEEDS

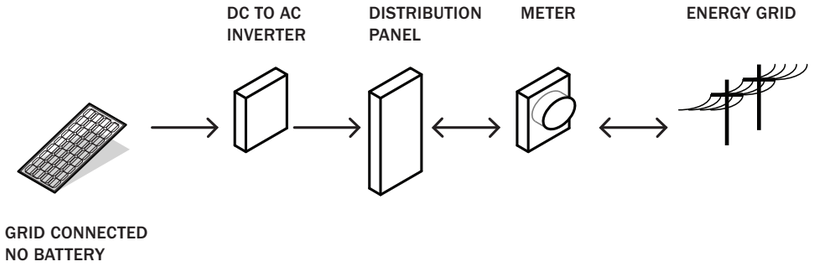
- Refer to Strategy 15 to determine your home's power needs and calculate how many panels are necessary.
- What percentage of power do you want to draw from solar PV?
- By how much do you want to reduce your electricity bill?
- How much do you need backup electricity?
- Are there many power outages because of grid failure?
- What is your budget for the PV system?



STEP 2 - IDENTIFY THE APPROPRIATE PV SYSTEM CONFIGURATION

- Panels are typically 3' x 5' in size and each one produces about a maximum of 250 watts. There are 3.5' x 7.5' panels that go up to 370 watts, but these are heavier and more difficult to install, maintain, and replace.
- A typical residential array produces about 3.5-5 kWh of direct current (DC) electricity. Critical loads require around 50% of that energy.
- Ensure the system complies with both local and national electrical codes and regulations (National Electric Code or NEC).
- Verify neighborhood regulations to comply with aesthetics.
- Note: The homeowner should be aware of the configuration, but a professional should install the system.

GRID CONNECTED NET METERING





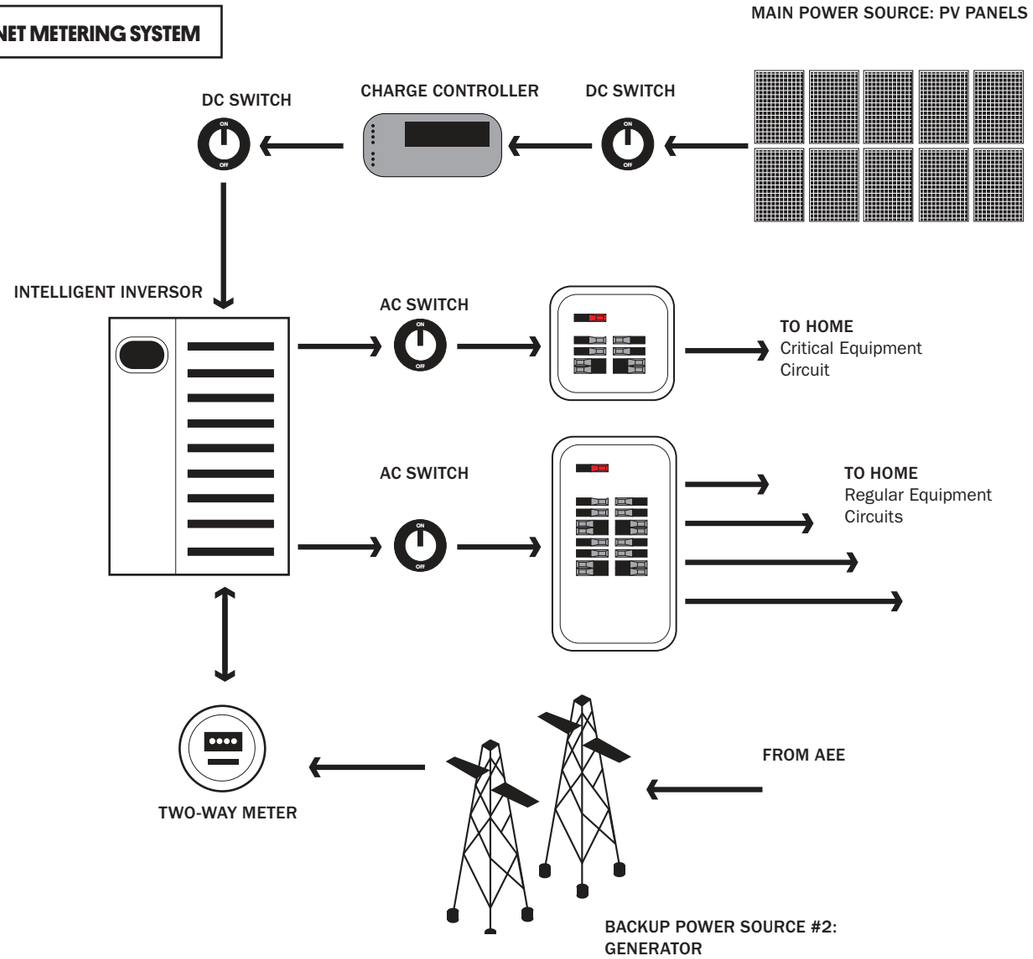
GRID CONNECTED-NET METERING

- Provides energy to running appliances (the house load). The energy contribution percentage depends on size of array and solar radiation available.
- Surplus energy generated beyond the load consumption is sent back to the power authority (PA) which is referred to as "net metering."
- Excess energy sent back to the grid is credited at a discounted service rate.
- Provides some stability to the grid.
- Reduces dependence on the PA.

✓
- Reduces dependence on PA
- Provides PA with renewable energy

✗
- If the PA fails, the user receives no energy, unless the fixture and appliances can work off direct current (DC) energy.
- Higher installation costs and longer return on investment.
- Complexity of automated or manual switch transfer during power outage.

NET METERING SYSTEM



STRATEGY 16

INTEGRATE SOLAR ELECTRICITY

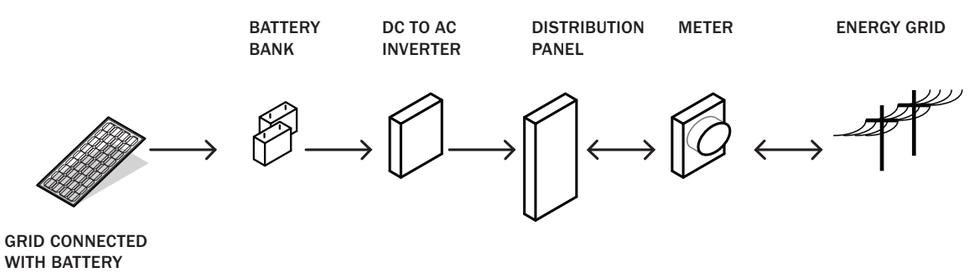
STEP 2 - IDENTIFY THE APPROPRIATE PV SYSTEM CONFIGURATION

GRID CONNECTED / HYBRID SYSTEM WITH BATTERY

- ► Recommended system.
- ► Can provide backup during grid outages.
- ► Surplus energy produced by the PV panels is stored in a battery bank and excess power is sent back to the PA.
- ► When excess energy is produced, the user can sell or “net meter” energy to the PA at a discounted rate.
- ► Provides backup power to critical equipment until storage is depleted.

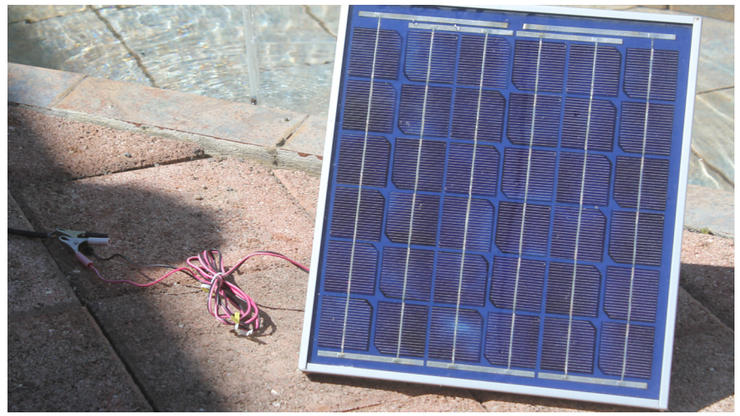
✔
- Reduces dependence on PA.
- Battery provides uninterrupted reliability if the grid fails.

✖
- Higher installation costs and longer return on investment.
- Flooded type batteries require maintenance.

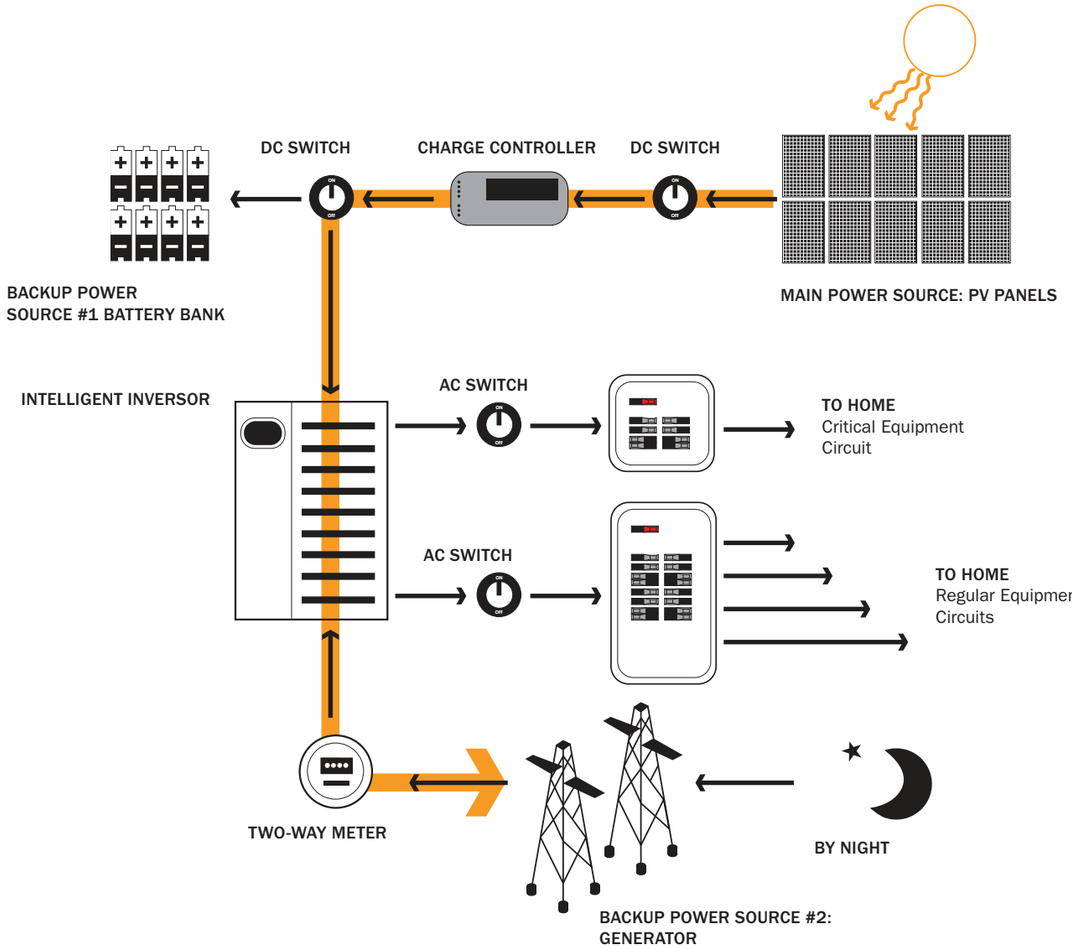


GRID CONNECTED WITH BATTERY





HYBRID/INTERCONNECTED SYSTEM



STRATEGY 16

INTEGRATE SOLAR ELECTRICITY

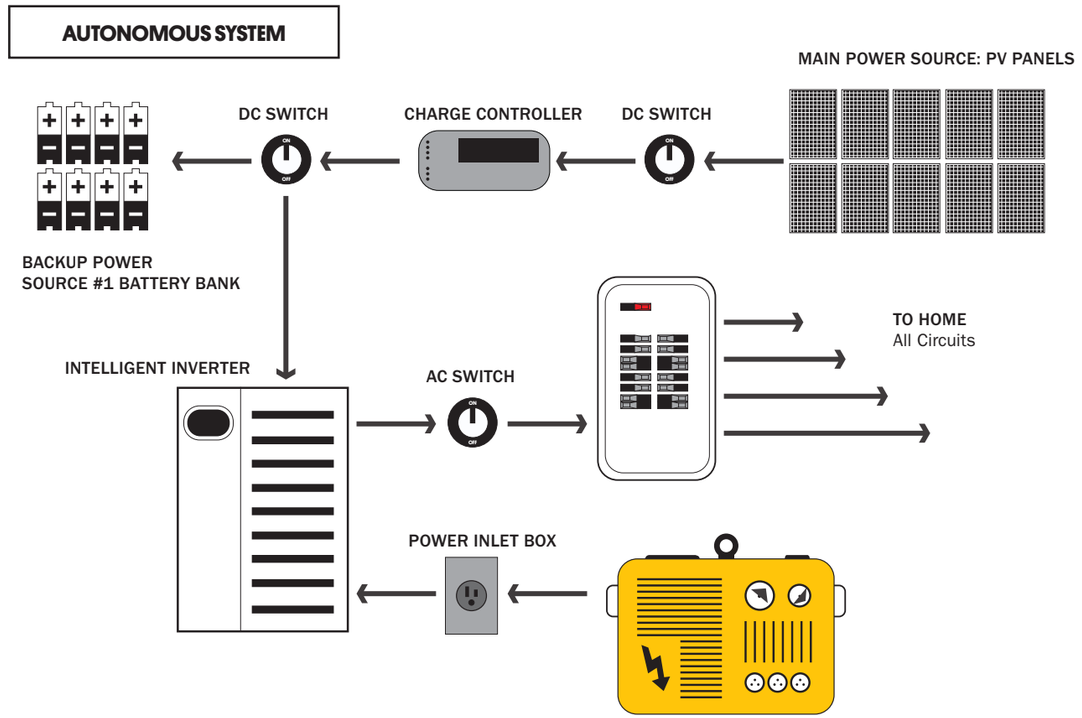
STEP 2 - IDENTIFY THE APPROPRIATE PV SYSTEM CONFIGURATION

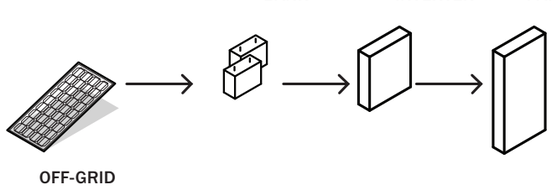
OFF GRID / AUTONOMOUS SYSTEM

- Completely disconnected from grid.
- Home relies on PV and on-site battery backup for all power needs.
- Recommended at remote locations or regions that are far away from existing public infrastructure.
- Complete independence from central grid.
- Safely runs appliances without damaging voltage spikes.
- For autonomous systems, some PV systems' inverters include charge controllers which redirect power from the PV or PA to charge the batteries. Charge controllers are needed for charging

✔
- Not affected by price and power fluctuations.

✖
- If battery depth of discharge or capacity is exceeded, the system will shut down and there will be no power during the night.







Laurie Schoeman Ecocenter at Herons Head Park





SCALE YOUR SYSTEM TO FIT YOUR NEEDS!

Installing solar panels can seem daunting and unattainable if you think of covering 100% of your electrical needs right from the start. Consider using solar panels with battery as backup power! Begin with a smaller array and battery backup exclusively to power up critical equipment or as backup during power interruptions. This will give your home a head start toward resilience. Plan this system to accommodate future home expansion.

Generally, smaller, autonomous 120VAC inverters, say 400W to 2000W (12V to 48V battery), need about triple the rated wattage to start-up a reactive/inductive electrical equipment (a compressor, electric chainsaw, motors in general, etc.). So, you won't be able to start a 380-watt small refrigerator with a 400-watt inverter. Consequently, the inverter will shut down, trip, or won't even start before damaging the equipment, although it is entirely possible that damage could happen. Consult the manufacturer listing of appliances the inverter can run on a specific wattage. On larger inverters (240VAC) for autonomous systems, there is a peripheral called an autoformer. This "transformer," usually a separate box attached to the main inverter, can play various roles. One of them is to be able to deal with the above mentioned inductive reactance startup. Another could be to balance the load across a 240VAC home electrical system.

STRATEGY 16

INTEGRATE SOLAR ELECTRICITY

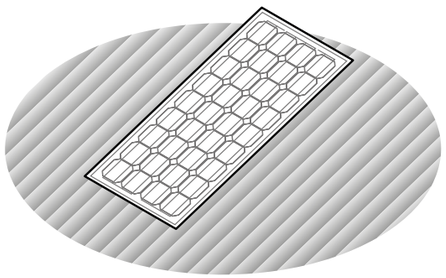
STEP 3 - INSTALL THE SYSTEM

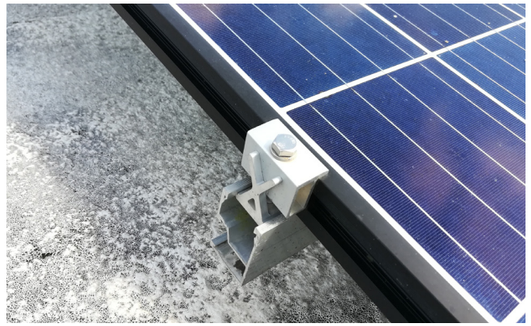
- Identify approved vendors and certified equipment for PV system at: http://www.prgef.com/resources and forms.
- Each PV panel weighs about 3-40 pounds. Anchor a panel properly so it does not blow away during strong winds. For more information, see FEMA's guide titled Rooftop Solar Panel Attachment: Design, Installation, and Maintenance.
- A PV system can last up to 30 years without replacement.
- Hire a professional to ensure installation complies with both local and national electrical codes and regulations.
- Do not connect the system to electric circuits by yourself. Hire an electric technician/engineer.
- A transfer switch should be installed. Refer to Strategy 18 for additional information.

A. LOCATION: ROOF

- Can be installed in any roof, regardless of material or inclination.
- Can be installed in innovative ways, such as over carports or awnings.
- May reduce shading from trees or neighbors' buildings.

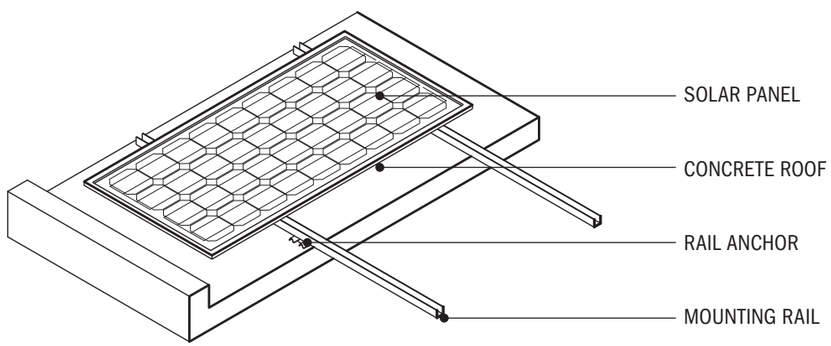
ROOFTOP MOUNTING







ROOF ANCHORAGE FOR CONCRETE ROOFS



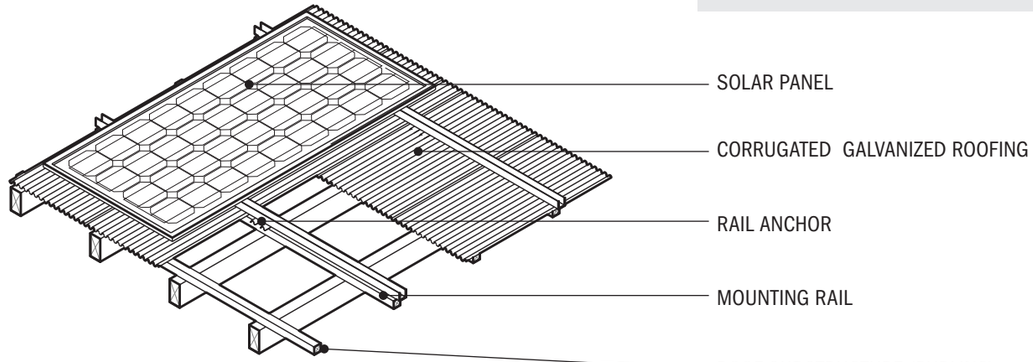
✓

- CAN BE INSTALLED IN ANY ROOF, REGARDLESS OF MATERIAL OR INCLINATION.
- CAN BE INSTALLED IN INNOVATIVE WAYS, SUCH AS OVER CARPORTS OR AWNINGS.
- MAY REDUCE SHADING FROM TREES OR NEIGHBORS BUILDINGS.

ROOF ANCHORAGE FOR WOODEN ROOFS

✗

- EXPOSED TO UPLIFTING CAUSED BY STRONG WINDS. ANCHOR PROPERLY.



Mounting rails and anchors are to be installed following the supplier's specifications for warranty.

STRATEGY 16

INTEGRATE SOLAR ELECTRICITY

STEP 3 - INSTALL THE SYSTEM

A. LOCATION: GROUND

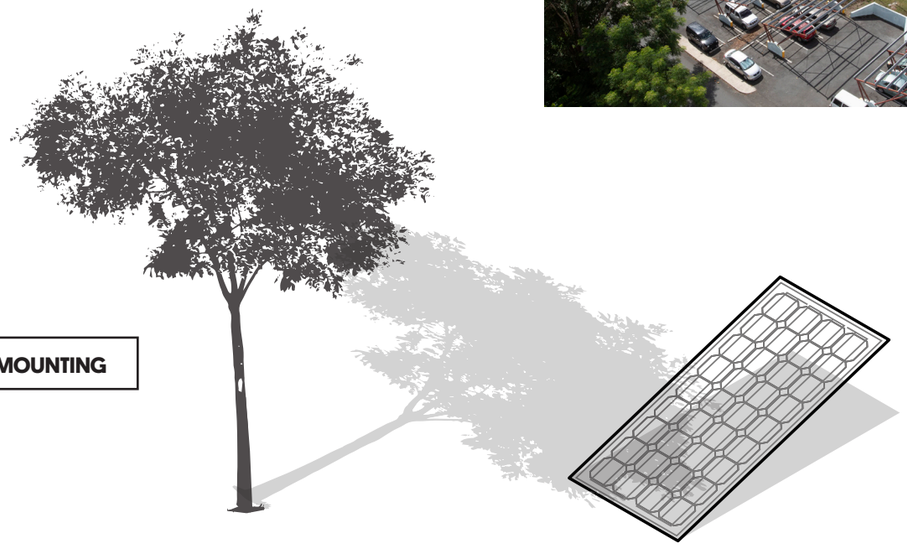
Ground mounting is the cheapest and easiest option for installation. As with the rooftop, it provides good airflow in the back. However, horizontal space and shading may be an issue. These are highly susceptible to theft.

- CHEAPEST OPTION
- NO NEED TO FORTIFY ROOF OR NO POTENTIAL DAMAGE TO ROOF MEMBRANE.
- CAN DISASSEMBLE BEFORE HIGH WINDS.
- CONVENIENT FOR HOMES THAT SIT ON A BIG LAND PLOT.

- TAKES UP A LOT OF SPACE IN SMALL LOTS.
- SUSCEPTIBLE TO THEFT.
- MAY BE MORE SUSCEPTIBLE TO SHADE BY NEIGHBORS' TREES OR BUILDINGS.
- EXPOSED TO UPLIFTING CAUSED BY STRONG WINDS. ANCHOR PROPERLY.







GROUND MOUNTING

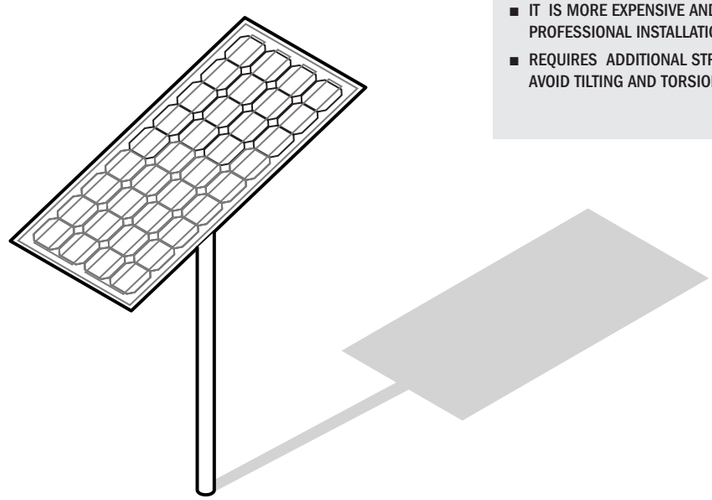
A. LOCATION: POLE

Pole mounting absorbs the benefit of sun exposure from rooftops as well as above-ground location freedom. However, these are the most difficult to install and will require additional structural support to avoid tilting and torsion due to storm winds.

- FLEXIBLE IN TERMS OF INSTALLATION AND PLACEMENT.
- CAN INCLUDE PASSIVE SOLAR TRACKING DEVICES THAT DETECT THE SUN'S PATH TO MAXIMIZE ENERGY COLLECTION.

- DEMANDS SPECIAL INSTALLATION BECAUSE OF STRUCTURAL LOADING SPECIFICATION NEEDS.
- IT IS MORE EXPENSIVE AND REQUIRES PROFESSIONAL INSTALLATION.
- REQUIRES ADDITIONAL STRUCTURAL SUPPORT TO AVOID TILTING AND TORSION.

POLE MOUNTING





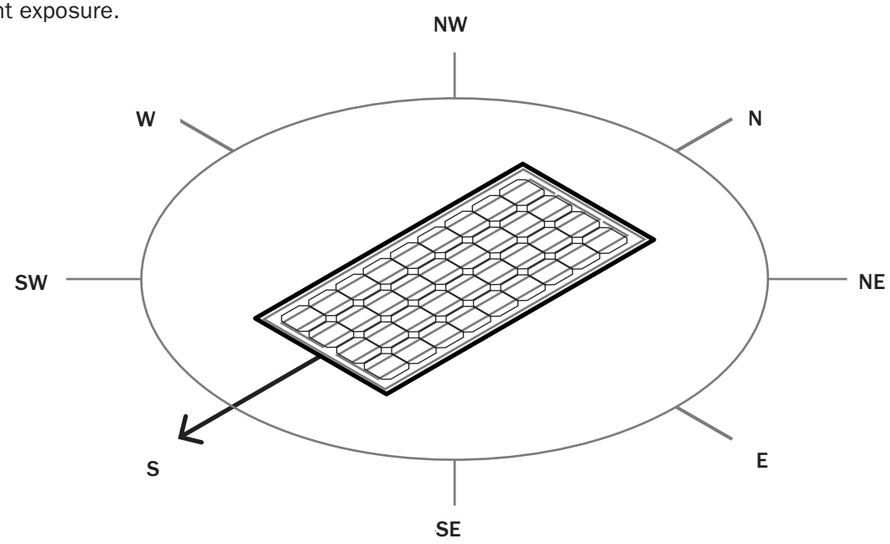
STRATEGY 16

INTEGRATE SOLAR ELECTRICITY

STEP 3 - INSTALL THE SYSTEM

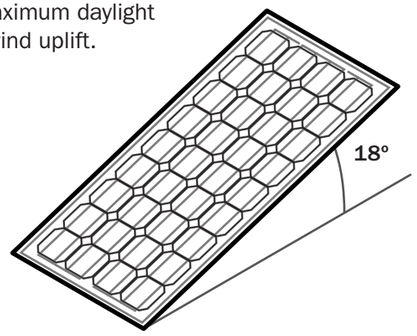
B. PLACEMENT: ROTATION

- Rotate panels so they face south, for maximum daylight exposure.



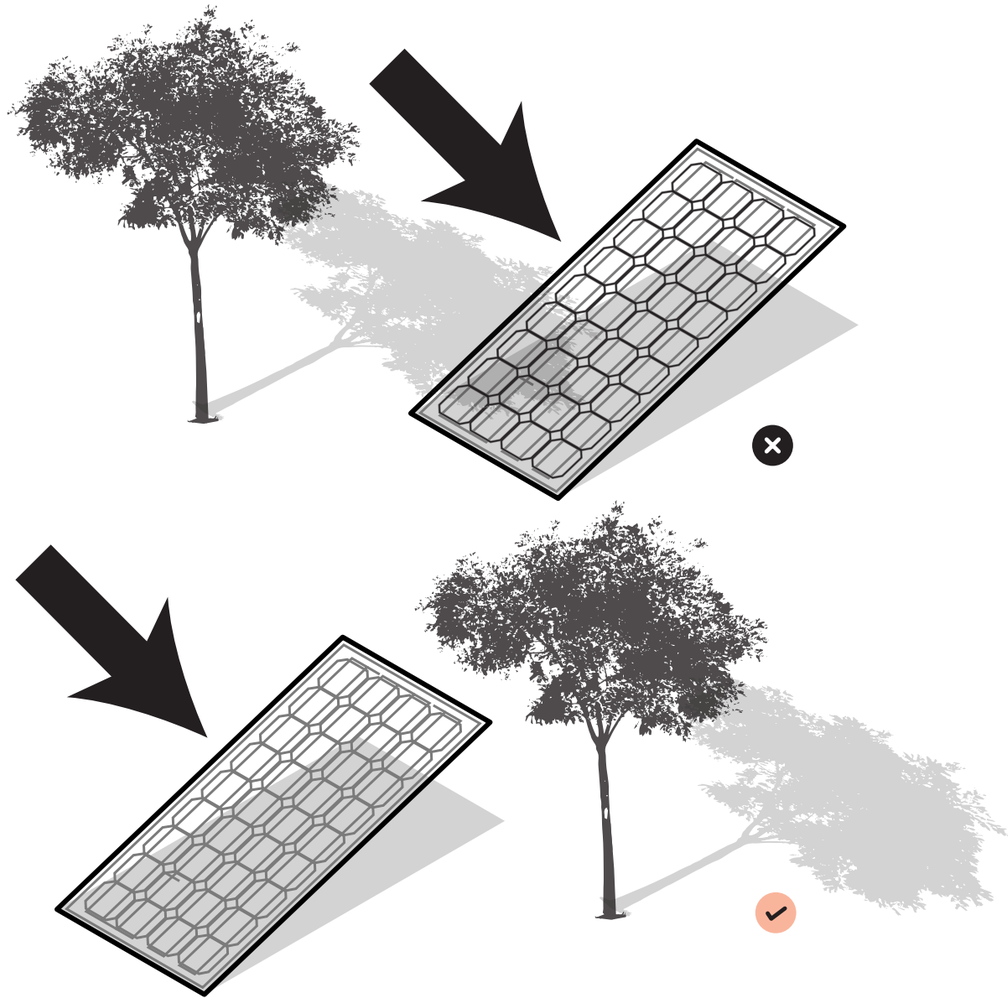
B. PLACEMENT: INCLINATION

- The location latitude degrees should equal degrees of PV panel inclination.
- In Puerto Rico, incline each panel by 18 degrees facing south for maximum daylight exposure and to minimize wind uplift.



B. PLACEMENT: VEGETATION

- Avoid placing panels near trees as shade will affect the system's efficiency.



STRATEGY

16 INTEGRATE SOLAR ELECTRICITY

STEP 4 - CONNECT THE RESIDENTIAL SYSTEM TO AN INVERTER

- Most inverters are made to provide excess energy to the grid.
- If you are considering a solar panel system for your home, the key decision you should make is the type of inverter you want to install. Inverters are devices that convert direct current (DC) to alternating current (AC) to power up fixtures and appliances. Most household appliances and fixtures use AC power.
- Inverters come in two phases: split-phase 240VAC and single-phase 120VAC inverters.
- A grid-tie inverter converts direct current (DC) from PV modules to alternating current (AC) and voltage levels compatible to the utility grid (synchronized to 60 hertz).

STRING INVERTER (GRID-TIED)

PV modules are connected in strings, providing interactive operation with the house load and grid. SMA Sunny Boy and Sunny Island have Secure Power Supply feature that runs appliances without grid and battery systems.

**SMA Sunny Boy and Sunny Island have the Secure Power System (SPS) feature that runs appliances without grid and battery systems.

PROS

- The most commonly used inverter and can be used with grid-tied or stand-alone.
- The secure power system (SPS) feature of the SMA module allows owner to manually power appliances in the home through a dedicated outlet to run appliances without batteries or grid.

CONS

- It does not typically operate as stand-alone.

MICRO-INVERTER (GRID-TIED)

PV modules are connected individually, eliminating the need for a central inverter while providing interactive operation with the house load and grid.

PROS

- Prevents system from failing due to panel malfunction.
- Equalizes the system for optimum performance.

CONS

- Shorter lifespan
- Will not work without the grid

STAND-ALONE INVERTER

PV modules are connected in strings, providing interactive operation with the house load, inverter, and battery backup. Recommended inverters: SMA Sunny Boy and Sunny Island, Schneider, Tesla, Outback and Matcha Sine Magnum are leading stand-alone inverters

PROS

- Operates as a stand alone system.

CONS

- Need to provide backup power to provide redundancy and power during the evening or times of low power.

- Stand-alone inverter converts stored energy in batteries, electrically transforming direct current (DC) to alternating current (AC).



- A hybrid inverter is primarily used for grid-tie (selling back to the utility company) purposes but also has the added feature that they provide backup power to your home when the electric utility fails.



HYBRID INVERTER/CHARGER 3KW 48VDC - NEEDS BATTERY BANK

A hybrid inverter is primarily used for grid-tie (selling back to the utility company) purposes but also has the added feature that they provide backup power to your home when the electric utility fails.

PROS

- Inverter inside the unit
- Storage space
- Battery is configurable if upgrade is desired.
- Better with extreme temperatures

CONS

- Capacity could be bigger

MICRO-INVERTER (GRID-TIED)

A hybrid inverter is primarily used for grid-tie (selling back to the utility company) purposes but also has the added feature that they provide backup power to your home when the electric utility fails.

PROS

- Inverter inside the unit
- Storage space
- Battery is configurable if upgrade is desired.

CONS

- Capacity could be bigger

HYBRID INVERTER 7.5 KW WITH BACKUP BATTERY CAPABILITY (400VDC NOM.)

A hybrid inverter is primarily used for grid-tie (selling back to the utility company) purposes but also has the added feature that they provide backup power to your home when the electric utility fails.

PROS

- It is compact and has the charge controller inside.
- Scaleable

CONS

- Premium cost
- Tesla requires Tesla battery brand

STRATEGY

16 INTEGRATE SOLAR ELECTRICITY

STEP 5 - CONNECT THE SYSTEMS TO BATTERIES

- ► Batteries store surplus energy for future use.
- ► Preferred; if connecting to batteries, a charge controller is needed to charge batteries.
- ► Battery chemistry is generally divided into two main categories: lead and lithium.

LEAD-ACID BATTERIES

- ► **Flooded Lead-Acid batteries** - they produce hydrogen outgas when charging and can be dangerous in poorly ventilated spaces.
- ► **Deep Cycle Lead-Acid Batteries** - [recommended] can discharge below 50% depth of discharge (DOD) without damaging the battery.
  - Produce hydrogen when charging
- ► **Valve-Regulated Lead-Acid (VRLA)** – it re-combines outgassing when charging with minimum emissions.
  - Sealed VR Wet
  - Absorbent Glass Matt (AGM)
  - Gel Type
- ► **Lead Nano-Carbon** – can discharge up to 70% depth of discharge, which is a way to identify how deeply the battery is discharged.

✔ ■ DISCHARGE BELOW 50% WITHOUT DAMAGING THE BATTERY

✕ ■ DANGEROUS IN POORLY VENTILATED SPACES



OPERATIONS AND MAINTENANCE TIPS

- ■ Register your system with your insurance company in case of natural disasters or theft.
- ■ Monitor PV array output monthly to detect any anomaly. Some PV installers or manufacturers offer real-time monitoring of system performance and maintenance plans.
- ■ Inspect your PV system to check for:
  - Dirt on array
  - Storm damages
  - Loose cables
  - Inspect and protect your system by dismounting your panels before a storm event, whether it is a pole-mounted system or a ground-mounted system.
- ■ For off-grid and bimodal systems, be sure to inspect your battery bank regularly and look out for:
  - Battery voltage inconsistencies
  -
  - Metal corrosion
  - If you have lead batteries, check depleted electrolyte levels by verifying water levels in the lead batteries.
- ■ Preparations prior to hurricane landfall:
  - Property owners or operators should have a maintenance staff or a contractor that adequately prepares their PV systems prior to landfalling hurricanes or forecasted severe windstorms by performing the following:
    - Debris removal from roof drains, scuppers, and gutters.
    - Removal of loose objects such as buckets, lumber, and sheet metal from the roof and surrounding areas.
    - If there is enough time, check tightness of the PV array's bolted connections with a torque wrench.
- ■ After a severe wind storm[1]:
  - Property owners or operators should have a maintenance staff or a contractor perform post severe windstorm damage assessments and take any actions needed for repairs or improvements to their system, including the following:
  - Check the PV array for damage.
  - Remove, replace, or temporarily secure loose panels.
    - Check the roof covering for damage caused by wind-borne PV panels or other debris.
    - Check tightness of the PV array's bolted connections.

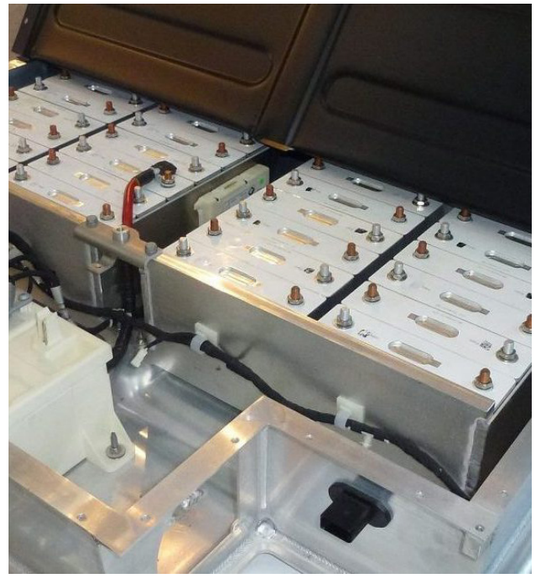
1 Rooftop Solar Panel Attachment: Design, Installation, and Maintenance https://www.fema.gov/media-library-data/1535554011182-e061c2804fab7556ec848ffc091d6487/USVI-RA5RooftopSolarPanelAttachment_finalv3_508.pdf

LITHIUM ION BATTERIES

- ► **Lithium Batteries** - (Longer Life: higher charge/discharge cycles) – higher initial cost ($)
- ► **Lithium-Ion** - can be discharged to 90% of its capacity. Typically, it can endure three times the number of cycles compared to lead-acid.
- ► **Lithium Ferro Phosphate** – usually found in nominal 24V and 48V packages.

✔ ■ DISCHARGE 90% OF ITS CHARGE

✕ ■ MORE EXPENSIVE



DISCLAIMER

DO hire a professional to ensure that installation complies with local codes and regulations. Code or NEC).

DO verify neighborhood regulations or talk with your neighbor to comply with aesthetic concerns.

DO NOT connect the system to electric circuits by yourself. Hire an electric technician/engineer for this purpose.

STRATEGY

17 INTEGRATE SOLAR THERMAL ENERGY

$-$$$$

Solar thermal systems use the heat from the sun to heat water as opposed to solar photovoltaic (PV) which uses solar energy to energize a home. This system allows it to depend less on electric water heating and reduce costs. This strategy focuses on explaining how the system works, how to purchase it, and how to install it.

Strategy in Action

1. Identify Home Hot Water Needs

2. Choose the System

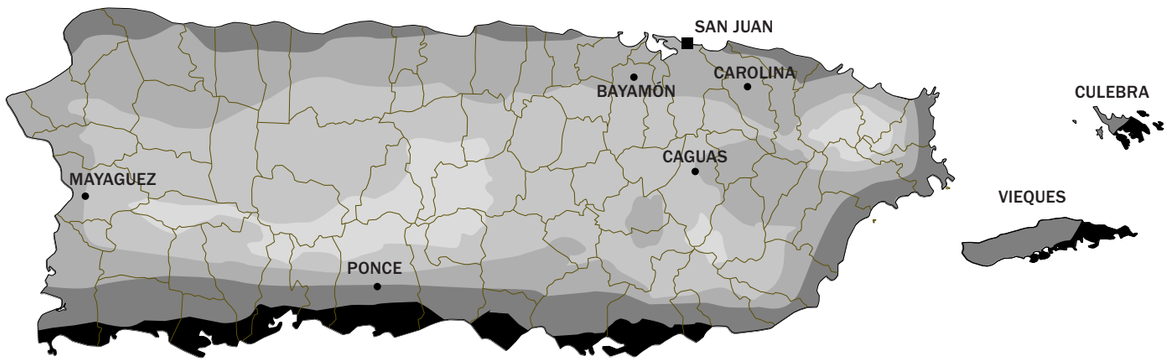
3. Install the System

4. Connect the System

WHAT YOU NEED TO KNOW

- A solar thermal collector is a device that transfers radiation from the sun to heat water for household use. It is typically located on the roof and must have access to the plumbing system.
- There are two types of solar thermal systems:
  - **Thermosiphon**: passive; does not require energy from the grid
  - **Flat Plate**: active; does require energy from the grid
- Water is pumped to the roof and then stored in a home water storage tank for household use.
- Consult a structural or civil engineering to verify that the home's roof can hold the weight.
- Solar systems with higher solar energy factor (SEF) and solar fraction (SF) perform better.
- Identify the system's warranty with your contractor or vender to ensure you are protected should it fail due to possible defects.
- Identify distance between the solar system on the roof and electric tank location.
- When the system is installed, check that the hot water delivery temperature valve is correctly set and not exceeding 130 degrees Fahrenheit.

HORIZONTAL SOLAR IRRADIATION IN PUERTO RICO



SUPPORTING STRATEGIES

10 Reduce Thermal Heat Gain

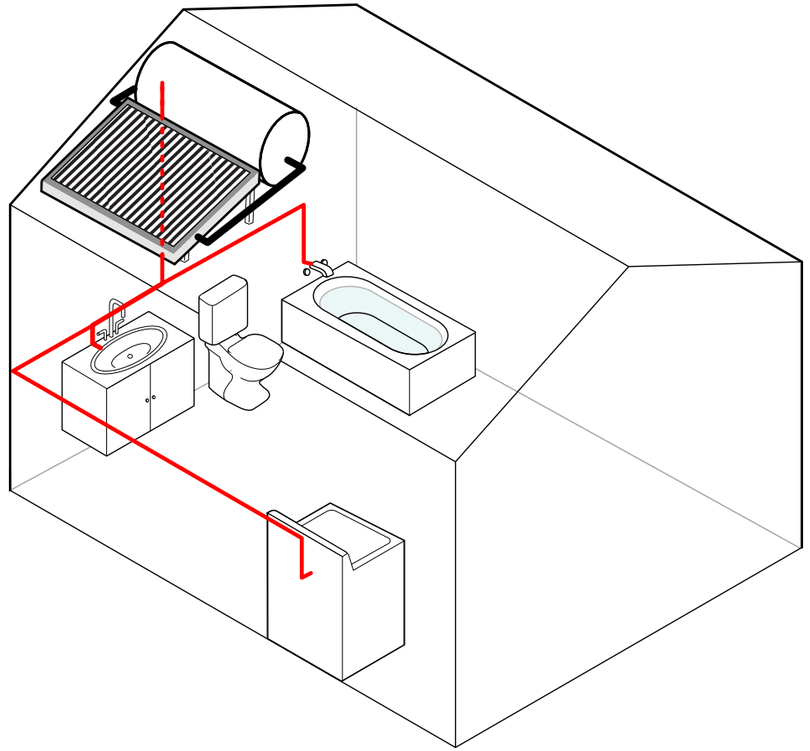
11 Increase Ventilation

12 Benefit from Natural Light

15 Reduce Your Energy Use

18 Install Energy Backup

SOLAR THERMAL PANEL



STRATEGY

17 INTEGRATE SOLAR THERMAL ENERGY

DISCLAIMER

- The system and its components should be certified by an accredited testing institution following international code and standards.
- Use a programmable 24-hour timer with battery backup clock to prevent the use of electric resistance heating. Program it according to your weekly occupancy. schedule.

STEP 1 - IDENTIFY HOUSEHOLD HOT WATER NEED

- A family of four using 52 gallons of hot water (125 Fahrenheit) would consume about 5.2 kilowatt-hours (kWh) per day.
- The appliances that are used for heating water (sinks, bathtubs, washing machines) determine how much hot water you will need. Using a flow meter is the most accurate way of identifying how much hot water you are using. in absence of a flow meter, collecting (weighing) a sample (timed in seconds) of hot water out of each faucet or shower is the most accurate way to identify how much water per person you are using.
- The more water conservation practices you have in place, the smaller your appliance and the less water you will need to heat with your solar thermal system.



STEP 2 - CHOOSE THE SYSTEM

THERMOSIPHON



- Used by itself with integrated storage, connected, or added to an existing tank to backup electric storage water heater and increase hot water capacity.
- Unlike an active system, the thermosiphon does not use an active pump.
- A thermosiphon collector heats water within the collector where hot water rises by convection into the top of the storage tank. Cold water flows down from tank to the collector therefore establishing a slow, natural flow without the use of a pump.
- Solar systems with higher solar energy factor (SEF) and solar fraction (SF) perform better. Look for an efficient system, with a SEF between 1.2 and 1.9 and a SF between 26% to 52% (.26 to .52).

FLAT PLATE



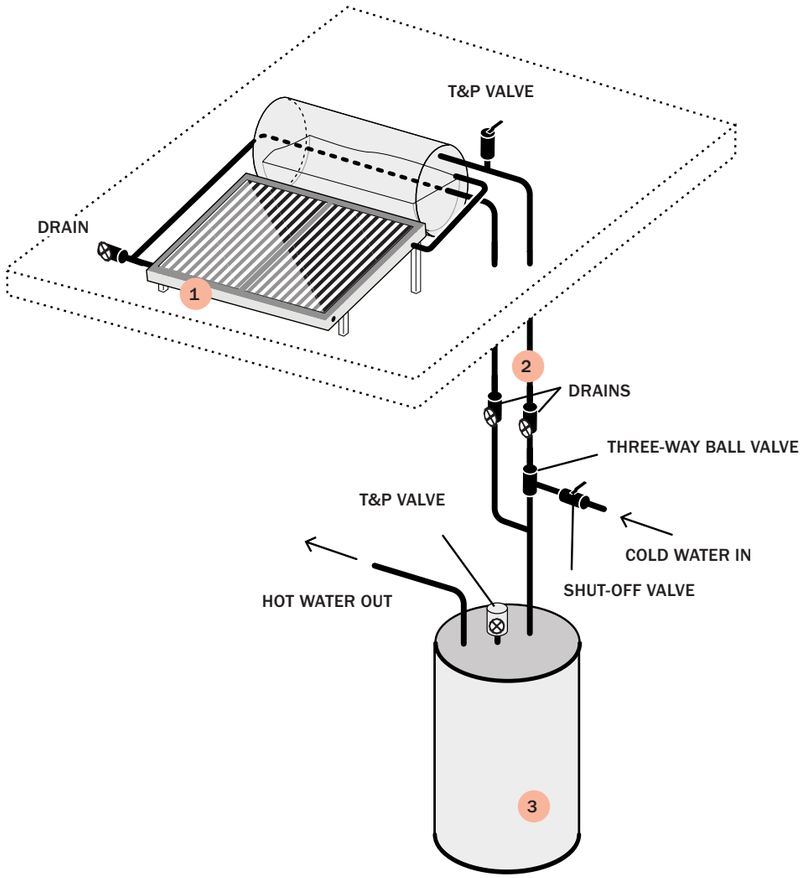
- Utilizes hot water circulation pump to provide higher level of efficiency.
- Utilizes a single larger storage tank (usually 50-120 gallons) depending on collector size or number of multiple collectors.
- Alternating current (AC) pumps provide higher pumping capacity, compared to direct current (DC) ones.
- Recommended for:
  - Homes with an integrated renewable energy system in place
  - Works for residential or commercial applications
  - When little power is needed for the pump to circulate water
- Solar systems with higher solar energy factor (SEF) and solar fraction (SF) to perform better. Look for an efficient system, with a SEF between 2.0 and 4.5 and a SF between 50% to 75% (.50 to .75).

STRATEGY 17

INTEGRATE SOLAR THERMAL ENERGY

STEP 2 - CHOOSE THE SYSTEM

1. SOLAR COLLECTOR
2. CIRCULATION PIPES & DRAIN
   The solar thermal panel heats waterflowing through the collector which transfers its heat to the holding tank.
3. HOLDING TANK
   Insulated tank hold the water.



THERMOSIPHON

SOLAR COLLECTOR

- Consists of an insulation, absorber plate and flow tubes.
- Absorbs the sun's light energy and transfers heat to water via pumped fluid circulating through the collector tubes.
- Can Use up to 3 collectors connected to a integrated 120 or 80 gallon tank size

INTEGRATED SOLAR STORAGE TANK

- Stores heated potable water in a separate tank with backup electric resistance element.

DRAIN VALVE

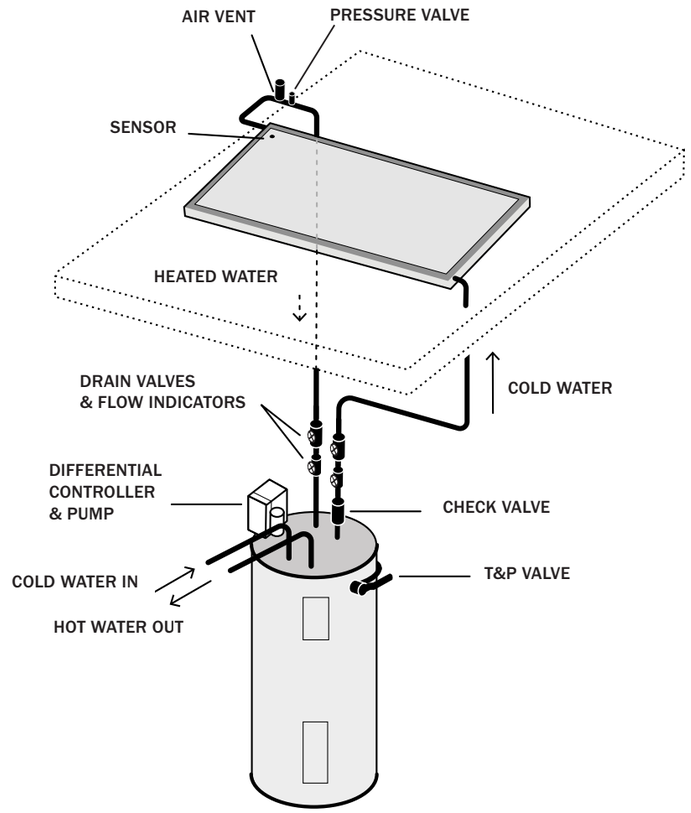
- Allows draining, filling, and servicing of the system.

ANTI-SCALD / MIXING VALVE

- Tempers hot water from the solar storage tank with cold water to maintain an adequate temperature of the hot water delivered to its end use.

COLD WATER CUT-OFF VALVE

- Isolates the system from incoming water supply.



FLAT PLATE

SOLAR COLLECTOR

- Absorbs the sun's light energy and transfers heat to water via pumped fluid circulating through the collector tubes.
- Can Use up to 3 collectors connected to a integrated 120 or 80 gallon tank size

AUXILIARY/MAIN STORAGE TANK

- Stores heated potable water as it circulates in a separate tank with backup electric resistance element.

SOLAR LOOP EXPANSION TANK

- Allows for the expansion and contraction of heat transfer. Outdoor solar systems should be equipped with temperature and pressure relief valves. The expansion tank will absorb thermal expansion of hot water from the solar system and prevent hammer shock when opening fixtures.

SERVICE DRAIN VALVES

- Pumps air out of circulation lines to allow proper water circulation.

ANTI-SCALD / MIXING VALVE

- Tempers hot water from the solar storage tank with cold water to maintain an adequate temperature of the hot water delivered to its end use.

AIR VENT

- Purges air from the collector.

DIFFERENTIAL CONTROLLER

- Controls alternating current (AC) over a timer, sensing the temperature at the bottom of the tank and outlet of the collector. It activates the pump when temperature is prime and prevents activation in case of overheating, overuse, or when the home is empty (so no water is used).

SOLAR PUMP/CONTROLLER

- Controls the operation of hot water circulation to the collector.water circulation.

STRATEGY 17

INTEGRATE SOLAR THERMAL ENERGY

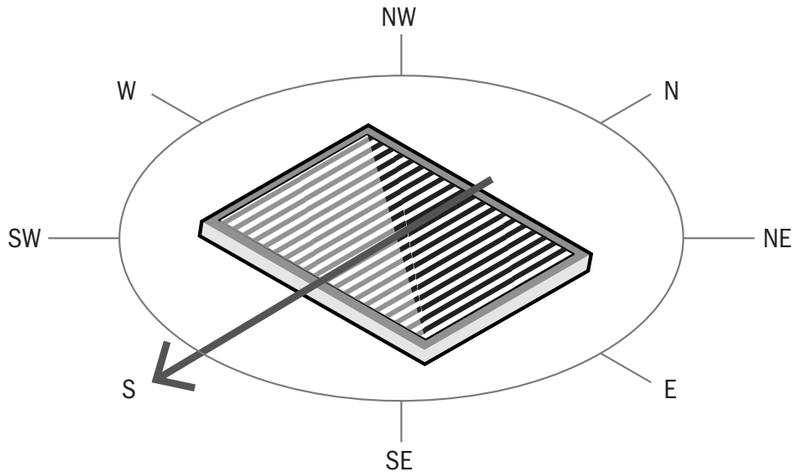
STEP 3 - INSTALL THE SYSTEM

- Install in accordance with local regulations and through a certified PV contractor as determined by Puerto Rico's regulations.
- Install a heavy-duty commercial grade 240VAC (30-amp) toggle switch that is easily accessible to cut-off power to the backup water heater. This is in addition to the existing 240VAC circuit panel breaker (20-amp for 120VAC small capacity water heaters).
- Utilize a tank wrap to prevent heat loss from storage tank.
- Install a mixing valve to prevent excessive hot water delivery to the use point. Note: most anti-scald mixing valves prevent hot water flow during pressure loss of city water mains; a thermostatic mixing valve is an alternative.

ORIENTATION



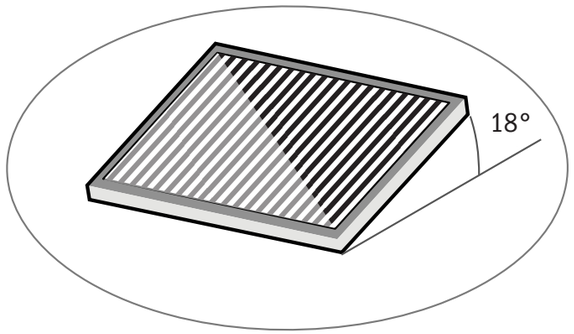
- The optimal angle for installation is usually pre-set by the rack support system supplied by the installer/manufacturer providing the optimum performance.
- Collector should face south and be free of shading.
- Incline 18 degrees, close to Puerto Rico's latitude. On the thermosiphon system, an inclination of less than 8 degrees or more than 30 degrees is unacceptable.
- Orient portrait facing south to reduce air bubbles.



LOCATION

- Place on a concrete slab, heavy-duty platform, or concrete roof.
- Ensure roof can hold the load of the equipment. The system can be more than 800 pounds.
- Proximity between tanks and equipment reduces piping losses.

- Aplique aislante de tubería (pared de ½", mín. R-3) a las líneas de conducción solar y de agua caliente. En los tramos exteriores, tape el aislante con una cubierta protectora para resguardarla de los elementos (rayos UV y humedad).
- Tape o recubra (con pintura) el aislante en los lugares donde esté expuesto a la luz del sol.
- Es posible que el código local requiera un vaso de expansión.
- Por lo general, un sistema solar por termosifón se añade en serie a un calentador eléctrico ya existente, así aumentando la capacidad de almacenamiento de agua caliente. Por ejemplo, se puede tener una cisterna solar de 80 galones en el techo y un calentador eléctrico de 40 galones ubicado en el cuarto de lavandería, para un total de 120 galones. La cisterna solar suministra agua caliente al tanque de 40 galones del calentador eléctrico en el hogar.
- En algunos casos, es posible utilizar solo un almacenamiento solar por termosifón, así evitando la necesidad de un calentador eléctrico primario de 40 galones.
- También es posible conectar una toma de termosifón a un calentador eléctrico pequeño sin tanque.
- Se puede utilizar una sola cisterna (de mayor capacidad) con dos puertos solares adicionales para canalizar el agua por bombeo desde la cisterna hacia el colector y viceversa.



STRATEGY

18 INSTALL ENERGY BACKUP

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Backup energy systems offer homes the ability to power essential equipment when the electrical grid is not available. This strategy focuses on explaining how to choose a generator and how to install it.

Strategy in Action

1. Choose a Generator

A. Identify Your Critical Load

B. Identify Wattage Required

C. Fuel

D. Site

2. Connect the System

WHAT YOU NEED TO KNOW

- Choose a generator based on:
  - Wattage (800W for portable generators – 130 kW for commercial generators)
  - Fuel (gasoline, propane, natural gas, diesel)
  - Size/Weight (portable or stationary)
  - Budget ($120 portable to $30,000 stationary)
  - Level of atmospheric pollution
  - Level of noise pollution
  - The more energy efficient your home is, the less backup power you need. Refer to Strategy 15 to know more about how to save energy.
  - A generator's capacity depends on the critical load. See Strategy 15.
  - Check local code requirements for generator equipment and fuel storage.
  - Consider methods of securing the generator to the site to prevent theft.



Old San Juan in the dark at night after Hurricane Maria

SUPPORTING STRATEGIES

10 Reduce Thermal Heat Gain	**11** Increase Ventilation	**12** Benefit from Natural Light
15 Reduce Your Energy Use	**17** Integrate Solar Thermal Energy	

STEP 1 - CHOOSE A GENERATOR

- Refer to Strategy 15 to determine power needs for household and calculate how many watts are necessary.
- What percentage % of power do you want to draw from solar (PV) or generator?
- By how much do you want to reduce electric bill?
- How much do you need backup electricity – are there many power outages because of grid failure.
- What is your budget for the generator?

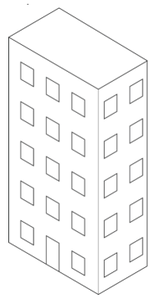
A. IDENTIFY YOUR CRITICAL LOAD

- Sizing your generator will be informed by how much "electrical load" you need to provide for sustaining your household when grid power is down. Critical load refers to the collective load of equipment in the home that should remain on consistently in order to safely inhabit the space.
- Refer to Strategy 15 to assist in identifying what load is necessary to provide power for so you can size your appropriate generator.

B. IDENTIFY WATTAGE REQUIRED

- Generators have a starting wattage and a running wattage.
- Starting wattage, also known as maximum surge wattage, is the amount of energy it requires to start up. This one is more critical when choosing.
- Running wattage is the amount of energy it requires to operate continuously.
- Use the critical load result from Strategy 15 to decide which capacity you need.
- For multi-family buildings, include emergency exit signs and emergency lighting.

GENERATOR POWER CAPACITY: MULTI FAMILY HOME



WATTAGE

CAN POWER



___ WATTS

- 1 to ___ Housing Units/per floor 2000 to 7000 Watts
- 1 to 3 Housing Units/per floor, limited to one small AC window unit or mini split (preferrably) and small refrigerator, few led lights and small tablet/compouter



UP TO 150,000 WATTS

- Common Load of Building
- Common area lighting
- Utility pumps
- Lighting in common areas
- Alarms
- Life safety equipment
- Elevator

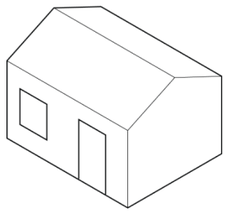
STRATEGY

18 INSTALL ENERGY BACKUP

STEP 1 - CHOOSE A GENERATOR

B. IDENTIFY WATTAGE REQUIRED, CONTINUED

GENERATOR POWER CAPACITY: SINGLE FAMILY HOME









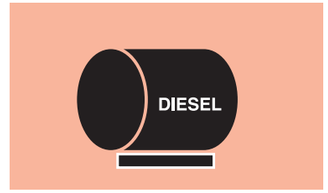
WATTAGE

2,500 WATTS	5,000 WATTS	7,500 WATTS
CAN POWER		
■ 1 refrigerator	■ 1 refrigerator	■ 1 refrigerator
■ 1 fan	■ 5 LED 60-watt bulbs	■ 9 LED 60-watt bulbs
■ 2 phone chargers	■ 2 fans	■ 5 fans
■ 4 LED 60-watt bulbs	■ 2 phone chargers	■ 4 phone chargers
	■ 1 sump pump	■ 1 well pump
	■ 1 well pump	■ 1 sump pump
	■ 1 security system	■ 1 security system
		■ 1 washing machine
		■ 1 computer
		■ 1 radio

C. FUEL







FUEL TYPE

DESCRIPTION

GASOLINE	PROPANE	DIESEL
■ **Type:** Single family home	■ **Type:** Medium Size Home	■ **Type:** Medium Size Home
■ **Emissions:** medium	■ **Emissions:** low	■ **Emissions:** medium
■ **Flammability:** High	■ **Flammability:** Lowest	■ **Flammability:** Medium
PROS		
■ Easy to store on site	■ Lighter weight and easy to store	■ Most fuel efficient
■ Fuel is easiest to find	■ Longer shelf life	■ Can be converted to biodiesel which can reuse oil.
■ Easy to store on site	■ Quieter	■ Fuel easy to obtain
CONS		
■ Limited storage life. Add fuel stabilizer for long storage time.	■ Availability may be limited	■ Diesel fueled generators are large, bulky, and can be loud. Highly flammable
■ Requires plan for cycling.		
■ Expensive		
■ Highly flammable		

REMEMBER



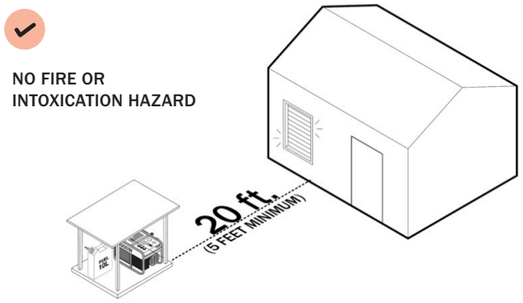
After an emergency or natural disaster, fuels may be in limited supply. Consider a smaller generator, therefore consuming the least amount of fuel to provide energy to essential needs

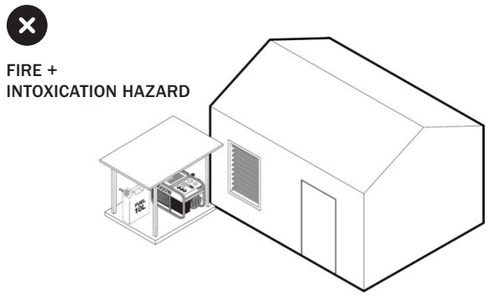
STRATEGY

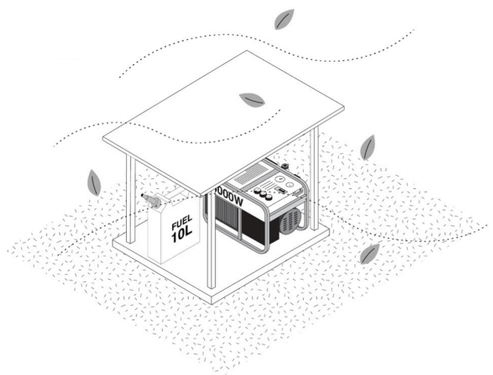
18 INSTALL ENERGY BACKUP

STEP 1 - CHOOSE A GENERATOR

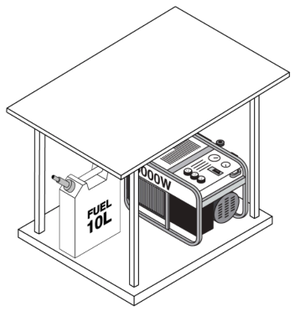
D. SITE

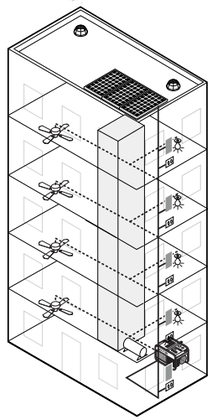








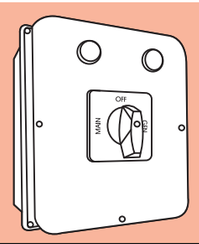




STEP 2 - CONNECT THE SYSTEM

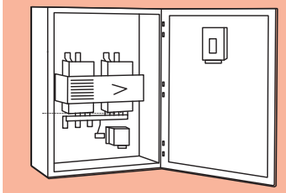
- The generator powers up an emergency circuit dedicated to critical loads, as established in Strategy 15.
- Install a transfer switch to switch from the regular system to emergency power.
- Locate the switch between the main distribution panel and the emergency circuits.
- Ensure the emergency distribution panel (or critical load panel) is isolated from the grid via the transfer switch for easier control when operating a generator.

TYPES OF SWITCHES



MANUAL TRANSFER SWITCH

Activate manually when the main power supply fails and deactivate when power is restored. This switch is less expensive, and it allows for a closer management of available energy, yet requires more effort to operate.



AUTOMATIC TRANSFER SWITCH

Continuously monitors electric power. It automatically switches to emergency power when the main power supply fails, and switches back when power is restored. The switch is more expensive but requires less effort to operate.

OPERATIONS AND MAINTENANCE TIPS

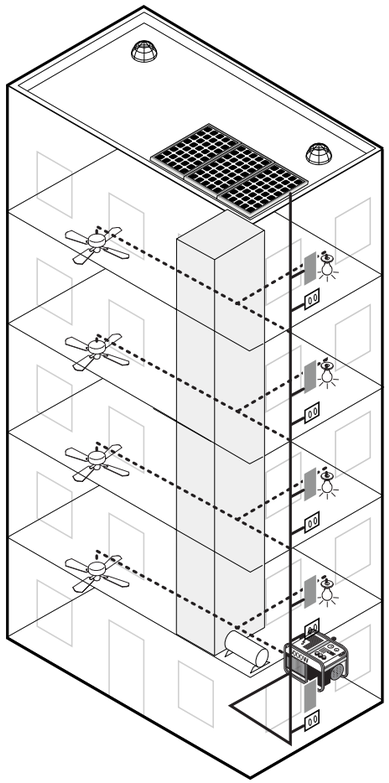
- All fuels must be appropriately stored and anchored to prevent fires!
- Exercise the generator at least once a month. Many modern models perform test runs automatically while some are manual.
- Perform exercise drills every month for a 2-hour period at 50% load capacity. This allows enough time for the unit to lubricate while allowing all moisture to evaporate.
- For portable generators, generator manufacturers recommend draining the fuel from the tank and running the carburetor dry prior to storing or if it has been stored for more than 6 months.
- Stock up on oils and filters. Most generators require their first oil change after 25 hours and then every 50 to 60 hours of use.
- Keep the tank full and remove all loads before shutting down the generator. Failure to do so will damage it.
- Contact a professional electrician upon the installation of the generator and schedule regular check-ups various times in a year.
- Have on hand the telephone/email of a professional electrician or manufacturer in case of an emergency.

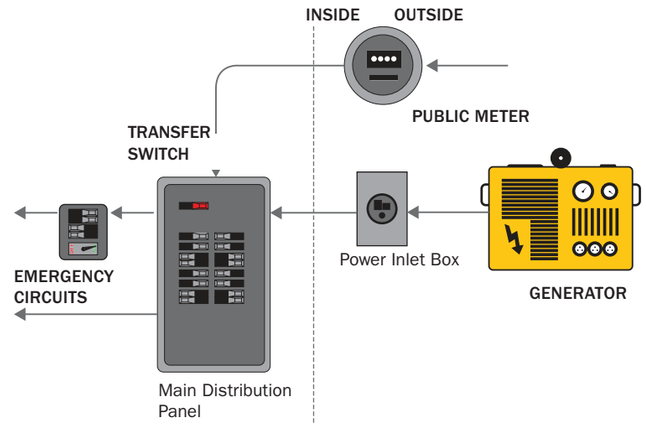
STRATEGY

18 INSTALL ENERGY BACKUP

STEP 2 - CONNECT THE SYSTEM

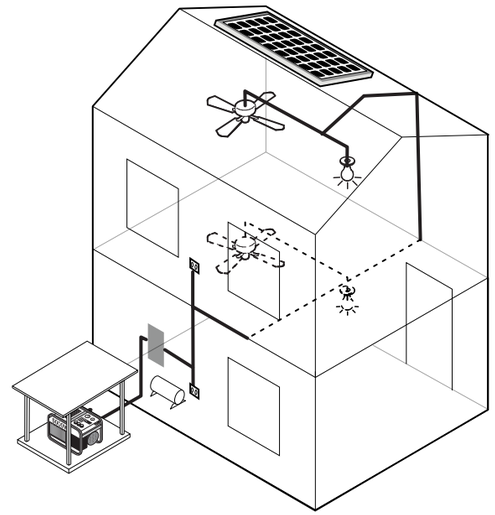
MULTI FAMILY HOME



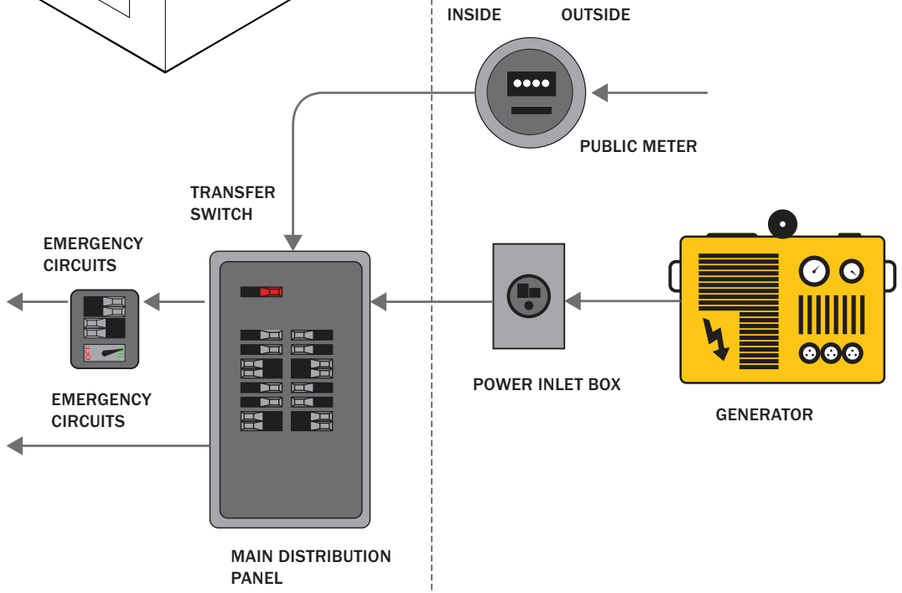




SINGLE FAMILY HOME





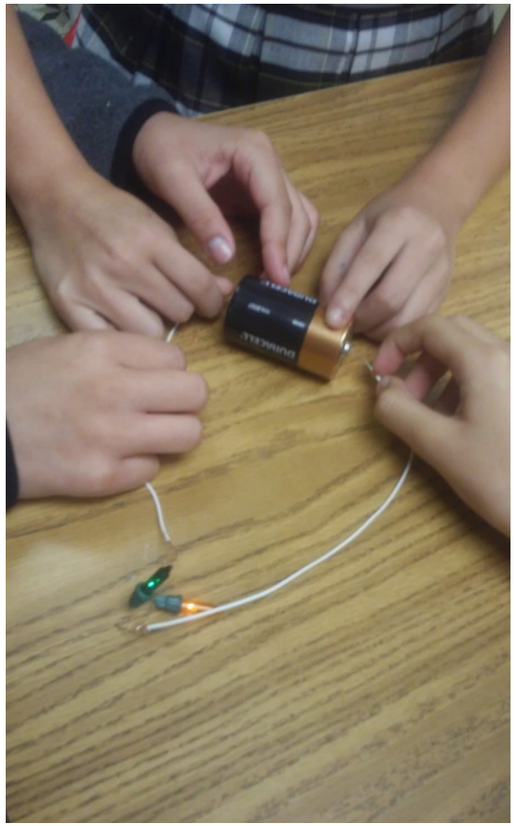


STRATEGY

18 INSTALL ENERGY BACKUP

TROUBLESHOOTING GUIDE

APPARENT PROBLEM	Generator running but no AC output available	Generator runs good but bogs down when loads are connected	Switches are not working with generator power	Appliances do not operate after utility power is restored	Only some loads work on generator power
PROBABLE CAUSE	☐ generator circuit breaker has tripped ☐ poor connection ☐ connected device is bad ☐ fault in generator	☐ short circuit in a connected load ☐ generator is overloaded ☐ try appliance startup one at a time	☐ switches are in OFF or LINE position ☐ generator circuit breaker has tripped ☐ poor connection or defective cord set ☐ connected device is bad ☐ fault in generator	☐ switches are in GEN or OFF position ☐ Circuit breaker tripped	☐ circuit breaker tripped ☐ poor connection or defective cord set
PROBABLE SOLUTION	☐ reset circuit breaker ☐ check and repair ☐ select a different load or appliance that is in good condition ☐ contact a qualified professional	☐ disconnect shorted electrical load ☐ review load power requirements and rearrange	☐ move switches to GEN position ☐ reset circuit breaker ☐ check and repair ☐ select a different load or appliance that is in good condition ☐ contact a qualified professional	☐ move switches to LINE position ☐ Reset circuit breaker	☐ reset circuit breaker ☐ check and repair



COMUNIDAD TORO NEGRO, INC., CIALES



Description: Comunidad de Toro Negro is located in Ciales, a municipality in Puerto Rico's inner mountains. This community is comprised of close to 60 families and has become renowned over the years for the numerous projects they have developed to improve the quality of life of its residents. Their developed projects include the construction of two concrete slabs to provide motor vehicle access across the Toro Negro River, and the development of hanging bridges [puentes hamaca] to provide access for residents if the river overflows, among other projects. Recently, the Puerto Rico Community Foundation (FCPR, by its Spanish acronym) and the non-profit organization SOMOS Solar, in partnership with Maximo Solar Industries, joined forces to develop an efficient solar system for the region. This is the first time that the system is run by a community-based organization whose members are the residents themselves.



JONATHAN MARVEL
FOUNDER, RESILIENT POWER PUERTO RICO

Founded in the wake of hurricane Maria, Resilient Power Puerto Rico is led by Jonathan Marvel and Puerto Rico-born New York attorney, Cristina Roig. Resilient Power Puerto Rico's long-term mission is to address the vulnerabilities of the island's existing, fossil-fueled electrical infrastructure by supporting initiatives that promote renewable, clean energy. Our vision is a Puerto Rico with redundant, reflexive, adaptable, and inclusive built and social infrastructures, where communities across our islands autonomously adapt and build a sustainable and equitable society.

As an architect, urban designer, and civilian who wants to help his hometown, the biggest lesson I've learned after Maria is to not wait for help. Set your goal, make your plan, and call it into action through execution. Always observe what people need first as the starting point. I have had a great deal of access to many communities across Puerto Rico through the work of my mother, Lucilla Marvel, who has worked with and documented the needs of informal communities for over 40 years. Members of these communities have taught me so much about putting ideas into action.

The donations we have received (from around the world and especially the Puerto Rican Diaspora) have gone straight to supporting communities throughout Puerto Rico. We have already solarized 25 communities, and after stepping back and observing what happened we have a plan to solarize an additional 75 communities. We are leveraging support to build systems that can be self-sustaining so that communities are empowered to control their own energy.

The basic installation of hardware package consists of 20 solar panels at 350 watts per panel, which enables us to power up a community center, which in turn allows households to power their lives. Our installations are designed to be off-grid and autonomous if necessary, with no need for fossil fuel–burning generators.



My recommendation for the federal agencies working towards rebuilding Puerto Rico is to seize this opportunity and utilize Puerto Rico's vast reserves of renewable energy as a key part of the recovery process as well as support Puerto Rico's energy resilient future. Future considerations should be to build decentralized systems (where deemed possible and appropriate) and create community scale solar hubs and microgrids to power up entire communities, working in partnership with each municipality, community by community.

I believe that housing, commercial industry, universities, and hospitals can all achieve 100% renewable energy source systems, if they are designed properly using rooftops and parking lots which can have a co-benefit of providing shading from the hot sun. We don't need to mount large scale solar systems on arable agriculture land and displace farms and economies. We must work to ensure a resilient and renewable future for Puerto Rico so that the heavy, old fossil-fuel energy plants that traditionally powered Puerto Rico can be a thing of the past.



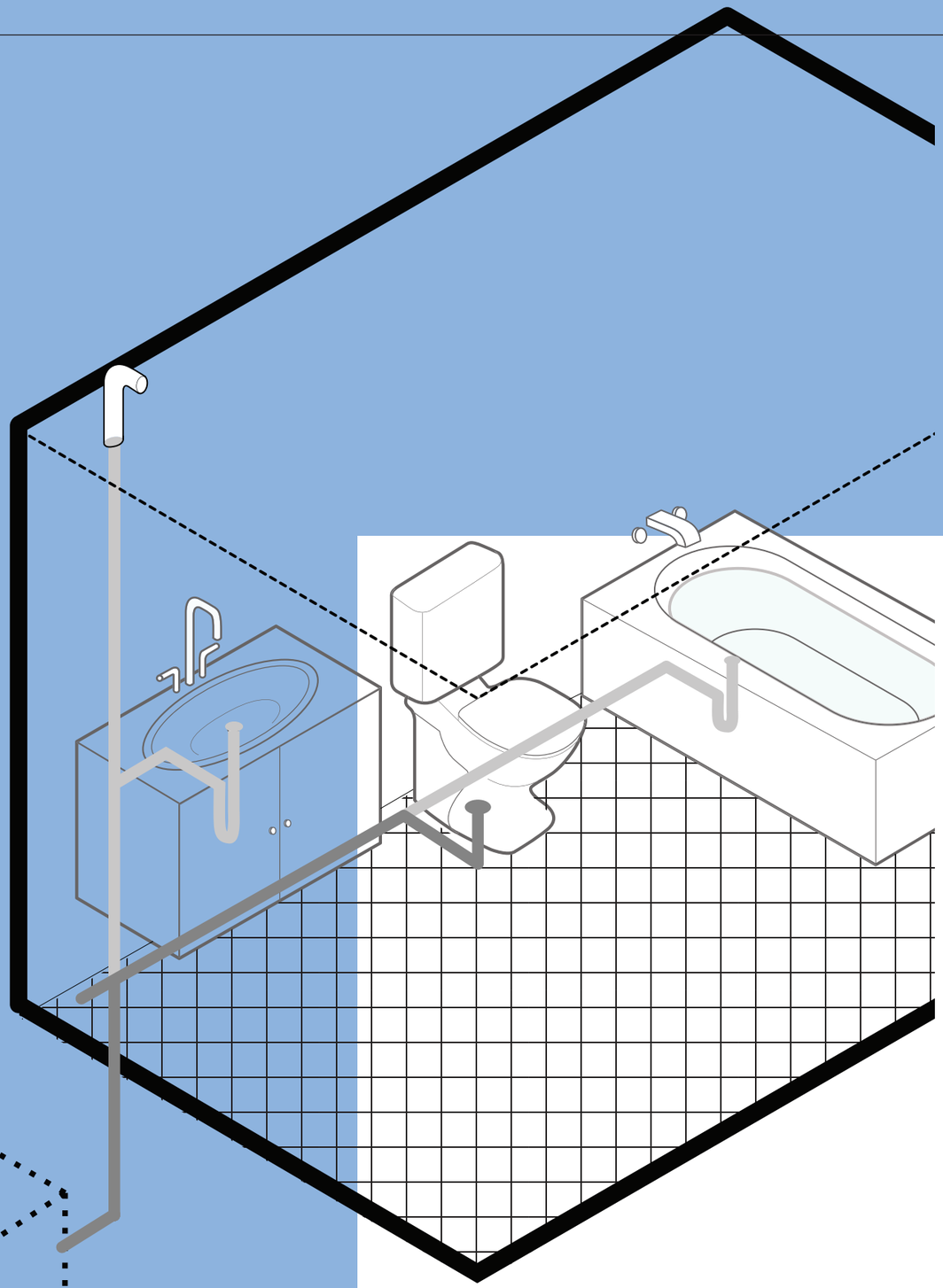
13,800

9,200

Gumersindo Torres
Executive Director of Rio Chiquito

CHAPTER

5



WATER MANAGEMENT AND STORAGE

Strategies that provide critical needs for water when a facility loses power or other services.

INTRODUCTION

TYPES OF STRATEGIES LISTED IN THIS SECTION

STRATEGY #	19	20	21	22
STRATEGY NAME/TITLE	REDUCE YOUR WATER CONSUMPTION	COLLECT AND USE RAINWATER	IMPROVE SEPTIC WASTE DISPOSAL SYSTEM	PREVENT WASTEWATER BACKFLOW IN HOMES
DESCRIPTION	As with electricity, reducing your water consumption will not only save you money, but it can also make you less dependent on the central water supply. Being in the habit of using less water means you can get by more easily if there is a shortage. This strategy identifies ways to use water efficiently.	This strategy shows how to harness stormwater on site for household use.	This strategy explains the basic components of a septic system, the design considerations for each part of the system, and an overview of how to build each part.	This backup can create unsanitary conditions for occupants by exposing them to bacteria contaminating potable water reservoirs, which may leave people without safe drinking water. This strategy identifies ways to mitigate these risks.
	$	$-$$	$$-$$$	$

During storms and other natural hazard events, drinking water -or “potable” water- can become scarce or contaminated, and non-potable water such as waste from sinks and toilets may have nowhere to go. Managing water resources to create a resilient household or residential building is critical to supporting household, building and community resilience.

Puerto Rico has some of the most abundant water resources on earth, with 1200 freshwater bodies irrigating it from mountain to coast, andan average of 30 to 170 inches of rainwater annually, depending on the area. However, there is not yet enough water treatment infrastructure to purify or distribute this water. This can leave homes and housing vulnerable to interruptions in potable water supply. Additionally, an interruption of electrical service, a fractured distribution pipe or a contaminated reservoir can jeopardize water security during a natural hazard event - which drives home the importance of taking resilient water management into our own hands.

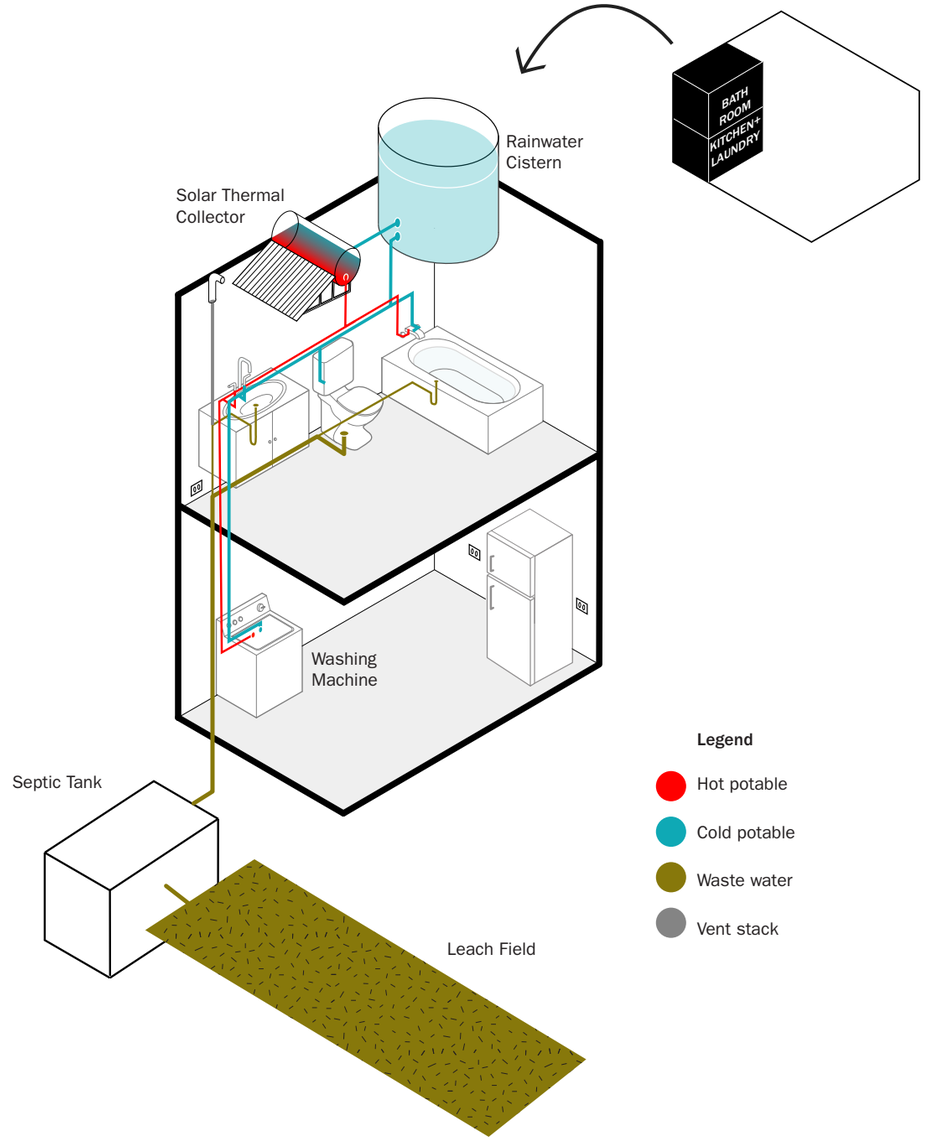


HOW DO WE USE WATER

Residential buildings manage water in two ways:"intake," or supply of potable water, and "outtake," or discharge of non-potable water.

- **SUPPLY**: Water is usually distributed to buildings from a large treatment facility after it is made safe for drinking. In the majority of cases, the systems that deliver water to a household faucet are pressurized - which means they need energy in order to operate.
- **DISCHARGE**: There are two types of water that leave our homes: rainwater, which can collect at the roof and at our site's surface, and wastewater, which comprises waste draining out of toilets, urinals, lavatories, sinks and washing machines. In the majority of cases, these systems use gravity tooperate, not electricity.
- Understanding these components and how they work at our homes will enable us to improve them. The strategies outlined in this chapter support conservation and management of both potable and wastewater on sites to ensure access to clean and safe water in the face of a natural hazard.

WATER SYSTEMS



STRATEGY

19 REDUCE YOUR WATER CONSUMPTION

$

As with electricity, reducing your water consumption will not only save you money, it can make you less dependent on the central water supply. Approximately 98% of Puerto Rico's houses depend on the public water system operated by the Puerto Rico Aqueduct and Sewer Authority (PRASA)/Autoridad de Acueductos y Alcantarillados de Puerto Rico (AAA). Nearly everyone is at risk of losing access to drinkable water if pipes in the system break, pumps stop working, or water becomes contaminated. Being in the habit of using less water means you can get by more easily if there is a shortage. This strategy identifies ways to conserve and use water efficiently.

Strategy in Action

1. *Calculate your household water use*
2. *Conserve water*
3. *Repair leaks*
4. *Install water-efficient fixtures*
5. *Incorporate graywater*

WHAT YOU NEED TO KNOW

- Understanding how much water your household uses now is important for measuring your progress. Simple changes in the way you use water on a daily basis can reduce your water consumption by 50%.
- Updating your plumbing fixtures will lower water use.
- Keeping your plumbing systems in good working order saves water and protects your house from damage.
- Modifying your water supply system gives you new sources of water for certain uses.



SUPPORTING STRATEGIES

01	02	14
Reinforce Site	Reinforce Site with Vegetation	Manage Pests

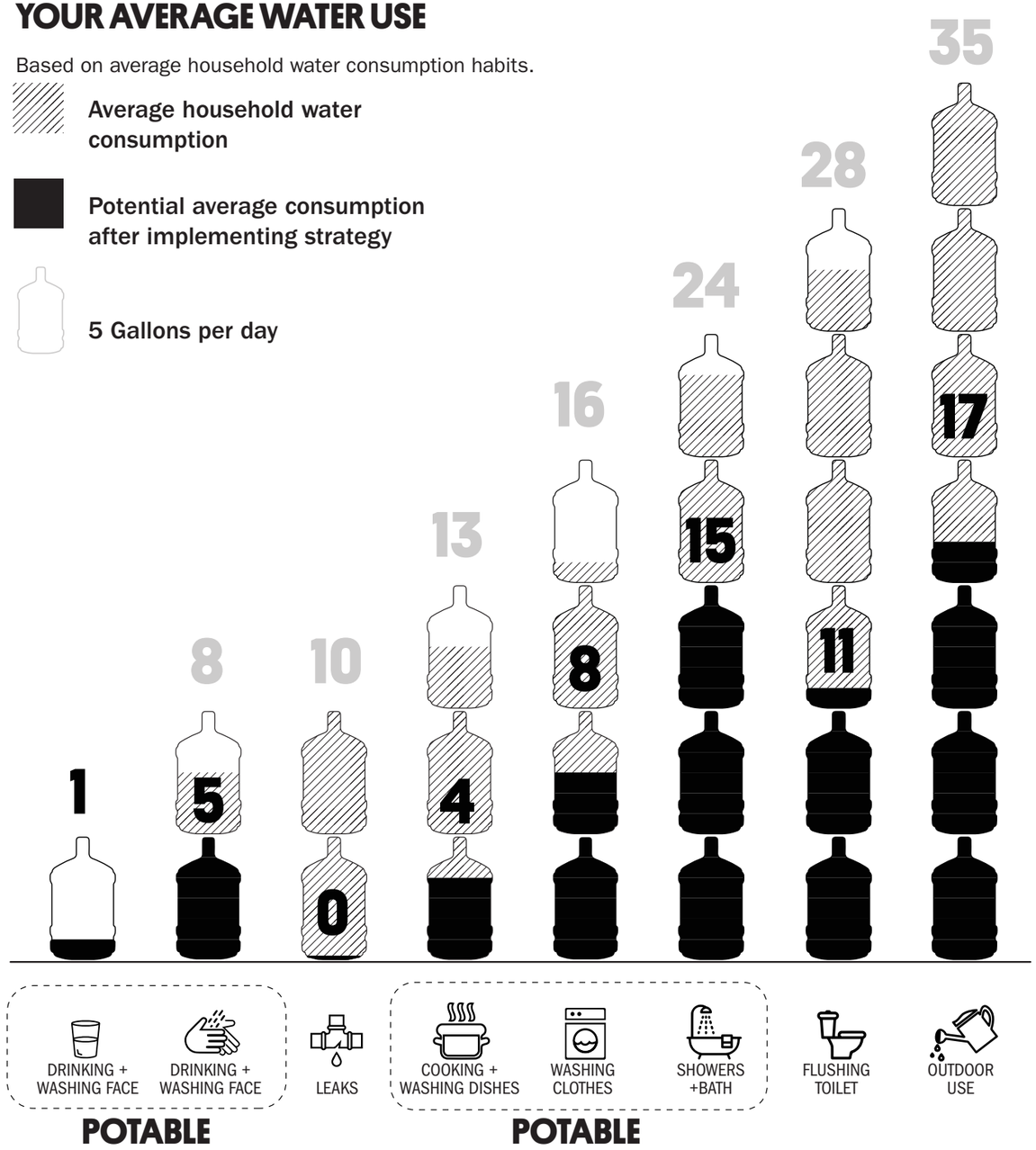
YOUR AVERAGE WATER USE

Based on average household water consumption habits.

Average household water consumption

Potential average consumption after implementing strategy

5 Gallons per day



STRATEGY 19

REDUCE YOUR WATER CONSUMPTION

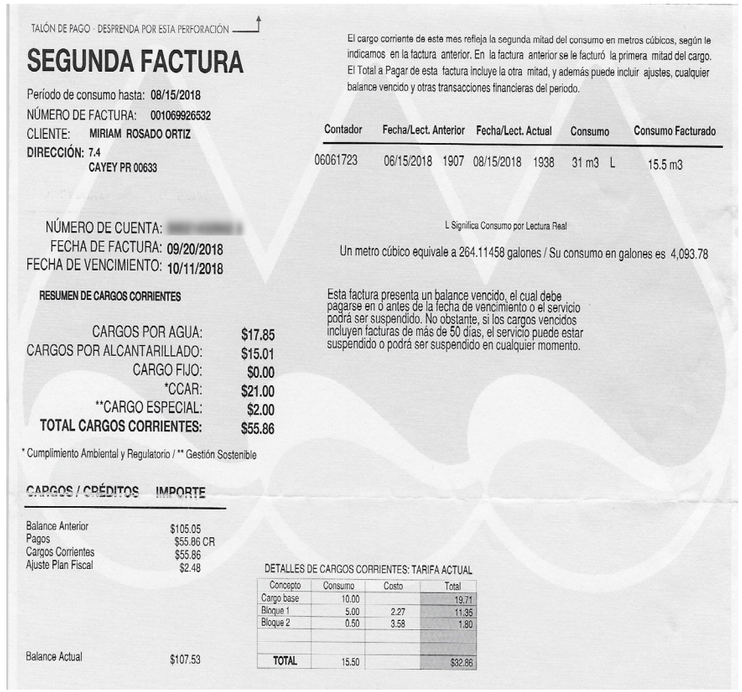
STEP 1 - CALCULATE HOUSEHOLD WATER USE

Analyze your water bill to see how much water you are using, and how much you are saving as you conserve. Try to reach far below the Autoridad de Acueductos y Alcantarillados average of 62.5 gallons per person per day.

WATER USE

Use the equation below to calculate your water use.

GALLONS PER DAY					GALLONS PER PERSON PER DAY				
gallons per month	×	days in the month	=	gallons per day	gallons per day	×	# family members	=	gallons per person per day



TALÓN DE PAGO - DESPRENDA POR ESTA PERFORACIÓN

SEGUNDA FACTURA

Período de consumo hasta: **08/15/2018**
NÚMERO DE FACTURA: **001069926532**
CLIENTE: **MIRIAM ROSADO ORTIZ**
DIRECCIÓN: 7.4
CAYEY PR 00633

El cargo corriente de este mes refleja la segunda mitad del consumo en metros cúbicos, según le indicamos en la factura anterior. En la factura anterior se le facturó la primera mitad del cargo. El Total a Pagar de esta factura incluye la otra mitad, y además puede incluir ajustes, cualquier balance vencido y otras transacciones financieras del periodo.

Contador	Fecha/Lect. Anterior		Fecha/Lect. Actual		Consumo		Consumo Facturado
06061723	06/15/2018	1907	08/15/2018	1938	31 m3	L	15.5 m3

L Significa Consumo por Lectura Real

Un metro cúbico equivale a 264.11458 galones / Su consumo en galones es 4,093.78

NÚMERO DE CUENTA: [redacted]
FECHA DE FACTURA: **09/20/2018**
FECHA DE VENCIMIENTO: **10/11/2018**

Esta factura presenta un balance vencido, el cual debe pagarse en o antes de la fecha de vencimiento o el servicio podrá ser suspendido. No obstante, si los cargos vencidos incluyen facturas de más de 50 días, el servicio puede estar suspendido o podrá ser suspendido en cualquier momento.

RESUMEN DE CARGOS CORRIENTES

CARGOS POR AGUA:	**$17.85**
CARGOS POR ALCANTARILLADO:	**$15.01**
CARGO FIJO:	**$0.00**
*CCAR:	**$21.00**
**CARGO ESPECIAL:	**$2.00**
TOTAL CARGOS CORRIENTES:	**$55.86**

* Cumplimiento Ambiental y Regulatorio / ** Gestión Sostenible

CARGOS / CRÉDITOS	IMPORTE
Balance Anterior	$105.05
Pagos	$55.86 CR
Cargos Corrientes	$55.86
Ajuste Plan Fiscal	$2.48
Balance Actual	$107.53

DETALLES DE CARGOS CORRIENTES: TARIFA ACTUAL

Concepto	Consumo	Costo	Total
Cargo base	10.00		19.71
Bloque 1	5.00	2.27	11.35
Bloque 2	0.50	3.58	1.80
TOTAL	15.50		$32.86

STEP 2 - CONSERVE WATER

Consume less water to save money and help the environment.



	BATH	SHOWER	BRUSHING TEETH
GALLONS / DAY	36	2-5	1-2
CONSERVATION PRACTICES	Take a shower instead of a bath.	Shower quickly with a low-flow showerhead.	Turn the faucet off when brushing.



	WASHING FACE/HANDS	SHAVING	WASHING DISHES
GALLONS / DAY	1	1	8-27
CONSERVATION PRACTICES	Turn the faucet off soaping hands and face.	Turn the faucet off when shaving.	Scrub first, then wash dishes while turning off faucet. Only run a dishwasher when it is full.

STRATEGY 19

REDUCE YOUR WATER CONSUMPTION

STEP 2 - CONSERVE WATER



WASHING CLOTHES

GALLONS / DAY: 8-14

CONSERVATION PRACTICES:

Wash clothes

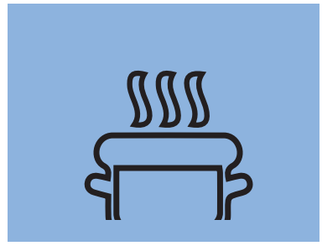


TOILET FLUSH

GALLONS / DAY: 3

CONSERVATION PRACTICES:

- Use toilets that are as “low flow”as possible ranging from 1.5 gpm to .6 Use toilets that are dual flush separating liquid and solids.
- Check toilet for leaks.



DRINKING AND COOKING

GALLONS / DAY: 2

CONSERVATION PRACTICES:

- Reuse water where possible.
- Measure water absolutely needed for cooking.
- Steam food when possible to conserve water.



IRRIGATION

GALLONS / DAY: 2

CONSERVATION PRACTICES:

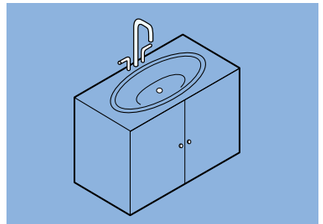
Prioritize functional landscape to fortify site, retain stormwater, encourage shading and other functions and use native plants whenever and wherever possible.

CALCULATE HOW MUCH WATER YOU SPEND YEARLY PER ACTIVITY

# of gallons	×	365	=	gallons in activity per year

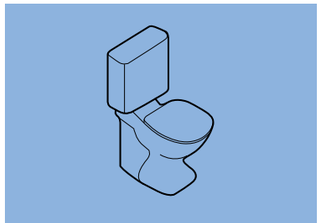
STEP 3 - REPAIR LEAKS

- Leaks can make you lose 40% of the potable water you pay for.
- Regularly check for leaks or monitor your bill or water meter for spikes in use, particularly for multifamily buildings. Hire a plumber to find leaks you can’t see. - Repair leaks quickly. Even slow drips can waste a lot of water over time.



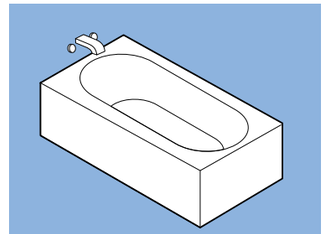
SINK

- Kitchen or bathroom
- Can leak due to open faucet or faulty gasket



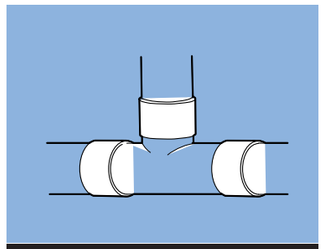
TOILET

Can leak due to open valve, faulty buoy or gasket



BATHTUB FAUCET

Can leak due to open faucet or faulty gasket



PLUMBING

Water will leak through any connection that is not completely sealed. Look for humidity marks on the walls and keep an eye out for a trickling sound coming from “inside” the wall.



STRATEGY 19

REDUCE YOUR WATER CONSUMPTION

STEP 4 - INSTALL WATER-EFFICIENT FIXTURES

- Replace old standard fixtures for more efficient models, or retrofit existing ones with aerators.
- Install a pre-rinse valve.
- Look for fixtures that have the Environmental Protection Agency's Water Sense label. WaterSense products use up to 20% less water than the regular models.
- Install Aerators in the Faucet which are various devices used mixing air and water. These devices allow you to use less water and maintain pressure.

BATHROOM



TOILET

- Convert a 5-10 gallon toilet to a 1.28 one using a WaterSense Fixture.
- Convert to a dual flush toilet
- Install low flush flushometer to existing toilet.
- Consider installing a first flush water diverter, which helps reduce solids.



FAUCET

- Convert to a WaterSense of 1.5gpm or less.



SHOWER HEAD

- Convert to a WaterSense .5 gpf "low flow" showerhead.



AERATOR

- An WaterSense aerator increases water pressure while decreasing water used.

IRRIGATION



IRRIGATION

- Water efficient fixtures for irrigation:
  - Irrigation Controller
- Spray Sprinkler Bodies that include:
  - Drip system for planting beds
  - Separate zoning for turf and plantings
  - Timer
  - Rain delay controller
  - Available in WaterSense

OPERATIONS AND MAINTENANCE TIPS

- Check regularly for leaks through a visual inspection of pipes and quality of water.
- Replace gaskets and rubber parts when needed.
- Use non-toxic cleaning supplies for water that goes into the graywater supply.
- Never expose occupants to Blackwater

KITCHEN / LAUNDRY



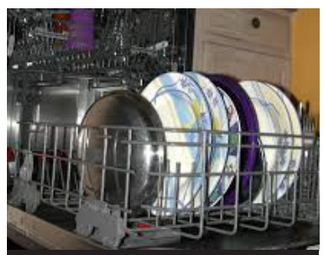
KITCHEN / SINK

- Convert to a WaterSense of 2.0gpm or less.
- Install a WaterSense aerator to increase pressure and decrease amount of water used.
- Install a recirculating pump to existing hot water system to reduce the time hot water arrives to fixture.



WASHING MACHINE

- Convert to an ENERGY STAR certified washer.



DISHWASHER

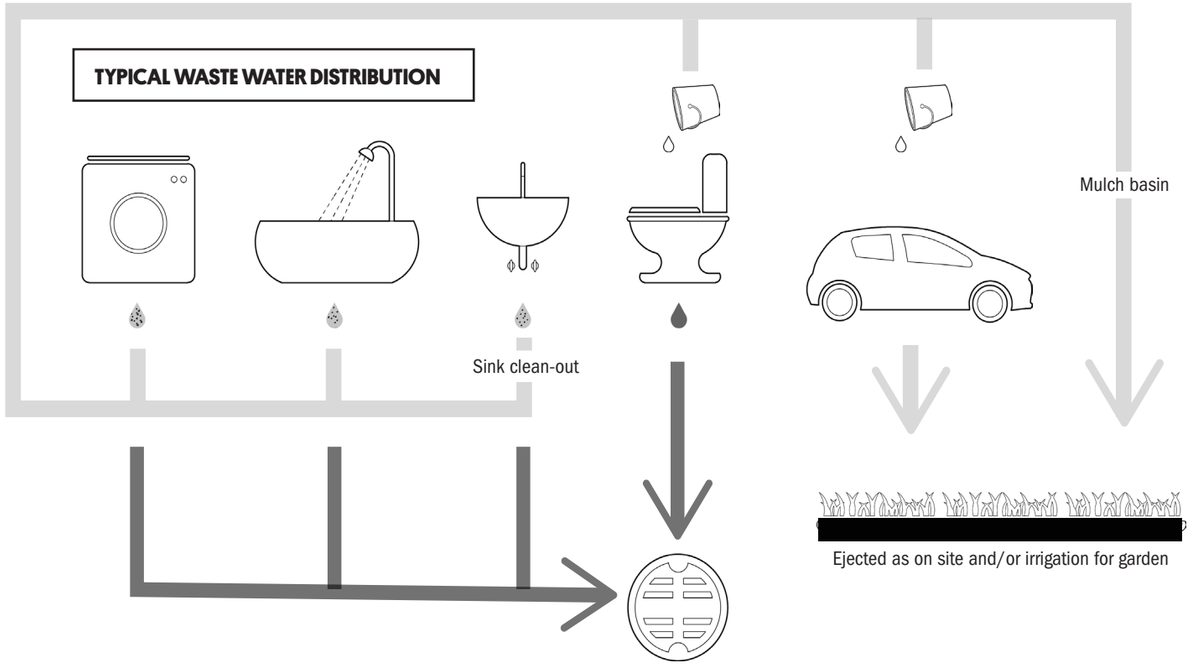
- Convert to a water efficient ENERGY STAR certified dishwasher.

STRATEGY 19

REDUCE YOUR WATER CONSUMPTION

STEP 5 - INCORPORATE GRAYWATER

- GRAYWATER: Only 30% percent of household water needs to be safe for drinking. A graywater system allows you to reuse water in certain fixtures, and can reduce the amount of water you draw from the water supply by as much as 50%.
- Graywater is water that drains from bathroom sinks, washing machines, and bathtubs. It can be used instead of drinking water to flush toilets, irrigate plants, or for anything except drinking or bathing. In tropical locations, graywater must be used that same day to prevent bacterial contamination.
- Blackwater is wastewater from toilets, and contains dangerous bacteria. People should not be exposed to it.

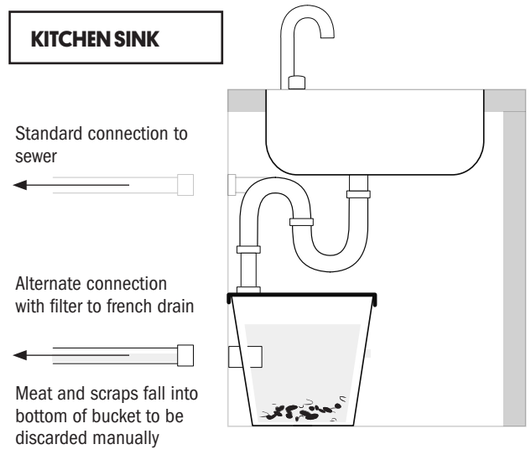


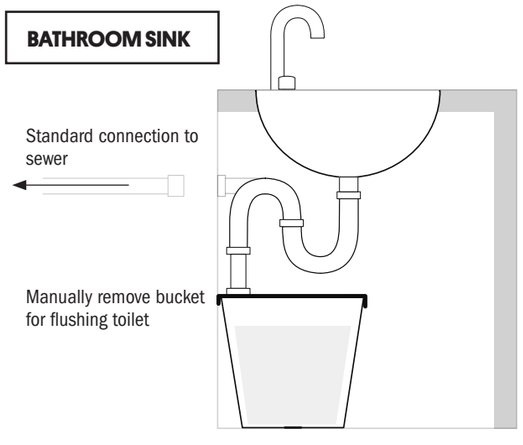
CODE

Per the IPC 2018 - Graywater used for flushing water closets and urinals shall be disinfected by an on-site water reuse treatment system complying with NSF 350.

BATHROOM AND KITCHEN SINK WATER

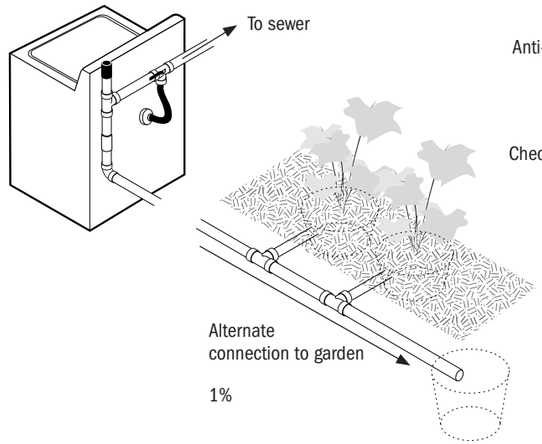
- Option #1: Adapt your plumbing system to use graywater. Water from kitchen sinks needs filtration.
- Option #2: Manually remove the J-Trap and place a bucket underneath. This water can be directly poured into the toilet.
- If using to water plants, do not use harsh soaps or detergents.





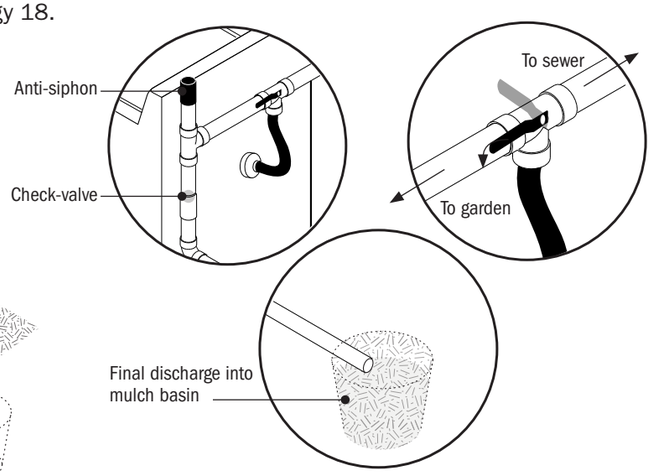
LAUNDRY WATER

- Switch to a detergent that does not contain harsh chemicals (phosphates or chlorine).
- Remove the discharge hose from the washing machine and connect it to a hose long enough to reach the garden.
- Create a mulch basin to absorb the water.
- This method has a risk of creating a backwater flow into the washing machine. See Strategy 18.



USE NATIVE LANDSCAPING

- 30-50% of a home's water consumption is dedicated to landscaping.
- Using Native Plants-using plants that are adaptive to the local environment will conserve water and potentially help anchor the site from erosion.
- Please refer to Strategies 02 and 03 for more info on resilient use of vegetation.



STRATEGY

20 COLLECT AND USE RAINWATER

$-$$

Rainwater harvesting is the collection and storage of rainwater for reuse on-site through irrigation. Regularly harvesting rainwater makes your home resilient by reducing the dependency on the system, minimizing storm water run-off, and preventing the septic system from overloading. This strategy focuses on showing how to harness storm water on-site.

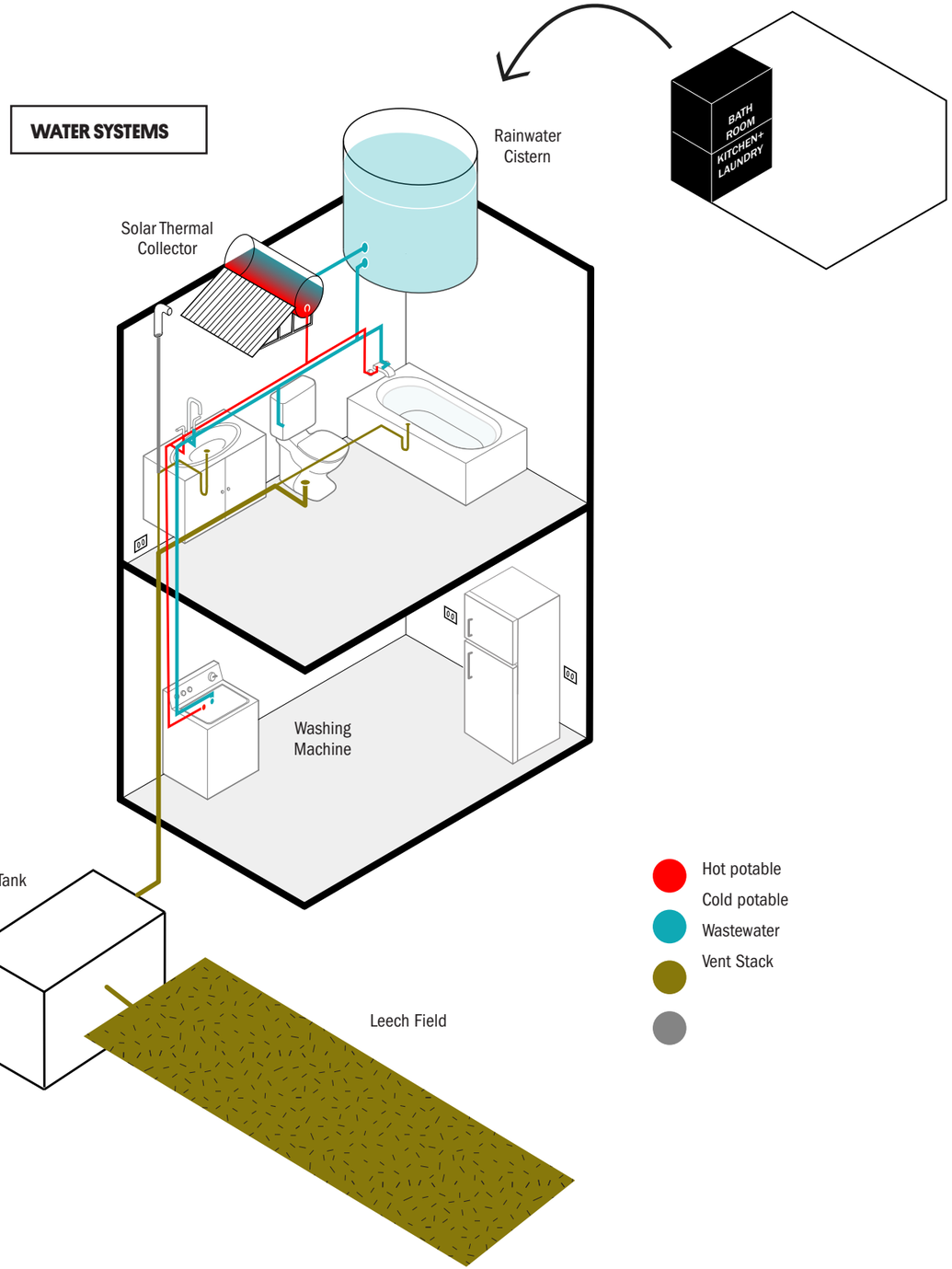
Strategy in Action

1. *Identify Soil Type and Properties*
2. *Choose and Plant Vegetation*
3. *Implement Resilient Sitescaping*

WHAT YOU NEED TO KNOW

- Rainwater is not naturally potable. To turn rainwater into drinking water, you must treat it and filter it so that it meets local health regulations and codes.
- Your entire roof assembly is surface to support rainwater catchment. Therefore, be considerate of the paints, materials, and slope of the roof to support maximum water capture.
- The water quality coming off a roof during a rainstorm tends to improve as the rain continues. The first inch of rainwater can contain the highest percentage of contaminants and should be filtered and flushed out of system before use.





SUPPORTING STRATEGIES

03 Plant an Edible Garden	**02** Reinforce Site with Vegetation	**18** Install Energy Backup
19 Reduce Your Water Consump-tion	**21** Improve Septic Waste Disposal System	**22** Prevent Waste-water Backflow in Homes

STRATEGY

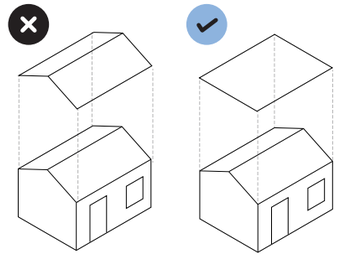
20 COLLECT AND USE RAINWATER

STEP 1 - CALCULATE ROOF WATER COLLECTION POTENTIAL

An average Puerto Rican single family home can collect up to 28 gallons of water per square foot. For a 1,000 sq. ft. home, this is equivalent to 2,800 gallons a year. Assuming a cost of $1 per gallon, this means almost $3000 in savings.

A. CALCULATE YOUR ROOF AREA IN FEET

Roof's Area: Make sure to measure area by multiplying length times width of roof's span (foot-print), not its superficial area.



Superficial Area

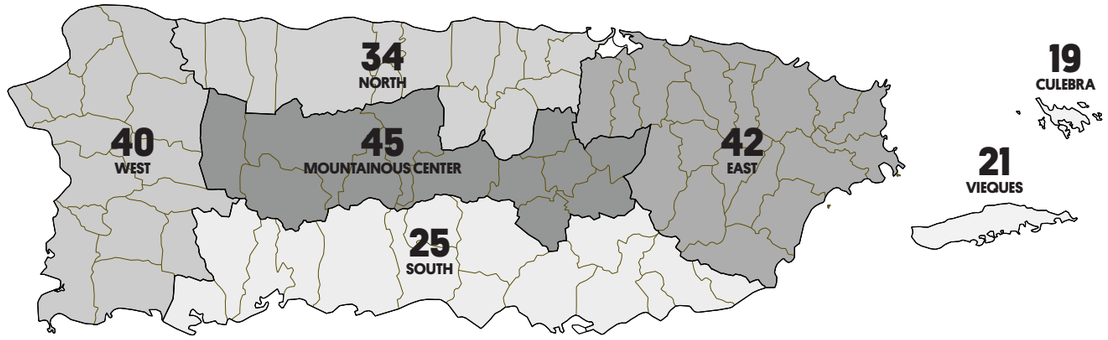
Area for Catchment Potential



ECOCENTER AT HERONS HEAD PARK

B. IDENTIFY ANNUAL RAINFALL IN YOUR AREA USING THE MAP BELOW

CATCHMENT POTENTIAL IN PUERTO RICO



C. PLUG IN RESULTS FROM PARTS A AND B TO DETERMINE YOUR POTENTIAL RAINWATER COLLECTION.

Use a co-efficient of .85 when measuring how much water will be harvested from your system for your household needs.

A: ANNUAL CATCHMENT POTENTIAL — gallons/sq.

×

B: ROOF AREA (LENGTH X WIDTH) — square feet

=

C: YOUR ROOF'S CATCHMENT POTENTIAL — gallons per year

COMPARE WITH: Water consumption calculated on STRATEGY 19*

WATER CONSUMPTION — gallons per year



STRATEGY 20

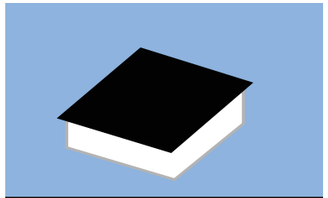
COLLECT AND USE RAINWATER

STEP 2 - OPTIMIZE + SLOPE YOUR ROOF AND GUTTER FOR WATER COLLECTION

- Slope, Materials, and Finishes, affect a roof's catchment potential.
- Water must be transferred and stored quickly; stagnant water may be too heavy for the roof.
- Regularly maintain the roof. Materials deteriorate over time and the loose roofing finishes can contaminate water.
- Use the appropriate filters in the tank coming off the roof.

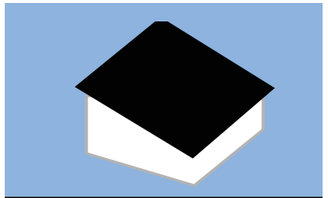
A. SLOPE

The ideal slope for catchment is 2%.

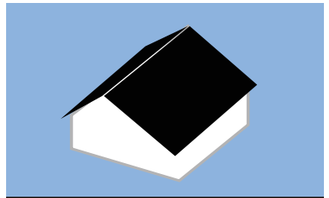


FLAT

Pooling water puts additional load on the structure and can damage it. Pooling water can also lead to pests like mosquitos that can cause health issues. See Strategy 14.



SINGLE PITCHED



MULTIPLE PITCHED

Ensure roof is sloped in every direction



PLENITUD, LAS MARIAS

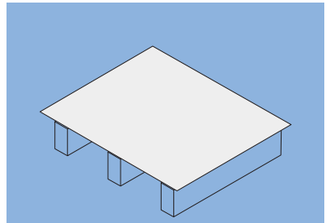


B. MATERIALS

REMEMBER

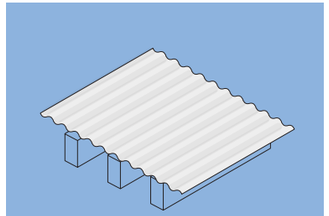
If you wish to use water from rivers or wellspring, test for bacteria. Most surface water sources are contaminated with deadly bacteria.

Materials used as catchment surface area and gutter should be free of pollutants like airborne chemicals that can leach into water.



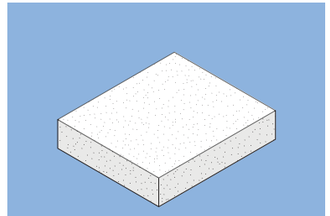
METAL ROOF

- Low porosity prevents it from absorbing water.
- Can become very hot and that could lead to water loss.
- Requires an additional finish to prevent rusting and corrosion.



CORRUGATED METAL ROOF

- Gutters help direct water for collection.
- Clean gutters regularly to prevent sediment build up.
- Place perpendicular to water flow to reduce its flow speed.
- Requires an additional finish to prevent rusting and corrosion.

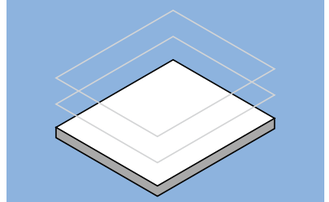


CONCRETE ROOF

- High porosity can create sediment build up.

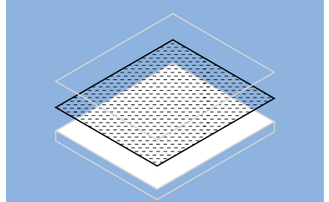
C. FINISH

Finishes used on catchment surface area and gutter should not have zinc or lead that can leach into water.



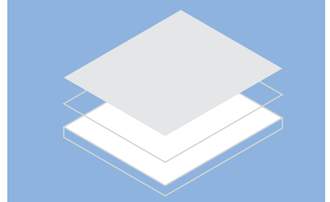
INSTALLATION

- Apply a protective layer to prevent chemicals from roof from contaminating harvested water.



SEALANT

- Seal with FDA approved sealants like Danosa. These elastomeric sealants are made with silicone, an elastic polymer that seals cracks and waterproofs surfaces.
- Maintain sealant as directed.



PAINT

- Apply an epoxy coat to prevent metal from rusting and contaminating harvested water.

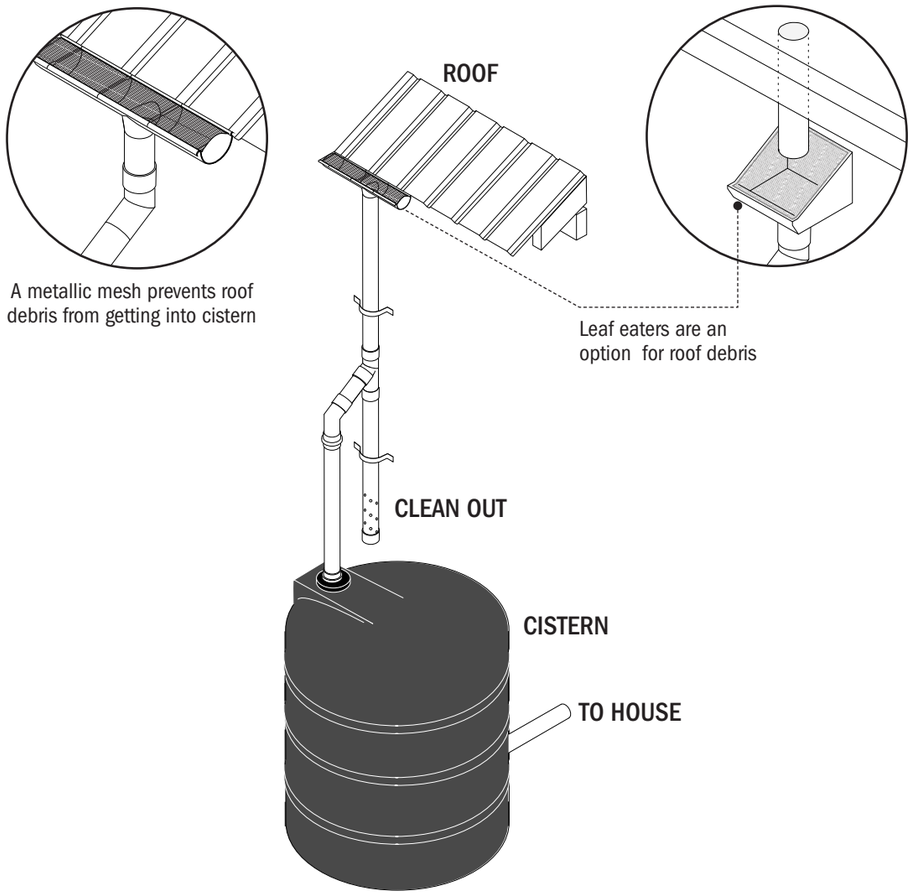
STRATEGY 20

COLLECT AND USE RAINWATER

STEP 2 - OPTIMIZE + SLOPE YOUR ROOF AND GUTTER FOR WATER COLLECTION

OPTIMIZE GUTTERS AS COLLECTION ELEMENTS

- Use a leaf catcher to prevent clogging and prevent large organic matter from entering your system.
- Anchor gutters to the structure during strong winds or a hurricane.
- Flush out the first 5 minutes of stream, using a clean-out device, to eliminate debris and dirty water with minimal loss.



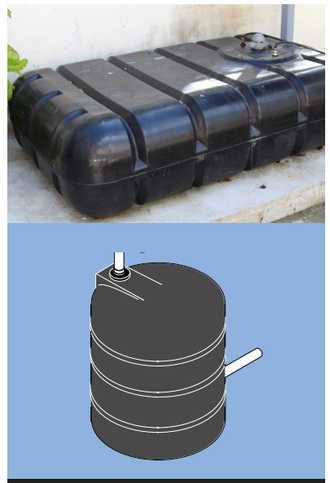
STEP 3 - SELECT A CISTERN

A. SIZE

- Use the number calculated on Strategy 19 to determine water needs.
- Have a redundant system — use multiple cisterns in case one fails. This is a higher upfront investment.

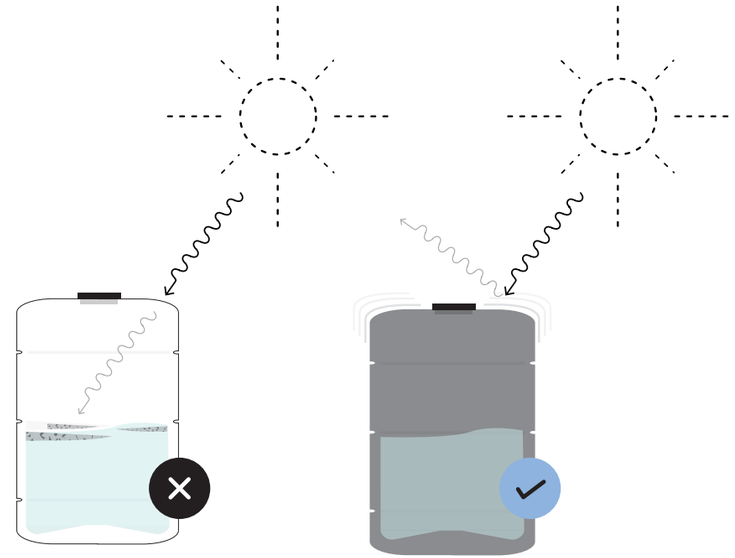
DAILY USE – STRATEGY 19				EMERGENCIES - 2 WEEKS
gallons/day	×	14 days	=	gallons per day

B. TYPE



PLASTIC

- Usually cylindrical, made of polyethylene plastic.
- Choose a tank with a curvature at the bottom to maximize water usage.
- Dark plastic tanks block sunlight and UV radiation, which protects your water from developing bacteria and algae.
- Support local brands, like Vassallo.



Sun rays pass through light color plastic and creates a favorable condition for algae growth

Protection against sun rays

Reflects heat

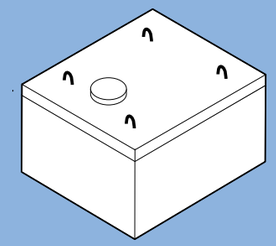
STRATEGY 20

COLLECT AND USE RAINWATER

STEP 3 - SELECT A CISTERN

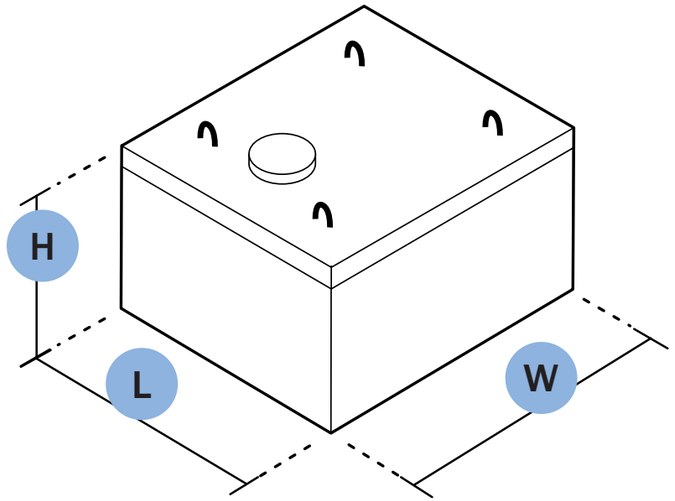
B. TYPE





CONCRETE

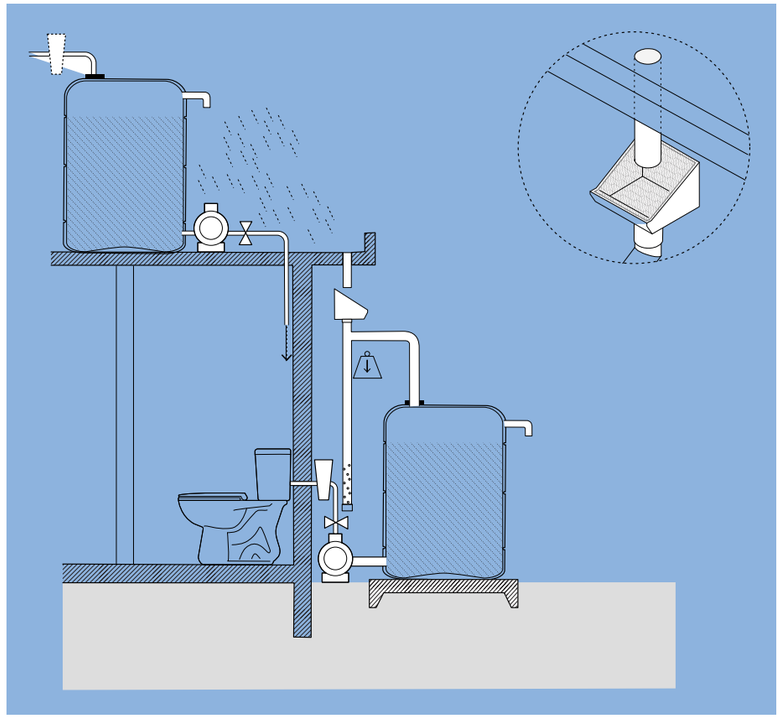
- Gutters help direct water for collection.
- Clean gutters regularly to prevent sedimentations building up.
- Place perpendicular to water flow to reduce water flow speed.
- Requires an additional finish to prevent rusting and corrosion.



$$\frac{\text{height}}{} \times \frac{\text{length}}{} \times \frac{\text{width}}{} = \frac{\text{gallons} \setminus 7.5}{}$$

C. LOCATION

- Water is heavy. A cubic foot of water weighs approximately 62 pounds.
- If the roof is not strong enough to support water weight, place the tank on the ground.
- Locate the tank higher than the home plumbing intake to create pressure for your fixtures.





ON ROOF

PROS

- Works by gravity
- NO pump needed

CONS

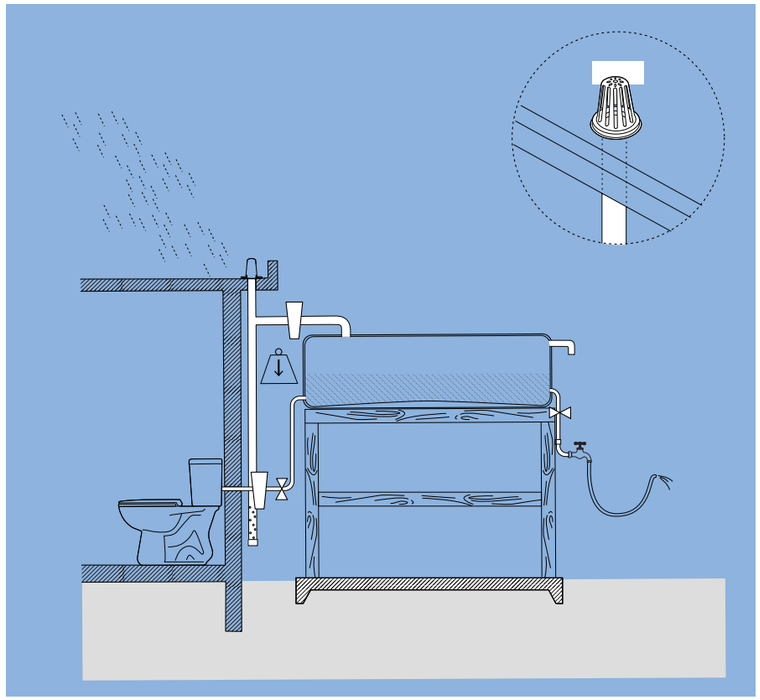
- Need a structural engineer to study load on roof.
- Higher cost



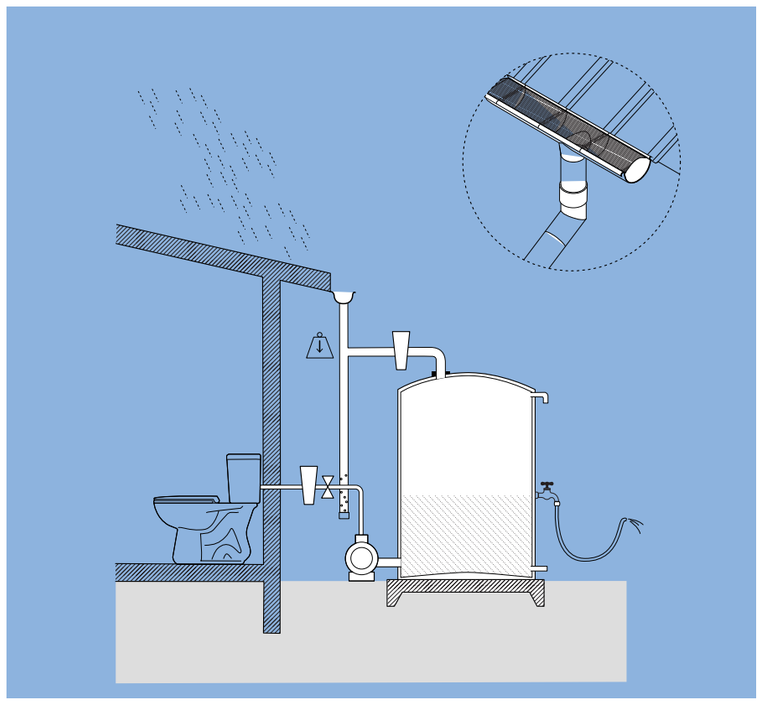
20 COLLECT AND USE RAINWATER

STEP 3 - SELECT A CISTERN

C. LOCATION









ELEVATED ABOVE GROUND

PROS

- Works by gravity
- NO pump needed
- NO additional load on home

CONS

- Requires a stand-alone structure
- Higher cost



ON GROUND

PROS

- Easy access for maintenance
- Easier to install
- NO additional load on home
- Cheapest option

CONS

- Requires pump for most indoor uses



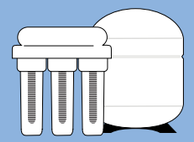
STRATEGY 20

COLLECT AND USE RAINWATER

STEP 4 - FILTER AND TREAT HARVESTED WATER

- Water for drinking, washing and plumbing fixtures needs to be treated. Water for landscaping does not.
- When in doubt, boil for 3 minutes to kill any bacteria. This water must be free of organic matter or solids.

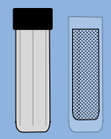




REVERSE OSMOSIS

Passes water through a permeable membrane to remove unwanted ions.

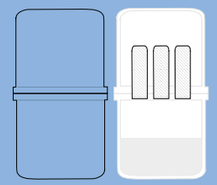




ACTIVATED CARBON

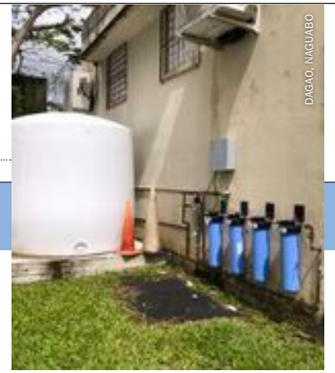
Removes some inorganic compounds and heavy metals.



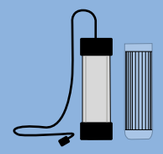


CERAMIC WATER FILTER

Porous nature of ceramic filters small particles and microorganisms. It is an inexpensive method and can be combined with passive filtration


DAGAO, NAGUABO


MARIANA



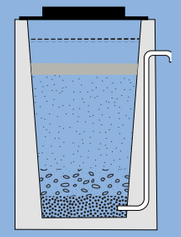
MICROFILTRATION

Filters water through a fine mesh membrane to remove particles and microorganisms.



PURIFICATION TABLETS

Kill pathogens in water, offer an easy purification option for emergencies and can be combined with passive filtration.



SLOW SAND FILTRATION SYSTEM

Removes particles as water passes through the different layers of different gravel and sand.

OPERATIONS AND MAINTENANCE TIPS

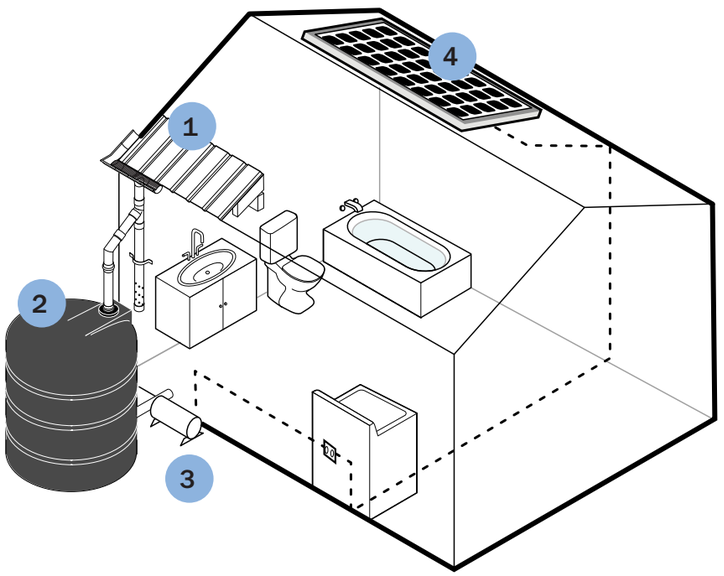
- The storage tank components should be visible and easy to access for regular maintenance and visual inspection.
- Apply FDA food grade approved roof sealants as indicated.
- Track dates to change filter and system components.
- If you want to distribute water for the toilets, revise the PRASA agreement, and install a sanitary water meter.
- The quality of harvested water depends on the maintenance of the catchment system surfaces and cistern. Humidity, including piping, helps bacteria develop and contaminates water.
- Clear roof of sediments regularly, especially after rain. Inspect the roof at least twice a year, during spring and fall.
- Flush out sediments that fall on the bottom of the tank.

STRATEGY 20

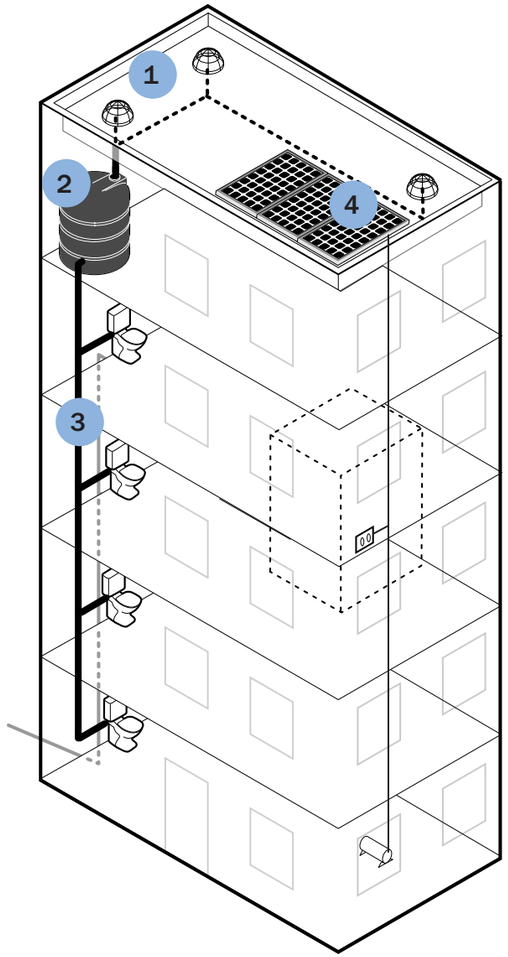
COLLECT AND USE RAINWATER

STEP 5 - DISTRIBUTE HARVESTED WATER

- Harvested water can be distributed by gravity or by a water pump system.
- 1-2 solar panels can be used to operate water pump system. See Strategy 17.
- On pitched roofs, a gutter at the lowest points of the roof will direct water into pipes.
- On flat roofs, the parapet will hold the water and regular drains will flush it out. The drains need to be connected to the catchment system.



1. ROOF
2. CISTERN
   Roof slope directs water to roof drain
3. DISTRIBUTION FIXTURES
   Can supply by gravity or pump according to cistern location and appliances. Distribution and filtering will vary on use.
4. OPTIONAL
   Supplemental PV system can operate pump if cistern is on below appliances and can serve for critical load.



1. ROOF
2. CISTERN
   Rainwater cistern on upper floor distributes to floors and gravity.
3. DISTRIBUTION OF PLUMBING & FIXTURES
   Rainwater supplies appliances not dependable on potable water by gravity.
4. OPTIONAL
   Supplemental PV system can operate pump if cistern is on ground floor and can also operate an Emergency Hub.



STRATEGY

21 IMPROVE YOUR SEPTIC SYSTEM

$$-$$$

In most of Puerto Rico, urban area homes are connected to a main sewer line owned and operated by the Puerto Rico Aqueduct and Sewer Authority (PRASA) that collects and treats household wastewater. Septic design is regulated by the 2018 International Building Code (IBC). On-site septic systems are a suitable form of wastewater treatment in rural and suburban areas where there is space to build them, where the site conditions are considered (including soil type and terrain), and where connections to the central system are not feasible or cost-effective. This strategy explains the basic components of a septic system, the design considerations for each part of the system, and an overview of how to build each part.

Strategy in Action

1. *Identify Soil Type and Properties*
2. *Choose and Plant Vegetation*
3. *Implement Resilient Site scaping*

WHAT YOU NEED TO KNOW

- A septic system is a mechanism for sewage to exit the home, be stored temporarily, and go back to the soil to inject nutrients and kill bacteria. Every step of the process should be considered as a treatment mode, with particular attention to leach field of design and maintenance such as ensuring adequate plants are used for nutrient uptake, that no heavy weights are placed on the field, and soil has the appropriate absorption and saturation capacity.
- Damaged septic systems can contaminate nearby water bodies and aquifers, leading to diseases that affect your home and community.
- Consult with a professional before installing a system and ensure that the local municipal health department allows it and provides you with all the necessary regulatory input.
- Septic systems fail because:
  - Old age, low or lack of maintenance, overloading the septic system above the design limitations, and poor soil conditions or damage to drainfield.
  - Septic tanks, particularly concrete or precast, are susceptible to leaks and cracks in landslides and seismic events if built without taking precautionary measures.
  - Drainfields can be damaged if heavy weight is placed over the lines or the field is flooded and lacks saturation capacity.
  - Solids from the septic system clog the small holes in the drainfield pipes.
  - Flushing fats, oils, greases, chemicals, solvents, paint, and other improper substances down the drain that can kill the bacteria that treat waste in the tank and in the drainfield.
  - Improperly positioned drainfield in a floodable area of the site.
  - They are overloaded by adding too much waste. This can happen in the case of garbage disposal use or adding additional occupants that exceed the system's design limitations.
  - Tree roots uplift drainfield lines.

SUPPORTING STRATEGIES

02 Reinforce Site with Vegetation

22 Prevent Wastewater Backup in Home













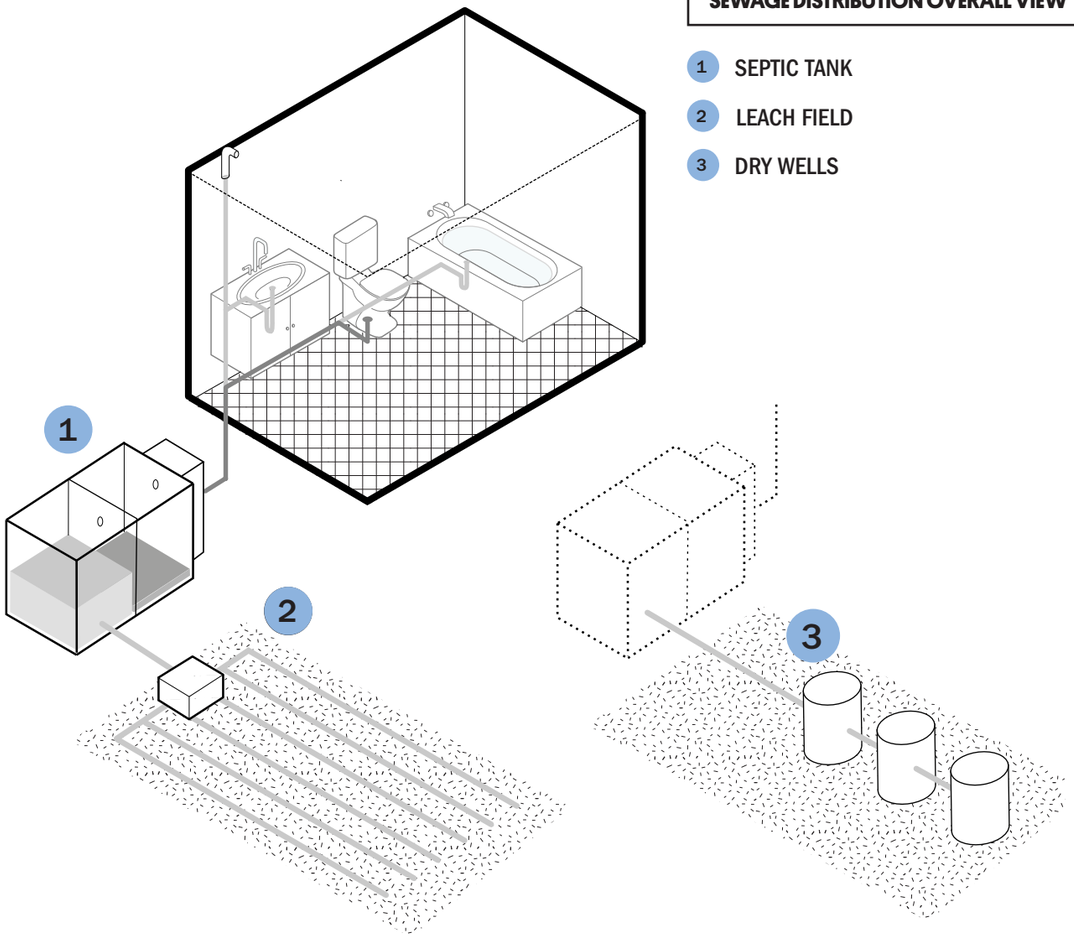
Huertas, Evelyn

STRATEGY 21

IMPROVE YOUR SEPTIC SYSTEM

STEP 1 - DISTRIBUTE HARVESTED WATER

Review Your Home Water Use and Create Water Efficiency and Conservation. Do this where possible. The less wastewater you produce or consider "effluent," the less water will need to be disposed and treated. See Strategy 19 for reducing your water consumption.

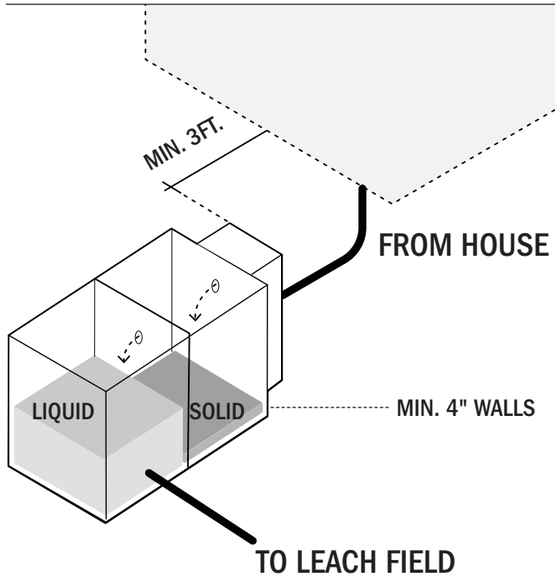


SEWAGE DISTRIBUTION OVERALL VIEW

1. SEPTIC TANK
2. LEACH FIELD
3. DRY WELLS

STEP 2 - SIZE AND CHOOSE A SEPTIC TANK

A septic tank is a container comprised of two chambers that separate solid from liquid waste. The solids stay in the tank until they are pumped out by a septic company, and the liquids drain into a leach field or dry well that injects them safely into the soil. Place the tank underground. Do not locate it in a high-water table since this could cause the tank to float.



SEPTIC TANK CAPACITY FOR ONE AND TWO FAMILY DWELLINGS

# BEDROOMS	SEPTIC TANK (GALLONS)
1	750
2	750
3	1,000
4	1,200
5	1,425
6	1,650
7	1,875
8	2,100

FOR SI: 1 GALLON = 3.785 L

STRATEGY 21

IMPROVE YOUR SEPTIC SYSTEM

STEP 2 - SIZE AND CHOOSE A SEPTIC TANK

SIZE

- The size of the septic tank depends on the number of people, and the amount of waste producer per person each day.
- Install a larger tank if you envision your home expanding.
- Larger tanks need to be emptied fewer times than a smaller tank.
- Follow guidelines from the local municipality, the Health Department, and the Junta de Calidad Ambiental.
- Work with a professional on designing and installing the tank, as it can become a health hazard for your home and community.
- Consider adding a septic effluent filter to the septic tank to catch suspended solids, smaller particles of debris which, as they pass out to the soil absorption system, or drainfield, which can create clogging of the drainfield lines and reduce absorption and treatment.
- Alarm septic tanks to warn of an operating problem with the system that could risk a sewage backup into the building.

OPERATIONS

- Hire specialized companies to pump out solids that may clog the small holes in the each field pipes.
- Never use bleach in tank.
- Check alarm systems regularly.
- Check regularly for any cracks or leaks, especially after a natural disaster.
- If the tank requires constant pumping or experiences continuous backups and overflows, it may be failing.
- Place a septic waste water filter in the tank to filter large particles from entering the leach field and clogging the system.
- Do not throw fats, oils, greases, chemicals, solvents, paint, and other substances down the drain. These may clog the system, kill the bacteria that treat waste in the tank, or contaminate the environment around the leach field.
- Use lightweight, septic-system safe toilet paper and do not flush bulky cotton items like paper towels or hygiene products.

REGULATORY AND CODE

- The 2018 IPSDC (International Private Sewage Disposal Code) provides tables with the minimum sizes for the septic tanks, pumping chambers and holding tanks, based on the number of bedrooms for one and two-family dwellings, and per bedroom for Apartment buildings and condominiums.
- 2018 International Private Sewage Disposal Code
- Regulations as established by Environmental Quality Board.

MATERIAL



PLASTIC

- Last longer, less maintenance required
- Higher cost



CONCRETE

- Can be custom built
- Inexpensive
- Gets damaged more easily

OPERATIONS AND MAINTENANCE TIPS

- **Document your system**
  Document every component of the septic system and keep these organized as a set of “as-builts” for current and future operations.
  Take photos of:
  - Septic tank location
  - Leach field layout or location of dry well
  - Layout of the drain field lines and the position of your tank in regards to the house plumbing
  - Layout of the drain field in regards to plantings
  - Electrical components
- Reduce putting any loads on leach field such as parking or heavy objects which can disrupt lines and compact soil preventing treatment from occurring.
- Don’t place bleach or chlorine down the drains because it can destroy critical bacteria colonies that treat wastewater in your septic tank.
- If possible, drain your septic system before any major climatic event. A good rule of thumb is to drain it around August, right before hurricane season is at its peak.
- **Septic Tanks**
  - Hire specialized companies to pump out solids.
  - Never use bleach in the tank.
  - Check that alarm systems are in working order.
- **Leach Field**
  - Maintain soil porosity and ensure that no significant weight is placed on the drainfield, such as parking or structures.
  - Ensure lines are properly buried and unclogged.

Keep an eye out for the following signs of septic system failure:

- Wastewater backing up into household drains.
- Bright green, spongy grass on the drainfield, especially during dry weather.
- Pooling water or muddy soil around your septic system or in your basement.
- A strong odor around the septic tank and drainfield.
- If the drainfield is overloaded with too much liquid, it can flood, causing sewage to flow to the ground surface or create backups in toilets and sinks.
- Septic tanks that require constant pumping or that experience continual backups and overflows during normal use may be in the first stages of septic system failure.

STRATEGY 21

IMPROVE YOUR SEPTIC SYSTEM

STEP 3 - SITE AND BUILD A TREATMENT SYSTEM FOR WASTE DISPOSAL

A leach field or drainfield is the final stage of the septic system and provides additional treatment of wastewater. A drainfield is arrangement of perforated pipes over a series of trenches on site filled with appropriate soil, sand or gravel. The liquid wastewater in the septic tank exits by gravity or pumps into the leach field and percolates into the soil, naturally injecting nutrients and removing harmful bacteria.

Using drain field is a best practice management for onsite treatment systems. The liquid wastewater in the septic tank exits by gravity or pumps into the leach field and percolates into the soil, naturally injecting nutrients and removing harmful bacteria.

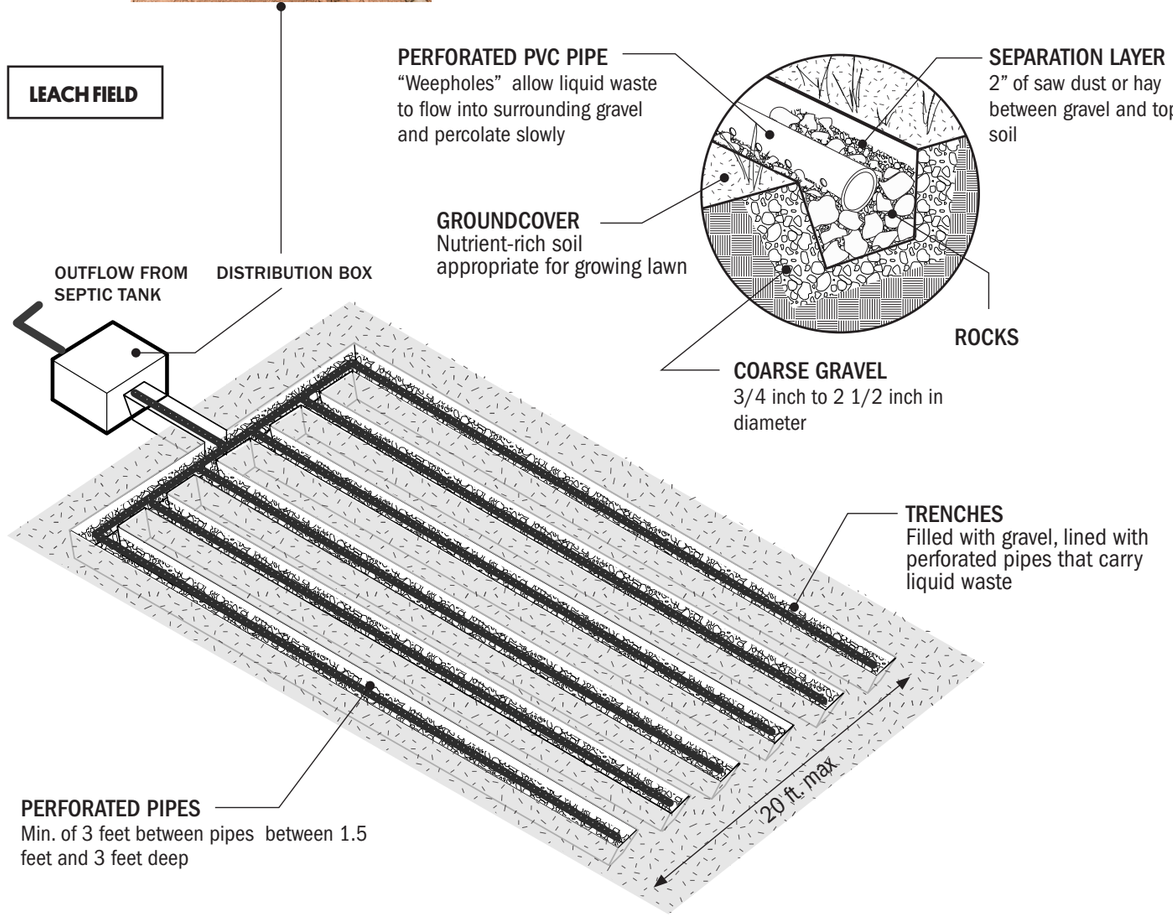












STRATEGY 21

IMPROVE YOUR SEPTIC SYSTEM

STEP 3 - SITE AND BUILD A TREATMENT SYSTEM FOR WASTE DISPOSAL

SIZE

- The size of the leachfield needed can range depending on the number of bedrooms, soil percolation rate, depth of field and composition of soil and use of aggregate like gravel .

OPERATIONS

- Maintain soil porosity and ensure no weight is placed on the leach field, like parking or structures.
- Ensure lines are properly buried and unclogged.
- Keep an eye out for:
  - Bright, green, spongy grass on the leach field, especially during dry weather
  - Pooling water or muddy soil around the system. If the leach field is overloaded it can cause sewage to flow to the ground, surface or create backups in plumbing fixtures.
  - A strong odor around the septic tank or leach field

SITE

- Place far away from habitational areas.
- Identify which soil is appropriate for the land plot.
- The soil percolation rate is a measurement of how much water a type of soil can absorb in a particular amount of time. It is recommended that the soil neither retain water nor let it pass through too quickly. Sandy loamy soil or sand have good draining capacity.
- Consult a soil engineer for a thorough percolation test and comprehensive soil analysis.
- Soil on top of the tank must be sloped downwards to allow surface water to flow away from the system.
- Set aside an area the same size as the primary drainfield for use as a replacement drainfield if something happens to the primary one.
- - Consult with the Puerto Rico Office of General Permit (OGPe) guidance on construction requirements and minimal distance from athe water body.

FIELDWORK

- Fence off or mark up the leach field to alert of its location.
- Cover the whole system with a layer of topsoil to prevent animals and surface runoff from reaching wastewater.

VEGETATION

- Plant vegetation and locate mounds of soil around the leach field so it absorbs excess water and nutrients from the septic tank.
- Choose a native plant species with a shallow root system that can uptake water and nutrients from effluent but will not clog the drain pipes.
- Do not plant trees or shrubs within 25 feet

SITE AND BUILD A DRY WELL

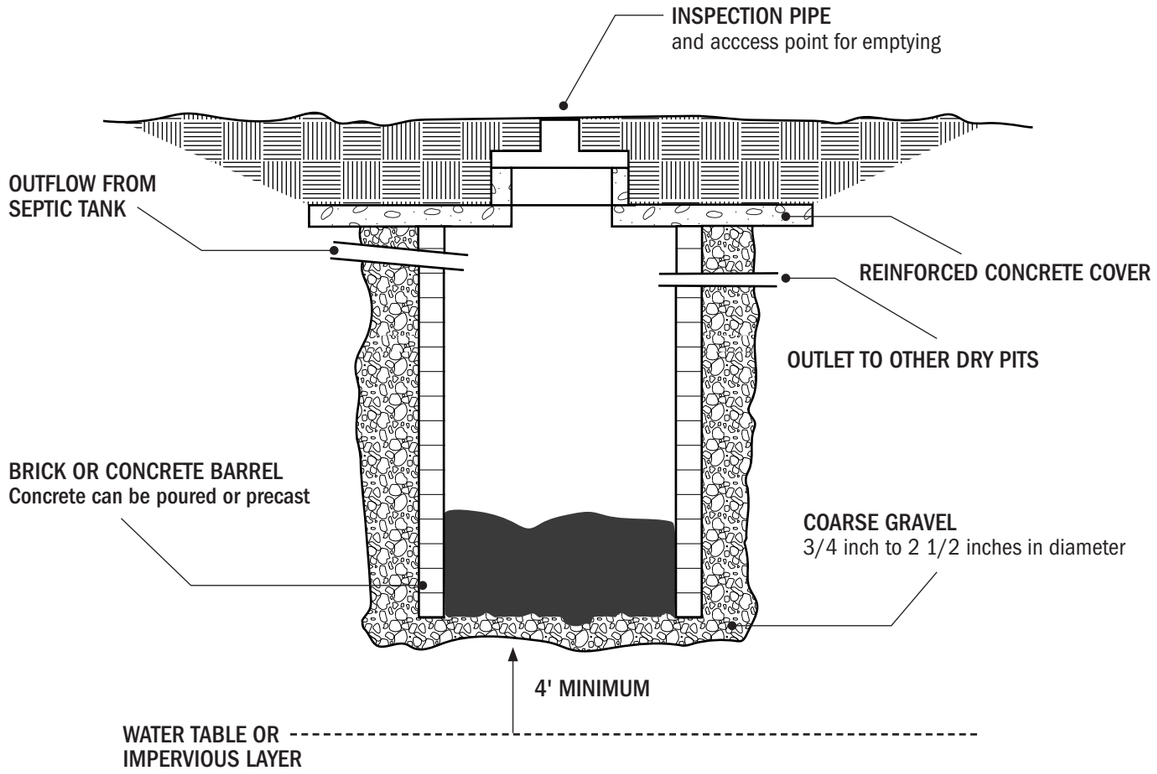
- Use in zones with inadequate soil absorption capabilities, limited space, or steep slopes.
- A dry well is a type of leaching mechanism which is an alternative to a traditional leachfield when conditions don't permit. It consists of a bottomless tank with holes on the side, and uses stone or aggregate material to control the injection process into the soil.

DRY WELL

A dry well utilizes gravel and other permeable materials to slow the injection process into the surrounding earth. It is an alternative to traditional leaching systems on lands with inadequate soil absorption capabilities.

- Add gravel around it at the bottom of the well so wastewater percolates into the soil while solids will remain in place for later disposal.





STRATEGY

22 PREVENT WASTEWATER BACKFLOW IN HOMES

Flooding from Stormwater, Coastal surge or a high water table, can overwhelm a home's waste treatment system, and it can cause wastewater and sewage to flow back into the home. This backup can create unsanitary conditions for occupants by exposing them to bacteria contaminating potable water reservoirs, which may leave people without safe drinking water. This strategy identifies ways to mitigate these risks.

Strategy in Action

1. Install a backflow preventer valve
2. Install a backwater alarm
3. Maintain pipes and sanitary vents
4. Deal with backflow in the leach field

WHAT YOU NEED TO KNOW

- Wastewater backflow is when water flows through sewage pipes in the wrong direction and backs up into the house or building, contaminating spaces as well as potable water.
- In urban areas, the biggest risk associated with backflow is contamination of water reservoirs.
- In rural areas, the biggest risk associated with backflow is failure of a leach field, which leads to flooding and health risks.





SUPPORTING STRATEGIES

19	20	21
Reduce Your Water Consumption	Collect and Use Rainwater	Improve Septic Waste Disposal System

REMEMBER

DO NOT MIX STORMWATER AND SEWAGE WATER!
Design the site to prevent storm water from going into the sewer. During a flood, holes may open and cause wastewater to overflow into water bodies, streets, or other homes.

STEP 1 - INSTALL A BACKFLOW PREVENTER VALVE

WHAT IS IT?

A backflow preventer valve is a cost-effective device that protects water from getting contaminated from wastewater overflow.

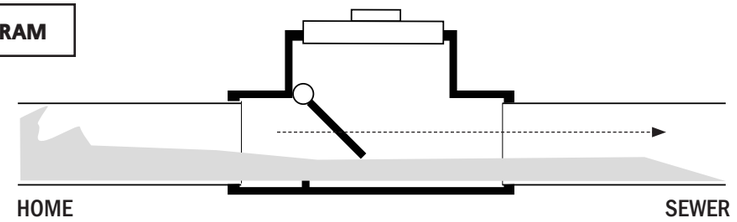
WHO NEEDS IT?

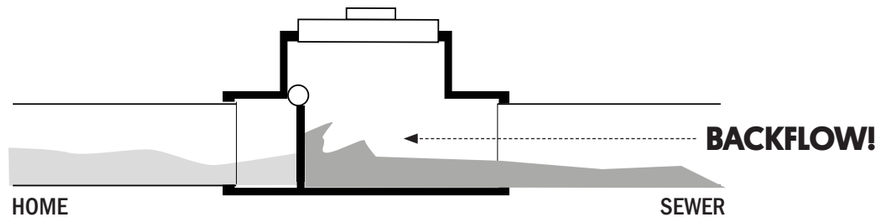
Install a backflow preventer valve if your home is in a flood zone or in a flood prone area.

WHY DO YOU NEED IT?

To ensure water is not backing up into household pipes from the septic system.

BLACKFLOW DIAGRAM





WHERE DOES IT GO?

- Install it where the water pipes exit so sewage only flows outward.
- A backflow preventer valve is typically installed inside a concrete pit with a waterproof cover that can be removed for easy access for maintenance.

HOW DOES IT WORK?

It works with a flapper that opens in the direction of home to sewer line but closes if water flows in the other direction. If the valve is closed, wastewater cannot enter or exit the building. If the valve is closed, the water collected from the roof and site cannot exit the pipes, so you must redirect it to gravel or grass. Failure to do this will result in the pipes flooding your home.



STRATEGY 22

PREVENT WASTEWATER BACKFLOW IN HOMES

STEP 2 - INSTALL A BACKWATER ALARM

WHAT IS IT?

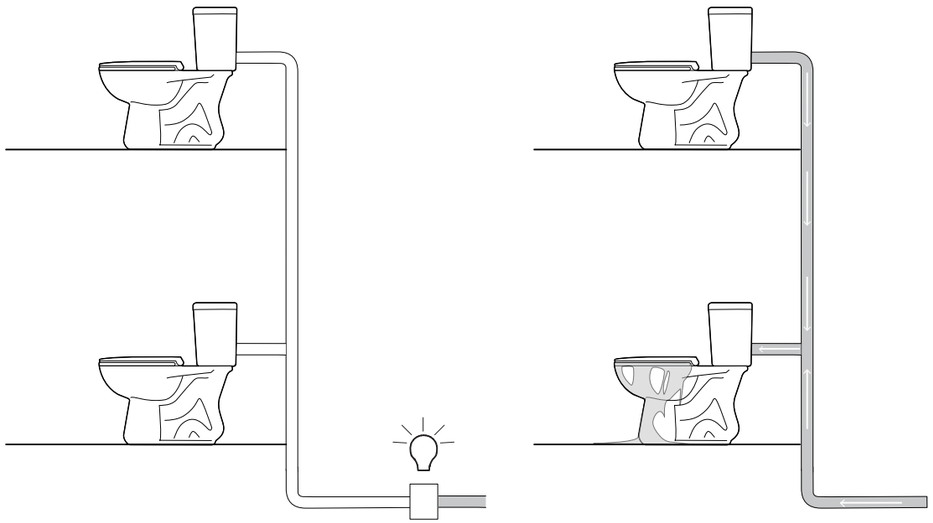
A backwater alarm is a device that alerts occupants that a backflow is happening, and they should not use fixtures until it settles.

WHO NEEDS IT?

Install a backwater alarm if your home is in a flood zone or in a flood prone area.

WHY DO YOU NEED IT?

To ensure you do not use contaminated water.



BACKFLOW!

WHERE DOES IT GO?

Sanitary plumbing lines, next to the backflow preventer valve.

HOW DOES IT WORK?

The device consists of an alarm box that runs a sensor to verify pipes are clean. If it detects that there is a water influx, the box emits a loud sound.

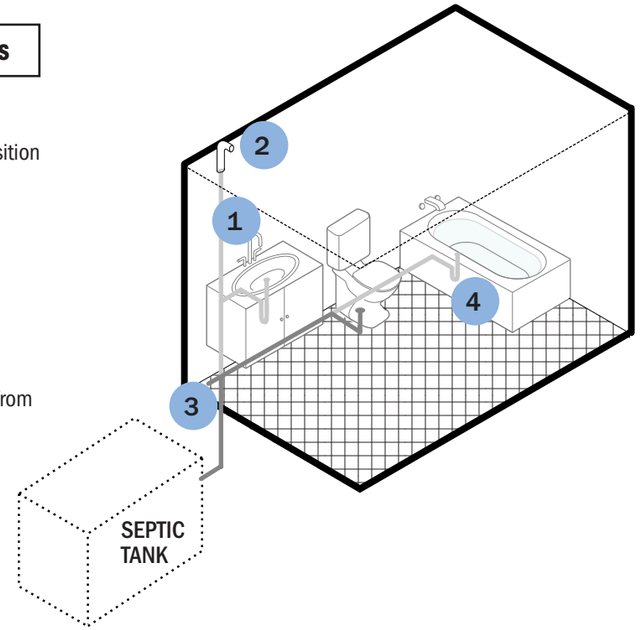


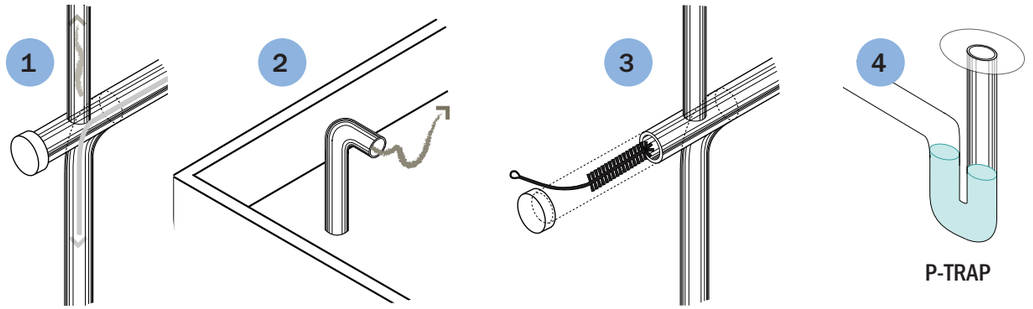
STEP 3 - MAINTAIN PIPES AND SANITARY VENTS

- Connect every plumbing fixture to a pipe that carries wastewater out of the home.
- Connect every water pipe to a vent pipe to allow air involved in the sewage movement process to exit.
- Connect every vent pipe to a vent stack, a vertical pipe that goes to the exhaust point at the roof.
- Ensure that all vent pipes (and soil lines in septic systems) are clear of any blockage. Do this by creating “cleanouts”, access points along waste lines that allow professionals to unclog or insert cleaning devices.
- Seal all pipes to prevent cockroaches, rats and other from entering the house or contaminating water.

SEWAGE DISTRIBUTION SYSTEM COMPONENTS

1. **VENT PIPES**
   expel gases that form during waste decomposition through stack vent.
2. **STACK VENT**
3. **CLEANOUT**
   located at every pipe turn, allows access for cleaning waste that might block the line.
4. **WATER SEAL**
   prevents cockroaches, rats and other critters from getting into your house.





STRATEGY 22

PREVENT WASTEWATER BACKFLOW IN HOMES

STEP 3 - MAINTAIN PIPES AND SANITARY VENTS



OPERATIONS AND MAINTENANCE TIPS

- Examine backwater valve once a year to monitor obstruction, rust and corrosion. Cast-iron valves can become rusted or corroded in areas where there is a lot of salt water. Prevent this by utilizing a rust-proof paint or sealant.
- Ensure sanitary vent discharge points are clear of debris and verify sanitary line cleanouts whenever the system seems sluggish.

CODE AND REGULATIONS

- The International Mechanical Code has a chapter that establishes all pertinent regulations for this type of system.

STEP 4 - DEAL WITH BACKFLOW IN THE LEACH FIELD

- Ensure you maintain your leach field appropriately to avoid flooding.
- Avoid contact with the sewage, as it may contain harmful bacteria.
- Contact the local health department or regulatory agency for guidance.
- Cleanup personnel should wear protective clothing (e.g., long rubber gloves, face splash shields).
- After cleanup is complete, thoroughly wash all equipment, tools, and clothing used during cleaning.
- Disinfect all items or areas exposed with a mixture of 90% water and 10% household bleach.
- Thoroughly dry out the affected area and do not use for at least 24 hours.
- See Strategy 21: Prevent Wastewater Backflow in Homes.



SAN JUAN BAY ESTUARY

PROGRAMA DEL Estuario de la Bahía de San Juan

Description: The San Juan Bay Estuary Program is a 501(c)(3) non-profit corporation that designs, implements, and monitors the recovery measures taken to improve the quality of water and the associated ecosystems within the San Juan Bay Estuary system and its basin. The Estuary system spans eight municipalities: Bayamon, Carolina, Cataño, Guaynabo, Loiza, San Juan, Toa Baja, and Trujillo Alto. This program involves citizens, visitors, and tourists. It is also associated with the government, scientific, private, academic, and community sectors.



ENLACE OF CAÑO MARTIN PEÑA PROJECT

Interviewee: ENLACE, Lyvia Rodriguez

For more information, visit http://cano3punto7.org/nuevo/index.html

Description: the ENLACE del Caño Martín Peña Project is the corporate umbrella of organizations that work together to complete dredging works along the 3.7 miles of expanse of the Martín Peña Channel, as well as the redevelopment of the eight communities bordering it, thus contributing to the transformation of the city as well. The ENLACE del Caño Martín Peña Project Corporation is an independent government entity whose mission is to coordinate and implement public policy related to dredging and channeling this body of water. This would also ensure the continuity, urban development, and socioeconomic growth of its eight neighboring communities. This project involves the active and effective participation of their residents, their community-based organizations, and the partnerships between communities, the public sector, and the private sector.

ENLACE is driven by the ENLACE del Caño Martín Peña Project Corporation, the G-8, Inc., and the Caño Martín Peña Community Land Trust. It is also supported by a large group of strategic partners including universities, foundations, companies, and government institutions. The corporation works towards achieving its vision of a united, safe, and prosperous community through a self-managed cohabitation model in the heart of San Juan.

INTERVIEW

Before the event, we prepared fact sheets about



its hazards to warn the community that this was something real and very dangerous. Since the Martín Peña Channel has always been a flood-prone area during heavy rainfalls, we prompted some of the residents to move to a shelter. Our fact sheet, which we delivered from house to house in the Channel's communities, provided all residents with suggestions on what to do before and after the hurricane. During this period, community leaders were very actively involved.

After the hurricane, we first walked through the streets to inventory structural damages and document the reach of the flood waters. The database and tools we previously had, such as documentation systems, were essential for this. We already had maps that showed us the streets and structures as they were before the event, which helped us document the state of the streets and buildings damaged by the floods. This helped us determine that the most pressing need at that moment was the tarps to cover home roofs; more than a 1,000 families had lost the roof of their homes. Once we identified this need, we started looking for a space with Internet service so we could contact our partners in the diaspora. As a result, our offices became collection centers; two weeks later, we had collected about 400 tarps.

We had a team in charge of coordinating and contacting our partners and collaborators. This team also made sure that the supplies made it safely from wherever they were (e.g., the airport) to our facilities. The distribution team, composed by community leaders, was in charge of delivering supplies to community residents. On the other hand, one of our biggest accomplishments was obtaining permission from the federal government to fill out FEMA assessment forms with the information we had already gathered about damages in the community. The agency provided the forms, and we went from house to house helping residents fill out the forms. This was crucial to speed up the process, since many people were unable to leave their homes and visit our centers, for whichever reason.

For the community to plan for and face similar situations, it is critical that the following exist:

- A subject or issue that is essential and relevant to every member of this organization.
- Acknowledgment of the community's weaknesses and strengths, as well as the extent of its vulnerability.
- Knowledge of the public policies implemented by the current central government and participation in the island's important processes to reduce its vulnerability.
- The establishment of a decision-making structure for situations involving key decision-making processes.
- Implementing communication methods for community involvement.
- A self-assessment process for community growth and to identify what works, what doesn't, and how to improve as a group.

We worked on different things after the hurricane, and we are still working on others. For example, as we were documenting the damages, we noticed that rats and mosquitoes were going to be a major public health problem. Consequently, donations allowed us to install rat traps and distribute two types of kits (one to repel mosquitoes and the other to treat mold). Aside from that, we also carried out awareness campaigns because, just three days after the hurricane, we had a few building owners starting to evict their tenants. This prompted us to counsel tenants as to their rights. Additionally, we developed a communication structure for each street in every community, leaving someone in charge to report any issues that came up there. In terms of rebuilding efforts, we provided popular self-build workshops for residents, where they were taught how to make the necessary alterations to their homes. This helped them fix their own homes safely, since these structures were built by the residents themselves. Therefore, this was a way for us to make sure to reduce home vulnerability. By distributing educational materials and providing step-by-step guidance in layman's terms, residents acquired the knowledge needed to do it themselves.



COMMUNAL AQUEDUCT, RIO CHIQUITO, INC









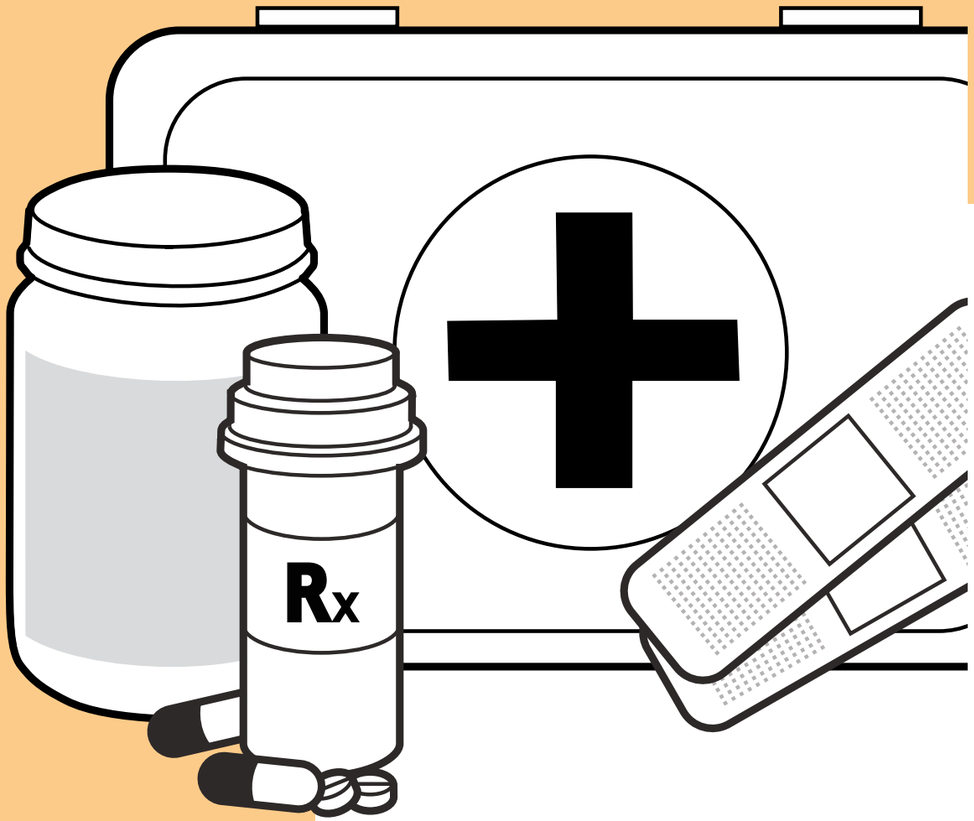
Communal Aqueduct Río Chiquito, Inc.
Bo. Río Chiquito Ponce
Contacts
José Álvarez Jiménez, Presidente
Gumersindo Torres, Director Ejecutivo

Vision and Mission: Acueductos Río Chiquito, Inc. has the purpose of fulfilling the will of the community, facilitating a supply of potable water ordered to all members of the community, protecting the aqueduct facilities, safeguarding public health and establishing the corresponding rights and obligations of the subscribers or users of this service. This organization was created with the purpose of promoting and promoting the welfare of the Río Chiquitos Community in the Municipality of Ponce, guaranteeing potable water for our community for more than forty years. Among the services offered by the Communal Aqueduct is the extraction of water resource, storage, disinfection processing, water distribution, pipe repair, billing, system maintenance, analysis and water testing required by all regulatory agencies like those of the Department of Health of the Department of State, among others.



CHAPTER

6



HOUSEHOLD EMERGENCY PREPAREDNESS

Tools to be ready in the event of loss of services

INTRODUCTION

TYPES OF STRATEGIES LISTED IN THIS SECTION

STRATEGY #	23	24	25
STRATEGY NAME/TITLE	DEVELOP A HOUSEHOLD EMERGENCY PLAN	CHOOSE A SPACE TO KEEP YOUR FAMILY SAFE	RESPOND + BEGIN HOUSEHOLD RECOVERY
DESCRIPTION	This strategy focuses on helping you and your household manage essential information, stay connected, and have essential supplies during and immediately after a disaster.	When an anticipated disaster is approaching, the first question you need to answer is whether you and your household members should leave the area, stay home (“shelter in place”) or go to a designated shelter nearby. Hurricanes give several days’ warning before they strike, but many other natural disasters do not. This strategy will help you determine the best options in all conditions and to act accordingly.	After an emergency event your household will need to respond, recover and rebuild. This strategy provides guidance to support your households through this process.
	$	$	$

After Hurricane Maria, Puerto Rico’s population lived without electricity for a long period of time, some homes went without it for over a year. According to FEMA’s After-Action Report, the response was the longest sustained air mission of food and water delivery in the agency’s history. For most people, it was impossible to live comfortably. Within two months of the storm, 179,000 people had left the island for mainland United States, with no certainty that they would be able to return.

No one could have imagined the scale of the hurricane’s destruction, or how it would change daily life. Now, with hurricanes and other extreme events becoming more common, everyone needs an emergency plan that addresses their household’s needs. All good plans have similar elements: they outline how to prepare beforehand, how to stay safe during an event, and the first steps to take to begin recovery.

The strategies in this section will help you build an emergency plan that suits your household and your home. Planning with your neighbors and community can also help prevent property damage and save lives. The following chapter focuses on how to build collective community plans. It will also help you determine what you and your household need to do before, during, and after a disaster.



Dagua Naguabo Emergency Manager

STRATEGY

23 DEVELOP A HOUSEHOLD EMERGENCY PLAN

$

Whether you have a household of one or many, establishing an emergency plan is vital to suit your household's unique needs. This strategy focuses on helping you and your household manage essential information, stay connected, and have essential supplies during and immediately after a disaster.

Strategy in Action

1. *Bring Your Family Together*
2. *Develop a Plan to Stay*

a. *Establish a Communication Plan*

b. *Make a 'Sheltering Stash' in Your Home*

c. *Tips for Sheltering in Place*

3. *Develop a Plan to Leave*

a. *Prepare a Go-Bag for Each Member of Your Household*

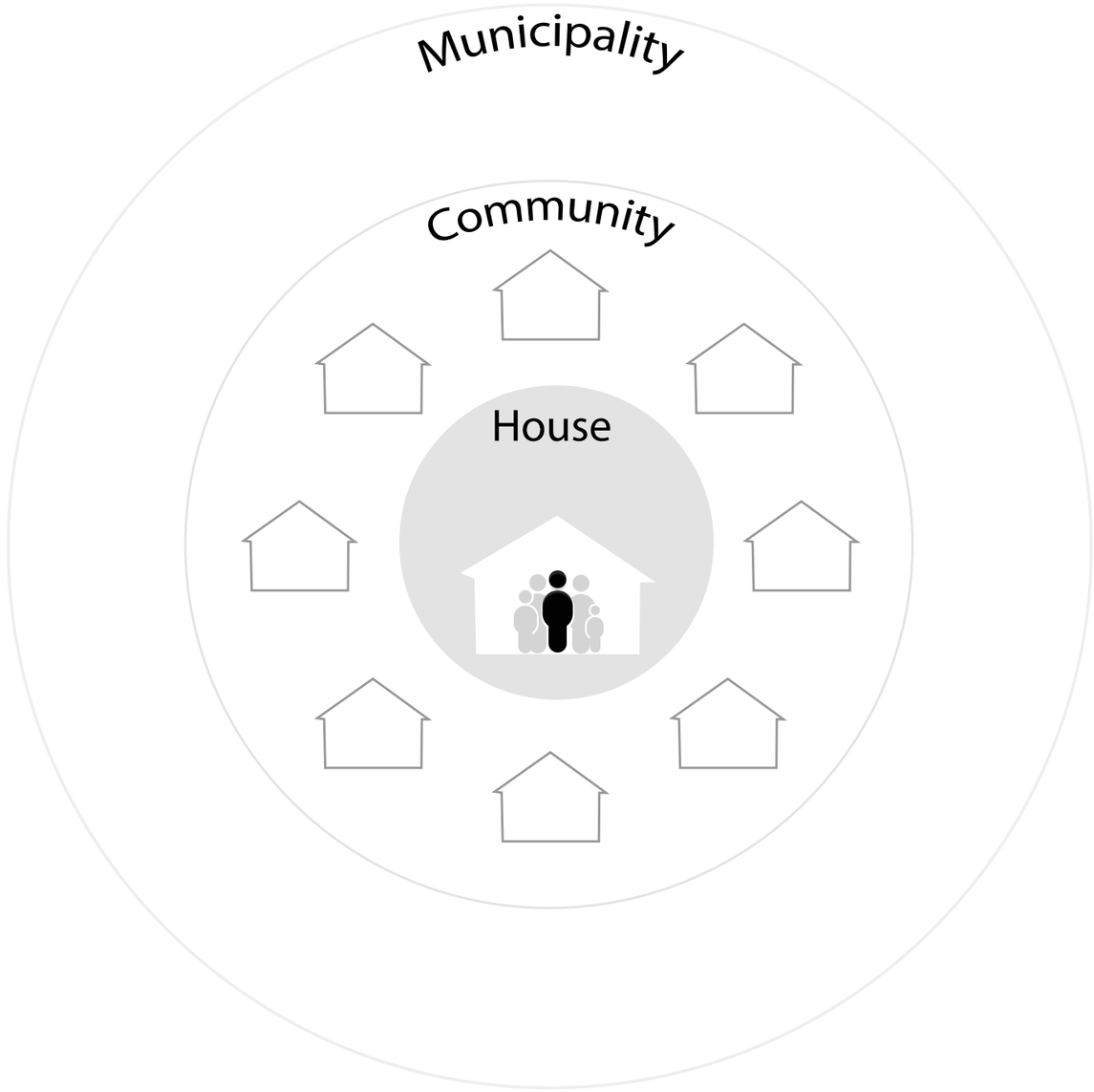
b. *Tips for Evacuating by Car*

c. *Close up Your Home*

WHAT YOU NEED TO KNOW

- While no one can anticipate all the consequences of a disaster, past events have taught us about the biggest and most likely challenges for most households and what can be done beforehand to help overcome them.
- Single-family homeowners can find tips on how to protect their buildings here; multi-family property owners and administrators have a different set of responsibilities, and more comprehensive resources on how to manage them can be found in Enterprise Community Partners Ready to Respond Tools for Resilience's webpage section.





SUPPORTING STRATEGIES

01	04	08	23	25	26	27	28
Reinforce Site	Assess the Priorities for Your Home or Building Structural Condition Prior to Event	Anchor, Seal and Protect Building Openings	Develop a Household Emergency Plan	Respond + Begin Household Recovery	Develop a Community Plan	Identify + Prepare Safe Community Shelter	Inspiring Post-Disaster Planning for Community

STRATEGY 23

DEVELOP A HOUSEHOLD EMERGENCY PLAN

STEP 1 - BRING YOUR FAMILY TOGETHER

WHAT TO ASK

- Ask questions about what would happen if a disaster struck and what each person could do. The answers are the beginning of your plan.
- How will we find each other?
- What are our options for shelter?
- How would we travel?
- What would we need to have with us?
- What will happen to our animals?
- How will we get news?
- Many organizations, such as the American Red Cross, have detailed workbooks and planning apps that you can use to complement your planning process. For more information, visit: https://www.redcross.org/local/puerto-rico.html

OPERATIONS AND MAINTENANCE TIPS

- Ensure the safe space at your home or where you have decided to weather the natural disaster is prepared as you:
- Remove any elements hanging on the walls such as shelves, mirrors, pictures, or artwork.
- Move heavy objects, like books, to lower shelves or plastic boxes on the floor.
- Repair fissures and seal openings to the exterior, such as windows, with wooden panels or storm shutters. See Strategy 08.

STEP 2 - MAKE A PLAN TO STAY OR GO

A. ESTABLISH A COMMUNICATION PLAN

Determine who your household members need to be in touch with, and how they will reach each other. Remember, downloading apps may be difficult.

Therefore, build connections now through several mediums to ensure smooth communication before, during, and after a disaster.



PHONE

- Expect local cellphone calls to fail. Keep calls brief and mostly use text messaging.
- Calls over land lines (such as public payphones) and long-distance calls are more likely to go through.



SOCIAL MEDIA

- Leverage existing networks on social-media apps like Twitter.
- Follow any local groups or people that might be active after disaster strikes.
- Structure group texts by cellphone or through WhatsApp or similar apps.



EMAIL

Head of household should send one email cc'ing the primary network members so email addresses are shared and stored.

	NAME	PHONE NUMBER	EMAIL/HANDLE
1		( ) -	@ /
2		( ) -	@ /
3		( ) -	@ /
4		( ) -	@ /
5		( ) -	@ /

STRATEGY 23

DEVELOP A HOUSEHOLD EMERGENCY PLAN

STEP 2 - MAKE A PLAN TO STAY OR GO

A. ESTABLISH A COMMUNICATION PLAN



PHYSICAL LOCATIONS

- Select two places to go if it is impossible to return home and communications are down. One should be nearby, such as a neighbor's home, and one should be outside your neighborhood. Both should have a place to leave a note in case you can't wait there.
- Plan how household members will alert the network when they arrive at or leave a place.



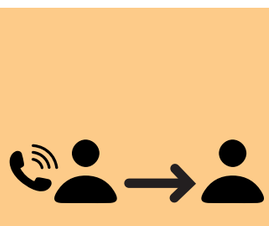
CONTACT LIST

Collect the telephone numbers, emails, handles, etc., of people in your primary network and create a contact list. Check everyone in your network has a paper copy of the list in their go-bags, protected in plastic, and that it's accessible online, perhaps via email or as a shared document. Everyone in the group should carry a printed copy during a disaster. If anyone may have trouble speaking, clip it to their clothing in case they get separated. See chart below.



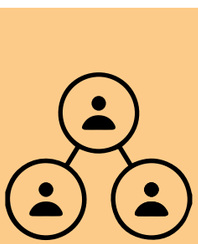
NEWS AND INFORMATION

Choose the news sources you will be monitoring during the event. Everyone should receive the same information at the same time. A suggested source is NOAA Weather Radio for weather updates and public messages.



DRILL

Practice your communications plan. At least once a year, have a drill with everyone in your primary contact network, including your out-of-area contact and your pet caretaker, to be sure things work the way they need to.



NETWORK

- Establish several means of reaching each other. Designate a primary network of people who will keep track of each other. This will include, but not be limited to:
- A designated head of household
- Other members of your immediate household
- An-out-of-area contact who can receive calls and serve as a news hub for your household and others
- A pet caretaker who can help your pet if you can't get home





STRATEGY 23

DEVELOP A HOUSEHOLD EMERGENCY PLAN

STEP 2 - MAKE A PLAN TO STAY OR GO

B. MAKE A 'SHELTERING STASH' IN YOUR HOME

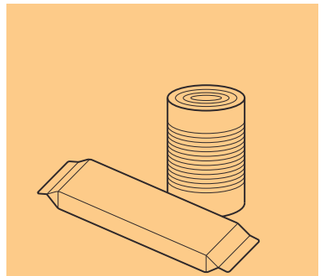
Gather at least 5 days' worth of supplies. If infrastructure around your area is weak, plan to stash 2 weeks' worth of supplies. Ensure the stash is in an area where supplies won't be damaged. Consider all the household members when considering supply quantities.

FOOD AND WATER



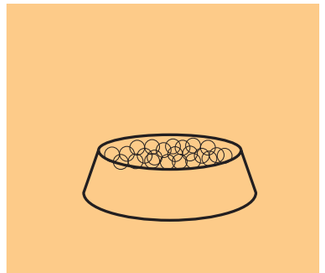
WATER

- Include 1 gallon per person per day and extra for pets.
- Water supplies should last for 5-14 days.



CANNED FOOD

- Canned goods or non-perishable dry foods in sealed packages that are familiar to your household and require no refrigeration, water, special preparation, or cooking are the best options.
- Verify expiration dates on all foods!



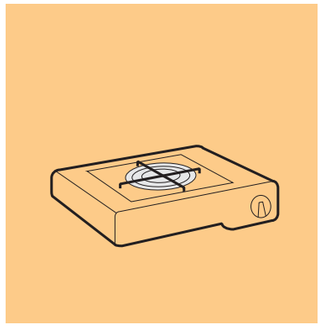
PET FOOD

- Non Perishable Food for Pets
- Bottles of Water



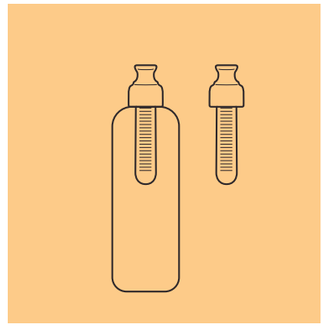
CONTAINERS

Disposable plates, cups, utensils and paper towels.



EQUIPMENT

Cooking supplies for after the storm (do not cook with heat until you are sure there are no gas leaks): charcoal or other fuel, sealed in watertight container if you have a grill, warming pot with canned fuel, solar oven or camp stove and matches.



WATER FILTER

Unscented liquid bleach, eyedropper, and large plastic bottle or approved container for purifying water (see Strategy 25 for instructions).



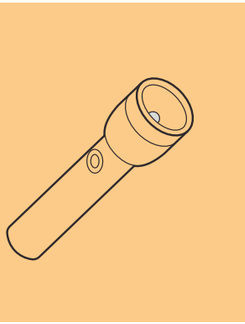
STRATEGY 23

DEVELOP A HOUSEHOLD EMERGENCY PLAN

STEP 2 - MAKE A PLAN TO STAY OR GO

B. MAKE A 'SHELTERING STASH' IN YOUR HOME

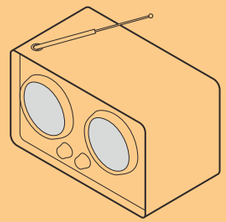
DEVICES



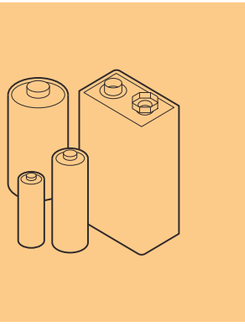
FLASHLIGHTS



SOLAR OR BATTERY-POWERED LANTERNS

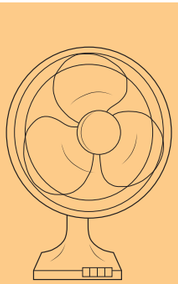


NOAA WEATHER RADIO WITH SOLAR OR CRANK CHARGER



BATTERIES

Ensure battery sizing works with your equipment.



FANS

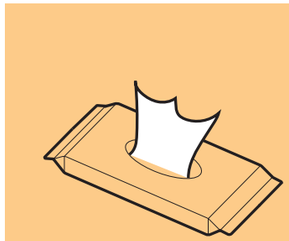
Hand fans or battery-operated fan (especially for elderly or heat-sensitive people).



APPLIANCE THERMOMETERS TO MONITOR FRIDGE AND FREEZER TEMPERATURES

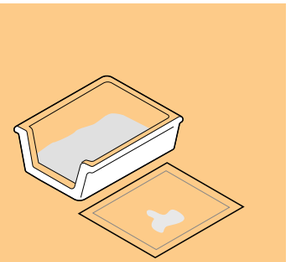
Appliance thermometers to monitor fridge and freezer temperatures.

HYGEINE



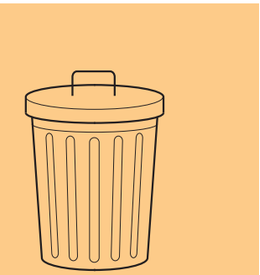
MOIST TOWELS

Cleaning and preparing food.



FOR PETS

Litter box or padding for pets to relieve themselves.



GARBAGE BAGS

Garbage bags, or sealable bin for garbage (especially for diapers and food waste).



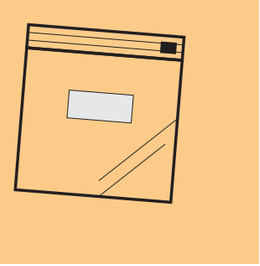
CLEAN UP SUPPLIES

Supplies that will help you clean up after the event: large strong garbage bags; eco friendly cleaning agents; mops, buckets, rubber gloves; safety goggles; N-95 respirators for the household.



FOOTWEAR

Outerwear and sturdy footwear for each household member in case you need to leave suddenly.



BATHROOM BAGS

Small sealable bags for bathroom garbage if toilet can't be flushed.

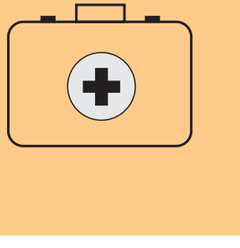
STRATEGY 23

DEVELOP A HOUSEHOLD EMERGENCY PLAN

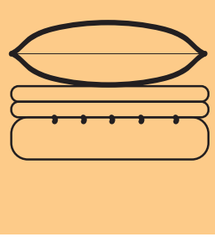
STEP 2 - MAKE A PLAN TO STAY OR GO

B. MAKE A 'SHELTERING STASH' IN YOUR HOME

WELLNESS



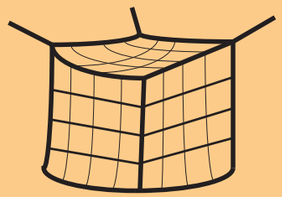
LARGE FIRST AID KIT



BEDDING, CUSHIONS, PILLOWS AND BLANKETS



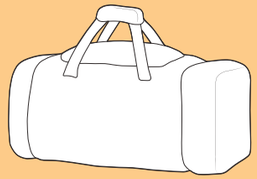
TOYS, GAMES, BOOKS AND MUSICAL INSTRUMENTS



MOSQUITO NETS



SUNSCREEN

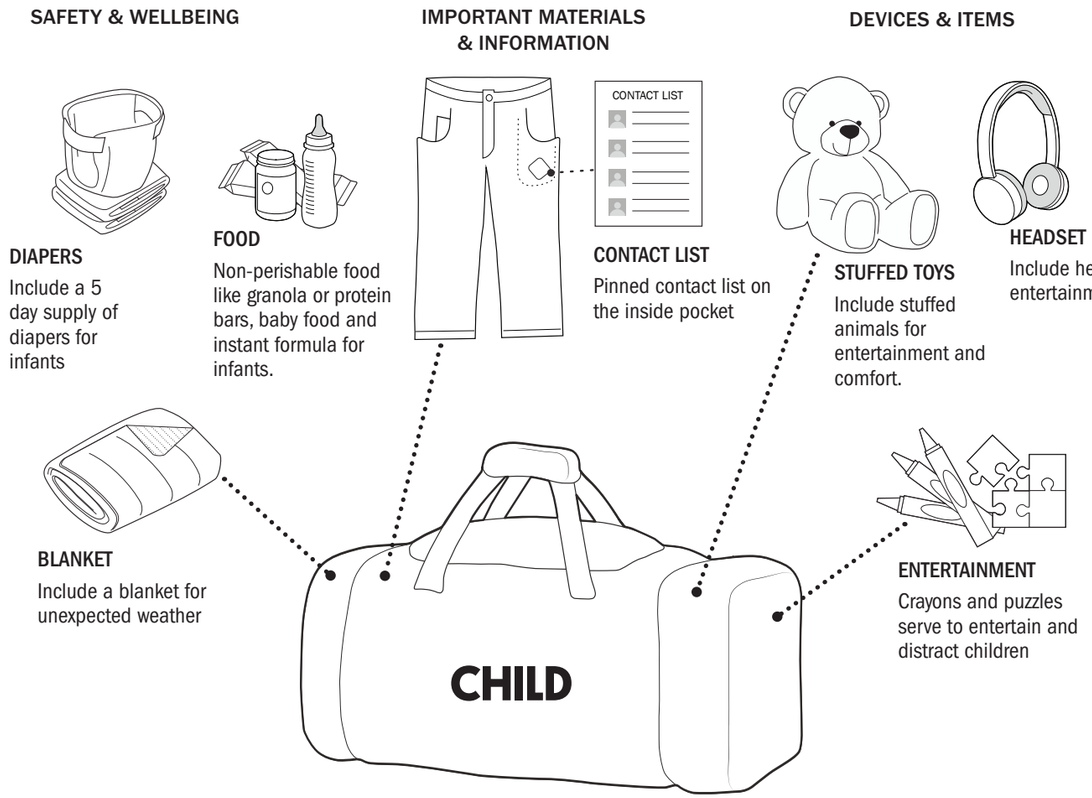


"GO BAG"

STEP 3 - MAKE A PLAN TO LEAVE

A. MAKE A 'GO BAG' FOR EACH MEMBER

Your bag should be durable and easy to carry, like a backpack or suitcase on wheels. Keep it where you can grab it quickly.



23 DEVELOP A HOUSEHOLD EMERGENCY PLAN

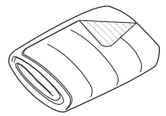
STEP 3 - MAKE A PLAN TO LEAVE

A. MAKE A 'GO BAG' FOR EACH MEMBER

SAFETY & WELLBEING



MEDICINE
Seven-day supply of vitamins and supplements



COMFORT ITEMS
A blanket, slippers or favorite small objects.

IMPORTANT MATERIALS & INFORMATION



MEDICAL EQUIPMENT LIST
Include make, model and style or serial number

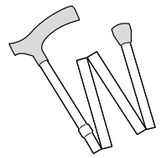


CONTACT LIST
Large-text version of all contacts and reunification hotline

DEVICES & ITEMS



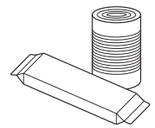
BATTERIES
Extra Batteries for Hearing Aids or other devices



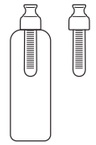
WALKING AID
Foldable cane or walking aid



SAFETY & WELLBEING



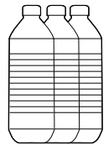
FOOD
Non-perishables like granola
OR energy bars.



WATER FILTER
Get a water bottle with filter & replacements.



MEDICAL SUPPLIES
Medications and first aid kit



WATER FILTER
Get a water bottle with filter & replacements



CLOTHES
Include at least two changes of clothing.



REPPELANT & SUNSCREEN
Make sure its the strongest available.



HYGIENE
Washing cloth, hand sanitizer, toothbrush and toothpaste.

IMPORTANT MATERIALS & INFORMATION



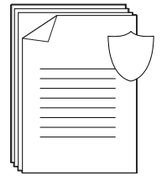
PROOF OF RESIDENCY
Store it in a safe water-proof container



ID
Store it in a safe water-proof container



MEDICAL RECORDS
Store it in a safe water-proof container



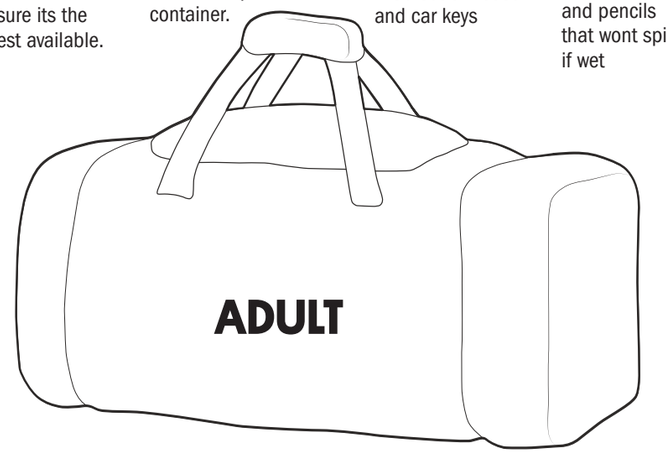
HEALTH CARE & INSURANCE
Store it in a safe water-proof container



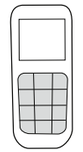
CASH
Store it in a safe water-proof container.



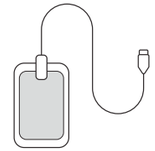
SPARE KEYS
Extra set of house and car keys



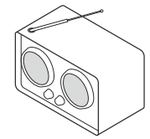
DEVICES & ITEMS



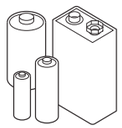
BACK-UP PHONE
With wall or USB charger



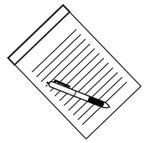
DEVICE CHARGER
A solar charger is preferred



RADIO
Must be battery powered. Take out batteries when in storage.



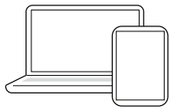
BATTERIES
Include an ample supply of AAA, AA, 9V, D batteries.



NOTEPAD & PENS
Include pens and pencils that wont spill if wet



FLASHLIGHT
Solar powered is preferred



LAPTOP OR TABLET
With wall charger

STRATEGY 23

DEVELOP A HOUSEHOLD EMERGENCY PLAN

STEP 3 - MAKE A PLAN TO LEAVE

A. MAKE A 'GO BAG' FOR EACH MEMBER

SAFETY & WELLBEING



MEDICINE & FIRST AID
Seven-day supply, include animal first aid kit with flea treatment.



FOOD
Three-day supply of food and water with foldable food and water dishes.

IMPORTANT MATERIALS & INFORMATION

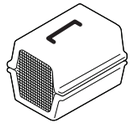


MEDICAL RECORD
Vaccination, Microchip ID, Photo with pet and family members in case of separation

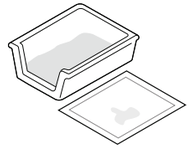


ID & CONTACT LIST
Include veterinarian and person who can help your animals if you can't get home.

DEVICES & ITEMS



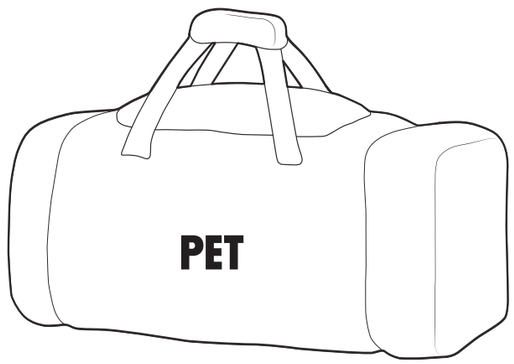
CARRIER
Include crate or carrier for your pets.



batteries
Include an ample supply of AAA, AA, 9V, D batteries.



COMFORT ITEM
Include a comfort item or toy.



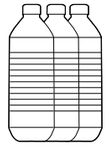


CLEAN-UP BAGS
Include clean-up bags for unexpected situations.

SAFETY & WELLBEING



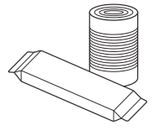
MEDICAL SUPPLIES
Medications and first aid kit



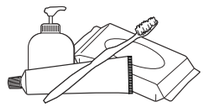
WATER FILTER
Three days worth per person if possible



BATHROOM HYGIENE
Washing cloth and toilet paper



SNACKS
Non-perishables like granola or energy bars



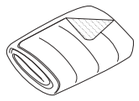
HYGIENE
Washing cloth, hand sanitizer, toothbrush and toothpaste.



REPELLANT & SUNSCREEN
Make sure its the strongest available.

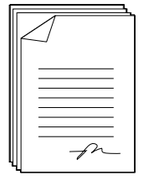


DIAPERS
Include a 5 day supply of diapers for infants

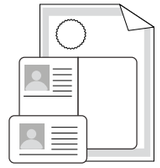


BLANKET

IMPORTANT MATERIALS & INFORMATION



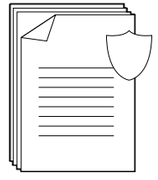
PROOF OF RESIDENCY
Store it in a safe water-proof container



ID
Store it in a safe water-proof container



MEDICAL RECORDS
Store it in a safe water-proof container



HEALTH CARE & INSURANCE
Store it in a safe water-proof container

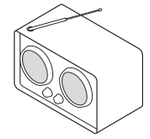


CASH
Store it in a safe water-proof container



SPARE KEYS
Extra set of house and car keys

DEVICES & ITEMS



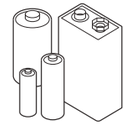
RADIO
Must be battery powered. Take out batteries when in storage.



CELL PHONE
With car charger



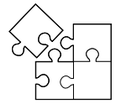
FLASHLIGHT
Solar powered is preferred



BATTERIES
Include an ample supply of AAA, AA, 9V, D batteries.



HAT
Include a hat to protect yourself from prolonged exposure to sun.



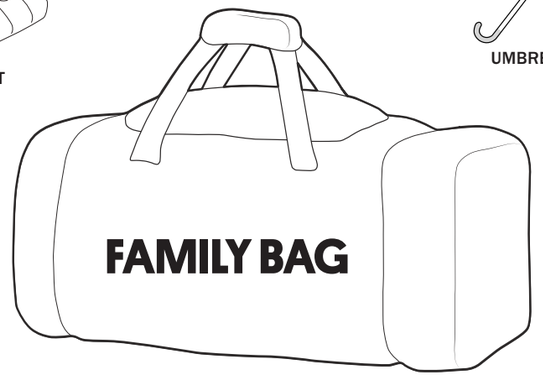
ENTERTAINMENT
Games and puzzles serve to entertain and distract.



UMBRELLA



COLLAR & LEASH



STRATEGY 23

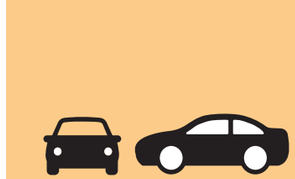
DEVELOP A HOUSEHOLD EMERGENCY PLAN

STEP 3 - MAKE A PLAN TO LEAVE

B. EVACUATE BY CAR



Fill up the gas tank early to avoid waiting in long lines. Consider carrying extra gas in an approved container.



Reduce traffic congestion by using one car per household. Offer a ride to neighbors if you have room.



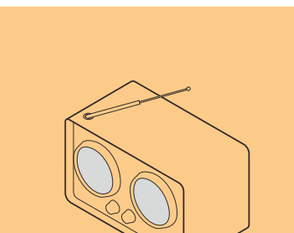
Anticipate heavy delays. In mass evacuation traffic, travel takes roughly four times as long as usual.



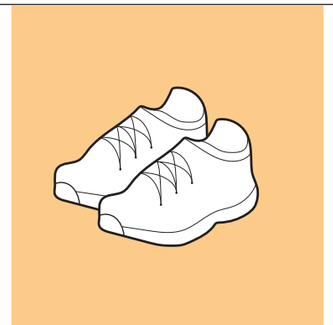
Learn designated evacuation routes or bring a paper map with the routes marked. Travel only on these routes as others may be blocked.



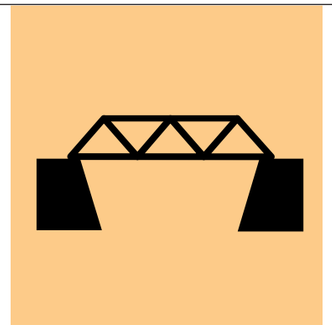
Do not drive into flooded areas. Just six inches of moving water can knock a person down, and one foot of moving water can sweep a vehicle away.



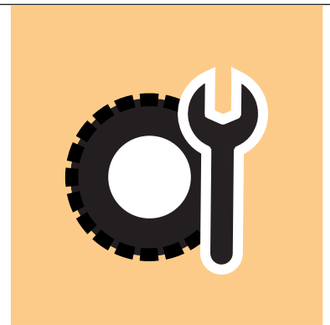
Keep the radio on, follow traffic notifications, and watch for hazards such as downed power lines and washed out bridges.



Wear sturdy shoes and comfortable protective clothing, such as pants and a long-sleeve shirt.



In a hurricane, expect bridges to be closed as wind speeds increase.



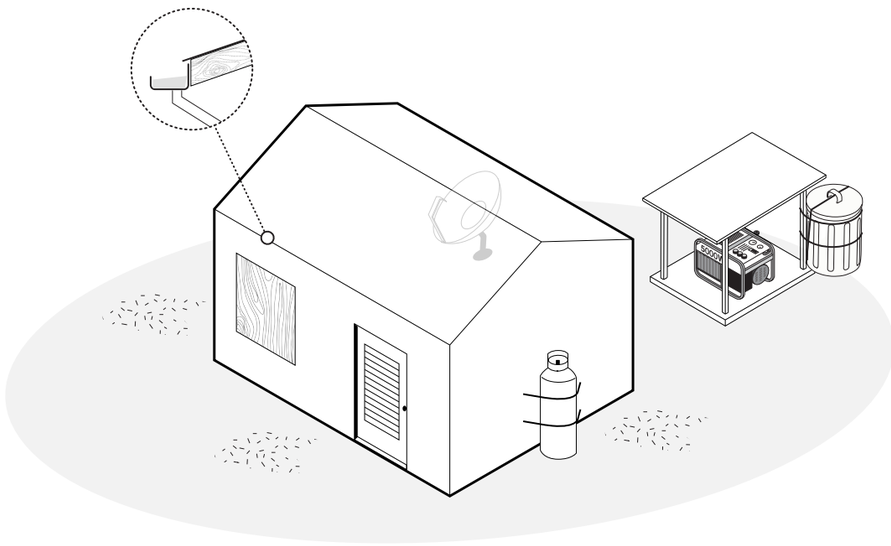
Have emergency supplies for the car itself, including a spare tire or patch kit, a large flashlight, first aid kit and basic repair tools.

C. CLOSING UP YOUR HOME

If you have time, protect your house and belongings.

OUTSIDE

- Tie down or move loose materials or equipment such as outdoor furniture, trash cans, grills, bicycles.
- Secure doors and cover windows with plywood or shutters.
- Anchor propane tanks and any containers of hazardous chemicals so they do not leak or float away.
- Clean gutters and drains, and move any objects that may block water from receding. Test the sump pump if you have one.
- If you have a generator for the house, it should have an approved transfer switch and be securely bolted down. Test it and fill it with fuel.



STRATEGY 23

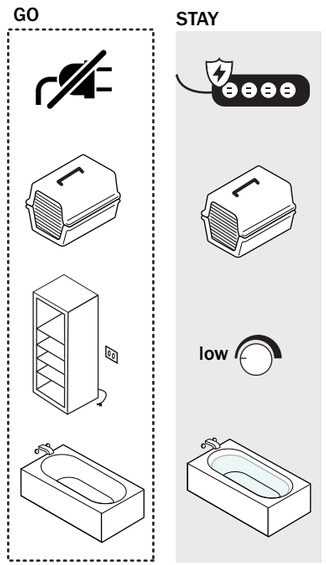
DEVELOP A HOUSEHOLD EMERGENCY PLAN

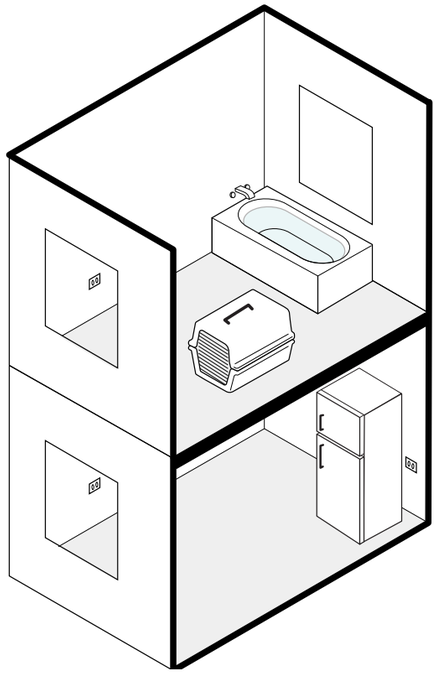
STEP 3 - MAKE A PLAN TO LEAVE

C. CLOSING UP YOUR HOME

INSIDE

- Move valuables to the highest floor if flooding is likely
- Fill the bathtub(s) and other clean large containers with water. You can use this to drink if needed.
- Keep your pets safe. Put them in a carrier or room where you can get them quickly when you are ready to leave or shelter
- If you are leaving, unplug all appliances. If you are staying, consider a surge protector for the refrigerator and freezer if you want to keep them plugged in.
- If you are evacuating, empty your fridge and freezer so you do not return to decayed food. Mold and odor inside a refrigerator or freezer can damage the appliance, and you may have to throw it out.
- If you are staying, turn the fridge and freezer to the lowest settings so food stays colder longer.

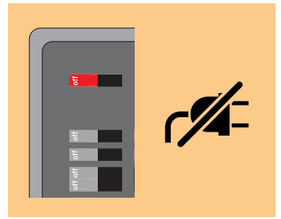




UTILITY SYSTEMS

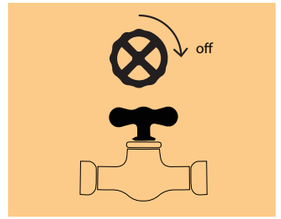
Shut off utility systems to minimize damage and danger. The hazards of utility outages usually come from when the systems go back on without being shut off properly. Have a professional show you how to shut these systems down before a disaster.

ELECTRICITY



- There are two places to turn off power: the circuit box inside and the main connection outside. Flip the switches you see in either of these places and power will go out.
- Unplug appliances to prevent them from being damaged by surges.
- If it is advisable to turn off your power, there will be a public alert message.

WATER



- The main shut-off valve works like the dial for a garden hose. Have a plumber identify it for you and label it with a plastic tag.
- If you are evacuating, shut off the main power and water.
- If you are sheltering in place, you should follow public messaging or turn off power and water preemptively.
- Whether you are evacuating or not, shut off gas to appliances. Use the valve next to the appliances, not the main valve.

STRATEGY

24 CHOOSE A SPACE TO KEEP YOUR FAMILY SAFE

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When an anticipated disaster is approaching, the first question you need to answer is whether you and your household members should leave the area, stay home ("shelter in place") or go to a designated shelter nearby. Hurricanes give several days' warning before they strike, but many other natural disasters do not. This strategy will help you determine the best options in all conditions and to act accordingly.

Strategy in Action

1. *Understand the Vulnerabilities of Your Household*
   - *a. Consider the Difficulties Each Person may Face*
   - *b. Understand the Risks at Your Building*
   - *c. Understand the Risks in Your Region*
2. *Decide Whether to Stay or Go*

DESCRIPTION AND FUNCTION

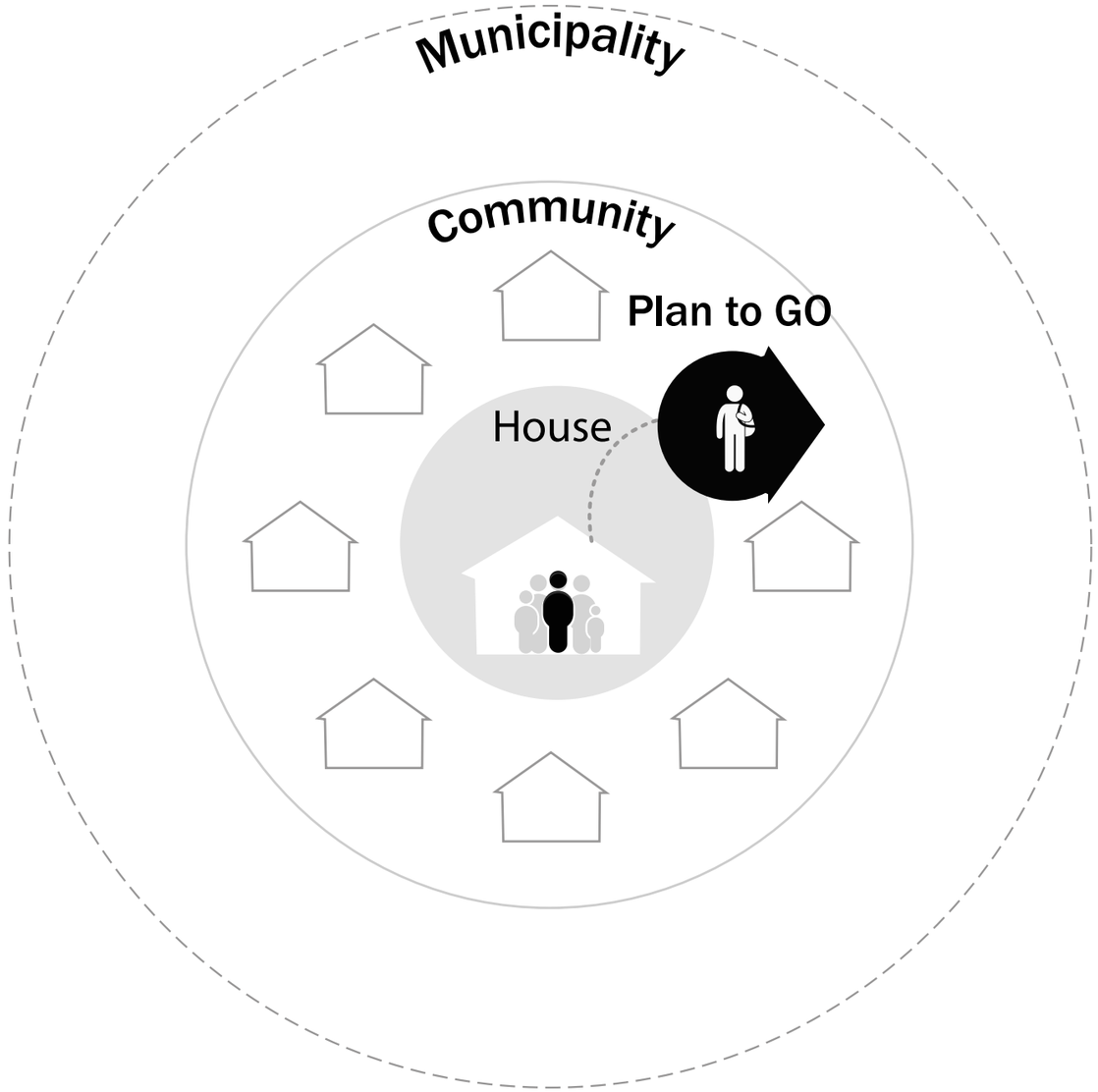
- When you assess the challenges that may arise for each member of your household during a disaster, your plan can address them in ways that lessen the impact.
- If you have advanced warning, you will be able to consider the safest place to weather the storm: your own home ("sheltering in place"), a local shelter, or a remote location such as with family, friends or a hotel safely away from the disaster zone. As part of planning, find two friends out of the area that your household can go to. If you need to make these decisions after the event, the same considerations apply.



Fotos Patillas







SUPPORTING STRATEGIES

01 Reinforce Site

04 Assess the Priorities for Your Home or

STRATEGY

24 CHOOSE A SPACE TO KEEP YOUR FAMILY SAFE

STEP 1 - UNDERSTAND VULNERABILITIES AT YOUR HOUSEHOLD



CONSIDER THE DIFFICULTIES EACH PERSON MAY FACE

- Can everyone travel long distances by themselves?
- Can everyone carry a moderately heavy bag?
- Does anyone need special food, medication, medical support, or equipment?
- Does anyone depend on power for life safety?
- Does everyone speak, hear, and see well?
- What options are there for keeping your animals safe?



UNDERSTAND THE RISKS AT YOUR BUILDING

- Identify your home's trouble spots (see Strategy 04 on how to do a visual inspection of your home).
- Consider a professional evaluation to learn about the ways different hazards could affect your building and whether or where it would be safe to shelter there during an emergency.



EMAIL

- Some events, such as hurricanes, can be predicted in advance, but there is no warning for many other disasters that are likely to happen in Puerto Rico. To understand the conditions of your location in comparison with the whole island, review Strategy 01.
- Are you in a FEMA designated Special Flood Hazard Area, or within a floodplain that is vulnerable to storm surge or flooding? Check the FEMA Flood Map Service Center online.
- Are you in an evacuation zone designated by your local government?
- Are you in an isolated area where access roads may easily be cut off?
- Will any possessions, debris, or chemicals at your site become dangerous for you and your neighbors?

STEP 2 - DECIDE WHETHER TO STAY OR GO

- ALWAYS ERR ON THE SIDE OF CAUTION! The simplest option is often to leave before an evacuation order, and stay with family and friends out of the area. Deciding early gives you the greatest number of options for travel, which is especially important if you have a household member with special needs or require a pet-friendly hotel.
- DO NOT FORGET ABOUT YOUR PETS!!!! Wherever you plan on staying, make sure it is a pet-friendly alternative. Options for pets include:
  - Going to pet-friendly hotel
  - Boarding them at a kennel in a safe area
  - Leaving them with a friend out of the area
  - Taking them to a pet-loving neighbor or pet-friendly community shelter.

WHAT IS AN EVACUATION ORDER AND WHAT CAN MAKE YOUR SITE UNSAFE?

- An evacuation order is a notice given by government agencies, including the Puerto Rico Emergency Management Agency (PREMA), through media coverage. It is issued when the land where your home sits is vulnerable to natural hazards such as flooding, storm surge, landslides, or high winds.
- The government may not always be aware about specific situations. Even if there is not an evacuation order in place, make sure that both your surroundings and your home are safe. See Strategy 01: Identify Risks at Your Location and Strategy 04: Assess Condition of a Residential Structure.

WHAT ARE THE CHARACTERISTICS OF A SAFE SPACE AT HOME?

- Strong and structurally sound foundations, walls, and roof (preferably concrete)
- Small number of windows, skylights, or other openings
- Plenty of provisions for people and pets
- This safe space can be:
  - An interior bathroom or closet located at the center of your home (not along an exterior wall)
  - A space that is specifically built as a shelter during disasters.

WHAT CAN BE A SAFE SPACE NEAR MY AREA?

- A safe space near your area can be a neighbor's home that is equipped with sufficient emergency supplies for all or a community-run shelter.

STRATEGY **24**

CHOOSE A SPACE TO KEEP YOUR FAMILY SAFE

STEP 2 - DECIDE WHETHER TO STAY OR GO







REMEMBER

ATTENTION! STAY HERE ONLY IF:

- Everyone is healthy enough to live with utility outages for an extended period. Anyone that needs medical care beyond basic first aid should ask their regular care provider for the best place to go.
- You have a way to communicate and get news.
- You feel emotionally prepared to ride out the emergency disaster situation.
- You're not alone.

Is there an evacuation order in your area?

Are you vulnerable after assesement of part one of this stategy ?

YES

NO

Is there a Safe Space at your home?

YES

Shelter in place

[Go to part 2 of STRATEGY 25]

NO

Is there a Safe Space near your area?

NO

Shelter outside your neighborhood

[Go to part 2 of strategy 28]

YES

Shelter at your neighborhood

[Go to part 2 of strategy 28]

STRATEGY

25 RESPOND + BEGIN HOUSEHOLD RECOVERY

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Dealing with the immediate and prolonged aftermath of a natural disaster can be one of the most difficult phases of household recovery. The landscape after a hurricane or earthquake can include power outages, water supply interruption and destruction of buildings. This strategy focuses on what to do during the emergency and how to manage early response for your home and members of your household so that your process of long-term recovery will be a foundation for future resilience.

Strategy in Action

1. *During the Emergency*
2. *After the Emergency: Safely Evaluate Your Home*
3. *Respond to Emergency Conditions*
4. *Understand the Recovery Process: Register for Assistance*
5. *Rebuild*

DESCRIPTION AND FUNCTION

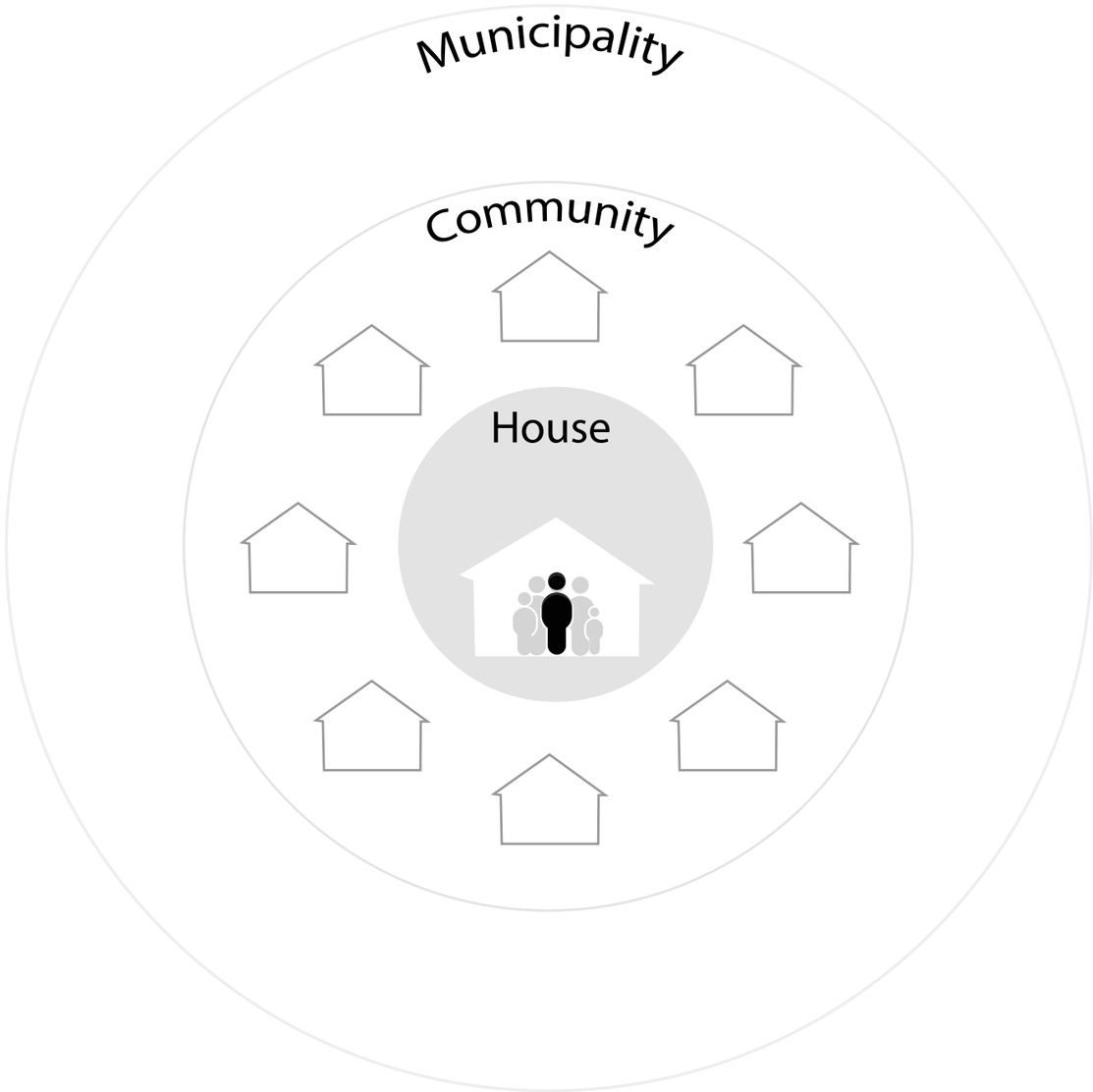
Breaking down the work of recovery into manageable pieces will help you move forward.



Jake Price Houston Texas Hurricane Harvey

OPERATIONS AND MAINTENANCE TIPS

- Ensure the safe space at your home or where you have decided to weather the natural disaster is prepared as you:
- Remove any elements hanging on the walls such as shelves, mirrors, pictures, or artwork.
- Move heavy objects, like books, to lower shelves or plastic boxes on the floor.
- Repair fissures and seal openings to the exterior, such as windows, with wooden panels or storm shutters. See Strategy 08.



SUPPORTING STRATEGIES

01	04	08	23	25	26	27	28
Reinforce Site	Assess the Priorities for Your Home or Building Structural Condition Prior to Event	Anchor, Seal and Protect Building Openings	Develop a Household Emergency Plan	Respond + Begin Household Recovery	Develop a Community Plan	Identify + Prepare Safe Community Shelter	Inspiring Post-Disaster Planning for Community

STRATEGY

25

RESPOND + BEGIN HOUSEHOLD RECOVERY-

STEP 1 - DURING THE EMERGENCY

- KEEP ONE PHONE OR RADIO ON AT ALL TIMES.
- STAY CALM, HELP OTHERS AND FOLLOW OFFICIAL ADVISORIES
- HAVE BOARD GAMES OR CARDS TO PASS THE TIME IN A CONFINED SPACE
- PROTECT VALUABLES. UNPLUG AND ELEVATE ELECTRONICS, AND STORE VALUABLES IN PLASTIC.

- RUN DOWN BATTERIES WITH UNESSENTIAL USES.
- TAKE BIG RISKS OR SEPARATE YOURSELF FROM OTHER PEOPLE.
- RISK YOUR LIFE TO SAVE ANY POSSESSIONS.
- GO OUT OF A SAFE SPACE UNLESS THE AUTHORITIES ANNOUNCE DANGER HAS PASSED

STEP 2 - AFTER THE EMERGENCY | SAFELY EVALUATE YOUR HOME

Storms and other disasters create new hazards in their wake. If you evacuated your home, return only when qualified officials deem it safe to do so. If you sheltered at home, don't go outside until you get an official alert that it is safe.



GOING OUT AFTER SHELTERING IN PLACE

- Signal to Emergency Crews and Neighbors
- Post a notice on the front door with big dark letters that says OK if you do not need emergency help, or HELP if you do.
- If you leave, post a message that says where you went, who you are with, and numbers where you may be reached (this can be your cell phone and your out-of-area contact)

STEP 2 - AFTER THE EMERGENCY | SAFELY EVALUATE YOUR HOME



RETURNING HOME

- Go inside cautiously, with a flashlight rather than a lantern or any source of flame. There may be gas or other flammable vapors that can cause fires.
- Watch out for broken glass and sharp debris. If you see, or smell mold (musky smell) leave the space.
- Water and electricity are dangerous together. NEVER turn on power if there is water inside.
- Document all damages to facilitate insurance, emergency and municipal response.
- Take photos or videos and document all damages in writing.
- Calculate total estimated losses in $.
- Keep track of all damages to show insurance company history of home.



MANAGING A FLOODED HOME

- Ventilate the space by opening windows and doors as soon as weather allows.
- Determine if there is mold. See Strategy 13.
- If there is no sign of mold, remove any wet material as soon as you can (drywall, fabrics, rugs and furniture, etc) to prevent mold from developing.
- If you think there might be mold, wear protective eyewear, gloves and a respirator mask. Spend only 15 minutes in the site at a time. Carefully document damage with photographs for your insurance company.



IN YOUR COMMUNITY

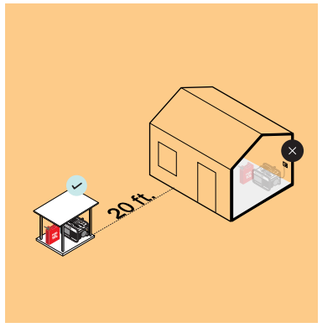
- Avoid walking or driving through flood waters, which can be electrically charged from damaged power lines or contaminated by sewage.
- Look out for landslides, especially after a lot of rain. Be aware of changes in the landscape such as new patterns of stormwater drainage on slopes (especially the places where runoff water converges), land movement, tilting trees and any cracks or shifting in parts of your building.
- Go to Strategy 29: Respond and Begin Community Recovery for more info.

STRATEGY

25 RESPOND + BEGIN HOUSEHOLD RECOVERY-

STEP 3 - RESPOND TO EMERGENCY CONDITIONS

- Disaster affects physical and mental health. Staying well helps you have a smooth recovery.
- Remember that you are part of a community and you can support each other. See Strategy 29 for more on community collaboration. See Strategies for Energy Generation + Backup and Water Management + Storage



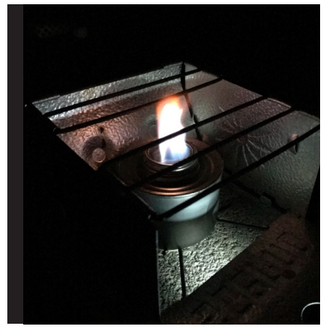
USE GENERATOR POWER

- NEVER use a generator indoors, as it produces deadly carbon monoxide. Place it outside, at least 20 feet away. Monitor inside air with a carbon monoxide detector that has new batteries.
- If you have a portable generator, store it in a covered space with ventilation, especially if you are worried that it might get stolen. For storing fuel, use an approved container and secure it in a protected location far from people.
- NEVER plug a generator into a wall outlet.



ACCESS SAFE FOOD AND WATER

- If you can't cook on your stove, grill outside, use a camp stove or a solar oven.
- If you don't have access to the outdoors use a propane stove near a window.
- Do not cook food over wood that has been painted or treated with chemicals- they are toxic
- Canned and sealed foods are the most sanitary options.



LIVE WITHOUT POWER

- Use minimal electricity until power is fully restored. Power supply may be reduced, lighter load on the grid means more power for more people.
- Identify household fire hazards (and develop appropriate risk mitigation measures).
- Use safe cooking, lighting and heating practices (e.g. do not leave appliances unattended, keep clothing/furniture away from appliances, etc.)
- Teach children about fire safety and promote safe behavior
- Share knowledge and ideas with neighbors.



STAY COOL IN THE HEAT

- Avoid things that make you sweat, such as salty food, physical activity, sitting in the direct sun.
- Working hard while wearing clothing that cover the body can cause:
  - Heat Exhaustion – Symptoms include heavy sweating, weakness, nausea, vomiting, headache, lightheadedness, and muscle cramps. Rest in a cool place, remove excess clothing and hydrate immediately.
  - Heat Stroke - If heat exhaustion persists, seek urgent medical attention. Symptoms include high body temperature, altered mental state or behavior, headaches, confusion, agitation, slurred speech, irritability, delirium, seizures, rapid breathing, fast pulse, and sweating that alternates with dry skin. Cool the person with any means available and call a health professional.



PREPARE FOOD

- NEVER eat food that has touched storm water. If cans or food containers get wet, remove paper labels (they can have bacteria), wipe with diluted bleach (1 tablespoon of unscented liquid chlorine bleach in 1 gallon of water) and let dry for an hour. If cans are bulging or damaged, they are likely contaminated and you should not eat the contents.
- When in doubt, throw it out! Food poisoning can be dangerous during an emergency. In fires, food is exposed to toxic chemicals, even inside the fridge, and should not be eaten.
- Without power, food should stay cold four hours in the refrigerator and up to 48 hours in the freezer.



PROTECT MENTAL HEALTH

- Living through a disaster is stressful. Long periods of stress can lead to depression, anger, and substance abuse.
- Eat healthfully, exercise often, sleep soundly, and avoid alcohol and other drugs.
- Share your feelings friends or family and maintain relationships with friends.
- Take breaks from dealing with the disaster and try to return to activities you enjoy if possible.
- Stay informed but avoid excessive exposure to media coverage of the event.
- Ask for help from a clergy member, counselor, non-profit (such as the Red Cross), or doctor.
- *REMEMBER: Disasters are particularly hard for children. Help them by:
  - Getting them back into a familiar routine as quickly as possible.
  - Reassure them, and answer their questions
  - Limit exposure to media coverage of the event.

STRATEGY

25

RESPOND + BEGIN HOUSEHOLD RECOVERY

STEP 3 - RESPOND TO EMERGENCY CONDITIONS



LIVE WITHOUT RUNNING WATER

- Stay hydrated. If you have a low supply of water, use it only for drinking.
- If bottled water is not available, treat your own. Dirty water leads to illnesses such as dysentery, cholera, typhoid and hepatitis. Follow guidance from the health department on how to treat water. Do not drink, bathe in, wash dishes, brush your teeth, or make ice with water that you are not sure is safe. Babies should breastfeed or drink formula, never water.
- Use rainwater caught in clean buckets for flushing toilets. Never use flood water.
- See Strategy 16 Reduce Your Water Consumption



MINIMIZE PESTS

- There can be debris nearby – including food scraps – that attracts pests. Watch out for open windows and doors that can allow rodents, insects and reptiles to come in and spread diseases.
- Protect yourself from Zika and Dengue viruses by using mosquito repellent and sleeping with mosquito nets. Pregnant women, or women that plan to have children should be aware the viruses are linked to complications with pregnancy.
- Use battery fans to keep air flow. Keeping your surroundings dry and cool dissuades mosquitoes.
- See Strategy 15: Manage Pests.



ENSURE SANITATION AND DEAL WITH YOUR SEPTIC SYSTEM

- Eliminate all non-essential water use and flush toilets as little as possible. Use hand sanitizer to keep hands clean.
- If pipes in your system carry sewage away, you can flush the toilet by pouring water down the bowl.
- If your pipes are backed up, keep them shut off. You will need to improvise a toilet.
- If you have a septic system: If the drain field becomes covered with water, do not use the system and avoid contact with any standing water that may contain sewage.



CLEAN UP AND MANAGE DEBRIS

- Use clothing and equipment that protect you during clean-up. You may be exposed to lead paint, asbestos and other toxins.
- Keep spaces well ventilated.
- Clean any wounds, cuts, or animal bites with soap and clean water.
- Clean up debris
- Protect human health, comply with regulations, reduce injuries, and minimize or prevent environmental impacts by cleaning up debris. Work with neighbors, See Strategy 27 for how to organize community collaborations.



TREAT WATER

- The most common ways to treat water are by boiling and chlorinating.
- Boil water for at least one minute then let it cool.
- Chlorinate water using regular, unscented bleach only. Household bleach has concentrations from 5.25% to 8.25%.
- For 5.25%, add 8 drops per gallon (approx. ⅛teaspoon)
- For 8.25%, add 6 drops per gallon
- Stir and let stand for 30 minutes. If it does not have a slight bleach odor, repeat the dosage and let it stand another 15 minutes. If it still does not smell of chlorine, discard it and find another source of water. Before drinking, let it sit for several hours and the bleach smell will dissipate.



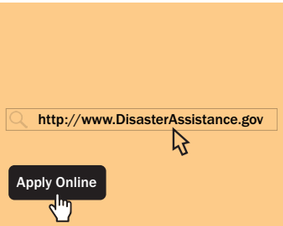
STRATEGY 25

RESPOND + BEGIN HOUSEHOLD RECOVERY-

STEP 4 - UNDERSTAND THE RECOVERY PROCESS: REGISTER FOR ASSISTANCE

Challenges arise regardless of whether you are performing small repairs or a rebuilding a house. Take the time to structure your project in the beginning, to save time and money in the long run.







INSURANCE

- The first thing to do is file an insurance claim.
- Funds for rebuilding (such as those from FEMA and other government agencies) are not usually calculated until your insurance claims are adjusted.

GOVERNMENT AGENCIES

- If a Presidential disaster declaration is issued, you will be able to apply for funding via FEMA. Register for FEMA assistance, either online at www.DisasterAssistance.gov, or at a Disaster Recovery Center. Registering directly with FEMA will help you understand the aid you qualify for.
- Determine whether you are eligible for a low-interest disaster loan with the U.S. Small Business Administration (SBA). The SBA offers low-interest disaster loans for businesses and nonprofit organizations, homeowners and renters.

NON-PROFIT ORGANIZATIONS

- If you cannot afford construction services, there may be volunteer groups or non-profit organizations that can do repairs and remove mold.
- If you need additional aid, such as food benefits, medical devices, mental health care, or small business assistance, ask FEMA if they can refer you to organizations like the American Red Cross, or follow word-of-mouth in your area.

STEP 5 - REBUILD

ESTABLISH YOUR PRIORITIES

Stay safe and healthy throughout the recovery process. This may mean you and your family stay at a safe shelter, a neighbor's or family's house or hotel.

ESTABLISH YOUR BUDGET

- Get information from your insurance company, FEMA and other aid sources about available funds, and the specific filing requirements for authorizing them.
- Construction projects are often more expensive than projected, even with a good contractor. Add a cushion of at least 20% to your budget for unexpected expenses.
- See "Putting It All Together"

DETERMINE YOUR PROJECT SCOPE

- Make a list of the services you need (carpentry, mold remediation, electrical.) to present to contractors for a bid.
- Architects help you determine how to build greener and safer within your budget.
- A Design Help Desk helps you plan your project and work with an architect. Follow news to find out about them.

KNOW THE LAW

- Work with local businesses that have proper licensing and insurance. You may be liable for any construction-related accidents on your premises if the builder does not have adequate workers compensation and liability insurance.
- Ensure your contract requires your contractor to get required permits and meet building codes.
- Confirm the contractor is certified to provide the service you need. For instance, mold remediation requires special certifications, as does handling lead paint.
- See "Putting It All Together"

FIND A GOOD CONTRACTOR

- Be careful selecting a contractor. There are many scams.
- Request bids from several contractors. The cheapest bid is not always the best.
- Establish a written contract. Include: full price, materials and timeline. The more detail, the better.
- Ask your insurance company for a recommendation.
- Communicate well and constantly with your contractor.
- Say no to cash-only deals, door-to-door solicitations that require you to commit right away, high upfront payments, handshake deals without a contract, free on-site inspections, or discount materials. Be cautious of a contractor that contacts you first.
- Get references from past customers, both old references, to check endurance of the work, and more recent ones to ensure it is still good.

CASA PUEBLO

Description: Casa Pueblo is a community-based non-profit organization located in Adjuntas, Puerto Rico. Casa Pueblo was the result of what started as a hard-fought struggle for land conservation in the central mountainous region of the island. Now, as a respected and admired institution, Casa Pueblo continues pursuing its goal: to educate the public on sustainable development issues and community activism. Located in Adjuntas, its headquarters serve as a cultural center where visitors can learn all about the history of the renowned Art and Culture Workshop. A guided tour through the center covers all of Casa Pueblo's achievements, from its initial efforts to stop the strip mining of the surrounding areas to the subsequent enactment of legislation in favor of land conservation in other municipalities. Other tourist attractions include a butterfly garden, a plant nursery, and an artisan shop.





TALLER SALUD, LOIZA

Interviewee: Tania Rosario, Taller Salud, Loiza

For more information, visit https://www.tallersalud.com/

Description: Taller Salud is a feminist, community-based organization whose goal is to improve women's access to healthcare, reduce violence in community settings, and promote economic development through education and activism. After Hurricane Maria, Taller Salud coordinated medical and psychological assistance brigades for over 2,000 people and distributed food to about 14,000 women and their families during the first three months after the event. Between January and March of 2018, an additional 3,000 people received supplies and primary healthcare based on their needs at the time, while an additional 1,000 people received medical and/or psychological assistance. Over the next six months after the hurricanes hit, our organization and our strategic partners helped an estimated total of 20,000 people in 15 municipalities as part of our emergency response.

INTERVIEW

The fact is that it was really tough for our communities in Loiza, where our offices are located. We were barely starting to handle the damages left in Loiza by hurricane Irma's passage, which destroyed 300 homes and brought down the water and power systems in the area. Our response to Maria was, in reality, a direct result of the emergency response to Irma. When it came to donations, this helped us have a good idea of what our residents needed to avoid receiving redundant aids when people asked what they could donate. This allowed resources to flow to other communities with different needs from those of our residents. Moreover, this also helped us identify the additional needs that we tend to forget during an emergency, such as reproductive and women's health care. Our day-by-day interactions involved daily meetings to determine aid categories and cover basic needs based on established priorities, including water, food, medications, medical assistance, clothes, necessities, pest control, materials, and household goods.

After Maria, we also established four lunchrooms in the community, where the women cooked and served about 1,000 meals per day for 8 weeks. Currently, we are working with the Recuperación Justa project, which has two goals: delivering aid supplies and community planning. Fundamentally, this project strives for the community to develop and perform organizational and political training work in the face of a real threat to the recovery discourse. For example, our Loiza community lives near a channel that needs dredging, and we are always told there is no money for it. Meanwhile, financing is readily available when it comes to proposals for housing developments or apartment projects. So we are working for the community and its residents to assume their responsibility and take on a political discourse and identity to tackle the recovery process and everything it entails. That is why we call it Recuperación Justa [fair recovery], not Disaster Recovery.





BARRIO MARIANA'S RECREATIONAL AND CULTURAL ASSOCIATION (ARECMA, BY ITS SPANISH ACRONYM)

Interviewees: Rosalina Abreu and Susana Sanabria, ARECMA, Inc.

For more information, visit https://arecma.wixsite.com/arecma

Description: Barrio Mariana's Recreational and Cultural Association (ARECMA, by its Spanish acronym) is a community-based non-profit organization located in the Mariana neighborhood in Humacao. This organization was created to work and ensure the well-being and comprehensive development of the neighborhood and its residents. Mariana is a mountainous community approximately 6 km away from the town's urban center. It is divided into three sectors (Mariana I, II, III) and is inhabited by almost 3,200 people. Mariana is a rural community, far from the urban center of town, which is why its residents have always had difficulty to access basic services such as electricity, phone, transportation, and drinking water systems. In light of this scenario, community residents decided to come together and create ARECMA almost 37 years ago, searching for solutions to these immediate needs. Located in the rural area of the municipality of Humacao, the Mariana neighborhood has become one of the most resilient communities in the aftermath of Hurricane Maria. After the emergency, this community has organized different projects in response to the needs of its residents. Among its different projects is ARECMA's common lunchroom, which served from 150 to 500 lunches for six months. The common kitchen is managed by a group of 7 to 11 women who are community residents. Although this initiative is still in place, it now operates as an exchange, where participants may donate $5.00 or work as volunteers in any of the different projects.

INTERVIEW

The first need we noticed was the lack of space for the community, so we bought the land (Loma de la Niña Mariana) 37 years ago and dedicated it to community projects. It is because of this land that we can now hold activities that have improved the economy and created opportunities for the community. Some examples of these activities are the Festival de la Pana, which has been celebrated for 36 years, summer camps that have been operating for 16 - 17 years, the common kitchen, and other similar community-focused activities. After Maria, it took us a couple of days to be able to leave our homes. Then, people started arriving at La Loma. The ARECMA team cleaned the surrounding areas because everything was destroyed due to the site elevation. The same happened with the community kitchen; one of our members saw what it was and suggested we do it here. We started cooking for ourselves, but then we noticed people needed food, so we decided to cook one meal per day to feed the community members. Occasionally, with what little signal we had, we posted what we needed on social media, and the help came. Little by little, the word spread and people came from neighboring towns, such as Yabucoa, Naguabo, and Juncos; this continued until recently. We used to gather as an organization to decide whether we accepted aid or not, because not everyone came to us with the best of intentions. Other challenges were the lack of communication services (like for most people) and not having a census before the hurricane to account for infrastructure and resident needs. One of our accomplishments was to have a group of dedicated leaders among us, a human network formed by those



who stepped up when the community needed them most: the emergence of voluntary service. We did not exactly have a group of volunteers as part our organization. However, volunteers joined because of what ARECMA represented for the community. These volunteers were young and they enthusiastically led most of the projects. By owning a space and proper facilities, we managed to store supplies; by having a kitchen, we were able to feed a lot of people. Media coverage, social media, and the aid received from the diaspora were all extremely important; thanks to them, we received supplies, food, and medicine. Moreover, we have a water cistern and solar panels because of donations received from American companies.

Calle 16

Calle 15

Calle 14

Calle 13

Calle 12

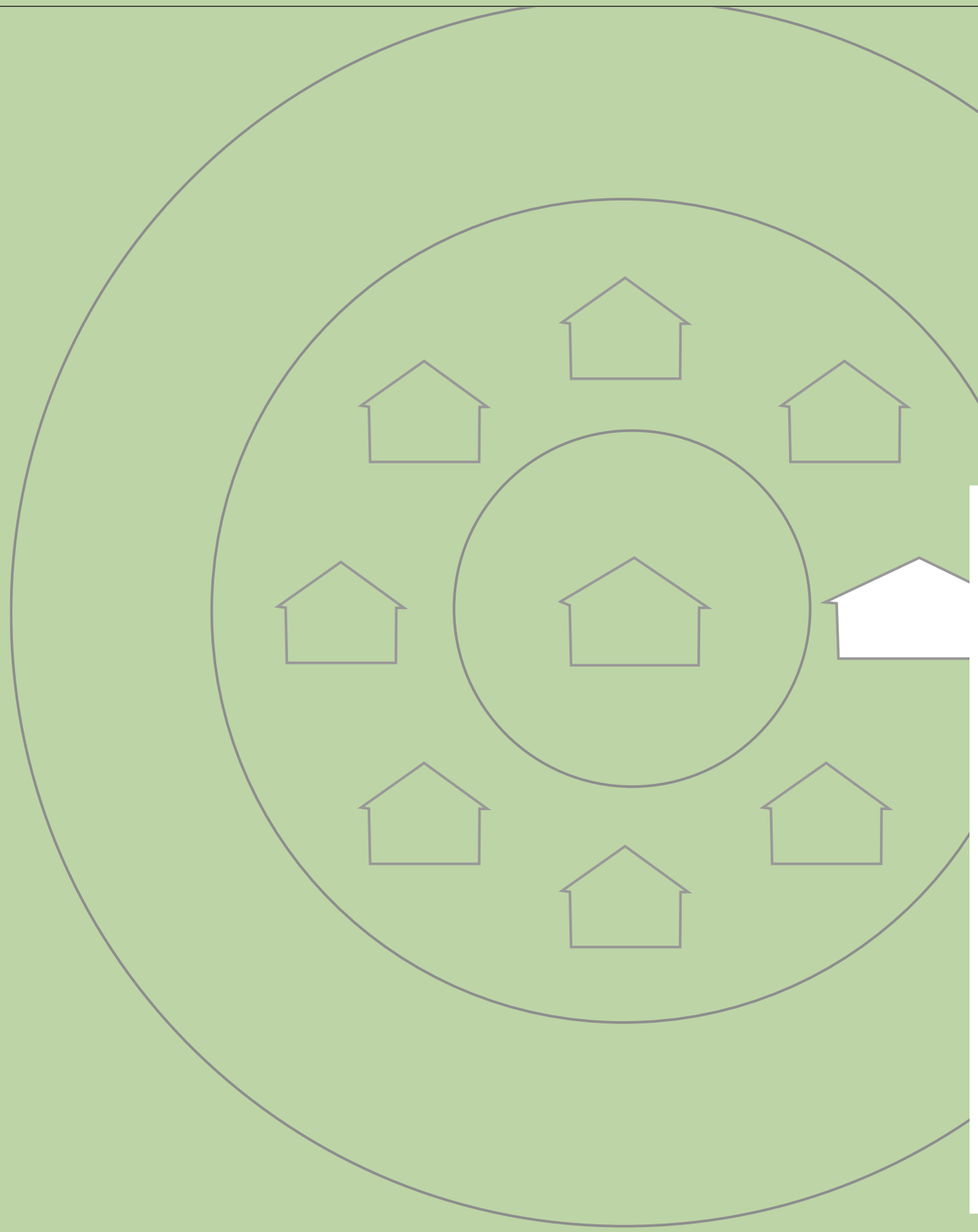
Plaza

PANADERÍA



CHAPTER

7



COMMUNITY ENGAGEMENT: PREPARE FOR ACTION TOGETHER

Ways in which a community can come together and prepare for and respond to future challenges

INTRODUCTION

Communities are the backbone of society. Even when households carry out their individual plans, people come together when they live in a shared neighborhood and have common concerns in terms of safety, housing, and services. Engaging communities to establish an emergency protocol that could apply before, during, and after the emergency is one of the best ways to prepare against adversity.

The aftermath of Hurricanes Irma and Maria has shown Puerto Ricans and people all around the globe that there is nothing more resilient than community bonds. Every person and family that went through these natural disasters can share a story on how a friendly neighbor threw an extension cord over to share power from their generator, how their community came together the day after the storm to clear up debris off of the streets, or how their neighborhood organized potlucks to share the food they had on hand.

TYPES OF STRATEGIES LISTED IN THIS SECTION

STRATEGY #	26	27	28
STRATEGY NAME/TITLE	DEVELOP A COMMUNITY PLAN	IDENTIFY + PREPARE SAFE COMMUNITY SHELTER	INSPIRING POST-DISASTER PLANNING FOR COMMUNITY
DESCRIPTION	To improve life quality, minimize damages and respond to a natural disaster, a community must have a committed and organized group of neighbors to enable the planning and implementation of projects that benefit the community as well as the receipt of aid when necessary. This strategy focuses on what to do and who can join the process of organizing your community for response and recovery.	Taking care of each other makes a community resilient. After an emergency, government and private sector assistance may take some time to arrive. Therefore, your community should be considered as the first line of response after a disaster. This strategy focuses on showing how to create a safe space in the community.	In the event of a natural disaster, having a community plan for emergency response minimizes the risks and allows greater effectiveness in recovery and response processes. This strategy helps create and implement a strategic plan so that your community can continue recovering from its identified immediate needs.
	$	$-$$	$-$$

In many cases, especially in communities around the mountainous central region of the main island, community groups provided first response and aid to impacted families, and they even helped save lives. One reason behind this is the fact that many municipalities were cut off from main distribution areas, not only because telecom failed, but also because fallen trees, electric poles, debris, and landslides blocked main roads. In more extreme cases, bridges that functioned as the sole access points to some communities caved in and fell, consequently isolating hundreds of families.

Community groups have also had an important impact in the long-term recovery of hundreds of families. Many of them, some working under non-profit organizations and religious congregations, transformed into relief brigades offering aid across the island in the form of food, supplies, water, medicine, shelter, and support for reconstruction. In fact, dozens of community groups that made a significant contribution to Puerto Rico's recovery are not residents: many groups of Puerto Ricans living in the continental United States and beyond organized aid from afar, demonstrating that community bonds know no frontier, surpassing any and every physical distance.

In the end, these times of turmoil became an opportunity for people across the island to get to know or develop deeper relationships with their fellow citizens and harness the power of mutual solidarity. To avoid dependence on governmental or any external aid, the best way to harness both short- and long- term resilience is to ensure health and safety across Puerto Rico and beyond through community empowerment.



Daguao Naguabo

STRATEGY

26 DEVELOP A COMMUNITY PLAN

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To improve life quality, minimize damages and respond to a natural disaster, a community must have a committed and organized group of neighbors to enable the planning and implementation of projects that benefit the community as well as the receipt of aid when necessary. This strategy focuses on what to do and who can join the process of organizing your community for response and recovery.

Strategy in Action

1. ***Create a community profile and make a map of your community***
2. ***Gather your community members***
3. ***Develop plans for:***
   - ***a. Evacuation***
   - ***b. Communication***
   - ***c. Transportation***

WHAT YOU NEED TO KNOW

- An organized community facilitates conversations with governmental and non-governmental organizations, as well as the private sector, to promote general welfare, the local economy and the opportunities to recover from a natural disaster.
- For a strategy to succeed, a community should work as a unit and there must be good communication between its members.



SUPPORTING STRATEGIES

23	24	25	27	28
Develop a Household Emergency Plan	Choose a Space to Keep Your Family Safe	Respond + Begin Household Recovery	Identify + Prepare Safe Community Shelter	Inspiring Post-Disaster Planning for Community

CREATE A COMMUNITY PROFILE AND MAKE A MAP OF YOUR COMMUNITY

It is important to be aware of what your community is like, who are its members, the location of each member, and the people around it. This will facilitate the community organization process and future planning.



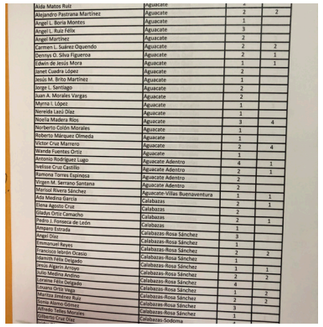


STRATEGY 26

DEVELOP A COMMUNITY PLAN

CREATE A COMMUNITY PROFILE AND MAKE A MAP OF YOUR COMMUNITY

DESCRIPTION



ELEMENT 1: NEIGHBOR DIRECTORY

- Members: Include a photo, telephone number, address and any special situation of each member in your community.
- Use this inventory for roll call in case of an emergency.
- Data: Include the telephone number and address of each neighbor.
- Identify vulnerabilities, sicknesses, and/or disabilities of each member in your community.
- See supporting document Neighbor Directory.



ELEMENT 2: COMMUNITY ORGANIZATION

- Identify and recruit people with special skills/talents in different areas (such as physical/mental health, construction, rescue, etc.)
- First aid: Identify people with medical and nursing training as well as people who are certified for cardiopulmonary resuscitation (CPR). Include the phone number and address for police stations, firefighters, emergency management agencies, National Guard, hospitals and ambulance services.
- Committees: Create work groups to help with emergencies, recreation, sports, cleaning, etc.
- Response vehicles: 4x4 vehicles, pick-ups and vans
- Communication: Identify neighbors that could facilitate communication efforts through satellite phone, sign language, other languages, as well as people with writing skills, etc.



ELEMENT 3: HOUSING

- Identify occupied and unoccupied homes, as well as their household composition while making sure you capture the following data (as applicable):
- Homes with pets
- Unoccupied homes
- Homes with water tanks
- Homes with renewable energy systems
- Homes with working power generators
- - Homes exposed to risk

DESCRIPTION



ELEMENT 4: PHYSICAL-NATURAL ENVIRONMENT

- Take photos and videos of the current conditions of your community. Identify:
- Natural characteristics, such as:
- Natural hydrographic elements: rivers, mineral springs, creeks, areas prone to flooding
- Green zones: forests, crops, trails
- Risk zones and safe zones (Chapter 1)
- Infrastructure
- Energy: substations, distribution cables, electrical boxes, electrical distribution wiring (underground, aerial, the location of power substations) and diagrams of how electricity reaches a home
- Water: drainage, ditches, dams, pump stations, access point water distribution pipes or cisterns, access points to drinking water
- Transportation: Main access roads, possible access routes, roads for emergencies, pedestrian paths, poles, traffic lights, signs
- Communications: Location of cable TV, Internet and telephone equipment (boxes, antennas, cables)

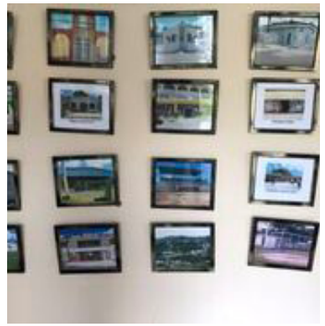


ELEMENT 5: SOCIO-ECONOMIC ENVIRONMENT

- Get to know your neighborhood beyond its homes. Identify suppliers of goods and services, such as:
- Health: Hospitals, ambulance services, pharmacies, drug stores
- Security: Fire departments, police and emergency stations
- Food and supplies: Gas stations, supermarkets, grocery stores and hardware stores
- Finances: Bank branches, credit unions, automatic teller machines (ATM)
- Solidarity in case of emergencies: Shelters, nearby communities



ARECEMA



ELEMENT 6: RECORD OF NATURAL DISASTERS

- Document the infrastructure's current conditions through photos, videos, and interviews to show evidence of damages and enable emergency services as well as the processing of claims with insurance companies.
- Add a new section for each natural disaster. This will allow you to see the evolution of the community and inform future building and repairs.

STRATEGY 26

DEVELOP A COMMUNITY PLAN

GATHER YOUR COMMUNITY MEMBERS

STEPS

DESCRIPTION

BEFORE THE MEETING

- Prepare an agenda (see example).

AT THE START OF THE MEETING

- Explain the purpose of the event.
- Explain the work dynamic to manage expectations for time use and desired achievements.
- Establish rules of order for the meeting.

AT THE END OF THE MEETING

- Provide a brief summary of the discussed contents.
- Acknowledge efforts and contributions.
- Receive opinions and suggestions.
- Identify conclusions, commitments and agreements.
- Encourage the next steps and sustained commitment.
- Call for a shared applause.




ENLACE


JACK PRICE

DEVELOP PLANS FOR:

EVACUATION

- Plan the community members' evacuation and practice it annually. In your home, practice evacuation routes to reach a shelter (Strategy 27), as well as the fulfillment of the assigned roles to each person and committees.
- Trace an evacuation route on a map and distribute it among the community.
- Designate a team to manage the vulnerable population or emergency cases during the evacuation.
- Take notes of what worked and what didn't work during the annual drill.
- Evacuate BEFORE the emergency. In case of an unexpected event, evacuate if it is safe to leave and if the route to the safe space does not present life-threatening risks. Take your Go-bag (Strategy 23) and follow the instructions from the heads of the household, community leaders and authorities.

COMMUNICATION

- Designate people to notify community members about drills or evacuations.
- Establish communication with the Emergency Management Agency to coordinate assistance processes.
- Create a system so that individuals can alert about the assistance they need.
- Designate a liaison person to provide important information before, during and after an emergency or disaster, as well as to update social media pages.
- You can also use text messaging on your smartphones, Facebook and WhatsApp as a tool to help you keep in touch with your local communities and when you are away from the community as well. Since the use of apps requires electricity and Internet signal, it is important to have electricity for the community in a centralized location.

TRANSPORTATION

- Identify evacuation routes as established by the community and Emergency Management Agencies.
- Organize assembly points from which to leave for the designated shelter.
- Promote walking or riding a bicycle through the community.

PARTIAL EVACUATION

- Evacuation of homes in risk zones
- Evacuation from homes to the community's safe space or municipal shelter

TOTAL EVACUATION

- Evacuation of the whole community.
- Evacuation from the community's safe space to a municipal shelter.

OPERATIONS AND MAINTENANCE TIPS

- The response capacity of your community will depend on how well-informed the action plan may be for the prevention and response to emergencies and disasters.
- Review your response documents before each season to ensure their validity.
- Make periodic inspections to ensure the usefulness of the community's assets.
- Confirm that the community has the economic resources to respond to disasters as a community (establishment of dues).
- Have trained human resources to operate the community's assets, either voluntarily or through paid services.
- Provide insurance protection against damages to shared properties.

STRATEGY

27 IDENTIFY + PREPARE SAFE COMMUNITY SHELTER

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Taking care of each other makes a community resilient. After an emergency, government and private sector assistance may take some time to arrive. Therefore, your community should be considered as the first line of response after a disaster. This strategy focuses on showing how to create a safe space in the community.

Strategy in Action

1. *Determine the Location*
2. *Space Considerations*
   a. *Interior*
   b. *Structure and Surroundings*
3. *Equipment*
4. *Design an Action Plan*
5. *Practice an Annual Emergency Evacuation Drill*

WHAT YOU NEED TO KNOW

- Use the search engine on the American Red Cross webpage (https://www.redcross.org/cruz-roja.html) for emergency shelters and stay tuned for the news to know when emergency shelters will open.
- You must occupy the community shelter when the location or structure of your home presents a risk to your safety.



SUPPORTING STRATEGIES

23	24	25	26
Develop a Household Emergency Plan	Choose a Space to Keep Your Family Safe	Respond + Begin Household Recovery	Develop a Community Plan

STEP 1 - DETERMINE THE LOCATION

Use the community map from Strategy 26 to identify which buildings are in a safe area within the community or its surroundings.

Once you identify these spaces, meet with the person responsible for the space to obtain authorization and discuss its best usage as a community shelter.

If your community surroundings DO NOT offer a safe space for shelter, you must move from your community to your nearest government emergency shelter.

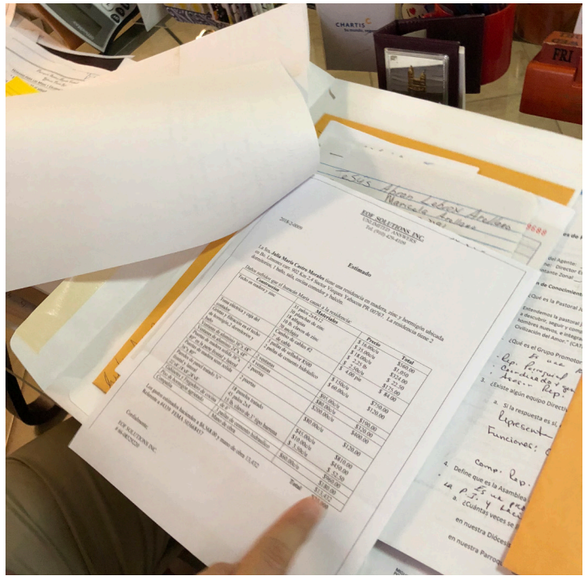
PUBLIC BUILDINGS

- Public schools
- Community centers, activity and recreation rooms
- Churches

PRIVATE BUILDINGS

- Malls
- Community centers, activity and recreation rooms
- Empty structures and buildings





STRATEGY

27 IDENTIFY + PREPARE SAFE COMMUNITY SHELTER

STEP 2 - SPACE CONSIDERATIONS

A. INTERIOR

NECESSARY SPACES

- Area for food preparation
- Area for sleep/rest
- Area for restrooms
- Space for pets
- Multipurpose space (for meetings, training, recreation, leisure)

STORAGE

- Food
- Hygiene products
- Equipment and refrigeration
- First-aid kits

B. STRUCTURE AND SURROUNDINGS

- **Access**: Must be suitable to allow access to a ground/air ambulance.
- Verify that the space complies with the local structure code for wind and seismic hazards and risks. (See FEMA P-361 Safe Rooms for Tornadoes and Hurricanes: Guidance for Community and Residential Safe Rooms)
- **Solid Waste:** Evaluate the distance of the structure where solid waste is headed to protect people's health.
- **Energy:** Consider a renewable energy supply system that powers a battery bank.
- **People with disabilities:** Access ramps for people with disabilities. The ramp should be 1:10 and 3' wide.
- **Risks:** Secure the premises from surrounding trees so that they will not affect the structure. Ensure the free flow of runoff water around the facilities.
- **Windows.** Check the functionality of window operators and sashes. They allow ventilation and natural lighting.



STEP 3 - EQUIPMENT

SUPPLIES

- Drinking water for consumption and hygiene. Consider one gallon of water per person per day.
- Non-perishable food. Consider the contribution of non-perishable products made by neighbors of the community.
- Fuels for lighting, kitchen, vehicles, tools, and power generators
- Tools and replacement parts for equipment in use
- Refrigerator for medicines and perishables

FIRST AID

- Life support equipment
- First-aid kit
- Defibrillator



Tesla Battery
Daguao Naguabo

COMMUNICATIONS

- Radio AM/FM
- Landline phone
- Radio (KP-4, HAM)



STRATEGY 27

IDENTIFY + PREPARE SAFE COMMUNITY SHELTER

STEP 4 - DESIGN AN ACTION PLAN

STEPS

DESCRIPTION

SPACE PREPARATION

- Security. Confirm that the chosen structure is reinforced to protect people during the emergency. Repair cracks. Seal openings with panels or shutters. Implement security strategies to avoid altercations or thefts.
- Minimize risks
- Trim trees as a preventive measure.
- Collect items that could become projectiles.
- Clean the sewage.
- Organize work teams and distribute tasks among community members.

USE REGULATIONS

- Establish use regulations such as:
- An operating schedule
- Behavior and coexistence
- Flow of people (to avoid lines and congestion)
- Proper water distribution and use
- Pet management (food, walks, rest, waste) in a responsible manner
- Clean-up of the areas
- Preparation and distribution of food and products. Have at least a 10-day supply. Make an inventory frequently. Verify that supplies are in a safe area.
- Establish a plan for solid waste management, recycling, reuse and composting.

COMMUNICATIONS

- Use the Directory that you developed in Strategy 26 for roll call.
- Communicate the existence, access, and use regulations of the space in community meetings.
- Contact emergency teams and authorities before, during and after the natural disaster to inform the community properly.
- Keep track of the authorities' news and instructions.

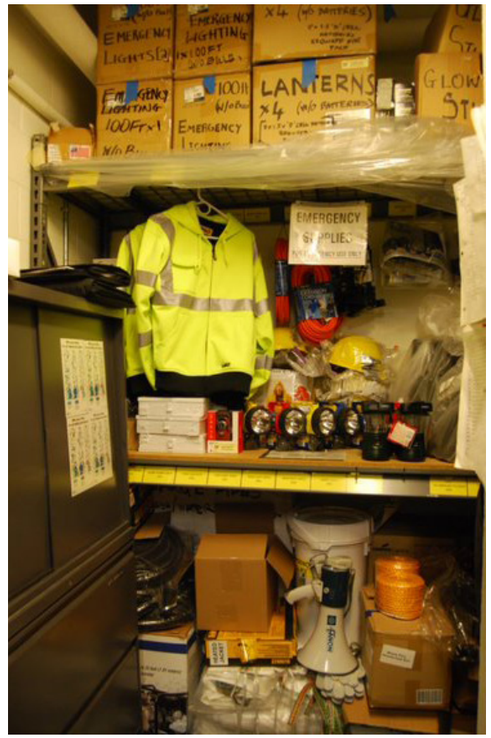


STEPS

DESCRIPTION

SPACE IN USE

- Implement your plan.
- Call for your work teams with their respective work plans; this will allow the community shelter to start functioning accordingly.
- Protect and monitor the vulnerable people of the community during the emergency. These are: people 65 and over, pregnant women, babies, children, people with disabilities, people with medical conditions or whose medical treatments need electricity (refrigeration, breathing assistance, dialysis, etc.).
- If possible, provide forms of entertainment, distraction and recreation during and after the event using musical instruments, radio, books for children and adults, coloring books, crossword puzzles, word search puzzles, word games, board games, card games, dice, dominoes, and toys.





STRATEGY

27 IDENTIFY + PREPARE SAFE COMMUNITY SHELTER

STEP 5 - PRACTICE AN ANNUAL EMERGENCY EVACUATION DRILL

- PRACTICE! Practice the evacuation of your community annually to confirm that the plan continues to be up to date and effective.
- Take notes of what worked and didn't work after each drill.
- Practice the evacuation routes for your community, the move to a shelter in the middle of a natural disaster, and the assigned roles to each person.



Cano Martin Peña, San Juan



STRATEGY

28 INSPIRING POST-DISASTER PLANNING FOR COMMUNITY

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In the event of a natural disaster, having a community plan for emergency response minimizes the risks and allows greater effectiveness in recovery and response processes. This strategy helps create and implement a strategic plan so that your community can continue recovering from its identified immediate needs.The following image describes the interactions of the short- and long-term planning cycle in a community.

Long-term preparation efforts support the short-term response. The more a community plans for emergency preparedness, the faster the response and recovery will be. As you can see in the image, this is a cyclical process that proposes mitigation after response as the best way to react towards natural disasters in the future.

Strategy in Action

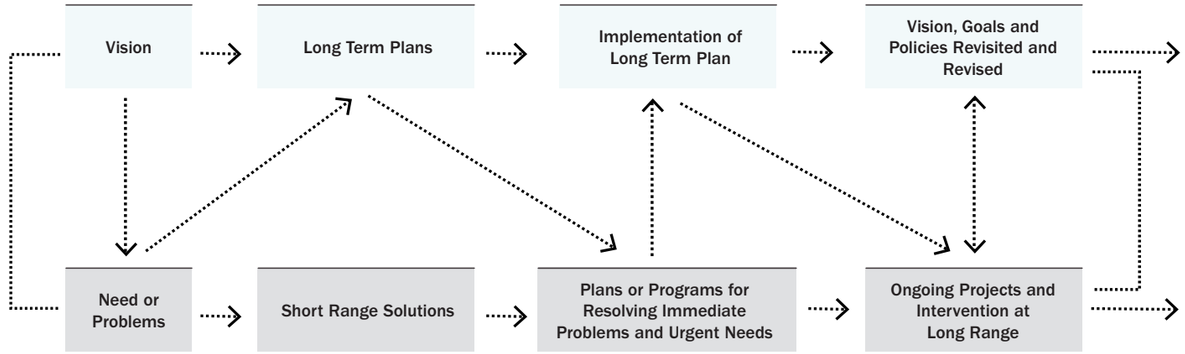
1. *Stage 1 – Response*
2. *Stage 2 - Recovery*
3. *Stage 3 - Mitigation and Long-Term Strengthening*

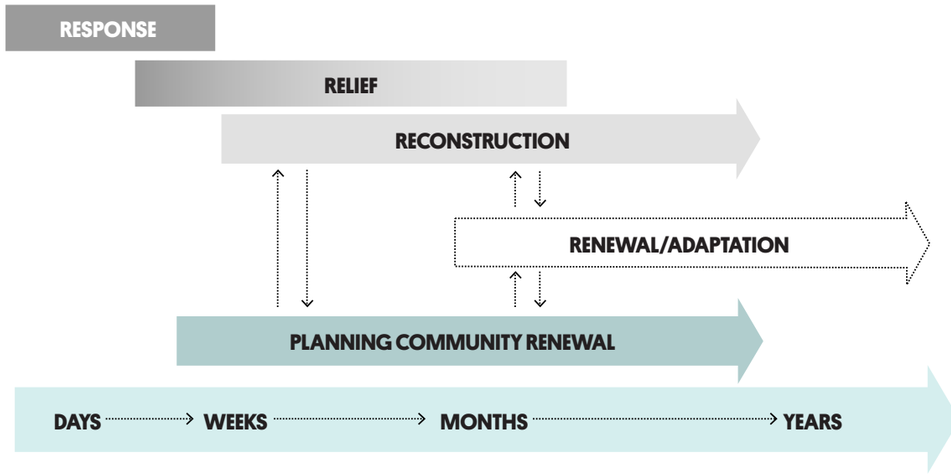
DESCRIPTION + OPERATION

- Ensure the well-being of those who survived the disaster or emergency... first life, then property. The post-emergency plan is divided into two stages:
- Stage 1 - Response: it consists of the actions taken when danger is imminent, currently happening, or has just occurred. These actions are meant to save lives, property, and the environment. This stage may include staying in a shelter, ensuring water and food, organizing search parties and rescue teams, providing medical attention to those in need, and creating access to provide help, among other possible activities.
- Stage 2 - Recovery: it consists of actions taken after the response, to bring the community back to its initial state and normal routine as soon as possible. This can include: the reinstatement of essential services, facility and home reconstruction, among others.
- Stage 3 - Mitigation and Long-Term Strengthening: involves enabling community recovery and its long-term improvement through a participatory strategic plan that serves to guide decision making for the benefit of all community members, to improve and resolve the basic needs of the community, and move it towards reaching its collective vision of the desired future.

It is important to understand the stages of the response process to a natural disaster since it starts immediately after the disaster and could take years to be completed. The following image contextualizes the stages of recovery and the time they could take.







STRATEGY

28 INSPIRING POST-DISASTER PLANNING FOR COMMUNITY

STAGE 1 – RESPONSE



STEPS

ESTABLISH A RESPONSE COMMITTEE

DESCRIPTION

- Train people in the community so that they can communicate and respond effectively.
- Certify the members of the committee through the CERT Program (Community Emergency Response Teams) for them to help while government rescue brigades arrive. The program requires candidates to be of legal age and three days of training.



COMMUNICATE

Register your community with the local and federal government for post-emergency assistance.

- **AEMEAD (Local Government Agency)**

The State Agency for Emergency and Disaster Management (AEMEAD, http://www.aemead.pr.gov) is the agency in charge of coordinating all of Puerto Rico's government and private sector resources to provide emergency services as quickly and effectively as possible.

- FEMA (Federal Government Agency)

The Federal Emergency Management Agency (FEMA, www.Disaster Assistance.gov) is a federal government entity that is in charge of organizing emergency help and sheltering assistance in the event of a natural disaster. Notify damages by calling 1-(800) 621-3362 or visiting their webpage.

Remember! It is always important that community members stay informed about location of shelters and how they operate (Strategy 27).



DOCUMENT THE DAMAGES

- Document all damages to facilitate communication with emergency agencies, towns and insurance companies.
- Take photos or videos, interview neighbors and highlight the damages on a map.
- Add the effects of every natural disaster to the community profile. This will help you register your community with emergency management agencies.



STEPS

ESTABLISH A PLAN TO MANAGE SOLID WASTE

DESCRIPTION

- Recycle as much as you can to reduce the amount of waste transported to dump sites.
- Identify recycling stations and stockpiling of recyclable waste.
- Do not burn trash for it could be a risk to the community's health and safety.
- Divide your waste to facilitate its management, and group waste such as:
  - Vegetative material - trees, branches, leaves, plants (DO NOT place these in bags)
  - Recyclable material - plastic, glass, metal, cardboard



- Non-recyclable material - demolition/construction materials (carpets, walls, furniture, wood, mattresses, plumbing material, roofing material, roof tiles, tiles); appliances (air conditioning, fridges, stoves, water heaters); and electronics (computers, televisions, radios and anything that has an electric cable).
- Make sure that waste does not block pedestrian accesses or traffic routes and is not in the way of runoff water or flood-prone areas.
- Contact your municipal administration or garbage collection service to notify that waste is separated and ready for collection.

STRATEGY 28

INSPIRING POST-DISASTER PLANNING FOR COMMUNITY

STAGE 2 – RECOVERY



PHYSICAL

DESCRIPTION

- Restore blocked accesses if possible.
- Contact public entities that can help restore essential services.
- Establish a plan for home reconstruction.



EMOTIONAL

DESCRIPTION

- Address the psychological and emotional aspects of those who survive a natural disaster.
- Restore normal conditions for young children through collaborative and recreational activities.
- Organize discussion groups to share emotions and provide a positive message.
- If possible, consider setting time and space for relaxation, exercise, or recreation because distractions help manage emotions during difficult times.



LONG-TERM

DESCRIPTION

- Use destruction as an opportunity to innovate and create a better future.
- Organize projects that focus on the future as a way to cope with recovery.
- Collaborate with non-profit organizations, educational institutions, and the private sector to find experts and identify funding.

STAGE 3 – MITIGATION AND LONG-TERM STRENGTHENING



ANALYSIS

DESCRIPTION

- In accordance with community organization processes and activities (Strategy 26), it is necessary to lead a discussion to rethink the community's desired future.
- Document priority needs of the physical environment.
- Identify and document hazards and opportunities.
- Recognize, document and share reconstruction and mitigation plans of neighboring communities as well as local, national and federal governments.



DIALOGUE

DESCRIPTION

- Facilitate a participatory dialogue that allows the establishment of a strategic plan for your community that includes future projects that will meet the identified needs.
- Document inputs, agreements and dissensions.
- Set priorities by consensus.
- Identify sources of funding to start projects.
- Establish a work schedule.



MOBILIZATION AND STRENGTHENING

DESCRIPTION

- Authorize the activation of recovery work committees.
- Develop the necessary supporting documentation to begin with long-term recovery tasks.
- Develop proposals that will allow the commencement of agreed projects.
- Monitor and inform the progress of tasks to keep the community motivated and committed.
- Identify the next generation of community administrators and enable the development of their abilities to achieve sustainable community empowerment.

CENTRO COMUNITARIO DE CAIMITO, SAN JUAN

Description: Centro Comunitario de Caimito offers a safe space to hold community meetings, talks, and cultural events. In addition to being a meeting point for the community, this center provides assistance for families that haven't had their electricity restored yet and offers community health services. The center became an energy source for the future following the installation of solar panels as part of the #EstuarioRevive campaign from the San Juan Bay Estuary Program. This effort was supported by the GivePower Foundation and the Cypress Creek Renewables company. These panels were installed in Centro Comunitario de Caimito in response to the need to pool all efforts in a single place for the benefit of all –efforts that are already underway, although with some difficulties due to the power shortage. This is the only center that provides free community services. This project was made possible by hundreds of people, individual donations, and about a dozen corporate partners across the United States.

For reference: https://www.noticel.com/ahora/centro-comunitario-de-caimito-recibe-paneles-solares-gratis/695621605



COMUNIDAD CORCOVADA, AÑASCO

For more information, visit https://comitecomunalcorcovada.weebly.com/actividades-y-proyectos.html

Description: a community that has its own aqueduct and solar energy systems. It runs community centers, gymnasiums, and a community school.

The Corcovada community is located in the municipality of Añasco. For almost 40 years, Corcovada has had its own aqueduct system that provides drinking water to 145 families. The second Saturday of every month, the committee treasurer opens the building (which used to be a school) from 3:00 p.m. to 5:00 p.m. so that residents can pay their water bills. Additionally, efforts were made to secure legislative and municipal funding for the reconstruction of the site of their newly built community center (funds totalled $350,000).

The community began building the center early in 2014, and its foundation stone, a symbol of its inauguration, was placed on Friday, February 21, 2014. This community center has the sole purpose of serving the community by providing a space for events and other services.



HOGAR ALBERGUE, JESUS DE NAZARET



Interviewee: Hogar Albergue para Niños Jesús de Nazaret, Patricia Valentin and Enactus RUM

For more information, visit: https://hogarjesusdenazaret.org/en/quienes-somos/el-hogar/

Hogar Albergue offers temporary living arrangements for children who have been victims of abuse, from newborns to 11-year-olds. Hogar provides a safe and positive environment where, aside from providing a loving atmosphere, the following basic needs are met: nutrition, transportation, education, medical care, and cultural activities. Hogar is a 501(c)(3) non-profit organization located in the municipality of Mayagüez.



INTERVIEW

Hogar Albergue is a residential space for abused children that have been removed from their homes. Here, children's basic needs are met, from the newborn stage until they reach 11 years of age. Enactus RUM began collaborating with Hogar because I approached them. Being a professor at the Mayagüez Campus, and as a volunteer of Hogar for many years, I saw the difficulties they faced every day, so I decided to talk with Enactus.

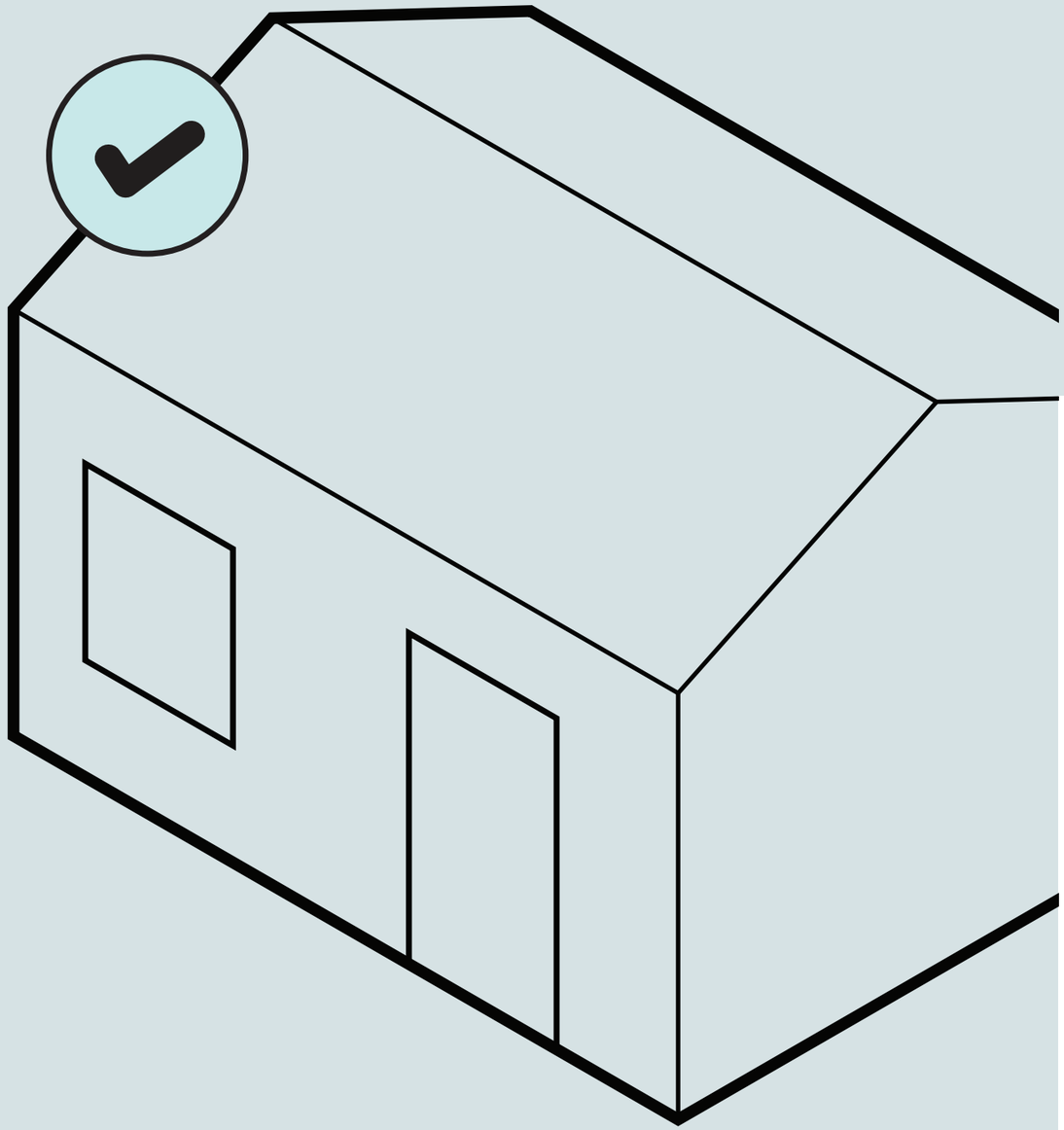
Hogar prepared for the hurricane just like everyone else, but they obviously did not expect the severity of the event. The administration and staff carefully planned and enacted their emergency plan (as required by law). When we saw the needs and difficulties Hogar faced because of the shortage of drinking water and electricity, as they tried to provide the best conditions possible for the 14 children under their care, we joined forces with Enactus RUM to consider how we could help reduce Hogar's weekly expenses, which amounted up to $1,000 a week in diesel alone. We also met with United for Puerto Rico and decided to submit a proposal for the installation of a rainwater



tank that would make Hogar sustainable for future events like the one we went through. Currently, the tank is installed and connected to the most critical equipment, such as the washing machine and the bathrooms. Besides the tank, and through the efforts of the University of Wisconsin, we are now working on a solar panel system to be installed in the future. Throughout the recovery process, the administration and staff were key participants, especially the "nannies" that stayed with the children during the hurricane. Meanwhile, neighbors also came to Hogar and donated food, water, and gas.

CHAPTER

8



PUTTING IT ALL TOGETHER

How to determine who should be involved in your building or rebuilding, what agencies and regulations are available to help you through the process, and how to find and navigate important resources.

GUIDANCE

ACTION PLAN: STEPS

Once you determine which resilience strategies to implement in your building or home, begin planning how to implement the work.

YOUR BUILDING TEAM

Your building team should consist of all of the professionals and stakeholders involved in implementing the strategies for housing resilience.

FINANCIAL AND PROGRAMMING RESOURCES

Resources available for housing repair and construction

A LIST OF RESILIENCE AND RECOVERY CONTACTS

Contacts and Organizations to help plan and rebuild.



DAGUAO, NAGUABO

BUILDING TO CODE

The main purpose of building codes is to protect public health, safety and general welfare with respect to the construction and occupancy of buildings and structures.

HOW TO OBTAIN A BUILDING PERMIT

The following section explains what projects require a construction permit and how you should go about the process.

WORKING WITH YOUR CONTRACTOR

Tips for working with your building contractor or building professional.

INSURING YOUR PROPERTY

As you determine your resilience improvements, it is important to understand the implications any building improvement may have on your property insurance premium or deductible, if applicable. Here is a list of sample questions to ask your insurance agent.

YOUR ACTION PLAN

PUTTING IT ALL TOGETHER

Once you determine which resilience strategies to implement in your building or home, begin planning how to implement the work. This section will help you determine your Action Plan:

- The steps to be able to implement a resilient strategy or strategies
- Financial and Programmatic Resources to support your improvement
- How to create your Building Team
- Working with a Contractor Tips
- When a Construction Permit is needed with Associated Regulatory Code
- Insuring your property and Improvement



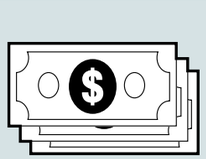


1

Determine the problem or building vulnerability you want to solve for.

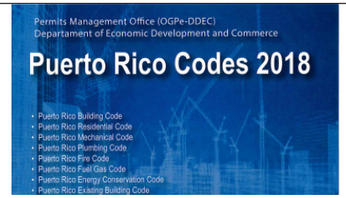
2

Read through the Guide and determine the Strategies to resolve the issue(s). Create scope of work for a safer and more resilient home or building.



3

Determine your budget and available Financing and Programming Resources.



4

Determine if you need a construction permit. Refer to How to Obtain your Building Permit. If you need a construction permit, contact a licensed architect or engineer because they will have to submit certified plans to the Permits Management Office (OGPe, by its Spanish acronym). There are a variety of ways to select a building team, including your architect and contractor, such as formal bidding. **If the structure is located in a flood zone as designated by FEMA, the designer will need to show how this risk will be mitigated.



5

Build your building team. Refer to your Building Team.



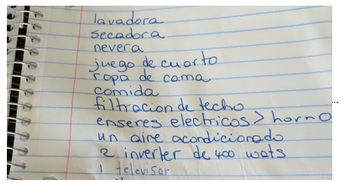
6

Consult with your insurance agent to determine if improvement will reduce or increase your insurance premium and deductible. See Insuring Your Property's questions to ask your insurance agent.



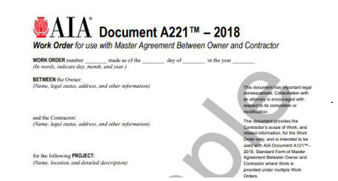
7

Contact at least two building professionals (architect, contractor, engineer) to obtain bids, and from there decide who do you want to work with. These individuals should have experience with the work you have in mind. Share this Keep Safe book with them. Refer to working with your contractor for tips.



8

Hire selected contractor who will secure workforce, permits, materials, and implement work. Refer to working with your contractor for tips.



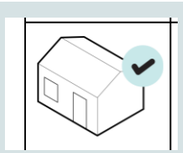
9

Develop a contract for the project. Refer to working with your contractor for tips.



10

Build, monitor a project's progress, and process payments in accordance with your contract.



11

Maintain and operate your improvement in good condition!



YOUR BUILDING TEAM



Your building team should consist of all the professionals and stakeholders involved in implementing the discussed strategies for home resilience. Here are some suggested team members:

MULTIFAMILY BUILDING RESILIENCY TEAM

- ► Building owner
- ► Owner's representative
- ► Architect
- ► Engineer
- ► General contractor
- ► Insurance agent
- ► Property manager
- ► Financing partner
- ► Non-governmental organization (NGO)

SINGLE FAMILY BUILDING RESILIENCY TEAM

- ► Homeowner
- ► Architect *
- ► Engineer *
- ► Contractor
- ► Insurance agent
- ► Hardware store merchant
- ► Non-governmental organization (if applicable)
- ► Neighbors

* To obtain a building permit, you need to work with an engineer or architect or professional certified to provide permits.



OROCOVIS, HEART 911TEAM

BUILDING TO CODE

Puerto Rico's adoption of new building codes marks a major milestone in the island's recovery, and it sets in motion a roadmap that leads to a safer, stronger, and more resilient Puerto Rico. The 2018 Puerto Rico Building Code (PRBC) represents the first significant revision since 2011 and includes hazard-resistant provisions that provide guidance for safer construction in all the island's 78 municipalities. The 2018

WHAT IS IT IMPORTANT TO BUILD HOUSING TO CODE-WHAT YOU NEED TO KNOW

- The main purpose of building codes is to protect public health, safety, and general welfare with respect to the construction and occupancy of buildings and structures.
- Building codes are a series of regulations created through consensus by building and design professionals, experts, product designers, researchers, and scientists that are designed to govern the safe design, construction, repair or alteration, and general maintenance of buildings.
- Building codes are created at the international level and adopted at the state and local levels. Typically, municipal jurisdictions adopt the model building codes set forth by the International Building Code (IBC) which creates consistency among communities on foundation for codes and prevents them from having to "reinvent the wheel." Codes are constantly improved to reflect building innovation, technological advancements, and/or real-life scenarios in which devastation could have been prevented through better building.
- Building to code and having appropriate "signoffs" enable you to ensure the property meets regulations should it be transferred to another owner. Moreover, it provides investors or banks some assurance as to the state of completion and safety of the structure.

International Codes are the foundation of the 2018 Puerto Rico Building Code, and these codes form the basis for laws and regulations affecting communities in the U.S. and worldwide

The Planning Board oversees code development. OGPe oversees code compliance, permitting processes, and inspections.

CODES REGULATING BUILDING DESIGN AND CONSTRUCTION

- A. 2018 International Building Code (IBC) as adopted by the 2018 Puerto Rico Building Code (PRBC) and references
- B. Energy Code – ASHRAE Standard 90.1 or International Energy Conservation Code (IECC)
- C. 2018 International Plumbing Code (IPC) as adopted by the 2018 PRBC
- D. 2018 International Mechanical Code (IMC) as adopted by the 2018 PRBC
- E. 2018 International Private Sewage Disposal Code (IPSDC)
- F. 2018 International Fire Code (IFC)
- G, 2018 International Green Conservation Code (IgCC)
- H. 2018 International Residential Code for One- and Two-Family Dwellings
- I. 2018 International Existing Building Code
- J. National Electric Code (NEC)
- K. ICC 700 National Green Building Standard (NGBS)
- L. 2015 International Solar Energy Provisions (ISEP)
- M. Americans with Disabilities Act (ADA)
- N. 2010 Joint Permit Regulation (Reglamento Conjunto de Permisos para Obras de Construcción y Usos de Terrenos)

BUILDING TO CODE

STRATEGY

CODE

01 REINFORCE SITE	02 REINFORCE SITE WITH VEGETATION	04 ASSESS PRIORITIES FOR YOUR HOME OR BUILDING
A, H	A, H, K, L	A, H
05 BUILD A STRONG FOUNDATION	**06 BUILD STRONGER WALLS**	**07 BUILD A STURDY ROOF**
A, H	A, H	A, H
08 ANCHOR, SEAL& PROTECT BUILDING OPENINGS	**09 FLOOD PROOF HOME**	**10 REDUCE THERMAL HEAT TRANSFER**
A, H, D	A, H, D	A, B
11 INCREASE VENTILATION	**12 BENEFIT FROM NATURAL LIGHT**	**13 CONTROL MOISTURE AND MOLD**
A, B	A, B	A, B, C
15 REDUCE YOUR ENERGY USE	**16 INTEGRATE SOLAR ELECTRICITY**	**17 INTEGRATE SOLAR THERMAL ENERGY**
A, B	A, B, L	A, B, C, L
18 INSTALL ENERGY BACKUP	**20 COLLECT AND USE RAINWATER**	**21 IMPROVE SEPTIC WASTE DISPOSAL SYSTEM**
J	A, C	A, E, C
22 PREVENT WASTEWATER BACKFLOW IN HOMES	**24 CHOOSE A SPACE TO KEEP YOUR FAMILY SAFE**	**27 IDENTIFY AND PREPARE A SAFE COMMUNITY SHELTER**
A, C	A	A, D

HOW TO OBTAIN A BUILDING PERMIT

Historically, many homeowners and contractors in Puerto Rico have not procured required construction permits when building, rebuilding, rehabilitating, or repairing their home. The following section explains what projects require a construction permit and how you should go about the process. If your project is found to have zoning or environmental concerns, additional revisions may be necessary and may require more time for review.

WHAT YOU NEED TO KNOW

- Permits can certify that your construction project is built to code. This is essential to not only ensure that your building meets minimum life safety requirements, but it provides the benefit of standards derived from the latest research, product innovation, and science.
- Since the permit reform in 2009, repairs, rehabilitation, and construction of single-family homes that do not require a zoning change can be submitted electronically through the Permits Management Office's/ Oficina de Gerencia de Permisos' (OGPe, by its Spanish acronym) website. OGPe should be consulted for all permits.
- The Planning Board GIS provides location, zoning, flooding, permitting, and other information of the properties and links to the municipalities' zoning maps. See http://gis.jp.pr.gov/GeoLocalizador/index.htm?refresh=501.
- If you need utility permits for:
  - Electricity, you will need to consult with the Puerto Rico Electric Power Authority (PREPA).
  - Water, you will need to consult with the Puerto Rico Water and Sewer Authority (PRASA).
  - The following agencies are involved in the permitting process:
  - OGPe is the lead office for construction permits, including permits for site identification and site work (erosion and sedimentation control plan, construction dust, and solid waste management). OGPe can relay your construction documents to an array of agencies to provide input and the necessary permits.
  - Environmental Quality Board (EQB)/ Junta de Calidad Ambiental (JCA) has the main function of protecting and conserving the environment and is the lead agency for environmental permits associated with site work, waste management, and related activities.

- **Step 1:** Determine the cost of your project to see if you will need a construction permit. Review the information below to know which types of projects require a permit.
- **Step 2:** If your project requires a construction permit, you need to contact a licensed architect or engineer who can assist you in the process of obtaining a permit through OGPe. If the project complies with zoning and can obtain an environmental determination via categorical exclusion, you can get your permit electronically. According to the EQB's Resolution 11-17 of November 21, 2011, a categorical exclusion is defined as "those actions, predictable or routine, that in the normal course of execution will not have a significant environmental impact."
- **Step 3:** Take into consideration that you must pay for any licensed professional services and additional fees that include filing fees, taxes, signage, and workers' compensation. See the example for a $100,000 construction project shown below.
- **Step 4:** The licensed professional will need proof that you are the owner of the property. If you are a renter, you will need to provide proof via a formal lease that authorizes you to carry out the project.
- **Step 5:** Make sure the licensed professional identifies an inspector to certify that the project was done according to plan. The inspector cannot be the same professional that applies for the construction permit.

PROJECTS THAT DO NOT REQUIRE A CONSTRUCTION PERMIT

- The following renovation projects do not require a permit unless they are part of a larger construction project:
- Painting
- Sealing roofs
- Landscaping projects
- Fixing cracks and leaks in a building or structure
- Plastering existing concrete surfaces
- Installing or removing non-structural interior wall partitions
- General maintenance
- Other minor repairs and construction or substitutions do not require a permit unless the work occurs in historical places. However, a project must be notified to OGPe if it exceeds $6,000 or the scope of work exceeds six months. The following projects do not require a permit if they meet the abovementioned requirements:
- Simple substitutions
- Repairs to concrete buildings
- Simple substitutions in plumbing and electric systems
- Simple substitutions in signage

PROJECT THAT REQUIRE A CONSTRUCTION PERMIT

If your project does not meet the requirements above mentioned, you need a construction permit. The following section describes what you can expect from the licensed professional procuring your permit.

1. Open a case file in OGPe's system. This case file contains information about the owner and requires proof of ownership. All construction projects need to create this file, even if the project is in an autonomous municipality.

2. File an environmental determination through a categorical exclusion. The licensed professional will need to submit an environmental determination. If the project complies with zoning and can obtain an environmental determination via categorical exclusion, you can get your permit electronically. According to the EQB's Resolution 11-17 of November 21, 2011, a categorical exclusion is defined as "those actions, predictable or routine, that in the normal course of execution will not have a significant environmental impact."

3. File the construction permit on OGPe's system. The construction permit requires a licensed professional to submit various documents, which include plans and specifications, owner authorization, flood map, septic tank diagram (if needed), certification that construction complies with code, and handling of solid waste, among others.

4. Notice of approval of construction permit. Once filed with OGPe, you will be notified when the permit is ready and of any additional fees that must be paid. When the notice of approval is issued, you will be asked to pay for taxes, workers compensation, and signage. OGPe issues the construction permit after payment is complete.

HOW TO OBTAIN A BUILDING PERMIT

OBTAINING PERMITS IN LARGER PROJECTS

A larger project goes through various stages in the permitting process. Each stage requires interaction with different agencies depending on the project location and complexity. The stages include: site selection, schematic drawings, design development, construction drawings, construction permits, final endorsements, and use permit. The chart below shows the agencies involved at each stage.



OGPE, San Juan

EXAMPLE OF PERMITTING COST FOR $100,000 CONSTRUCTION PROJECT IN SAN JUAN:

Cost	Detail
$ 100,000.00	Construction Cost
$ 600.00	Stamp and Taxes
$ 35.00	Construction Filing Fee
$ 75.00	Exclusion Categorica
$ 2,288.00	Workers Compensation (CFSE)
$ 3,000.00	Tax over hard cost (Arbitrios)
$ 2,500.00	Licensed Professional
$ 108,498.00	





Humacao



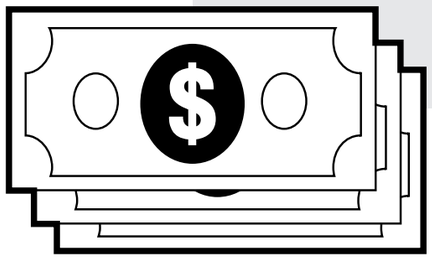
For More information on process visit:
https://www.doingbusiness.org/content/dam/doingBusiness/country/p/puerto-rico/PRI.pdf

FINANCIAL AND PROGRAMMATIC RESOURCES

If you cannot finance your implementation of the resilient strategies on your own, there are a variety of financial and programming resources available to help you do so. Funding for a project can be provided to homeowners or residential building owners through loans, grants, or by participating in a program administered by a federal, state, municipal, or non-profit organization. The following table summarizes some of the institutional resources available and what type of assistance they provide: funding resilient upgrades, range of direct grants, subsidies, and loans may be available for housing repair and construction. It is important to check newspapers and websites for updates and availability of new programs. These were the programs available at the time of this guide's publication.

Additional list of resources–visit: https://www.fema.gov/media-library-data/1474548130660-db3c22abcc037416428fe7db69d45926/FundingResources.pdf.

TYPE / RESOURCE	LOAN	GRANT	DIRECT SUPPORT
	■ Single-Family Housing Repair Loans and Grants (USDA) (Section 504 Home Repair Program) ■ Disaster Loan Assistance (SBA) ■ Single-Family Housing Direct Home Loans in Puerto Rico (USDA) (Section 502 Loan Program) ■ Single-Family Housing Guaranteed Loan Program in Puerto Rico (USDA) ■ Multi-Family Housing Loan Guarantees (USDA) or (Section 538 progarm) ■ Multi-Family Housing Direct Loans in Puerto Rico (USDA)	■ Puerto Rico Department of Housing (Departamento de la Vivienda) Repair and Construction Programs ■ Single-Family Housing Repair Loans and Grants (USDA) (Section 504 Home Repair Program) ■ USDA Emergency Community Water Assistance Grants ■ USDA Community Facilities Direct Loan & Grant Program ■ USDA Water & Waste Disposal Loan & Grant Program	■ Weatherization Assistance Program (WAP) ■ Puerto Rico Department of Housing (Departamento de la Vivienda) Repair and Construction Programs ■ Solar Power Purchase Agreement (PPA) ■ FEMA programs ■ Range of Non Profit and Institutional Support



LOAN PROGRAMS

SINGLE-FAMILY HOUSING REPAIR LOANS AND GRANTS (USDA) (SECTION 504 HOME REPAIR PROGRAM)

This program provides loans to very-low-income homeowners to repair, improve or modernize their homes or grants to elderly very-low-income homeowners to remove health and safety hazards. Grants for very low-income seniors may be used to pay for the costs of home repairs and improvements of up to $7,500 that will remove identified health and safety hazards, or repair or remodel dwellings to make them accessible for household members with disabilities. https://www.rd.usda.gov/programs-services/single-family-housing-repair-loans-grants

DISASTER LOAN ASSISTANCE (SBA)

The Small Business Administration (SBA) provides low-interest disaster loans to businesses of all sizes, homeowners, and renters. SBA disaster loans can be used to repair or replace the following items (damaged or destroyed in a declared disaster): real estate, personal property, machinery, equipment, inventory, and business assets. Loans for homeowners may range from $40K-$200K. www.DisasterAssistance.gov, or call 1-800-621-3362

SINGLE-FAMILY HOUSING DIRECT HOME LOANS IN PUERTO RICO (USDA) (SECTION 502 LOAN PROGRAM)

Program assists low- and very low-income applicants obtain decent, safe, and sanitary housing in eligible rural areas by providing payment assistance to increase an applicant's repayment ability. Loan funds may be used to make general repairs and improvements to properties or to remove health and safety hazards including: replacement of heating, plumbing, electrical services, roof, or basic structure as well as weatherization, water, and waste disposal systems. Loans are at a 1% interest rate for very low-income applicants. The USDA direct loan is beneficial for very low-income families who cannot obtain a home loan through traditional means. https://www.rd.usda.gov/programs-services/single-family-housing-direct-home-loans/pr

SINGLE-FAMILY HOUSING GUARANTEED LOAN PROGRAM IN PUERTO RICO (USDA)

This program assists approved lenders in providing low- and moderate-income households the opportunity to own adequate, modest, decent, safe, and sanitary dwellings as their primary residence in eligible rural areas. Eligible applicants may build, rehabilitate, improve, or relocate a dwelling in an eligible rural area. The program provides a 90% loan note guarantee to approved lenders in order to reduce the risk of extending 100% loans to eligible rural homebuyers. https://www.rd.usda.gov/programs-services/single-family-housing-guaranteed-loan-program/pr

MULTI-FAMILY HOUSING LOAN GUARANTEES (USDA) OR (SECTION 538 PROGARM)

The program works with qualified private-sector lenders to provide financing to qualified borrowers to increase the supply of affordable rental housing for low- and moderate-income individuals and families in eligible rural areas and towns. Eligible uses of the program include new construction costs of the project, acquisition with moderate rehabilitation of at least $6,500 per unit, and revitalization of Section 515 properties. Development includes family, senior, and farm labor housing properties. It is usually paired up with 9% low-income housing tax credit (LIHTC). Available to Non-profits, for profits and state governments. https://www.rd.usda.gov/programs-services/multi-family-housing-loan-guarantees

MULTI-FAMILY HOUSING DIRECT LOANS IN PUERTO RICO (USDA)

This program provides competitive financing for affordable multi-family rental housing for low-income, elderly, or disabled individuals and families in eligible rural areas. This program assists qualified applicants that cannot obtain commercial credit on terms that will allow them to charge rents that are affordable to low-income tenants. This program funds may also be used to buy and improve land, and to provide necessary infrastructure and facilities such as water and waste disposal systems. This program allows up to a 30-year payback period. https://www.rd.usda.gov/programs-services/multi-family-housing-direct-loans/pr

FINANCIAL AND PROGRAMMATIC RESOURCES

GRANTS

PUERTO RICO DEPARTMENT OF HOUSING (DEPARTAMENTO DE LA VIVIENDA) REPAIR AND CONSTRUCTION PROGRAMS

Range of programs funded through the Community Development Block Grant - Disaster Recovery Program (CDBG-DR). These programs are available to support the repair and construction needs of homes and residential facilities. The Housing Department oversees programming of homeowner repair programs funded by CDBG-DR funds.

SINGLE-FAMILY HOUSING REPAIR LOANS AND GRANTS (USDA) (SECTION 504 HOME REPAIR PROGRAM)

This program provides loans to very-low-income homeowners to repair, improve or modernize their homes or grants to elderly very-low-income homeowners to remove health and safety hazards. Grants for very low-income seniors may be used to pay for the costs of home repairs and improvements of up to $7,500 that will remove identified health and safety hazards, or repair or remodel dwellings to make them accessible for household members with disabilities. https://www.rd.usda.gov/programs-services/single-family-housing-repair-loans-grants.

USDA EMERGENCY COMMUNITY WATER ASSISTANCE GRANTS

This program helps eligible communities prepare, or recover from, an emergency that threatens the availability of safe, reliable drinking water.

https://www.rd.usda.gov/contact-us/state-offices/pr

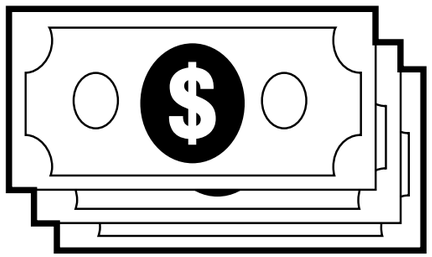
COMMUNITY FACILITIES DIRECT LOAN & GRANT PROGRAM

This program provides affordable funding to develop essential community facilities in rural areas. https://www.rd.usda.gov/contact-us/state-offices/pr.

USDA WATER & WASTE DISPOSAL LOAN & GRANT PROGRAM

This program provides funding for clean and reliable drinking water systems, sanitary sewage disposal, sanitary solid waste disposal, and storm water drainage to households and businesses in eligible rural areas.

www.rd.usda.gov/contact-us/state-offices/pr



DIRECT SUPPORT

WEATHERIZATION ASSISTANCE PROGRAM (WAP)

The Weatherization Assistance Program (WAP) enables low-income families to reduce their energy bills by making their homes more energy efficient and more affordable to operate. Direct installation and construction work in energy, thermal performance, water efficiency, and associated rehabilitation work is performed by contractors free of charge to the owner and supports a variety of building envelope and efficiency improvements. The average expenditure is $6,500 per home. http://www.pppe.pr.gov/Programas/Pages/Weatherization-Assistance-Program.aspx.

PUERTO RICO DEPARTMENT OF HOUSING (DEPARTAMENTO DE LA VIVIENDA) REPAIR AND CONSTRUCTION PROGRAMS

Range of programs funded through the Community Development Block Grant - Disaster Recovery Program (CDBG-DR). These programs are available to support the repair and construction needs of homes and residential facilities. The Housing Department oversees programming of homeowner repair programs funded by CDBG-DR funds. https://www.vivienda.pr.gov/.

SOLAR POWER PURCHASE AGREEMENT (PPA)

PPA's can help a housing unit or facility incorporate a solar photovoltaic (PV) system into their facility by providing a third party with rights to use the roof to generate renewable energy that will be "leased" back to the owner at no charge. The PPA will typically finance, build, and operate a renewable energy system. There are a variety of vendors that perform this work, make sure to check references and watch out for fraudaulent vendors. This program should not require an owner deposit.

FEMA PROGRAMS

Assistance from the Federal Emergency Management Agency (FEMA) is available before and after disaster events to help individuals and families affected by hurricanes to take care of necessary expenses and serious needs that are not covered by insurance or other forms of assistance. Assistance to homeowners might include rental support, home repair, and home replacement as well as social services support and other technical assistance. https://www.fema.gov/es/huracan-maria.

CONTACTS FOR RESILIENCE PLANNING AND PROTECTION

PUERTO RICO COMMUNITY FOUNDATION

This foundation stimulates community investment and maximizes the impact of each contribution made for Puerto Rican communities so that they may achieve social transformation and economic self-sufficiency through skills development.

Contact: (787) 721-1037 www.fcpr.org

AMERICARES

A health-focused relief and development organization that responds to people affected by poverty or disaster with life-changing medicine, medical supplies, and health programs.

Contact: (203) 658-9500 www.americares.org

AMERICAN RED CROSS

Its purpose is to meet the immediate post-disaster needs of individuals, families, and communities. Explore how they respond to disasters across the country, both big and small, by using their contact information.

Contact: (800) 733-2767 www.redcross.org

HABITAT FOR HUMANITY OF PUERTO RICO

Habitat works toward our vision by building strength, stability, and self-reliance in partnership with families in need of decent and affordable housing. Habitat homeowners help build their own homes alongside volunteers and pay an affordable mortgage.

Contact: (787) 368-9393
www.habitatpr.org

REIMAGINA PUERTO RICO

Presents pathways to resilience and resources for building, financing and policy.

Contact: (787) 324-1703
www.resilientpuertorico.org

MERCY CORPS

Offers cash grants, technical assistance, workshop hosting, business development training, and support to community organizations.

Contact: (800) 292-3355 / (503) 896-5000
www.mercycorps.org

OXFAM INTERNATIONAL

Partners with communities to protect vulnerable populations and rebuild homes and infrastructure.

Contact: +254 (0) 20 2820000
www.oxfam.org

HEART 9/11

HEART 9/11 provides hands-on training for resilient construction techniques and volunteer roof repair.

Contact: Bill Keegan, billkeegan@heart911.org
https://heart911.org/

PARA LA NATURALEZA

Fosters tourism by restoring cultural and natural assets.

Contact: (787) 722-5834
https://www.paralanaturaleza.org/en/

RESILIENT POWER PUERTO RICO

Designs and installs solar power in homes and community centers.

Contact: (787) 289-9494
info@marvelarchitects.com

PUERTO RICO SCIENCE TECHNOLOGY AND RESEARCH TRUST

Builds economic capacity and offers educational programming on resilience and well-being.

Contact: (787) 523-1592
https://prsciencetrust.org/

ISRAAID

IsraAID works toward providing access to safe water, mental health, and psychosocial support to communities recovering from Hurricane Maria.

Contact: 972 (0) 3 947 7766
http://www.israaid.org/contact

PARALLEL 18

Promotes entrepreneurship in Puerto Rico. Welcomes innovators from around the globe to help them scale from Puerto Rico to global communities beyond the island.

Contact: cobi @parallel18.com
https://parallel18.com/about.html

COLMENA 66

Non-profit organization that helps to open a business or supports business growth.

Contact: (787) 525-4111
https://www.colmena66.com/en/home

CAFE CORMO

First organic certified coffee plantation in Puerto Rico. Offers courses and certificates unique to the island.

Contact: (787) 600-2332 http://www.uprutuado.edu/academicos/proyectos/cafe-cormo

GRUPO GUAYACAN, INC.

A non-profit organization that aims to develop, strengthen, and advance Puerto Rico's entrepreneurial ecosystem.

Contact: (787) 641-6028
https://www.guayacan.org/about-grupo-guayacan/

ASPIRA

Provides educational services to children, youth, and economically disadvantaged adults in Puerto Rico. Its programs are aimed at the full development of a person, family, and community.

Contact: (787) 641-1985
https://www.aspirapr.org

WORKING WITH YOUR CONTRACTOR

TIPS TO SUCCESSFULLY FIND AND CHOOSE BETWEEN SMALL OR LARGE CONTRACTOR COMPANIES

Inform your contractor that you are rebuilding for resilience, and that you want to reduce damage and carry out replacement works in the event of a future natural disaster. Show them this guide, discuss what you would like them to work on, and if they have experience with any of the guide's strategies. Contact local contractor associations and the Better Business Bureau (BBB) to confirm past references and complaints.

BEFORE ENTERING INTO A CONTRACT:

- Set up a formal service agreement (contract for services) with your contractor outlining scope or work scheme, budget, timeframe, and payment schedule. The contract should be signed by the homeowner and contractor. Note: See the AIA Standard Service Agreement below. In the agreement, specify a minimum of 10% retainage on each invoice to the contractor to ensure quality control and progress. Note: This is the best practice in the building industry.
- Identify a person in yo ur household, neighbor, or friend who can provide quality control oversight of contractor at certain junctions and can function as the owner's representative, especially if the owner has little to no building experience.
- Before signing the contract, determine whether you save on costs by offering to directly purchase materials and confirm this process with the chosen contractor.
- On larger projects, consider getting a performance bond to ensure that the work is completed on time and per its established scope.

AFTER JOB COMPLETION AND UPON FINAL PAYMENT:

- Have a third party who is knowledgeable about construction (either an architect or engineer [if it is in your budget], or another contractor) inspect the completed work or "commission" the work before final payment. Do not pay for work that is not completed or lacking in quality.
- Ask for a set of as-builts (drawings) for completed work.
- Get the Certificate of Occupancy before closing out the job and paying for all work done.
- Ask for a manufacturer's warranty on all equipment to be provided at end of the project.
- Ask for labels and specifications on finishes and major equipment installed in case you need to call the manufacturer or make future household repairs.
- Obtain proof and receipts of payment for all the materials bought for the job and their warranties.
- Consider asking contractor for a lien release or waiver which is a legal document signed by a contractor, subcontractor, materials supplier, or equipment lessor stating that they have received payment. This can protect you from future liens against your property.

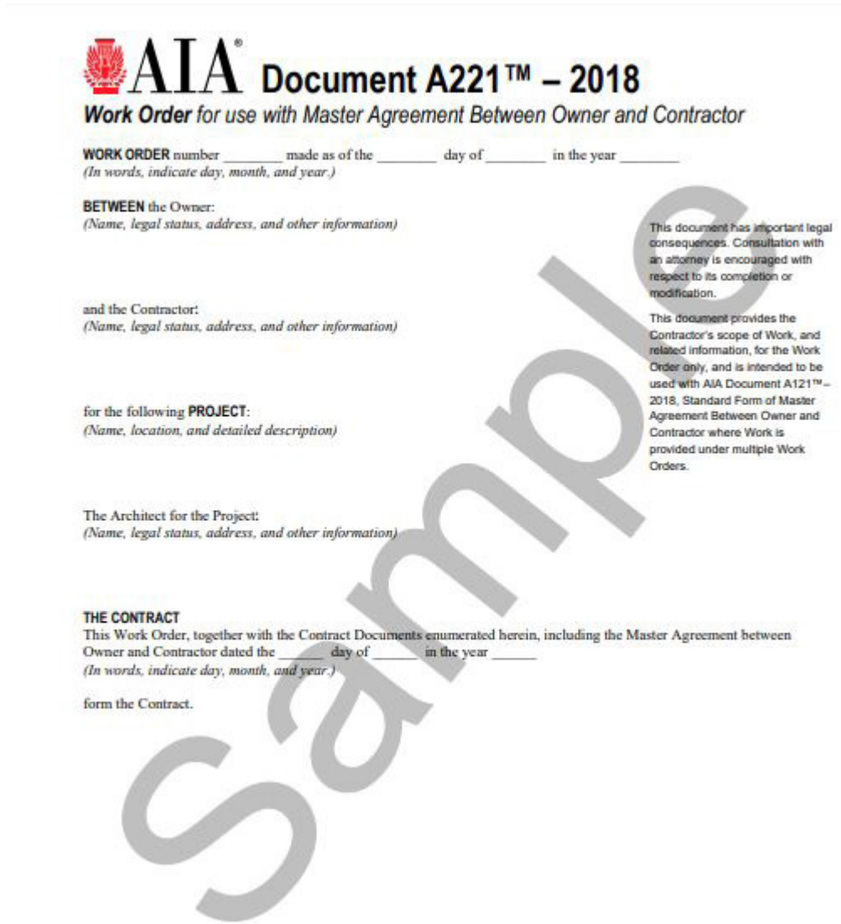
THE CONTRACTOR SHOULD DO THE FOLLOWING:

- Show credentials and references.
- Be registered with the Department of Consumer Affairs (DACO, by its Spanish acronym).
- Give you the address of his office or business headquarters, phone number, and employee identification.
- Provide evidence of public responsibility insurance and insurance for any damage to your structure. Also state insurance for the workers, as well as payment and performance bond if required. With the bond, an insurance carrier guarantees the payment and/or the performance of the contractor.
- Provide a contract that includes:
- Signed copy of plans and specifications that is approved by the Permits Management Office (OGPe, by its Spanish acronym)
- A construction permit granted by OGPe
- Employees' insurance from the state for the duration of the construction period
- List of the work to be done and expected costs
- Work itinerary that includes the start and expected end date
- Number of workdays, excluding holidays
- Penalties for delays
- Specify a paying method of which you can retain 10% until the job is finished.
- Provide warranties for the work and materials used.
- Not ask you for money in advance for materials.
- Construct by code and as designed by the architect or engineer.
- *Note: You should maintain a record of the days the contractor has worked, track the progress of all replacement/repair work, and be present during any inspections.

WORKING WITH YOUR CONTRACTOR

Example of a template contract that can be used between a homeowner and contractor. This template agreement is provided for free and can be downloaded from the AIA webpage.

Utilize the AIA standard form of contract where payment is a stipulated sum: https://contractdocs.aia.org/PreviewFiles/Preview_A101-2017.pdf.



AIA® Document A221™ – 2018

Work Order for use with Master Agreement Between Owner and Contractor

WORK ORDER number _____ made as of the _____ day of _____ in the year _____
(In words, indicate day, month, and year.)

BETWEEN the Owner:
(Name, legal status, address, and other information)

and the Contractor:
(Name, legal status, address, and other information)

for the following **PROJECT**:
(Name, location, and detailed description)

The Architect for the Project:
(Name, legal status, address, and other information)

THE CONTRACT
This Work Order, together with the Contract Documents enumerated herein, including the Master Agreement between Owner and Contractor dated the _____ day of _____ in the year _____
(In words, indicate day, month, and year.)

form the Contract.

This document has important legal consequences. Consultation with an attorney is encouraged with respect to its completion or modification.

This document provides the Contractor's scope of Work, and related information, for the Work Order only, and is intended to be used with AIA Document A121™ – 2018, Standard Form of Master Agreement Between Owner and Contractor where Work is provided under multiple Work Orders.

Sample

American Institute of Architects Sample Contract Template



YUISA RIOS
FEMA PHOTO LIBRARY

INSURING YOUR PROPERTY

Always purchase sufficient insurance for your property to ensure your home and assets as well as to proceed with the necessary rebuild and repair efforts after an emergency or a natural disaster.

As you determine your resilience improvements, it is important to understand the implications any building improvement may have on your property insurance premium or deductible, if applicable. Here is a list of sample questions to ask your insurance agent. If you don't have insurance, these questions might help you identify how much your insurance policy would be if you implemented resilience improvements.

Be careful when you negotiate for a cheaper insurance premium (monthly payment) in exchange for higher deductible. If you don't have funding to cover the deductible if there is an event, you won't be repaid by insurance!

QUESTIONS TO ASK YOUR INSURANCE AGENT:

- Will your property be valued at actual cash value or 100 % replacement cost?
- How much is my deductible—the amount that needs to be paid before insurance can be paid- and as yourself do I have that funding on hand should an emergency occur and claim needs to be filed.
- What other kinds of insurance will you need?
- Are any of your property coverage policies subject to a co-insurance penalty if your values are understated?
- Does your policy cover the cost of required upgrades to code (law and ordinate coverage)?
- Do I pay deductibles on a per asset basis or per policy basis?
- What does your policy require you do if a claim is made?
- What kind of documentation does your insurance company require?
- Are you fully covered for loss of income (loss of rent) and extra expenses during a business interruption caused by a disaster? If so, how long is such coverage provided? Is coverage provided for loss of rent or extra expenses incurred both because of on- and off-premises interruptions?
- Are you covered for the actions of a government authority that requires evacuation or limits access to a property?
- How will putting in effect a disaster management plan or upgrading infrastructure to mitigate the impact of a disaster affect your rates or your ability to obtain coverage?
- Is there a separate environmental and hazardous materials coverage in addition to other coverage?
- Do you have appropriate coverage for hazards common in your area (flood, earthquakes, wildfires, etc.)? Does this coverage exist?

List of home insurance providers for flood and other climate hazards in Puerto Rico as of the date of this publication:

American International Group

Tel. (787) 767-6400

Antilles Insurance

Tel. (787) 474-4900

Integrand Assurance

Tel. (787) 781-0707

QBE Insurance

Tel. (787) 765-2100

MAPFRE

Tel. (787) 250-5200

Multinational Puerto Rico

Tel. (787) 758-8080

Seguros Multiples

Tel. (787) 758-0101

Triple-S

Tel. (787) 749-4600

Universal

Tel. (877) 641-7171

USIC group

Tel. (787) 273-1818

RESOURCES

FOUNDATIONAL RESOURCES

- Fourth National Climate Assessment, Chapter 20: U.S. Caribbean https://nca2018.globalchange.gov/chapter/20/box 20.1
- Puerto Rico Building Code 2018 http://jp.pr.gov/Portals/0/Construction%20Code/ICC%20Codes/Puerto_Rico_Codes_2018.pdf?ver=2018-11-28-133126-680
- FEMA Homebuilders Guide to Coastal Construction https://www.fema.gov/media-library-data/20130726-1538-20490-2983/fema499web_2.pdf
- Enterprise Strategies for Multifamily Building Resilience https://www.enterprisecommunity.org/download?fid=2154&nid=4325

INTRODUCTION

- Caribbean Coastal Ocean Observing System: https://www.caricoos.org
- Universidad Nacional de Ingeniería de Nicaragua. Buenas Prácticas para la Construcción de una Vivienda Segura.
- FLASH, GCCDS and Architecture for Humanity. Resilient Home Building Guide: High Wind Wood Frame Construction.
- National Weather Service Heat Threat Monitor: https://www.weather.gov/sju/heat_risk
- http://www.dhses.ny.gov/recovery/mitigation/archive/documents/2011/3.11-Extreme-Temperatures-2011.pdf
- United States Drought Monitor: http://droughtmonitor.unl.edu/CurrentMap/StateDroughtMonitor.aspx?PR
- National Integrated Drought Information System (NIDIS) https://www.drought.gov/drought/states/puerto-rico
- National Drought Mitigation Center: http://drought.unl.edu/Education/DroughtIn-depth.aspx
- https://phys.org/news/2015-06-parched-caribbean-widespread-drought-shortages.html
- Fire Weather Watch: https://www.weather.gov/sju/fire
- IBHS: http://disastersafety.org/wildfire/
- National Fire Protection Association (NFPA), Preparing Homes for Wildfire https://www.nfpa.org/Public-Education/By-topic/Wildfire/Preparing-homes-for-wildfire
- NFPA, “Community Wildfire Safety Through Regulation: A Best Practices Guide for Planners and Regulators” https://www.nfpa.org/-/media/Files/Public-Education/By-topic/Wildland/WildfireBestPracticesGuide.ashx?la=en
- Ready, Set, Go! Program. http://www.wildlandfirersg.org
- USGS Wildfire Hazards: A National Threat: https://pubs.usgs.gov/fs/2006/3015/2006-3015.pdf
- USGS GeoMAC Wildland Fire Support: https://www.geomac.gov
- National Interagency Coordination Center (NICC): This website provides information about eleven different regions of the United States for wildfire awareness and mitigation (http://www.nifc.gov/nicc/).
- FEMA Flood Map Service Center: https://msc.fema.gov/portal/search
- National Storm Surge Hazard Maps by the National Oceanic and Atmospheric Administration (NOAA) and the National Hurricane Center (NHC) http://noaa.maps.arcgis.com/apps/MapSeries/index.

01 | REINFORCE SITE WITH INFRASTRUCTURE

- Puerto Rico Climate Change Council assessment of coastal resources at risk due to climate http://drnapmzc.maps.arcgis.com/apps/webappviewer/index.html?id=ab48c72f102b440ab021e59c3f1f2cdb
- NOAA Storm surge and sea level rise maps http://noaa.maps.arcgis.com/apps/MapSeries/index.html?appid=d9ed7904dbec441a9c4dd7b277935fad&
- Landslide Identification Map https://blogs.agu.org/landslideblog/2017/10/05/hurricane-maria-1/
- FEMA Flood Map Service- these do not account for future risk from climate change https://msc.fema.gov/portal/home
- National Park Service U.S. Department of the Interior. What is a Green Roof https://www.nps.gov/tps/sustainability/new-technology/green-roofs/define.htm
- U.S. Environmental Protection Agency. Reducing Urban Heat Islands: Compendium of Strategies. https://www.epa.gov/heat-islands/heat-island-resources

02 | REINFORCE SITE WITH VEGETATION

- Guía educativa conociendo el ecosistema del humedal de la Departamento de Recursos Naturales de Puerto Rico. http://drna.pr.gov/wp-content/uploads/2017/04/GuiaEducativa_ConociendoElHumedal.pdf
- Departamento de Recursos Naturales y Ambientales en Puerto Rico http://drna.pr.gov/wp-content/uploads/2015/04/Dunas-de-Puerto-Rico.pdf
- Región cafetalera de Puerto Rico, Sección Suelos: Caracteristicas y manejo http://academic.uprm.edu/mmonroig/HTMLobj-1785/Suelos.pdf
- United States Department of Agriculture, Guide to the Ecological Systems of Puerto Rico https://www.fs.fed.us/global/iitf/pubs/IITF_gtr35.pdf
- Suelos Inventario de Recursos de Agua de Puerto Rico, 2004, Los Suelos Principales en Puerto Rico http://www.recursosaguapuertorico.com/Los_Suelos_Principales_en_Puerto_Rico.pdf
- Maderas de Puerto Rico http://edicionesdigitales.info/maderaspr/maderaspr/ucar.html#0
- Hojas de Nuestro Ambiente. Las Plantas Nativas y su importancia en la reforestación. Gobierno de Puerto Rico. Departamento de Recursos Naturales de Puerto Rico http://drna.pr.gov/documentos/los-arboles-hojas-de-nuestro-ambiente/
- Useful Tropical Plants Database http://tropical.theferns.info/
- Estacion biologica el verde http://floraelverde.catec.upr.edu/

03 | PLANT AN EDIBLE GARDEN

- Setting up Community Garden. Cornell Cooperative Extension. http://warren.cce.cornell.edu/gardening-landscape/growing-techniques
- Hydroponics Systems 101 https://www.fullbloomhydroponics.net/hydroponic-systems-101/
- Plant Diseases http://genesee.cce.cornell.edu/gardening/plant-diseases
- Sustainable Development Guidance: http://websites.suagm.edu/cedes/node/25
- Herbs and Supplements. U. S. National Library of Medicine https://medlineplus.gov/druginfo/herb_All.html

04 | ASSESS THE PRIORITIES FOR YOUR HOME STRUCTURAL CONDITION PRIOR TO AN EVENT

- Federal Alliance for Safe Homes. Resilient Design Guide: High Wind Wood Frame Construction Edition. http://flash.org/resilientdesignguide.pdf
- Hurricane Prep: Is your home safe? https://hurricanepreparednesstips.com/assessing-homes-hurricane-risk/
- FEMA
  - MAT REPORT https://www.fema.gov/hurricane-maria
  - https://www.fema.gov/media-library/assets/documents/158123
  - FEMA P-499 https://www.fema.gov/media-library/assets/documents/6131
- Cosas de Architectos Universidad Nacional de Ingeniería. Buenas Prácticas para la Construcción de una Vivienda Segura Tomo 2. https://www.cosasdearquitectos.com/2017/10/buenas-practicas-la-construccion-una-vivienda-segura/
- Hurricanes in Puerto Rico Guide to Mitigation of Damages: Before, During and After the Hurricane. http://www.ciapr.net/templates/CIAPR/docs/MitigaciondeHuracanes.pdf
- US Forest Service. Research and Development. Corrosion of Metals in Wood. https://www.fs.fed.us/research/highlights/highlights_display.php?in_high_id=278
- Build Change Seismic retrofit for Housing: https://buildchange-web.s3.amazonaws.com/resources/pdfs/13-11-13_BCH_Retrofit%20Picture%20Guide_(EN).pdf
- Homeowners Guide to Hurricane Preparedness: http://seagrant.soest.hawaii.edu/homeowners-handbook-to-prepare-for-natural-hazards/

05 | BUILD A STRONG FOUNDATION

- FEMA P-550 Recommended Construction for Coastal Areas for Strong Foundations https://www.fema.gov/media-library/assets/documents/3972
- Colegio de Ingenieros y Agrimensores de Puerto Rico. Huracanes en Puerto Rico: guía de mitigación de daños, https://issuu.com/ciapr/docs/guia_huracanes
- Home Building and Renovating: Foundation Systems and Soil Types https://www.homebuilding.co.uk/foundation-systems-and-soil-types/

RESOURCES

06 | BUILD STRONGER WALLS

- FEMA Fact Sheet 3.2 - 3.5 Homebuilders Guidance for Coastal Construction https://www.fema.gov/home-builders-guide-coastal-construction-technical-fact-sheet-series-fema-p-499

07 | BUILD A STURDY ROOF

- FEMA NFIP Technical Bulletin flood-damage resistant construction materials: https://www.fema.gov/media-library/assets/documents/2655
- FORTIFIED Home™ standards: https://disastersafety.org/fortified/resources/
- FEMA Repair and Replacement of Wood Residential Roof Covering Systems https://www.fema.gov/media-library-data/1527685619799-4c209e6758885a243000b159c2d4ed6f/PR-RA6RepairandReplacementofWoodResidentialRoofCoveringSystems_5_23.pdf

08 | ANCHOR, SEAL AND PROTECT OPENINGS

- FEMA Window, Doors, Opening Protection: https://www.fema.gov/media-library-data/20130726-1707-25045-9020/chapter10.pdf
- Colegio de Ingenieros y Agrimensores de Puerto Rico. Huracanes en Puerto Rico: guía de mitigación de daños. https://issuu.com/ciapr/docs/guia_huracanes
- ASTM E1996-17, Standard Specification for Performance of Exterior Windows, Curtain Walls, Doors, and Impact Protective Systems Impacted by Windborne Debris in Hurricanes http://www.stormsolutionsusa.com/ASTM/ASTM%20E1996-09.pdf

09 | FLOOD PROOF HOME

- Technical Bulletin 2, Flood Damage-Resistant Materials requirements. 2008. https://www.fema.gov/media-library-data/20130726-1502-20490-4764/fema_tb_2_rev1.pdf
- FEMA P-312: Homeowner's Guide to Retrofitting. 3rd. FEMA. https://www.fema.gov/media-library/assets/documents/480

10 | REDUCE THERMAL HEAT TRANSFER

- Abruna and Musgrave—Tools to support Passive Habitability: http://www.abrunaandmusgrave.com/resources/
- Carbon footprint calculator for households https://www3.epa.gov/carbon-footprint-calculator/
- Data on carbon dioxide emissions from Puerto Rico http://cdiac.ess-dive.lbl.gov/trends/emis/pue.html
- U.S. Environmental Protection Agency, Heat Island Effect: https://www.epa.gov/heat-islands
- "ThermalMass."Greenspec, www.greenspec.co.uk/building-design/thermal-mass/.

11 | INCREASE VENTILATION

- Whole Building Design Guide, Natural vent section, Nat'l Institue of Bldg Sci doc: https://www.wbdg.org/resources/natural-ventilation
- Florida Solar Center Cooling with Ventilation http://publications.energyresearch.ucf.edu/wp-content/uploads/2018/06/FSEC-CR-1658-86.pdf

12 | BENEFIT FROM NATURAL LIGHT

- Solar gain and the optimal solar panel direction. https://www.australiansolarquotes.com.au/buyers-guide/what-direction-should-my-solar-panels-face/
- Site Planning For Your Survival Homestead http://www.freesurvivalist.com/incredible-information-site-planning-for-your-survival-homestead/

13 | Control Moisture and Mold

- Enterprise Community Partners. A field guide for Clean-up of Flooded Homes. https://www.enterprisecommunity.org/resources/creating-healthy-home-field-guide-clean-flooded-homes-13753
- Environmental Protection Agency Mold Homepage https://www.epa.gov/mold
- Energy Star: Facts about Mold and Dampness
- https://www.energystar.gov/ia/partners/bldrs_lenders_raters/downloads/ENERGY_STAR_V3_Building_Science.pdf?d387-4a5e
- World Health Organization (WHO) Guidelines for Indoor Air Quality: Dampness and Mold (PDF) http://www.euro.who.int/__data/assets/pdf_file/0017/43325/E92645.pdf

14 | MANAGE PESTS

- "Pest Prevention by Design: Authoritative Guidelines for Building Pests Out of Structures," San Francisco Department of the Environment. https://sfenvironment.org/download/pest-prevention-by-design-guidelines
- The National Center for Healthy Housing, Integrated Pest Management in Affordable Housing: http://nchh.org/Training/IntegratedPestManagement.aspx
- Ewg's 2018 Guide To Environmentally friendly Bug Repellents https://www.ewg.org/research/ewgs-guide-bug-repellents/repellent-chemicals

15 | REDUCE YOUR ENERGY USE

- Energy Star list of Energy Efficient Appliances: https://www.energystar.gov
- US Department of Energy Appliance Energy Calculator https://www.energy.gov/energysaver/save-electricity-and-fuel/appliances-and-electronics/estimating-appliance-and-home
- Load evaluation Calculator https://www.wholesalesolar.com/solar-information/start-here/offgrid-calculator#load-evaluation
- Power Consumption Table https://pdf.wholesalesolar.com/Download%20folder/Power-table.pdf?_ga=2.96879767.962209199.1538406981-498380606.1536777410
- How much power do your appliances use? https://www.wholesalesolar.com/solar-information/how-to-save-energy/power-tabl

16 | INTEGRATE SOLAR ELECTRICITY

- FEMA Rooftop Solar Panel Attachment: Design, Installation, and Maintenance https://www.fema.gov/media-library-data/1535554011182-e061c2804fab7556ec848ffc091d6487/USVI-RA5RooftopSolarPanelAttachment_finalv3_508.pdf
- PVWatts calculator to determine how much solar energy you can harvest - https://pvwatts.nrel.gov/
- List of Certified Equipment and Solar PV Installers – Oficina Estatal de Politica Publica Energetica http://www.prgef.com/resourcesandforms
- Clean Energy Council Guide to Installing a Household Battery Storage System https://www.solaraccreditation.com.au/consumers/purchasing-battery-storage.html

17 | INTEGRATE SOLAR THERMAL ENERGY

- ENERGY STAR Solar Water Heaters https://www.energystar.gov/products/water_heaters/water_heater_solar)
- Solar Water Manual Design and Installation & Repair and Maintenance http://www.nabcep.org/wp-content/uploads/2013/08/FSEC_Solar_Water_and_Pool_Heating_Manual.pdf

18 | INSTALL ENERGY BACKUP GENERATOR

- Applications of Solar Technology for Catastrophe Response, Claims Management, and Loss Prevention www.nrel.gov/docs/fy99osti/25866.pdf
- Siemens Generator Sizing Guide Including Load Calculators www.siemens.com/download?BTLV_40972
- Portable Generator Wattage Chart, Lowes. https://www.google.com/url?q=https://www.lowes.com/projects/pdfs/portable-generator-wattage-chart.pdf&sa=D&ust=1539373745134000&usg=AFQjCNHUy34_asoTVmewr1f_89-nfuNZSw

19 | REDUCE YOUR WATER CONSUMPTION

- Technical Notes on Drinking Water, Sanitation and Hygiene in Emergencies, World Health Organization, http://www.who.int/water_sanitation_health/publications/technotes/en/
- Recursos de Agua de Puerto Rico, http://www.recursosaguapuertorico.com/Uso-de-Agua.html
- The USGS Water Science School, https://water.usgs.gov/edu/qa-home-percapita.html
- United States Environmental Protection Agency, Water Calculator https://www.epa.gov/watersense/watersense-calculator
- WaterSense label, www.epa.gov.watersense
- USGS Water Consumption Chart https://water.usgs.gov/edu/qa-home-percapita.html
- "Ahorro del Agua, Conservación del Recurso" http://www.acueductospr.com/comunicaciones/folletoseducativos/download/BROCHURE%20CONSERVACION%20FINAL.pdf

RESOURCES

20 | COLLECT AND USE RAINWATER

- NOAA Atlas 14 Point Precipitation Frequency Estimates for Puerto Rico. https://hdsc.nws.noaa.gov/hdsc/pfds/pfds_map_pr.html.
- United States Environmental Protection Agency Water Savings Tool
- https://www.epa.gov/watersense/start-saving
- Rainwater Connection-How much water storage do I need? http://www.rainwaterconnection.com/rainwater-harvesting/8-rainwater-harvesting/6-how-much-water-storage-do-i-need
- Selection and Consequences of Roofing and Gutter Materials for Rainwater Harvesting http://www.thecenterforrainwaterharvesting.org/2_roof_gutters2.htm

21 | IMPROVE YOUR SEPTIC SYSTEM

- U.S. Environmental Protection Agency, "A Homeowner's Guide to Septic Systems.": https://www3.epa.gov/npdes/pubs/homeowner_guide_long.pdf
- Septic Systems, What to do after a flood? EPA, https://www.epa.gov/ground-water-and-drinking-water/septic-systems-what-do-after-flood
- Home Aerobic Wastewater Treatment, An alternative to septic systems, PIPELINE, http://www.nesc.wvu.edu/pdf/WW/publications/pipline/PL_WI96.pdf
- Do Your Part Get Septic Smart Infographic (spanish), EPA, https://www.epa.gov/sites/production/files/2018-06/documents/septicsmart_infographic_spanish_060118.pdf
- Pozos sépticos, Recursos de Agua de Puerto Rico, http://www.recursosaguapuertorico.com/pozos-septicos-p3.html

22 | PREVENT WASTEWATER BACKFLOW IN HOMES

- Information on Backwater Valves protectiveplumbingcanada.ca/backwater-valves/

23 | DEVELOP A HOUSEHOLD EMERGENCY PLAN

- Cruz Roja: Plan de Emergencia Familiar
- http://www.cruzroja.org.ec/index.php/2-uncategorised/369-plan-de-emergencia-familiar
- Haga un plan https://www.ready.gov/es/haga-un-plan (Make a Plan)
- Registros Vitales https://www.ready.gov/es/registros-vitales
- Enterprise Community Partners Ready to Respond Disaster Planning Toolkit: https://www.enterprisecommunity.org/solutions-and-innovation/disaster-recovery-and-rebuilding/ready-respond-disaster-staffing-toolkit

24 | CHOOSE A SPACE TO KEEP YOUR FAMILY SAFE

- Plan de Evacuacion https://www.ready.gov/es/como-usted-y-su-familia-deben-evacuar (ENG) https://www.ready.gov/evacuating-yourself-and-your-family
- Shelter finder: https://www.redcross.org/get-help/disaster-relief-and-recovery-services/find-an-open-shelter.html
- Guidance on Sheltering https://www.ready.gov/shelter
- Guidance for Pets and Animals https://www.ready.gov/animals
- Details on Food Safety: https://www.fsis.usda.gov/wps/portal/fsis/topics/food-safety-education/get-answers/food-safety-fact-sheets/emergency-preparedness
- FEMA Safe Room specifications: https://www.fema.gov/residential-safe-rooms
- Mobile Apps
  - Notifications and open shelters: FEMA: www.fema.gov/mobile-app
  - Forecasts and impacts: The Weather Channel: www.weather.com
  - Reunification: American Red Cross "Safe and Well": https://safeandwell.communityos.org/cms/index.php
  - In Spanish: https://safeandwell-es.communityos.org/cms/index.php (ENG) https://safeandwell.communityos.org/cms/index.php

25 | RESPOND + BEGIN HOUSEHOLD RECOVERY

- Hiring a Contractor
  - Better Business Bureau tips: https://www.bbb.org/en/us/article/tips/14081-bbb-tip-hiring-a-contractor
  - American Association of Retired Persons AARP pagina oficial en espanol https://www.aarp.org/espanol/?intcmp=AE-HP-FTR-ESPANOL (ENG) https://www.aarp.org/livable-communities/info-2014/7-steps-to-hiring-a-contractor.html
- Tips for Cleanup
  - Environmental Protection Agency's Debris Management Planning: https://www.epa.gov/large-scale-residential-demolition/disaster-debris-planning
  - Crear un Hogar Saludable: Guía Práctica para la Limpieza de Hogares Inundados: https://www.enterprisecommunity.org/resources/guia-practica-para-la-limpieza-de-hogares-inundados (ENG) https://www.enterprisecommunity.org/download?fid=5140&nid=4465
- Coping with Disaster
  - Red Cross: Cómo ayudar a los niños a confrontar una catástrofe https://www.redcross.org/content/dam/redcross/atg/PDF_s/Preparedness___Disaster_Recovery/General_Preparedness___Recovery/Emotional/Helping_children_cope_with_disaster_-_Spanish.pdf

26 | Organize Your Community

- Community Preparedness Toolkit. https://www.ready.gov/community-preparedness-toolkit
- Community Disaster Preparedness Guide. Department of Disaster Management, Virgin Islands. http://www.ifrc.org/docs/IDRL/-%20To%20add/Community%20Disaster%20Preparedness%20Guide.pdf
- Training Community Members to Prepare for Disasters. Corporation for National and Community Service. https://www.nationalservice.gov/resources/disaster-services/training-community-members-prepare-disasters
- Para referencias adicionales de planes de manejo de emergencias comunitarias, vea:
  - Plan de Emergencia del Barrio Los Gandules, Porvernir, en San Pedro de Macorís, República Dominicana, ver: http://www.desastre.org/home/data/pdf/articles/esp/Plan%20Comunitario%20de%20Emergencia%20del%20Barrio%20Los%20Guandules%20San%20Pedro%20de%20Macoris.pdf
  - Creating a Disaster Preparedness Implementation Plan, https://www.polygongroup.com/en-US/blog/creating-a-disaster-preparedness-plan–implementation/

27 | Identify + Prepare Safe Community Shelter

- The Sphere Project: Humanitarian Charter and Minimum Standards in Humanitarian Response. https://cms.emergency.unhcr.org/documents/11982/36756/The+Sphere+Handbook/455f4992-27fd-46f8-aca2-77f15739d61d.
- USAID provee una guía para el manejo de albergues de emergencia: https://scms.usaid.gov/sites/default/files/documents/1866/SSM%20-%20RM.pdf
- Para más información sobre normas sobre el alojamiento de emergencia: https://emergency.unhcr.org/entry/115874/emergency-shelter-standard
- FEMA P-361 Safe Rooms for Tornadoes and Hurricane https://www.fema.gov/fema-p-361-safe-rooms-tornadoes-and-hurricanes-guidance-community-and-residential-safe-rooms

RESOURCES

28 | Inspiring Post-Disaster Planning for Community

- FEMA Long Term Community Recovery Planning Process: A Self-Help Guide: https://www.fema.gov/media-library-data/20130726-1538-20490-8825/selfhelp.pdf
- What to do until help arrives: https://community.fema.gov/until-help-arrives
- Resources for mental health after a Disaster: https://www.samhsa.gov/disaster-preparedness/publications-resources
- To recover impacted infrastructure after a disaster: https://www.ifrc.org/PageFiles/71111/PostDisaster_Infrastructure-Guidelines.pdf
- Introduction to Certified Emergency Response Team: https://www.preparecenter.org/sites/default/files/topics/cert_training.pdf
- Community Recovery Management Toolkit: https://www.fema.gov/community-recovery-management-toolkit
- How to Help Your Community Recover from Disaster: A Manual for Planning and Action: https://www.scra27.org/files/2114/0605/7122/SCRA_Disaster_Recovery_Manual.pdf
- Importance of Community Participation after a Disaster: https://www.unocha.org/story/community-engagement-centre-disaster-response
- FINANCIAL AND PROGRAMMING RESOURCES
  - FEMA listing of resources for Recovery: https://www.fema.gov/media-library-data/1474548130660-db3c22abcc037416428fe7db69d45926/FundingResources.pdf
  - FEMA's registration process: https://www.fema.gov/news-release/2017/09/07/fact-sheet-what-expect-when-you-register-fema-disaster-assistance
- BUILDING TO CODE
  - Puerto Rico Building Code Link http://jp.pr.gov/Portals/0/Construction%20Code/ICC%20Codes/Puerto_Rico_Codes_2018.pdf?ver=2018-11-28-133126-680
- WORKING WITH YOUR CONTRACTOR
  - How to Hire a Contractor www.consumer.ftc.gov/articles/0242-hiring-contractor
  - Preventing Contractor Fraud www.sbpusa.org/public/uploads/general/SBP_ContractorFraudChecklist-2017_170310_162735.pdf
  - American Institute of Architects provides low-cost legal contract templates to use for projects: https://www.aiacontracts.org/

ENDNOTES

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- Housing Units. U.S. Census Bureau, 2017 American Community Survey 1-Year and 10 year Estimates
- Historical Temperature Puerto Rico 1901-2015. The World Bank Group. Climate Change Knowledge Portal
- Projected Monthly Max Temperature 2020-2100 Mean. Scenario RCP4.5 (Moderate Emissions) Model csiro_mk360. The World Bank Group. Climate Change Knowledge Portal
- The National Climate Assessment (NCA) presents the most recent scientific findings on climate change and what they mean for people and places now and in the future. It reflects the research of over 300 experts from federal, state, and local governments, tribes and indigenous communities, national laboratories, universities, and the private sector, along with external stakeholders. Throughout this section we will be citing statistics drawn from the NCA climate models. According to the 6th IPCC report, the past three decades have been Earth's warmest since reliable surface temperature records began in 1850, and based on NOAA data, the 2017 average global temperature across land and ocean surface areas was 0.84°C (1.51°F) above the 20th-century average of 13.9°C (57.0°F), making 2017 the third-warmest year on record behind 2016 (warmest) and 2015 (second warmest).
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  - i NOAA National Centers for Environmental Information. Significant Earthquakes.
  - ii Coffman, J.L. and C.A. von Hake. Earthquake History of the United States, Pub. 41-1, U.S. Department of Commerce, Boulder, CO, 1973, and 1982 Supplement.
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- FEMA MAT REPORT https://www.fema.gov/hurricane-maria
- Universidad Nacional de Ingeniería. Buenas Prácticas para la Construcción de una Vivienda Segura Tomo 2.
- Federal Alliance for Safe Homes. Resilient Design Guide: High Wind Wood Frame Construction Edition.

PASSIVE HABITABILITY

- Strategies and technologies for facades that adapt to environmental conditions https://www.di.net/articles/adaptive-structures-building-for-performance-and-sustainability/
- Puerto Rico Building Code 2018, http://jp.pr.gov/Portals/0/Construction%20Code/ICC%20Codes/Puerto_Rico_Codes_2018.pdf?ver=2018-11-28-133126-680
- National Institute of Environmental Health Sciences, NIEHS Disaster Recovery: Health and Safety Essentials for Workers, Volunteers, and Homeowners: Worker Education & Training Program https://tools.niehs.nih.gov/wetp/public/hasl_get_blob.cfm?ID=9855 (Download)

ENERGY GENERATION + BACKUP

- United States Environmental Protection Agency. Identify and Prevent Rodent Infestations
- The National Center for Healthy Housing, Integrated Pest Management in Affordable Housing: This webpage has resources dedicated to IPM in affordable housing, including model RFPs and contract language for greener pest control, case studies and training. http://nchh.org/Training/IntegratedPestManagement.aspx
- US Department of Energy. https://www.energy.gov/energysaver/energy-saver
- ACONER - Asociación de Consultores y Contratistas de Energía Renovable en Puerto Rico, http://www.aconer.com/index.php?node=1361

WATER MANAGEMENT + STORAGE

- Recursos de Agua de Puerto Rico, http://www.recursosaguapuertorico.com/Uso-de-Agua.html
- United States Environmental Protection Agency, Water Calculator https://www.epa.gov/watersense/watersense-calculator
- U.S. Environmental Protection Agency, "A Homeowner's Guide to Septic Systems." Download at: https://www3.epa.gov/npdes/pubs/homeowner_guide_long.pdf

HOUSEHOLD EMERGENCY PREPAREDNESS

- Federal Emergency Management Agency. Make a Plan. https://www.ready.gov/make-a-plan
- American Red Cross. Tipos de Emergencias. https://www.redcross.org/cruz-roja/obtener-ayuda/tipos-de-emergencias.html
- Municipal Emergency and Disaster Management Office (OMMEAD). List of Shelters by Area (San Juan). http://sanjuanciudadpatria.com/en/services/emergency-management/

COMMUNITY ENGAGEMENT: PREPARE FOR ACTION TOGETHER

- Community Preparedness Toolkit. Ready. https://www.ready.gov/community-preparedness-toolkit
- Planning for emergencies module OSHA, https://www.osha.gov/dte/grant_materials/fy07/46e0-ht10/emerg_pg_module_4.pdf
- Para la recuperación de infraestructura impactada por un desastre, ver: https://www.ifrc.org/PageFiles/71111/PostDisaster_Infrastructure-Guidelines.pdf

PUTTING IT ALL TOGETHER

- Oficina de Gerencia de Permisos (OGPe) https://ogpe.pr.gov/freedom/
- Huracanes en Puerto Rico. Guía de mitigación de daños; antes, durante y después del huracán. by Colegio de Ingenieros y Agrimensores de Puerto Rico, Defensa Civil Estatal de Puerto Rico y Federal Emergency Management Agency. (p.59-60)
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Thank you to all of the following partners who shared their photos with us to make this book so vibrant. Especially all of our community partners who provided us with photos capturing the spirit of their efforts:
The entire team at Tsang Seymour who worked with all of our photos—high resolution, low resolution, no resolution—and turned them into a fantastic book
Adalberto Martinez
Chris Balas, Heart 911 and the entire Heart 911 team on the ground in Orocovis fixing homes, training workforce and rebuilding lives.
Stuart Adams on behalf of FEMA
Pablo Marvel, Jonathan Marvel, Scott Lahn and Diana Serrano at Resilient Power Puerto Rico
Tamara Elena Pérez
Maria Nieves who graciously provided us with a tour of La Perla's Community Garden
Evelyn Huerta
Yanel de Ángel
Larisa Oviles
NYC Office of Emergency Management
FEMA Photo and Media Library
The Creative Commons platform and the dozens of photographers who provided open source material for this guide for more information: https://creativecommons.org/

KEEP SAFE: A GUIDE FOR RESILIENT
HOUSING DESIGN IN ISLAND COMMUNITIES

Published by Community Enterprises, Inc.

First edition 2019
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Curated and Produced by Laurie Schoeman
Edited by OGMA San Juan, Puerto Rico
Designed by Patrick Seymour with Eric Turner, @TsangSeymour
Printed by Go Print
This book is typeset in Trade Gothic

Library of Congress Cataloguing-in-Publication data available from the publisher.
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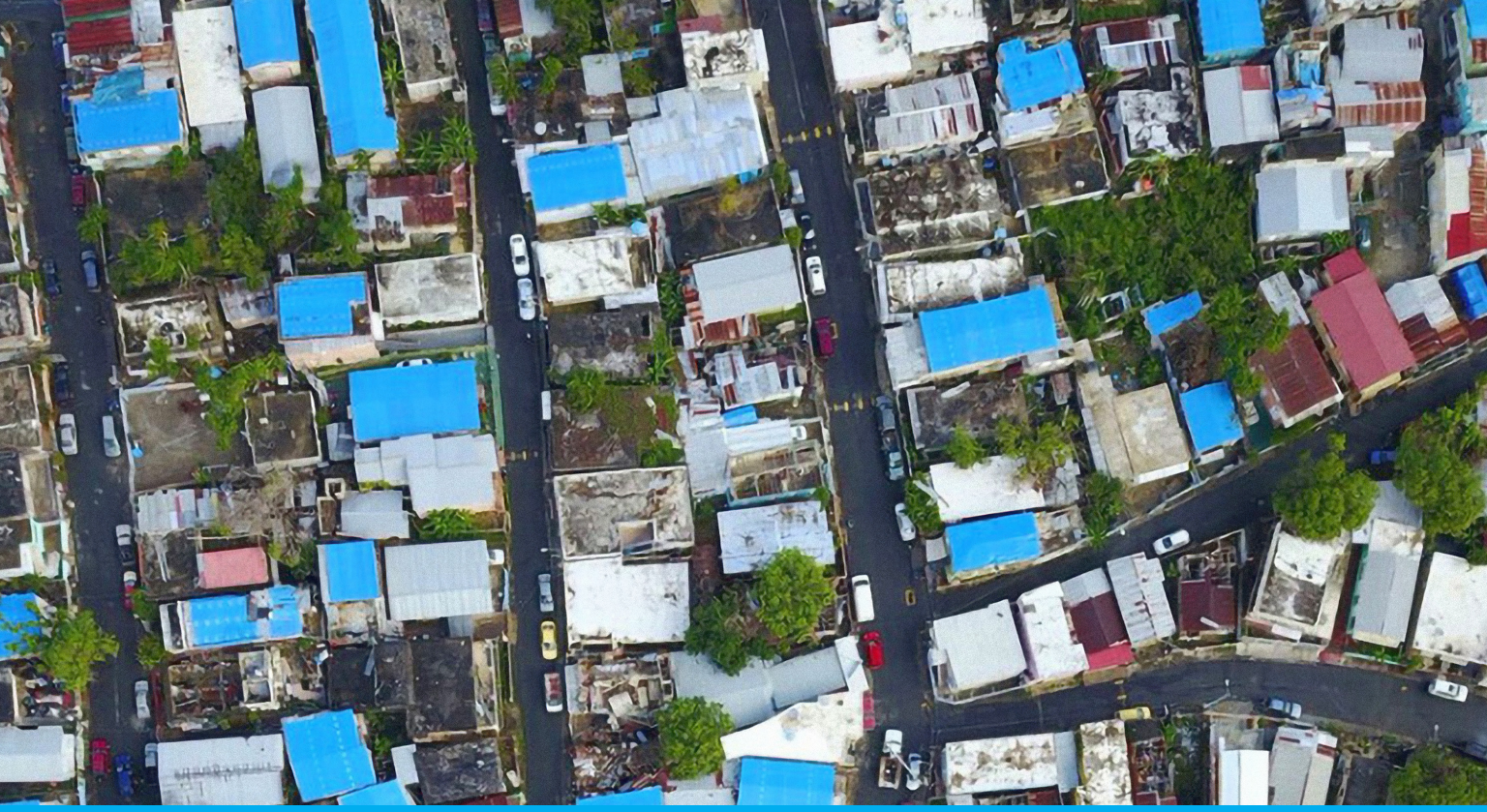
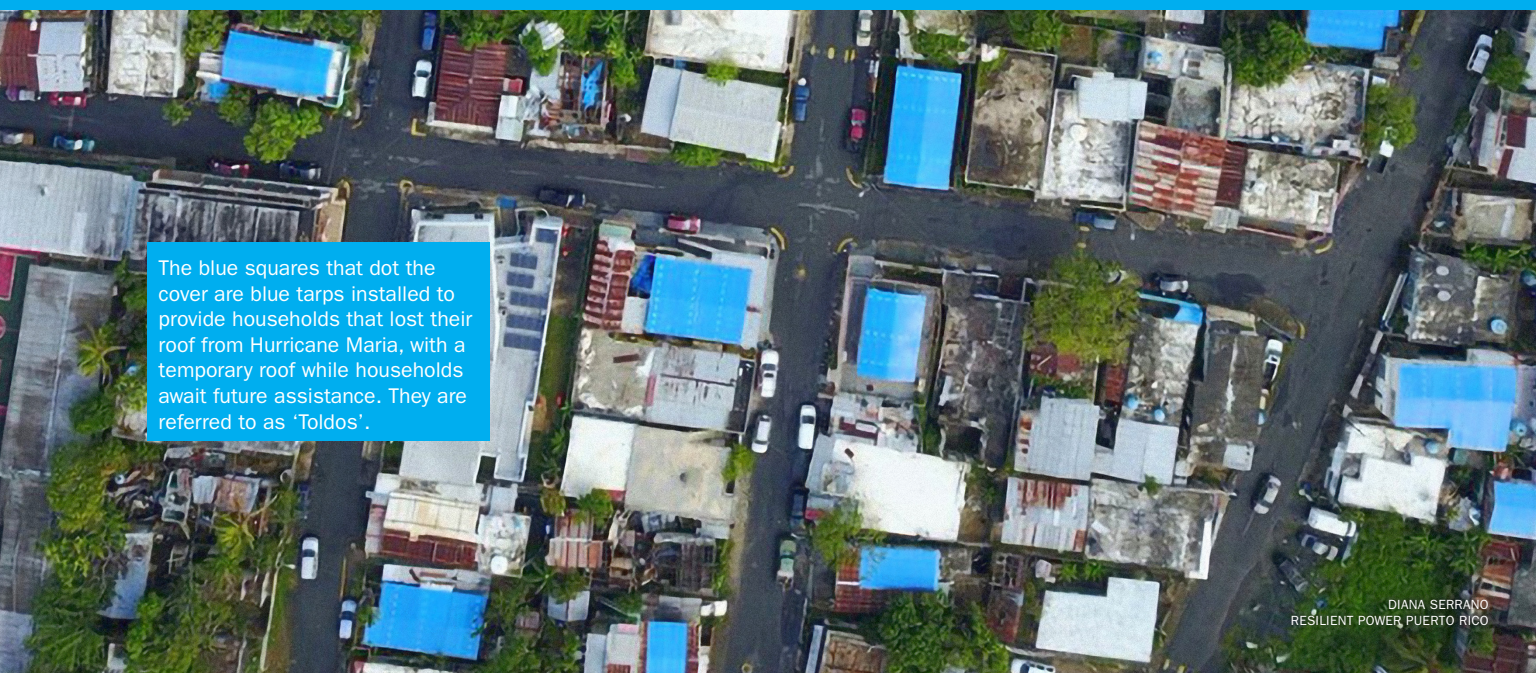
Printed in San Juan, Puerto Rico



We created this resource to enable people to build back stronger so that when tens of billions of dollars of federal aid arrived, the money could be used to protect residents from future harm. And as you will see, we wanted to provide practical and affordable ideas for rebuilding homes.



The blue squares that dot the cover are blue tarps installed to provide households that lost their roof from Hurricane Maria, with a temporary roof while households await future assistance. They are referred to as 'Toldos'.

DIANA SERRANO
RESILIENT POWER PUERTO RICO