City & County of Honolulu

Climate Adaptation
DESIGN PRINCIPLES FOR URBAN DEVELOPMENT

December 2020

TOD HONOLULU Transit-Oriented Development

RESILIENT O'AHU

SSFM International

ARUP

Purpose of this Document

The purpose of this document is to outline design principles that can be used to help develop policy and regulations for property in Honolulu's transit-oriented development (TOD) and other urban areas that may be vulnerable to sea level rise (SLR) and other climate change-related hazards. The guidance in this document identifies recommended tools and best practices to consider in designing building sites and structures to be resilient to SLR, flooding, extreme heat, and groundwater inundation.

A companion document, Climate Adaptation: Background Research, summarizes international best practices and local initiatives related to climate adaptation in the built environment, including recommendations for next steps. The companion document is available at www.honolulu.gov/tod.

Why Design for Climate Resilience?

Climate change will affect all aspects of life in Hawai'i, from natural ecosystems to human health and the built environment. It is imperative to plan for it now. Many U.S. cities are doing so by adopting new regulations and design guidelines to make the built environment more resilient to SLR flooding, heat, gradual inundation, and other hazards. In developing this guidance, examples were consulted from New York, Boston, San Francisco, Miami, New Orleans, and other similar cities around the world to identify best practices applicable to Honolulu.

How is the City Addressing Resilience to Climate Change?

The City and County of Honolulu (the City) has committed to plan for and adapt to the effects of climate change through the establishment and actions of its Office of Climate Change, Sustainability, and Resiliency (CCSR) and the Honolulu Climate Change Commission.

Mayor's Directive 18-2 (2018) requires all City agencies, departments, and consultants to City projects to consider climate change and SLR in all City plans, programs, and capital improvement projects, and to apply planning benchmarks assuming 3.2 to 6 feet of SLR by the end of this century.

In 2019, the CCSR prepared the O'ahu Resilience Strategy for the City with 44 actions to guide implementation. The CCSR is now preparing a Climate Action Plan to mitigate greenhouse gas emissions. In addition to mitigating emissions, the City recognizes that adaptation will be needed as SLR and other climate-related impacts intensify. This will require measures to protect or enhance existing development, as well as determining when retreat or relocation is called for.

Policies are being established in new and existing documents, including sustainable community/development plan updates. Changes to regulations for both public and private development are also being considered, some of which are highlighted on the next page. In anticipation of more requirements to enhance resilience in the planning, design, and construction of building and infrastructure projects, the City will increasingly look for developers to consider climate change and incorporate best practices for mitigation.

Developers and design professionals may choose to utilize these principles as well when developing new project applications, or when considering adaptation options for existing projects. However, the current regulatory framework may limit the ability to implement certain strategies. At the same time, the discretionary review processes may provide some flexibility, such as through TOD permits.

Learning from any interim/pilot projects will further inform development of the City's climate change adaption policies and regulations, which are expected to take years to fully implement.

Scan here for the companion Background Research document

www.honolulu.gov/rep/site/dpptod/climate_docs/Climate_Adaptation_Background.pdf

Scan here for the O'ahu Resilience Strategy

www.resilientoahu.org/resilience-strategy

What Regulatory Changes are Anticipated?

Key City regulations and policies that have been recently updated or are in the process of being updated to incorporate resilient design principles are summarized below.

Ordinances & Codes

→ **Building Code:**
The City has adopted the 2012 International Building Code (IBC) and International Residential Code (IRC), as incorporated into the Revised Ordinances of Honolulu (ROH) Chapter 16.

The 2012 IBC requires new construction to be designed with one foot *freeboard** above current *Base Flood Elevation* (BFE) in hazardous flood zones. The 2012 IRC limits impervious surfaces of some residential developments to 75 percent of the total lot area. The 2018 IBC is anticipated to be adopted in 2021. It contains additional provisions for resilience.

→ **Flood Hazard Areas:**
Following adoption of the 2012 IBC, amendments to ROH Chapter 21A are forthcoming to reflect changes in the requirements for designing buildings in flood hazard areas.

→ **Plumbing Code:**
The City is proposing updates to the Plumbing Code (ROH Chapter 19) that would allow more applications for on-site water reuse for residential and commercial properties.

→ **Rules Related to Water Quality:**
The 2018 update incorporates requirements for low impact development (LID), green infrastructure, and source control best management practices (BMPs). Other updates are underway or expected to be formalized into updated City codes and regulations within the next one to five years.

→ **Special Management Area and Shoreline Setbacks:**
A working group is preparing updates to regulations of the Shoreline Setbacks (ROH Chapter 23) and Special Management Area (ROH Chapter 25) to incorporate State-identified *Sea Level Rise Exposure Areas* (SLR-XA) and improved mapping.

Plans, Programs, & Policies

→ **Climate Adaptation Strategy:**
Action 28 of the City's Resilience Strategy calls for the preparation of an O'ahu Climate Adaptation Strategy, which the City has initiated. The Strategy is expected to include policy guidance and a recommended framework for approaching adaptation islandwide. However, it will not recommend specific adaptation strategies at a regional or neighborhood scale. Regional or neighborhood scale adaptation strategies will need to continue to be developed through community, special district, and functional plans. For more information, see www.climatereadyoahu.org.

→ **Climate Resilience Design Guidelines:**
Action 14 of the City's Resilience Strategy calls for the City to establish Future Conditions Climate Resilience Design Guidelines that incorporate forward-looking climate change data and provide specifications to inform the design of City and private facilities and infrastructure (essentially expanding on this document).

→ **Stormwater Utility:**
In accordance with Action 31 of the City's Resilience Strategy, the City is exploring the formation of a stormwater utility. This would establish fees for impervious surfaces and further incentivize the use of green infrastructure, LID, and water conservation in new development and redevelopment. For more information, see www.stormwaterutilityoahu.org.

→ **Urban Tree Canopy:**
In accordance with Action 33 of the City's Resilience Strategy, the City is establishing policies and practices that improve the management of trees to mitigate increasing temperatures resulting from climate change. Mayor's Directive 20-14 (2020) requires City departments and agencies to consider climate change mitigation and environmental benefits of a healthy urban tree canopy when making decisions that affect city trees. This policy requires the protection of trees that pose no threat to safety and do not undermine an essential government function, as well as planting more trees to expand urban canopy.

A TOD Street Tree Plan is under development. This plan will provide guidance for street tree type selection to maximize canopy and streetscape coherency in the TOD neighborhoods.

How to make buildings and sites more resilient?

International, national, and local best practices and tools that can be used to make buildings and sites more resilient are highlighted on the following pages. These practices and tools are presented in four categories:

A: Understanding Applicable Hazards
B: Managing Stormwater
C: Design for Flooding and Sea Level Rise
D: Mitigating Extreme Heat

In addition, resilient design best practices are illustrated for three urban building typologies:

1: Tower & Podium
2: Mid-Rise
3: Low-Rise Walk-Up

* *Italicized terms are defined at the end of this document*

A: Understanding Applicable Hazards

A first step in resilient design is to identify and utilize current information on climate science and hazards to determine what hazards may affect the property or building site. This information can be used to inform siting and design of structures to support reduced risk, enhanced safety, and long-term protection of natural systems, people, and structures. Land use, community planning, and zoning practices are critical implementation tools for long-term hazards and financial risk mitigation for the City, its residents, and businesses.

The Climate Ready O'ahu Web Explorer (bit.ly/climatereadyoahumap) is an online mapping tool that features data from the City, State, and Federal governments. The data represents best available science for a variety of climate change stressors and other regulatory layers. Mayor's Directive 18-2, "City and County of Honolulu Actions to Address Climate Change and Sea Level Rise," requires the use of such information for a variety of City functions for planning, design, and long-term operations. This tool can also be used by private landowners and developers to assess what climate change-related hazards may impact their site, thereby informing design decisions.

The Web Explorer incorporates SLR data from the State of Hawai'i Sea Level Rise Vulnerability and Adaptation Report (2017), which utilized modeling of combined impacts from passive flooding due to SLR, annual high wave flooding, and coastal erosion to identify SLR-XA's across the state for up to 3.2 feet of SLR (www.hawaiisealevelriseviewer.com).

The Web Explorer also incorporates data from the National Oceanic and Atmospheric Administration (NOAA) SLR Viewer (https://coast.noaa.gov/slr/), which identifies areas impacted by 6+ feet of SLR. The six foot level can be used for siting or designing critical infrastructure or projects with a lifespan of 50 or more years.

→ *How to Use the Climate Ready O'ahu Web Explorer:*

Explore the map by zooming around or searching by address or Tax Map Key (TMK), and investigate which areas of the island are projected to be at risk of flooding (due to SLR and/or rainfall) and extreme heat (due to rising temperatures and the urban heat island effect).

Different layers can be turned on or off and expanded in the Layers tab (stacked papers icon). Some layers require zooming in to view and take longer to load. Additional map resources, information, and metadata are available on the Details tab (information "i" icon in circle).

Scan here to explore the Climate Ready O'ahu Web Explorer

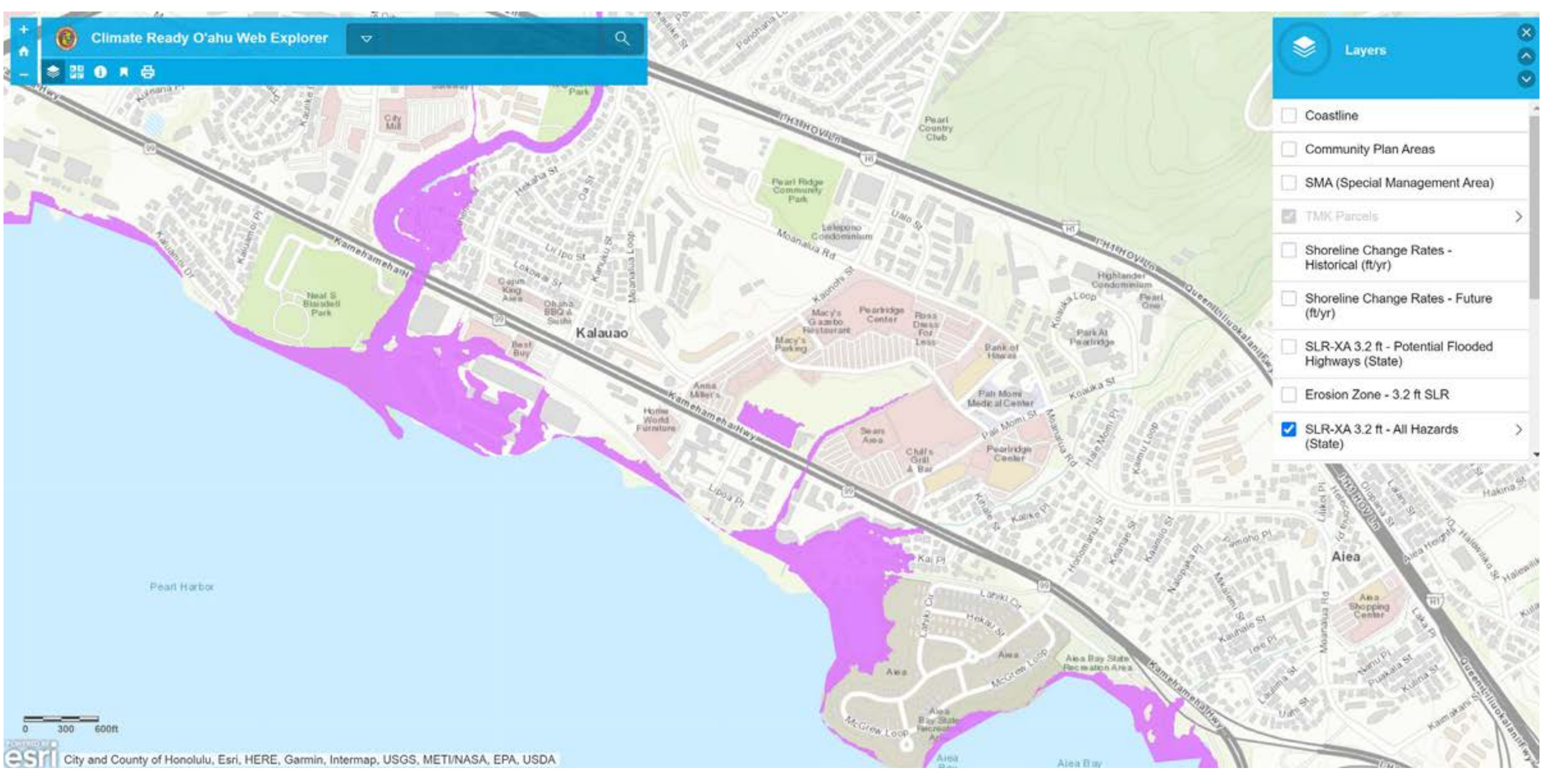
bit.ly/climatereadyoahumap

→ *Data Available on the Climate Ready O'ahu Web Explorer :*

- *SMA (Special Management Area)*
- *TMK Parcels*
- *Shoreline Change Rates (ft/yr); historical & future*
- *SLR-XA 3.2 ft - Potential Flooded Highways (State)*
- *Erosion Zone - 3.2 feet SLR*
- *SLR-XA 3.2 ft - All Hazards (State); includes passive flooding, annual high wave flooding, & coastal erosion*
- *Oahu Digital FIRM*
- *SLR 6 ft (NOAA)*
- *Heat Index - Afternoon*
- *Tree Canopy - Land Cover (2010)*

Climate Ready O‘ahu Web Explorer - Urban Honolulu with 6 feet SLR-XA

Climate Ready O‘ahu Web Explorer - Aiea, TMK view with 3.2 feet SLR-XA



B: Managing Stormwater

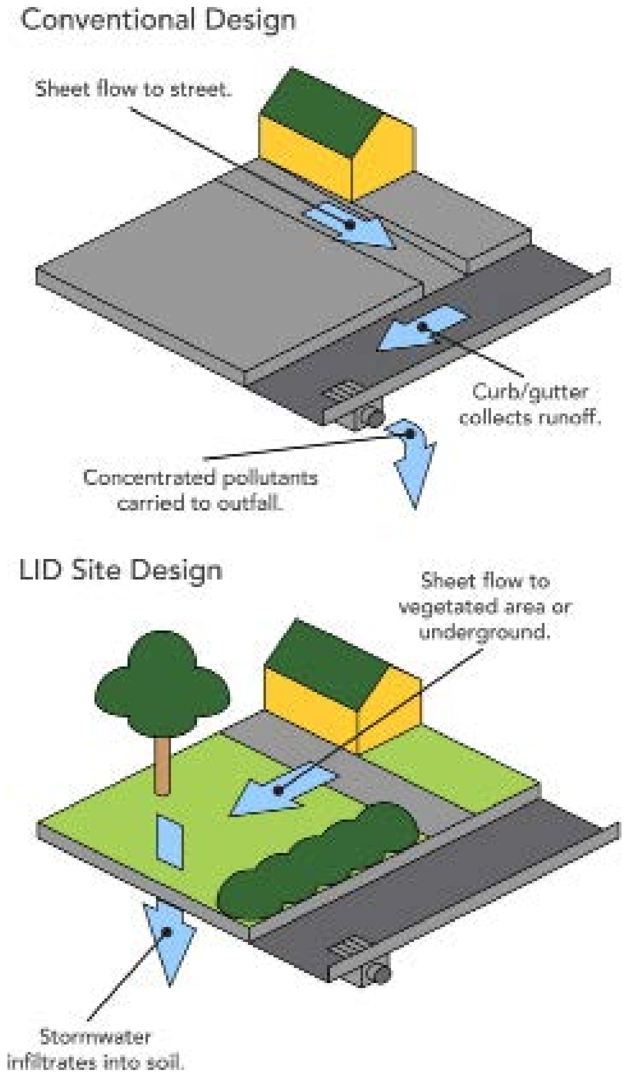
Climate change is expected to increase the frequency and intensity of storms in Hawai'i, making stormwater management a key concern for resilient site design. In addition to complying with existing rules, the following are recommended strategies for managing stormwater:

- Minimize impervious surfaces in site design;
- Adopt strategies to infiltrate, evaporate, and reuse rainwater;
- Utilize LID and green infrastructure strategies that increase detention and manage the rate of stormwater flow; and
- Install stormwater infiltration, detention, and storage.

Specific examples of LID and green infrastructure technologies include bioswales, rain gardens, rainwater harvesting for reuse, green roofs, blue roofs, living walls, and detention basins or tanks. Trees and pavement suspension technologies or structural soils can also manage rainwater in dense urban environments.

The City Storm Water BMP Guide for New and Redevelopment (2019) provides details on post-construction measures that can be integrated into building design. An appendix to the BMP Guide is currently under development that will provide more detailed specifications and guidelines for LID features, including infiltration basins and trenches, vegetated bioretention basins, permeable pavement and pavers, vegetated swales, biofilters, and buffer strips.

→ *Collect, Slow, and Infiltrate Stormwater with Green Infrastructure and LID*

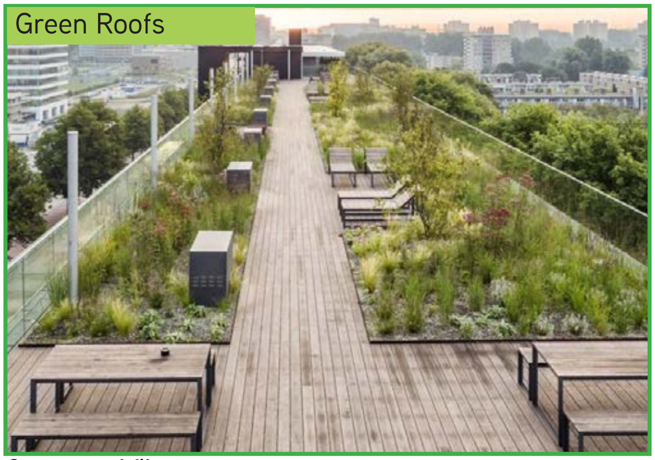


Source: City and County of Honolulu. "Post-Construction Water Quality Rules"

Scan here for info on Post-Construction BMPs

www.honolulu.gov/rep/site/dfm/Post_Construction_WQR_July_2019_booklet.pdf

→ Green Infrastructure/LID Examples



Capture and filter stormwater

Source: Hans van Heeswijk Architecten. "Rooftop Garden". Amsterdam, Netherlands.

Temporarily store rainwater in detention systems

Source: Flickr.com. "Green Infrastructure Pilot Projects in NY". New York.

Help to filter stormwater before it enters the storm drain

Source: Hawaiilife.com. "Living Walls are Becoming Popular in Honolulu". Ala Moana Center.

Store and collect rainwater as well as filter overflow

Source: Behance.net. "Rain Garden Display Panel". Kailua.

Store rainwater that can be reused for irrigation and indoor non-potable uses following plumbing codes

Source: Artspace.org. "Olas Ka'ilima Artspace Lofts". Honolulu.

Capture water in place while filtering it and potentially replenishing aquifers

Source: Google Maps. "Street View Kapiolani Park". Honolulu.

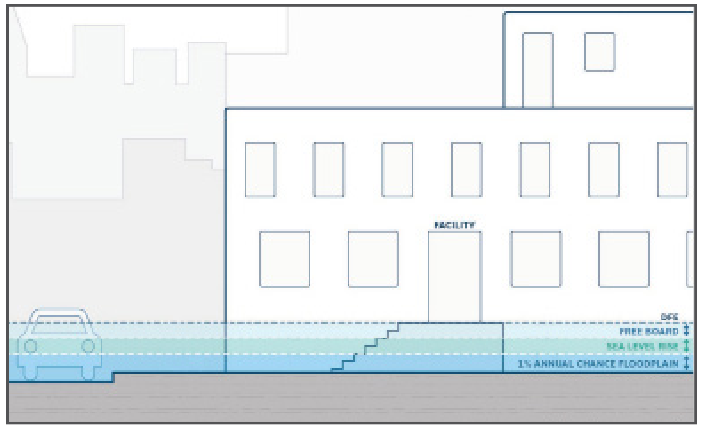
C: Design for Flooding and Sea Level Rise

Land use and zoning regulations for where and how development occurs are some of the primary tools to mitigate against the impacts of direct and permanent SLR and groundwater inundation (e.g., the extent to which development may be allowed in hazardous areas). Additionally, to mitigate and protect against future event-based flooding, municipalities are exploring *Design Flood Elevations* (DFE) that require building for greater inundation as a result of SLR and/or more extreme rainfall events. This concept uses BFE from *Federal Emergency Management Agency's Flood Insurance Rate Maps* (FEMA FIRM), plus freeboard and other risk factors to account for greater inundation.

In addition to compliance with existing regulations, such as ROH Chapter 21A Flood Hazards Areas and ROH Chapter 16 Building Code, anything below DFE/BFE should be floodproofed and designed to withstand loads from projected flooding. Sensitive uses and equipment, such as power systems and residential units, should be elevated above the ground floor or DFE/BFE. Utility connections below the DFE/BFE, and underground utilities within areas subject to groundwater inundation, should be waterproofed as well as account for a transition to future elevated streets.

For larger flooding events, sites can also be designed to include features that provide both function and flood retention, such as floodable parking structures and plazas, or wetland areas that can accommodate greater flows. Likewise, on-site rainwater harvesting can be used for the dual benefit of flood mitigation and water conservation.

→ *Elevating with Freeboard and DFE*

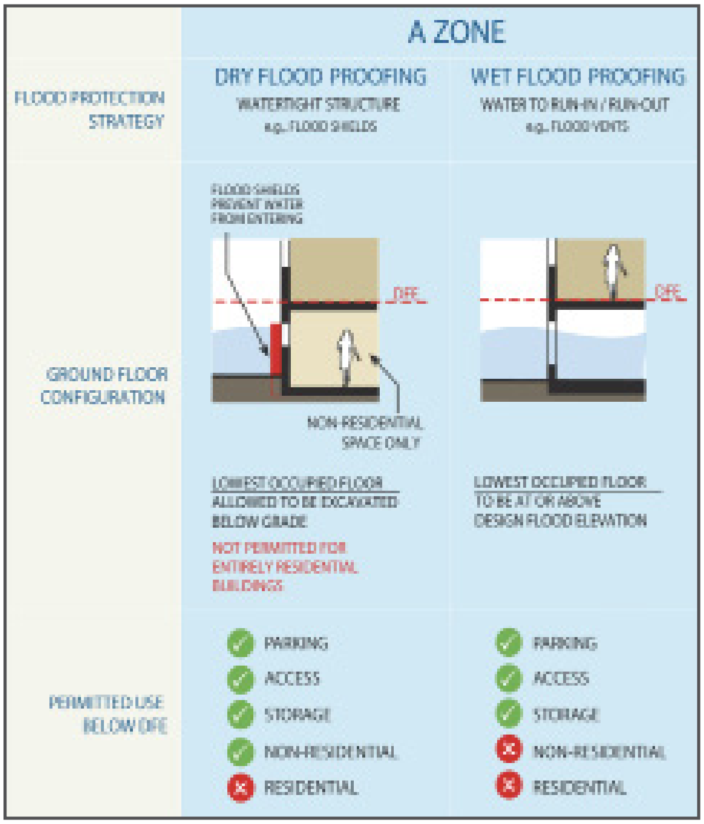


Source: NYC Mayor's Office of Recovery and Resiliency. "Climate Resiliency Design Guidelines".

→ *Raised Building Transitions to Pedestrian Zones*

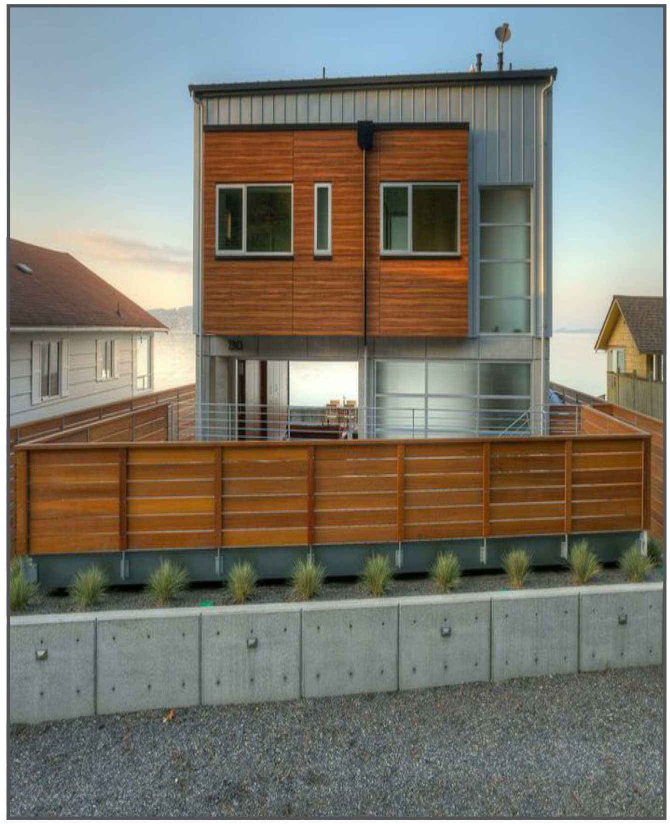
Source: DP Architects. Wisma Atria. Singapore.

→ *Dry Floodproofing, Wet Floodproofing, and Elevated Floodproofing*



The difference between dry floodproofing and wet floodproofing

Source: City of New York. "Coastal Climate Resilience: Designing for Flood Risk".

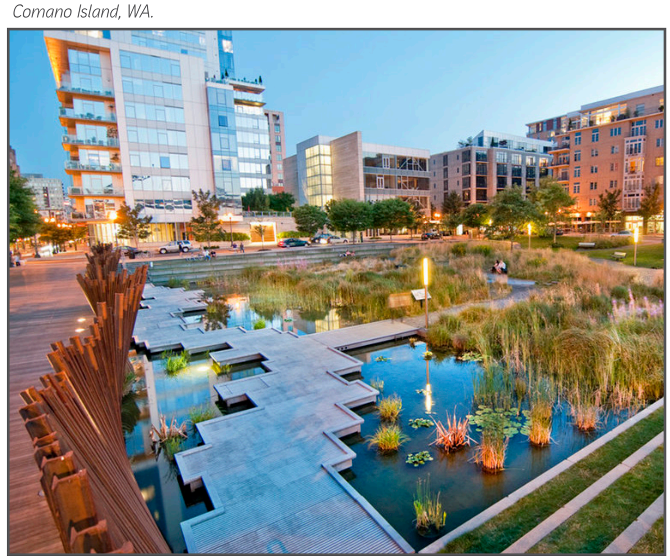


Dry floodproofed townhome

Source: Smithsonianmag.com. "This House is Built to Withstand the Force of a Tsunami". Comano Island, WA.

Ground floor windows designed to withstand high water pressures with steel bulkheads

Source: Flooddefences.org. "Germany, Hamburg". Hafen City, Hamburg.



Wetland character stormwater retention park

Source: Greenworkspc.com. "Tanner Springs Park". Portland, OR.

D: Mitigating Extreme Heat

As the atmosphere warms, Hawai'i can expect more record high temperatures and heat waves, which bring associated threats to human and environmental health. Design recommendations to mitigate extreme heat include:

- Providing shade through trees, awnings, or canopies;
- Using high solar reflectance building materials and colors for windows, pavements, and coatings, within acceptable local ordinances. (See ROH Chapter 21 Land Use Ordinance for special districts design details and requirements);
- Promoting landscaping on rooftops and around buildings for cooling; and
- Designing common outdoor areas with shade, seating, shelters at bus stops, and other amenities.

Trees are long-term green infrastructure features with a recognized and substantial return on investment. An urban tree canopy offers multifaceted benefits, including heat mitigation, carbon sequestration, stormwater management, improved air quality, energy savings, and business enrichment.

Scan here for the O'ahu Community Heat Map

bit.ly/oahuheatmap

→ Design Recommendations to Mitigate Extreme Heat

Urban Tree Canopy

Source: Honolulu Civil Beat. "Bringing Order to Design Chaos at Manoa". Honolulu.

Landscaping and Vegetation

Source: City and County of Honolulu. "Design Guidelines: Transit-Oriented Development". Honolulu.

Awnings

Source: City and County of Honolulu. "Design Guidelines: Transit-Oriented Development". Honolulu.

Living/Green Walls

Source: City and County of Honolulu. "Design Guidelines: Transit-Oriented Development". Honolulu.

Solar Reflective Roofing Building Materials

Source: Coolroofstore.net. "The Cool Roof Store Hawai'i". Honolulu.

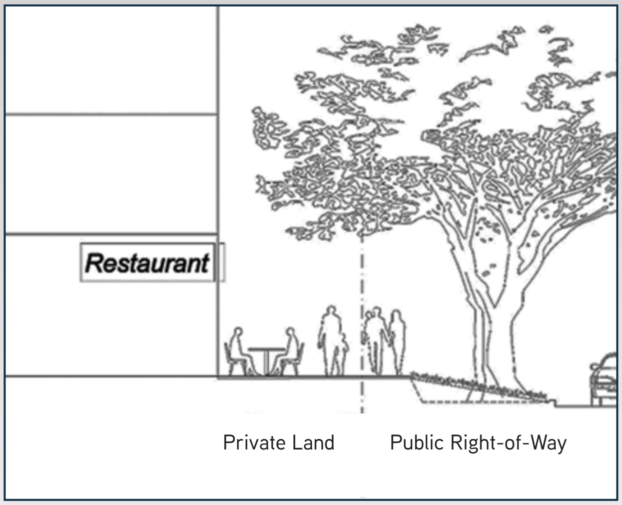
Three Common Typologies for

Resilient Buildings & Site Design

This guidance provides resilient design recommendations for three building typologies that are representative of existing and new development in urban Honolulu:

1: Tower & Podium | 2: Mid-Rise | 3: Low-Rise Walk-Up

The following section includes graphics and descriptions showing common features of each building typology and applicable best practices for resilient design, with an emphasis on building-scale urban design solutions and principles for streetscape transition zones. Many of the design solutions described for one building type can be used for other building types and uses.



Example of Desired Resilient Streetscape Transition Zone
Source: City and County of Honolulu. "Transit-Oriented Development and Green Infrastructure".

Scan Here for the ADA Accessibility Guidelines

www.access-board.gov/guidelines-and-standards/buildings-and-sites/about-the-ada-standards/background/adaag

Resilient Streetscape Transition Zone

The Resilient Streetscape Transition Zone is the area between the street curb and building façade, providing for an accessible slope up to the building's required BFE or DFE (until adjacent streets and other properties are raised to same level). This zone should mitigate the impact of the elevation change on the public realm by including amenities such as flood-resistant plantings, sidewalks, seating, trees, awnings, and other placemaking elements or design considerations.

This zone typically transcends from the project site into the public right-of-way (ROW), and also interfaces with adjoining properties. Consequently, these principles will require public and private landowner collaboration, including partnerships and agreements over construction and maintenance responsibilities, to plan a coherent street block and pedestrian streetscape that minimizes the impacts of hills/valleys and off-site drainage.

As all improvements must comply with existing regulations and standards, including the Americans with Disabilities Act (ADA) Accessibility Guidelines, certain modifications will likely need to be considered.

→ *REPRESENTATIVE BUILDING TYPOLOGIES*

1. TOWER & PODIUM

2. MID-RISE

3. LOW-RISE WALK-UP

Sources: 1. TOD. "Keahou Place". Honolulu, HI.
2. "Redfin Estimate for 400 Keawe". Honolulu, HI.
3. TOD. "Low-Rise Façade". Honolulu, HI.

1: TOWER & PODIUM

Description

The Tower & Podium building typology is a commercial or residential tower constructed over a multi-level, mixed-use podium structure. On large lots, tower height ranges from eight to 40 or more stories with residential and/or commercial uses. A three- to seven-story podium base typically contains retail, residential, recreational, building lobby space, or some combination of these uses.

The tower's scale and density are mitigated by façade stepbacks and building articulation. The podium is designed to be of pedestrian scale with a high degree of ground floor transparency. Exposed portions of any structured parking provided in the podium base are wrapped by residential floors or retail development, or screened from view by landscaping or decorative mesh.

The Resilient Streetscape Transition Zone includes flood-resistant landscaping, pedestrian amenities, shade structures, and paths for use by the building tenants and the general public.

The building is typically located along a high-volume "complete street" that provides equitable access to the development and balances transport modes, with emphasis on active mobility, including walking and bicycling.

Key Climate Resilient Design Guidelines

1. Provide amenity-rich Resilient Streetscape Transition Zone, which includes saltwater tolerant plantings, flood damage-resistant landscape materials, and green infrastructure.

2. Provide shade structures in the Resilient Streetscape Transition Zone and wide tree canopy in the planter strip zone between the road and sidewalk.

3. Provide sustainable roof systems, such as blue-green roofs, energy producing roofs, and reflective roofs. These systems can mitigate heat island effect; capture, treat, provide on-site reuse, and release stormwater; generate solar energy; and provide space for urban gardening and tenant amenities.

4. Locate critical systems above the BFE or DFE (on roof and/or on intermediate floors), including heating, ventilation, and air conditioning (HVAC) and power generators.

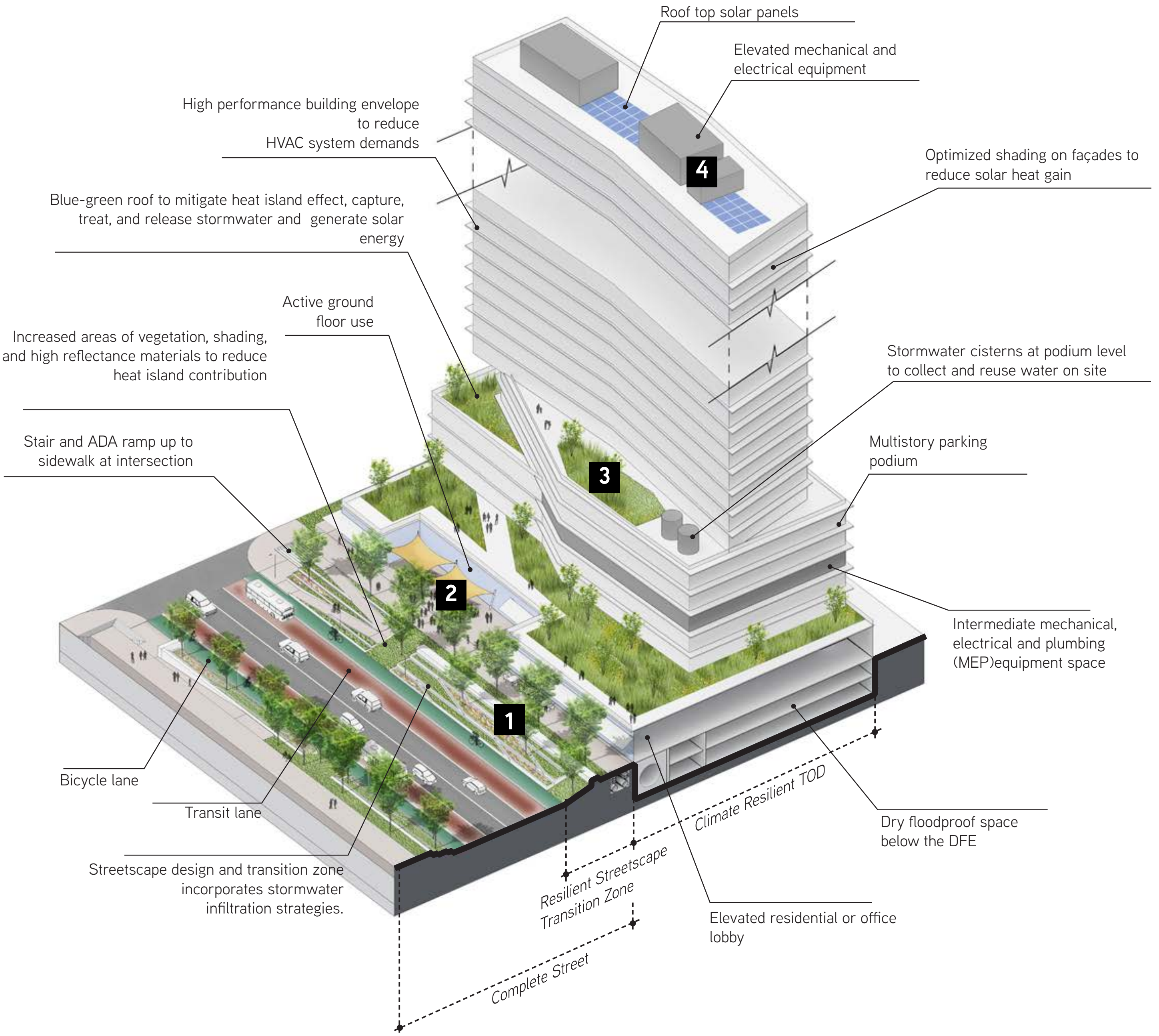
1


2

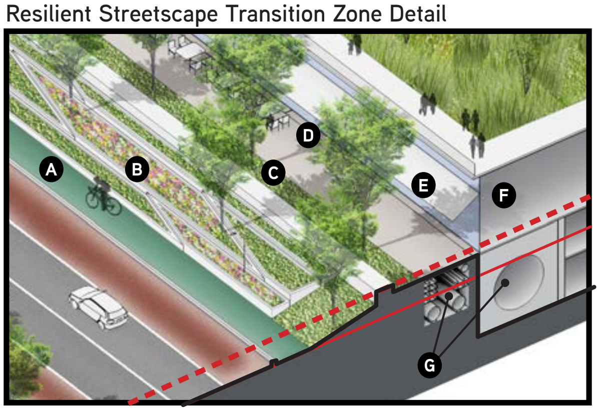

3


4


Sources: 1. Studio DWG. "Pedestrian Pocket Patio". Austin, TX.
2. Asla.org. Urban Grove at Central Harf Plaza, Boston, Charles Mayer Photography.
3. Unknown. "Rooftop Garden". Singapore.
4. www.thomasnet.com/insights/how-cities-are-driving-growth-in-the-green-roofing-market



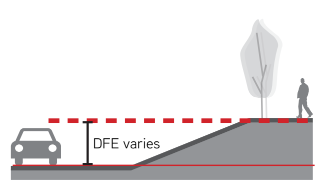
Resilient Streetscape Transition Zone Detail



All Resilient Transition Zones must be ADA compliant

Design Flood Elevation

Standard Design Elevation



- **A** Bike Lane
- **B** Transitional planters
- **C** Tree lawn
- **D** Street furniture
- **E** Active ground floor use
- **F** Raised ground floor
- **G** Supporting Infrastructure

2: MID-RISE

Description

The Mid-Rise building typology is a four- to seven-story building that typically contains residential units above active ground floor uses, such as a lobby or retail space, that is visually and physically accessible from the public ROW. Residential units may be provided on the ground floor of the building. If off-street parking is provided, it is obscured from the public ROW, such as a parking structure wrapped by residential floors or sited at the back of the lot.

Typical layouts for Mid-Rise buildings include rectangular, U-shaped, L-shaped, and perimeter building forms with internal courtyards and green roofs. Flood resilient features, such as green infrastructure, saltwater tolerant plantings, and flood damage-resistant landscape materials, are provided within the Resilient Streetscape Transition Zone. These features allow for a welcoming forecourt to the building's ground floor. The building is normally located along a "complete street" that provides equitable access to the development and balances transport modes, with emphasis on active mobility, including walking and bicycling.

Key Climate Resilient Design Guidelines

1. Provide an amenity-rich Resilient Streetscape Transition Zone, which should include saltwater tolerant plantings, flood damage-resistant landscape materials, and green infrastructure.

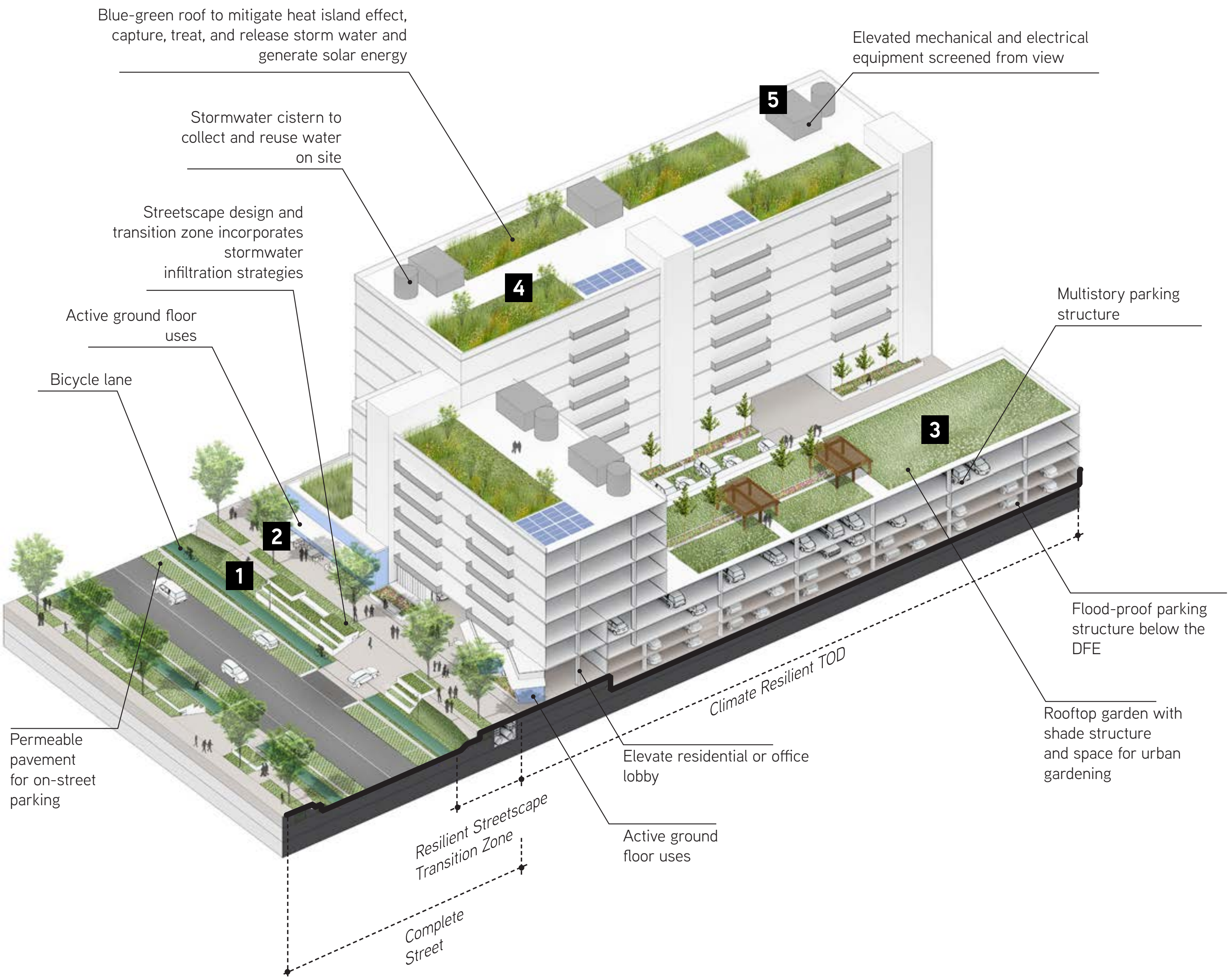
2. Provide landscaped surfaces, wide canopy trees, and shade structures, such as over seating areas, to mitigate the heat island effect.

3. Provide sustainable roof systems, such as blue-green roofs, energy producing roofs, and reflective roofs. These systems can mitigate heat island effect; capture, treat, provide on-site reuse, and release stormwater; generate solar energy; and provide space for urban gardening and tenant amenities.

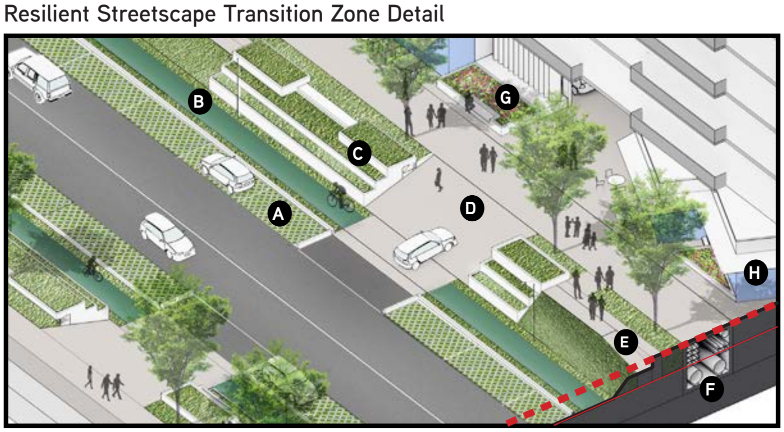
4. Provide systems for on-site water reuse, which can aid in water conservation and flood mitigation through rainwater capture. Cisterns at the podium level can irrigate on site and in the Resilient Streetscape Transition Zone.

5. Locate critical systems above BFE or DFE (on the roof or intermediate floors), including HVAC and power generators.

Sources: 1. Townshend Landscape Architects. "Sidewalk". London, UK.
2. TOD. "South Shore Market". Honolulu, HI.
3. Hans van Heeswijk Architecten. "Rooftop Garden". Amsterdam, Netherlands.
4. Andrew Neuman. "Ola Ka 'Ilima Artspace Lofts". Honolulu, HI.
5. Finegardening.com. "Outtakes from a Rooftop Garden".

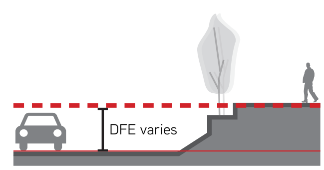


Resilient Streetscape Transition Zone Detail



Design Flood Elevation

Standard Design Elevation



- **A** Permeable pavement
- **B** Bike lane
- **C** Transitional landscape
- **D** Parking entrance
- **E** Barrier-free ADA ramp up to sidewalk from intersection
- **F** Supporting infrastructure
- **G** Planters with seating
- **H** Active ground floor use

All Resilient Transition Zones must be ADA compliant

3: LOW-RISE WALK-UP

Description

The Low-Rise Walk-Up building typology is an attached, two- to four-story multi-family residential building. The first floor is built several feet above the BFE or DFE, allowing for an additional layer of privacy and the option of parking underneath. The building has a relatively shallow setback from the street edge, which provides space for pedestrian access and flood-resilient features in the Resilient Streetscape Transition Zone, such as green infrastructure, saltwater tolerant plantings, and flood damage-resistant landscape materials. Blue/green roofs can provide additional green space for urban gardening, aesthetics, heat management, and rain catchment for irrigation.

If off-street parking is provided, it is either sited at the rear of the development or as an integrated "tuck-under" parking garage, and not prominently viewed from the public ROW. Access to the parking may be provided by a mid-block driveway or alley behind the development.

The building is typically located along a local street with relatively low traffic volumes. These streets could have a travel lane in each direction, pedestrian and bicycle infrastructure, and on-street parking.

Key Climate Resilient Design Guidelines

1. Provide a Resilient Streetscape Transition Zone. Include saltwater tolerant plantings, flood damage-resistant landscape materials, and green infrastructure.

2. Provide building façade enhancements with street trees and other green elements to soften or screen parking from public view.

3. Provide wet floodproofed basement or storage area below BFE or DFE.

4. Site critical mechanical and electrical systems on the roof, including HVAC and power generators. Visually screen mechanical equipment from view with landscaping and/or decorative fencing.

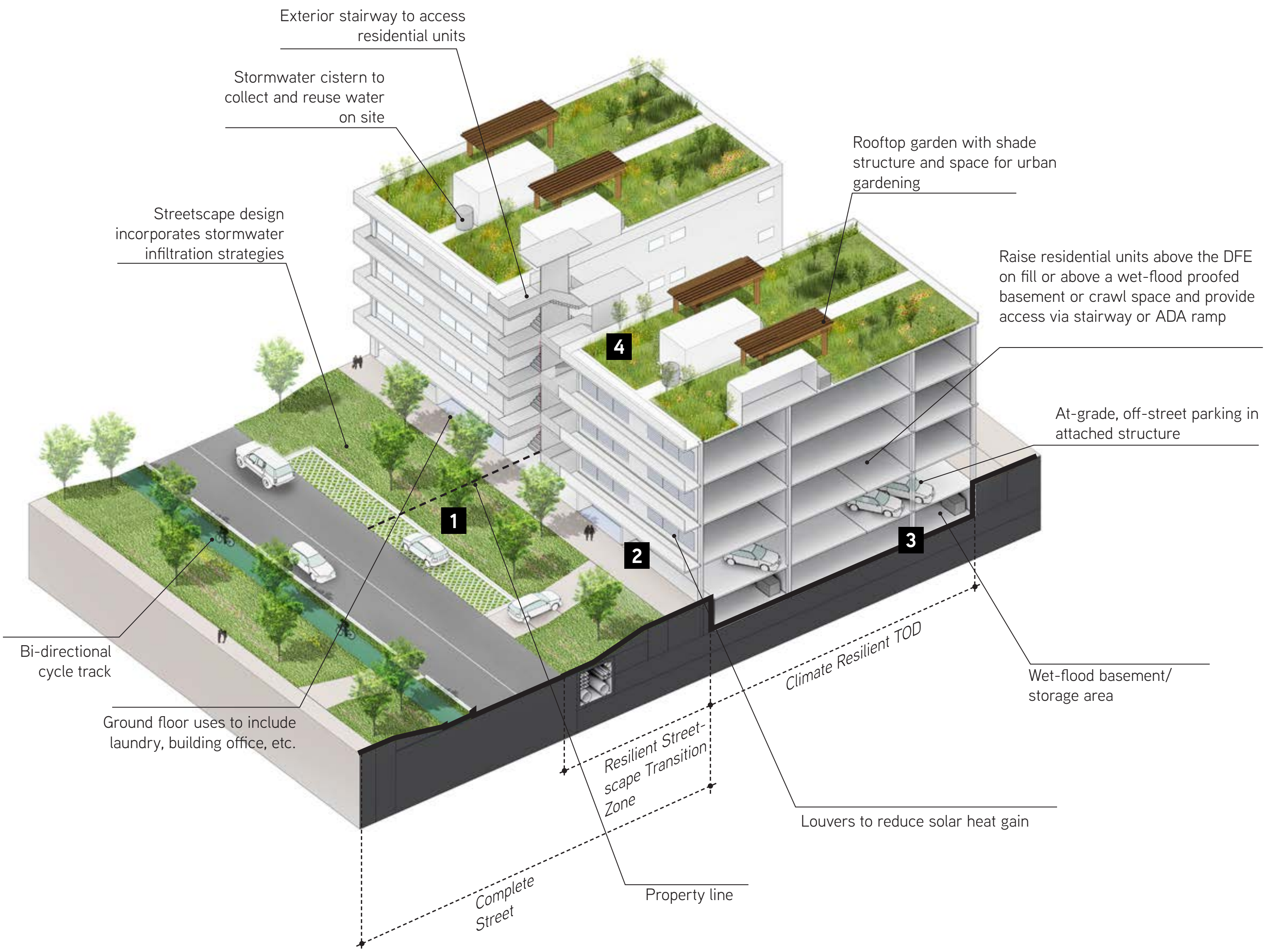
1


2

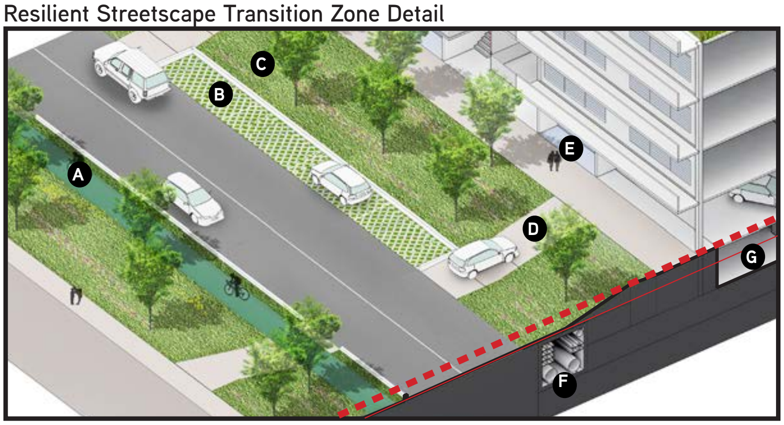

3


4


Sources: 1. Taylor Cullity Lethlean with Wright + Associates. "Rain Garden". Auckland, New Zealand.
2. TOD. "Low-Rise Façade". Honolulu, HI.
3. Indianafoundation.com. "Crawl Space Dehumidifier".
4. Dilkhush Landscaping. "Rooftop Garden". New Dehli, India.



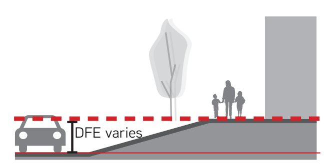
Resilient Streetscape Transition Zone Detail



All Resilient Transition Zones must be ADA compliant

Design Flood Elevation

Standard Design Elevation



- **A** Cycle track
- **B** Permeable pavement
- **C** Transitional landscape
- **D** Parking entrance
- **E** Building lobby or office use to promote active frontage
- **F** Supporting infrastructure
- **G** Wetflood proofed storage space/basement

Relevant Links & Resources

CODES & ZONING

Hawai'i State Building Code (2012 International Building Code). (2018). Available from: https://ags.hawaii.gov/wp-content/uploads/2012/09/buildingcode-20170918.pdf

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ROH Chapter 16: Building Code. (2020). Available from: www.honolulu.gov/rep/site/ocs/roh/ROH_Chapter_16a1_vb__.pdf

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ROH Chapter 23: Shoreline Setbacks. (N.D.). Available from: www.honolulu.gov/rep/site/ocs/roh/ROH_Chapter_23__.pdf.pdf

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Climate Change Brief. (2018). Climate Change Commission. Available from: www.resilientoahu.org/s/Climate-Change-Brief.pdf

Guidance on Revisions to the Revised Ordinance of Honolulu Chapter 23, Regarding Shoreline Setbacks. (2019). Climate Change Commission. Available from: https://resilientoahu.org/climate-change-commission

Ola: O'ahu Resilience Strategy (2019). City and County of Honolulu, Resilient O'ahu, 100 Resilient Cities. Available from: https://resilientoahu.org/resilience-strategy

Sea Level Rise & Climate Change White Paper. (2018). Sea Grant University of Hawai'i. Available from: https://cc3cbeb5-ec5a-4085-a604-bf234e6332b7.filesusr.com/ugd/e3bef4_895ce35390524667926439 5f47f764ef.pdf

Sea Level Rise Guidance. (2018). Climate Change Commission. Available from: https://static1.squarespace.com/static/5e3885654a153a6ef84e6c9c/t/5ef121c353bdf278e3e4d253/1592861125312/FINAL+ADOPTED+w_rev_+Sea+Level+Rise+Guidance+2018.pdf

CLIMATE HAZARDS

Assessment of Groundwater Inundation as a Consequence of Sea Level Rise. (2012). Rotzoll, K., Fletcher, C. Available from: www.nature.com/articles/nclimate1725

Assessing the Feasibility and Implications of Managed Retreat Strategies for Vulnerable Coastal Areas in Hawai'i. (2019). Office of Planning, Coastal Zone Management Program, State of Hawai'i. Available from: https://files.hawaii.gov/dbedt/op/czm/ormp/assessing_the_feasibility_and_implications_of_managed_retreat_strategies_for_vulnerable_coastal_areas_in_hawaii.pdf

Hawai'i Sea Level Rise Viewer. (2017). Pacific Islands Ocean Observing System. Available from: www.pacioos.hawaii.edu/shoreline/slr-hawaii/

Hawai'i Sea Level Rise Vulnerability and Adaptation Report. (2017). Tetra Tech; DLNR; Office of Conservation and Coastal Lands. Available from: https://climateadaptation.hawaii.gov/wp-content/uploads/2017/12/SLR-Report_Dec2017.pdf

Multi-Hazard Pre-Disaster Mitigation Plan for The City & County of Honolulu. (2019). Department of Emergency Management. Available from: www.honolulu.gov/dem/resources/disaster-info

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Complete Streets Design Manual. (2016). City and County of Honolulu. Available from: www4.honolulu.gov/docushare/dsweb/Get/Document-187742/160908%20Honolulu%20Complete%20Streets%20Design%20Manual_Final.pdf

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Green Infrastructure for Homeowners. (2012). City and County of Honolulu. Available from: https://www.honolulu.gov/rep/site/dfm/green_infrastructure_homeowners.noENV.pdf

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Oʻahu Community Map. (2019). Office of Climate Change, Sustainability, & Resiliency. Available from: http://cchnl.maps.arcgis.com/apps/View/index.html?appid=ff1b73d836074cf6b2aca420fffbd930

Rules and Regulations Relative to Planting and Maintenance of Street Trees. (1971). Department of Parks and Recreation. City and County of Honolulu. Available from: www.honolulu.gov/rep/site/dpr/rules/Rules_Trees_Street.pdf

Trees for Hawaiʻi's Future Website. (N.D). Available from: www.treesforhonolulu.org/

Urban Reforestation Master Plan. (2006). City and County of Honolulu. Available from: https://resilientoahu.org/trees/learn-more

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Urban Tree Canopy Report. (2013). U.S. Department of Agriculture. Available from: https://smarttreespacific.org/wp-content/uploads/Tree-Canopy-Report-Honolulu-2016_revised091117.pdf

TOD DESIGN GUIDANCE AND NEIGHBORHOOD PLANS

Ala Moana Neighborhood TOD Plan. (2016). City and County of Honolulu. Available from: www.honolulu.gov/tod/neighborhood-tod-plans/dpp-tod-alamoana

Aiea-Pearl City Neighborhood TOD Plan. (2016). City and County of Honolulu. Available from: www.honolulu.gov/tod/neighborhood-tod-plans/dpp-tod-aiea-pearlcity

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Definitions

- **Base Flood Elevation, or BFE,** is the computed elevation to which the flood is anticipated to rise during the base flood. The base flood is also referred to as the one-percent annual chance flood or 100-year flood.
- **Design Flood Elevation, or DFE,** refers to a base flood elevation that incorporates future SLR and flooding projections.
- **Federal Emergency Management Agency Flood Insurance Rate Map, or FEMA FIRM,** is described as "the official map of a community on which FEMA has delineated both the special hazard areas and the risk premium zones applicable to the community" (FEMA Flood Map Service Center, 2017). The FIRM is the basis for determining subsidies available to communities with floodplain management through the National Flood Insurance Program (NFIP).
- **Freeboard** is the elevation of a building's lowest floor above predicted flood elevations by a small additional height. Freeboard is not required by the NFIP standards, but local governments are encouraged to adopt at least a one-foot freeboard to account for the one-foot rise built into the concept of designating a floodway and the encroachment requirements where floodways have not been designated.
- **Right-of-Way, or ROW,** is a public path, road, or area of land that people are legally allowed to travel along.
- **Sea Level Rise Exposure Area, or SLR-XA,** is identified in the State of Hawai'i's Sea Level Rise Vulnerability and Adaptation Report. SLR-XA was developed based on modeling that combines anticipated impacts from passive flooding due to SLR, annual high wave flooding, and coastal erosion.

Stay Informed

If you have questions or comments on this document, please contact tod@honolulu.gov.

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