Objectives

- **Set Context for Action (Adapt and Mitigate!)**
- **Convey Opportunity (Financial, Resilience, & Community Benefit)**
- **Align to Local Policy / Goals (100%RE, Resilience Hubs)**
- **Raise Risk of Non-action (future retrofit?)**
- **Share Examples (to build confidence)**
- **[Understand Psychology of Choice and Why People Won't Act]**

1. District Systems Infrastructure

An Approach for Affordable, Resilient, Healthy Communities

2. Flexible Adaptation Pathways

An Approach for Sea Level Rise and Flood Infrastructure

Cole Roberts, PE, LEED AP
cole.roberts@arup.com
415-957-9445

Jack Hogan, PE
Jack-W.Hogan@arup.com
415-957-9445

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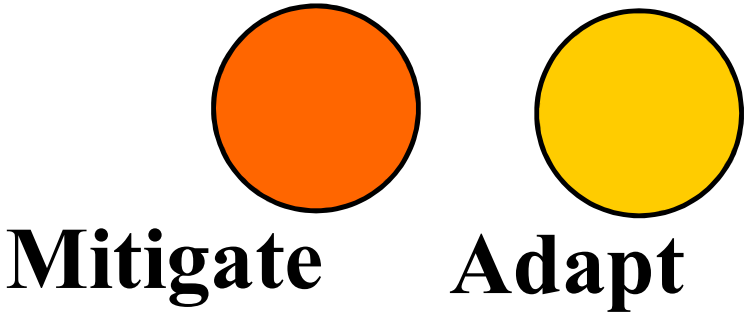
Context Reminder



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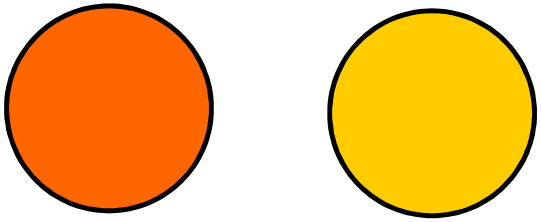
Context Reminder



Reduction Resilience

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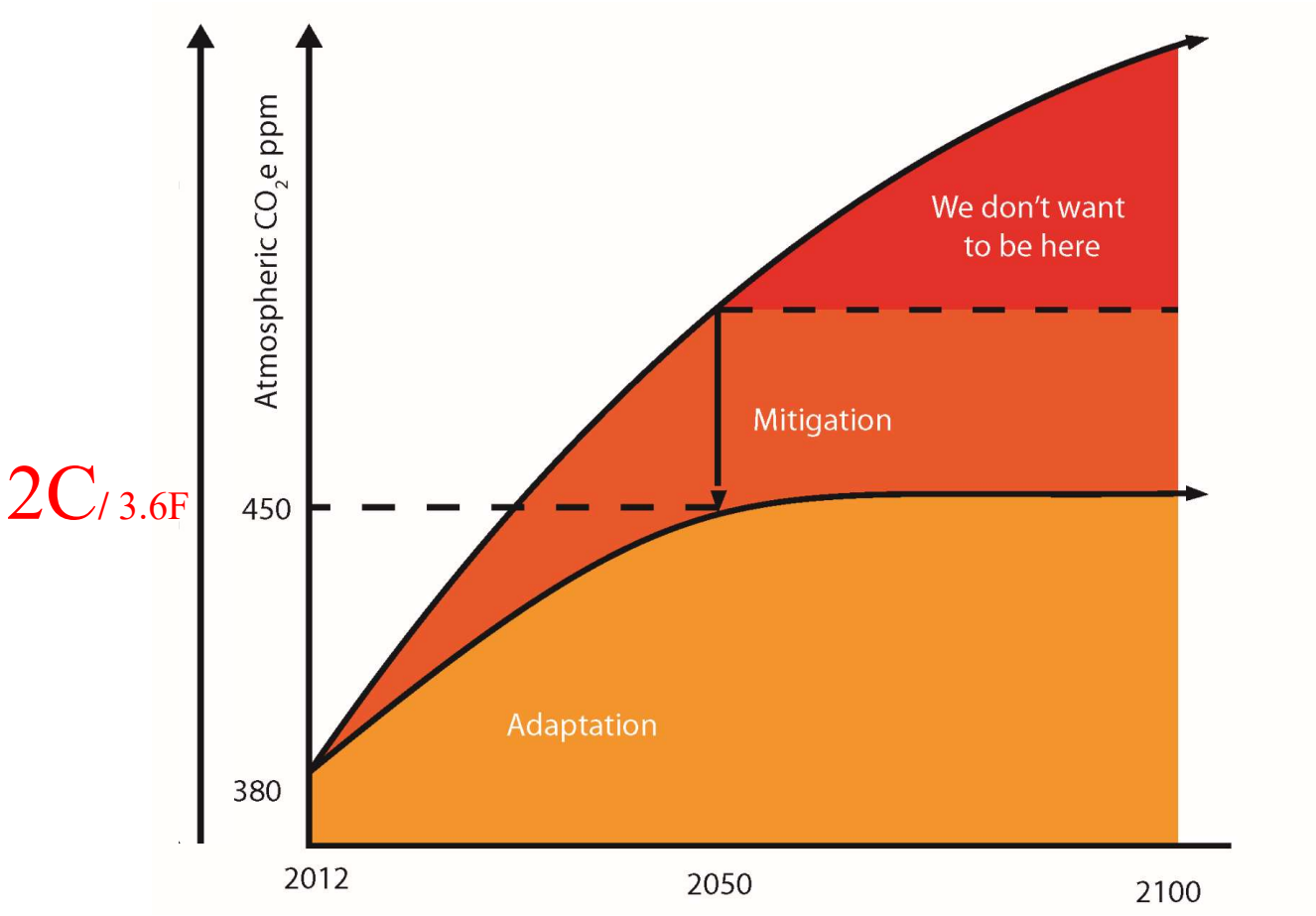
2C/ 3.6F
Atmospheric CO_2e ppm
450
380
We don't want
to be here
Mitigation
Adaptation
2012
2050
2100

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Early & *Right* Action

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Recognize a problem

Choose to act to remedy or avoid the problem

Act effectively

Adapted from Collapse *– How Societies Choose to Fail or Succeed, Jared Diamond*

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BUSINESS TRENDS , LIFESTYLE , SUSTAINABILITY – SEPTEMBER 6, 2018

The Cost of Climate Change in Hawaii

GOVERNMENT – JANUARY 7, 2020

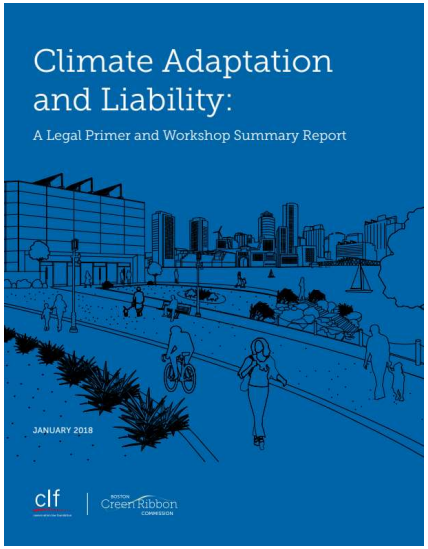
Hawai‘i’s Future Liabilities are Expected to Cost $88 Billion

Action has been voluntary. That is changing.

"Failure to act in the face of climate risk could result in legal liability.

...prevailing practices... [and] explicit standards.... are not the only factors that determine legal responsibility for... failing to act reasonably in the face of ascertainable climate risk.

...obligations can be heightened when considerations of public health or safety are at issue.



clf | Conservation Law Foundation

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District Systems Infrastructure

An Approach for Affordable, Resilient, Healthy Communities

Focus on Energy Systems in Dense Areas

Cole Roberts, PE, LEED AP
cole.roberts@arup.com
415-957-9445

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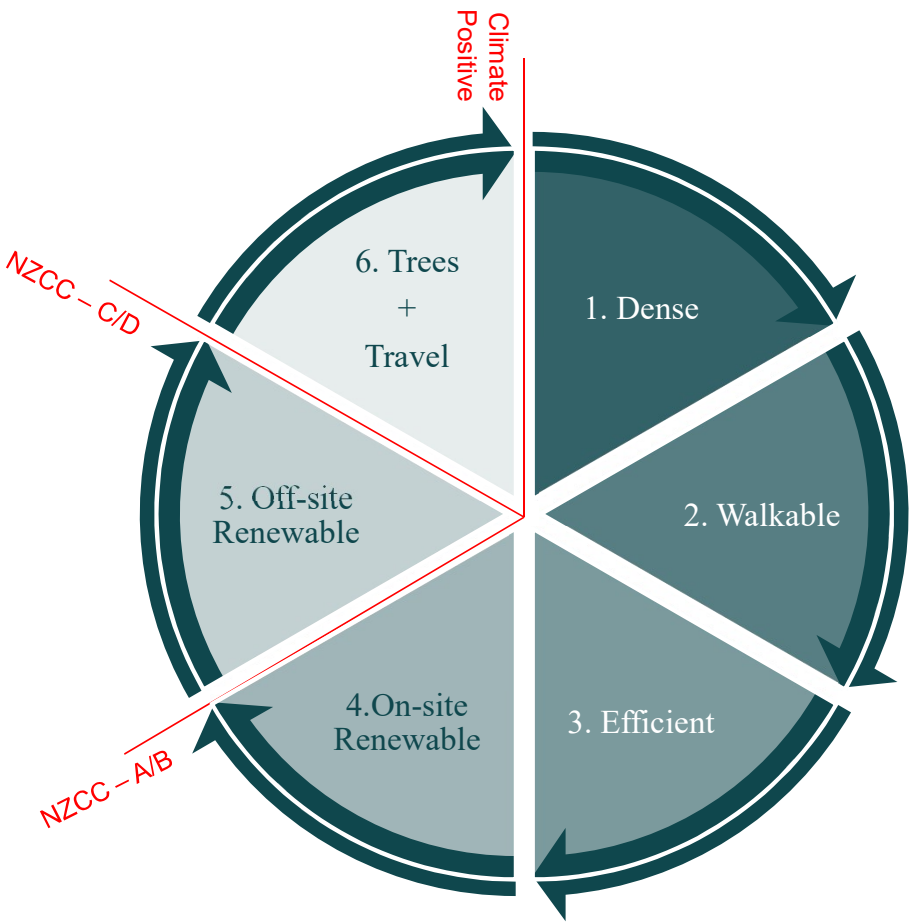
Effective Action – Climate Positive Community



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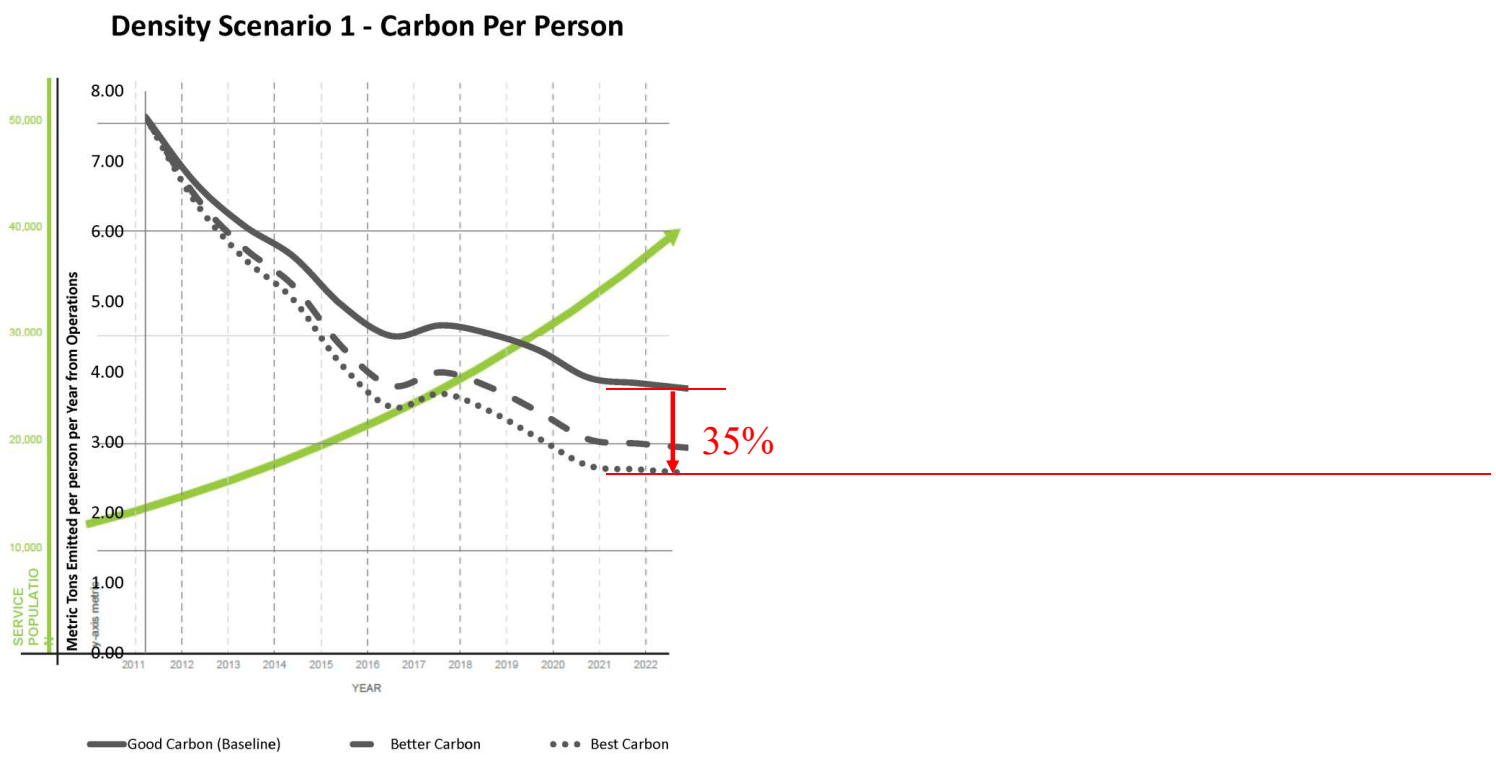
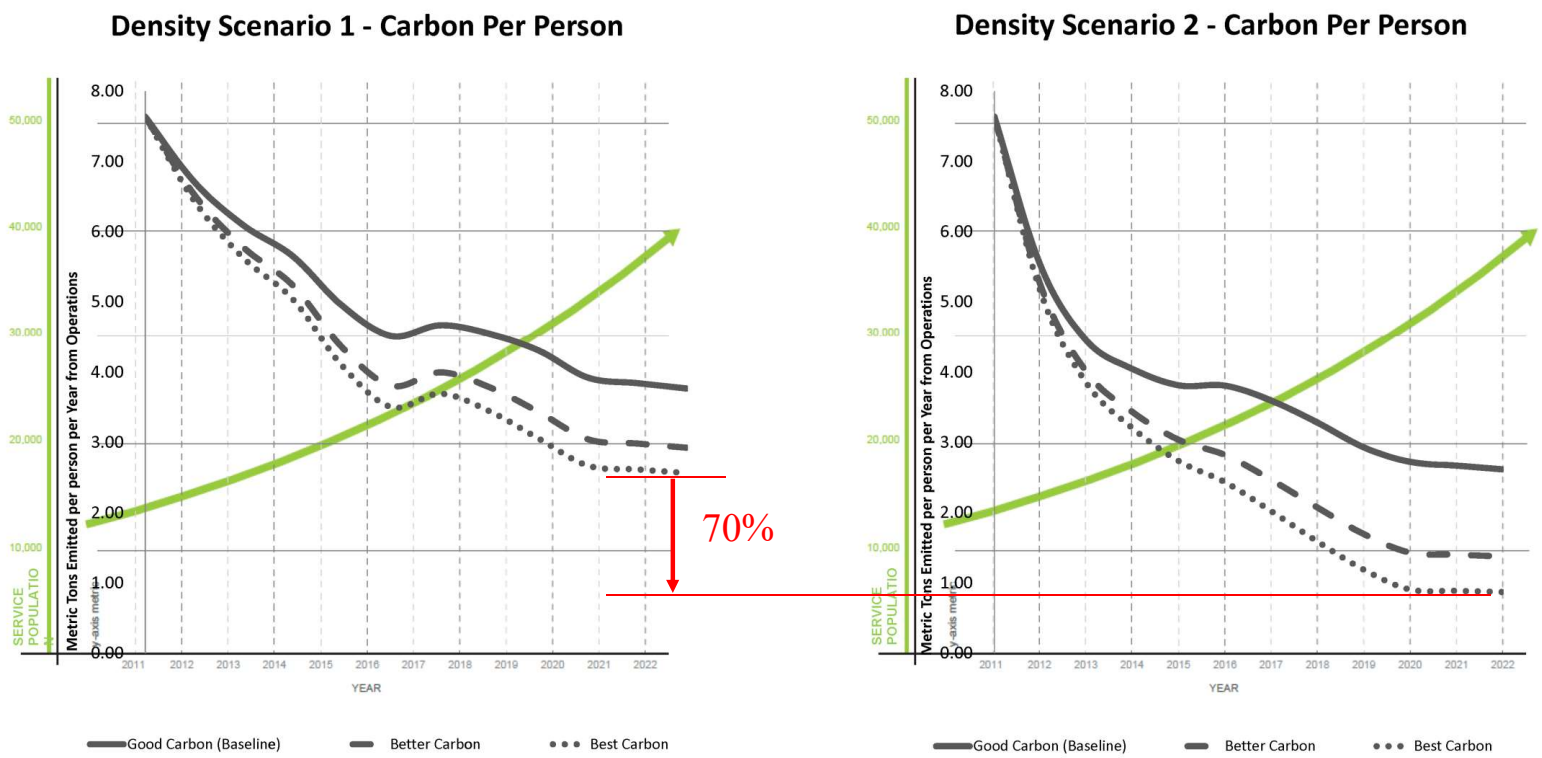
Density Enables Deep Improvements



Density
(FAR of 1x)

ARUP

Density Enables Deep Improvements



Density
(FAR of 1x)

2x Density
(FAR of 2x)

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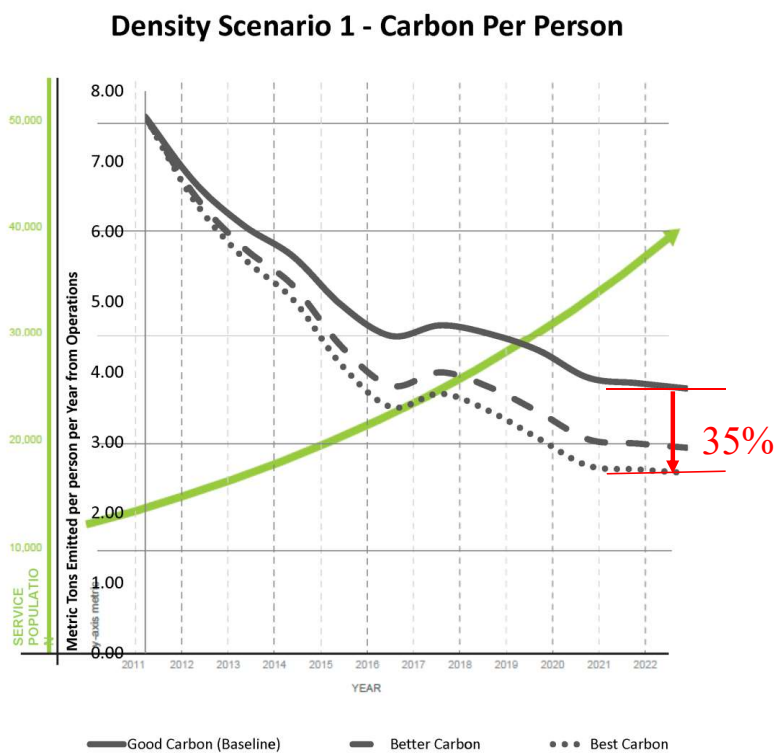
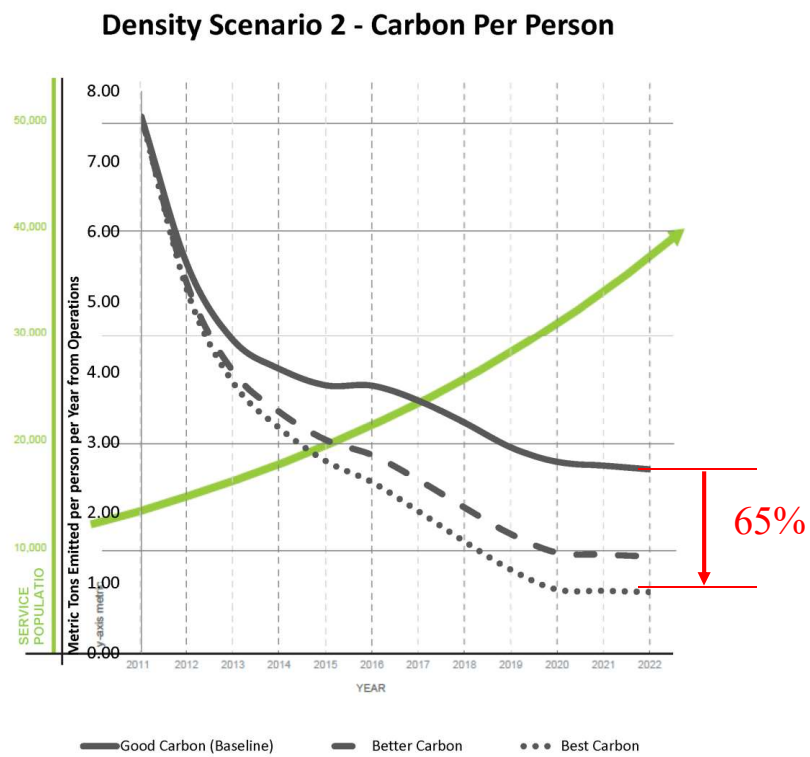
Density Enables Deep Improvements

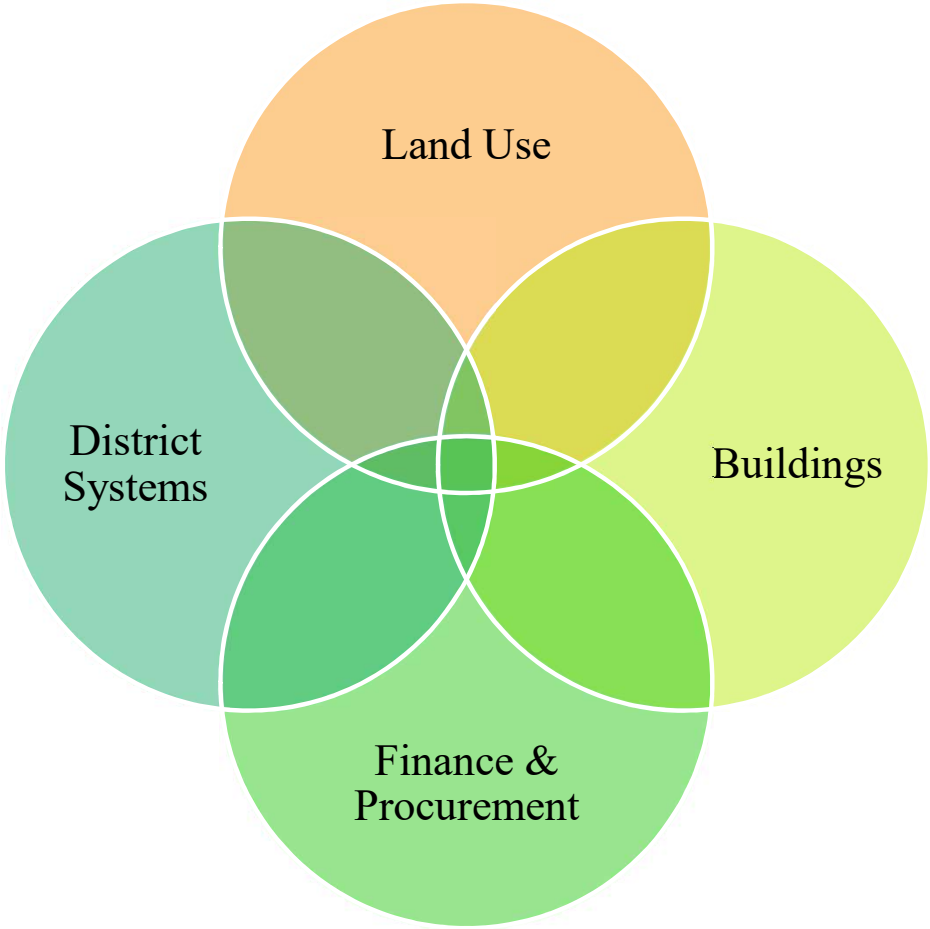


Density
(FAR of 1x)



2x Density
(FAR of 2x)

ARUP



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O’ahu Resilience Strategy

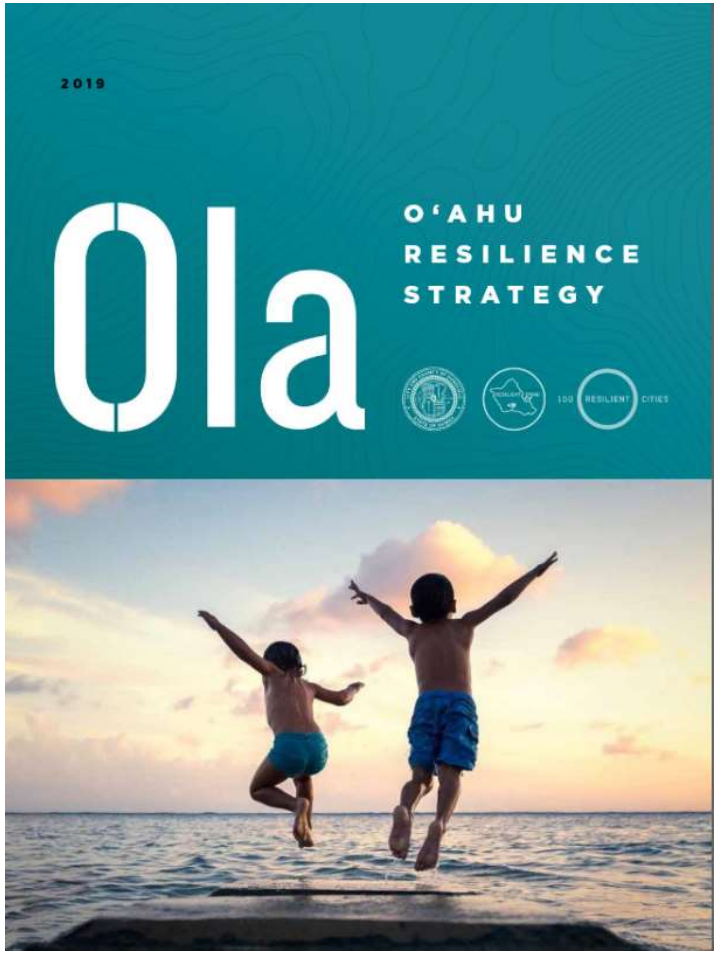
“Driven by distance and isolation, islands have long been incubators of innovation, pioneers of self-sufficiency, and builders of social capital”

Action 7: Reduce utility costs

Action 15: Develop resilience hubs

Action 22: Expand district cooling

Action 32, 33, and many more



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Developing high performance districts at scale which utilizes renewable, thermal and electrical technologies in order to…

- Reduce utility costs and optimize performance for buildings and key infrastructure/operational systems
- Help to achieve long term Hawaiian goals for 100% RE, water/waste performance, and new resilience hubs.
- Achieve regional environmental goals including greenhouse gas emissions, habitat restoration, sea level rise mitigation and regional air & water quality improvements

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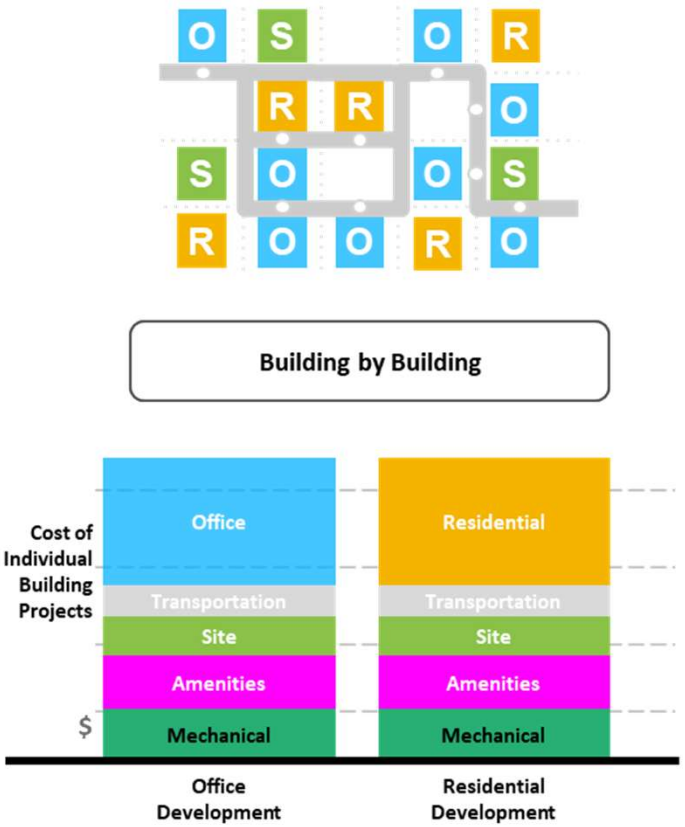
VALUE: Place Based District Development Significantly Increases the Quality of Place While Minimizing Costs



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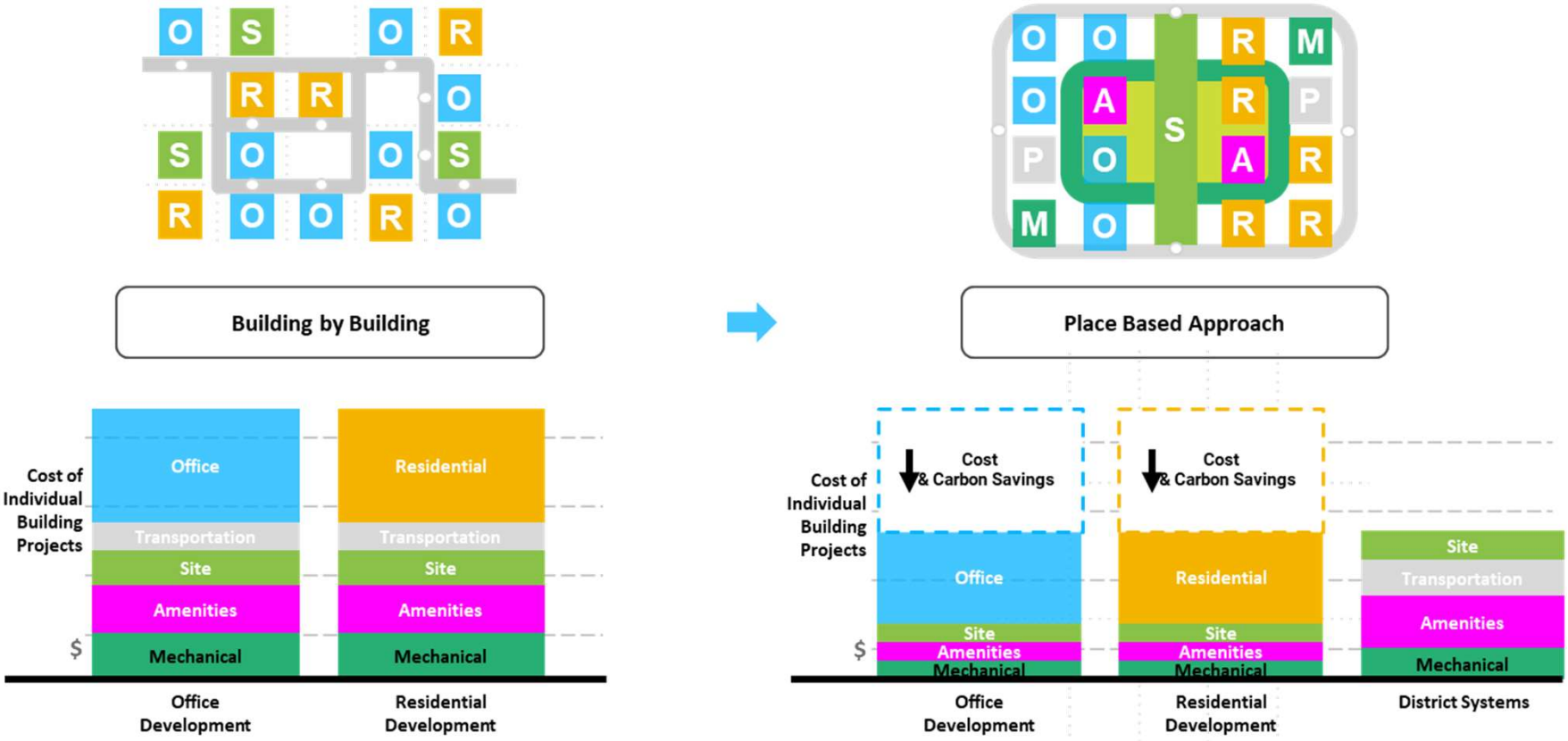
VALUE: Place Based District Development Significantly Increases the Quality of Place While Minimizing Costs



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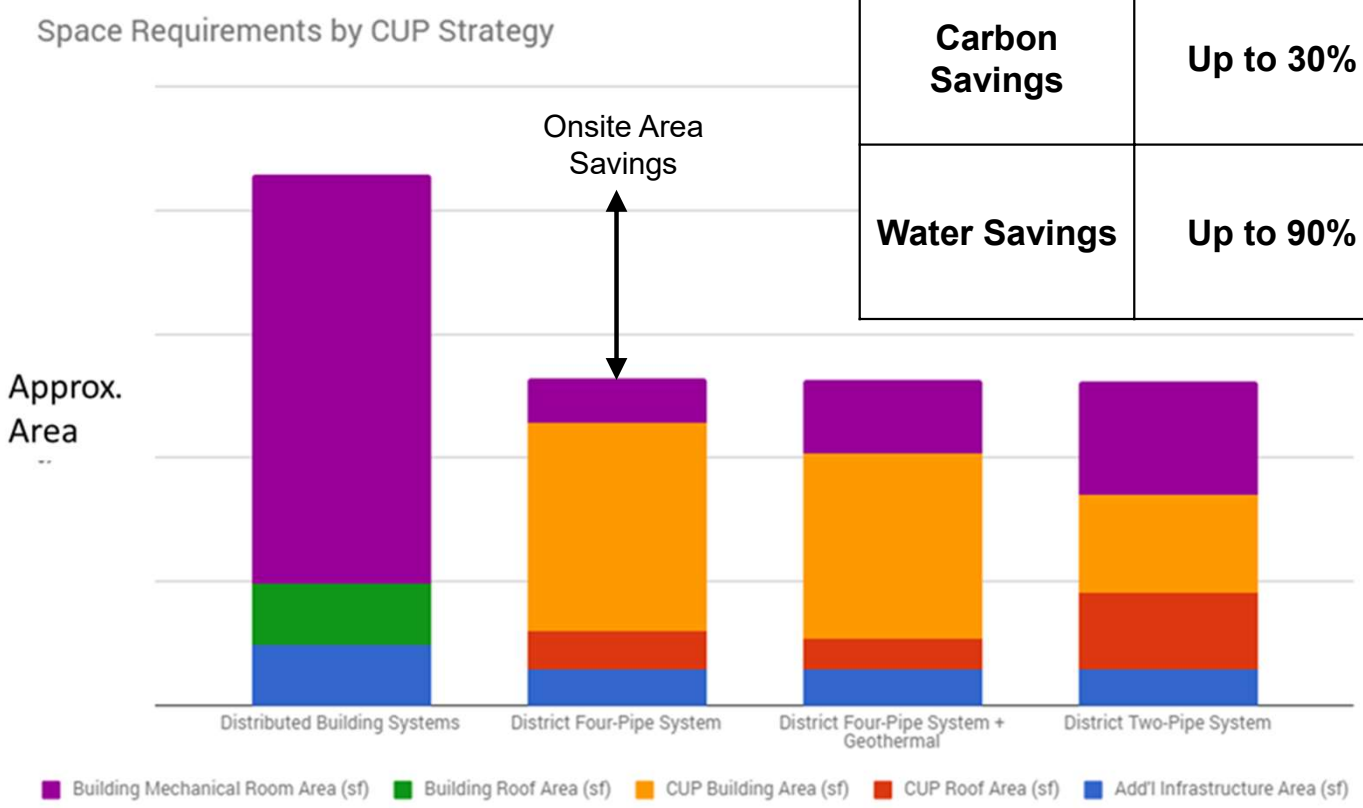
VALUE: District Systems Return Space to Buildings, While Reducing Resource Consumption



Carbon Savings	**Up to 30%**
Water Savings	**Up to 90%**

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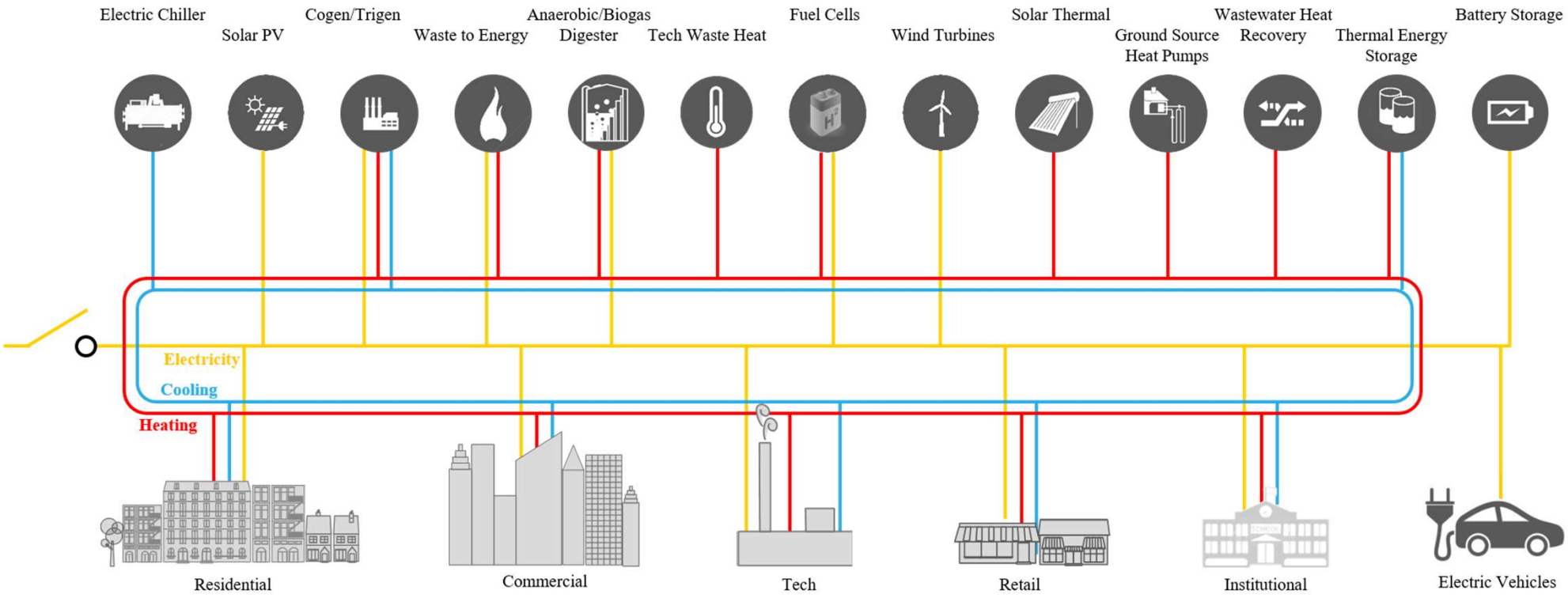
ENERGY: There are Many Solutions and Each TOD Area is Unique



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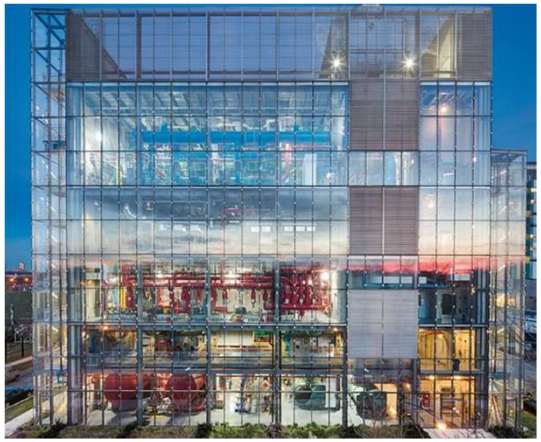
District Systems Have Proven Powerful as Attractive Showcases and Tourist Destinations

Department of General Services, Sacramento, CA

Hammarby-Sjostad, Sweden

False Creek, Vancouver, Canada

Stanford University, Palo Alto, CA



University of Chicago, Chicago, IL

University of Chicago, Chicago, IL

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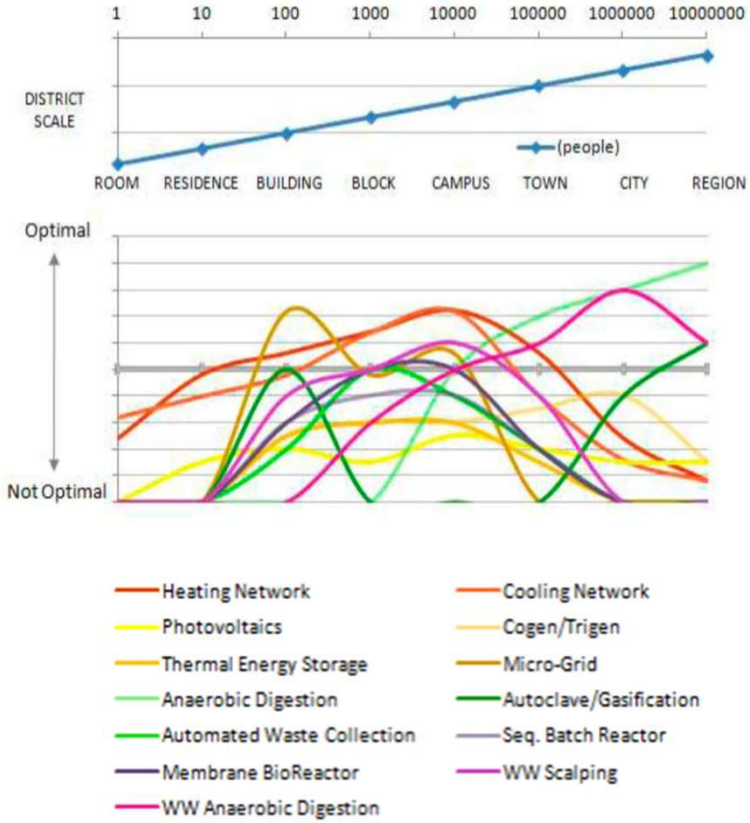
VALUE: Infrastructure Systems Can Optimize at a District Scale and Provide Additional Financial and Operational Benefits

1. Increased system efficiency
2. Greater control of sources & systems
3. Reduced carbon emissions
4. Reduced water consumption
5. Expandable to new projects & customers
6. Resource recovery potential
7. Reduced operating cost
8. Streamlined maintenance
9. More space in buildings for Googlers



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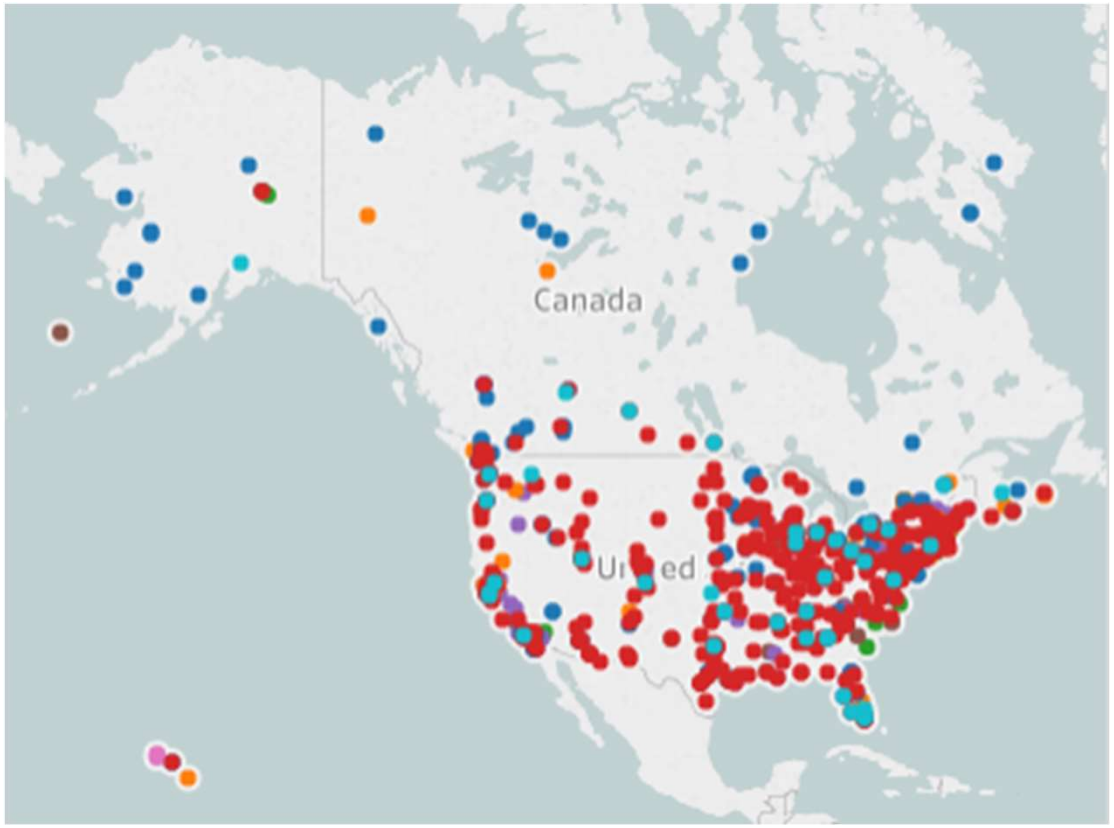
LEADERSHIP: District-Scale is the New Norm, But Net-Zero and Islandable Systems are the New Frontier



- ~200 projects in recent years in the US and Canada
- Examples:
  - Atlanta Station
  - District Energy St. Paul
  - Fort Detrick
  - **Hawaii Seawater Air Conditioning**
  - Longwood Medical Area
  - NRG Energy Center Phoenix
  - Stanford University
  - University of Oklahoma

Sourced from:

- IDEA
- NCPPP
- IEA
- NRG Thermal
- Corix
- Chevron Energy Services
- Veolia Energy
- Macquarie Infrastructure

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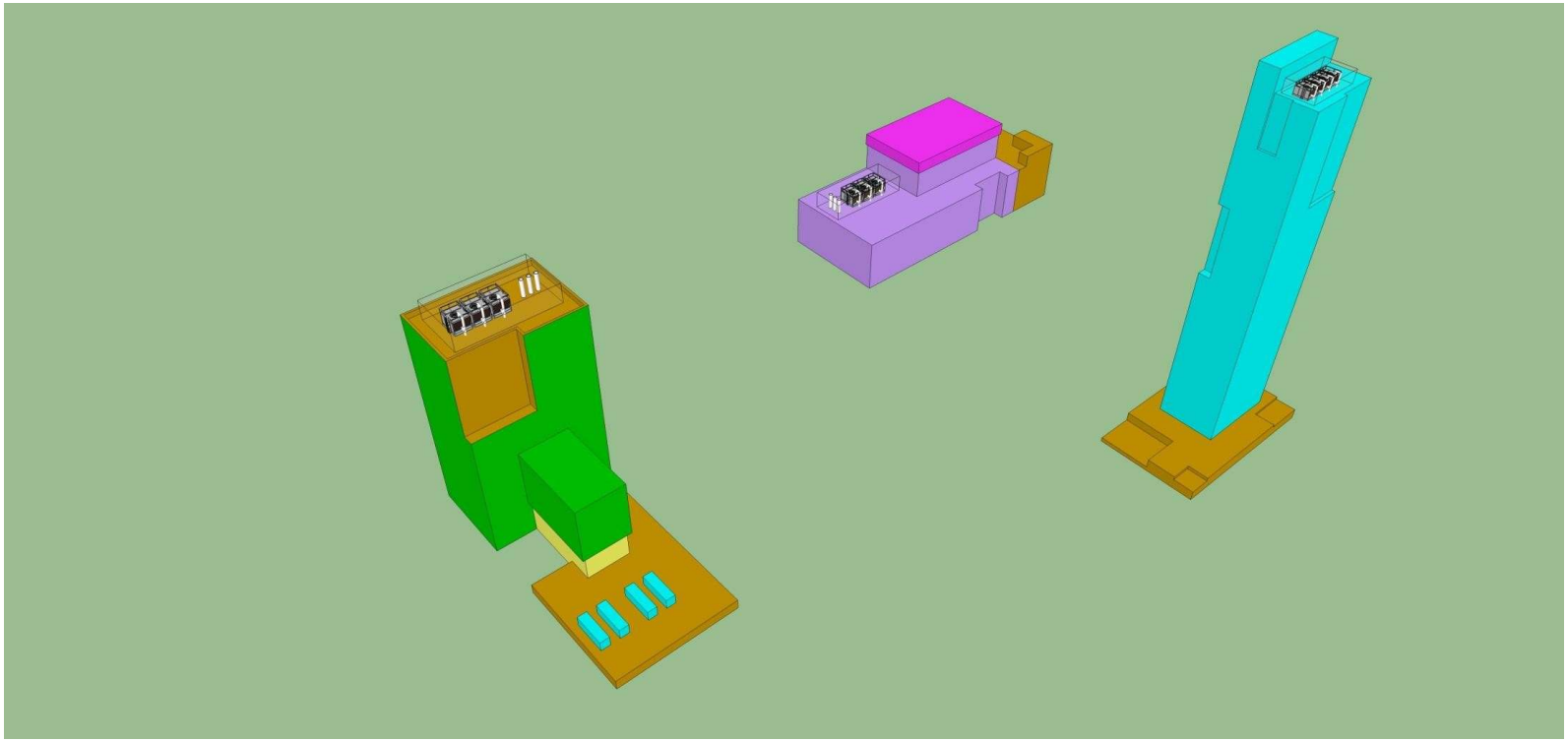

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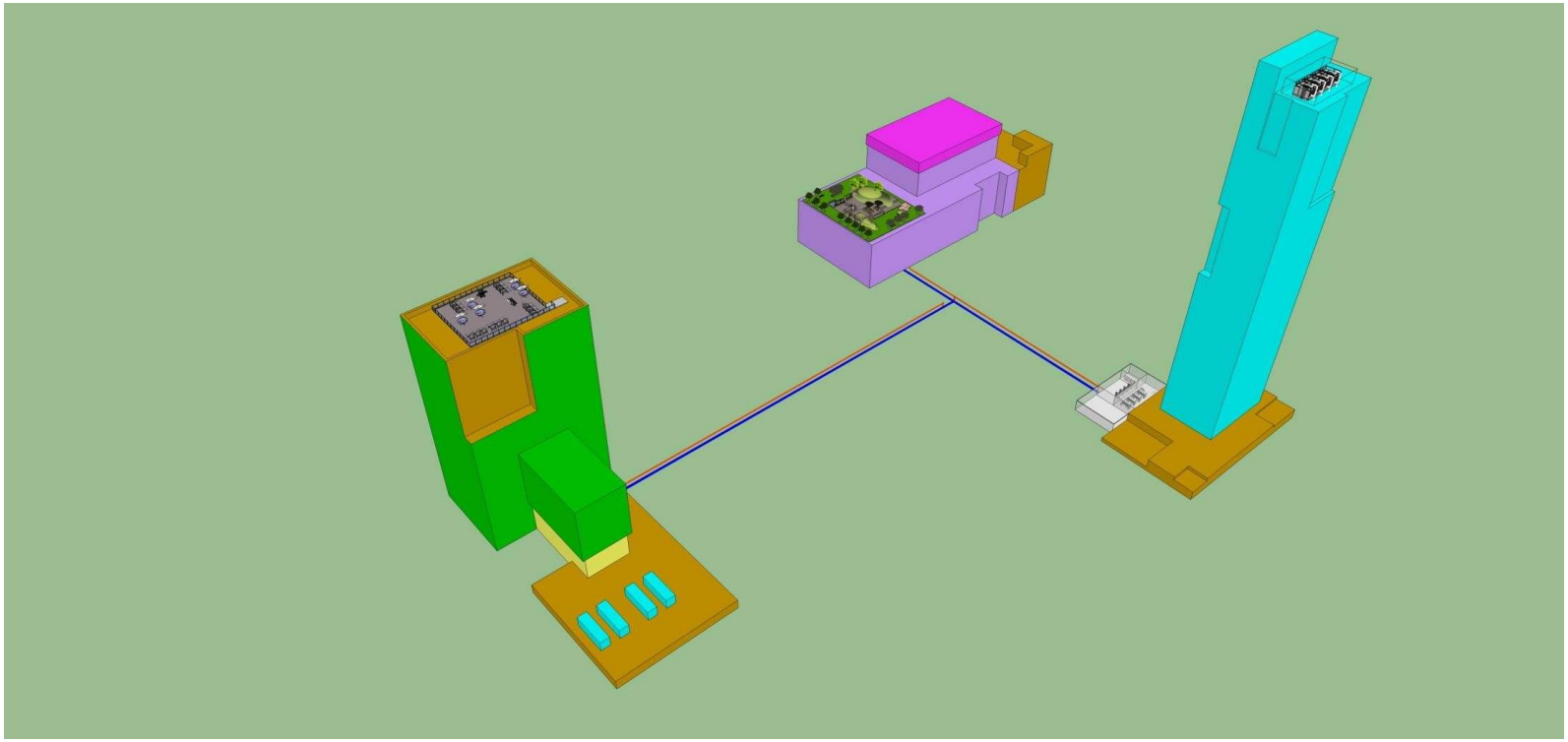

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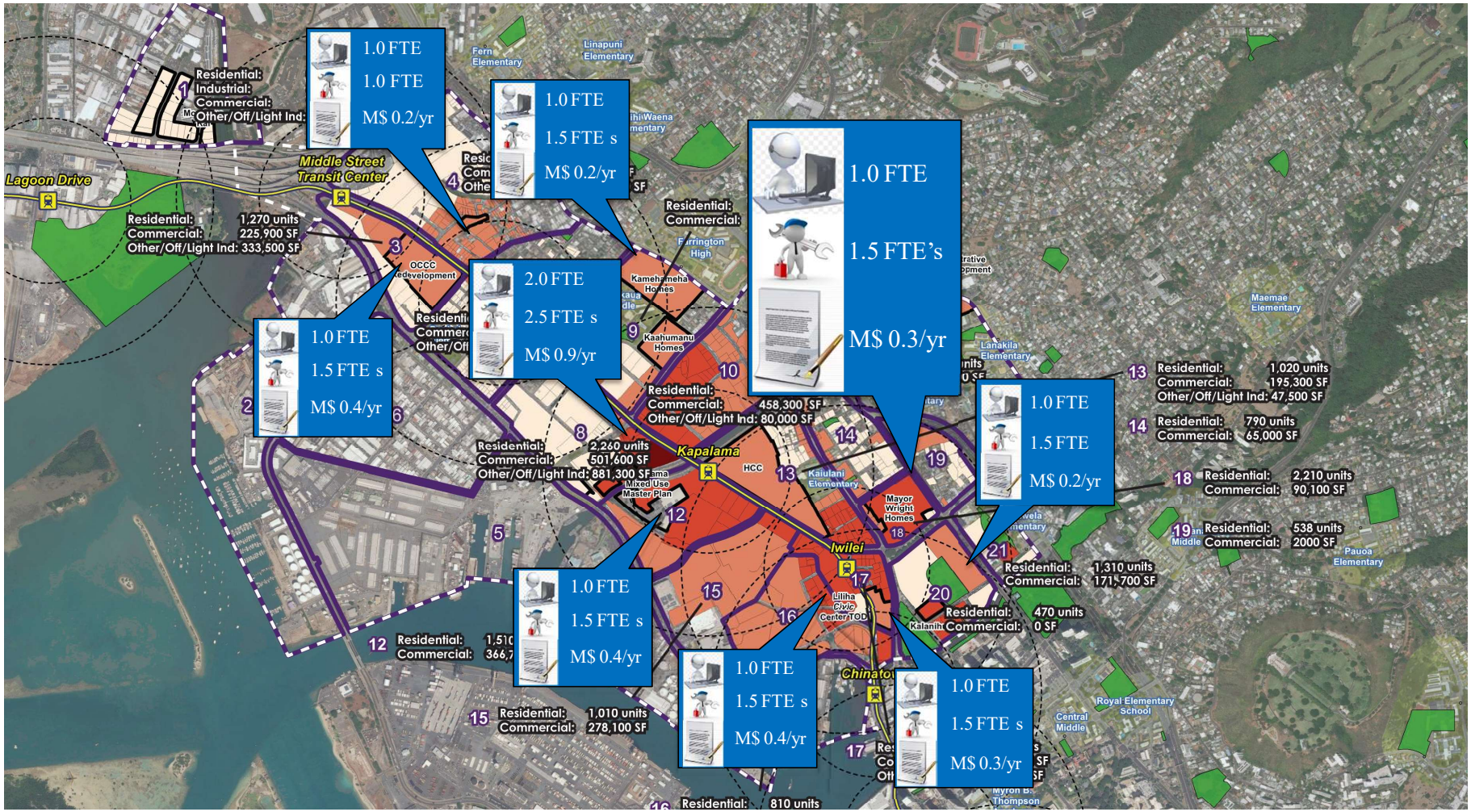
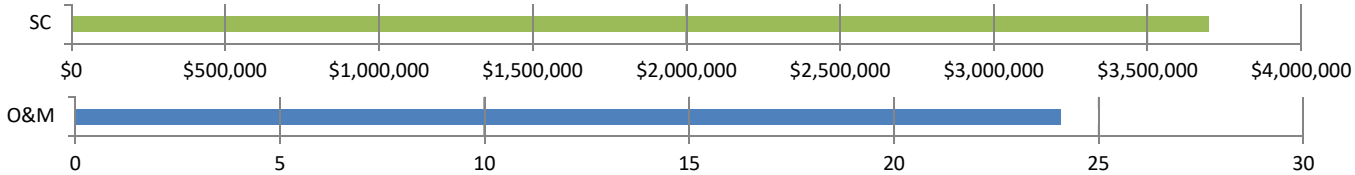

1.0 FTE
1.0 FTE
M$ 0.2/yr
1.0 FTE
1.5 FTE s
M$ 0.2/yr
1.0 FTE
1.5 FTE's
M$ 0.3/yr
2.0 FTE
2.5 FTE s
M$ 0.9/yr
1.0 FTE
1.5 FTE s
M$ 0.4/yr
1.0 FTE
1.5 FTE
M$ 0.2/yr
1.0 FTE
1.5 FTE s
M$ 0.4/yr
1.0 FTE
1.5 FTE s
M$ 0.4/yr
1.0 FTE
1.5 FTE s
M$ 0.3/yr
Residential:
Industrial:
Commercial:
Other/Off/Light Ind:
Lagoon Drive
Middle Street Transit Center
Residential: 1,270 units
Commercial: 225,900 SF
Other/Off/Light Ind: 333,500 SF
Residential: 2,260 units
Commercial: 501,600 SF
Other/Off/Light Ind: 881,300 SF
Residential: 1,510
Commercial: 366,7
Residential: 1,010 units
Commercial: 278,100 SF
Residential: 810 units
Residential: 1,020 units
Commercial: 195,300 SF
Other/Off/Light Ind: 47,500 SF
Residential: 790 units
Commercial: 65,000 SF
Residential: 2,210 units
Commercial: 90,100 SF
Residential: 538 units
Commercial: 2000 SF
Residential: 1,310 units
Commercial: 171,700 SF
Residential: 470 units
Commercial: 0 SF
Residential:
Commercial:
Other/Off/Light Ind: 458,300 SF
Other/Off/Light Ind: 80,000 SF
Kapalama
Iwilei
Chinatown
Fern Elementary
Linapuni Elementary
Farrington High
Kamehameha Homes
Kaahumanu Homes
Kaiulani Elementary
Mayor Wright Homes
Lanakila Elementary
Maemae Elementary
Pauoa Elementary
Royal Elementary School
Central Middle
Myron B. Thompson
HCC
Liliha Civic Center TOD
Mixed Use Master Plan
OCCC redevelopment


SC
$0
$500,000
$1,000,000
$1,500,000
$2,000,000
$2,500,000
$3,000,000
$3,500,000
$4,000,000
O&M
0
5
10
15
20
25
30

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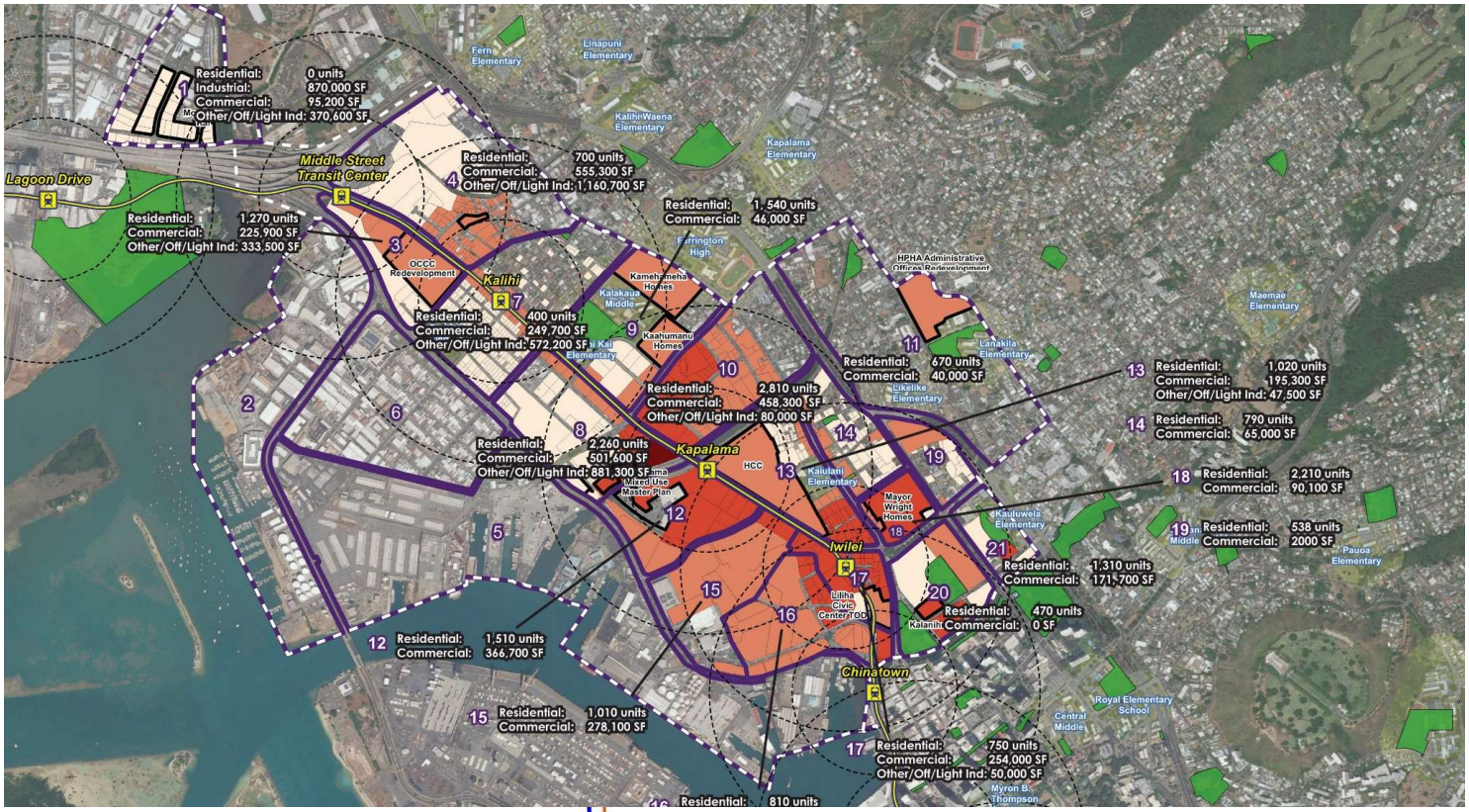
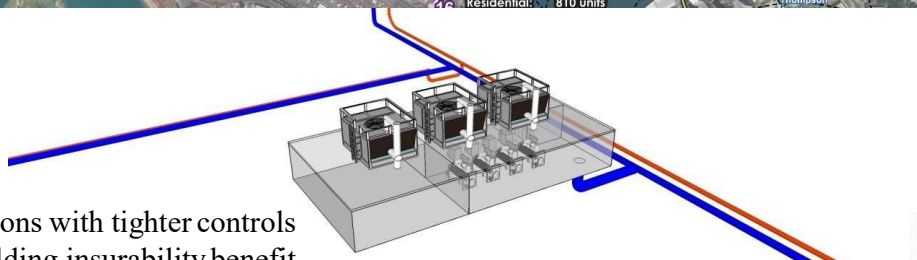
10.0 FTE

14 FTE's

M$ 3.7/yr





5.0 FTE's

6.0 FTE's

M$ 1.0/yr

+ Consolidated emissions with tighter controls
+ Building insurability benefit
+ Building occupant safety
+ More sophisticated controls

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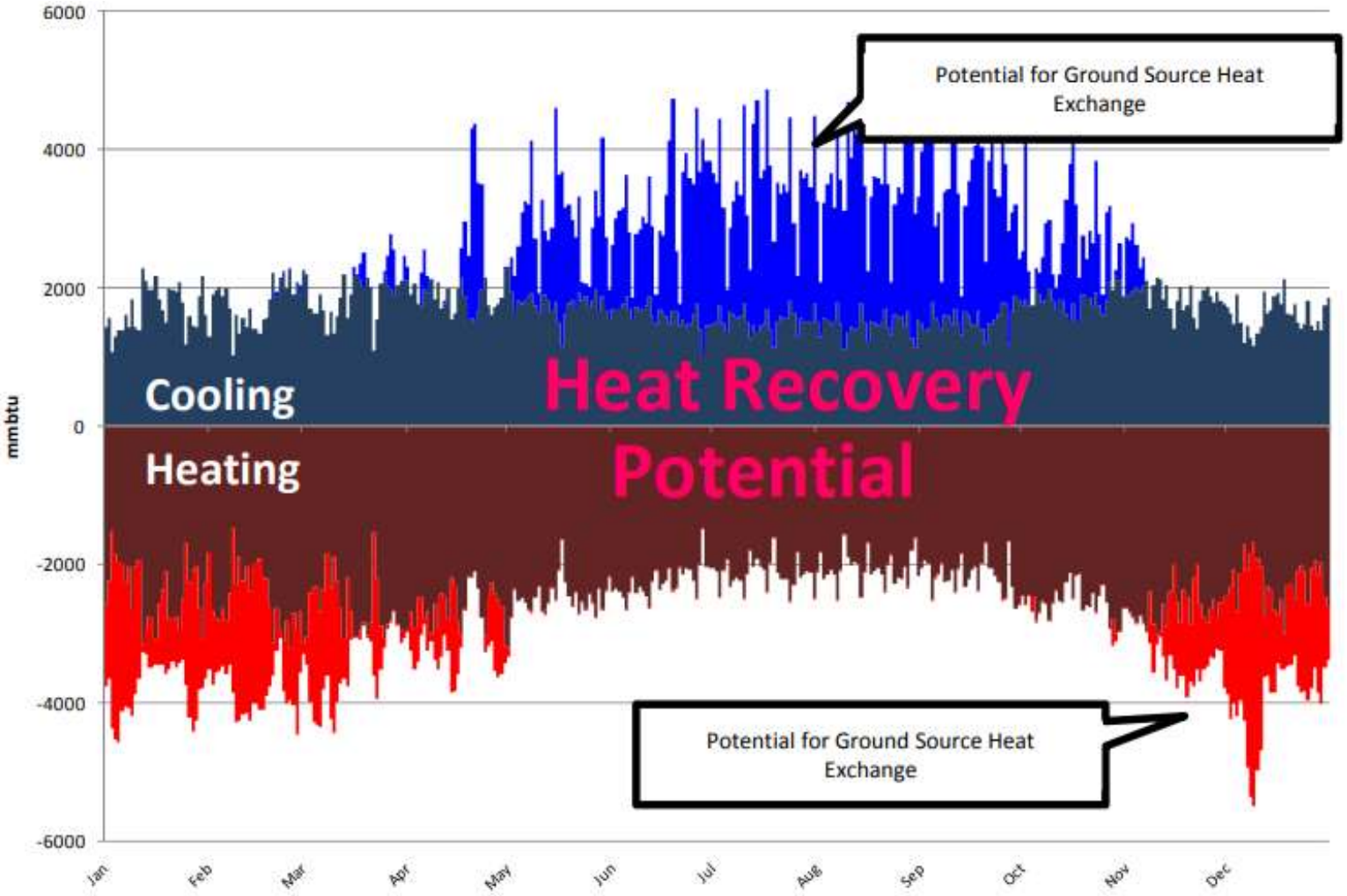
Energy Recovery



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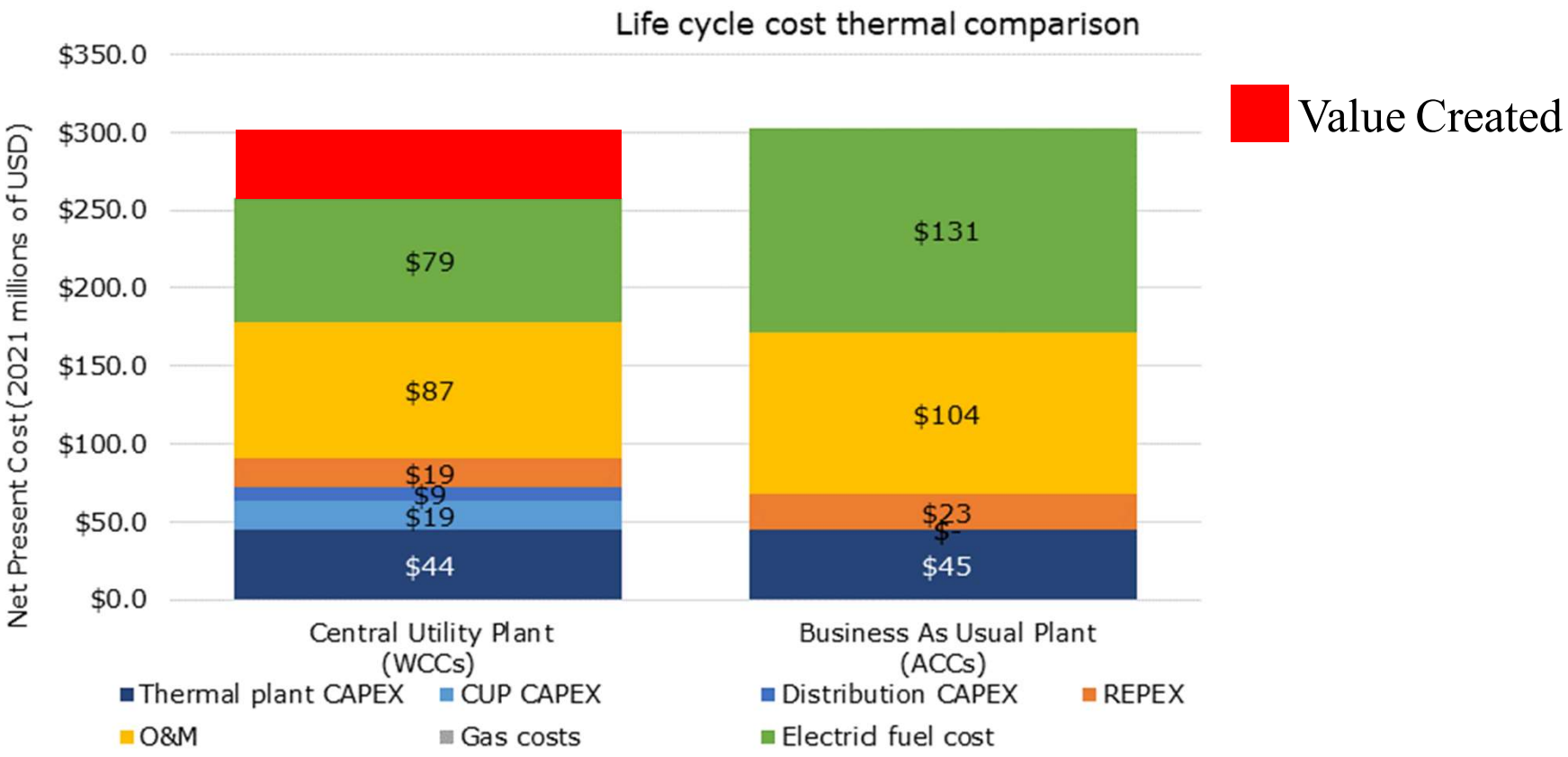
Saving Millions of Dollars per Year (Reducing Utility Costs)



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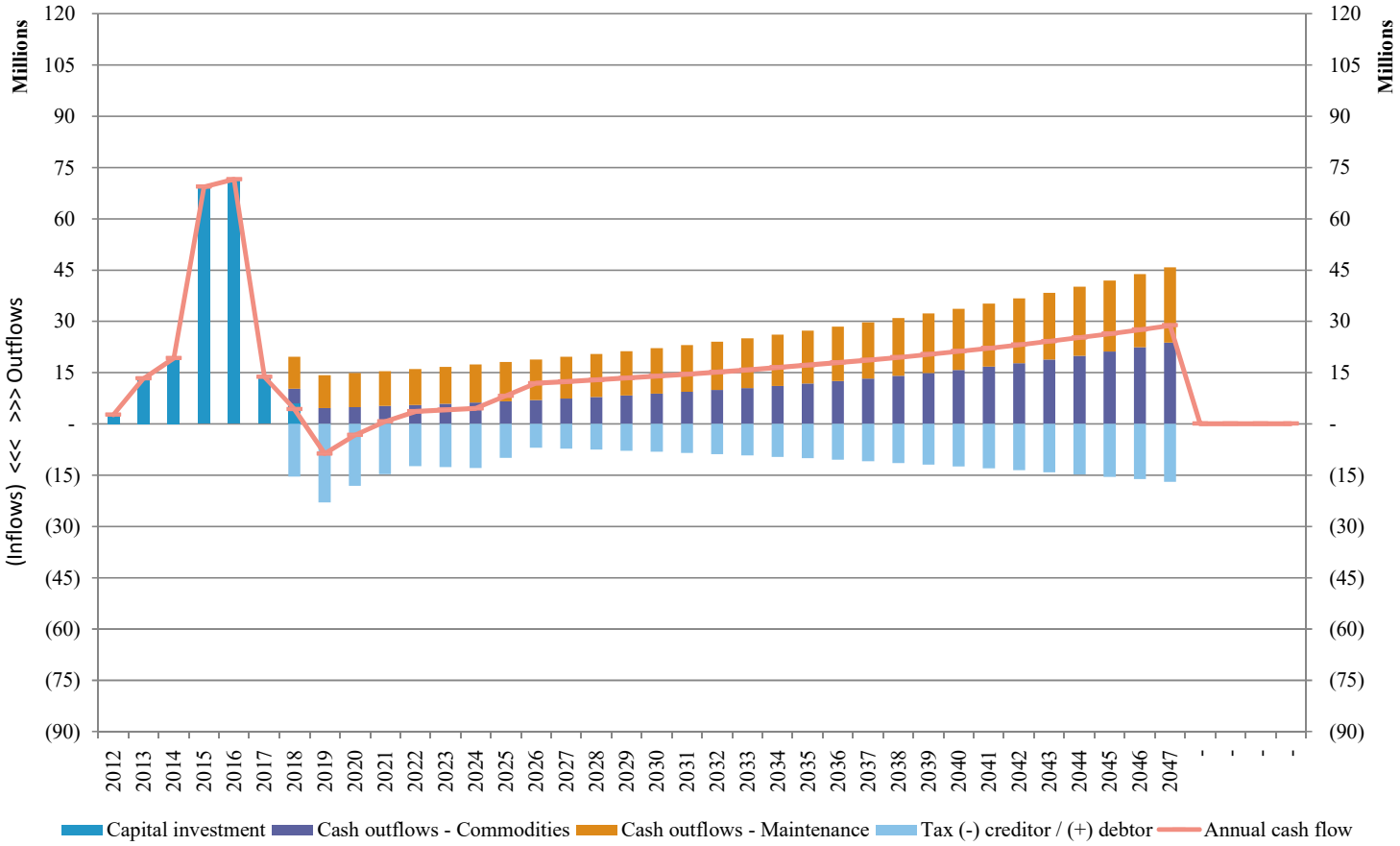
Self-Perform Case - Annual Cash Flow (US$)



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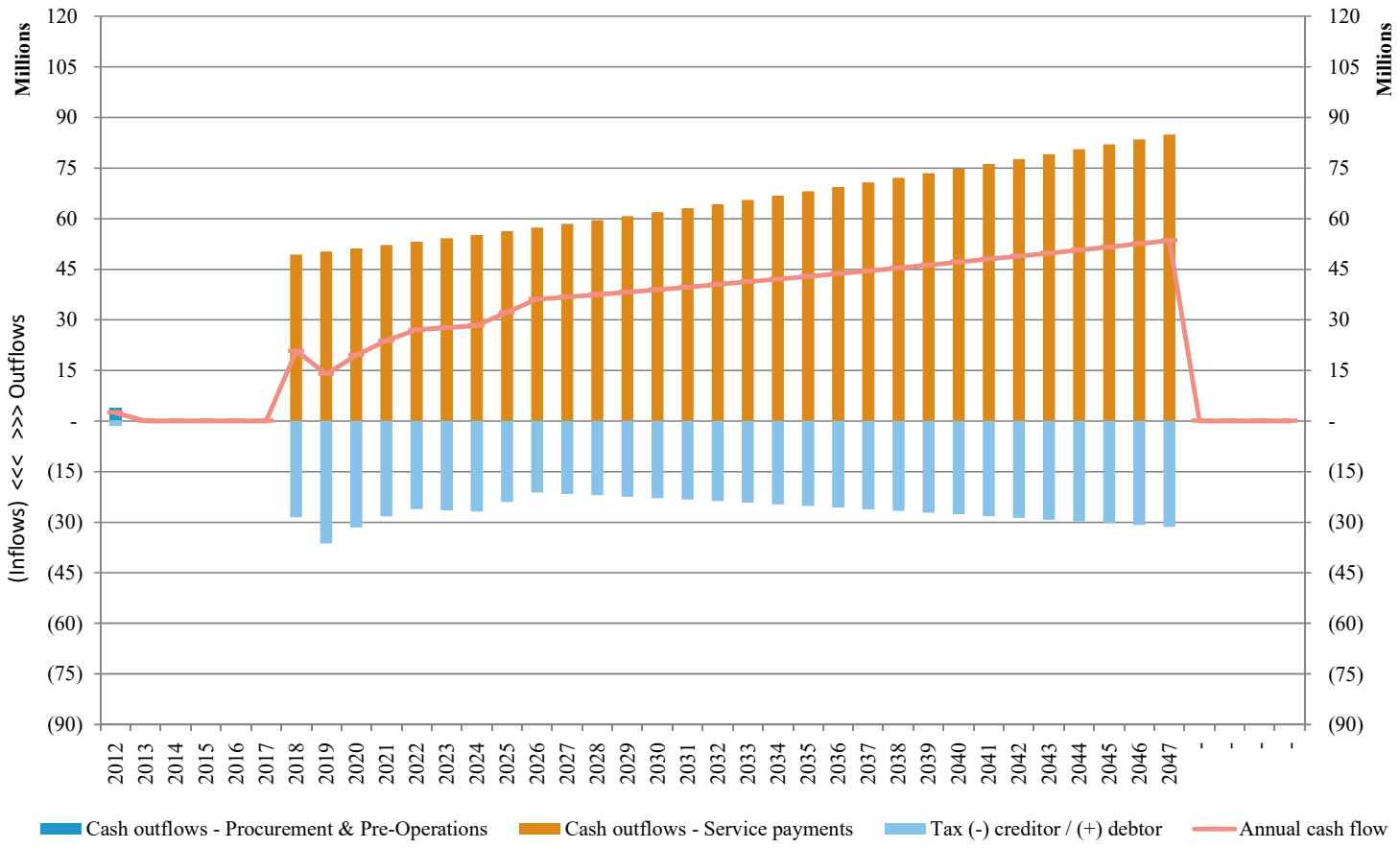
P3 - Cash Flow (US$)



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CASE STUDY: Atlantic Station

Atlantic Station is unique because the $2B commercial redevelopment project was undertaken with the assumption that a district cooling system would be built concurrently.

KEY FIGURES

Procurement: Build-own-operate

Financing: $24M revenue bond, plus other funding sources

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CASE STUDY: Honolulu SWAC

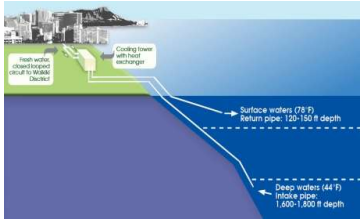
Honolulu Seawater Air Conditioning (SWAC) is a district cooling project planned to serve about 40 buildings in downtown Honolulu. The project is in the procurement phase, and expects to begin construction in 2020 with operations beginning in 2021.

KEY FIGURES

Procurement: Build-own-operate

Cost: $250 – 300M

Financing: $145M tax-exempt revenue bonds
$113M taxable revenue bonds
$47.8M private equity



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Flexible Adaptation Pathways

An approach for Sea Level Rise and Flood Infrastructure

Focus on Iwilei-Kapalama

Jack Hogan, PE
Jack-W.Hogan@arup.com

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Objectives

- Describe Flexible Adaptation Pathways
- Demonstrate appropriateness for State TOD planning projects
- Highlight recommendations for implementation

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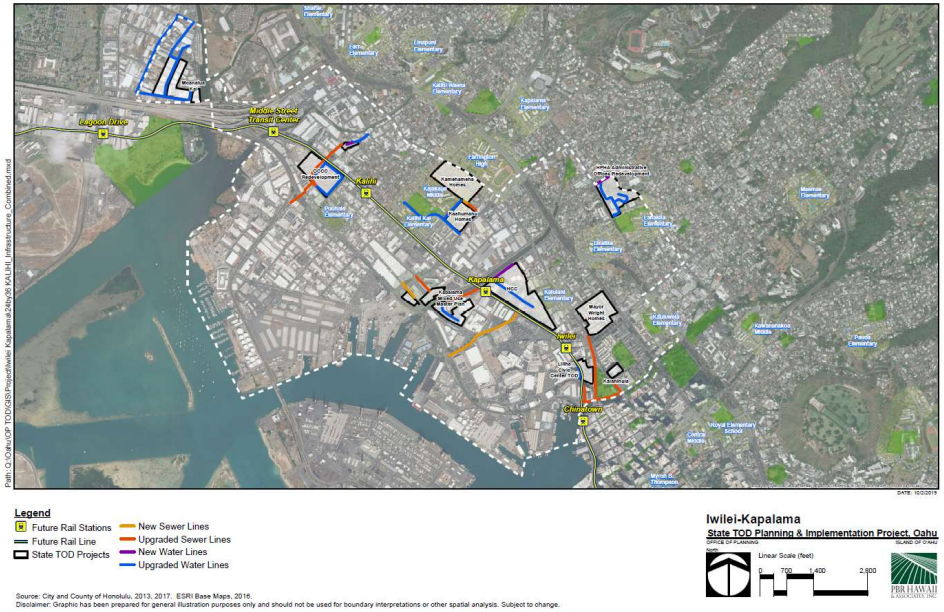
Infrastructure Needs Assessment - Existing



Work in Progress:

- East Kapolei
- Halawa Stadium
- Iwilei Kapalama

Infrastructure	Plans Outlined	Costs Estimated
Sewage	✓	✓
Water	✓	✓
Drainage	✓	✓
Storm water quality	✓	✓
Intersections and roadways	✓	✓
Coastal flooding	✗	✗

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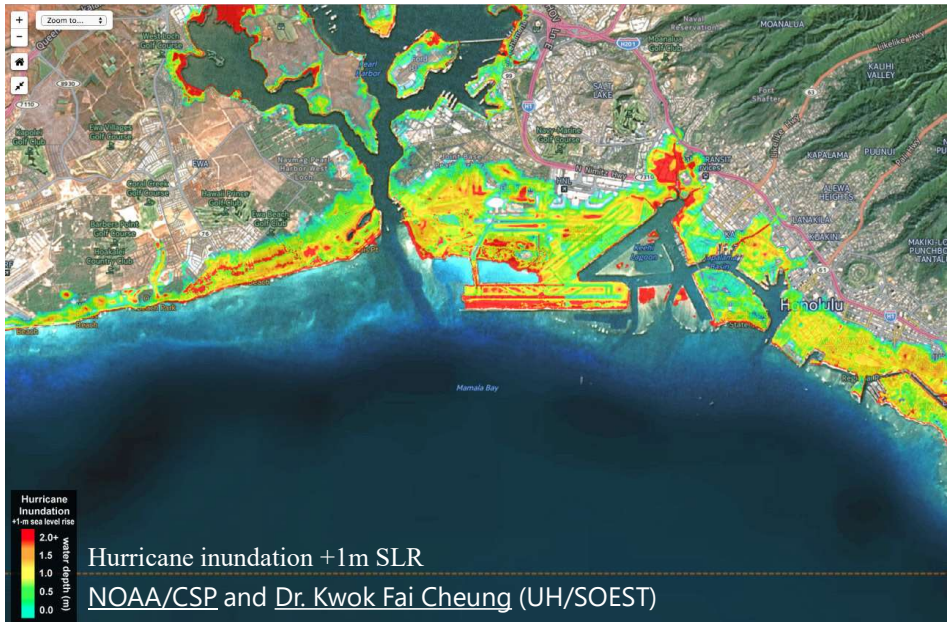
Infrastructure Needs Assessment – Future (Proposed)



(Proposed) Large scale flood infrastructure needs considered for TOD areas

(Proposed) Flexible Adaptation Pathways applicable to infrastructure evaluation and planning

Infrastructure	Plans Outlined	Costs Estimated
Sewage	☑	☑
Water	☑	☑
Drainage	☑	☑
Storm water quality	☑	☑
Intersections and roadways	☑	☑

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Challenge

- Large scale infrastructure is ***capital-intensive*** and ***long-lived***
- ***Uncertainty*** in how the future may unfold due ***climate*** and ***socio-economic*** conditions

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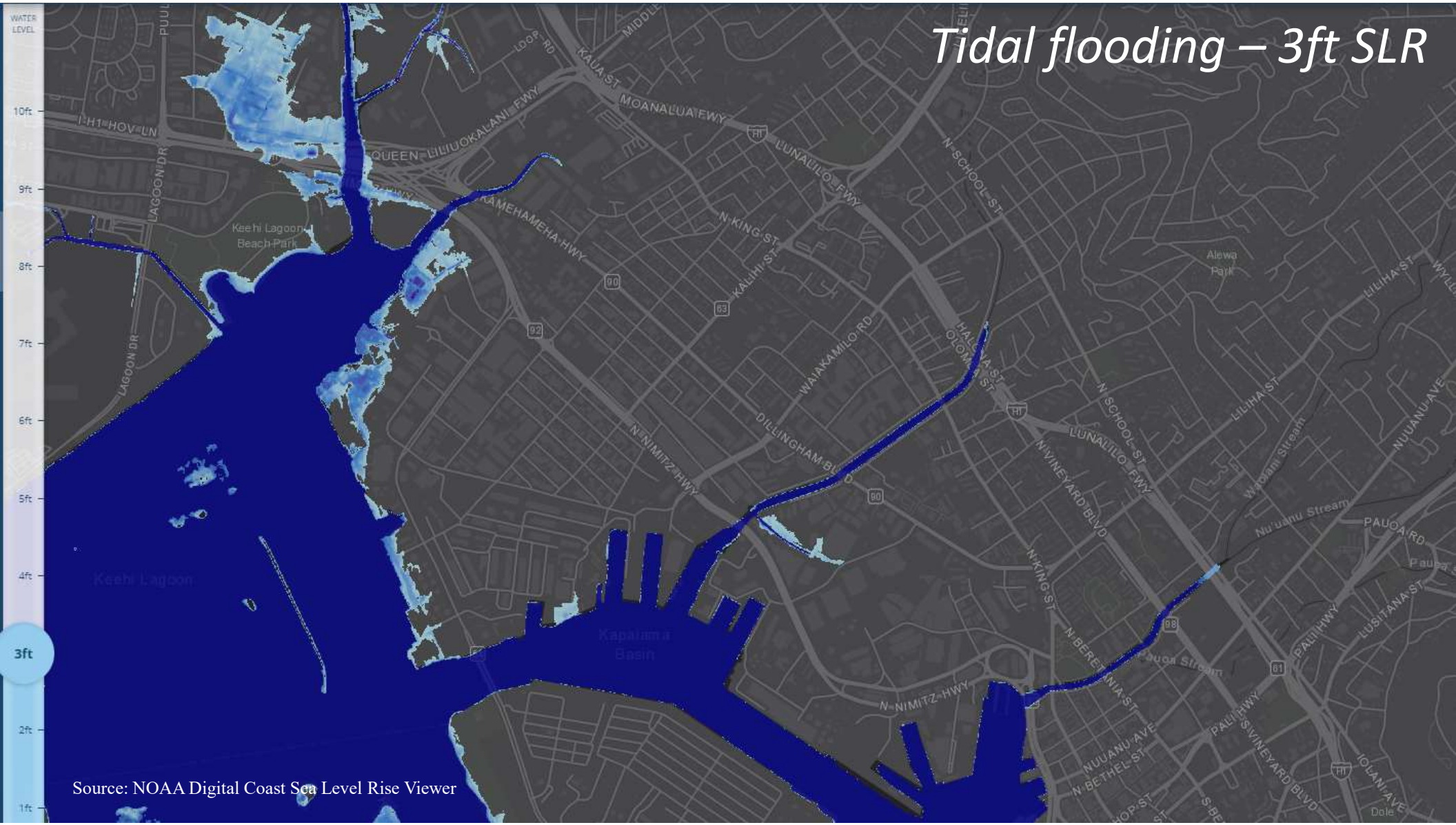
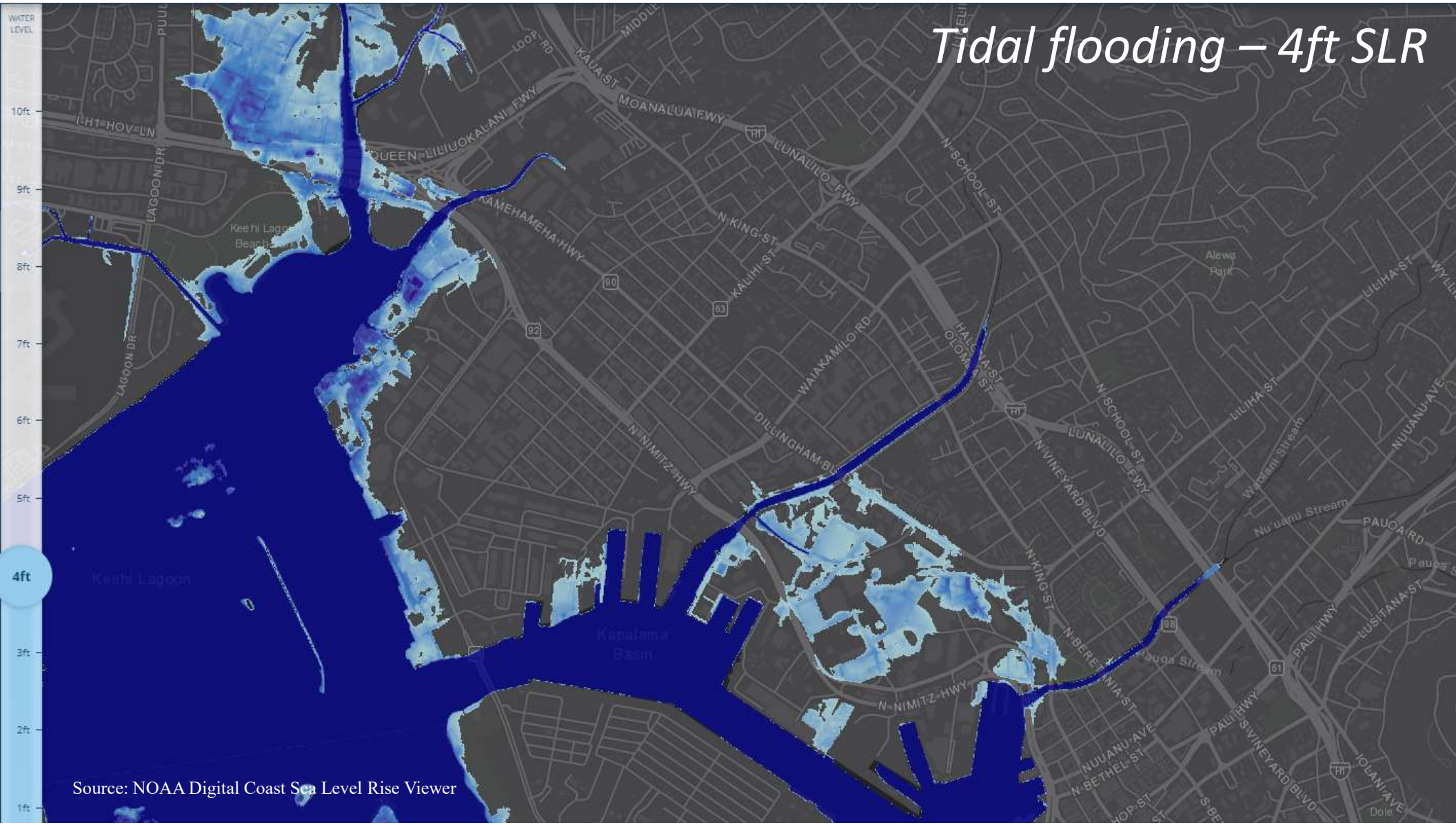
Tidal flooding – 3ft SLR



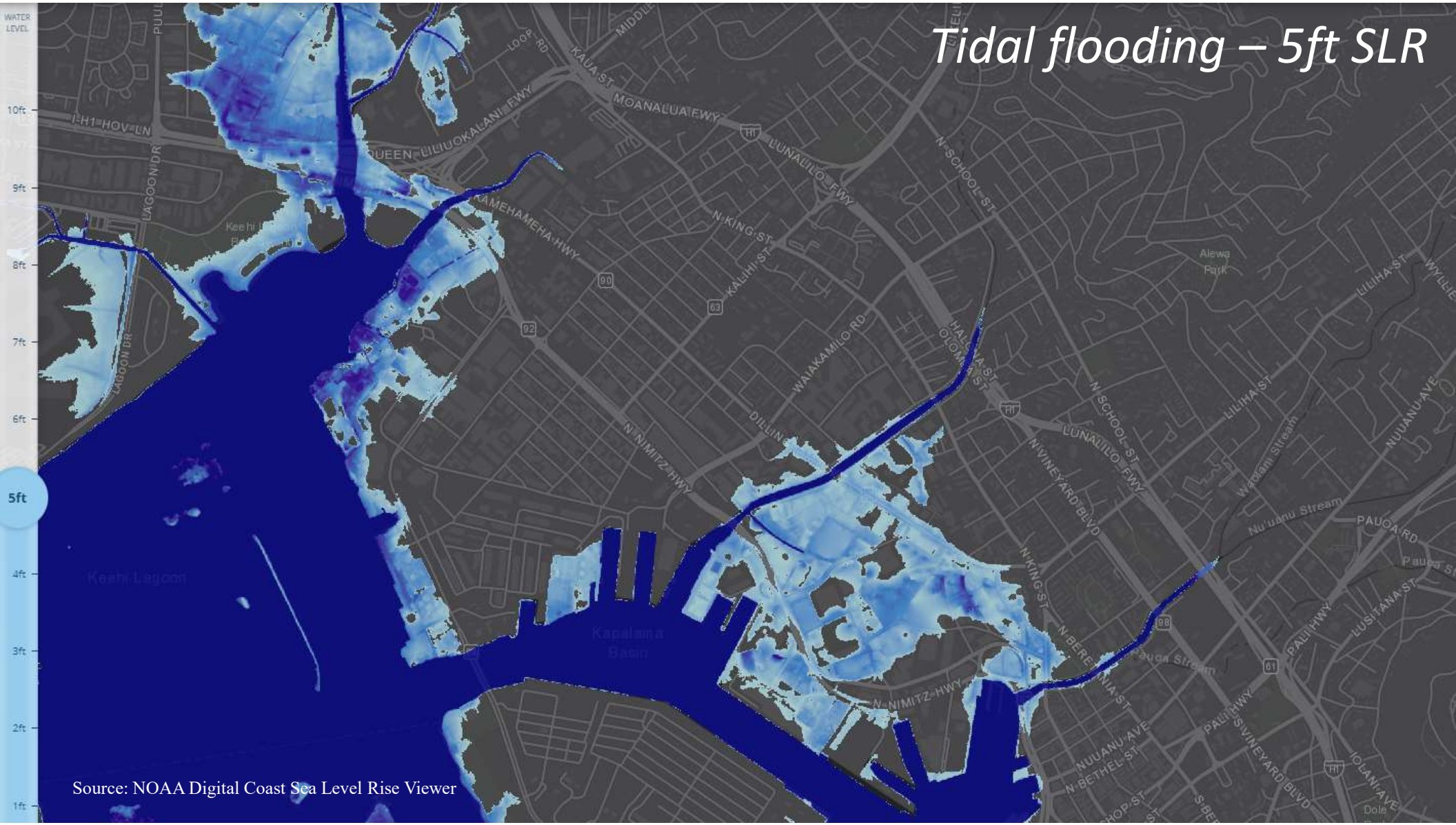
Source: NOAA Digital Coast Sea Level Rise Viewer

Tidal flooding – 4ft SLR



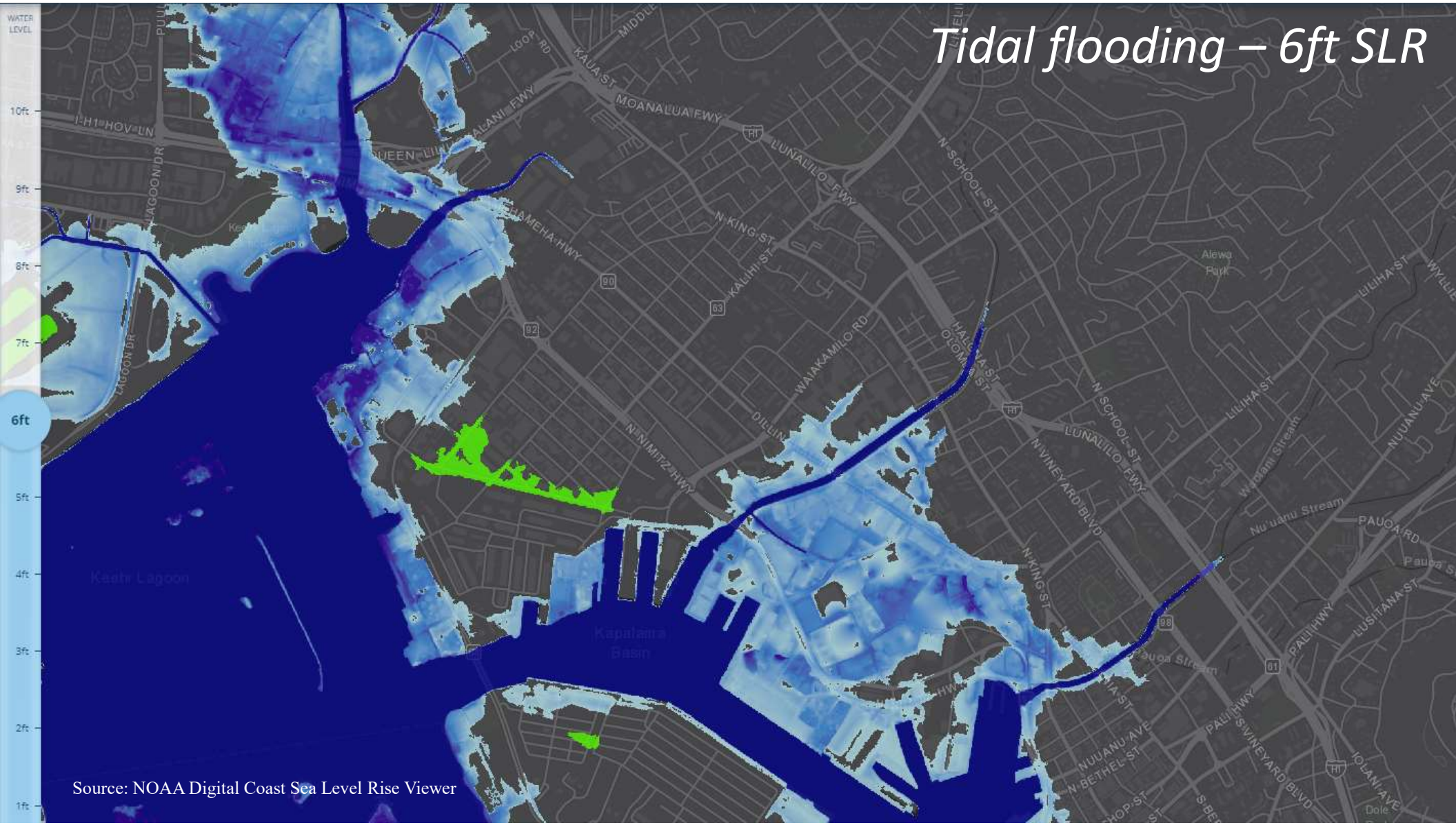
Source: NOAA Digital Coast Sea Level Rise Viewer

Tidal flooding – 5ft SLR



Source: NOAA Digital Coast Sea Level Rise Viewer

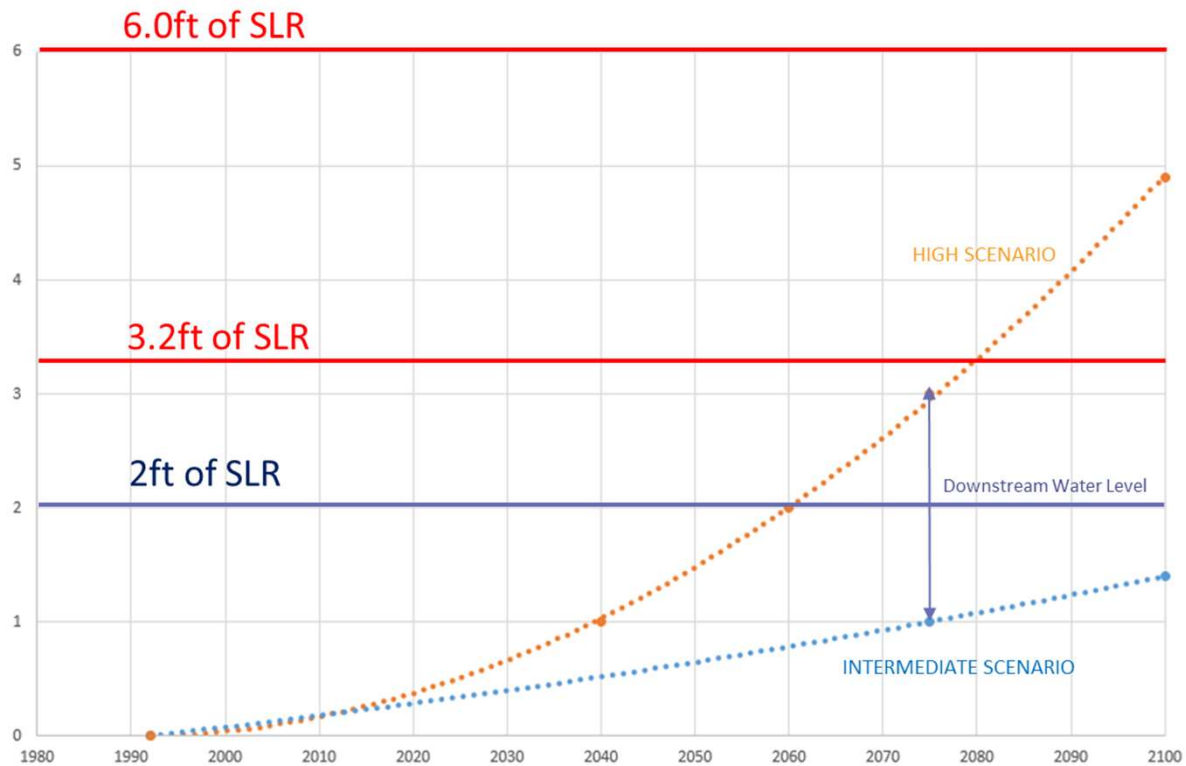
Tidal flooding – 6ft SLR



Source: NOAA Digital Coast Sea Level Rise Viewer

Uncertainty – When and How Much?

Accumulated Sea Level Rise (feet) at Kapalama Canal



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Response – Infrastructure Planning – Static Approach

- Static ‘optimal’ plan using a single ‘most likely’ future
- Static ‘robust’ plan that will produce acceptable outcomes in most plausible future worlds

(Dessai and Hulme, 2007; Dessai and Van der Sluijs, 2007; Hallegatte et al., 2012).

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Response – Infrastructure Planning – Dynamic Approach

- Dynamic adaptive plans contain a strategic vision of the future, commit to short-term actions, and establish a framework to guide future actions

(Albrechts, 2004; de Neufville and Odoni, 2003; Haasnoot et al., 2011; Hallegatte, 2009; Hallegatte et al., 2012; Ranger et al., 2010; Schwartz and Trigeorgis, 2004; Swanson et al., 2010).

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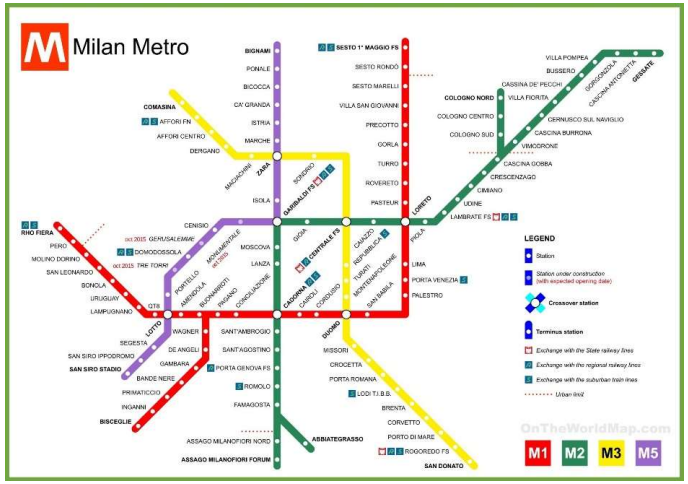
Flexible Adaptation Pathways – Concepts



- Real options – infrastructure options that are fitted with flexibility to adapt to future changes, rather than for a specific design scenario
- Potential lock-ins – when an option leads to a failure to adjust adequately to a changed environment; path-dependency of investment decisions can lead to stranded assets if conditions change
- No regrets options – options which achieve positive outcomes under all plausible projections of climate change
- Trigger and Tipping points - tipping point is the point at which a particular action is no longer adequate for meeting objectives; a trigger indicates when a decision is needed for a forthcoming action
- Flexible adaptation pathway map – path of actions that result in least regrets and achieves overall objectives

(Haasnoot et al. / Global Environmental Change 23 (2013) 485–498)

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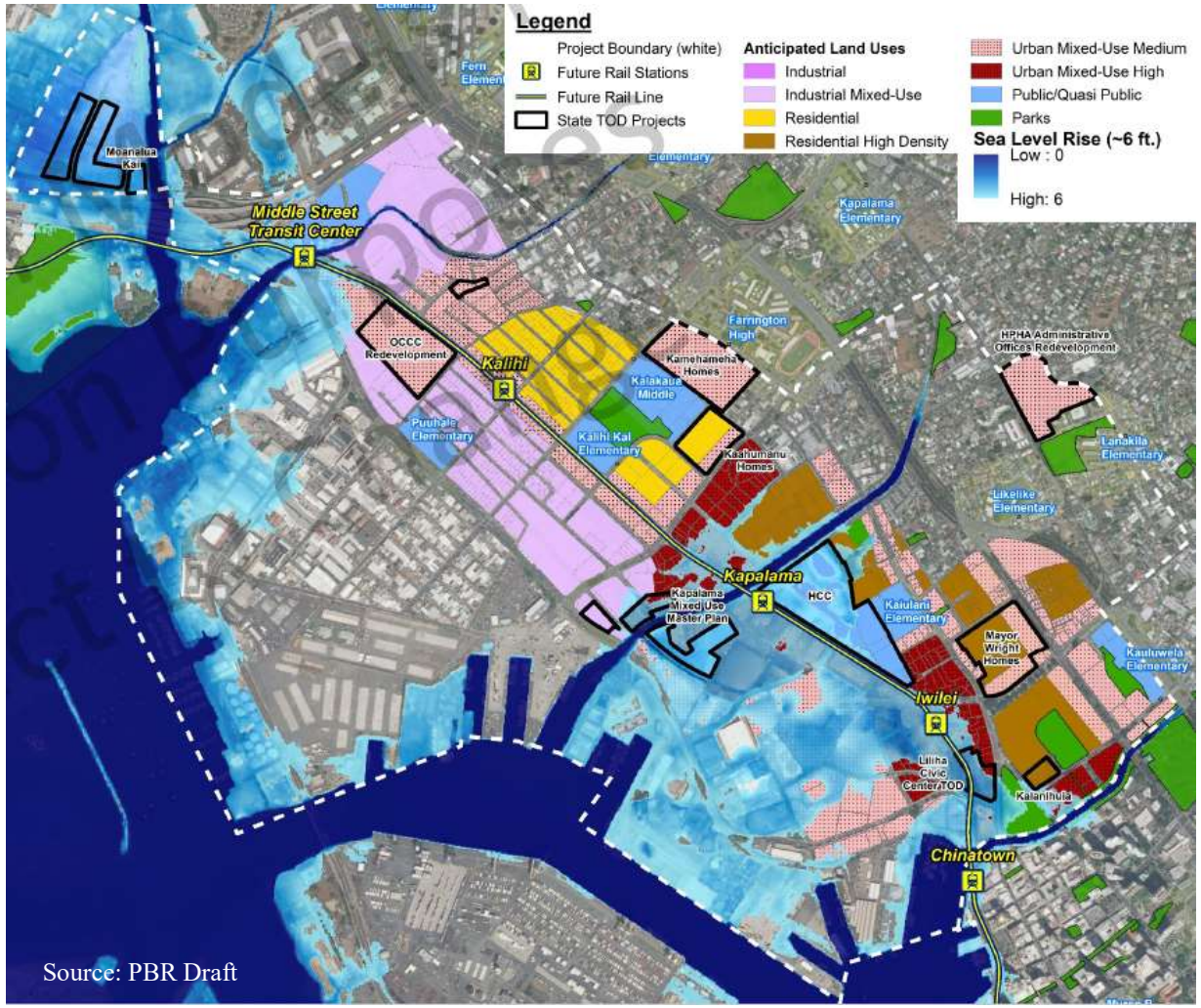
Iwilei-Kapalama

Objective: Ensure adequate infrastructure capacity and *flood protection* for TOD area investments *through 2100*



Source: PBR Draft

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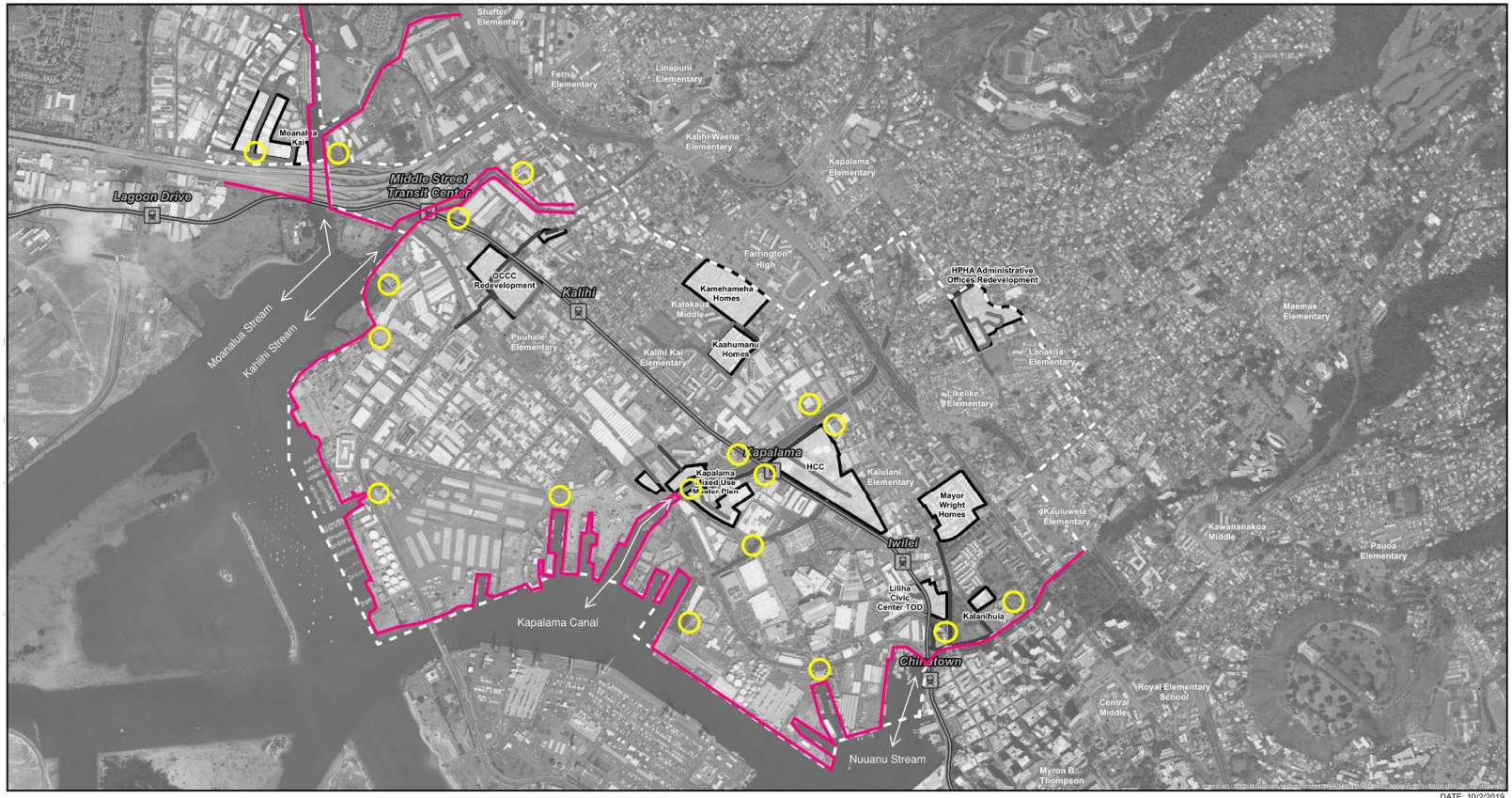

DATE: 10/2/2019

Legend

- Future Rail Stations
- Future Rail Line
- State TOD Projects
- New Sewer Lines
- Upgraded Sewer Lines
- New Water Lines
- Upgraded Water Lines

Long-Term Upgrades

- Upgraded Seawall
- Future Pump Stations

Option 1
PROTECT AND PUMP

Hypothetical infrastructure concept – for demonstration purposes only

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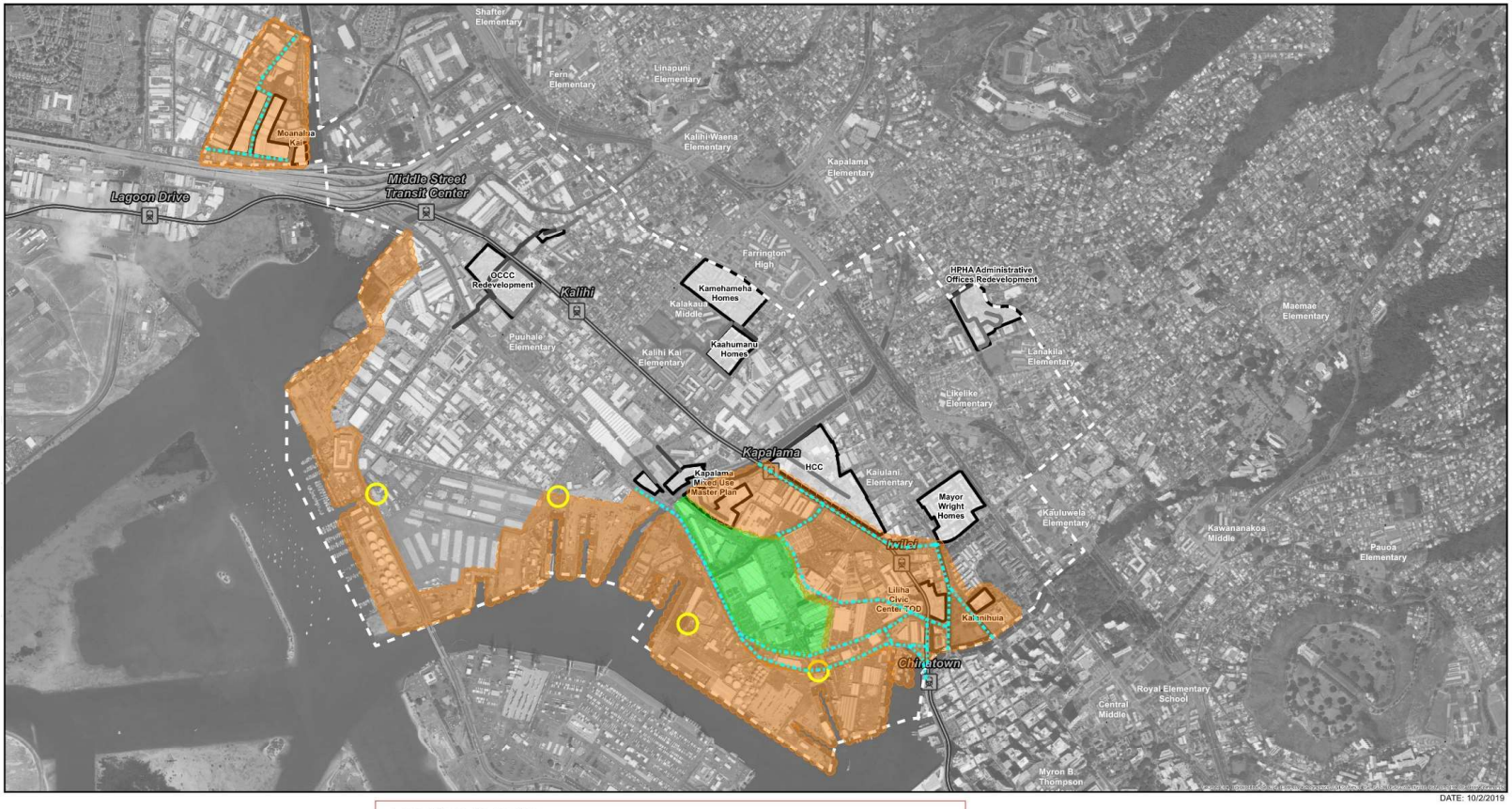

DATE: 10/2/2019

Legend

- Future Rail Stations
- Future Rail Line
- State TOD Projects
- New Sewer Lines
- Upgraded Sewer Lines
- New Water Lines
- Upgraded Water Lines

Long-Term Upgrades

- Upgraded Port Seawall
- Future Pump Stations
- Elevated Roadway
- Future Raised Development Area
- Future Restored Wetland Area

Option 2
RAISE AND RESTORE

Hypothetical infrastructure concept – for demonstration purposes only

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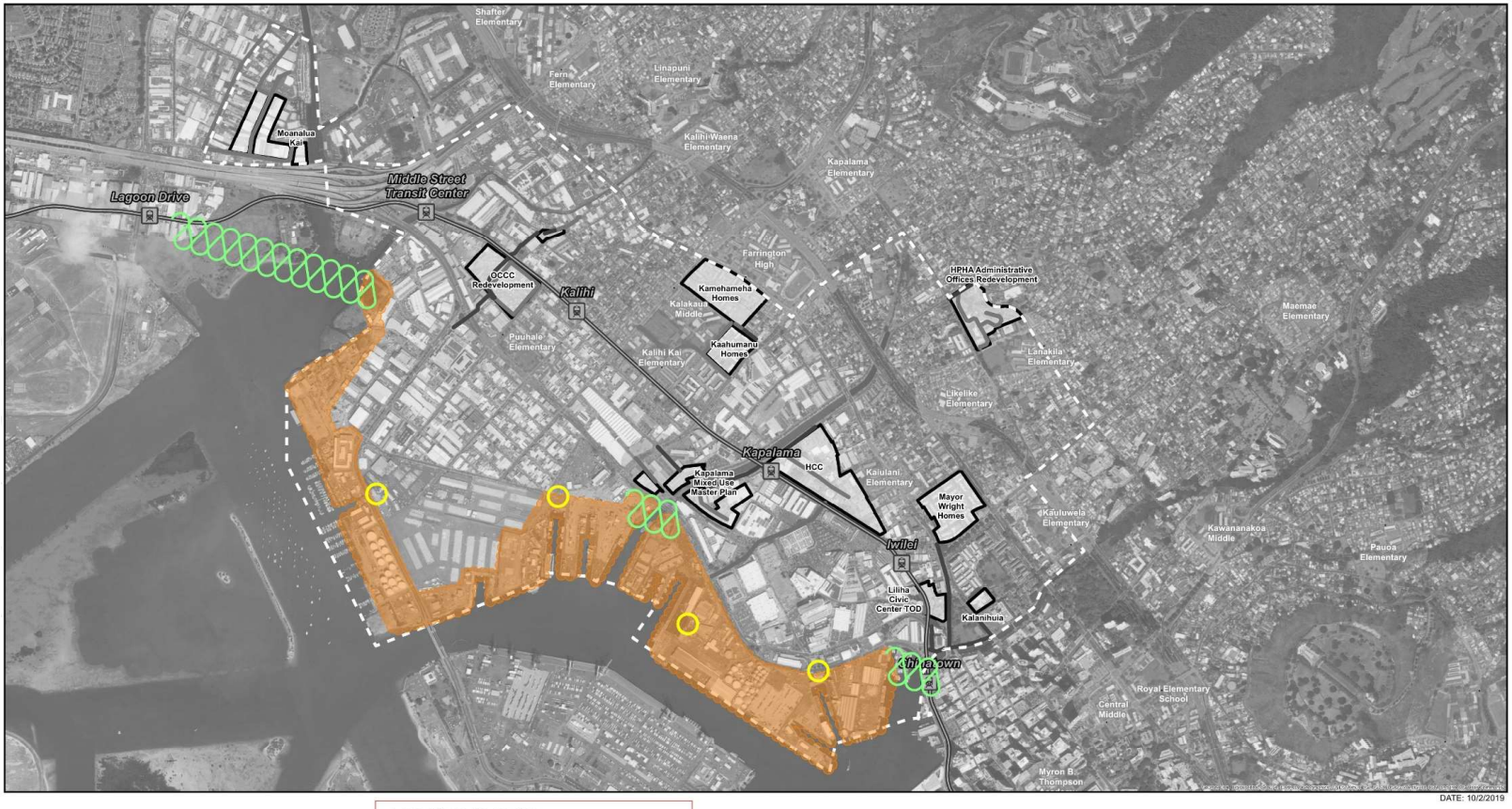

Legend

- Future Rail Stations
- Future Rail Line
- State TOD Projects
- New Sewer Lines
- Upgraded Sewer Lines
- New Water Lines
- Upgraded Water Lines

Long-Term Upgrades

- Future Raised Development Area
- Tidal Barrier
- Future Pump Stations

Option 3
BARRIERS AND BULKHEADS

Hypothetical infrastructure concept – for demonstration purposes only

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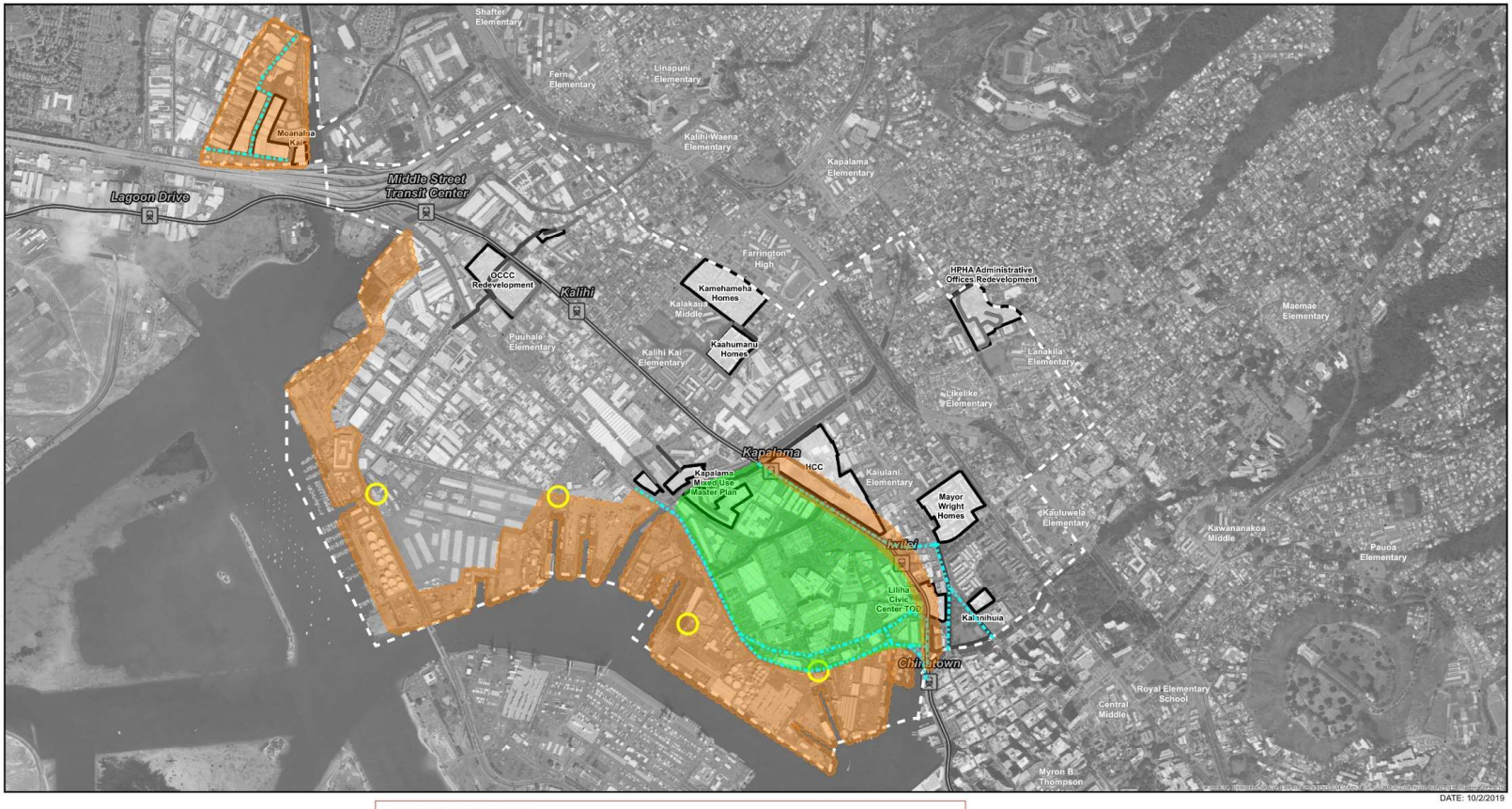

Legend

- Future Rail Stations
- Future Rail Line
- State TOD Projects
- New Sewer Lines
- Upgraded Sewer Lines
- New Water Lines
- Upgraded Water Lines

Long-Term Upgrades

- Upgraded Port Seawall
- Future Pump Stations
- Elevated Roadway
- Future Raised Development Area
- Future Restored Wetland Area

Option 4
RETREAT AND RESTORE

Hypothetical infrastructure concept – for demonstration purposes only

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Flexible Adaptation Pathways – Objective and Options

Option 1
(Protect and Pump)

Option 2
(Raise and Restore)

No Action

Option 3
(Barriers and Bulkheads)

Option 4
(Retreat and Restore)

Objective: Ensure adequate infrastructure capacity and *flood protection* for TOD area investments through 2100

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Flexible Adaptation Pathways - Triggers, Timing, and Thresholds

Option 1
(Protect and Pump)

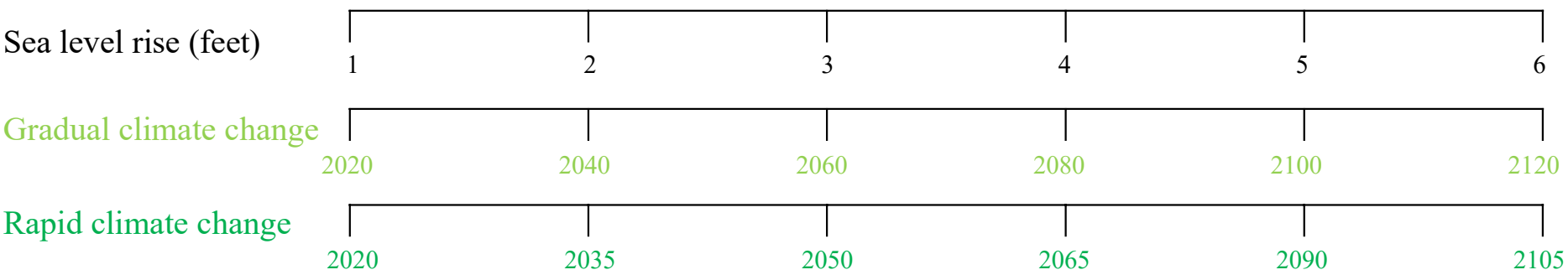
Option 2
(Raise and Restore)

No Action

Option 3
(Barriers and Bulkheads)

Option 4
(Retreat and Restore)

Objective: Ensure adequate infrastructure capacity and *flood protection* for TOD area investments through 2100



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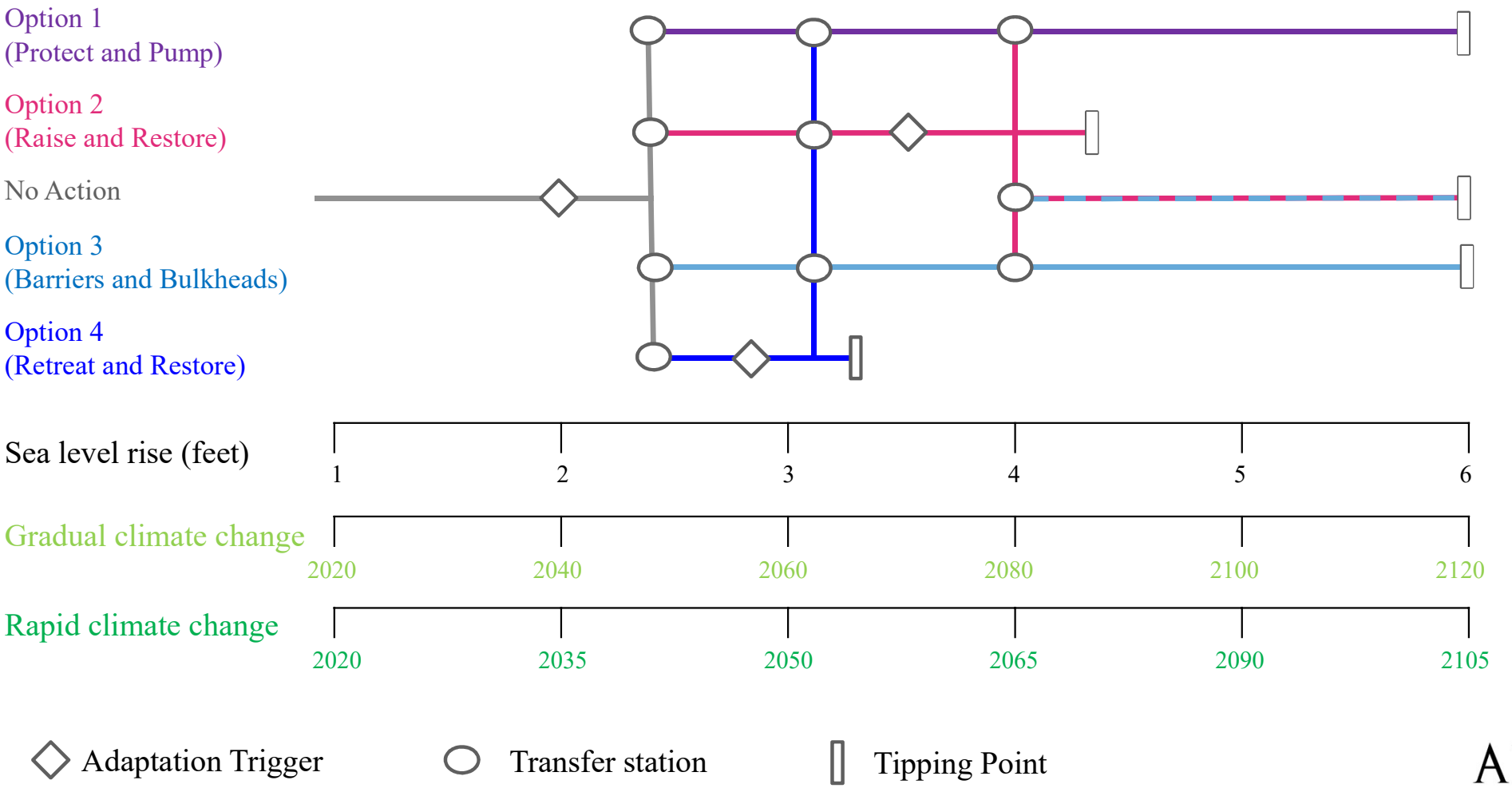
Flexible Adaptation Pathway - Map



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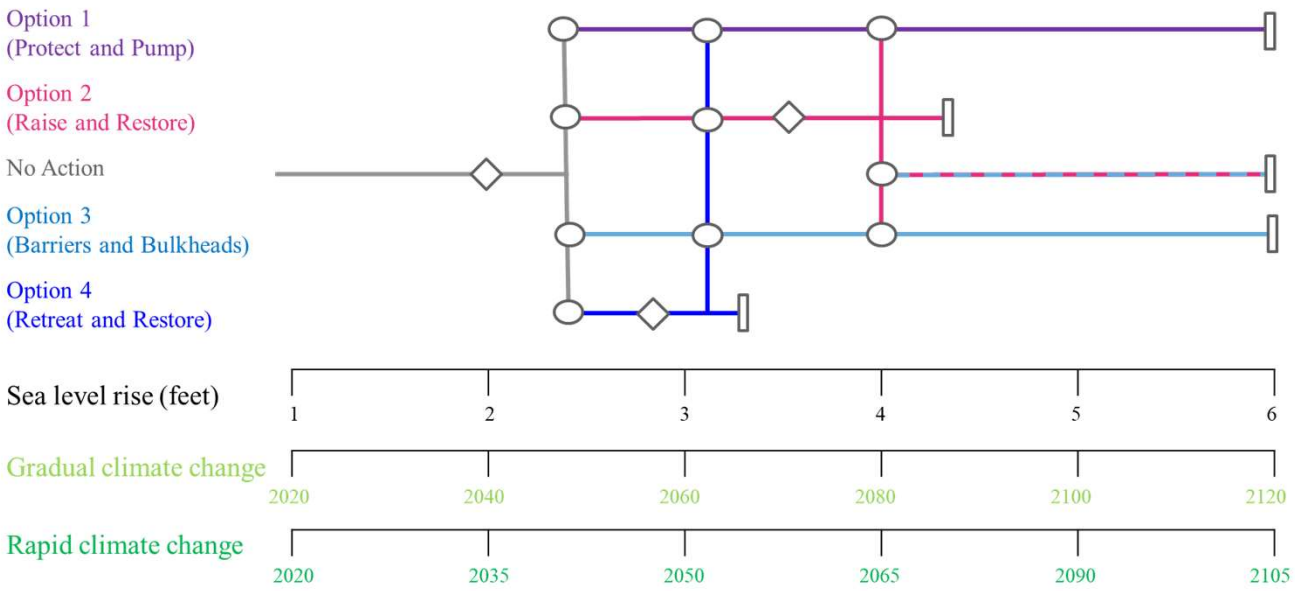
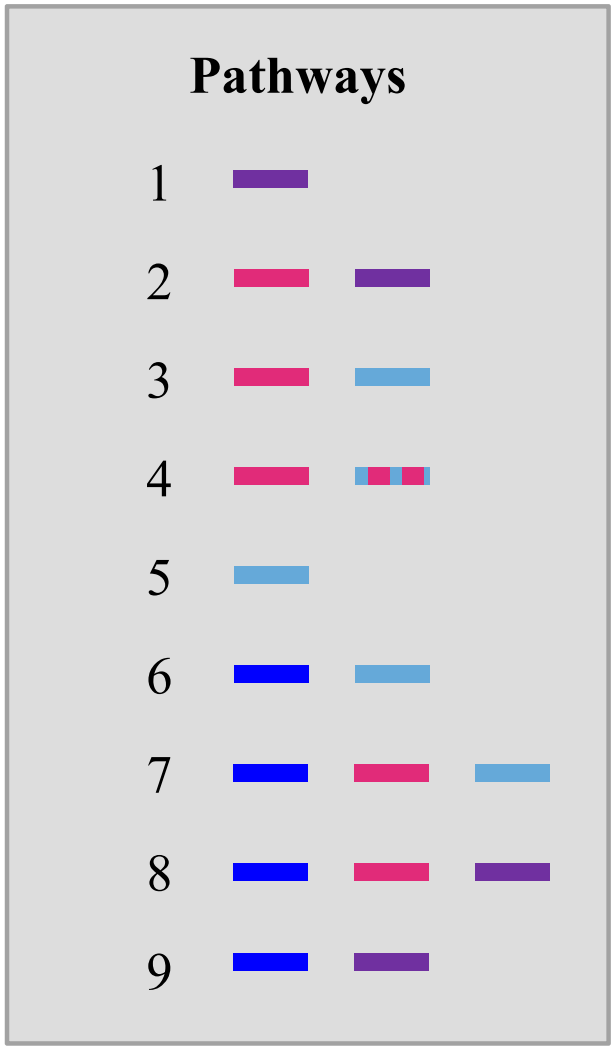
Flexible Adaptation Pathways





Adaptation Trigger Transfer station Tipping Point

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Flexible Adaptation Pathways – Evaluate (Near-Term)

Pathways	Costs	Benefits	Net Present Value
1	- - - -	+ + +	$
2	- - - - -	+ + + +	$ $ $
3	- - -	+ + + + +	$ $ $ $ $
4	- - - -	+ + + + +	$ $ $ $
5	- - -	+ + +	$
6	- - - -	+ +	$ $ $
7	- - - - -	+ + +	$ $
8	- - - - - -	+ + + +	$
9	- - - - -	+ +	$

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Flexible Adaptation Pathways - Selection

Pathways	Costs	Benefits	Net Present Value
1	- - - -	+ + +	$
2	- - - - -	+ + + +	$ $ $
3	- - -	+ + + + +	$ $ $ $ $
4	- - - -	+ + + + +	$ $ $ $
5	- - -	+ + +	$
6	- - - -	+ +	$ $ $
7	- - - - -	+ + +	$ $
8	- - - - - -	+ + + +	$
9	- - - - -	+ +	$

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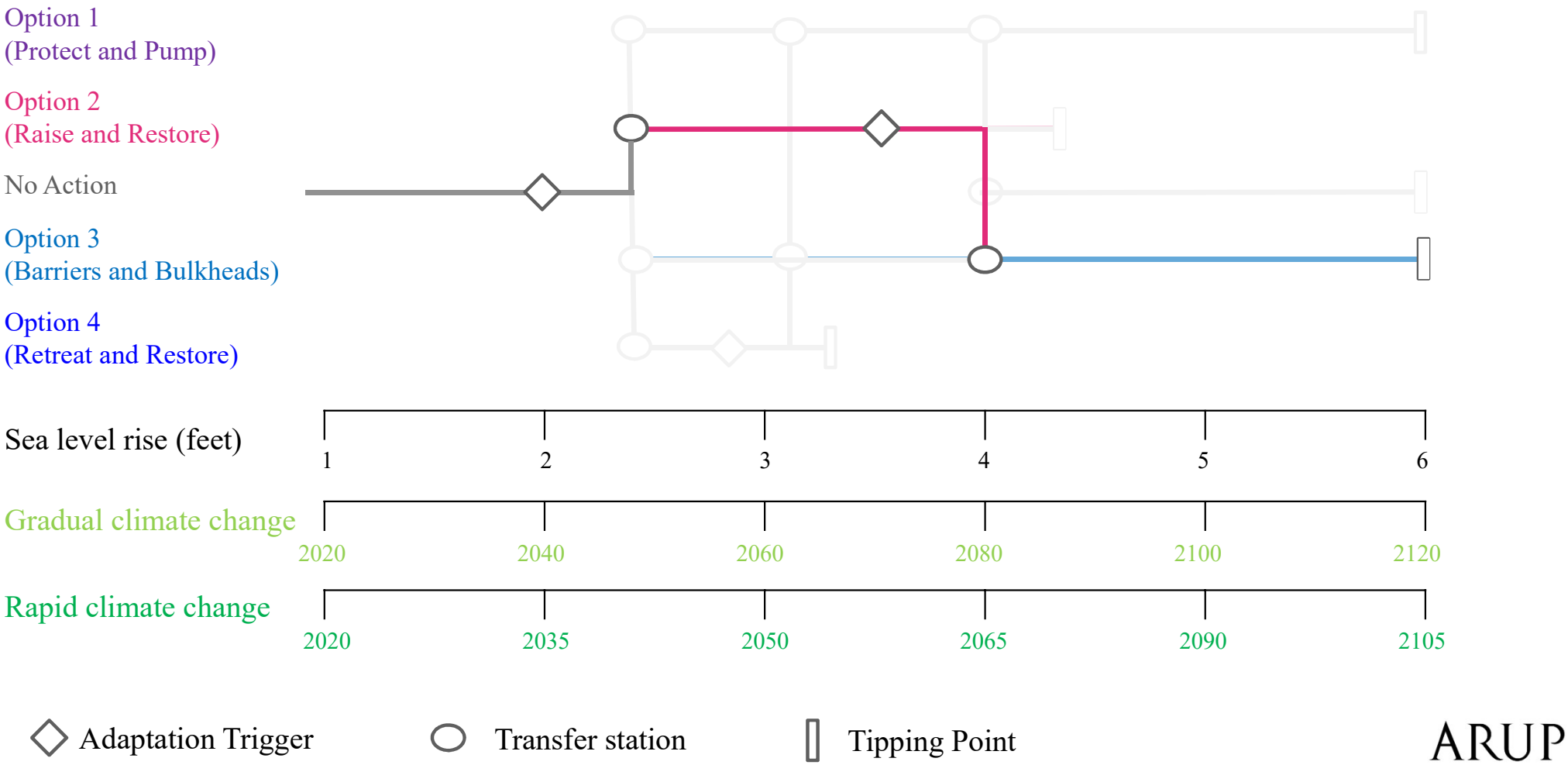
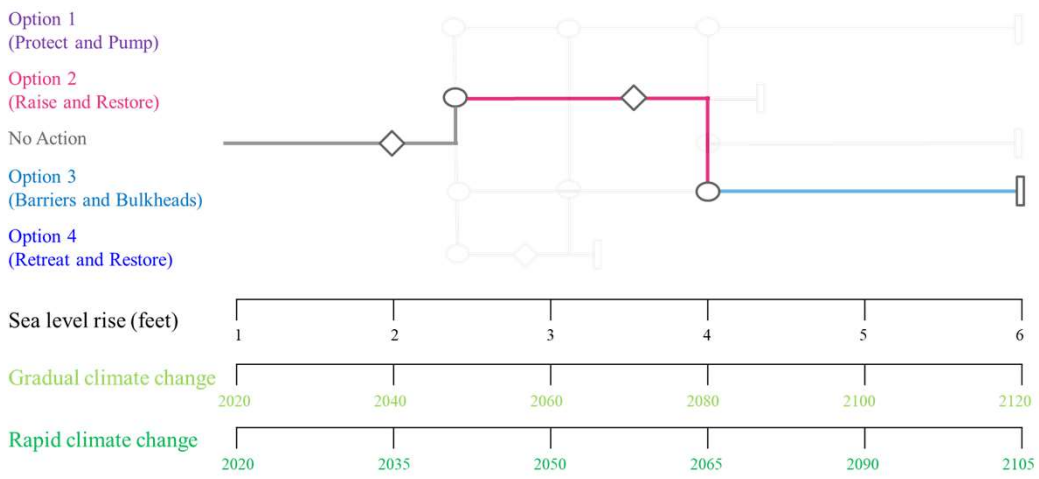
Flexible Adaptation Pathway – Hypothetical



Flexible Adaptation Pathway



Core Findings (Hypothetical)
• Port and waterfront parcels require protection in all scenarios (no-regrets solution)
• Raising parcels is ineffective as a standalone solution (eventual transfer essential)
• Implementing seawalls or tide barriers too early could be economically inefficient
• Restoration combined with protection leads to co-benefits and high NPV
• Upfront costs of hard infrastructure can be deferred but only temporarily
• Early commitment to protection or retreat focused options promote path-dependence

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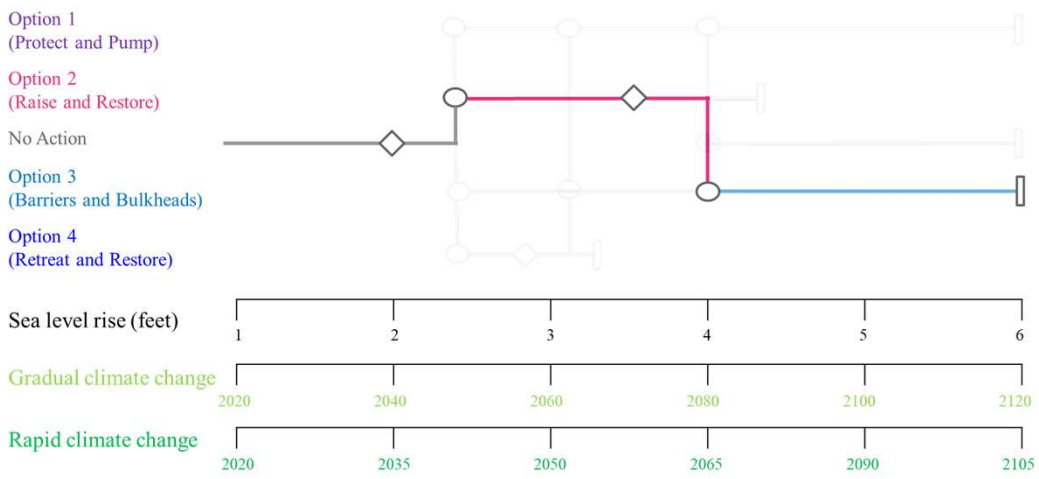
Flexible Adaptation Pathway



Trigger	Action (Hypothetical)
SLR 1ft *2020-2030*	• Initiate comprehensive flexible adaptation pathways study
SLR 2ft *2030-2040*	• Raise all waterfront parcels • Restore lower Iwilei wetland
SLR 3ft *2040-2060*	• Install pump stations
SLR 4ft *2060-2080*	• Construct tidal barriers • Reinforce waterfront bulkheads
SLR 5ft *2070-2100*	• Monitoring
SLR 6ft *2080-2120*	• Evaluate future plans

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Flexible Adaptation Pathways - Benefits

- Providing flexibility to adapt infrastructure planning to uncertain climate change outcomes
- Avoiding lock-in decisions and identifies near-term ‘no regret’ options
- Clearly outlining future decision (trigger) points for investment
- Presenting approachable framework for cost-benefit analysis
- Mapping out achievable pathways towards successful future outcomes

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‘Real’ Recommendations for Implementation (2020-2030)

- Conduct demonstration study focusing on large scale flood infrastructure needs
- Develop initial suite of ‘real options’ - fitted with flexibility to adapt to future change
- Flood *risk* study required for cost-benefit analysis of ‘real options’
- Map out realistic timing, thresholds, tipping points for decisions
- Pre-work for various adaptation pathways include may include technical studies for groundwater, coastal flooding, and sea level rise

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1. District Systems Infrastructure

An Approach for Affordable, Resilient, Healthy Communities

2. Flexible Adaptation Pathways

An Approach for Sea Level Rise and Flood Infrastructure

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The Default Condition is…

Safe since others did it (think protection in groups)

Easy since we've done it before (think existing tools)

Known since we can see it (think existing data)

Inexpensive since anything better or new should always cost more (think marketing)

Hard to change (think existing city streets)

Politically nonconfrontational (think NIMBY'ism)

Appropriate since it reflects our culture (think the sexy automobile)

Financeable since the financial system knows how to pay for it (think loan underwriting)

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Facilitating

	Option 1	Option 2
First Cost	θ	θ
Life Cycle Cost	-	+
LEED® Impact	-	+
Flr to Flr Height	-	+
Daylighting	-	+
Roof Impact	-	+
Design Change	-	+
Other System Impact	-	+
	☒	☑

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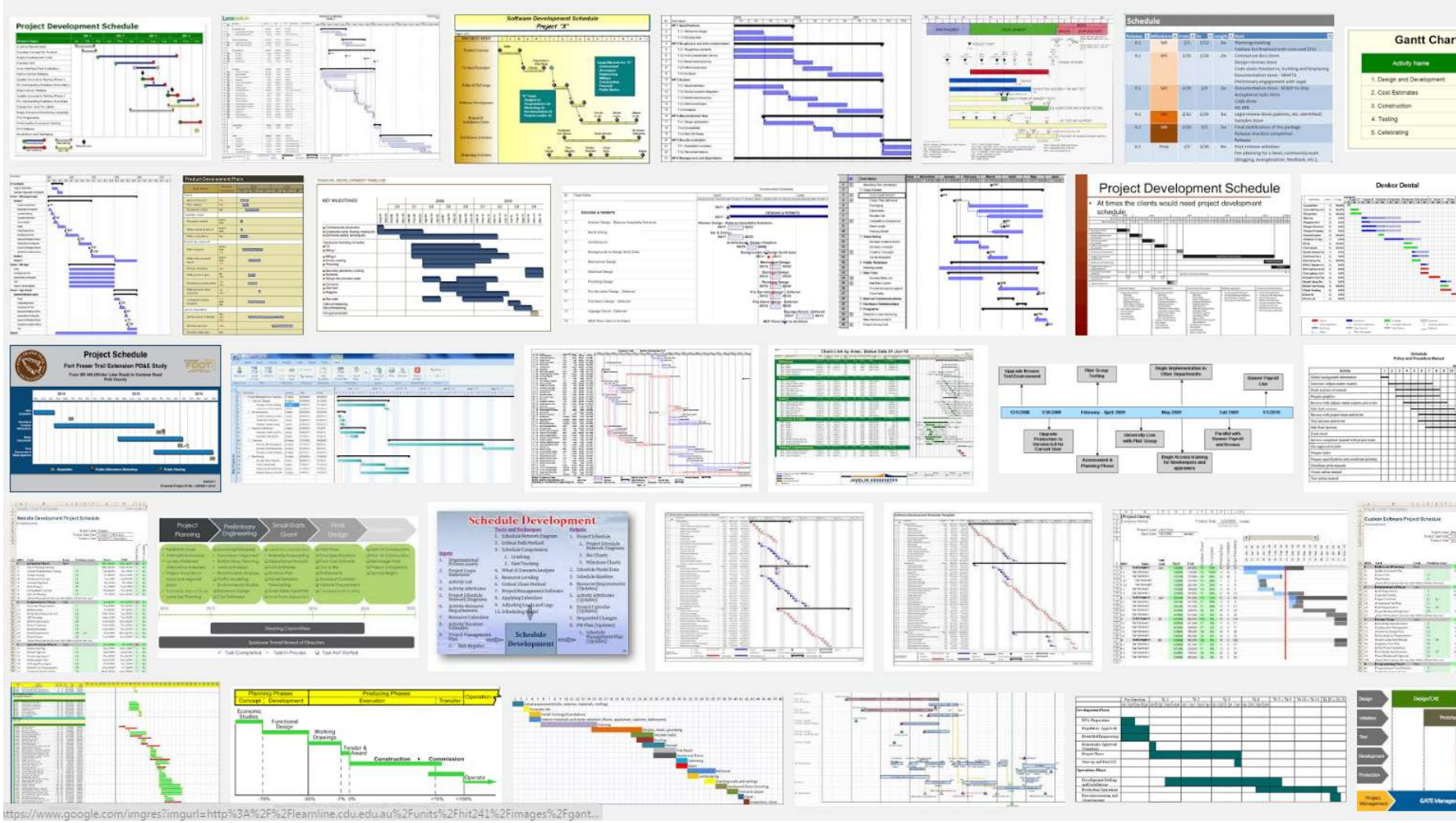
Signaling



https://www.google.com/imgres?imgurl=http%3A%2F%2Flearnline.cdu.edu.au%2Funits%2Fhit241%2Fimages%2Fgant...

Here is Edward Bear, coming downstairs now,

bump,
bump,
bump,

on the back of his head, behind Christopher Robin. It is, as far as he knows, the only way of coming downstairs, but sometimes he feels that there really is another way, if only he could stop bumping for a moment and think of it.

E.H. Sheppard

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