



Climate Adaptation and Transportation Planning

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UH is member of National Domestic Preparedness Consortium



ndptc.hawaii.edu



National Center



**Emergency Response
Surface Transportation**



Center for
Domestic
Preparedness



FEMA



National Domestic Preparedness Consortium

- **EMRTC** Explosive and incendiary attacks
- **NERRTC** Incident Management, EMS, Hazmat, Public Works, Threat and Risk Assessment, Senior Executive Programs
- **NCBRT** Prevention, deterrence and response to terrorist acts, chem-/bio-/ag-related terrorism response
- **CTOS** Prevention, deterrence and response to radiological/nuclear attacks
- **CDP** Prevention, deterrence and response to Chemical, biological and nuclear attacks involving hazmat
- **TTCI** Transportation research and testing organization, providing emerging technology solutions for the railway industry
- **NDPTC** Monitoring natural hazards, evaluating risks to urban populations and planning for the response, recovery and reconstruction of areas following a disaster.



UN Secretary General Ban-ki Moon

“The need to engage fully in *disaster risk reduction* has never been more pressing... Disaster risk reduction is about stronger **building codes**, sound **land use planning**, better **early warning systems**, **environmental management** and **evacuation plans** and, above all, **education**. Its about making communities and individuals aware of their risks and how they can reduce their vulnerability. We have a **moral, social, and economic** obligation to **act now** in building resilient communities...”

Risk-based Urban Planning

1. Where are the hazards located?
2. Where are assets located?
 - People
 - Jobs
 - Economic activity
 - Critical urban infrastructure
3. Vulnerabilities
 - susceptibility
 - coping capacity(Birkmann Framework)



NDPTC Training Courses



TSUNAMI AWARENESS AWR-217



This awareness-level course provides a basic understanding of tsunamis, hazard assessment, warning and dissemination, community response strategies to effectively reduce tsunami risk. No advanced knowledge and experience of tsunamis is required. The goal of this course is to enhance participants' abilities to support their organizational preparedness and response efforts.

Course modules cover science and assessment tools used to build tsunami resilient communities, the tsunami detection and warning process, and the products and methods used to warn all levels of government and coastal communities.

Effective response requires pre-event planning and preparation to ensure that the public knows what to do and where to evacuate to before destructive waves arrive, and that afterward, knows when it is all-clear and safe to return.

MODULES

- ✓ Science and Hazard Assessment
- ✓ Tsunami Warning
- ✓ Preparedness and Response
- ✓ Exercise Scenario
- ✓ Tsunami Mitigation

COURSE OBJECTIVES

- ✓ Explain differences between local and distant tsunamis
- ✓ Discuss what scientists learn from historic records and the importance of indigenous knowledge in tsunami preparedness
- ✓ Learn the purpose, scope, and goals of tsunami modeling
- ✓ Describe tsunami warning information and how tsunami warning centers work
- ✓ Describe the warning process and how it reaches "the last mile on the coast"
- ✓ Describe types of tsunami messages
- ✓ List tsunami hazard assessment tools and methodology and warning processes to preparedness and mitigation options
- ✓ Evaluate need for vertical evacuation
- ✓ Discuss techniques for outreach and education to increase public reaction to warnings
- ✓ Identify considerations for land use and site planning
- ✓ Summarize local and distant tsunami response and identify how to improve response
- ✓ Explain the impact of local and distant tsunamis to at-risk tsunami communities
- ✓ Use warning center messages in a scenario to identify community response actions
- ✓ Summarize the End-to-End Tsunami Warning System numerical modeling

TARGET AUDIENCE

- ✓ Governmental administrative
- ✓ Emergency management
- ✓ Fire service
- ✓ Coastal zone managers
- ✓ Planners/Developers
- ✓ Law enforcement
- ✓ Emergency medical services
- ✓ Hazardous materials personnel
- ✓ Public utilities
- ✓ Public health
- ✓ Non-government organizations

Min/Max Enrollment: 25/30
Hours: 8
Prerequisite: None



- Tsunami
- Coastal Resilience
- Coastal Flooding
- Hurricanes/Cyclones
- Volcanoes
- Social Media
- Senior Caregivers
- Security Professionals
- Community Leaders

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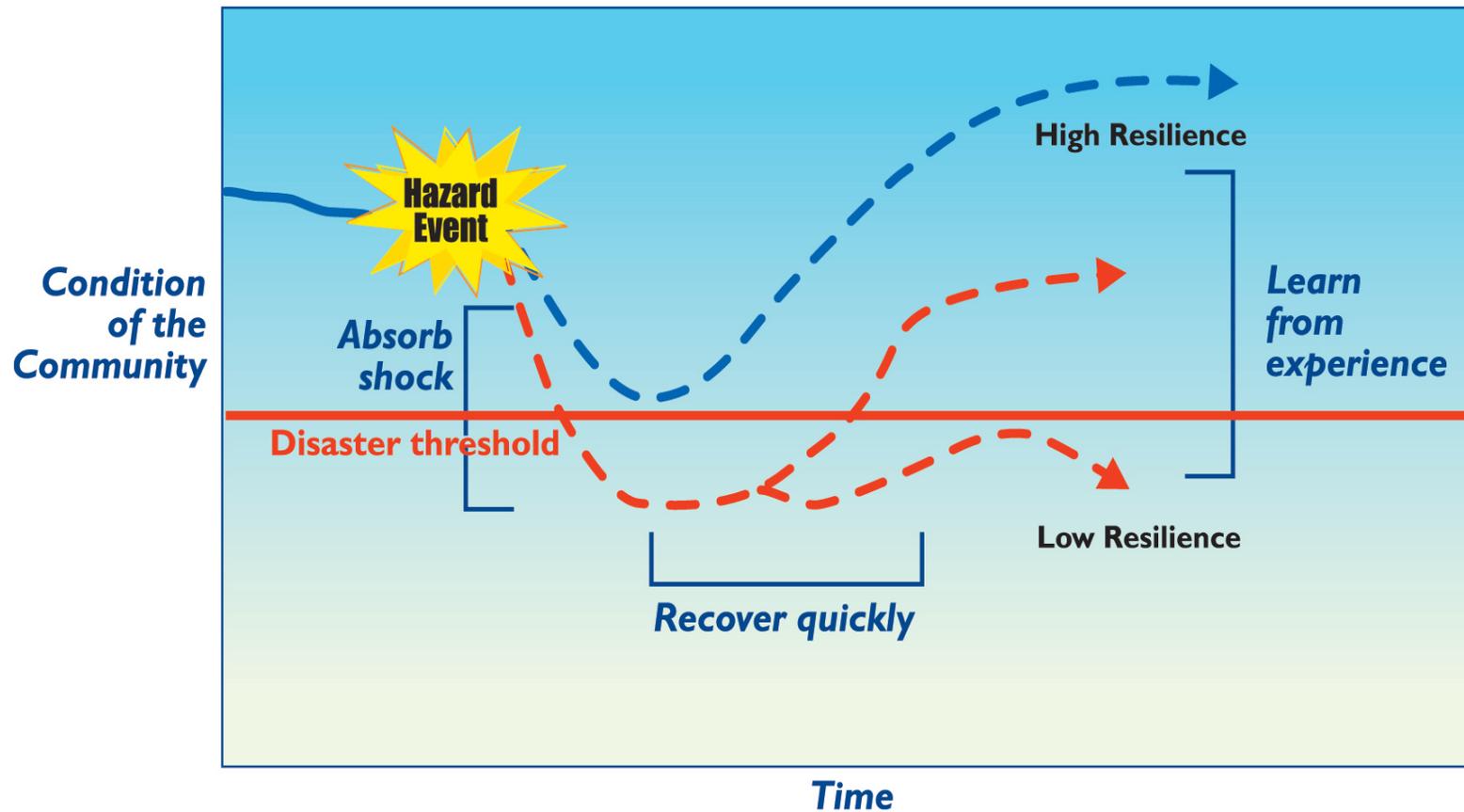


Overview

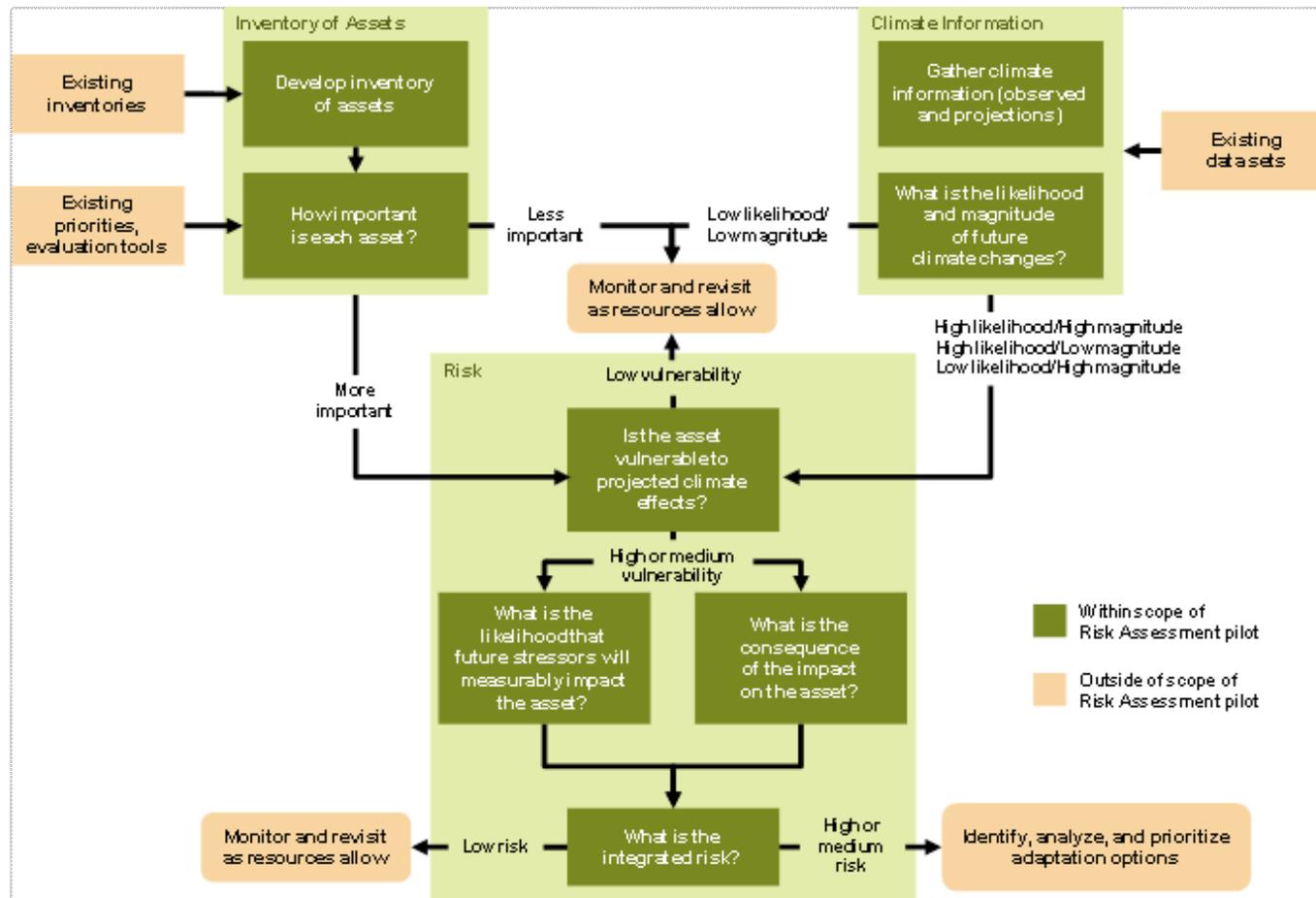


- 1. Climate and Transport**
- 2. Mitigation, Mitigation, Mitigation**
- 3. ADAPTATION**
- 4. Resiliency**
 - a. “Avoid the unmanageable”**
 - b. “Manage the unavoidable...”**

Coastal Community Resilience



Inventory->RISK<-Hazard



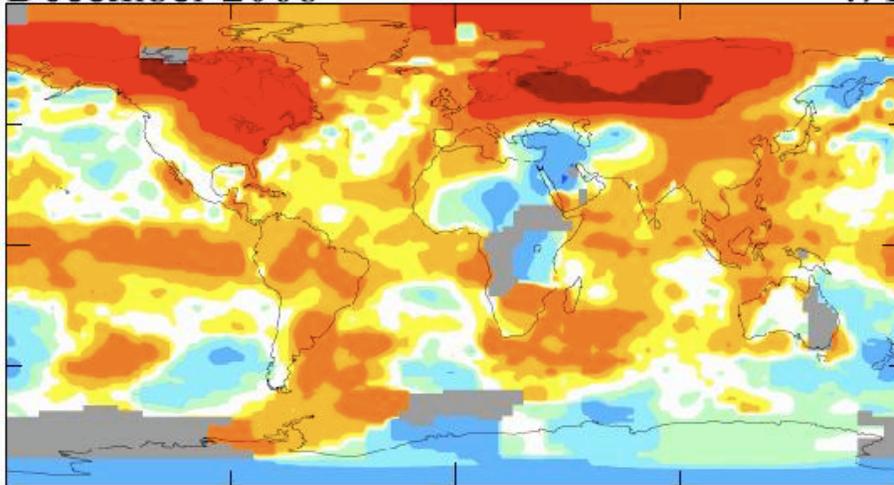
http://www.fhwa.dot.gov/hep/climate/conceptual_model62410.htm

Climate Change is *Unavoidable*

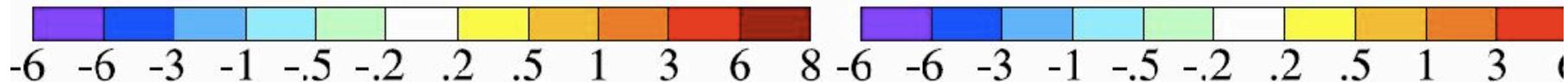
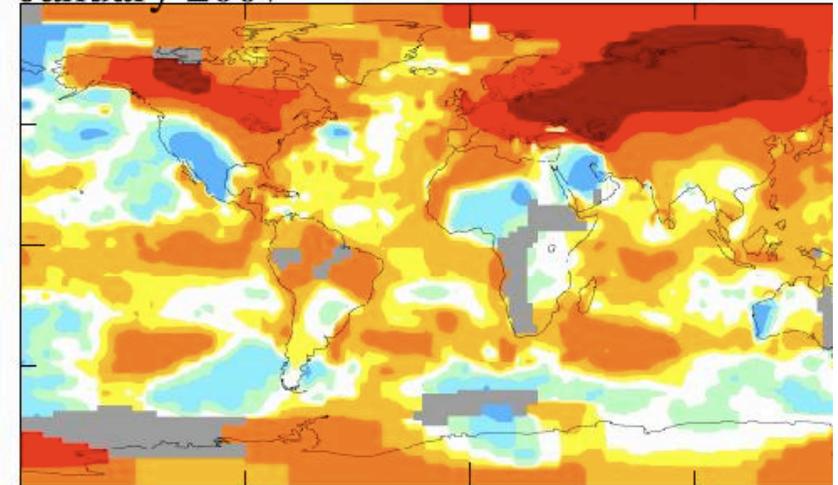
Surface Temperature Anomaly ($^{\circ}\text{C}$) [Base Period 1951-80]

December 2006

.71

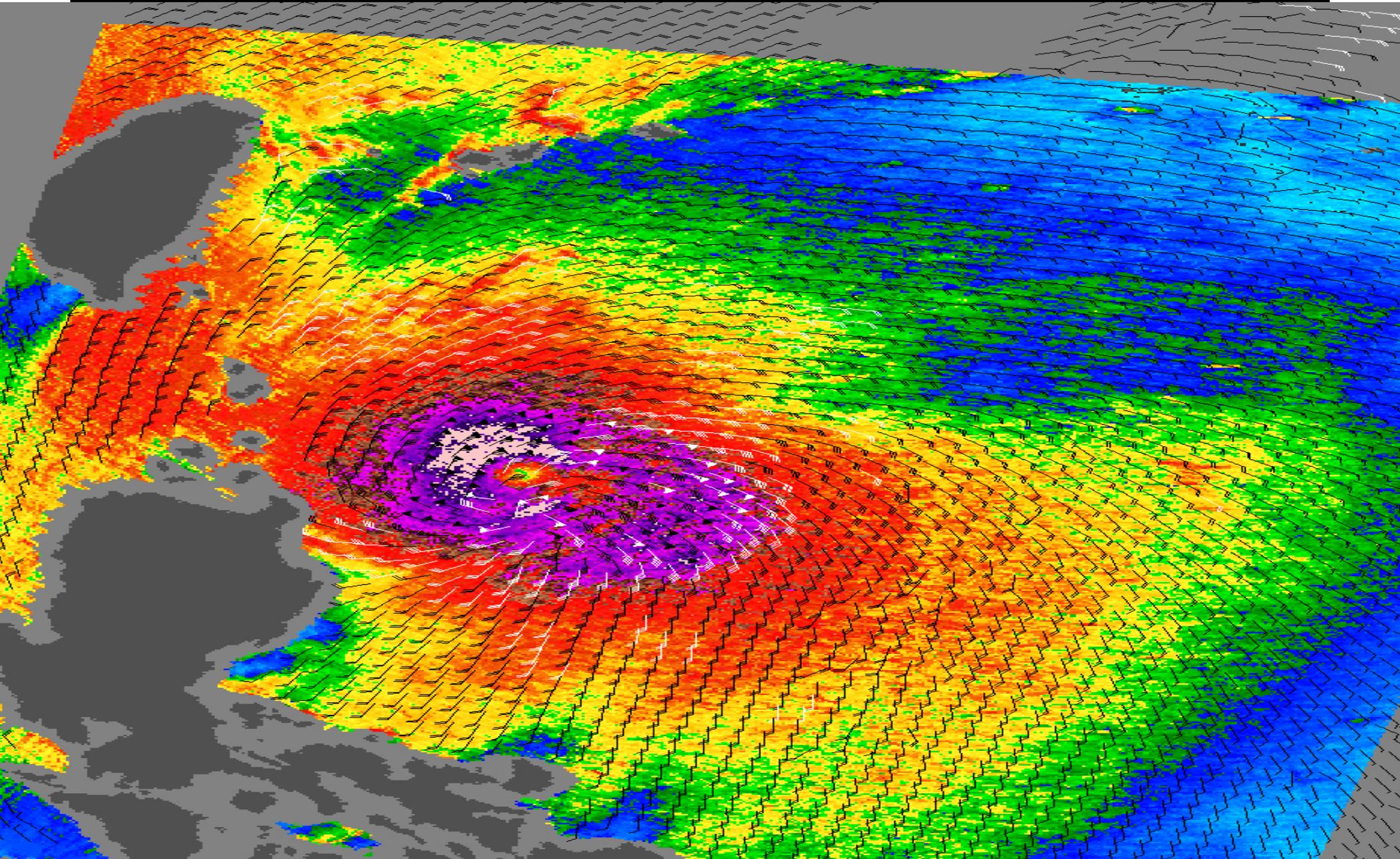


January 2007



December 2006 was the Warmest December on Record
and January 2007 was the Warmest January on Record.

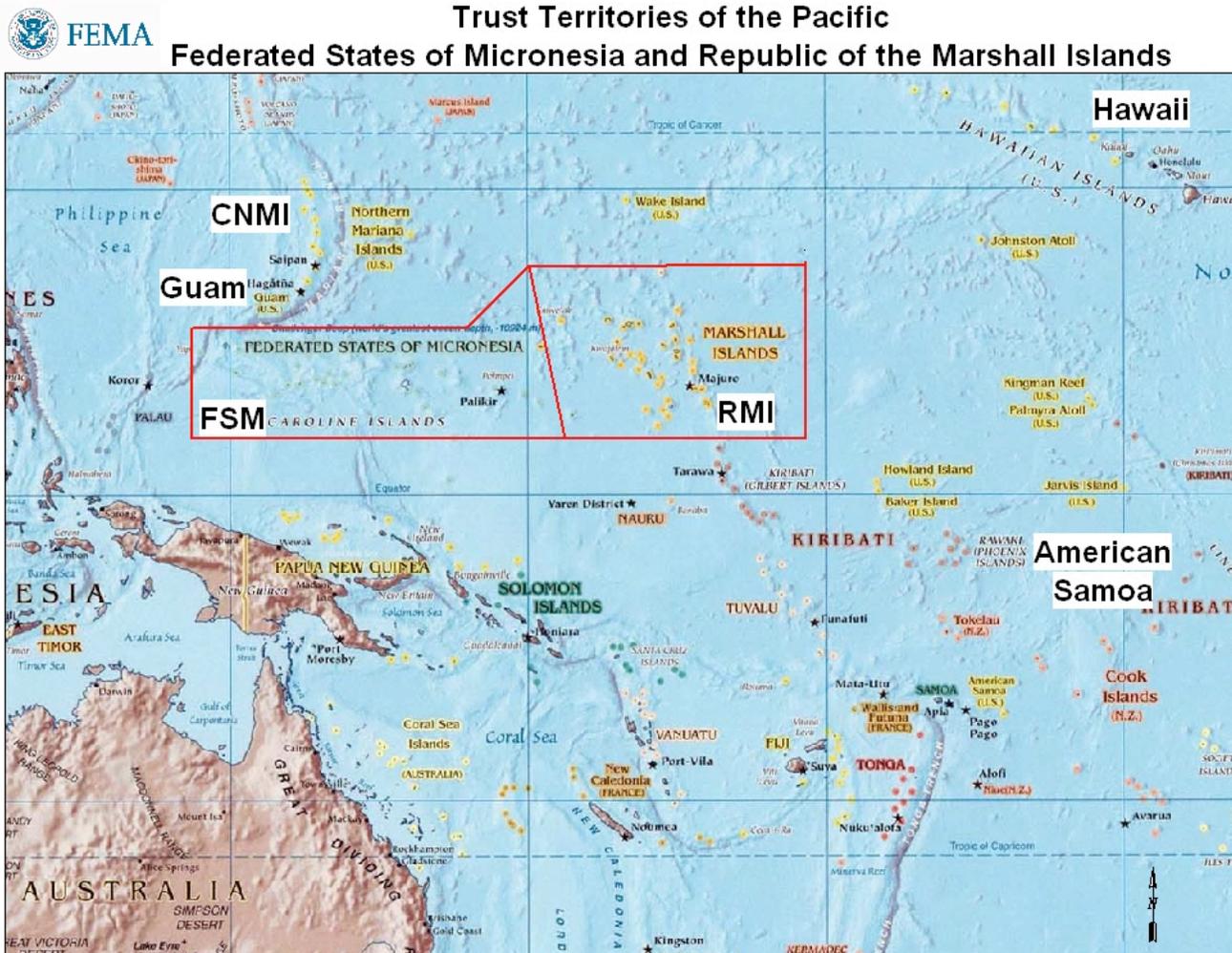
How to Manage the *Unavoidable*?



Impacts in the Pacific *are* Significant



Concerns Throughout the Region



Mitigation in Three Acts (Versions)



V1: *Mitigation of Hazards*

Hurricanes

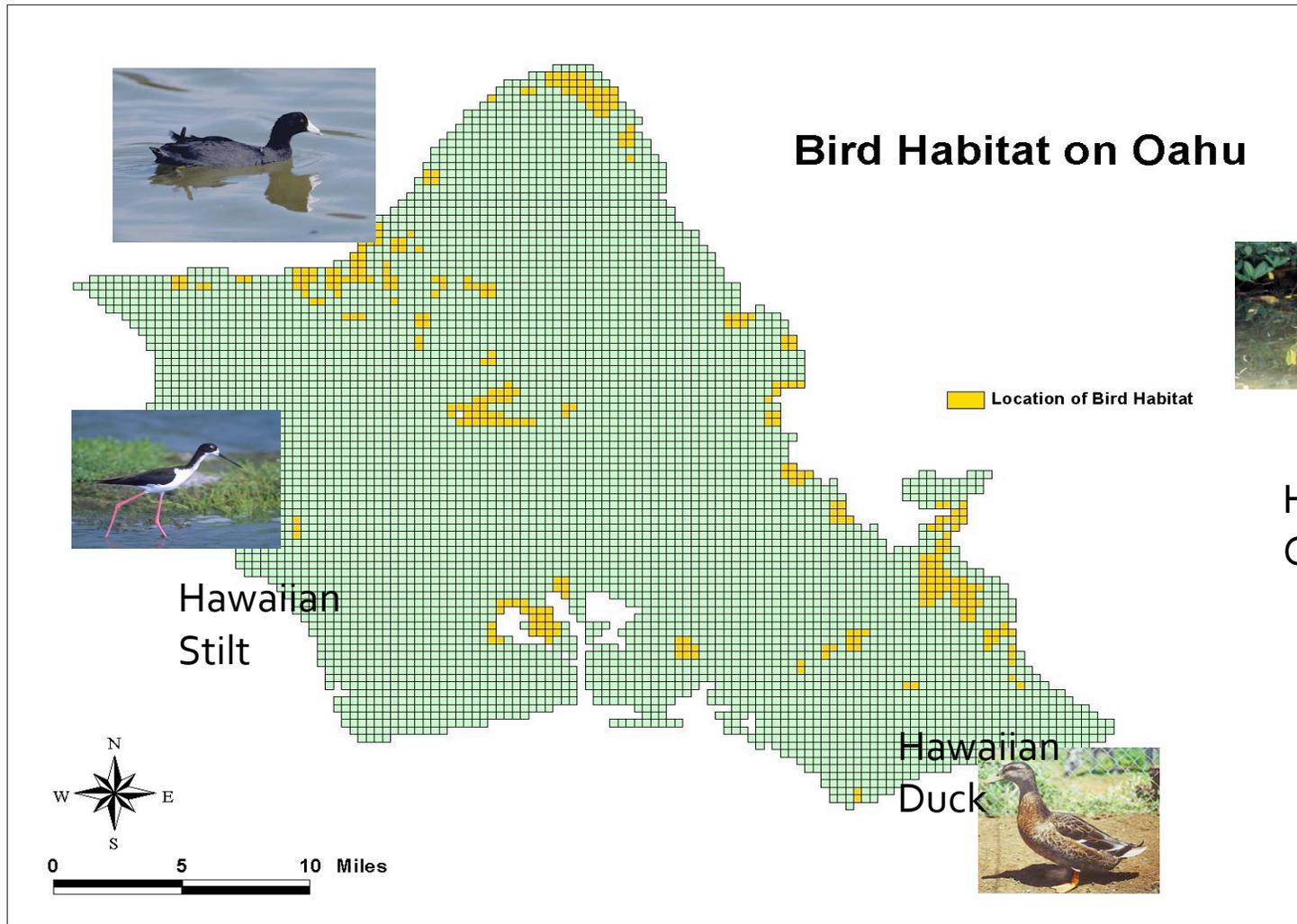


Storm Surge



Flash Flooding

V2: Mitigation of Development (EIS)



V₃: Mitigation of *Greenhouse Gases*

235,800 Trees

60% Streets

40% Parks

213 Species

Savings Electricity 1,943 MWh

3,340 tonnes CO₂

8,345 lbs pollutants removed

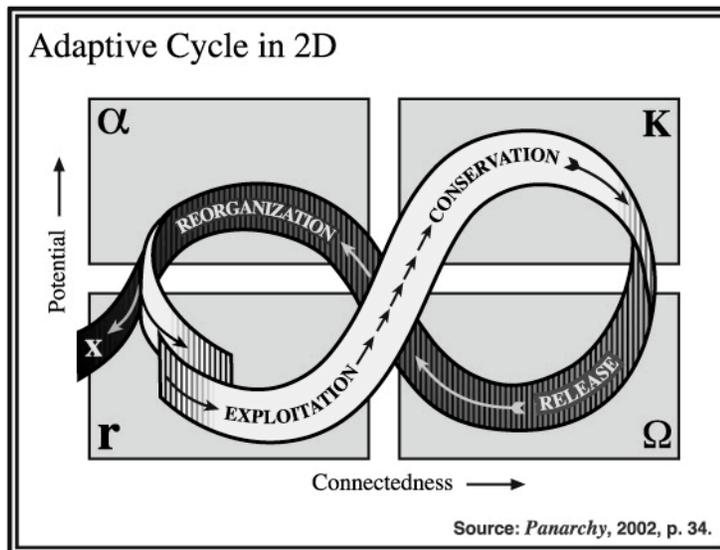
35 million gallons storm runoff

\$3.9 million benefits



Hazard Mitigation (v1) v. Adapatation

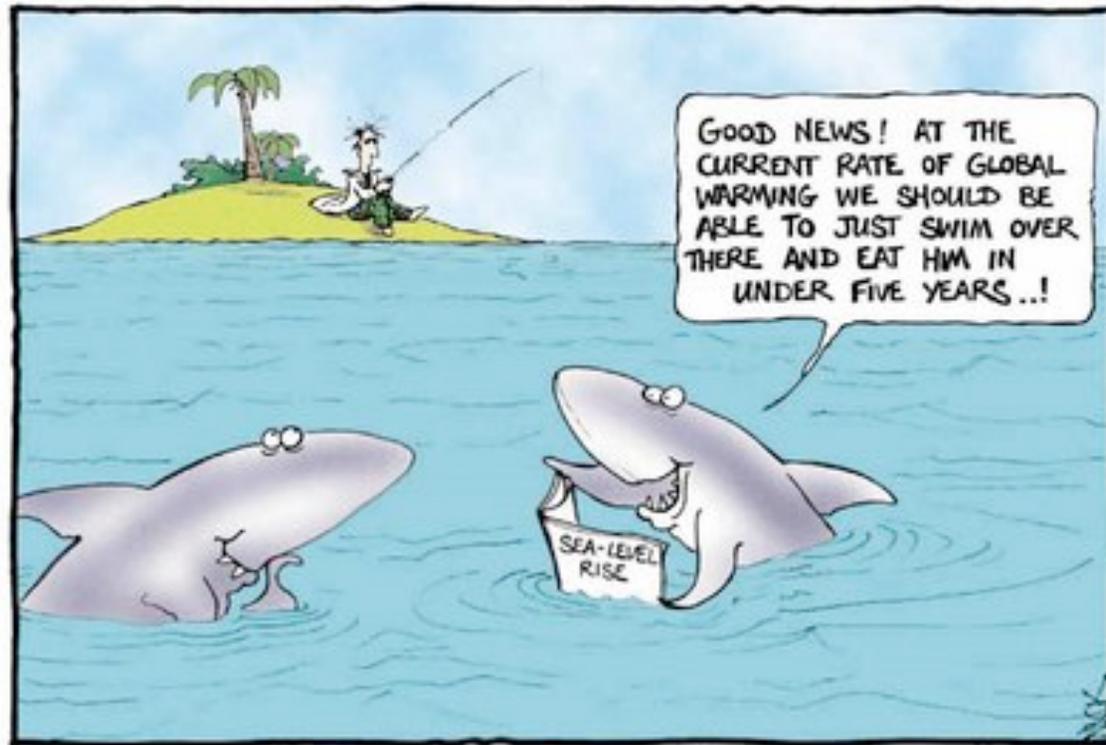
- Hazard Mitigation:
 - Actions taken to reduce risks of harm (loss of life, injury, property damage, disruption) from hazards
- ADAPTATION:



- Growth/Exploitation
- Conservation
- Collapse/Release
- Renewal/
Reorganization

(Holling & Gunderson, 2002)

Adaptation?



Adaptation: Hawaiian Style?



Is this Adaptation?



1992



2007

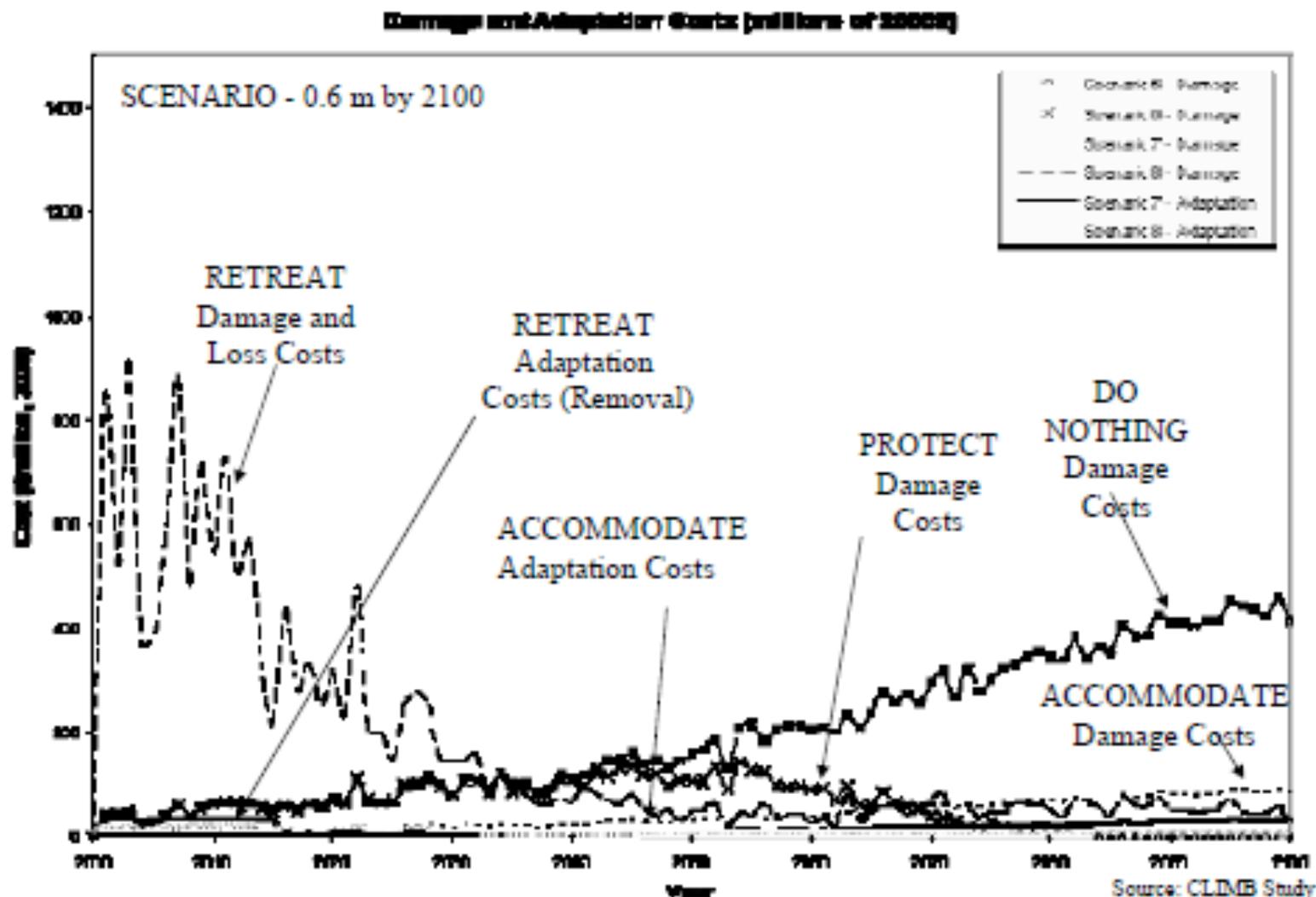
Adaptation Strategies



- Do Nothing
- Protect
- Elevate
- Retreat
- Transform

1. Analytical Framework(s)
2. Data Requirements
3. Analytical Capabilities
4. Physical Science + Social Science

Scenarios Analysis: Options & Timeframes Matter



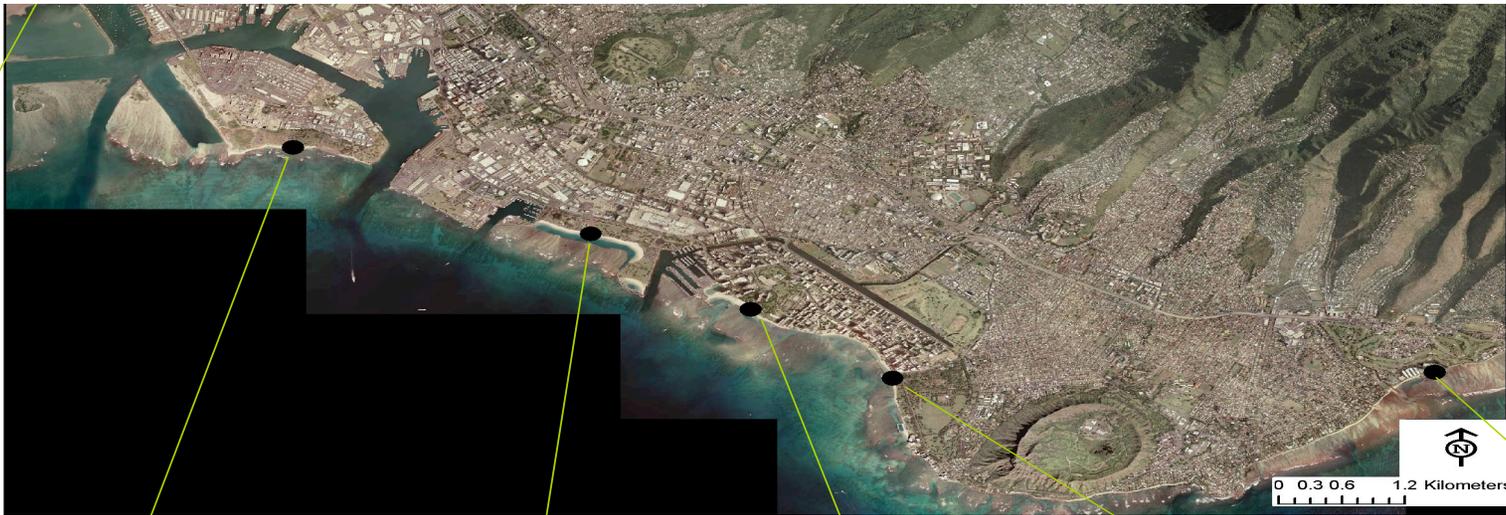
Data Sources for *Initial Analysis*

Data	Source
Sea Level Scenarios	ICF International. (2007). The Potential Impacts of Global Sea Level Rise on Transportation Infrastructure, Phase 1 – Final Report: the District of Columbia, Maryland, North Carolina and Virginia: Study Goals and Methodologies. http://www.bv.transports.gouv.qc.ca/mono/0965210.pdf
MHHW and HOWL	Elevations on Station Datum National Ocean Service (NOAA) for Station number 1612340 (Honolulu Harbor, Oahu). Epoch: 1983-2001. http://tidesandcurrents.noaa.gov
Coastline	NOAA Composite Shoreline http://shoreline.noaa.gov/data/datasheets/composite.html
Shapefiles (road, parcel, networks, land use)	The State of Hawaii GIS Data and the City and County of Honolulu GIS Data.
Elevation	NGA LIDAR = National Geospatial-Intelligence Agency Light Detection and Ranging

Sea Level Rise Assumptions

	2000	2025	2050	2075	2100
Regularly inundated (Low)	Below MHHW (El. < +32.9 cm)	MHHW to MHHW + 6cm (El. +32.9 cm to +38.9 cm)	MHHW to MHHW + 13cm (El. +32.9 cm to +45.9 cm)	MHHW to MHHW + 21cm (El. +32.9 cm to +53.9 cm)	MHHW to MHHW + 30cm (El. +32.9 cm to +62.9 cm)
Regularly inundated (High)	Below MHHW (El. < +32.9 cm)	MHHW to MHHW + 6.5cm (El. +32.9 cm to +39.4 cm)	MHHW to MHHW + 17.5cm (El. +32.9 cm to +50.4 cm)	MHHW to MHHW + 31cm (El. +32.9 cm to +63.9 cm)	MHHW to MHHW + 48.5cm (El. +32.9 cm to +81.4 cm)
At-risk (Low)	MHHW to HOWL (El. +32.9 cm to +78.3 cm)	MHHW + 6cm to HOWL + 6cm (El. +38.9 cm to +84.3 cm)	MHHW + 13cm to HOWL + 13cm (El. +45.9 cm to +91.3 cm)	MHHW + 21cm to HOWL + 21cm (El. +53.9 cm to +99.3 cm)	MHHW + 30cm to HOWL + 30cm (El. +62.9 cm to +108.3 cm)
At-risk (High)	MHHW to HOWL (El. +32.9 cm to +78.3 cm)	MHHW + 6.5cm to HOWL + 6.5cm (El. +39.4 cm to +84.8 cm)	MHHW + 17.5cm to HOWL + 17.5cm (El. +50.4 cm to +95.8 cm)	MHHW + 31cm to HOWL + 31cm (El. +63.9 cm to +109.3 cm)	MHHW + 48.5cm to HOWL + 48.5cm (El. +81.4 cm to +126.8 cm)

Data Issues (DEM v LIDAR etc.)



Le



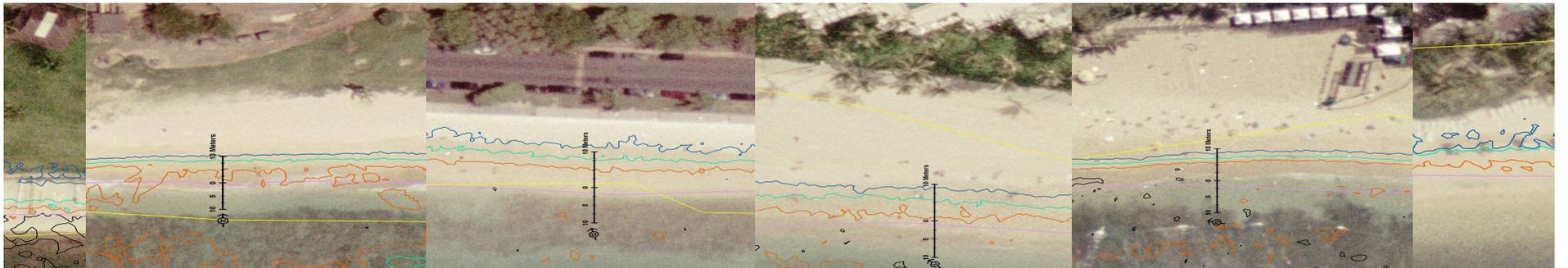
Sand Island

Ala Moana

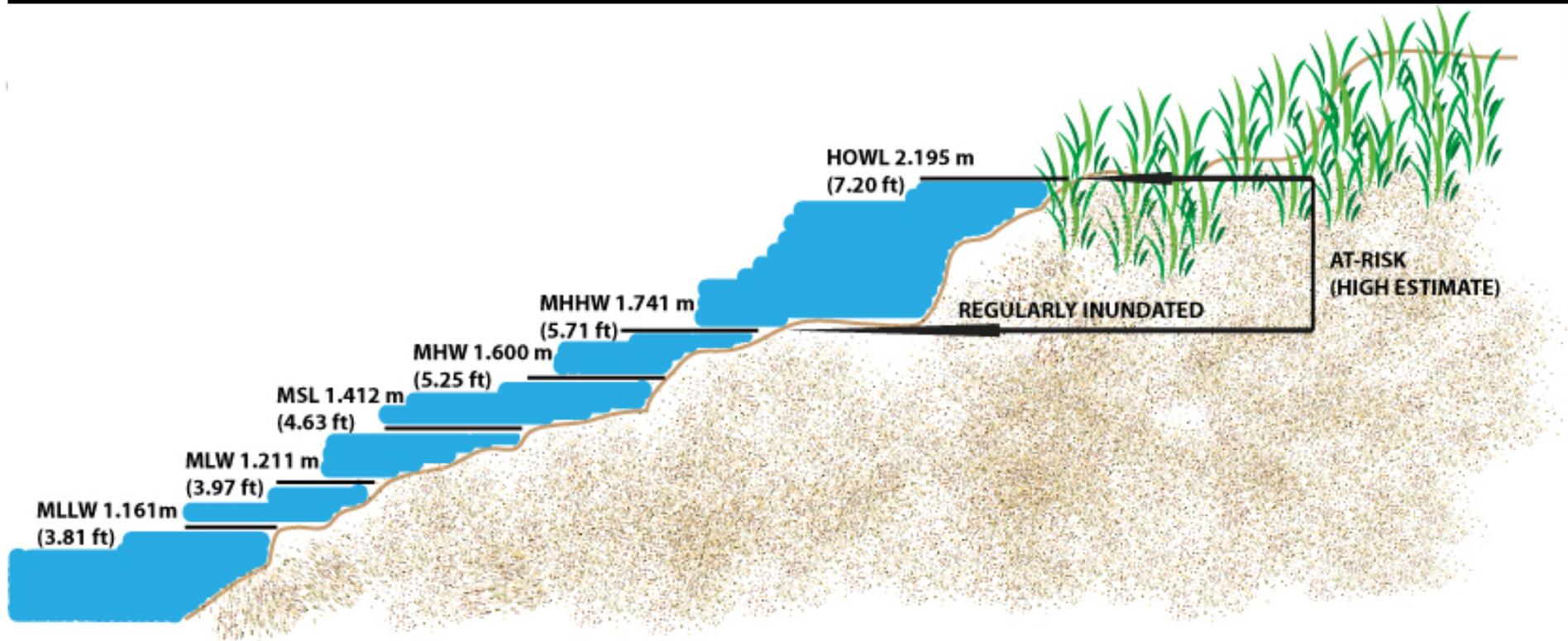
Waikiki (Hale Koa)

Waikiki (Zoo)

Kat



Estimated Levels in 2000



Mean Lower Low Water (MLLW): The average of the lower low water height of each tidal day observed.

Mean Low Water (MLW): The average of all the low water heights observed .

Mean Sea Level (MSL): The arithmetic mean of hourly heights observed.

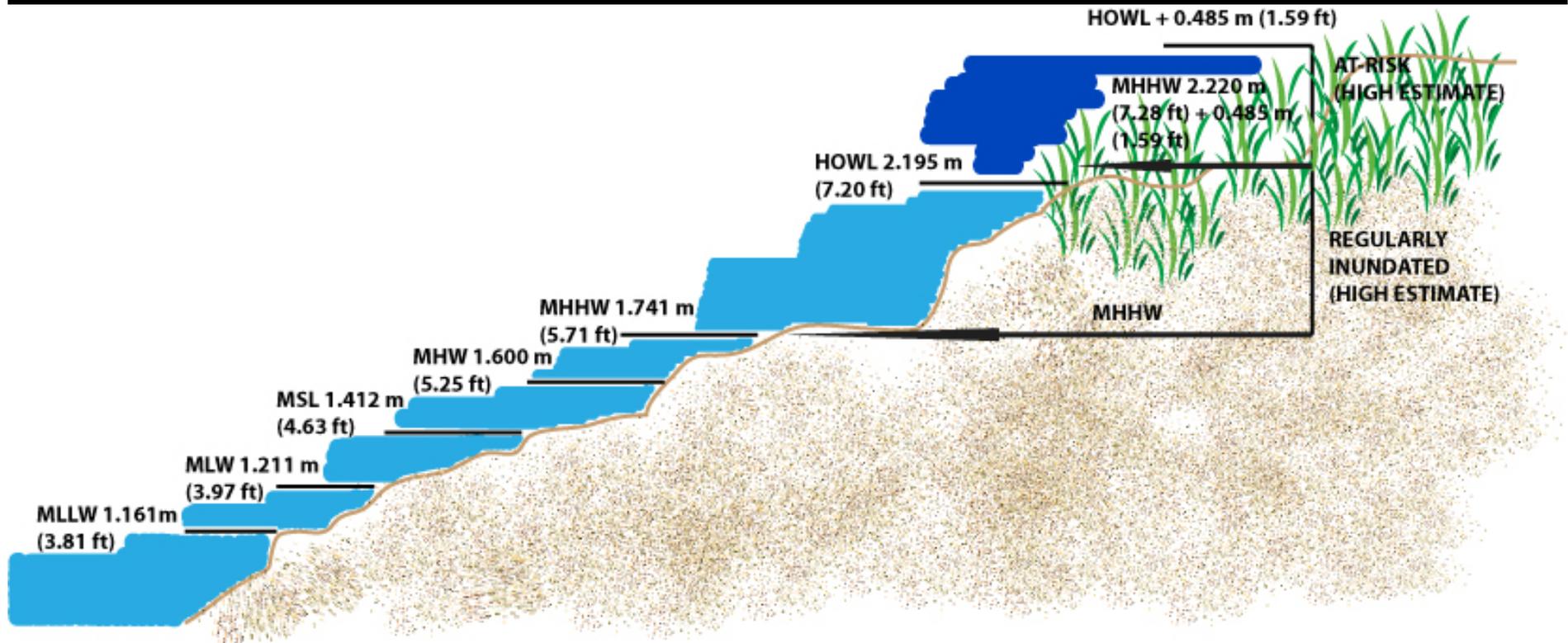
Mean High Water (MHW): The average of all the high water heights observed.

Mean Higher High Water (MHHW): The average of the higher high water height of each tidal day observed.

Highest Observed Water Level (HOWL): A science definition for storm surges.

 Sea Levels Based on NOAA Buoy Station Elevations

2100 Estimated levels with SLR



Mean Lower Low Water (MLLW): The average of the lower low water height of each tidal day observed.

Mean Low Water (MLW): The average of all the low water heights observed .

Mean Sea Level (MSL): The arithmetic mean of hourly heights observed.

Mean High Water (MHW): The average of all the high water heights observed.

Mean Higher High Water (MHHW): The average of the higher high water height of each tidal day observed.

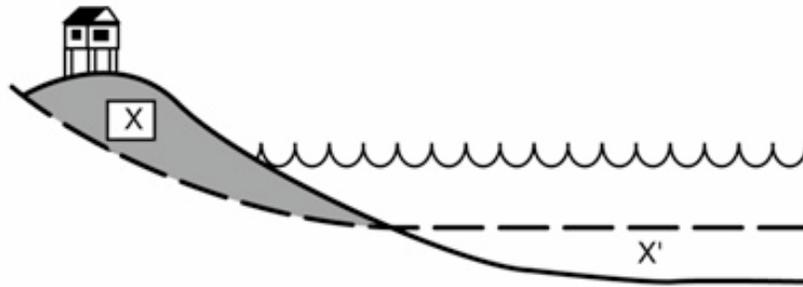
Highest Observed Water Level (HOWL): A science definition for storm surges.

Sea Levels Based on NOAA Buoy Station Elevations

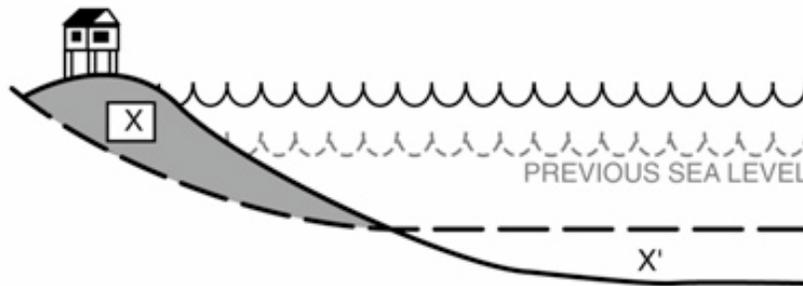
Estimated Sea Levels for 2100

Implications for Coastal Erosion

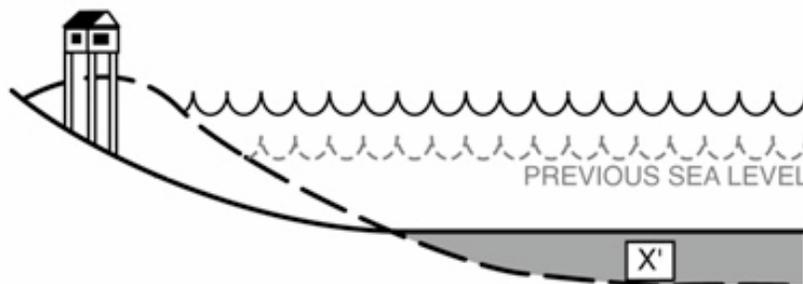
(a) Initial Condition



(b) Innundation

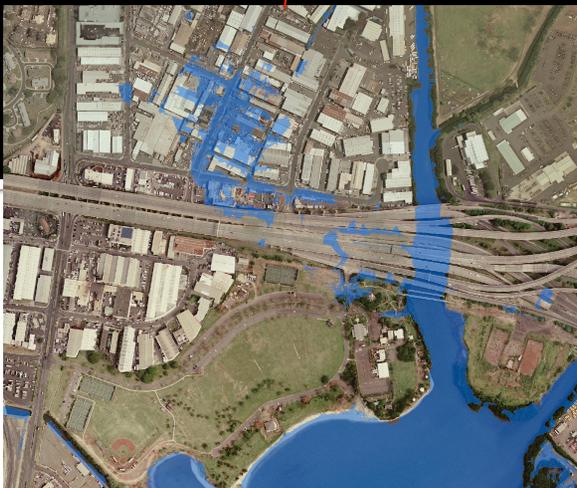
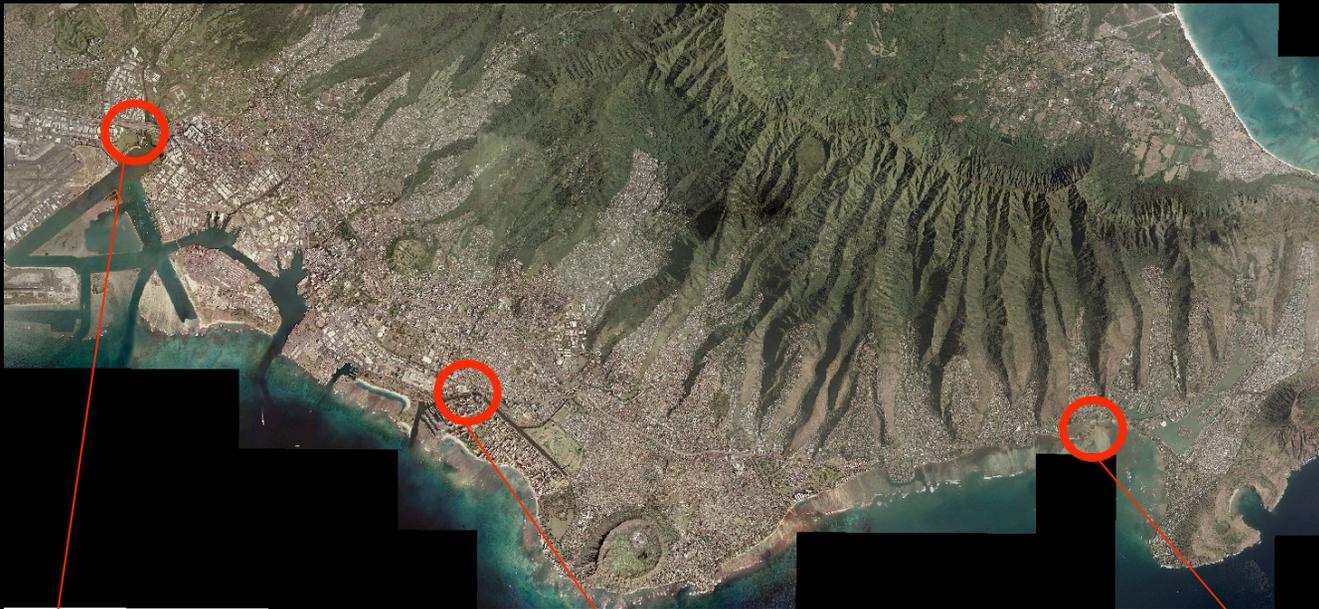


(c) Subsequent Erosion

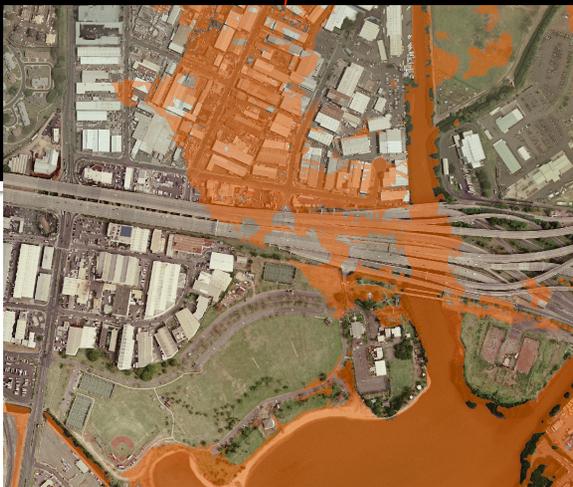
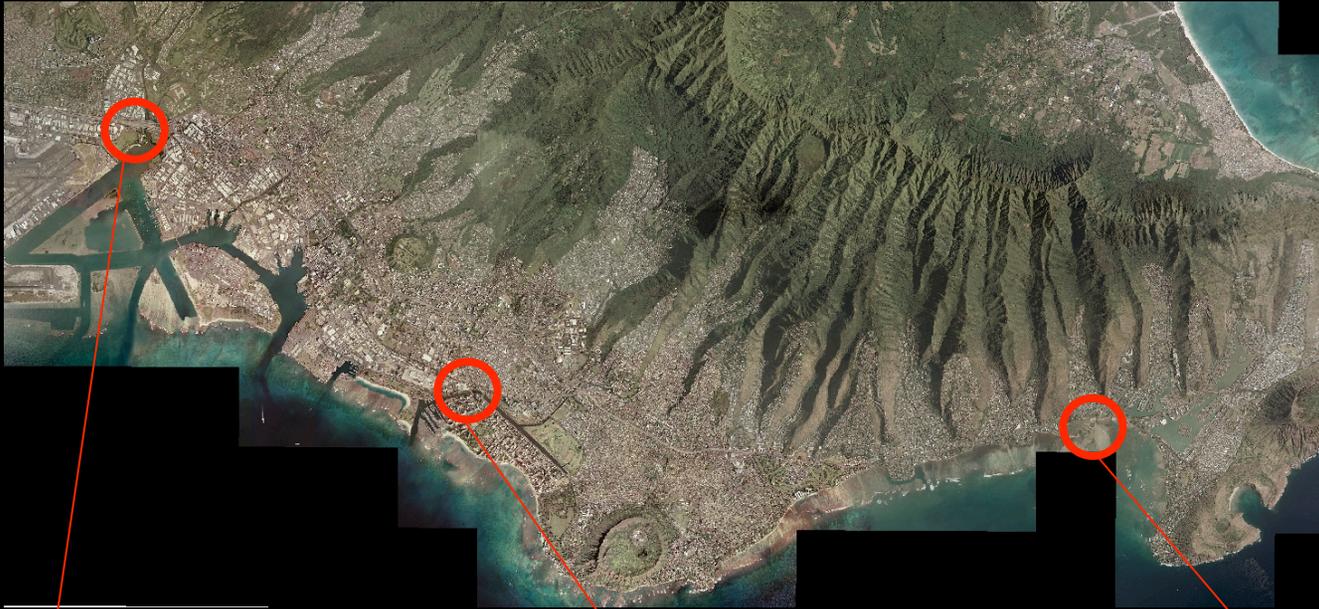


1. Water Height
 2. Beach Loss (Erosion)
 3. Inland intrusion
 4. Spatial-Temporal
 5. Structural Responses
1. Replenishment
 2. Barriers
 3. Elevation
 4. Retreat

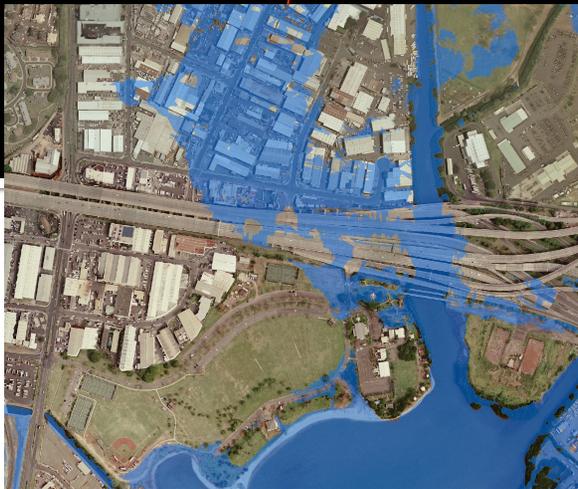
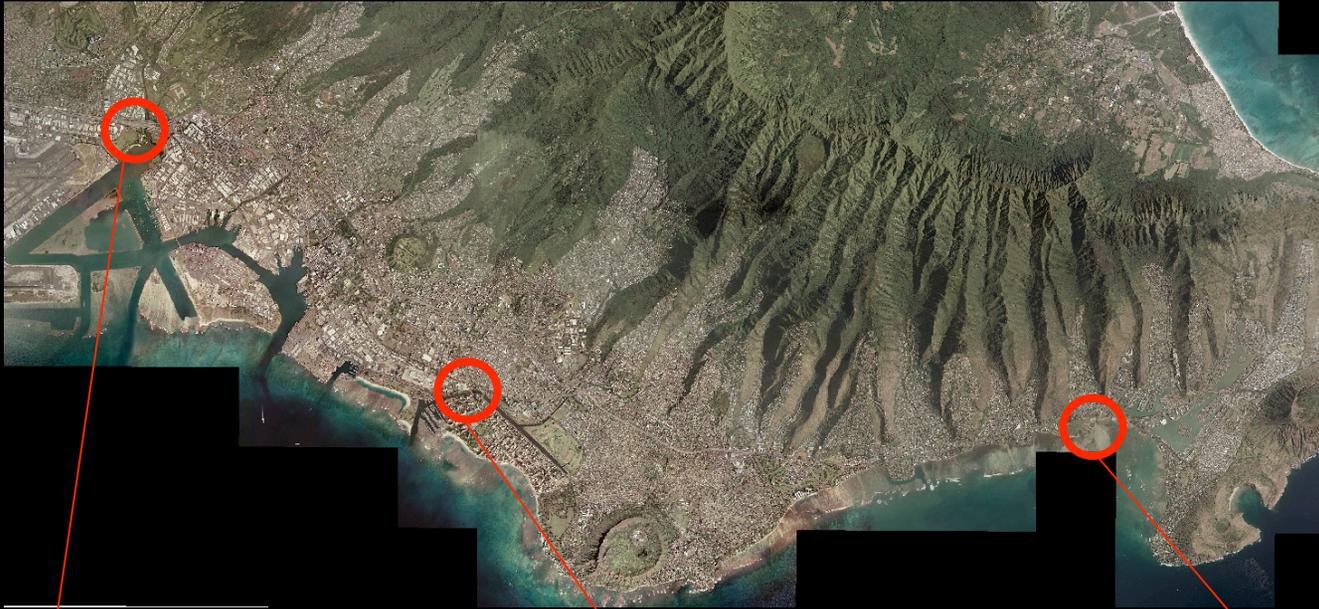
2000 MHHW (Mean Higher High Water)



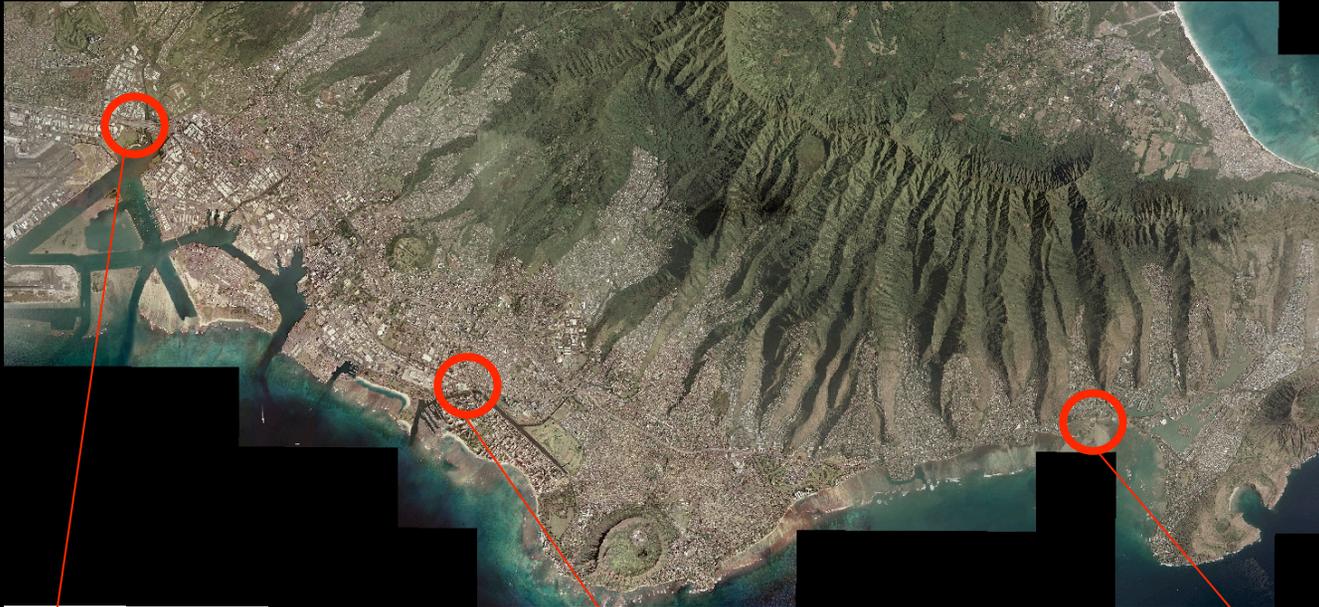
2000 HOWL (Highest Observed Water Level)



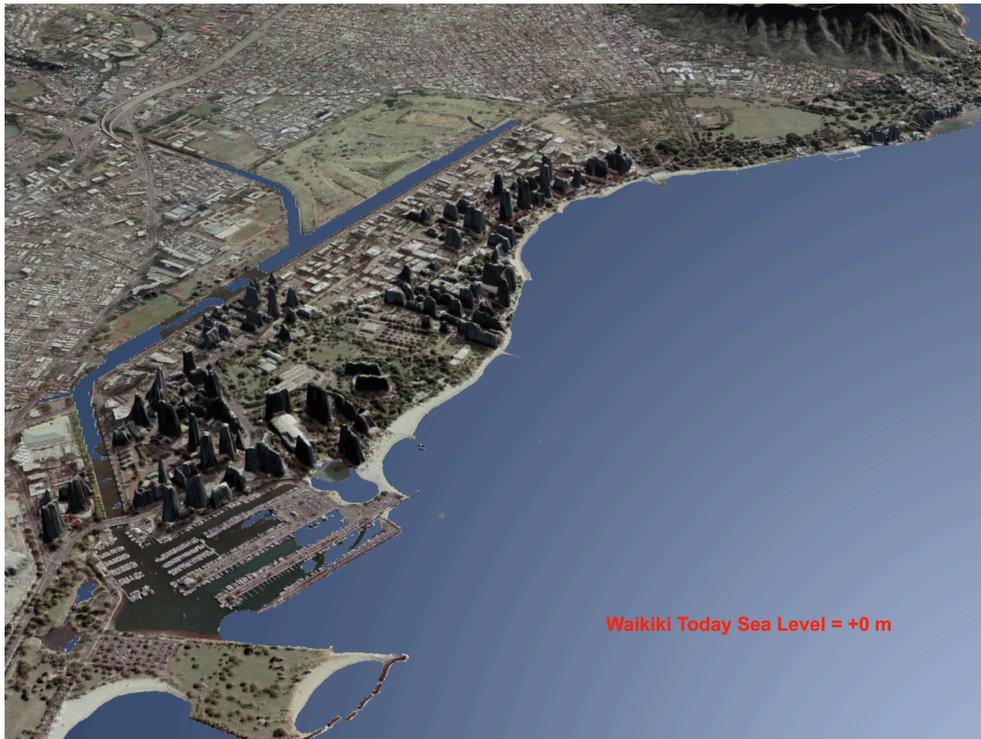
2100 MHHW + .485 m SLR

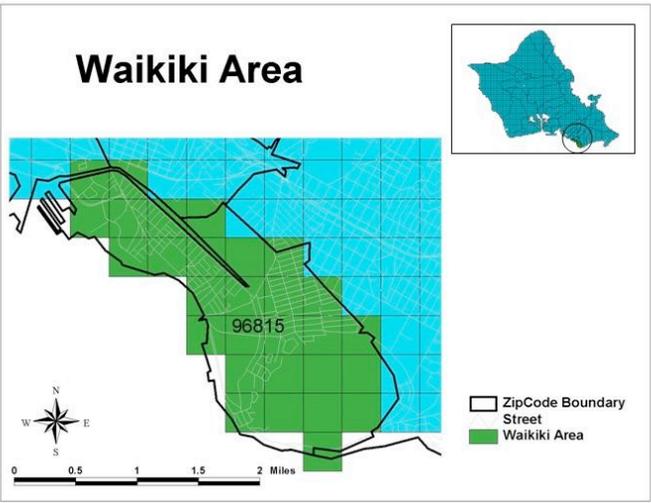
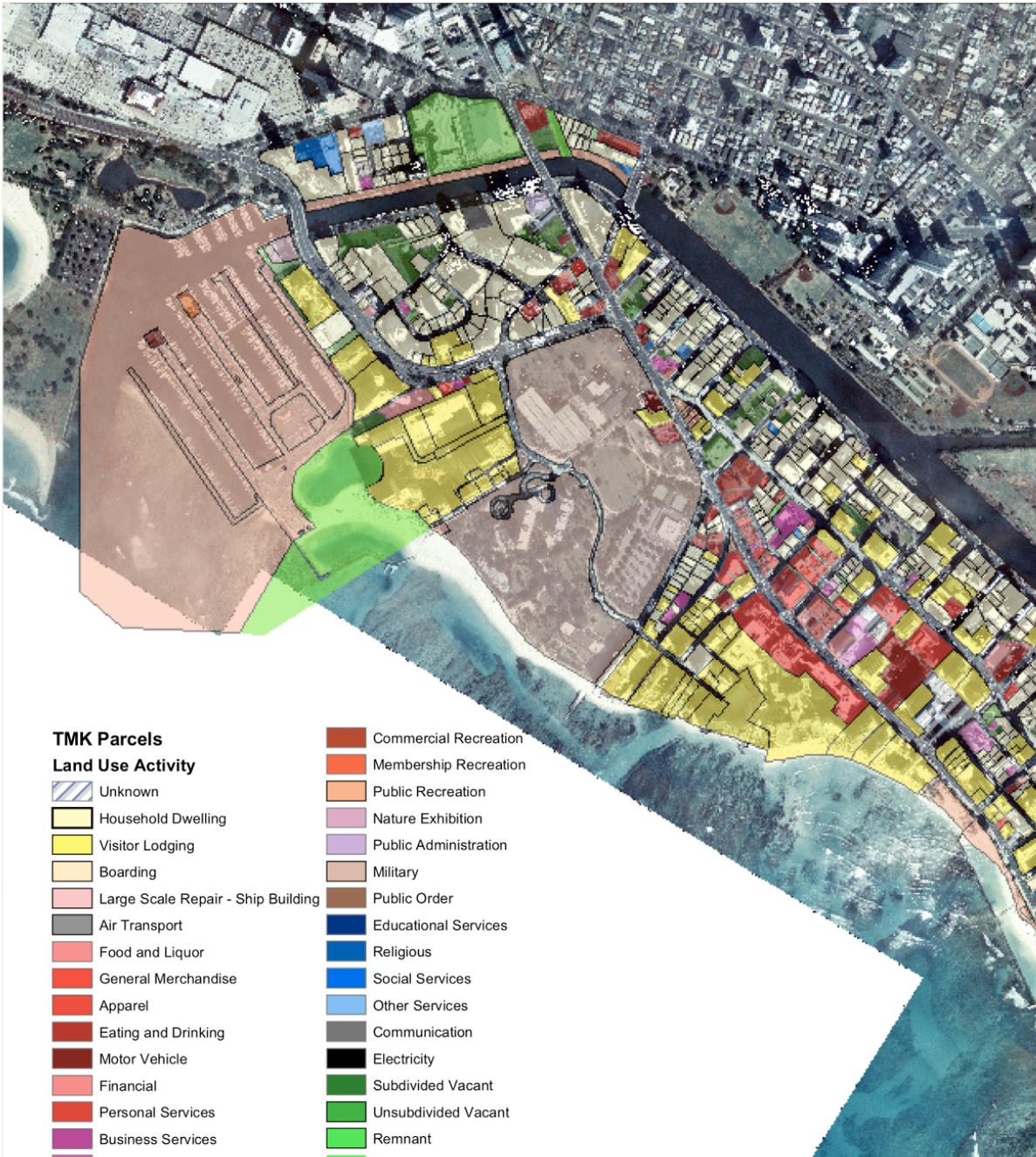


2100 MHHW + HOWL + .485m SLR



Fletcher, C. et. al.





TMK Parcels
Land Use Activity

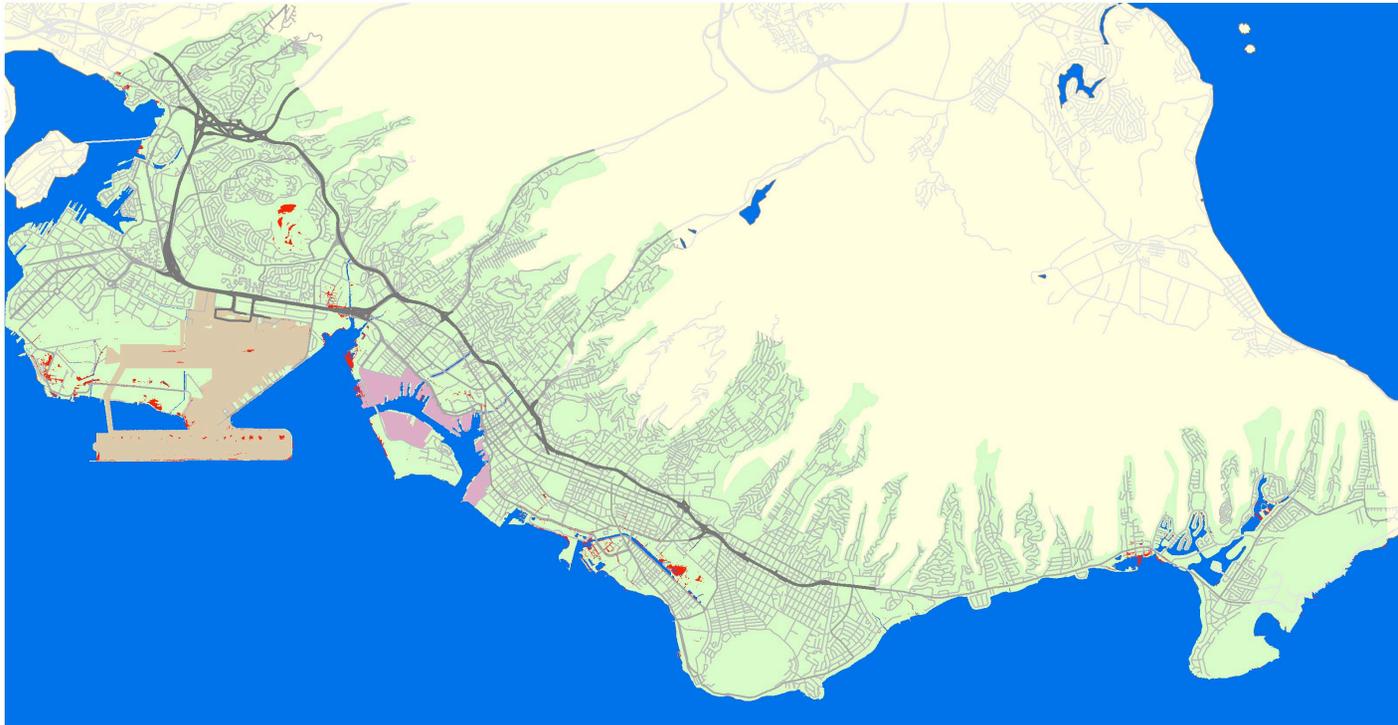
- | | |
|---|--|
| <ul style="list-style-type: none"> Unknown Household Dwelling Visitor Lodging Boarding Large Scale Repair - Ship Building Air Transport Food and Liquor General Merchandise Apparel Eating and Drinking Motor Vehicle Financial Personal Services Business Services Automotive Services Entertainment | <ul style="list-style-type: none"> Commercial Recreation Membership Recreation Public Recreation Nature Exhibition Public Administration Military Public Order Educational Services Religious Social Services Other Services Communication Electricity Subdivided Vacant Unsubdivided Vacant Remnant Restricted Right of Way Other |
|---|--|

Urban Honolulu Infrastructure

population = 408,256; job count = 337,241 (2000 est.)

<u>Infrastructure</u>	<u>Unit</u>	<u>Total</u>
Freeways	Lineal feet	356,798
Main Arteries	Lineal feet	819,320
Minor Roads	Lineal feet	3,618,419
Airport	Square feet	101,282,975
Harbor	Square feet	22,737,943
Overall Area	Square feet	1,606,092,470

2000 MHHW (Mean Higher High Water)



Inundation Zone in 2000

Water Level = Mean Higher High Water (Mean Sea Level + 1.276 ft)



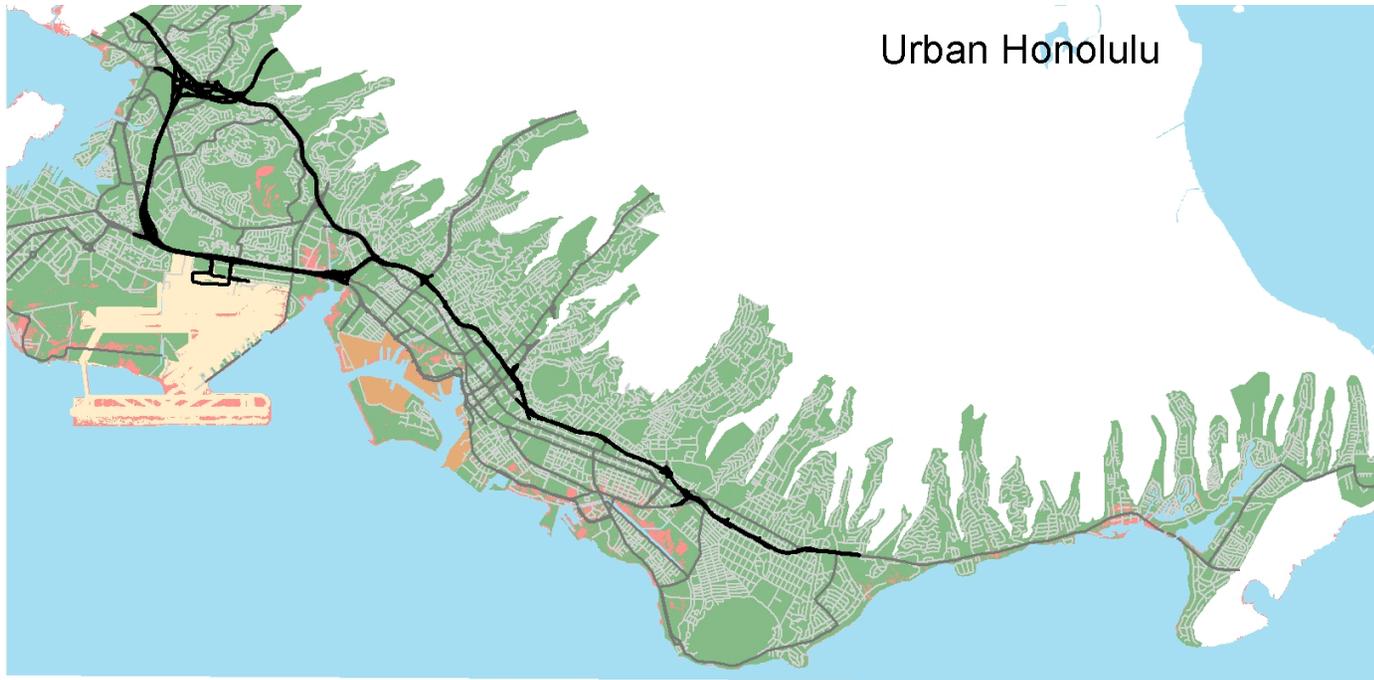
Legend

- Focus Area
- Affected Area
- Roadway Network
- Honolulu Harbor
- Honolulu Airport

Description	Unit	Length or Area Within Focus Area	Length or Area Affected	Percentage Affected
Freeways	Miles	67.58	-	0.00
Highways	Miles	154.51	0.39	0.25
Minor Roads	Miles	684.11	2.63	0.38
Airport Area	Acres	2,339.48	32.56	1.39
Harbor Area	Acres	552.14	8.04	1.46
Urban Area	Acres	36,870.81	286.69	0.78



2100 MHHW + .485m SLR



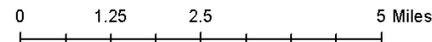
Legend

- Freeways
- Highways
- Minor Roads
- Regularly Inundated
- Airport
- Harbor
- Urban Area

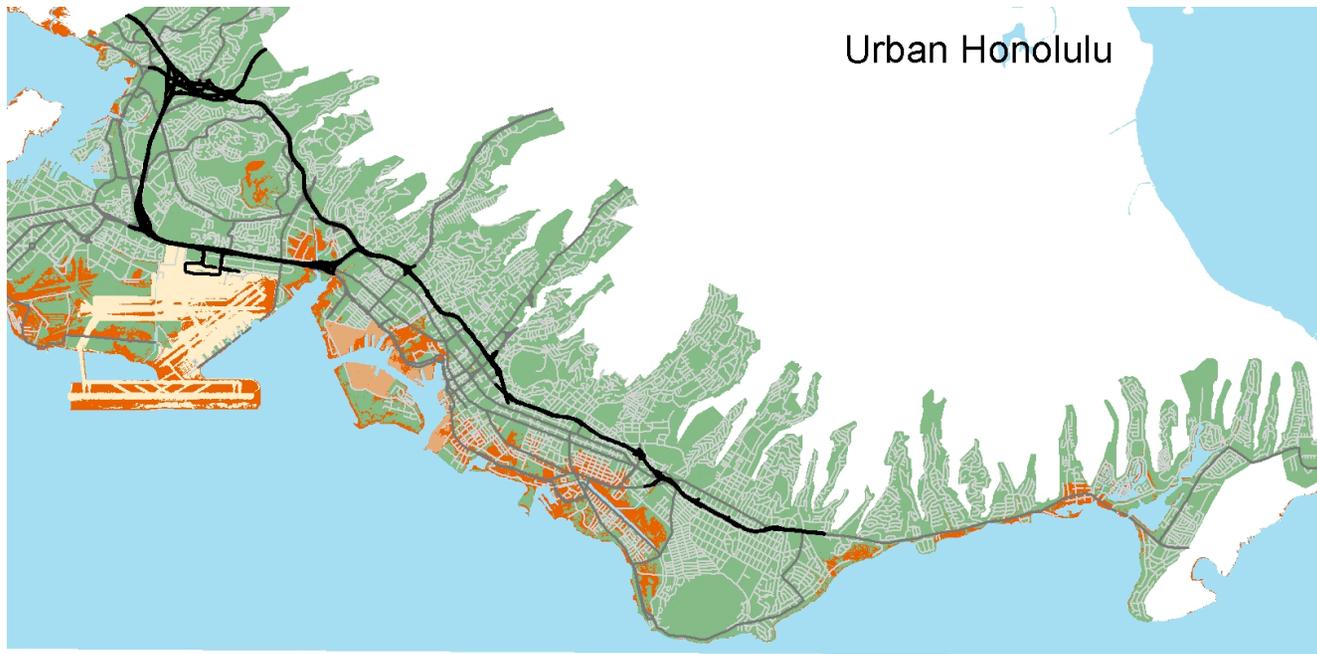
Regular Inundated - High Estimate (2100)

	Unit	Total within Urban Area	Affected	Percent Affected
Freeways	Feet	356,802	5,236	1.47
Highways	Feet	819,320	43,557	5.32
Minor Roads	Feet	3,618,491	104,809	2.90
Airport Area	Sq.Feet	101,282,975	10,344,878	10.21
Harbor Area	Sq.Feet	22,733,943	1,131,941	4.98
Urban Area	Sq.Feet	1,547,538,422	60,603,950	3.92

water level at MHHW (Mean Higher Hig Water) + 0.485m



2100 HOWL + .485m SLR



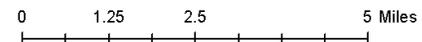
Legend

- Freeways
- Highways
- Minor Roads
- At Risk
- Airport
- Harbor
- Urban Area

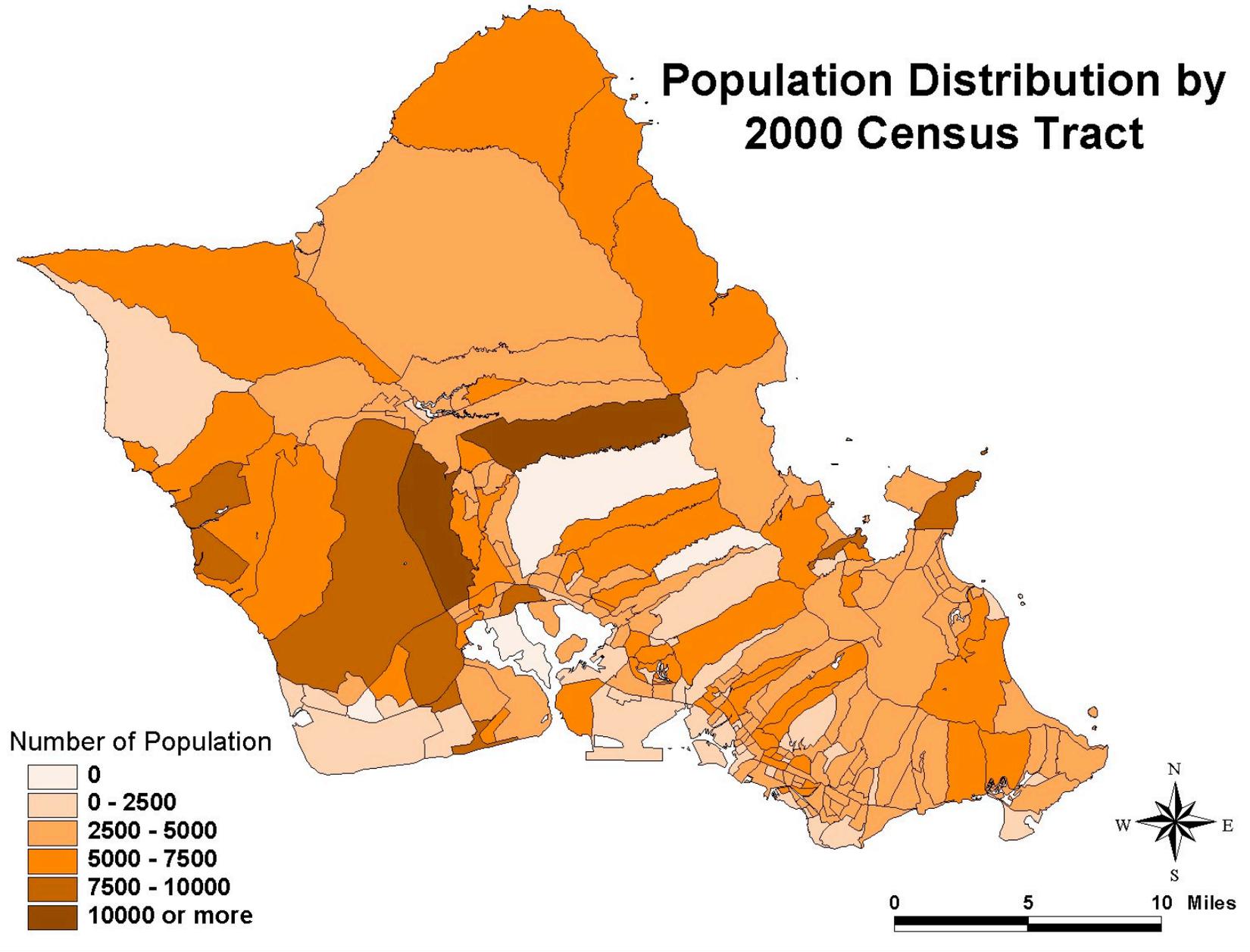
At Risk - High Estimate (2100)

	Unit	Total within Urban Area	Affected	Percent Affected
Freeways	Feet	356,802	9,624	2.70
Highways	Feet	819,320	105,352	12.86
Minor Roads	Feet	3,618,491	281,119	7.77
Airport Area	Sq.Feet	101,282,975	28,250,285	27.89
Harbor Area	Sq.Feet	22,733,943	4,033,848	17.74
Urban Area	Sq.Feet	1,547,538,422	156,397,813	10.11

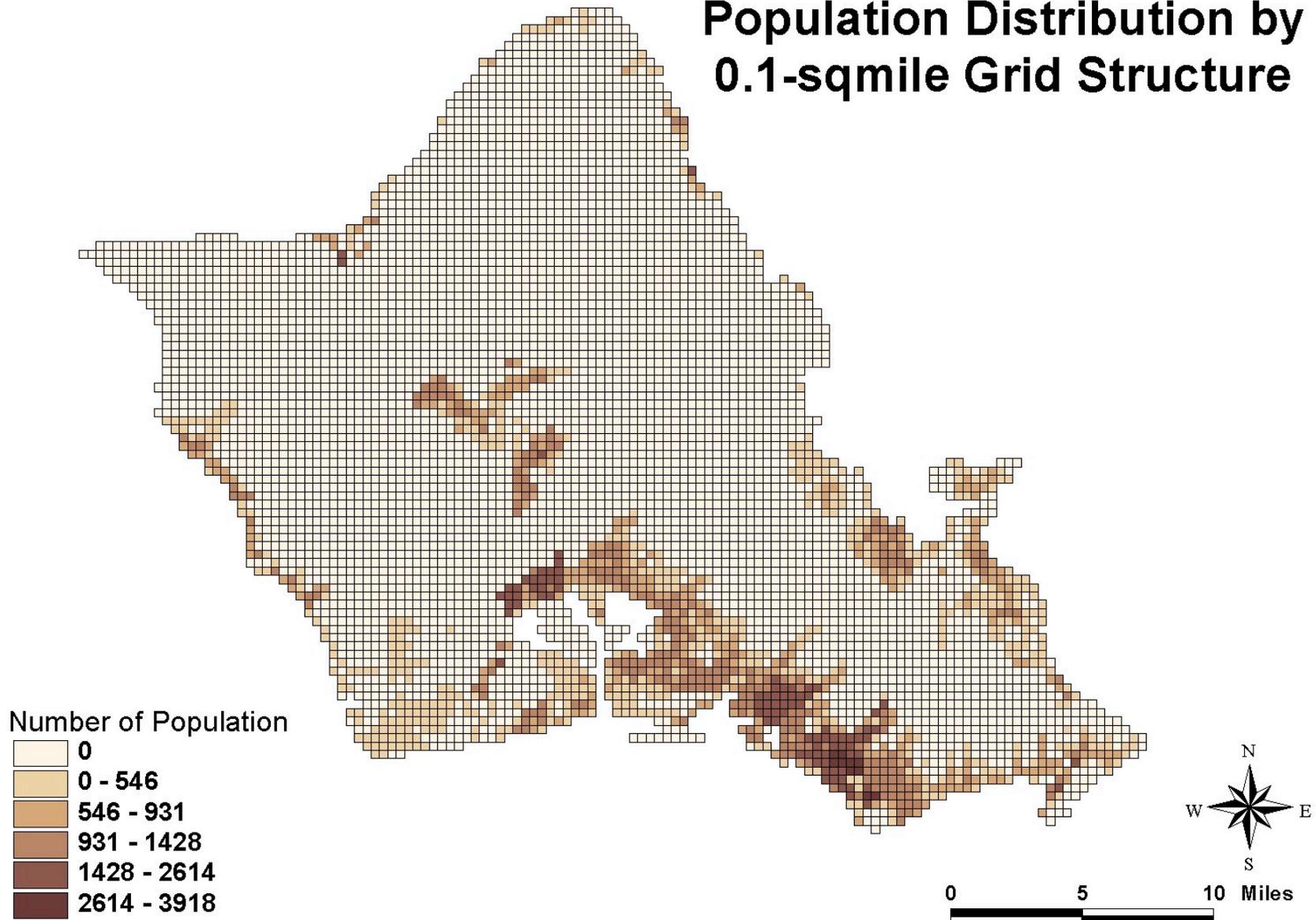
water level at HOWL (Highest Observed Water Level) + 0.485m



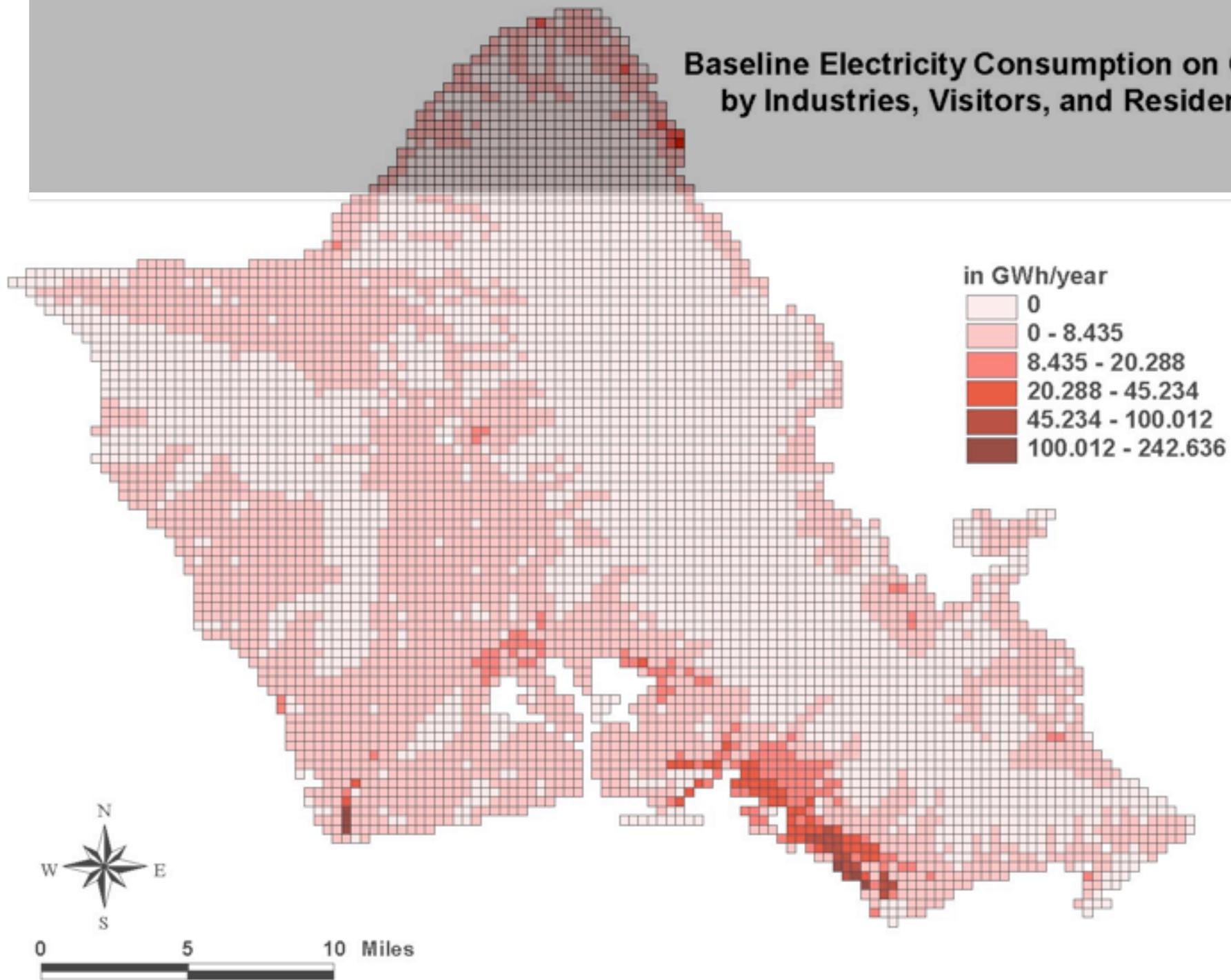
Population Distribution by 2000 Census Tract



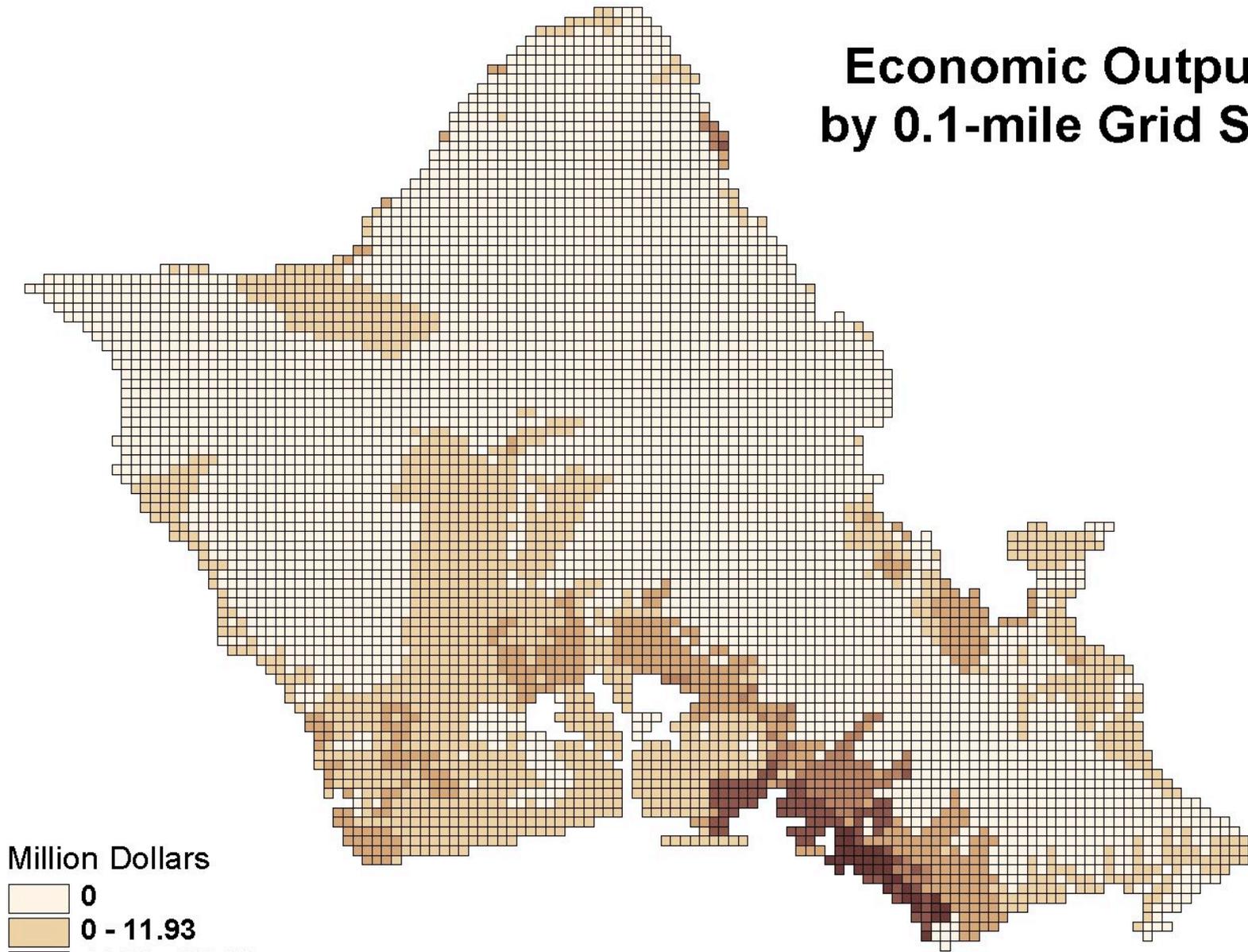
Population Distribution by 0.1-sqmile Grid Structure



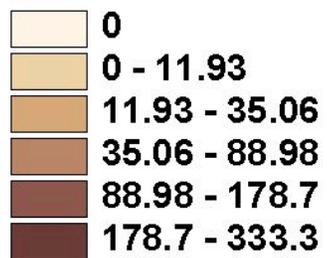
Baseline Electricity Consumption on Oahu by Industries, Visitors, and Residents



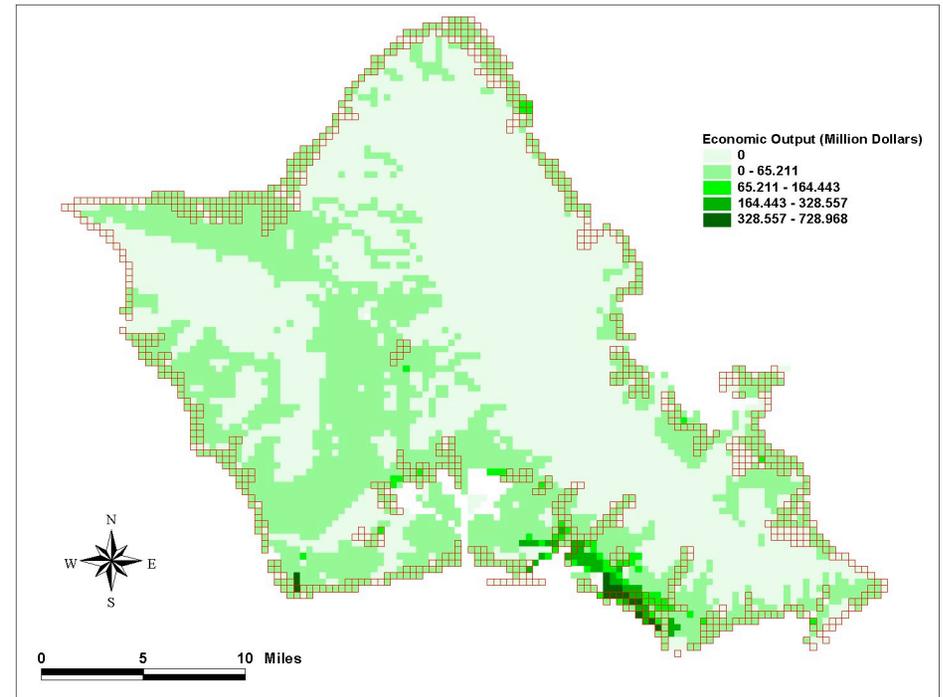
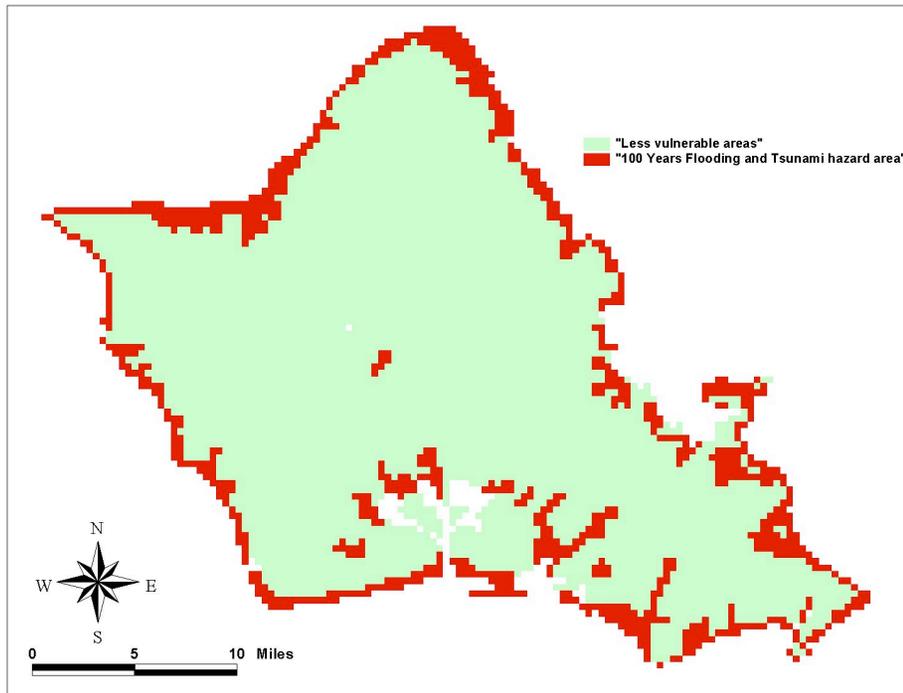
Economic Output Total by 0.1-mile Grid Structure



Million Dollars

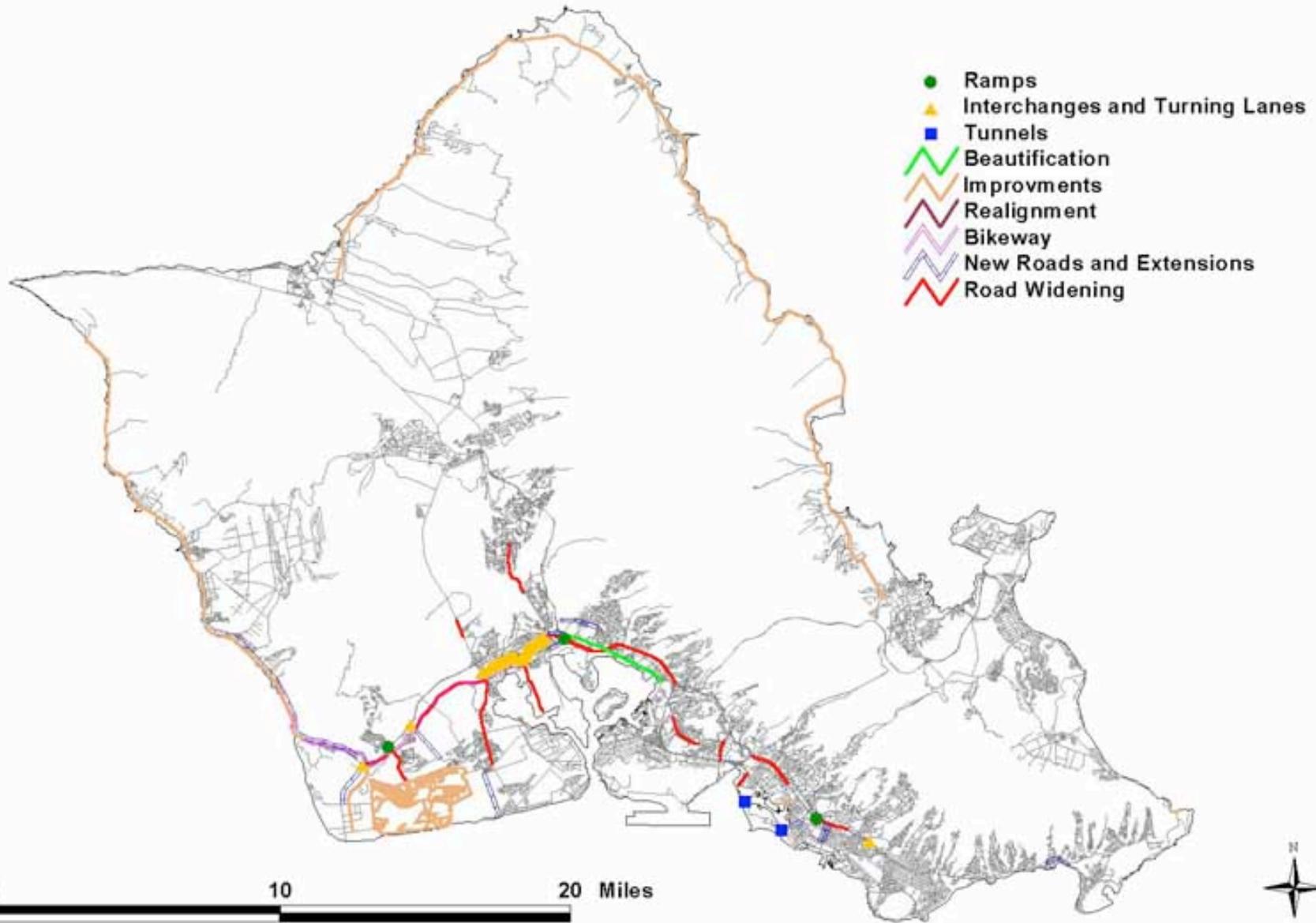


Estimated Annual Economic Activity in Flood and Tsunami Zones

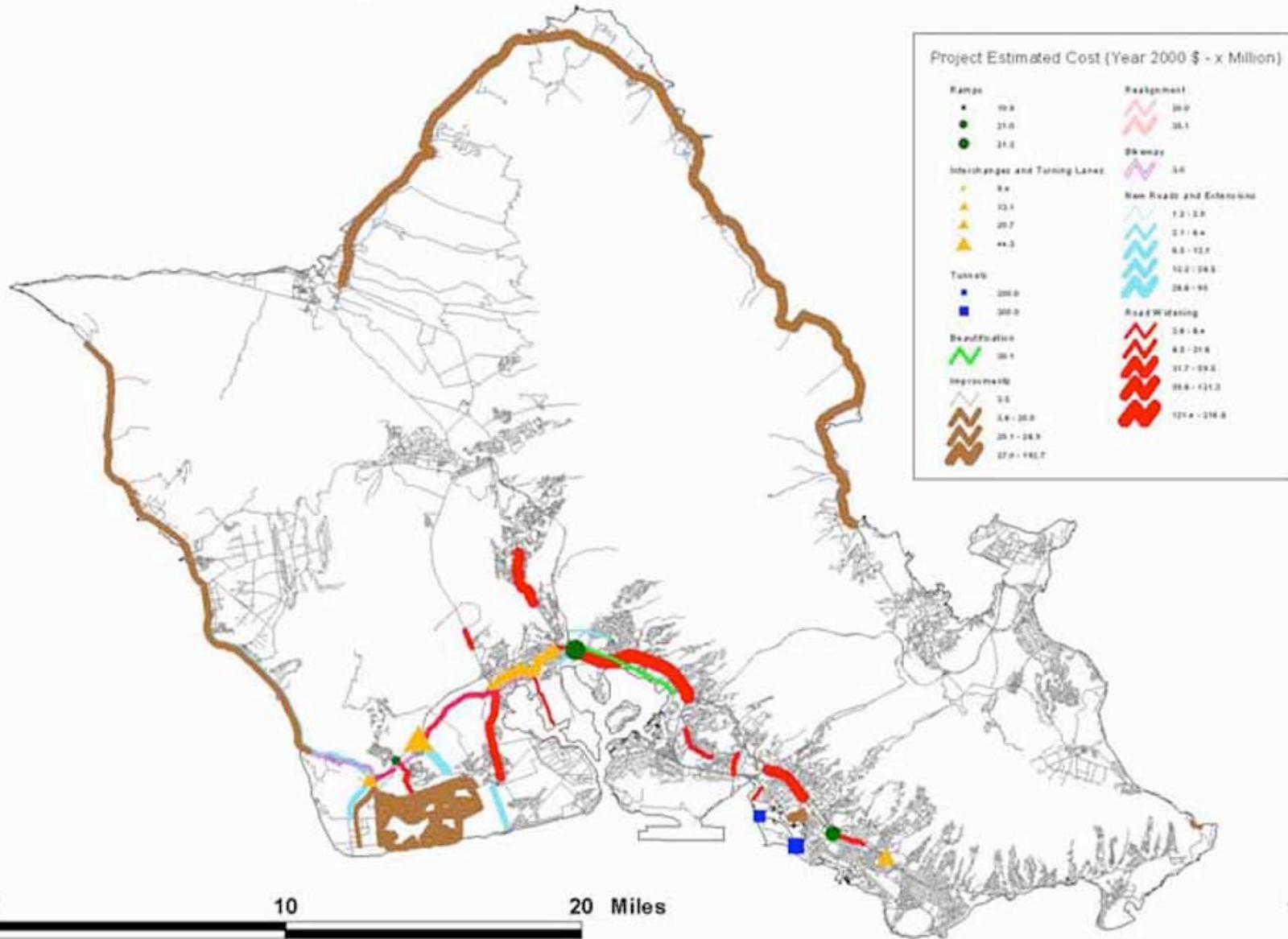


\$ 15.662 Billion

Oahu Regional Transportation Plan



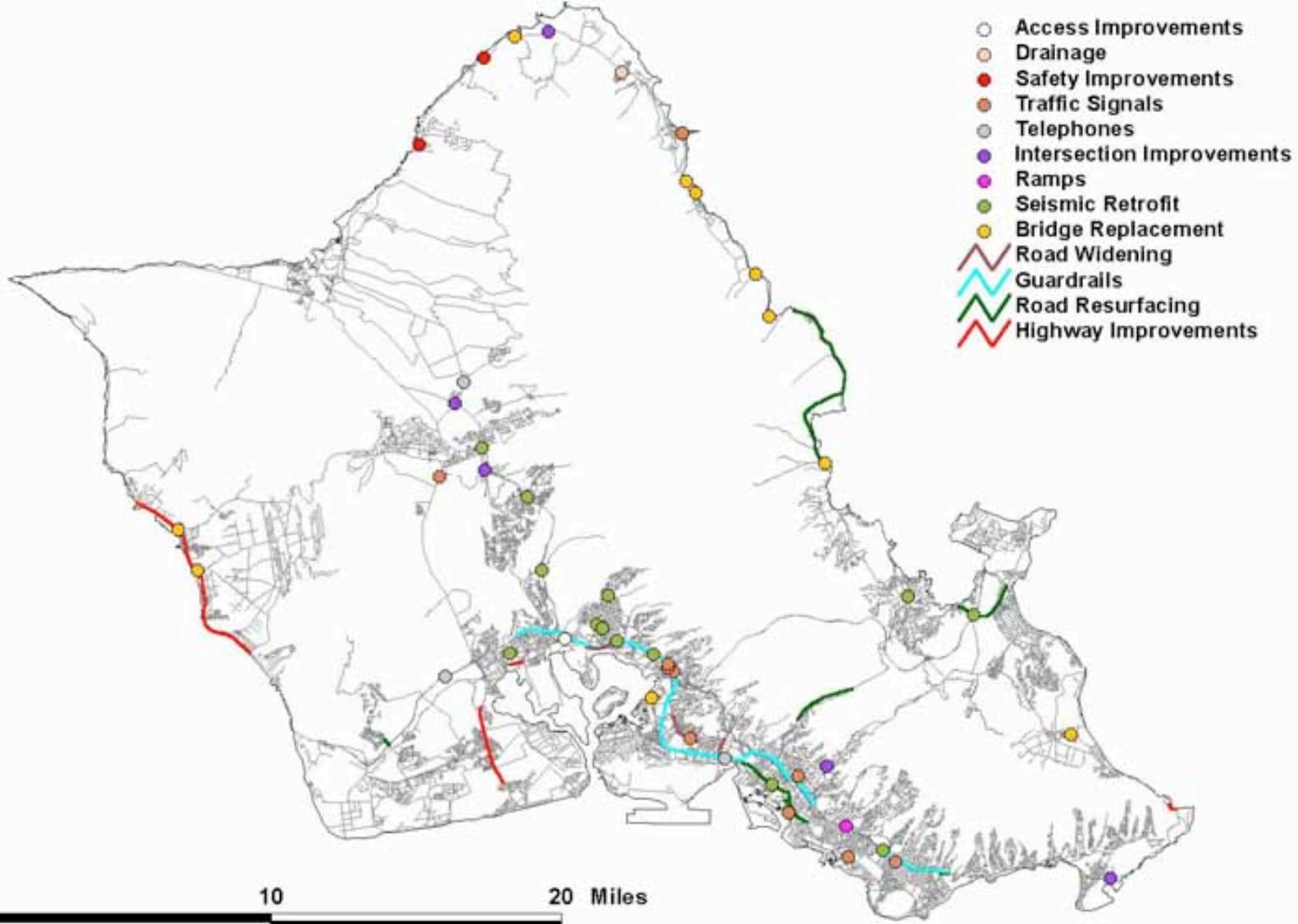
Oahu Regional Transportation Plan



0 10 20 Miles



Oahu Transportation Improvement Program

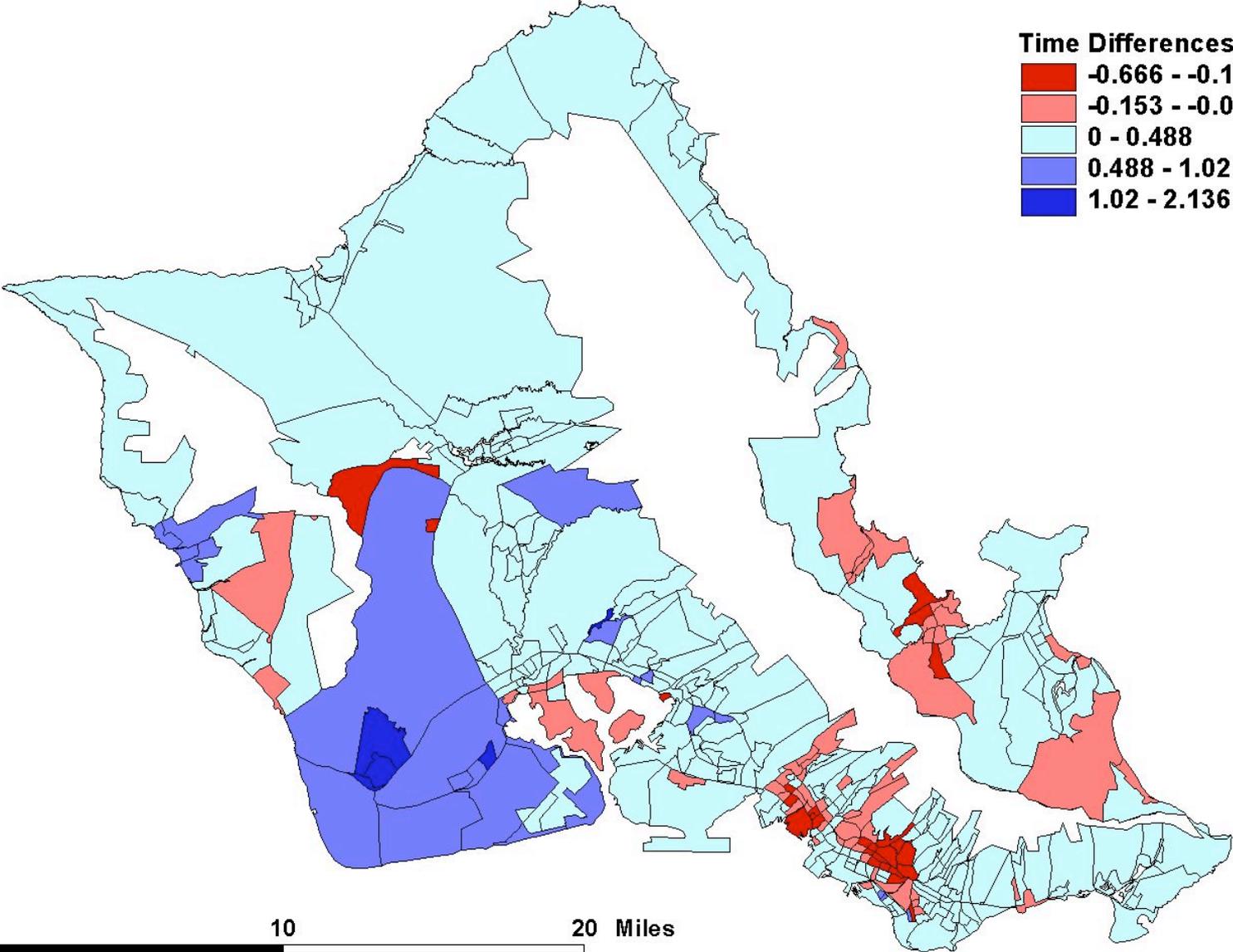
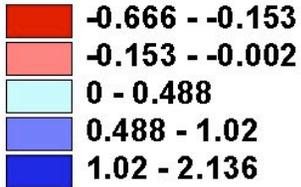


Transport Criteria

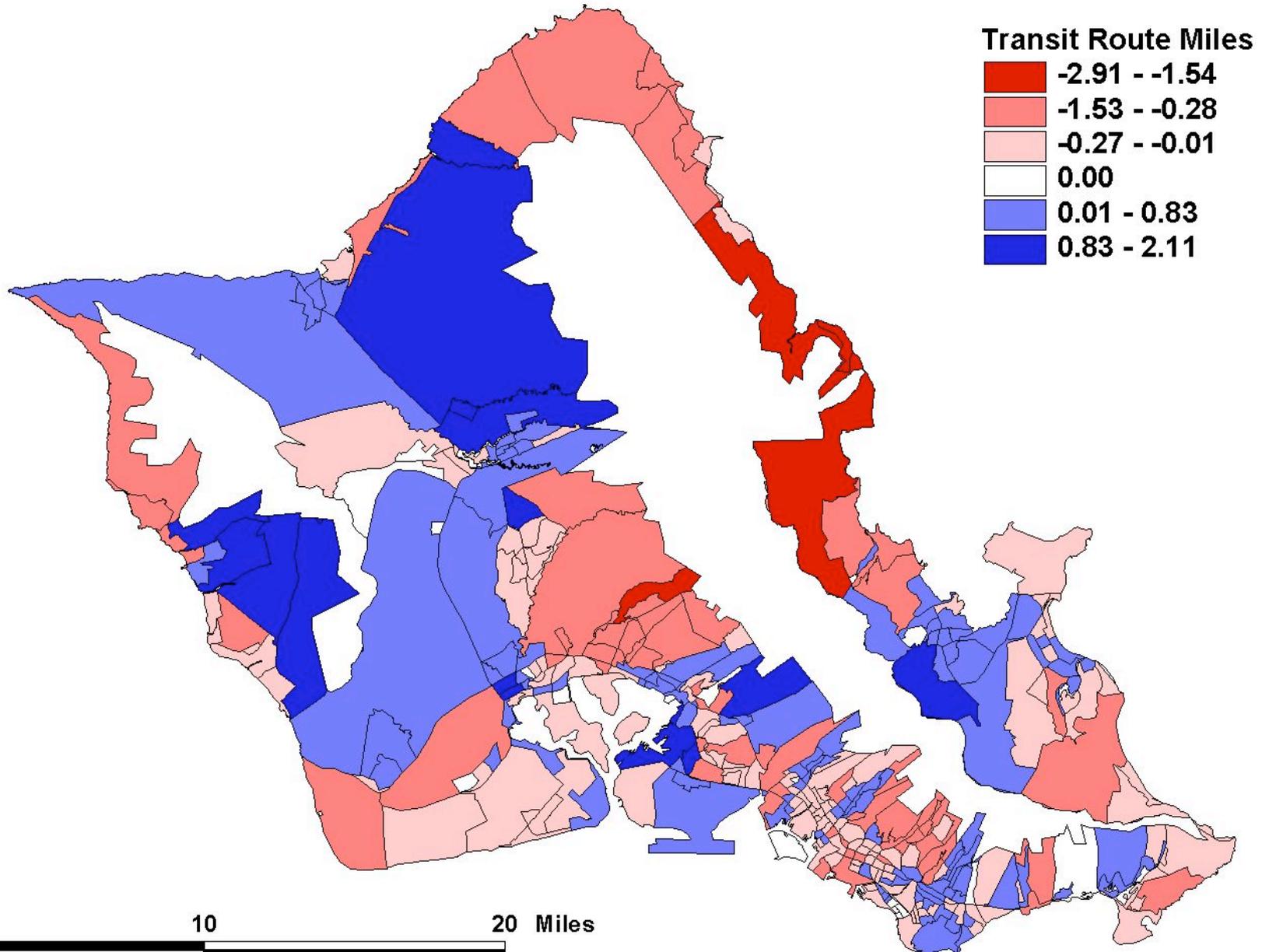
- *Mobility: What is the impact of SLR on the **household travel** from one location to another in terms of **speed, travel time, cost**?*
- *Accessibility: What is the impact on different modes (**auto, bus, rail, bike, pedestrian, etc.**)?*
- *Safety: Who is at risk of increased **mortality** and **morbidity** and exposure?*
- *Development: What is impact on **land use, development, growth, change, urbanization**?*
- *Vulnerable at-risk, **EJ Populations**?*

AM Peak Travel Time Differences Between the Base Case and with ORTP Improvements

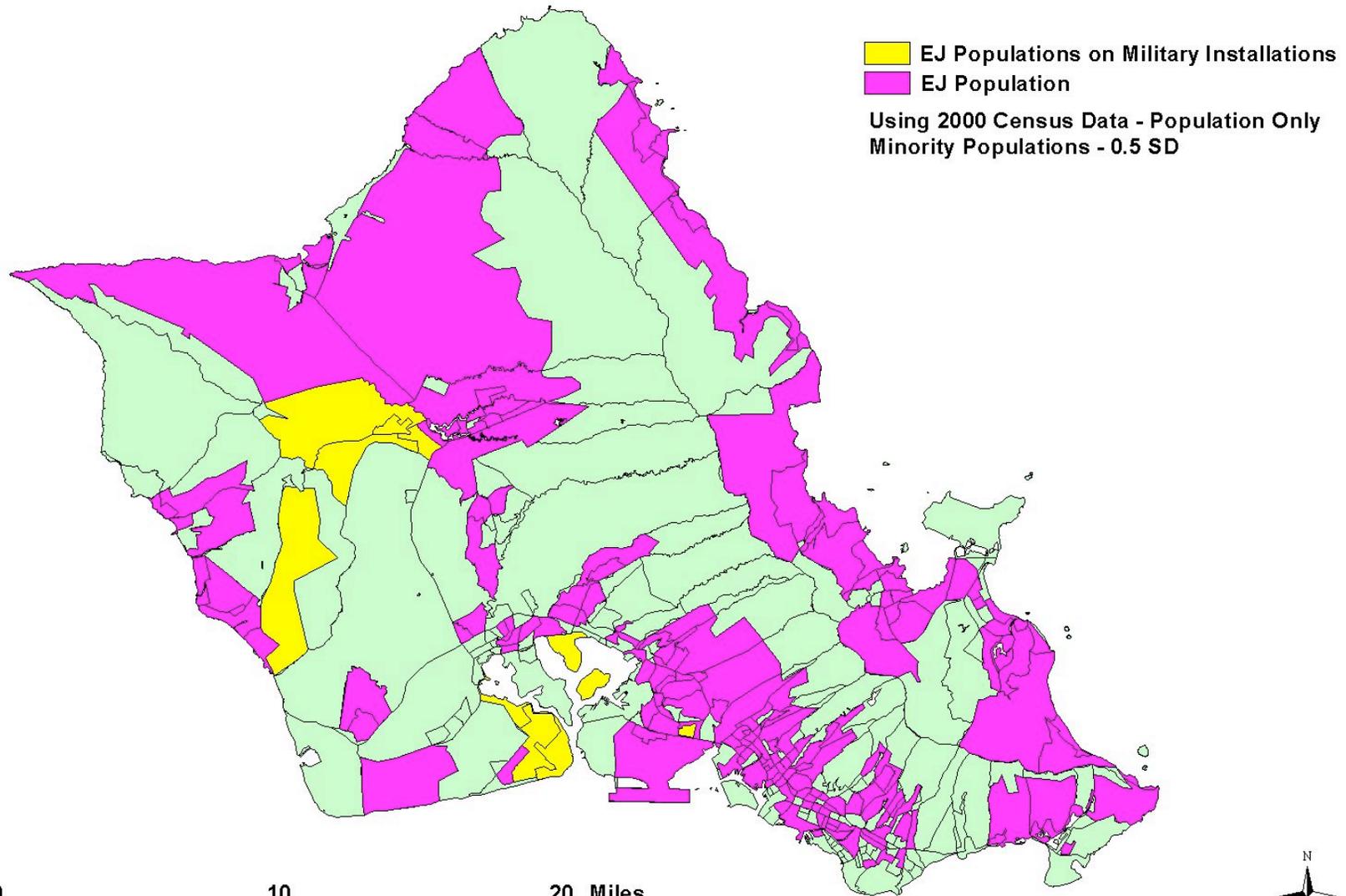
Time Differences (AM Peak)



Differences in Transit Route Miles Between the Base Case and with ORTP Improvements



Title VI and Environmental Justice Populations



Summary and Conclusions

- Data integration for risk reduction
- Natural/Environmental Science + Social Science
- Need criteria for success
- Transport
 - Critical Infrastructure
 - Data Rich Environment
 - Interactions between transport facilities, land use, development, especially in coastal area

COLLABORATION for ADAPTATION...



Disaster Management and Humanitarian Assistance: An International, Multi-Institution Collaboration of the Asia Pacific Initiative (API)



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