Sacramento Valley Station

Area Plan

Technical Appendix C

Technical - Environmental

City of SACRAMENTO

Perkins&Will

May 2021

Sacramento Valley Station

Microclimate Assessment

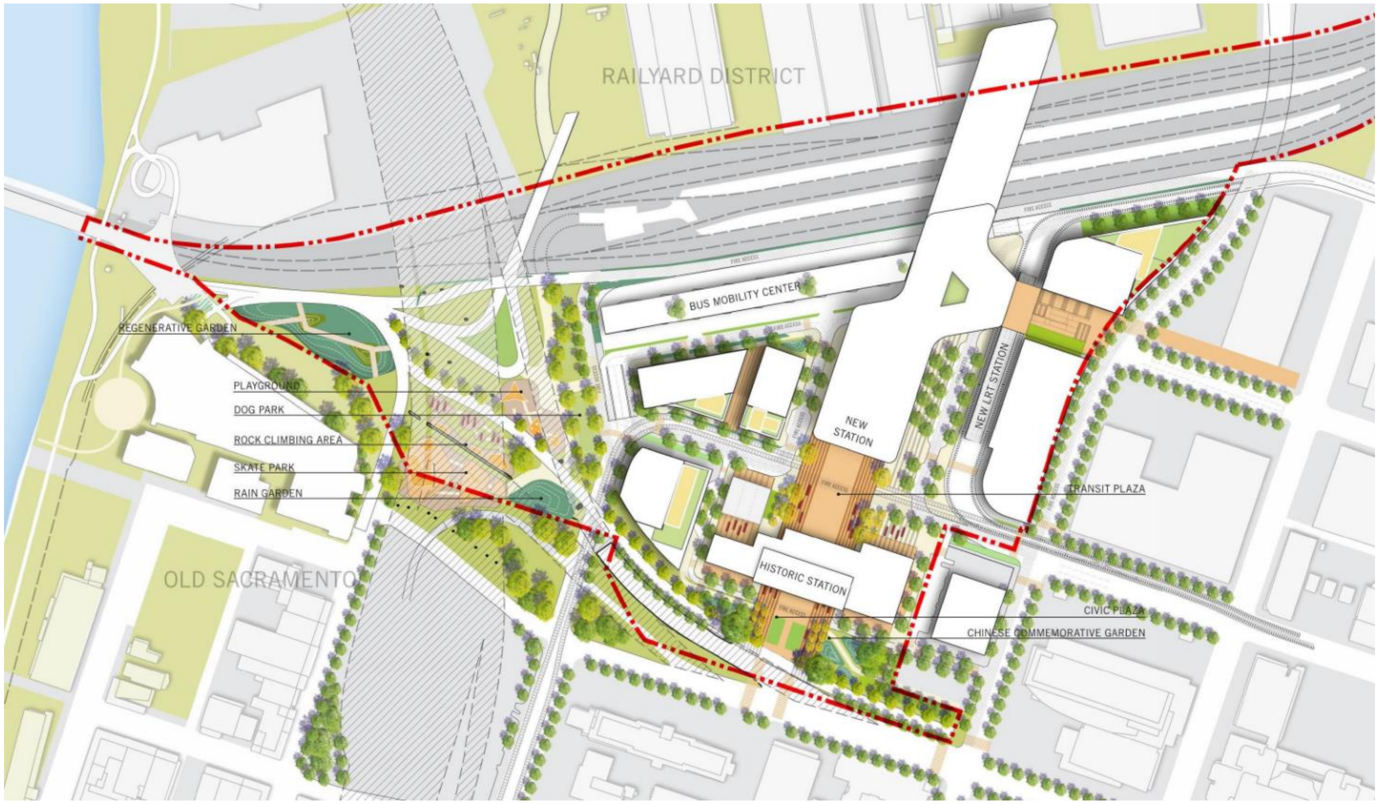
March 6th, 2020

ARUP

Aim

The aim of this microclimate assessment is to determine the windiness and outdoor thermal comfort on the Sacramento Valley Station site.

This assessment is meant to indicate potential areas of wind and thermal discomfort throughout a typical year for two massing options.



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Site Geometry

Massing Options

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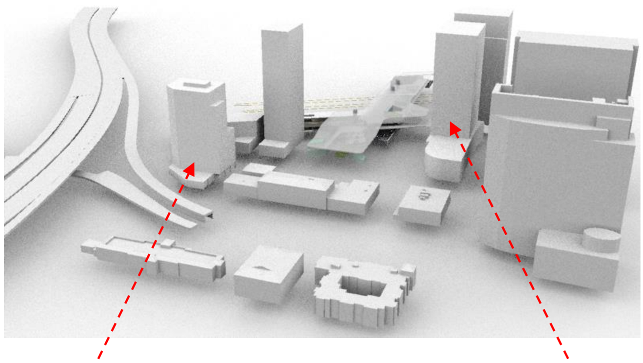
Massing Options

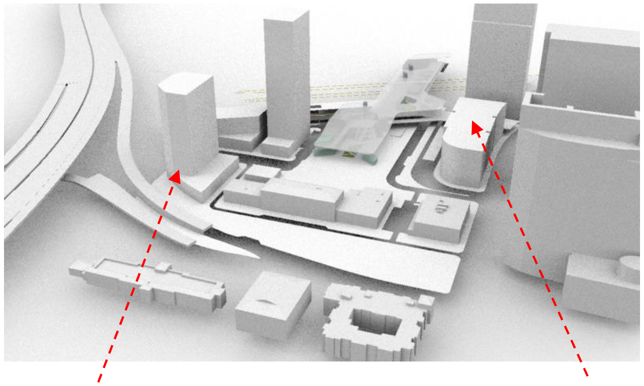
Massing Option A



E-W Orientation

Tower

Massing Option B



N-S Orientation

No tower

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Climate

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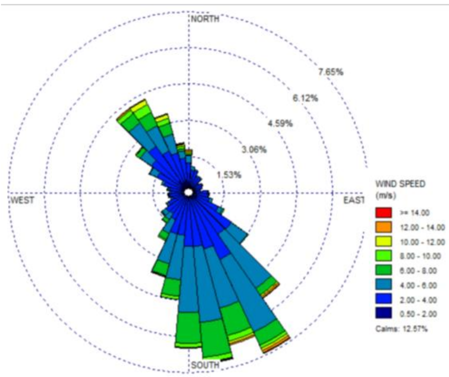
Weather stations

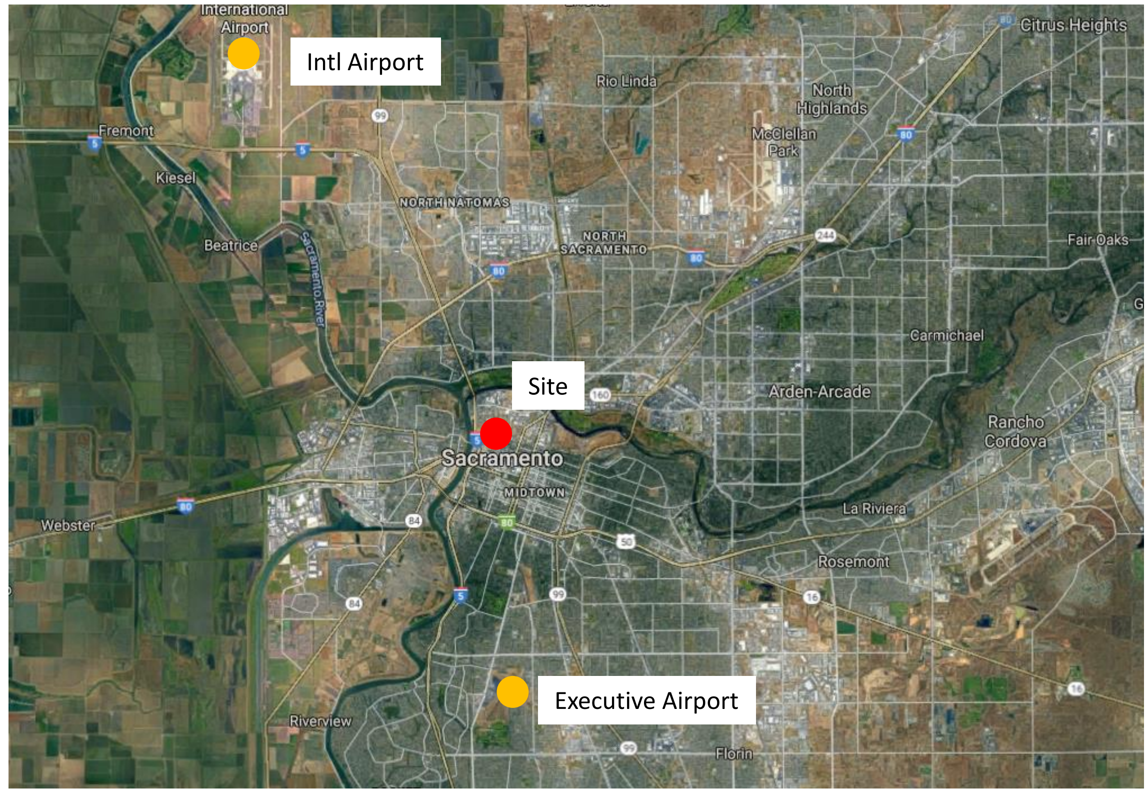
The site is located in downtown Sacramento, between Sacramento Intl Airport and Sacramento Executive Airport.

Sacramento Executive Airport is located in an urban environment, which is expected to have a strong influence on the recorded wind speeds, and therefore will not be used for this assessment.

Sacramento Intl Airport is on the northern side of the city, in a more exposed location, and will be used for this assessment.

Sacramento International Airport





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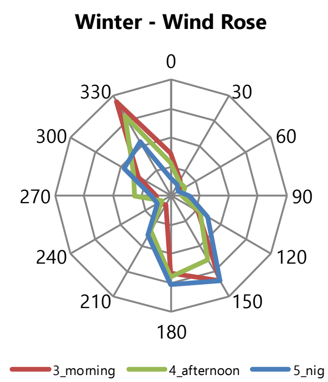
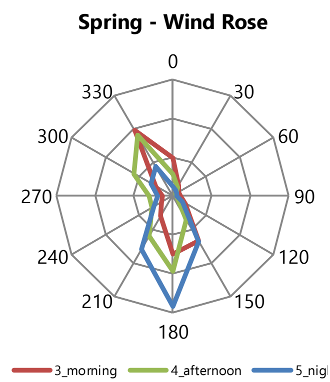
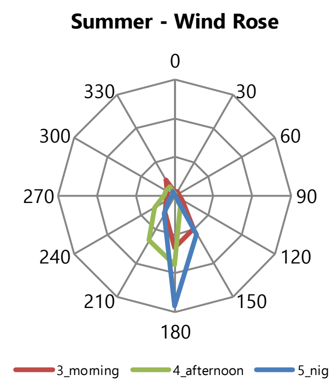
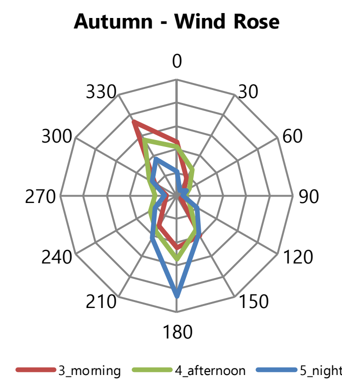
Sacramento | Wind

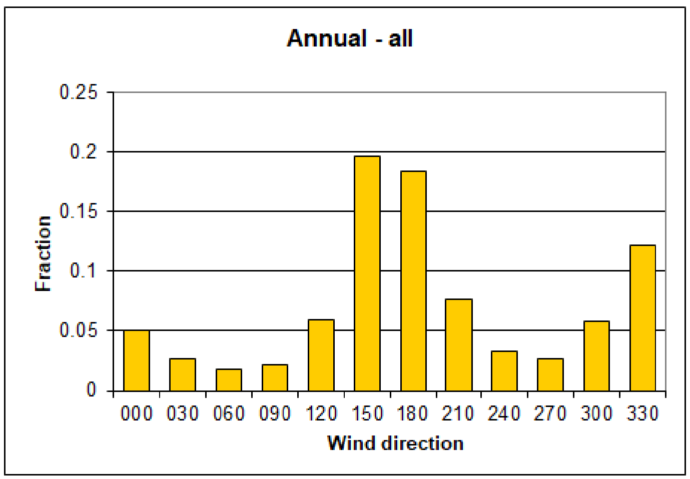
- The airport data shows that wind is predominantly from the South-Southeast directions (150 & 180 deg) and, to a lesser extent, from the Northwest (330 deg).
- The wind speeds are generally not above 10 m/s (~22 mph) and are on average closer to 3.4 m/s (7.6 mph)
- During the summer months, the wind is predominantly from the south.
- In Spring and Fall, the wind is from the South and Northwest.
- In Winter, wind comes from the South-southeast and Northwest directions.

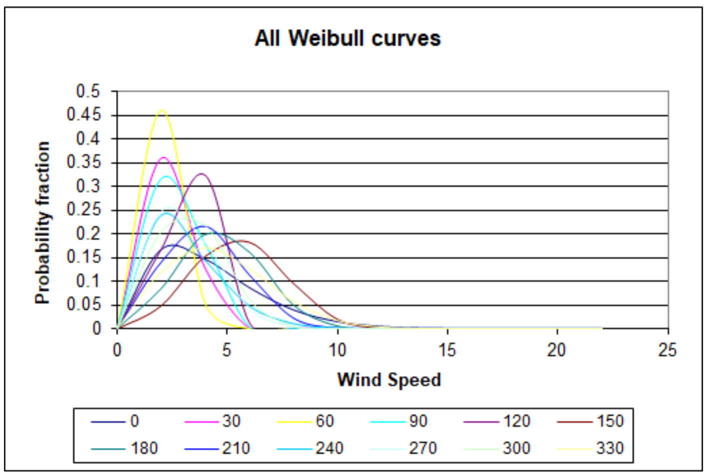






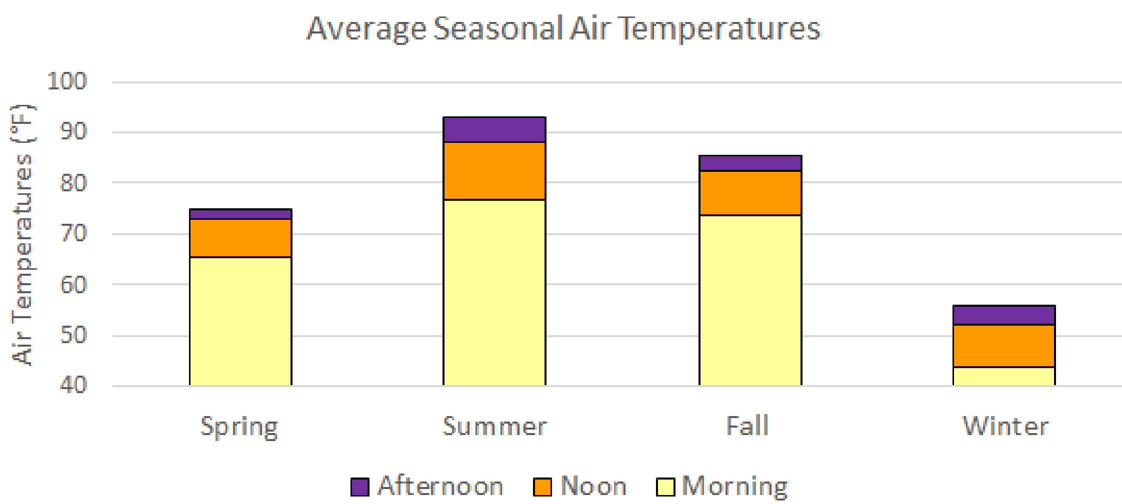






Sacramento | Average Air Temperatures

- The site is mild to warm during Spring and Fall.
- During summer, high average temperatures can be seen in noon and afternoon times.
- Winter temperatures are on the cool to cold side, particularly in the morning times.



Results

Wind Assessment

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Web Visualization of Results

- Arup developed a 3D web visualization tool to serve as a companion to this report.
- It shows seasonal results for the average conditions during selected times of morning (7-10am), afternoon (12-3pm), and evening (4-7pm).
- The web visualization shows results for comfort, wind and solar conditions on the site and points of interest.
- The website can be accessed at http://52.27.53.30:3000/
    - Username: svs
    - Password: svs123

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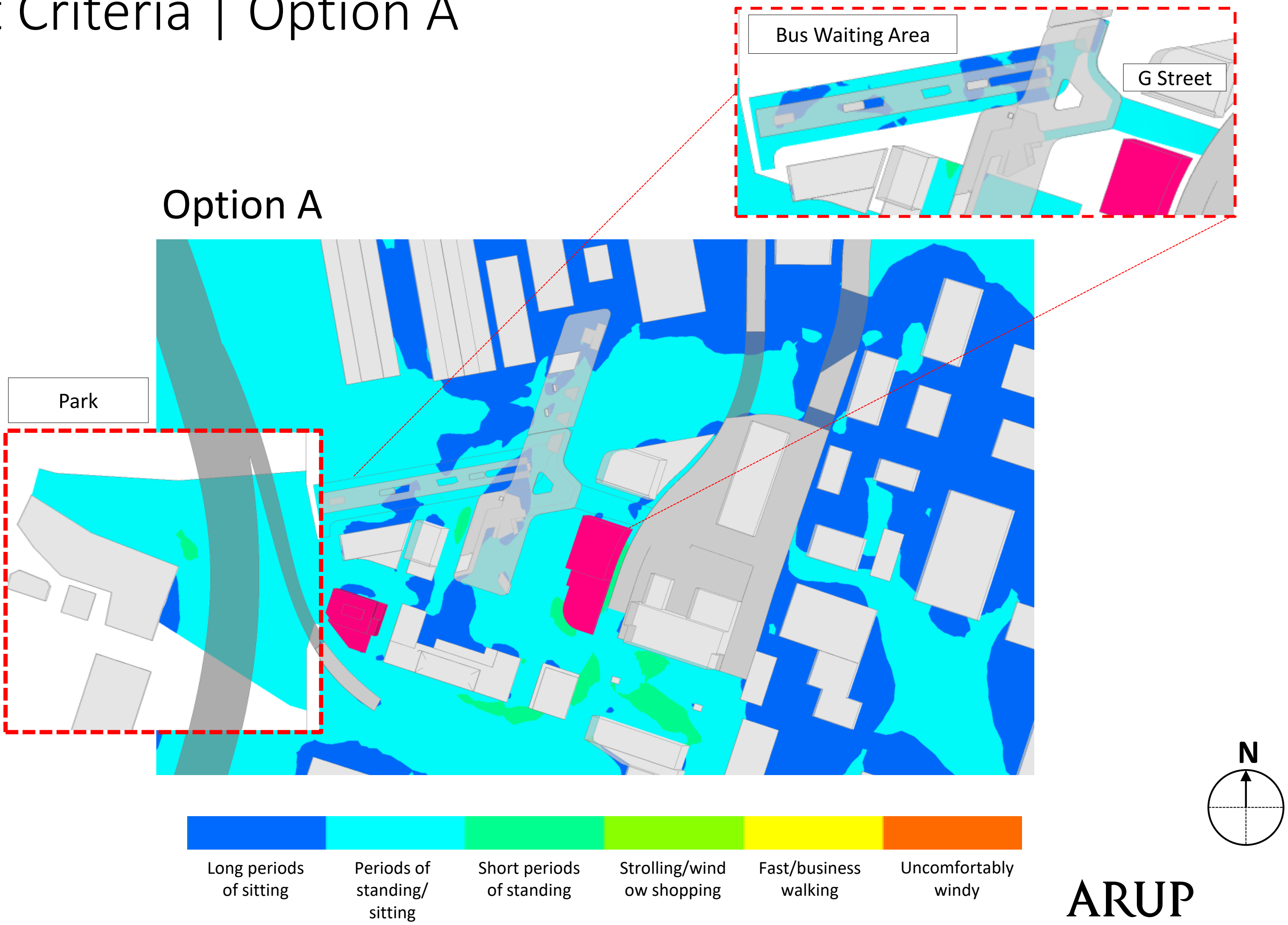
Wind Comfort Criteria | Option A

Wind comfort is assessed by simulating a typical weather year and mapping wind speeds against a space use scale. This help identify areas of high and low windiness as well as appropriate space use.

The results shown compare the windiness of the site for Option A.

In general, the site is suitable for short periods of standing and sitting, which is acceptable for outdoor spaces where people switch between standing and sitting.

This shows that there is low windiness on the site.



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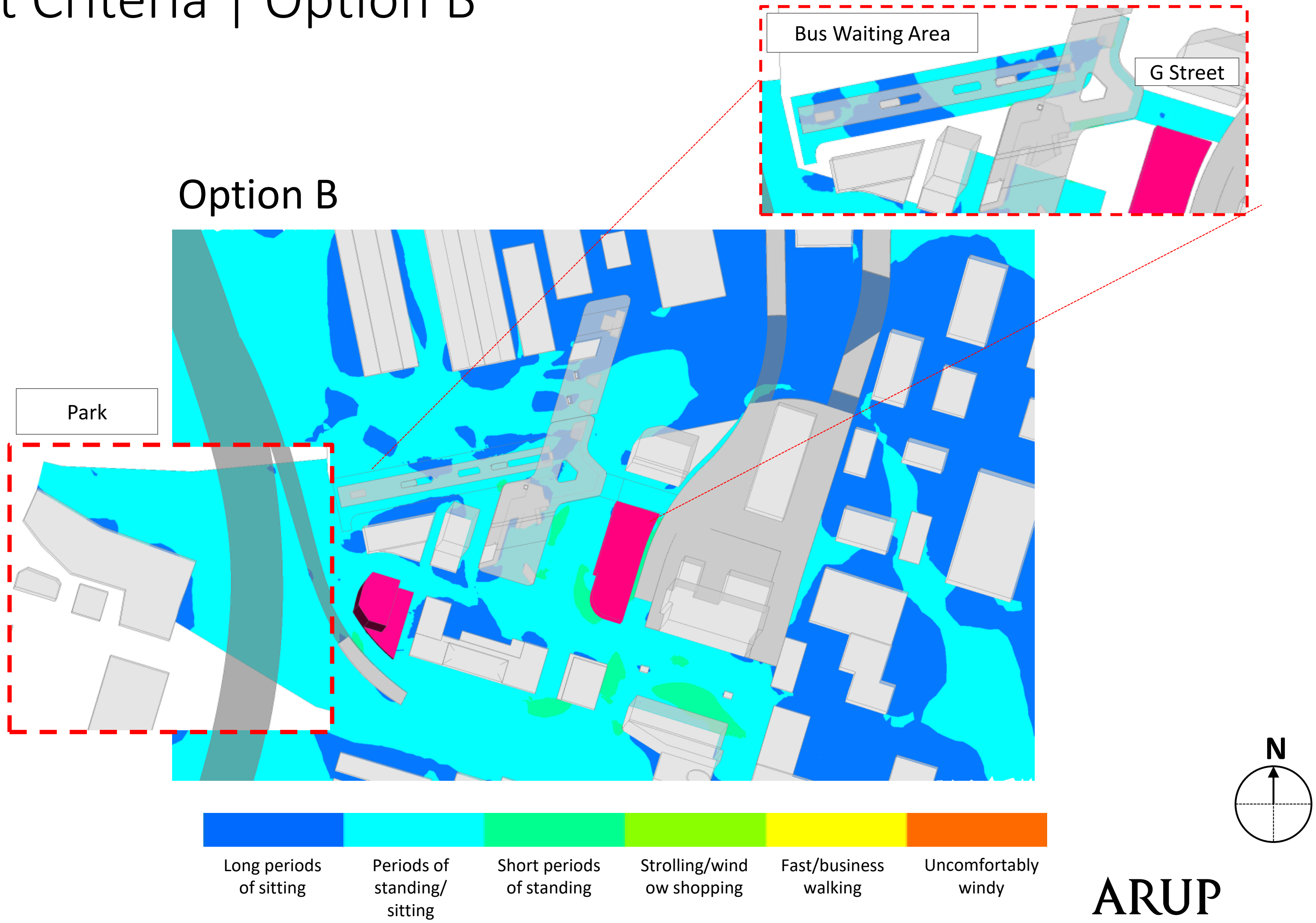
Wind Comfort Criteria | Option B

The results shown compare the windiness of the site for Option B.

In general, the site is suitable for short periods of standing and sitting, which is acceptable for outdoor spaces where people switch between standing and sitting.

This shows that there is low windiness on the site and is comparable to Option A.



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Results

Yearly Cumulative Solar Assessment

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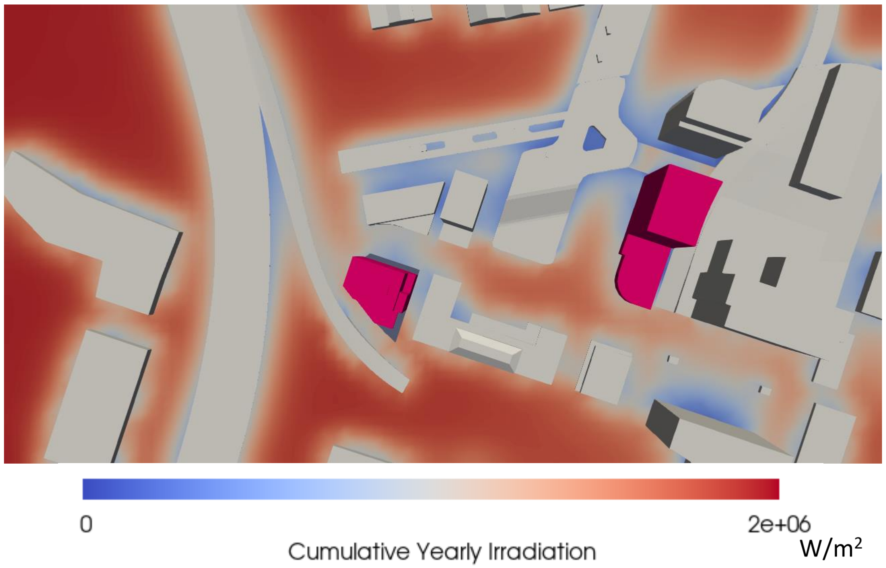
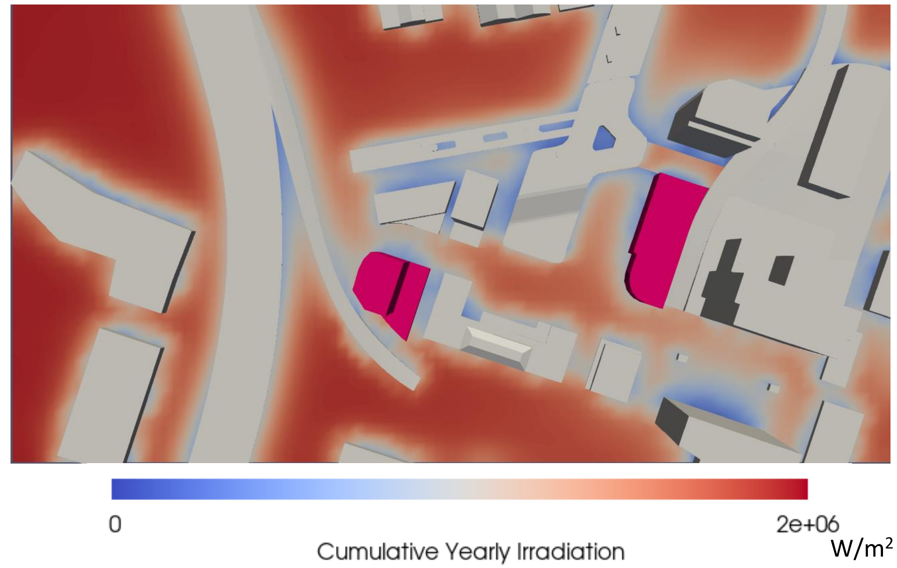
Cumulative Solar

Option A

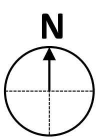


Option B



The plots above show the cumulative solar radiation for a year on the site for Massing Options A and B.

The majority of the site is similar. However, Option A leads to more shading on G Street. This shading is provided by the tower in Option A.



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Results

Outdoor Thermal Comfort Assessment

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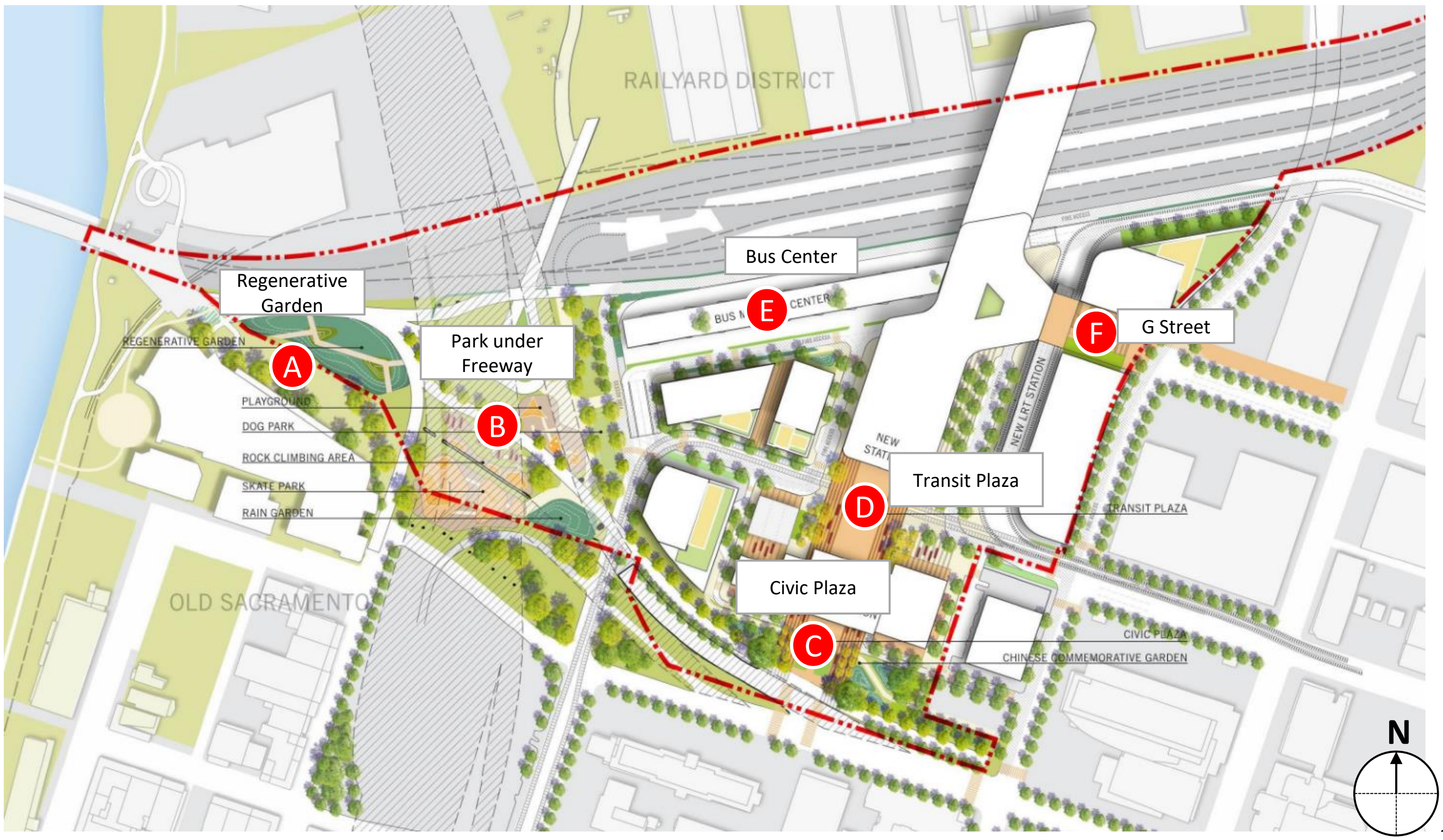
Points of Interest

- Six locations of interest were chosen to be evaluated for outdoor thermal comfort for both massing options A & B
- The results indicate comfort conditions during "occupied" hours of 7 am to 7 pm



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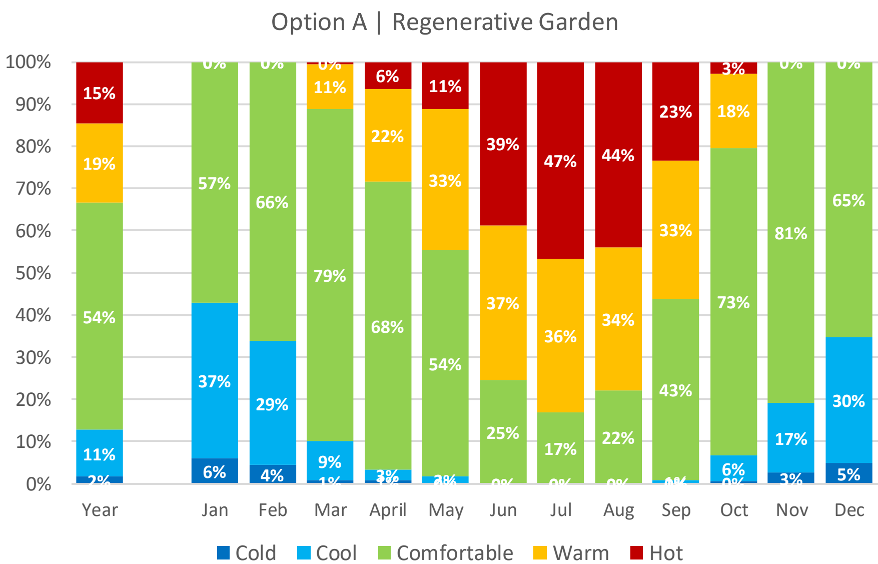
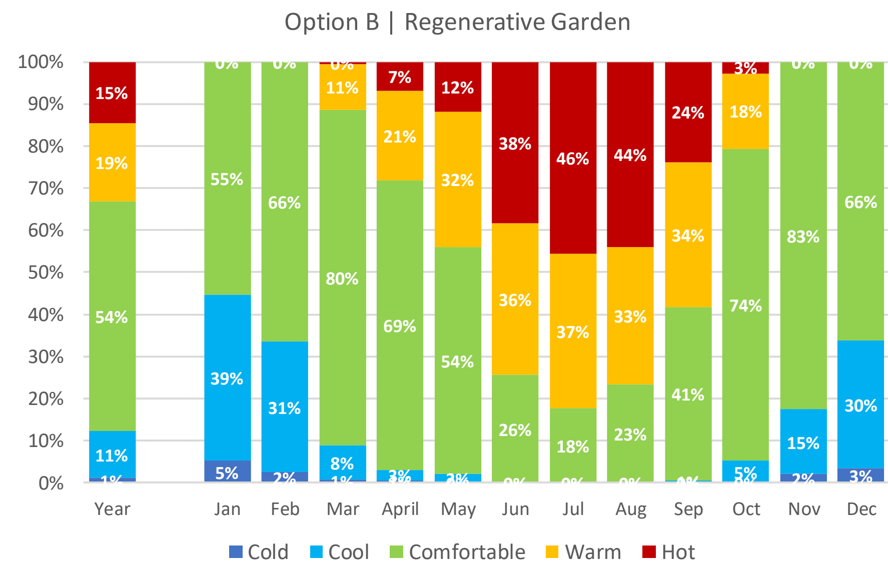
Outdoor Comfort | Regenerative Garden





Option A and Option B lead to same comfort results. This is because the buildings of interest in the different massing options do not affect the conditions at the regenerative garden.

Seasonal Summary:

- Winter: Cool to cold conditions for about 30-40% of the season. Rest of time is comfortable
- Spring/Fall: Mostly comfortable to warm with <10% of hours that are too hot.
- Summer: 40-47% of season is too hot. Shading strategies can mitigate these hot conditions.

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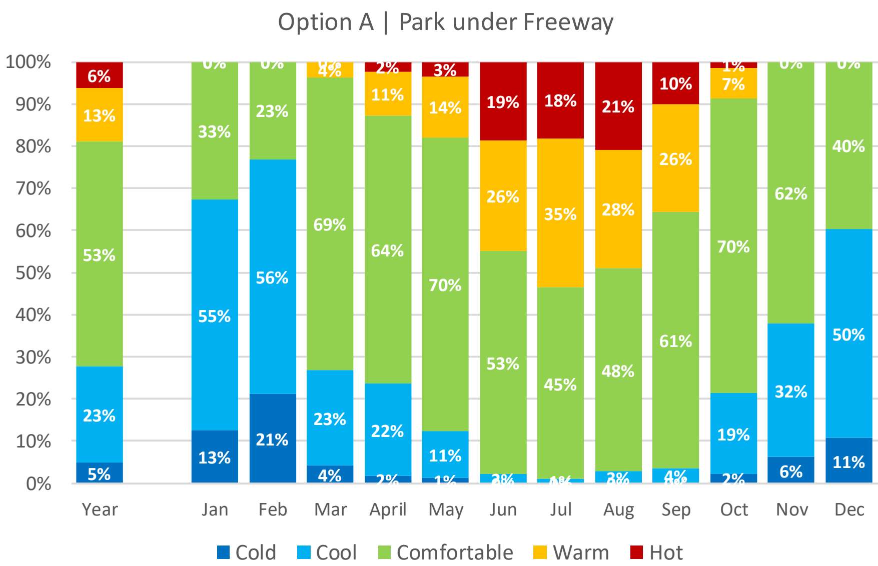
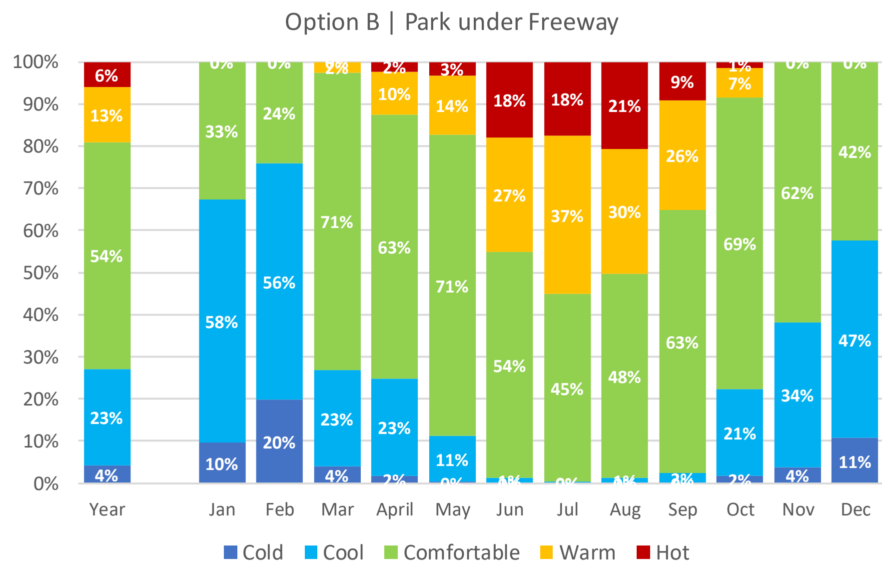
Outdoor Comfort | Park under Freeway

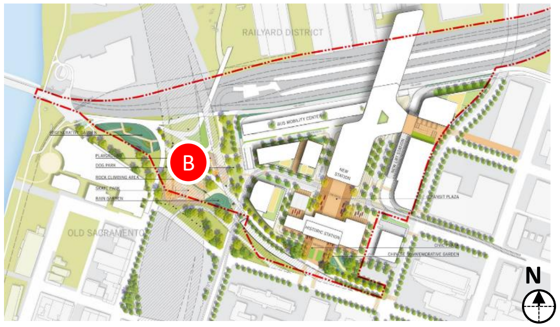




Option A and Option B lead to same comfort results. This is because the buildings of interest in the different massing options do not affect the conditions at the park area under the freeway.

Seasonal Summary:

- Winter: Cool to cold conditions for about 30-56% of the season. Rest of time is comfortable
- Spring/Fall: Mostly comfortable to warm with <3% of hours that are too hot.
- Summer: About 20% of season is too hot. This is due to the shading provided by the freeway.



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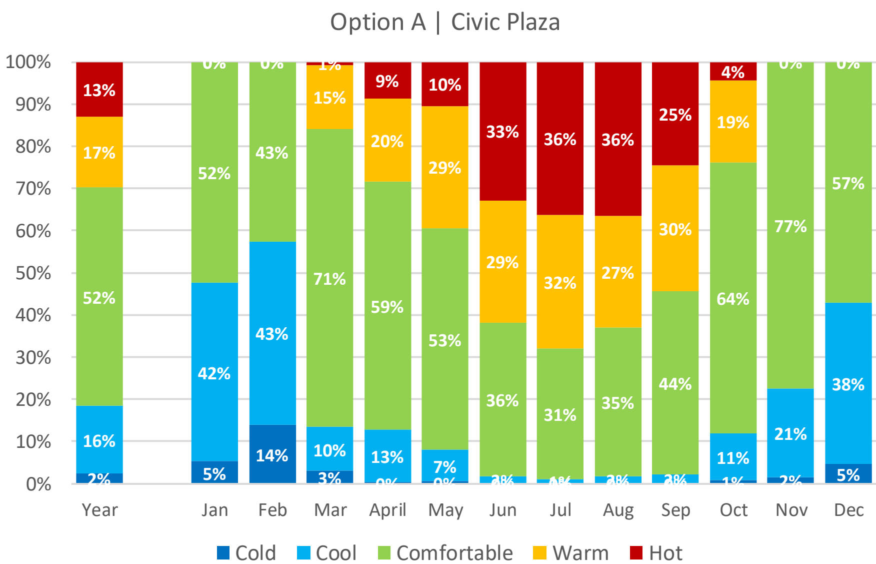
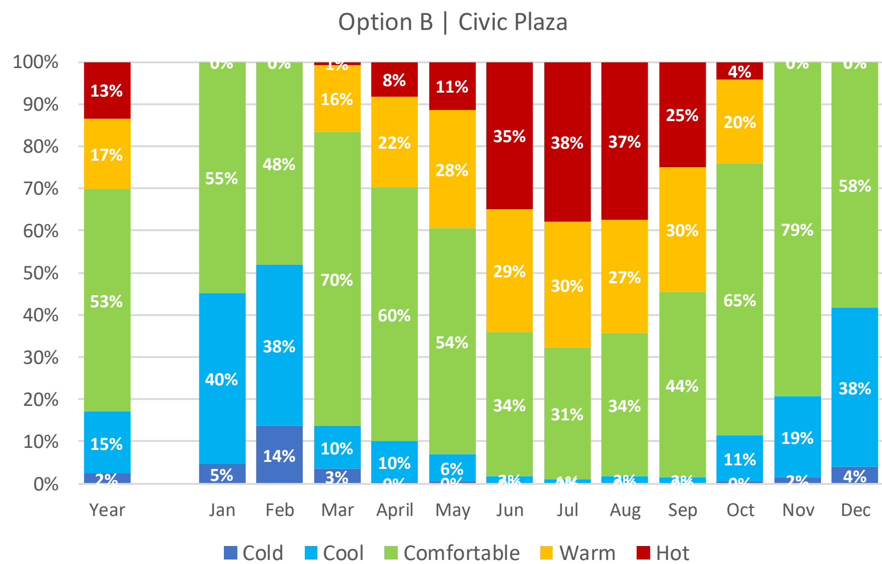
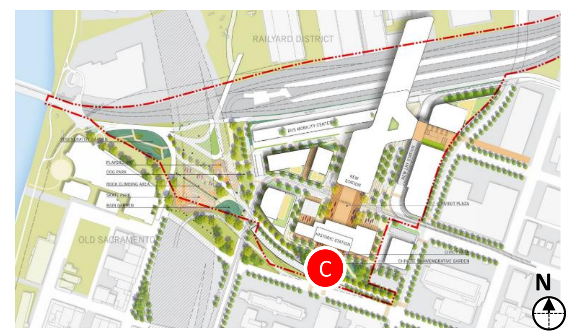
Outdoor Comfort | Civic Plaza





Option A and Option B lead to similar comfort results. This is because the buildings of interest in the different massing options do not affect the conditions at the Civic Plaza.



Seasonal Summary:

- Winter: Cool to cold conditions for about 40% of the season. Rest of time is comfortable
- Spring/Fall: Mostly comfortable to warm with <10% of hours that are too hot.
- Summer: About 37% of season is too hot. Shading strategies can mitigate these hot conditions.

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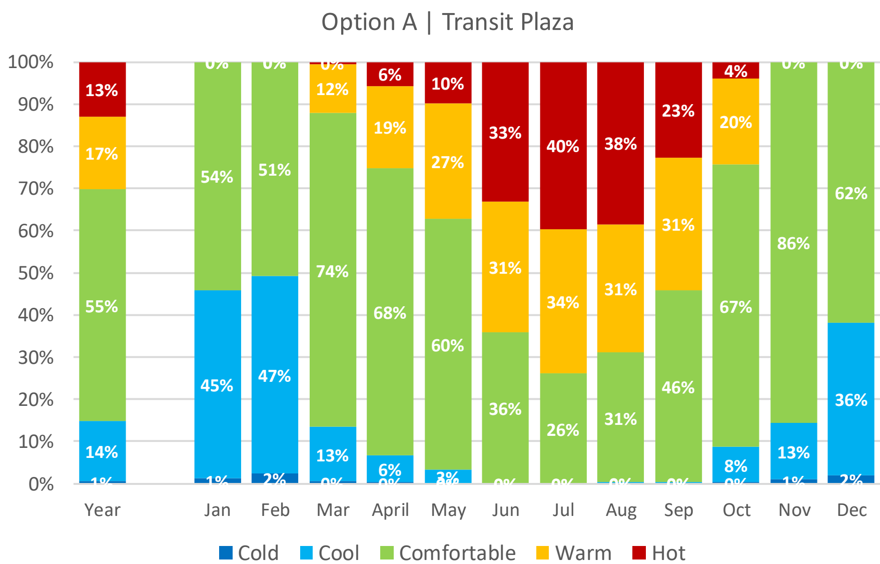
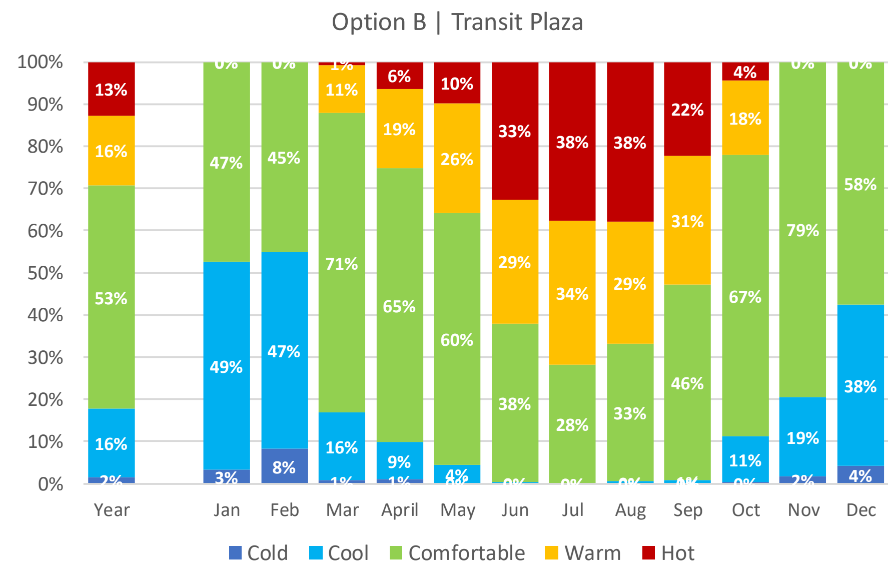
Outdoor Comfort | Transit Plaza

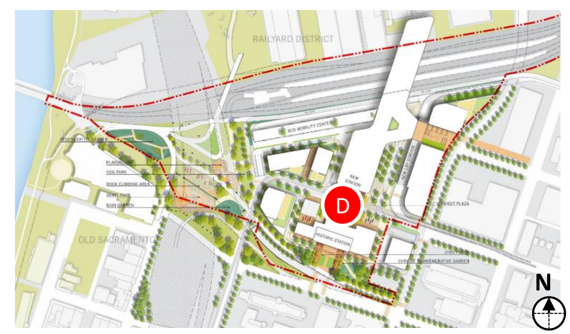




Option A and Option B lead to similar comfort results. This is because the buildings of interest in the different massing options do not affect the conditions at the Transit Plaza.

Seasonal Summary:

- Winter: Cool to cold conditions for about 36-47% of the season. Rest of time is comfortable
- Spring/Fall: Mostly comfortable to warm with <10% of hours that are too hot.
- Summer: About 40% of season is too hot. Shading strategies can mitigate these hot conditions.



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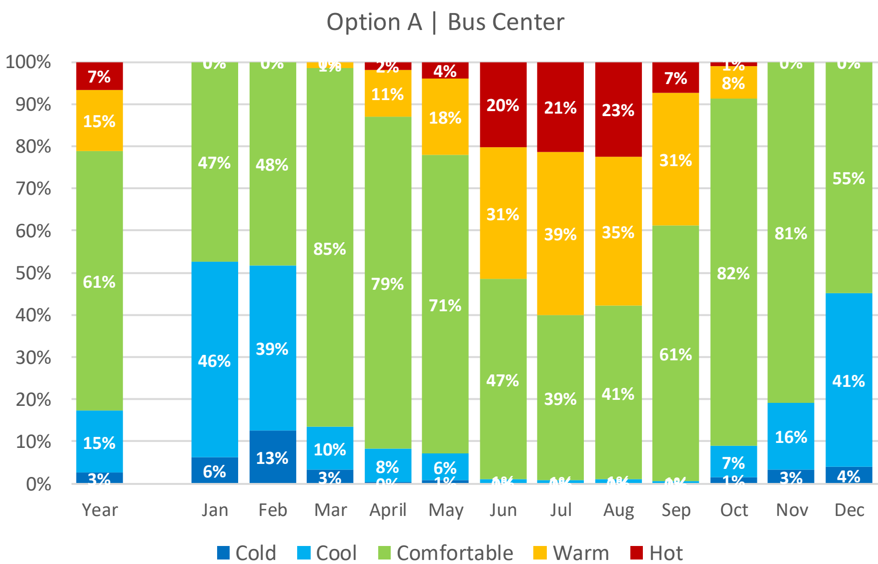
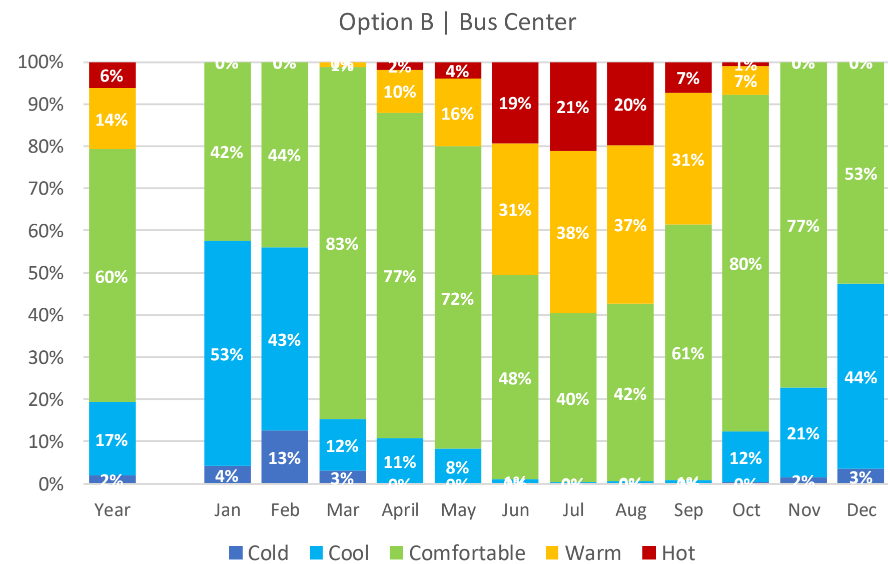
Outdoor Comfort | Bus Center





Option A and Option B lead to similar comfort results. This is because the buildings of interest in the different massing options do not affect the conditions at the Bus Center platform.

Seasonal Summary:

- Winter: Cool to cold conditions for about 40% of the season. Rest of time is comfortable
- Spring/Fall: Mostly comfortable to warm with <4% of hours that are too hot.
- Summer: About 20% of season is too hot. This is due to the shading provided by the roof.

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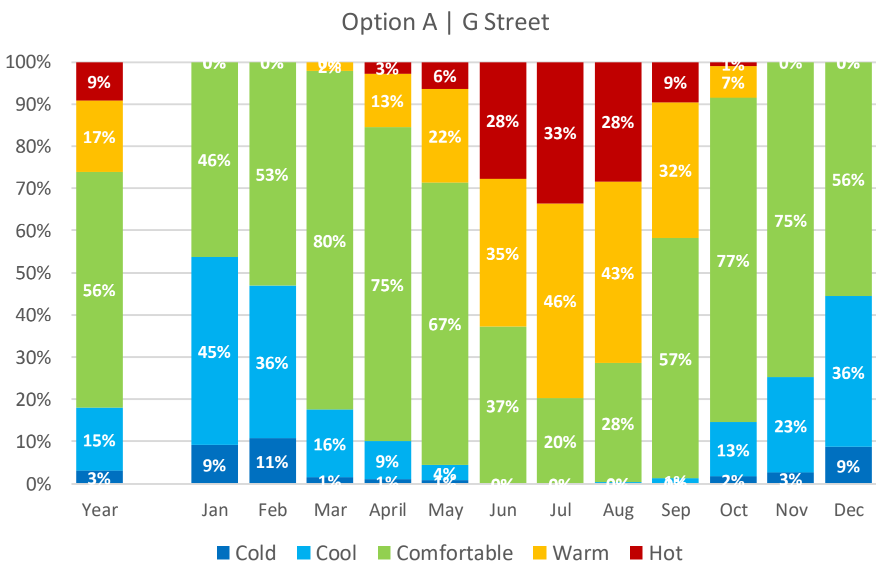
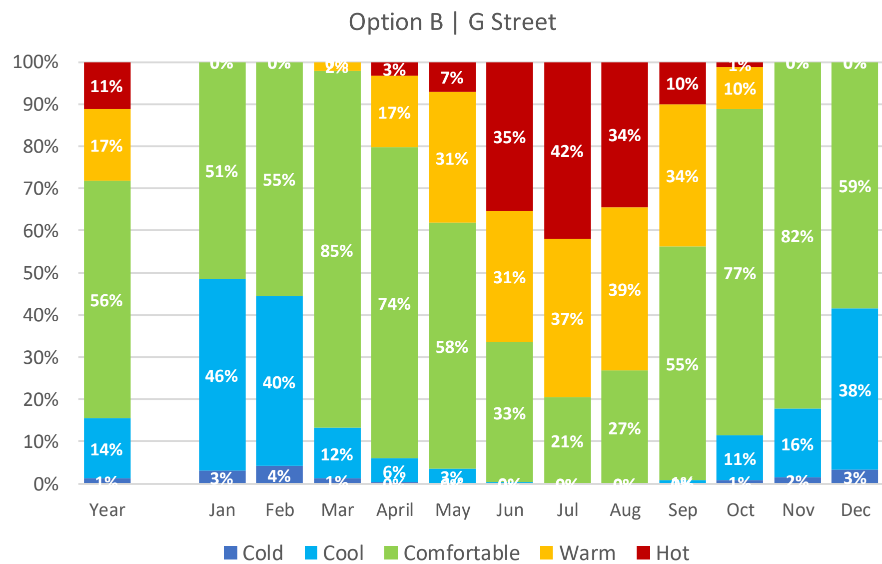
Outdoor Comfort | G Street





Option A and Option B lead to slightly different comfort results. This is because the tower in massing Option A provides more shading that Option B.

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Seasonal Summary:

- Winter: Cool to cold conditions for about 40% of the season. Rest of time is comfortable
- Spring/Fall: Mostly comfortable to warm with <3% of hours that are too hot.
- Summer: Option A provides more shading than Option B. About 30% (Option A) to 40% (Option B) of season is too hot.

Mitigation Strategies

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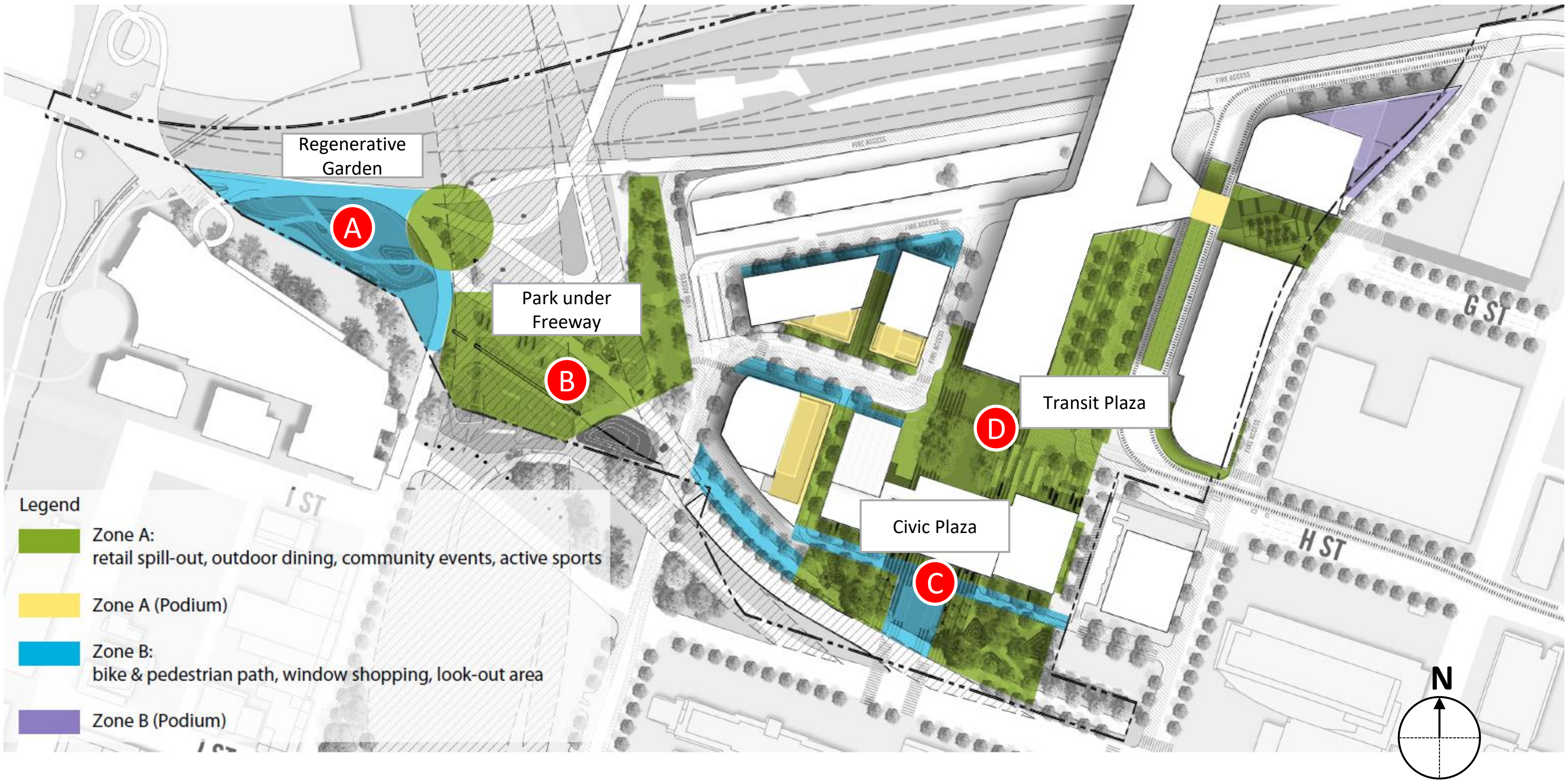
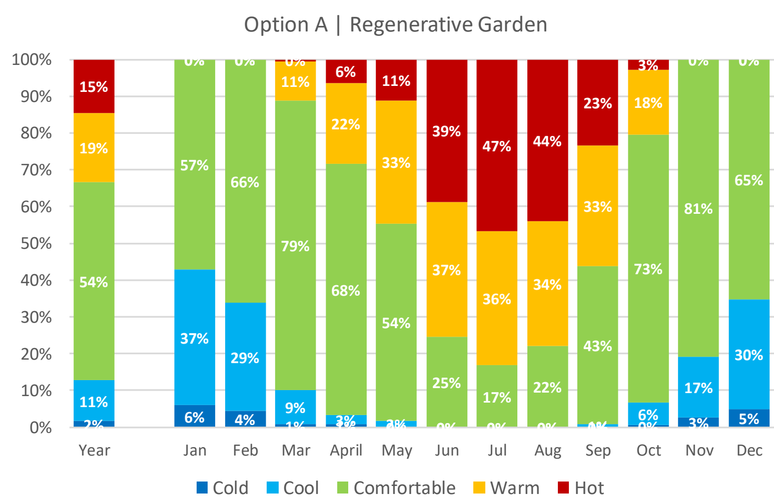
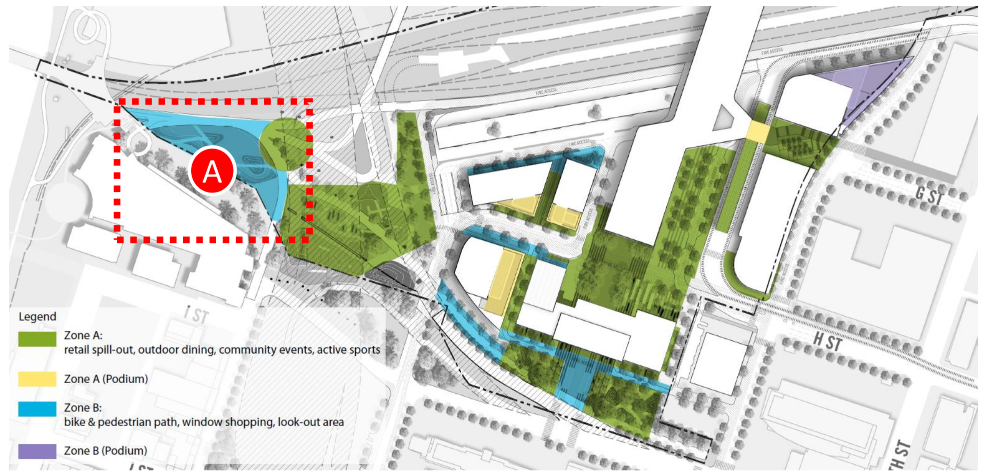
Provided Program Areas by Zone



Point A | Regenerative Garden, Zone B

Program Types: bike and pedestrian path, window shopping, look-out area

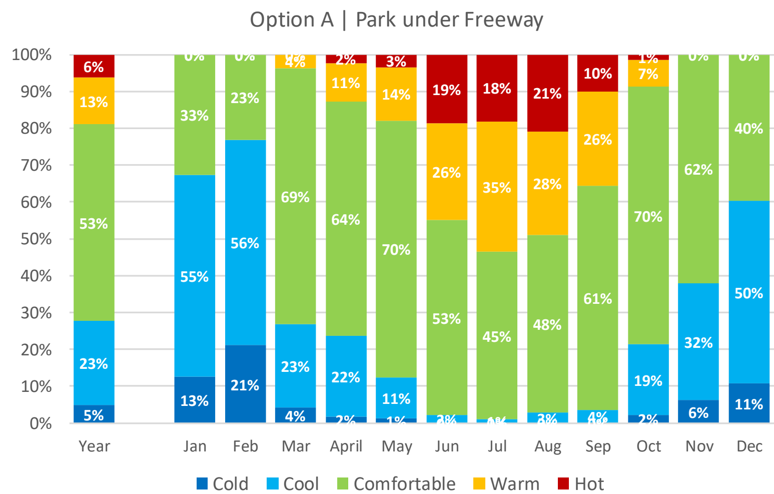


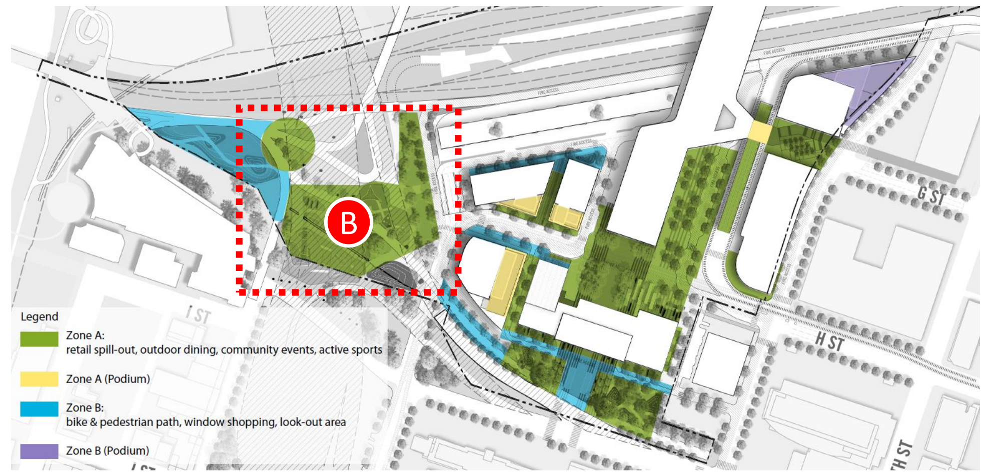


The results for this area indicate that a majority of occupied hours during the year (54%) will be deemed as comfortable. During the summer months of June, July, and August, there will be about 40% of hours that are deemed hot. **Local shading from the retail stores** will improve comfort for window shoppers. Since the expected use of the space is for transit and is transient in nature, additional cooling or ventilation may not be necessary.

Point B | Park Under Freeway, Zone A

Program Types: retail spill-out, outdoor dining, community events, active sports

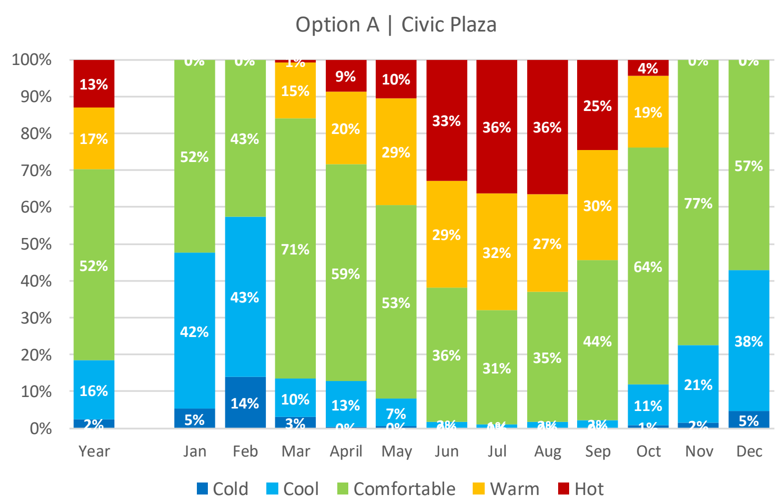


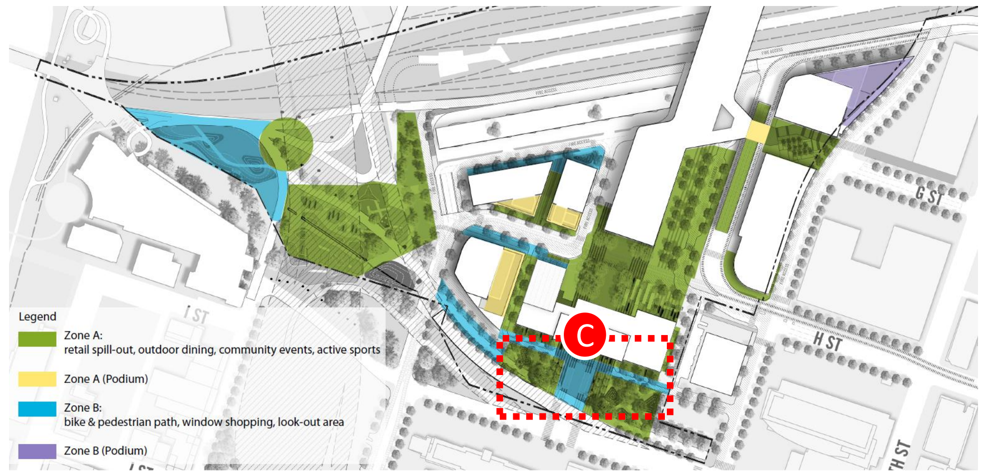


The results for this area indicate that a majority of occupied hours during the year (53%) will be deemed as comfortable. During the summer months of June, July, and August, there will be about 20% of hours that are deemed hot. The freeway already provides shading and that improves comfort. To further improve comfort, **adding misting or additional ventilation to dining or event areas** is recommended.

Point C | Civic Plaza, Zone B

Program Types: bike and pedestrian path, window shopping, look-out area

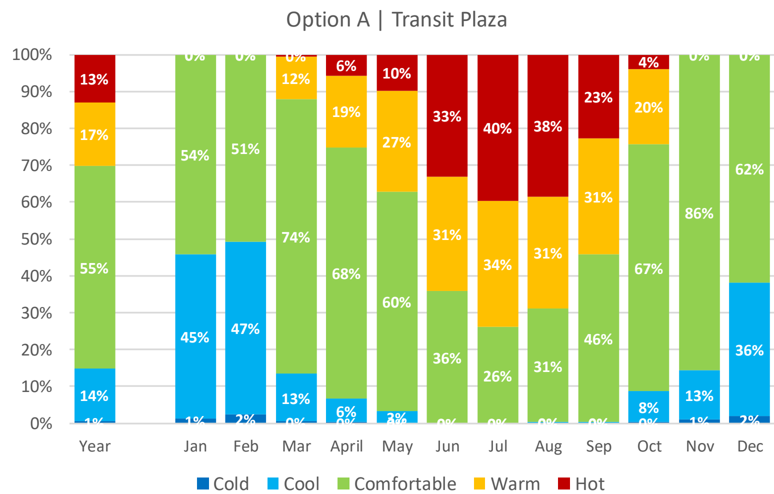


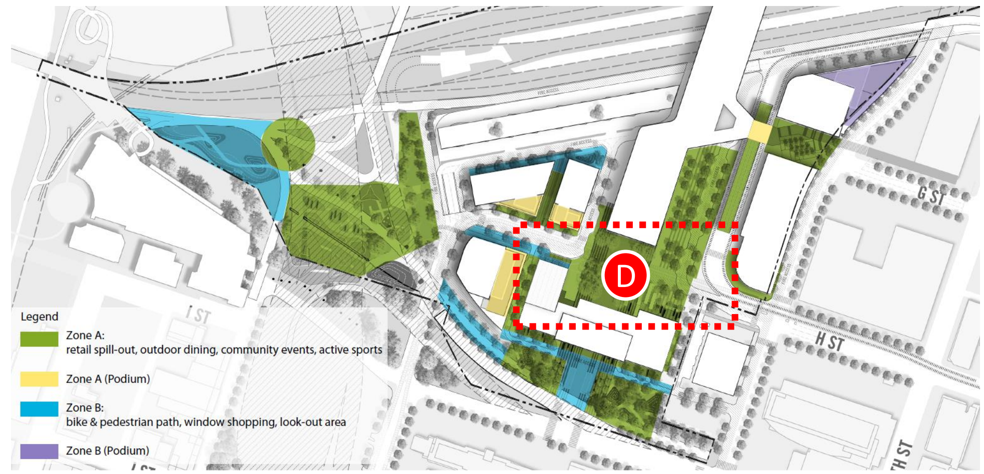


The results for this area indicate that a majority of occupied hours during the year (52%) will be deemed as comfortable. During the summer months of June, July, and August, there will be about 36% of hours that are deemed hot. **Local or seasonal shading** in the Civic Plaza will reduce these hot periods. To further improve comfort, **misting or increased ventilation via fans** is recommended if long dwell times or dining areas are expected.

Point D | Transit Plaza, Zone A

Program Types: retail spill-out, outdoor dining, community events, active sports





The results for this area indicate that a majority of occupied hours during the year (55%) will be deemed as comfortable. During the summer months of June, July, and August, there will be about 30-40% of hours that are deemed hot. **Local or seasonal shading** in the Transit Plaza will improve comfort during warm months. To further improve comfort, **adding misting or additional ventilation to dining or event areas** is recommended.

Appendix

Average Wind Velocities on Site by Season

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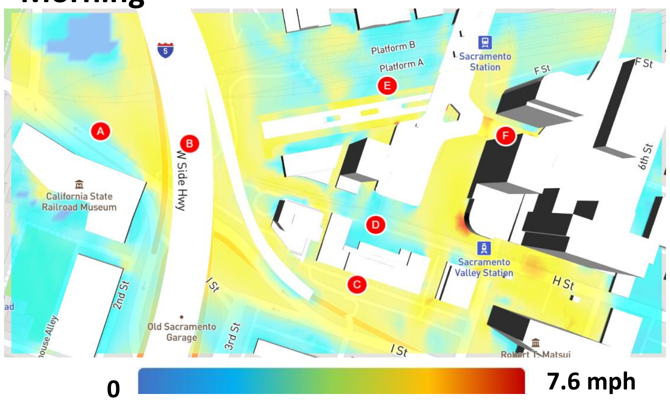
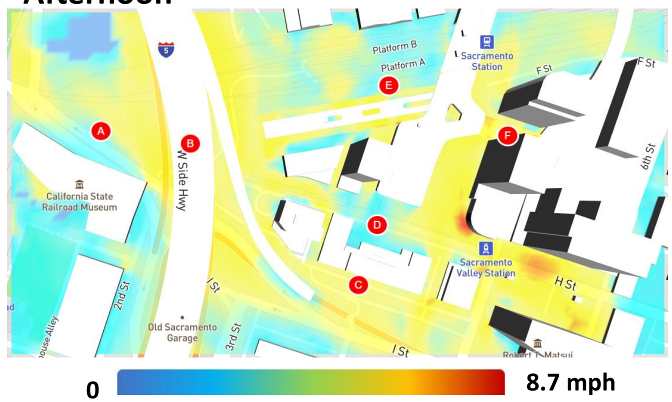
Average Wind Velocities on Site by Times for **Winter**

Option A

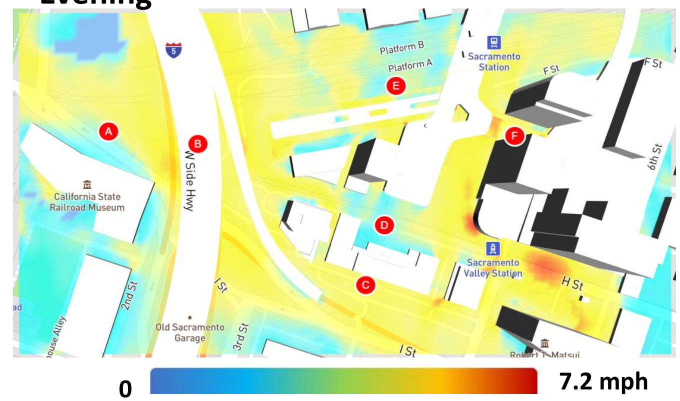
Morning



Afternoon

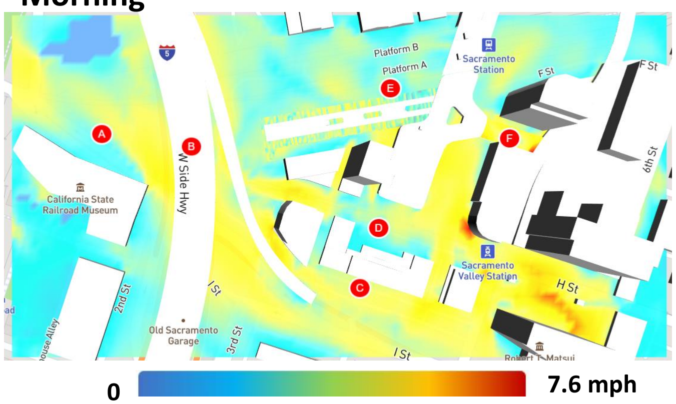


Evening

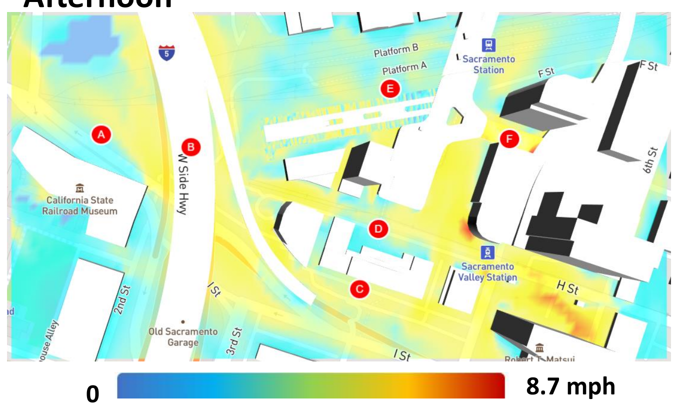


Option B

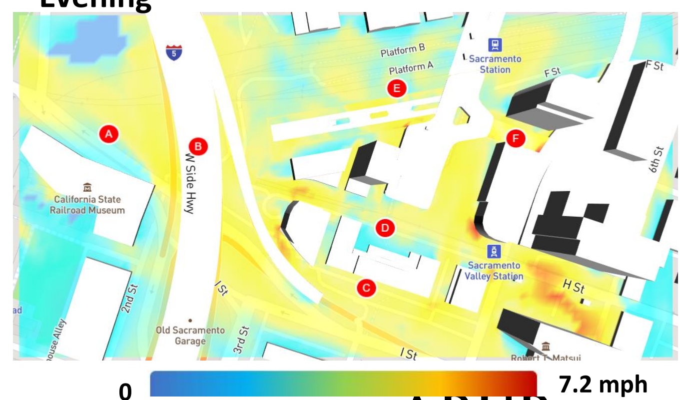
Morning



Afternoon



Evening



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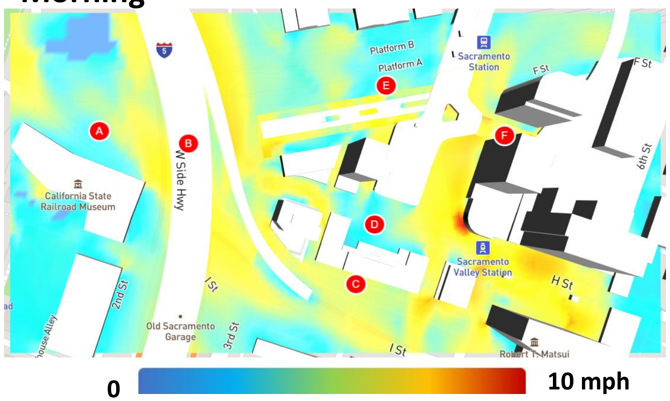
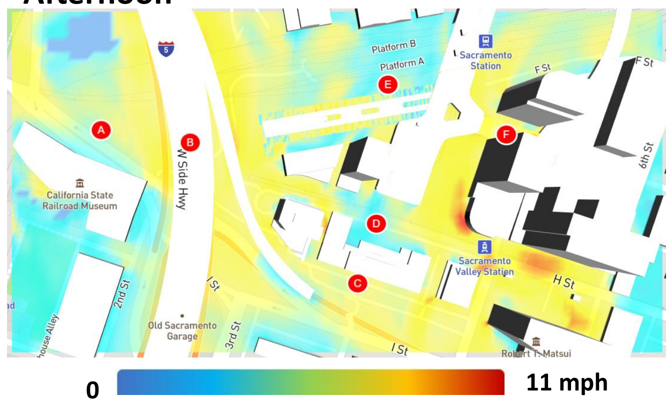
Average Wind Velocities on Site by Times for **Spring**

Option A

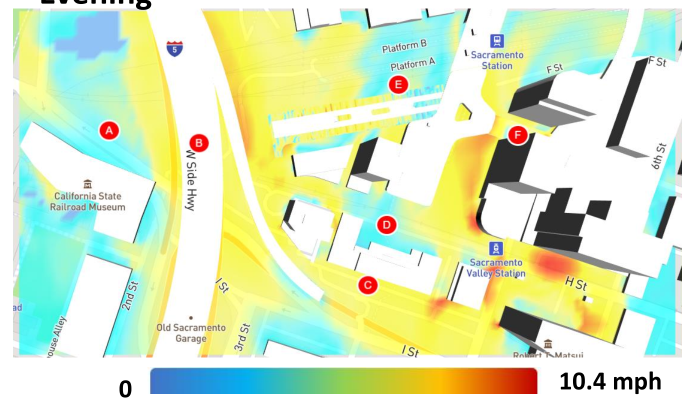
Morning



Afternoon

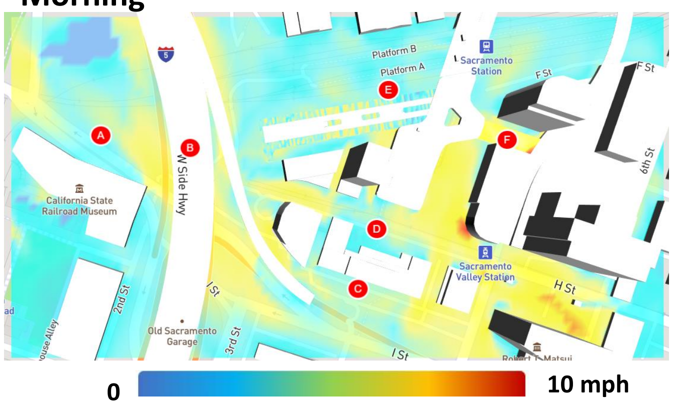


Evening

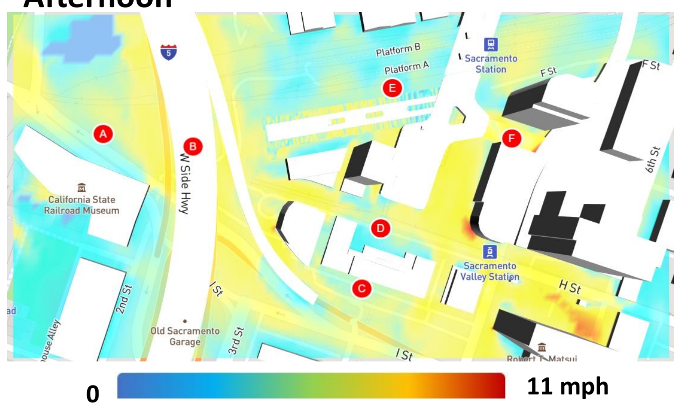


Option B

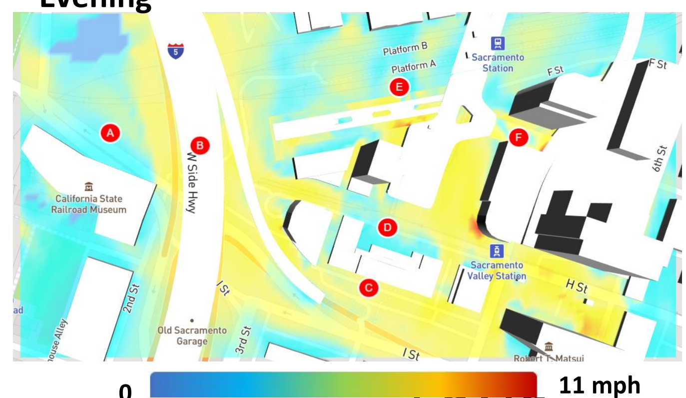
Morning



Afternoon



Evening



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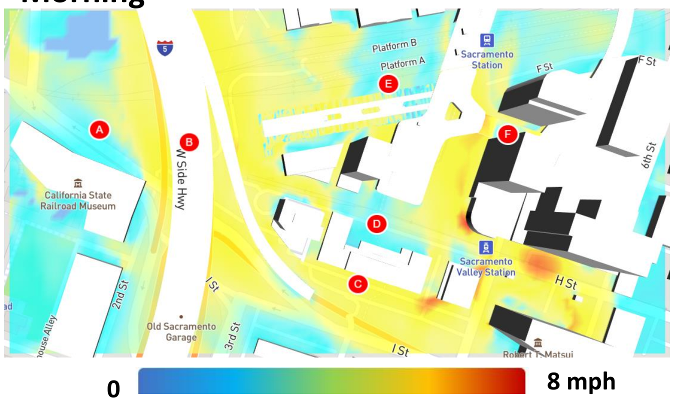
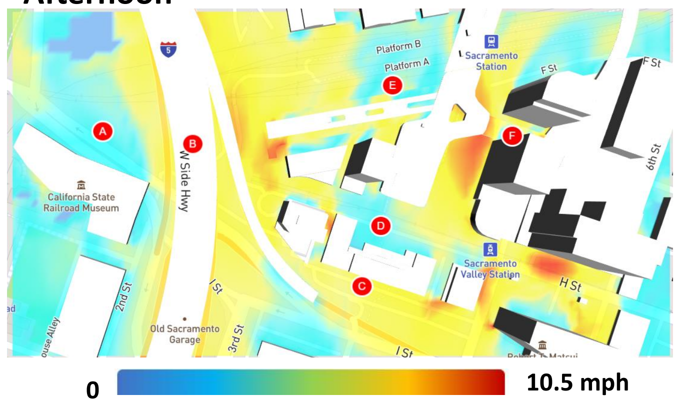
Average Wind Velocities on Site by Times for **Summer**

Option A

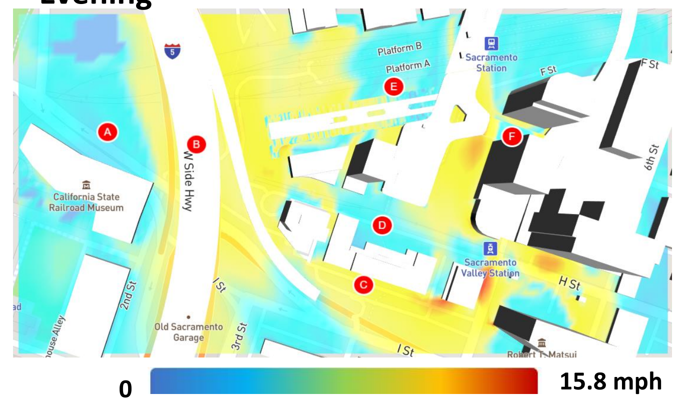
Morning



Afternoon

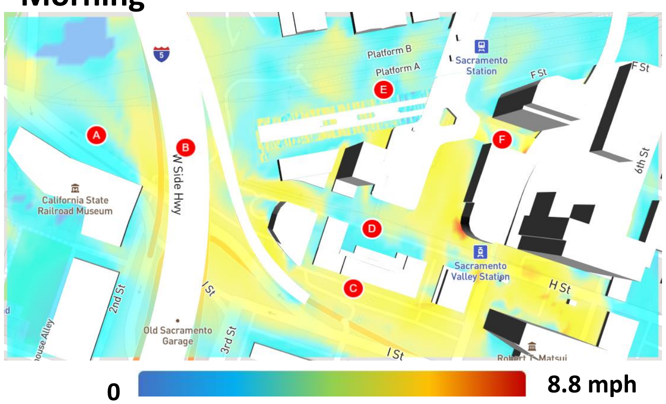


Evening

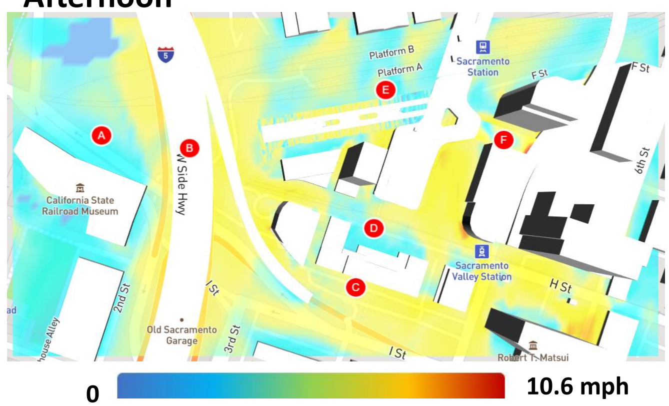


Option B

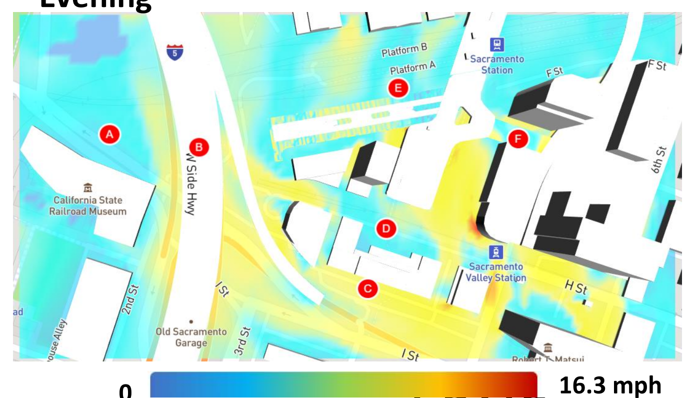
Morning



Afternoon



Evening



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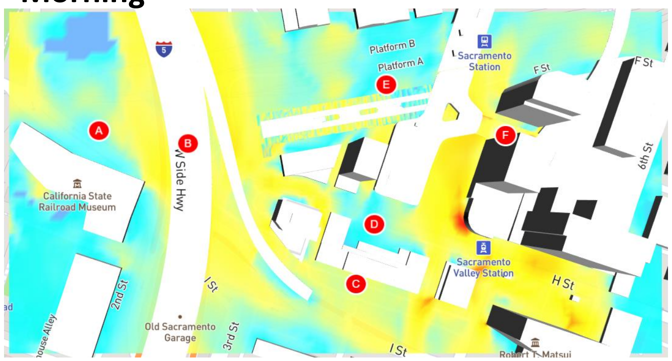
Average Wind Velocities on Site by Times for **Fall**

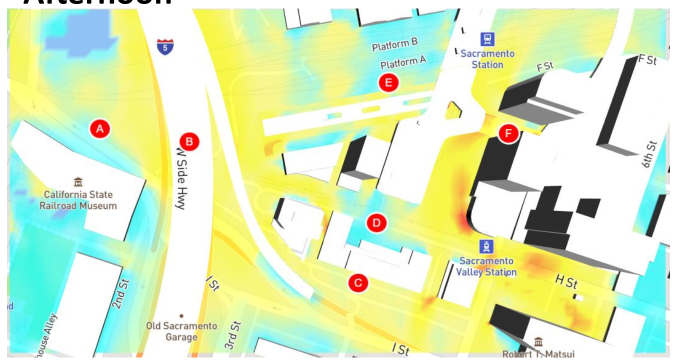
Option A

Morning



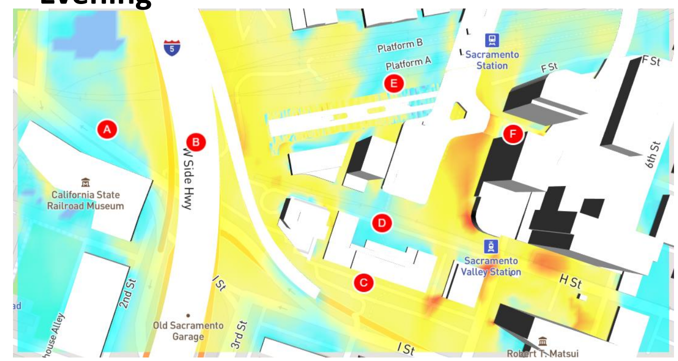
0 — 8.6 mph

Afternoon



0 — 8.7 mph

Evening



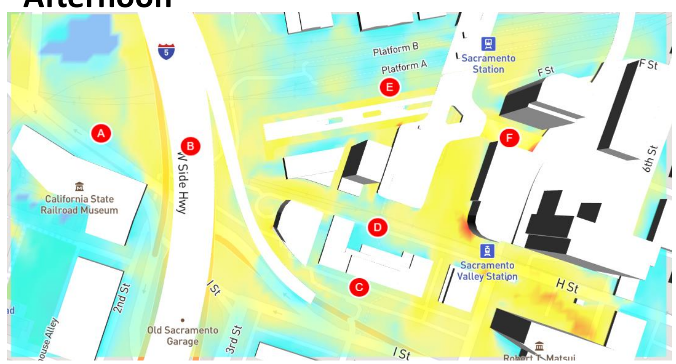
0 — 7.6 mph

Option B

Morning

0 — 8.8 mph

Afternoon



0 — 9.2 mph

Evening

0 — 8.3 mph

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Appendix

Wind Velocities Ratios by Major Wind Directions

ARUP

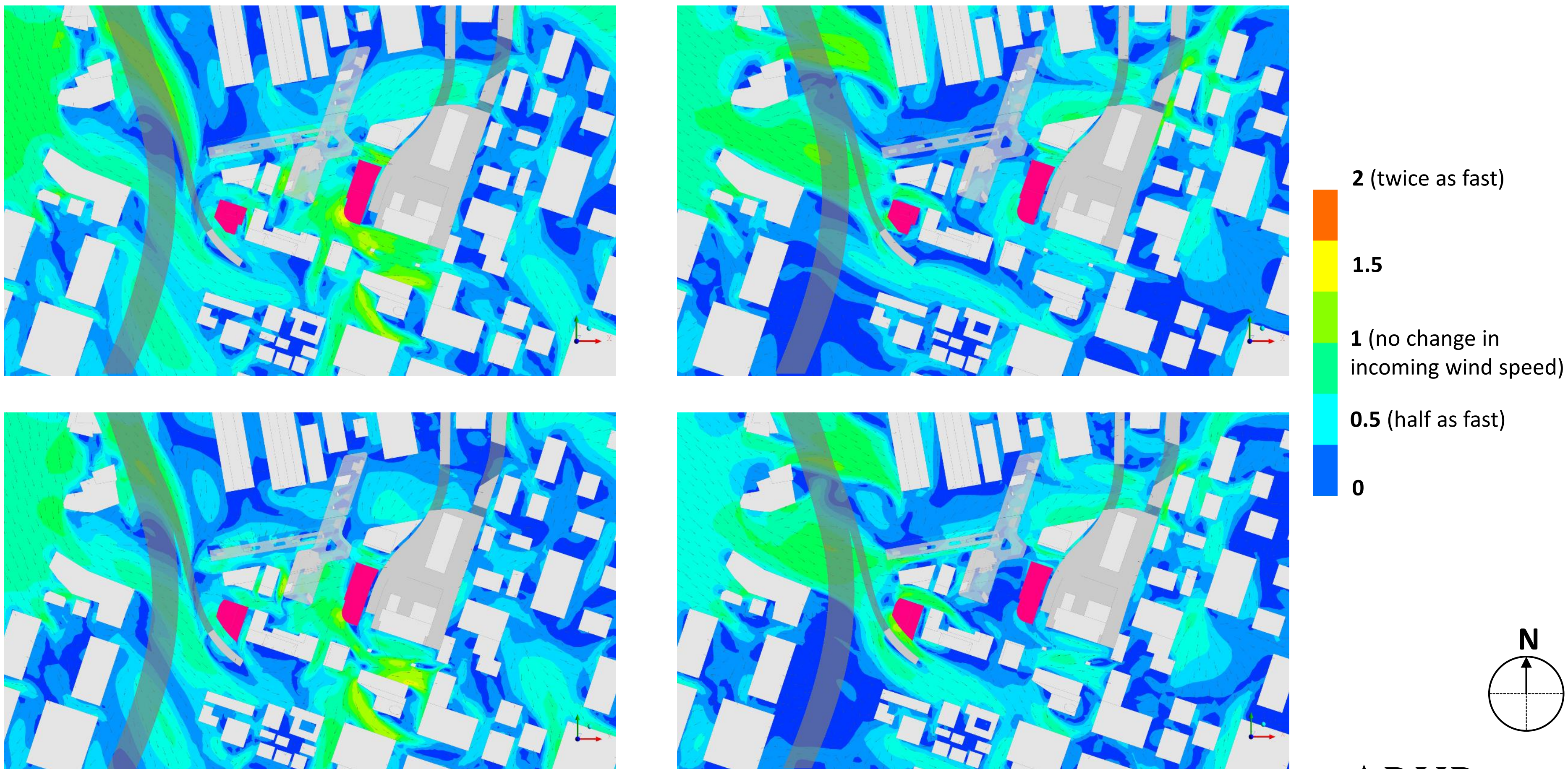
Major Wind Directions- Wind Ratios | Northwest

Wind Direction: 330

Wind Direction: 300

Option A

Option B



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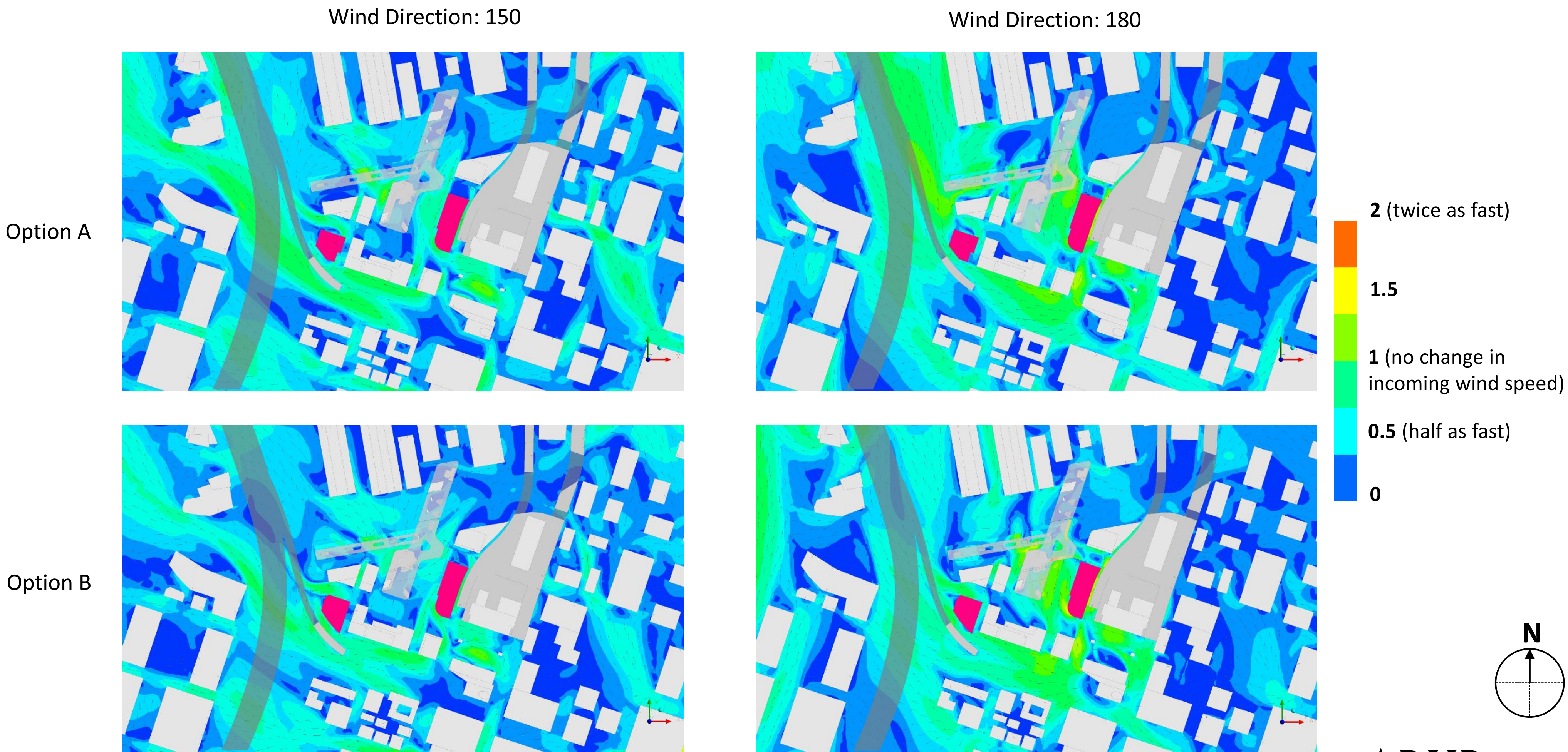
Major Wind Directions- Wind Ratios | Southeast



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Methodology

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Wind Comfort Criteria

- The Lawson comfort criteria estimates the likeliness of wind-related risk for pedestrians in external areas and categorizes the areas by typical activities for which they could be used. Table 1 provides a summary of the Lawson comfort criteria.
- Figure 1 illustrates how climate data and analysis is used to obtain the wind comfort for the site to be compared against the Lawson comfort scale.

Comfort Criteria	Activity Description	Equivalent Beaufort Wind Criteria
Sitting	Reading a newspaper and eating and drinking	Category 2 – Light Breeze (wind speed less than 7mph)
Standing or short-term sitting	Bus stops, window shopping, and building entrances	Category 3 – Gentle Breeze (wind speed less than 12mph)
Walking or strolling	General areas of walking and sightseeing	Category 4 – Moderate Breeze (wind speed less than 17mph)
Fast or business walking	Local areas around tall buildings where people are not expected to linger	Category 5 – Fresh Breeze (wind speed less than 24mph)
Potentially dangerous	Areas that could limit movement — umbrellas become difficult to use	Category 6 and higher – Strong Breeze (wind speed greater than 25mph)

Table 1 : Lawson comfort criteria

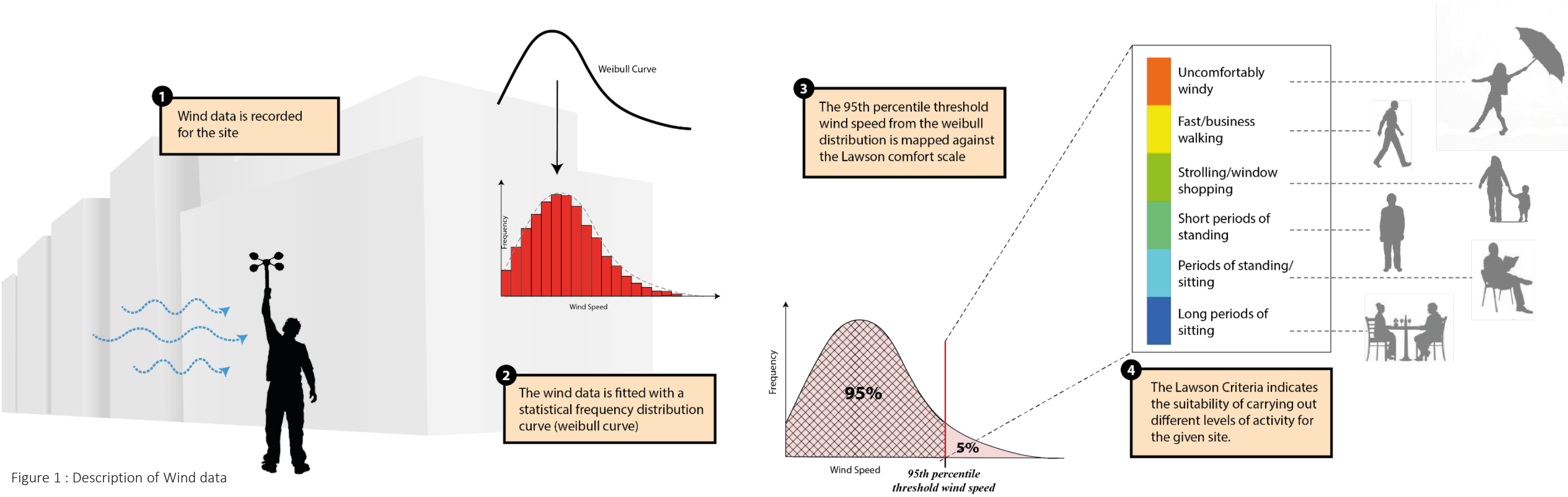


Figure 1 : Description of Wind data

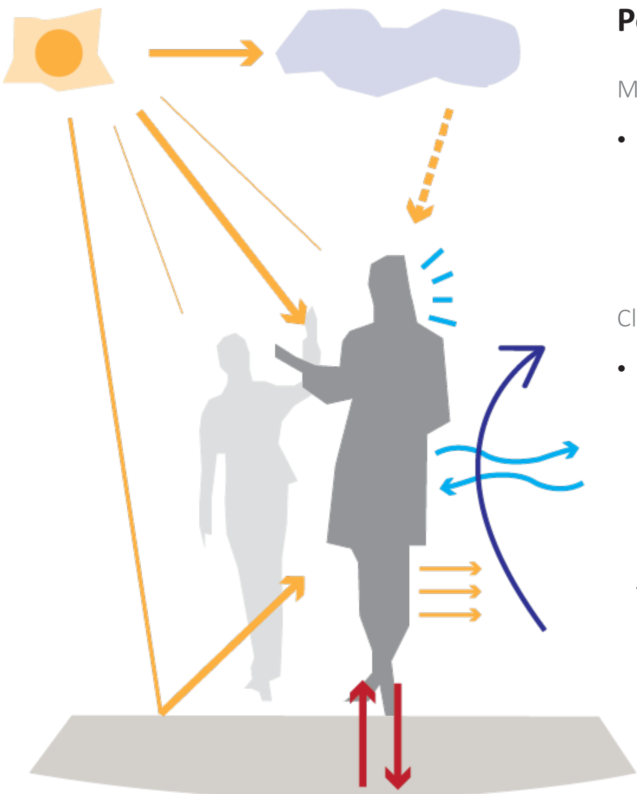
Wind Velocities | Beaufort Scale

- The Beaufort scale bins wind velocities into classes of increasing wind intensity and describes the conditions during those wind bins. It is used to measure wind strength.
- Figure 1 illustrates the wind speed bins and the observed conditions during those wind speeds.

Figure 1 : Beaufort Scale

Wind speed [mph]	Description of Conditions
0-1	Calm (smoke rises vertically)
1-3	Light Air (direction of air shown by smoke drift but not by wind vanes)
4-7	Light Breeze (Wind felt on face; leaves rustle; ordinary vanes moved by wind)
8-12	Gentle Breeze (Leaves and small twigs in constant motion; wind extends light flag)
13-18	Moderate Breeze (Raises dust and loose paper; small branches are moved)
19-24	Fresh Breeze (Small trees in leaf begin to sway; crested wavelets form on inland waters)
25-31	Strong Breeze (Large branches in motion; whistling heard in telegraph wires; umbrellas used with difficulty)

Outdoor Thermal Comfort



Factors Affecting Thermal Comfort

Personal Factors

Metabolic rate

- The level of transformation of chemical energy into heat and mechanical work by metabolic activities within an organism, usually expressed in terms of unit area of the total body surface.

Clothing level

- The amount of thermal insulation worn by a person has a substantial impact on thermal comfort, because it influences the heat loss and consequently the thermal balance.

Environmental Factors

Air temperature

- The air temperature is the average temperature of the air surrounding the occupant

Mean radiant temperature

- The mean radiant temperature, depends on the temperatures and emissivity of the surrounding surfaces as well as the view factor, or the amount of the surface that is “seen” by the object.

Air speed

- Air speed is defined as the rate of air movement at a point, without regard to direction

Relative Humidity

- Relative humidity is the ratio of the amount of water vapor in the air to the amount of water vapor that the air could hold at the specific temperature and pressure.

Thermal Comfort Metric: Universal Thermal Climate Index (UTCI)

About UTCI: http://www.utci.org/utci_poster.pdf

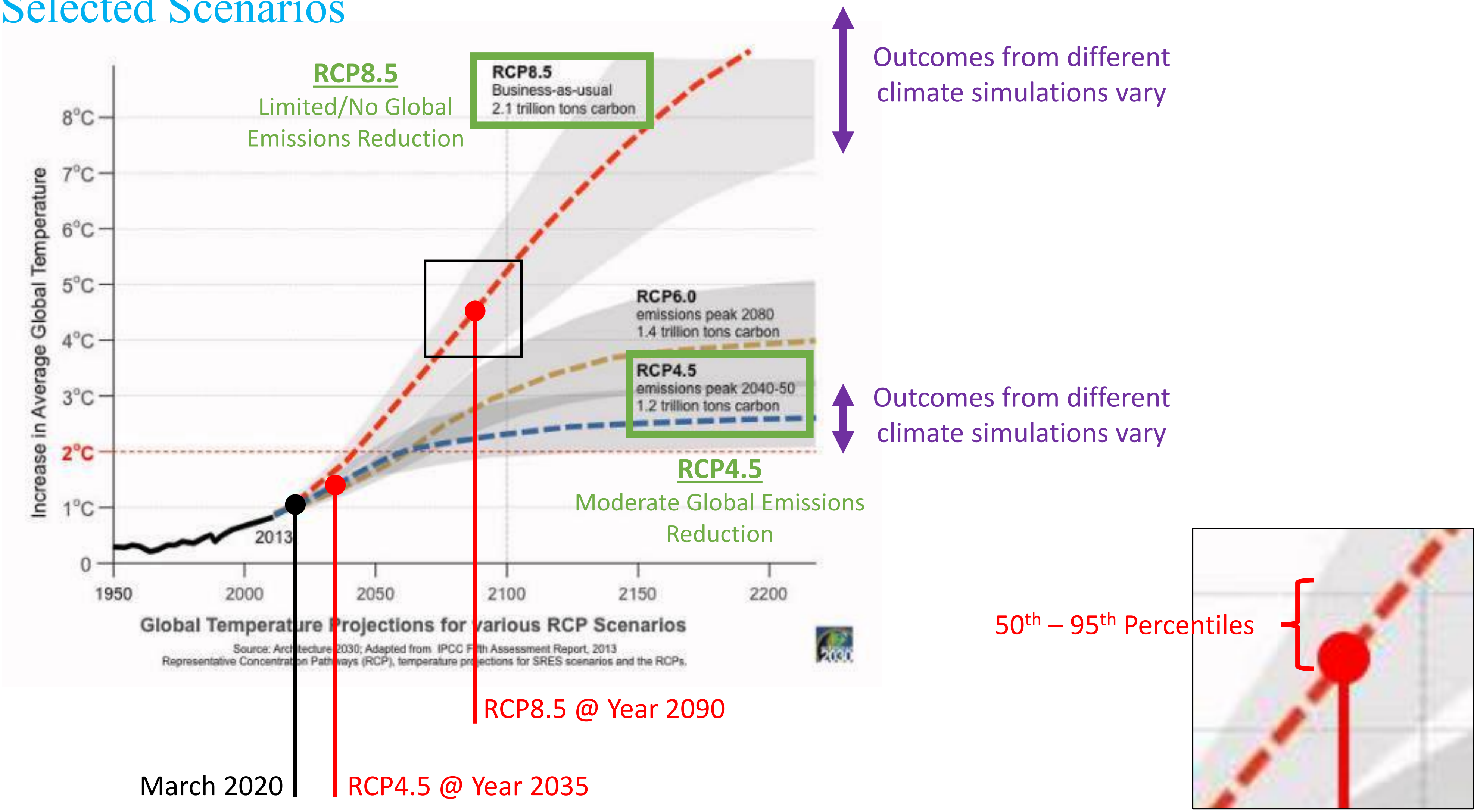
ii. Weather-shift climate predictions

Sacramento Valley Station:
Initial Future Climate Capacity Assessment

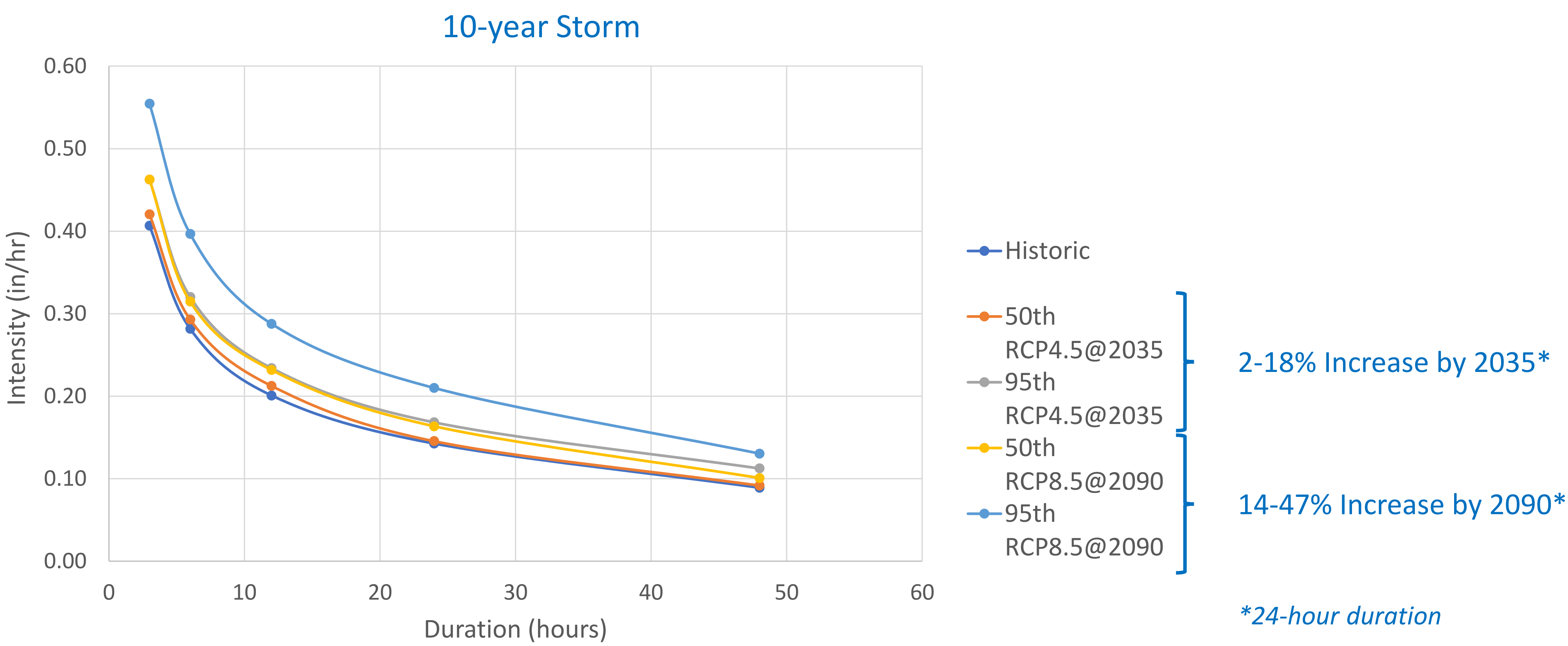
Arup
April 24, 2020

ARUP

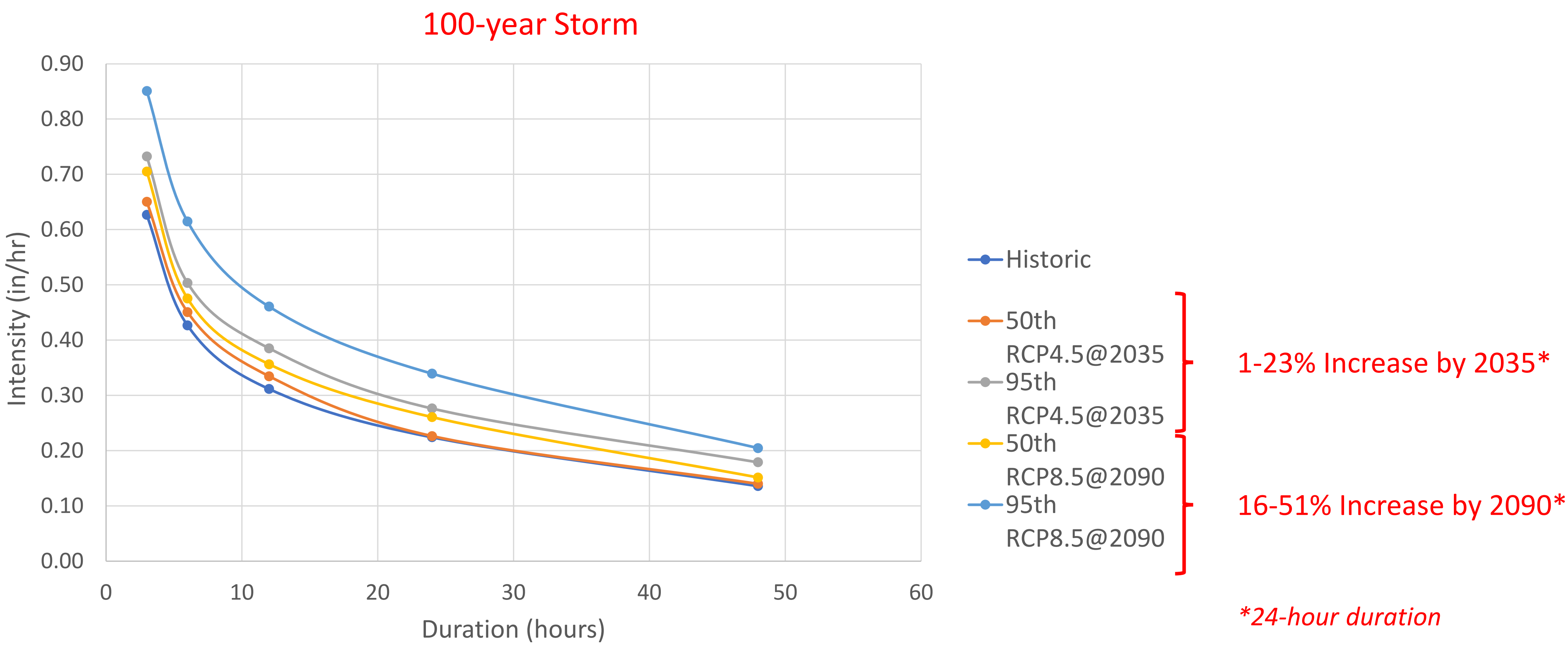
Selected Scenarios



10-Year Storm Intensity Comparison, Sacramento



100-Year Storm Intensity Comparison, Sacramento



Preliminary Capacity Assessment

RAILYARDS DMP REPORT, KIMLEY HORN, OCT 2016

Planned Total Peak Flow Capacity = 378 cfs
(37% above modeled 10-year storm)

FINAL SUBSEQUENT EIR, ESA, OCT 2016

Planned 100-year Peak Design Flow = 450 cfs
Planned Total Peak Flow Capacity = 600 cfs
(117% above modeled 10-year storm)
(39% above modeled 100-year storm)

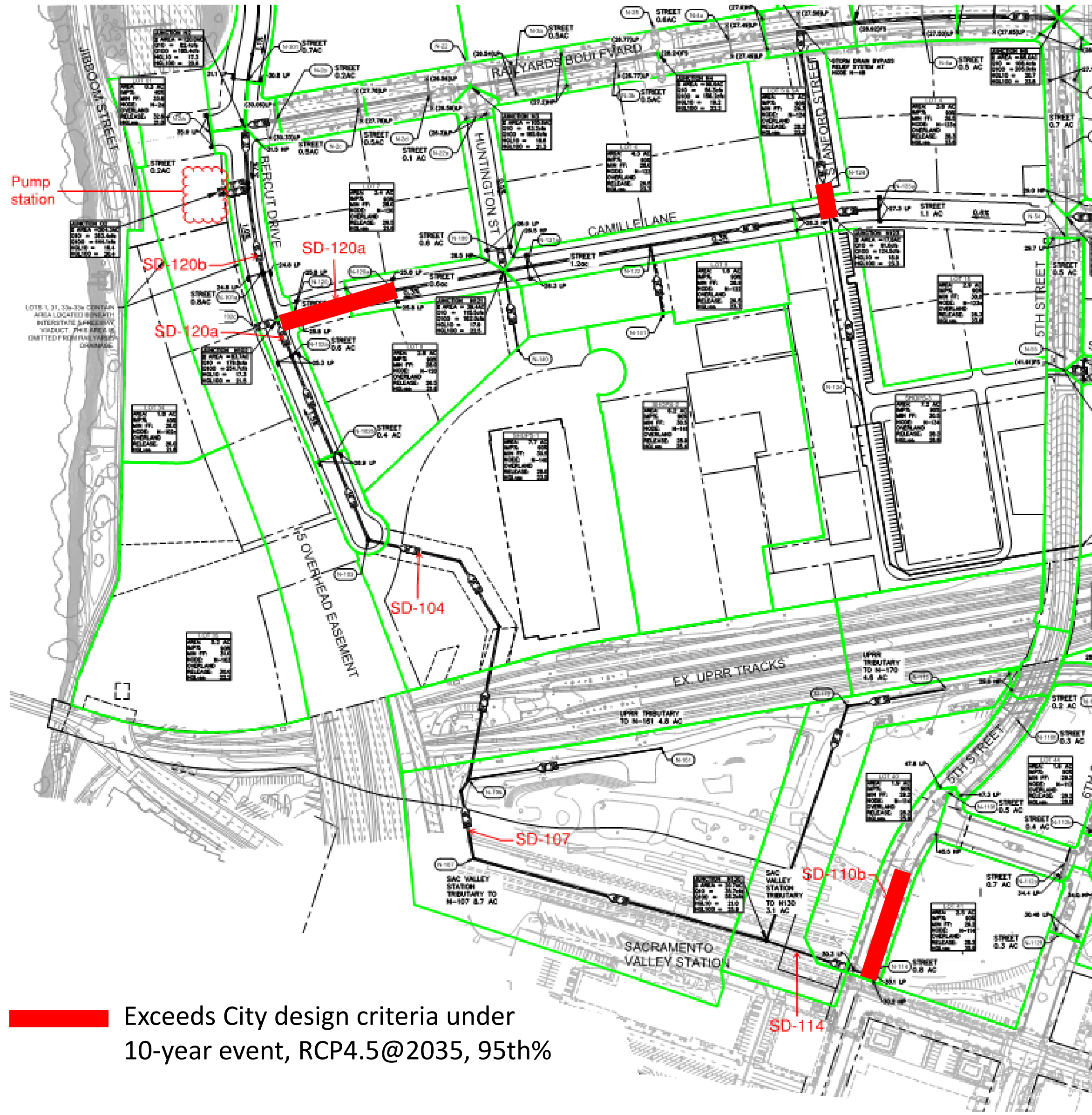
WEATHERSHIFT PRELIMINARY CAPACITY ASSESSMENT

RCP4.5 @ Year 2035

10-year Pump Station Inflow (cfs)	
Existing	276
RCP4.5 50th%	288
ΔQ	12
% Increase	4%
RCP4.5 95th%	366
ΔQ	90
% Increase	33%
100-year Pump Station Inflow (cfs)	
Existing	431
RCP4.5 50th%	452
ΔQ	21
% Increase	5%
RCP4.5 95th%	533
ΔQ	102
% Increase	24%

RCP8.5 @ Year 2090

10-year Pump Station Inflow (cfs)	
Existing	276
RCP8.5 50th%	353
ΔQ	77
% Increase	28%
RCP8.5 95th%	412
ΔQ	136
% Increase	49%
100-year Pump Station Inflow (cfs)	
Existing	431
RCP8.5 50th%	507
ΔQ	76
% Increase	18%
RCP8.5 95th%	575
ΔQ	144
% Increase	33%



Exceeds City design criteria under 10-year event, RCP4.5@2035, 95th%

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Sacramento Valley Station: District Energy Update

Arup
March 5, 2020

ARUP

Table of Contents

Summary of Findings

ARUP

Scenarios Evaluated

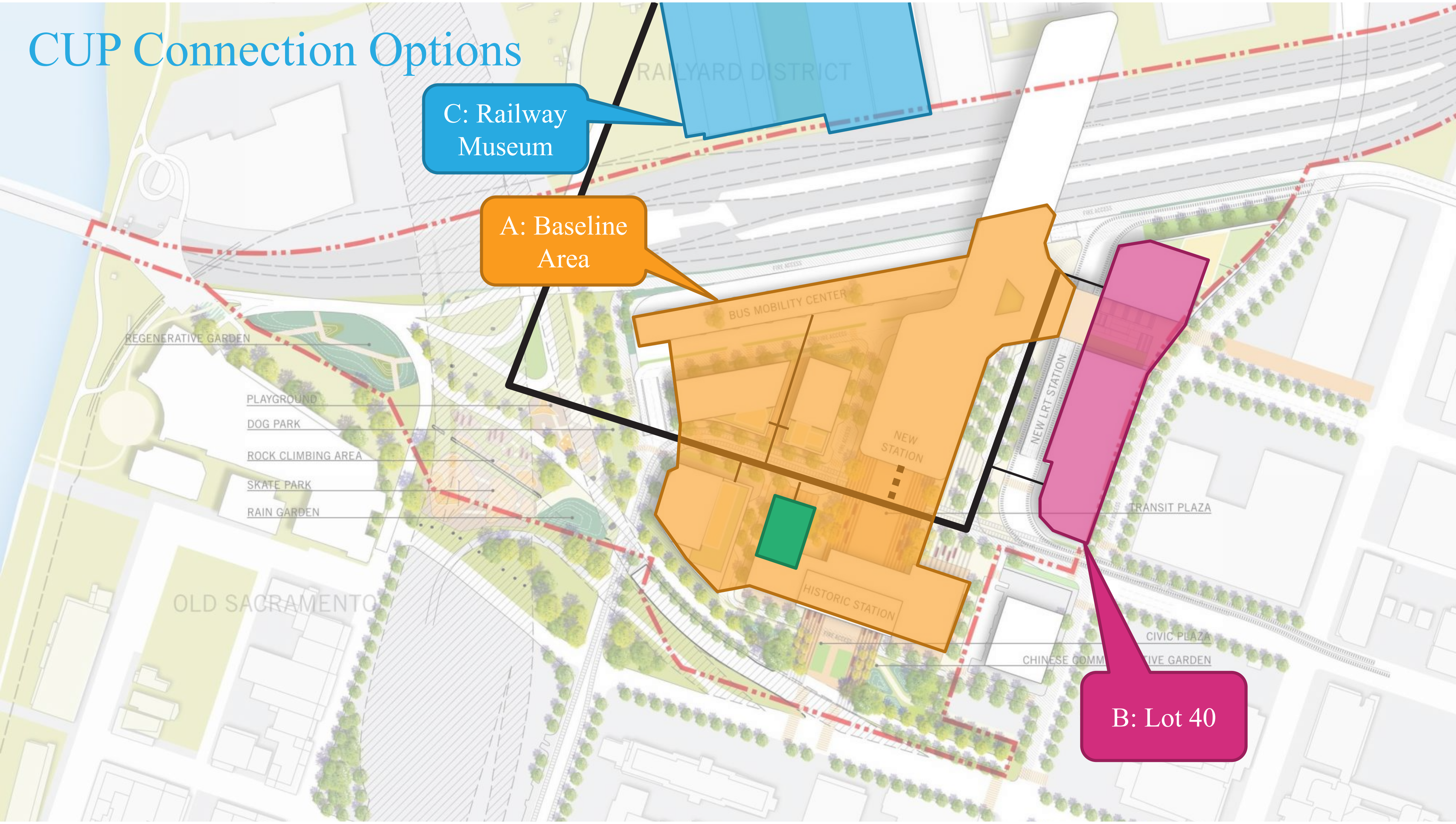
Prior Studies

	A: Base Area	B: Base + Lot 40	C: Base + Railway Museum
0: Business as Usual (Building by Building Systems	0A	0B	0C
1: All-Electric Baseline CUP: Chillers + Cooling Towers, and Air Source Heat Pumps	1A	1B	1C
2: All-Electric CUP + GSHP (Still includes Chillers + Cooling Towers, Air Source Heat Pumps)	*2A*	*2B*	*2C*
3: All-Electric CUP + Sewer Heat Recovery (Still includes Chillers + Cooling Towers, Air Source Heat Pumps)	*3A*	*3B*	*3C*
4: All-Electric CUP + GSHP + Sewer Heat Recovery (iCUP) *(Still includes Chillers + Cooling Towers, Air Source Heat Pumps)*	4A	4B	4C

Not Included in these Results

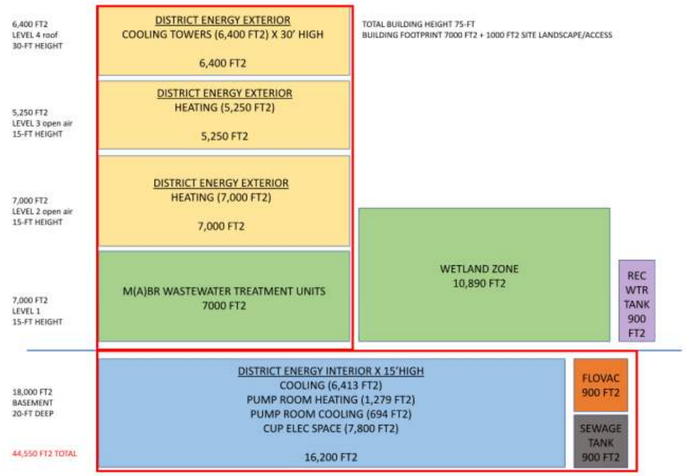
ARUP

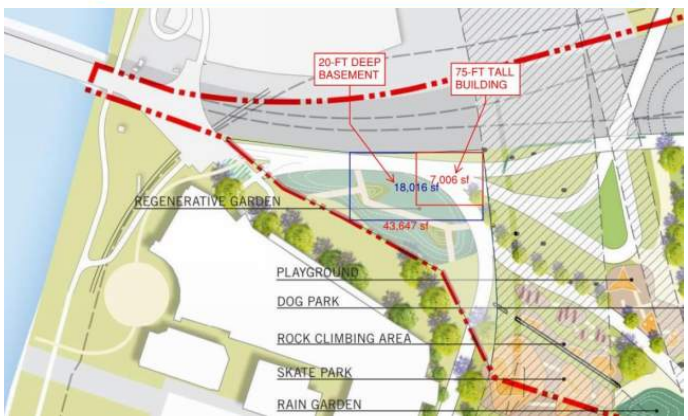
CUP Connection Options



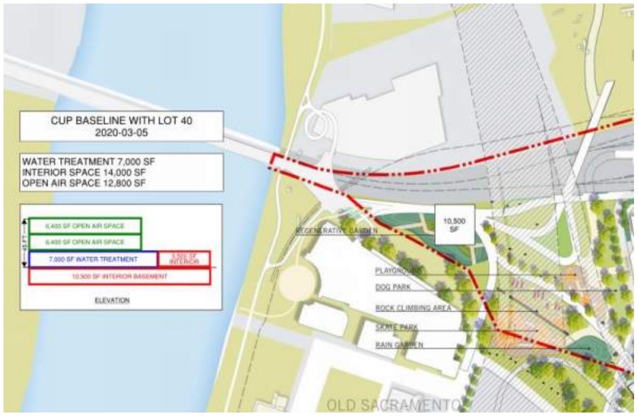
Space Findings

Prior Space Requirement

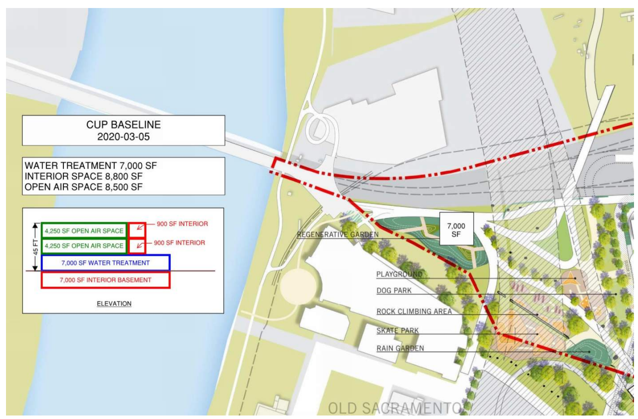




Updated with Lot 40



Updated without Lot 40

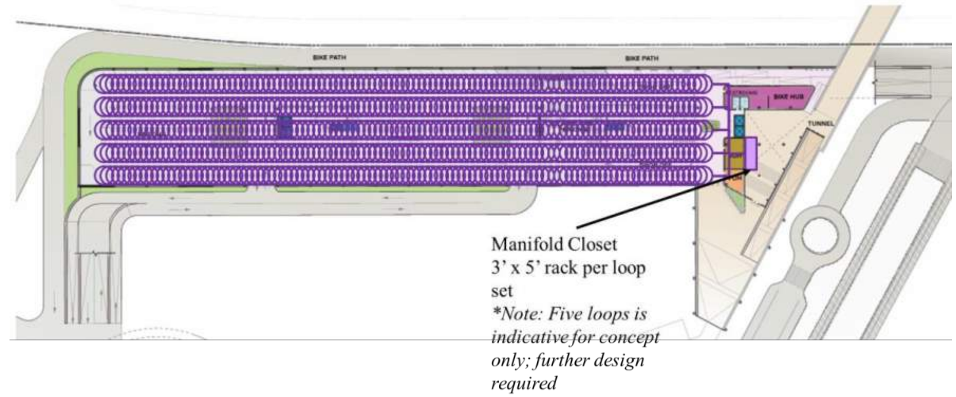


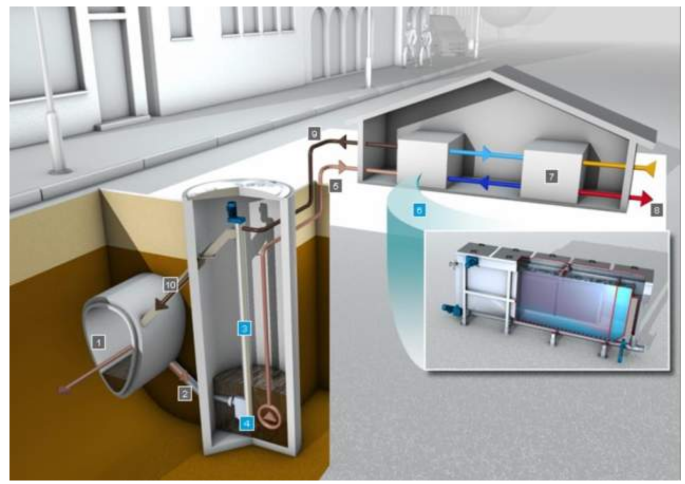
- Refined calculation reduced space with Lot 40
- Adding GSHP and SHR reduces space further, particularly for above ground equipment
- Railway Museum may require slightly increase required footprint depending on load (currently estimated)

ARUP

Ground Source Heat Pump + Sewer Heat Recovery

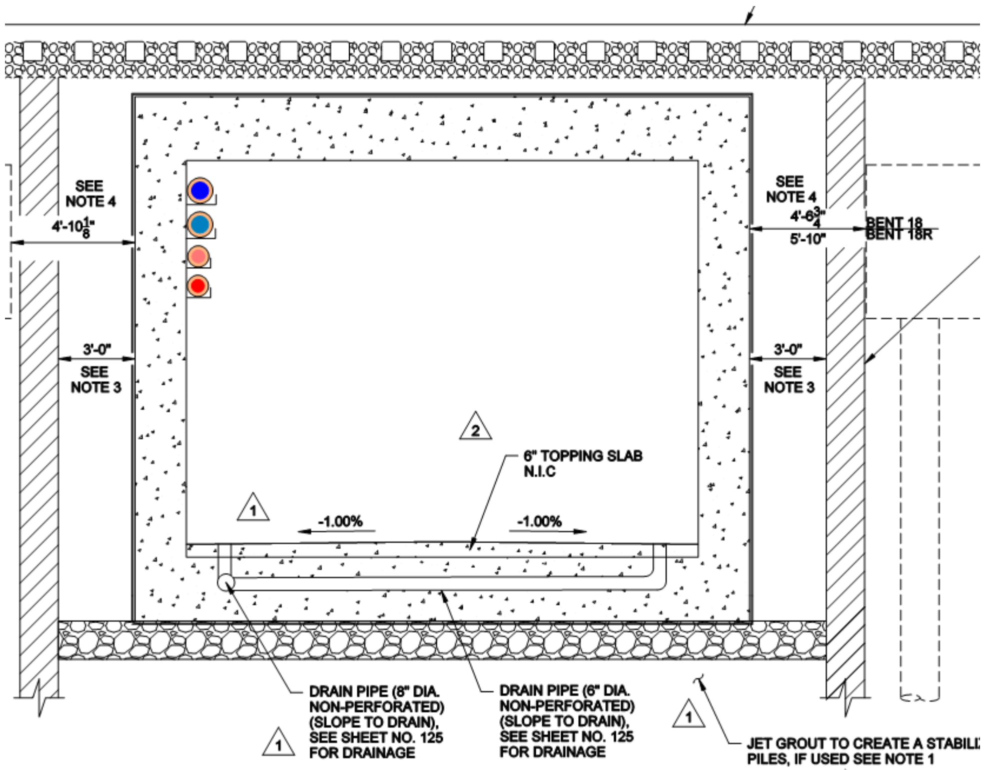
- GSHP provides water savings and reduces open air area at CUP
- SHR only impactful if connecting to Bercut sewer
  - On-site flows achieve 4% of heating
  - Bercut achieves up to 40%
- Combined solution has some risk in permitting
  - Ground source more proven
  - Sewer heat recovery likely requires approval and coordination with public works





ARUP

Railway Museum Connection



- Load not definitively known
- Estimates of load indicate up to 8" chilled water and 6" heating hot water pipes may be required
  - Likely smaller
- Marginally increases installed capacity requirement, might be achievable in same CUP area
- Increases utilization of GSHP, reducing energy use of system per SF

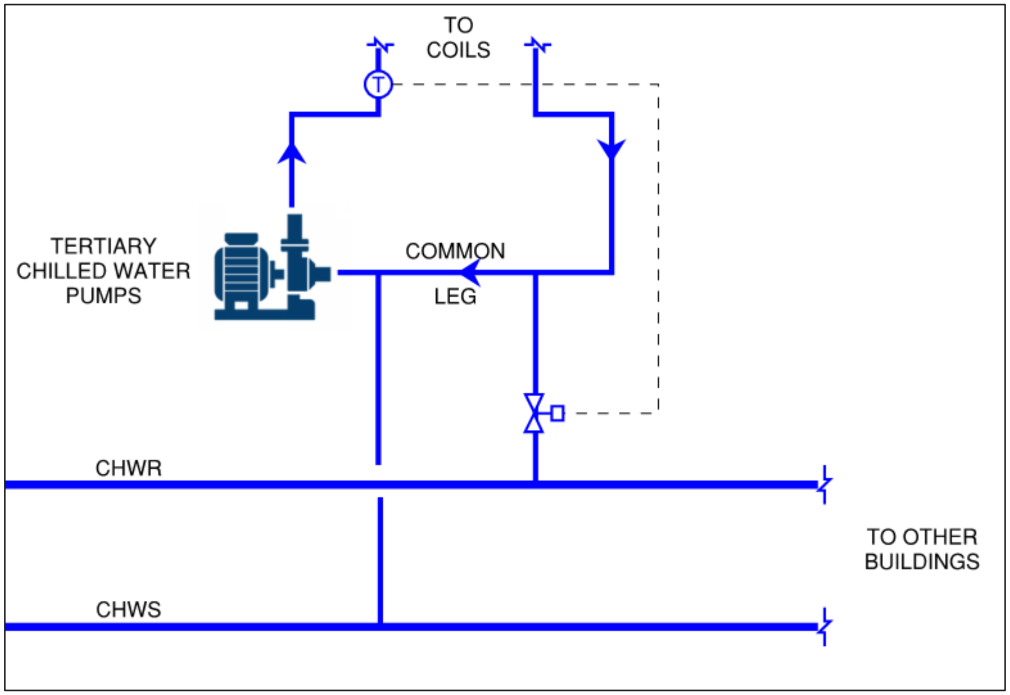
ARUP

Connecting Lot 40

- Bring utilities to vault 5’ outside building floor plate, valve and cap in vault

- Connect into building at time of construction via either:
  - Heat exchangers at building (adds some loss to system)
  - Tertiary pumps with bypass

- Header pipe requires upsizing; can likely be achieved without performance impact to SVS, and minimal cost (i.e., 10” CHW to 12” CHW, with slight increase in flow rate)



ARUP

Options Summary: Installed Capacity

	A: Base Area	B: Base + Lot 40	C: Base + Railway Museum
0: Business as Usual (Building by Building Systems	Heating: 13.0 Cooling: 14 .0	Heating: 23.0 Cooling: 32.0	Heating: 13.8 Cooling: 16.5
1: All-Electric Baseline CUP: Chillers, Towers, and Air Source Heat Pumps	Heating: 11.0 Cooling: 12.4	Heating: 16.8 Cooling: 23.5	Heating: 11.5 Cooling: 13.7
4: All-Electric CUP + GSHP + Sewer Heat Recovery (iCUP) *(Still includes Chillers, Towers, Air Source Heat Pumps)*	Heating: 12.3 Cooling: 12.1	Heating: 16.6 Cooling: 23.5	Heating: 12.1 Cooling: 13.7

ARUP

Options Summary: Energy Use

	A: Base Area	B: Base + Lot 40	C: Base + Railway Museum
0: Business as Usual (Building by Building Systems	1.60 GWh	3.11 GWh	1.81 GWh
1: All-Electric Baseline CUP: Chillers, Towers, and Air Source Heat Pumps	0.98 GWh *(39% reduction)*	1.90 GWh *(39%)*	1.1GWh *(39%)*
4: All-Electric CUP + GSHP + Sewer Heat Recovery (iCUP) *(Still includes Chillers, Towers, Air Source Heat Pumps)*	0.85 GWh *(48% reduction)*	1.65 GWh *(47%)*	0.96 GWh *(47%)*

ARUP

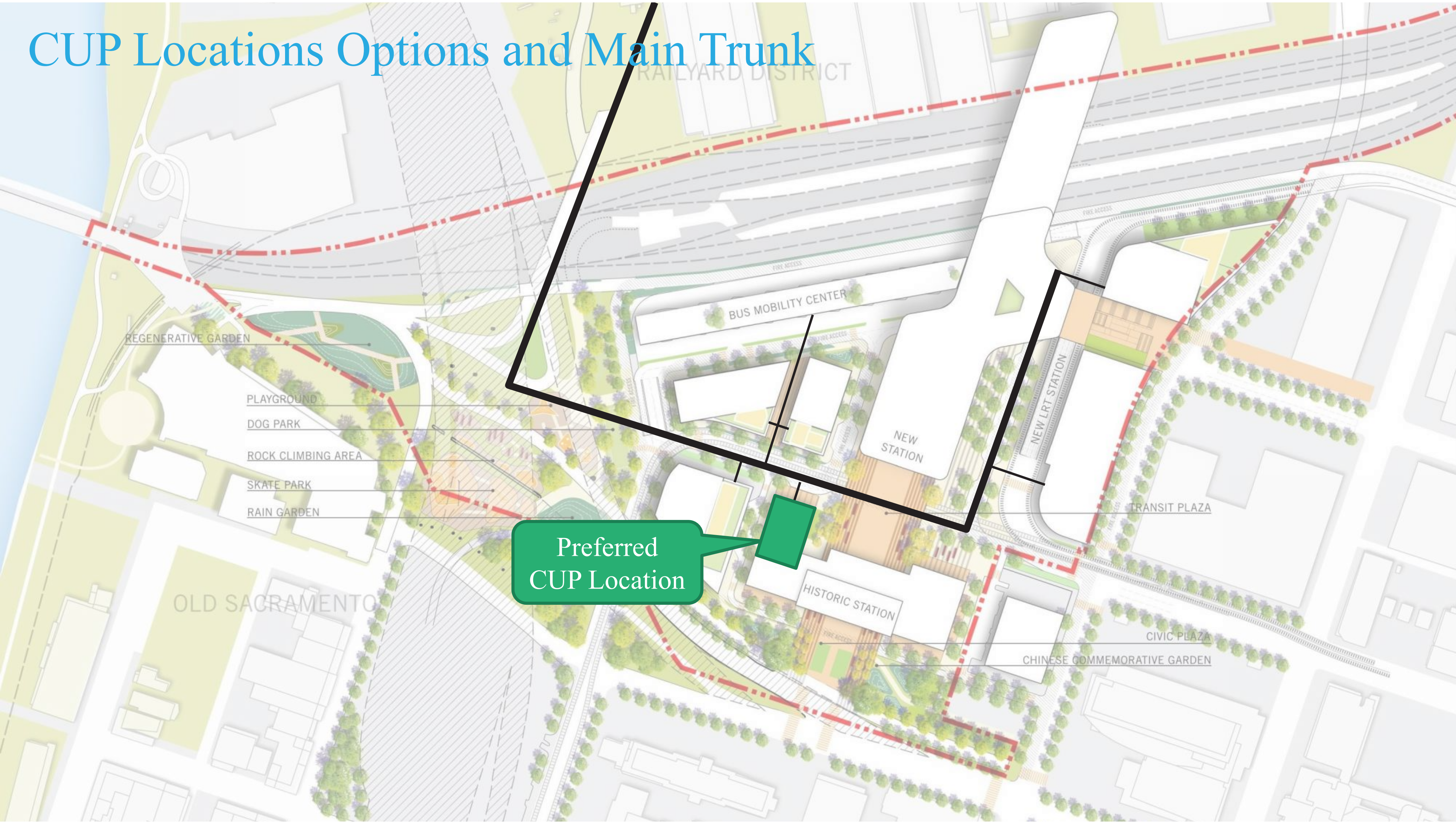
Options Summary: Space Required

	A: Base Area	B: Base + Lot 40	C: Base + Railway Museum
0: Business as Usual (Building by Building Systems	Interior: 13.1K SF Roof: 12.7K SF	Interior: 22.3K SF Roof: 21.7K SF	Interior: 14.8K SF Roof: 14.4K SF
1: All-Electric Baseline CUP: Chillers, Towers, and Air Source Heat Pumps	Interior: 8.8K SF Roof: 8.5K SF	Interior: 14.0K SF Roof: 12.8K SF	Interior: 9.2K SF Roof: 8.5K SF
4: All-Electric CUP + GSHP + Sewer Heat Recovery (iCUP) *(Still includes Chillers, Towers, Air Source Heat Pumps)*	Interior: 10.5K SF Roof: 4.0 SF	Interior: 14.6K SF Roof: 7.4K SF	Interior: 10.8K SF Roof: 4.0K SF

ARUP

Site Map and Technology Options

CUP Locations Options and Main Trunk



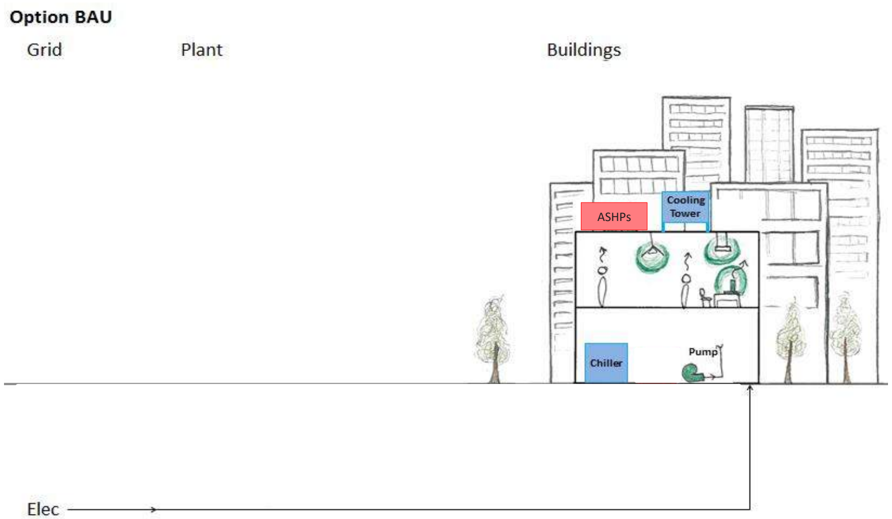
Location Alternates and Considerations/Constraints

- Location near the bus station reduces piping connection + pumping energy to proposed ground loops below bus station
- Location near residential, hotel buildings reduces piping connection + pumping energy to serve load
- Thermal CUP requires interior space and rooftop/open to air space; can be directly stacked or separated with other uses in between
- Underutilized space in station or residential/hotel blocks may be viable locations

ARUP

Scenarios Evaluated

	A: Base Area
0: Business as Usual (Building by Building Systems	0A
1: All-Electric Baseline CUP: Chillers, Towers, and Air Source Heat Pumps	1A
2: All-Electric CUP + GSHP *(Still includes Chillers, Towers, Air Source Heat Pumps)*	2A
3: All-Electric CUP + Sewer Heat Recovery *(Still includes Chillers, Towers, Air Source Heat Pumps)*	3A
4: All-Electric CUP + GSHP + Sewer Heat Recovery *(Still includes Chillers, Towers, Air Source Heat Pumps)*	4A



ARUP

Technology Systems

	A: Base Area
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1: All-Electric Baseline CUP: Chillers, Towers, and Air Source Heat Pumps	1A
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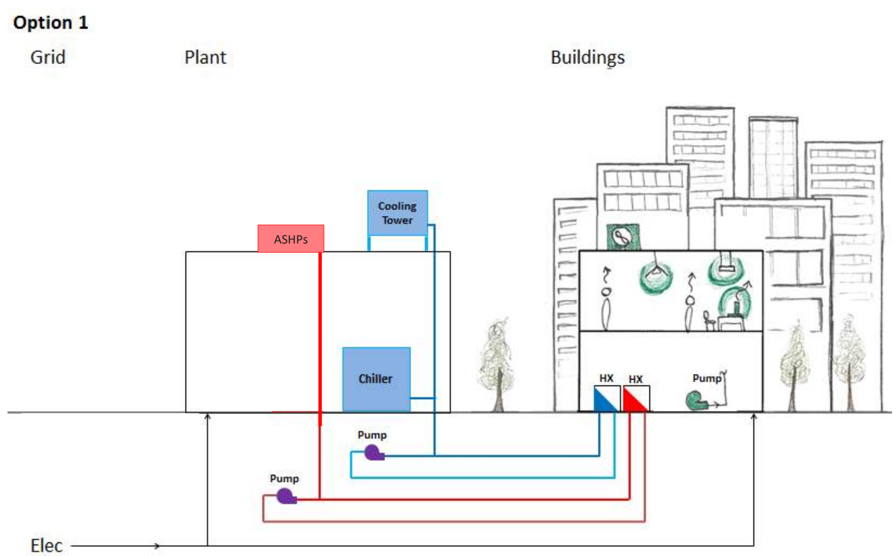

ARUP

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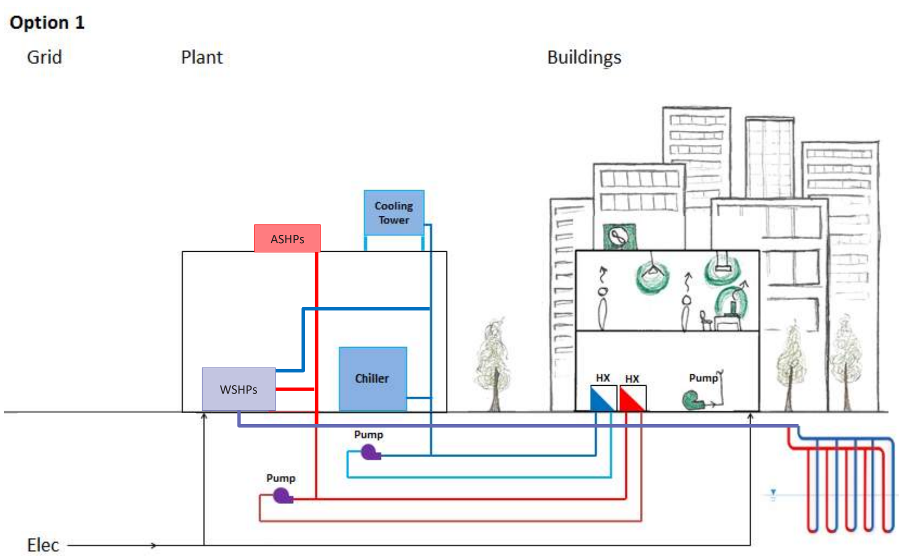
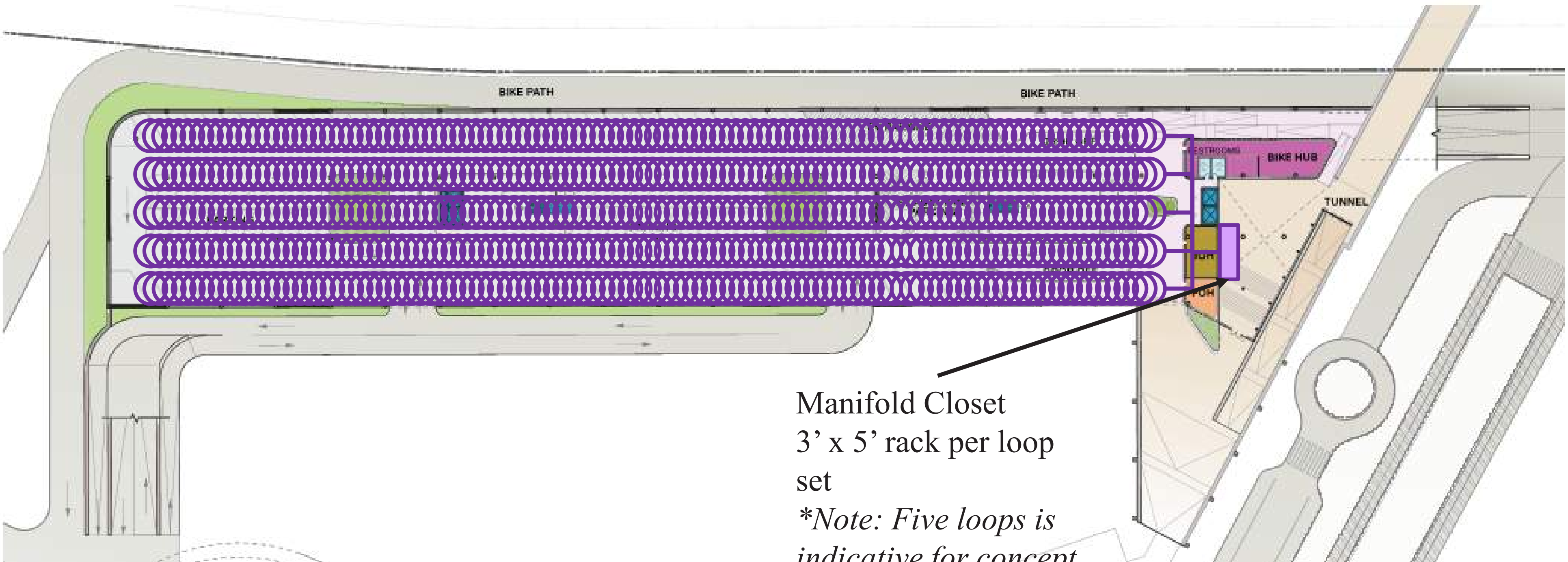


ARUP

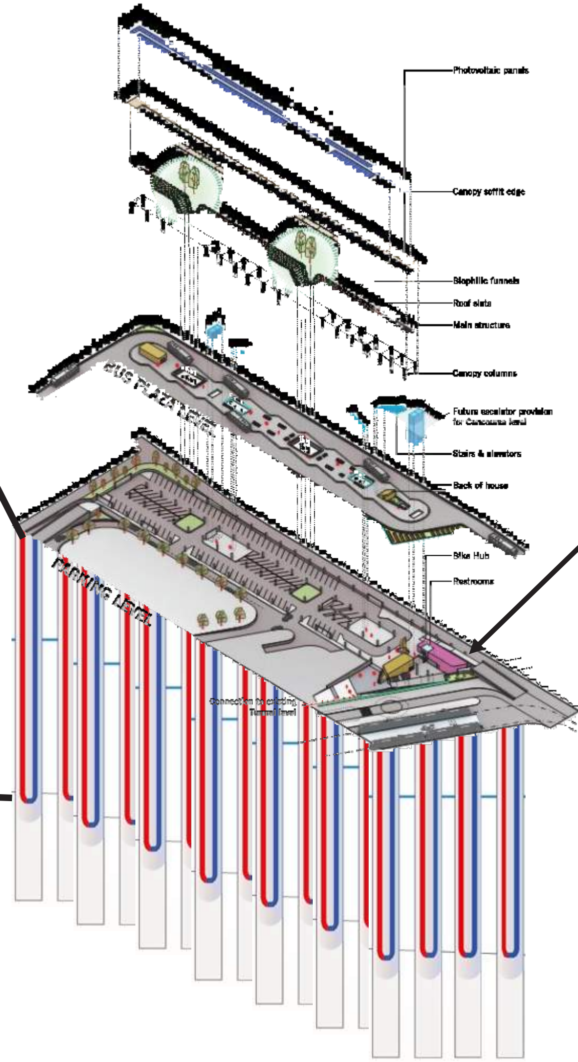
Bus Facility Ground Source



Manifold Closet
3' x 5' rack per loop set
**Note: Five loops is indicative for concept only; further design required*

ARUP

Bus Facility Energy Piles



Similar manifold space required in station (3’ x 5’ rack per zone, likely 2-4 zones)

65’ deep piles with 2-4 pipes per pile

ARUP

Technology Systems

	A: Base Area
0: Business as Usual (Building by Building Systems	0A
1: All-Electric Baseline CUP: Chillers, Towers, and Air Source Heat Pumps	1A
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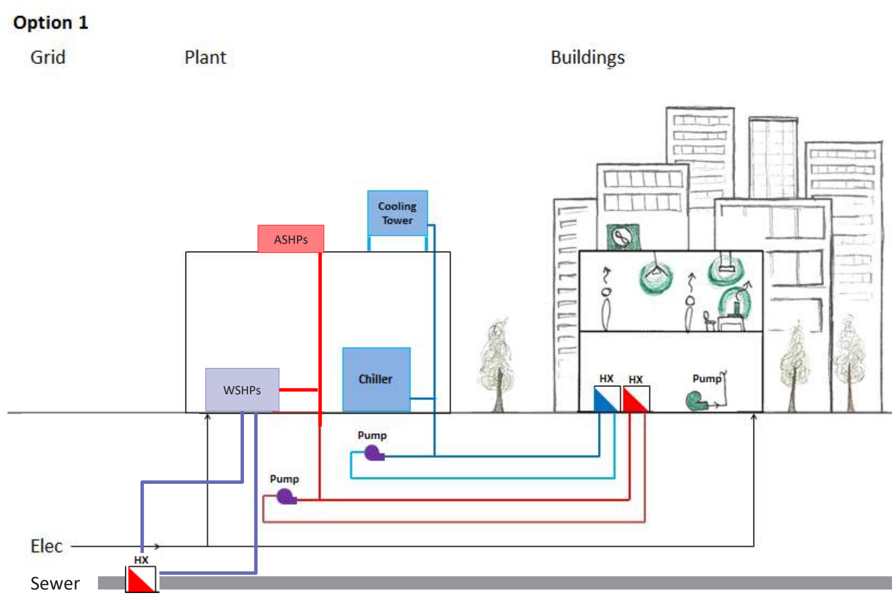


ARUP

On-Site Sewer Heat Recovery

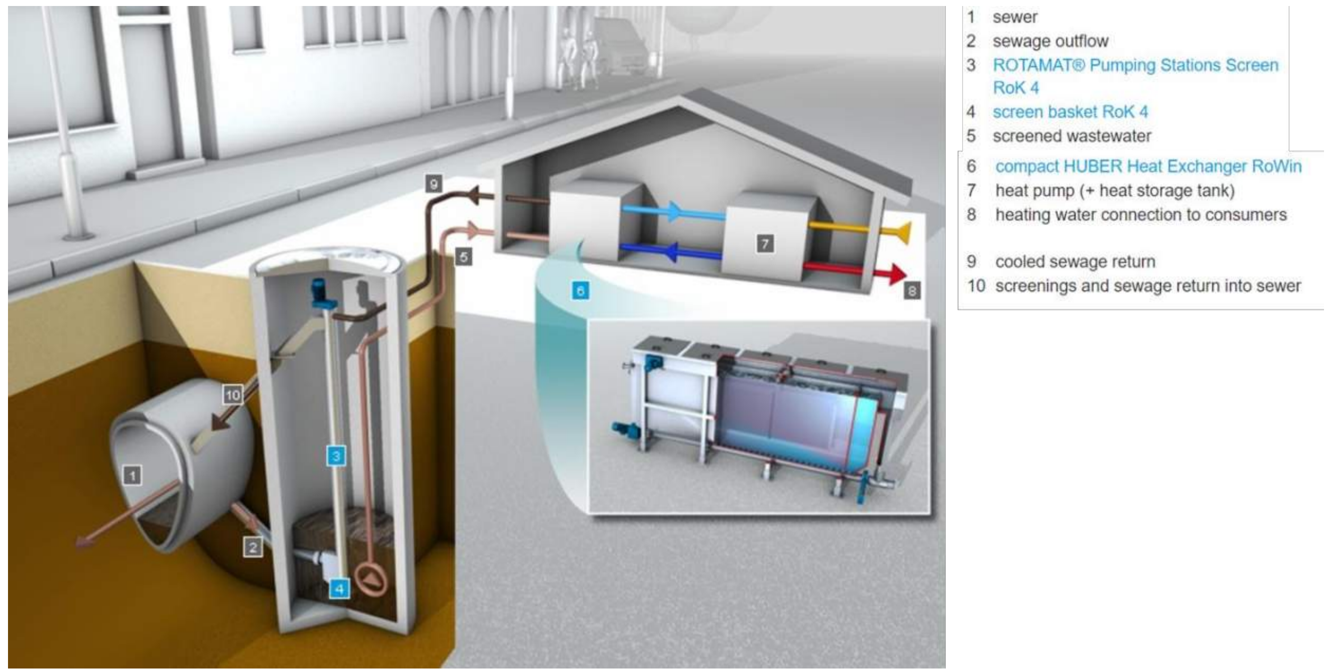
- Total flow available from on-site wastewater recovery: 100,000 gpd
- Heat recovery can be added to treatment train to absorb heat from effluent
    - Possibly can also reject heat; requires further study and not considered as peak capacity
- Assuming flow is continuous, can be counted as peak capacity
- Lower limit of heat absorption defined by fat/oil/grease solidification

Example Product: Huber Technologies (HUBER Heat Exchanger RoWin)

ARUP

Bercut Sewer Heat Recovery

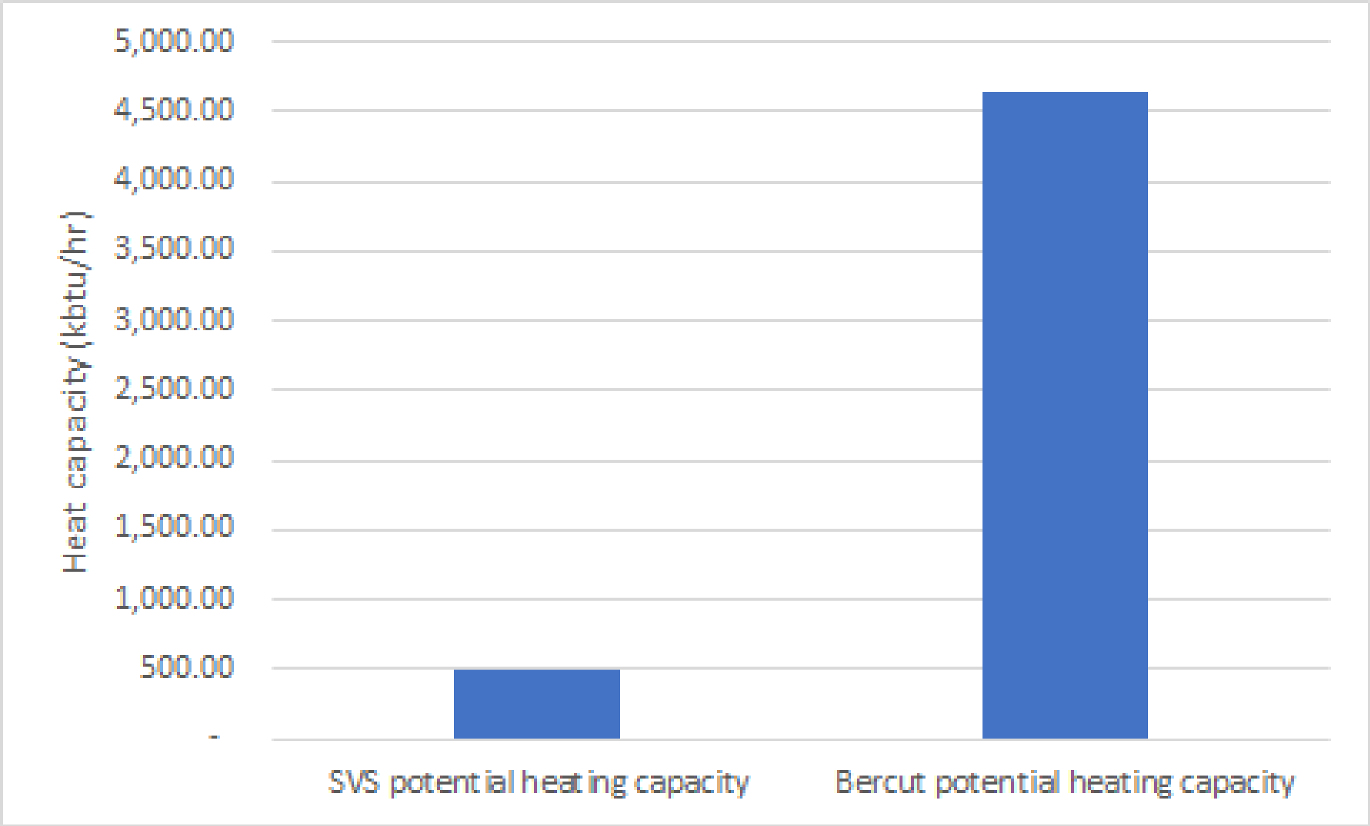
- Total flow available from on-site wastewater recovery: 2,500,000 gpd
- Heat extracted from warm wastewater in sewer and transferred to heating network via heat pump and heat exchanger
- Assuming flow is continuous, can be counted as peak capacity
- Lower limit of heat absorption defined by fat/oil/grease solidification (~10 °C)
- Existing Examples: False Creek, Vancouver, and Wintower in Winterhur, Switzerland



Example Product: Huber Technologies (HUBER ThermWin)

ARUP

Bercut vs. On-Site Flows



ARUP

Technology Systems

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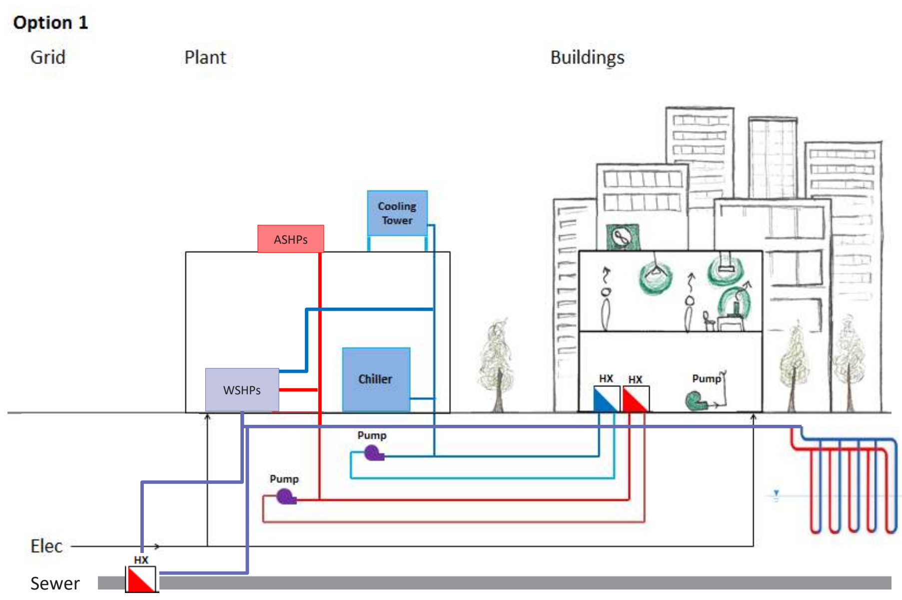
4: All-Electric CUP + GSHP + Sewer Heat Recovery *(Still includes Chillers, Towers, Air Source Heat Pumps)*	4A

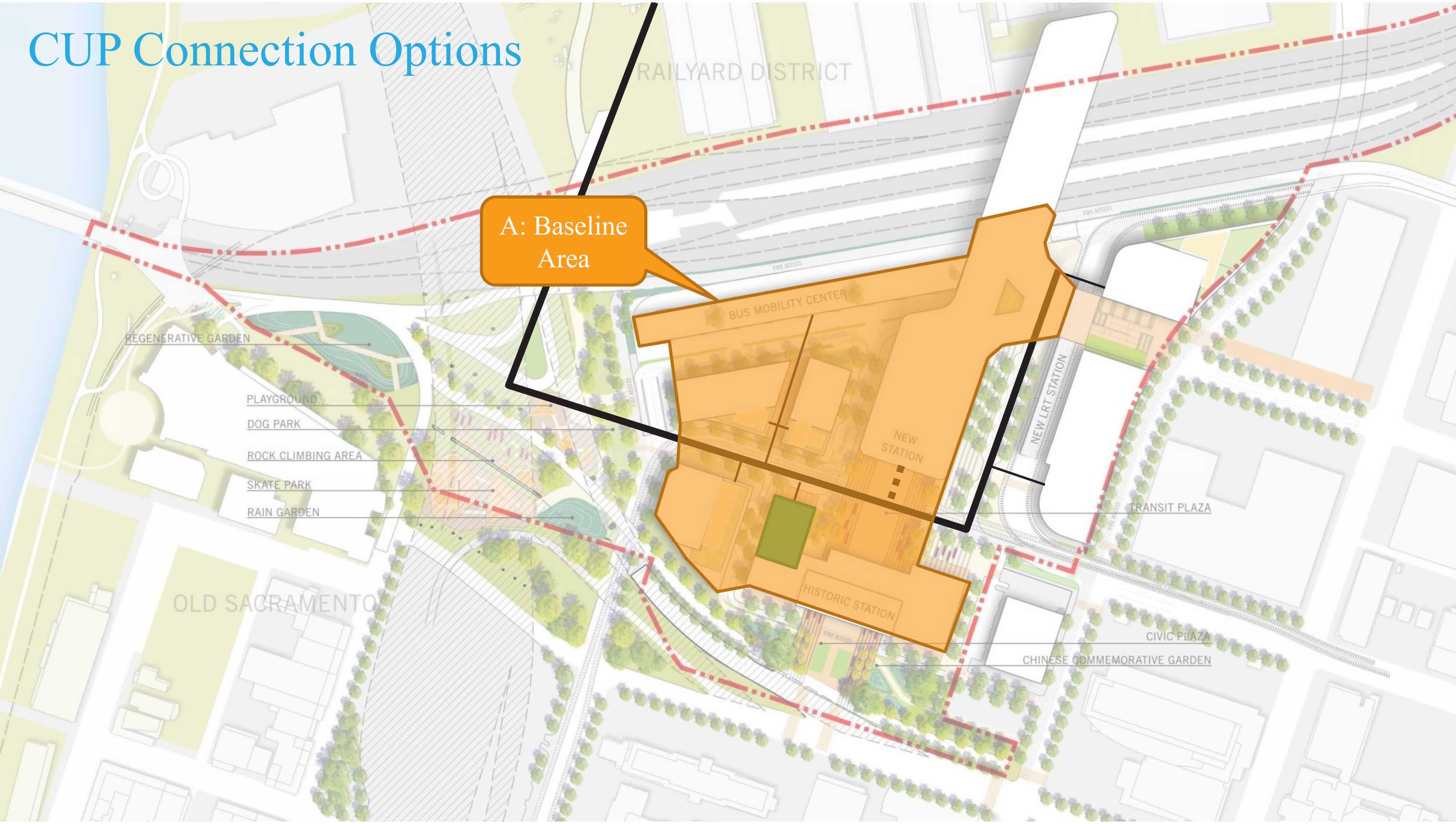


ARUP

A Options: Serving Station + Residential + Hotel

ARUP

CUP Connection Options

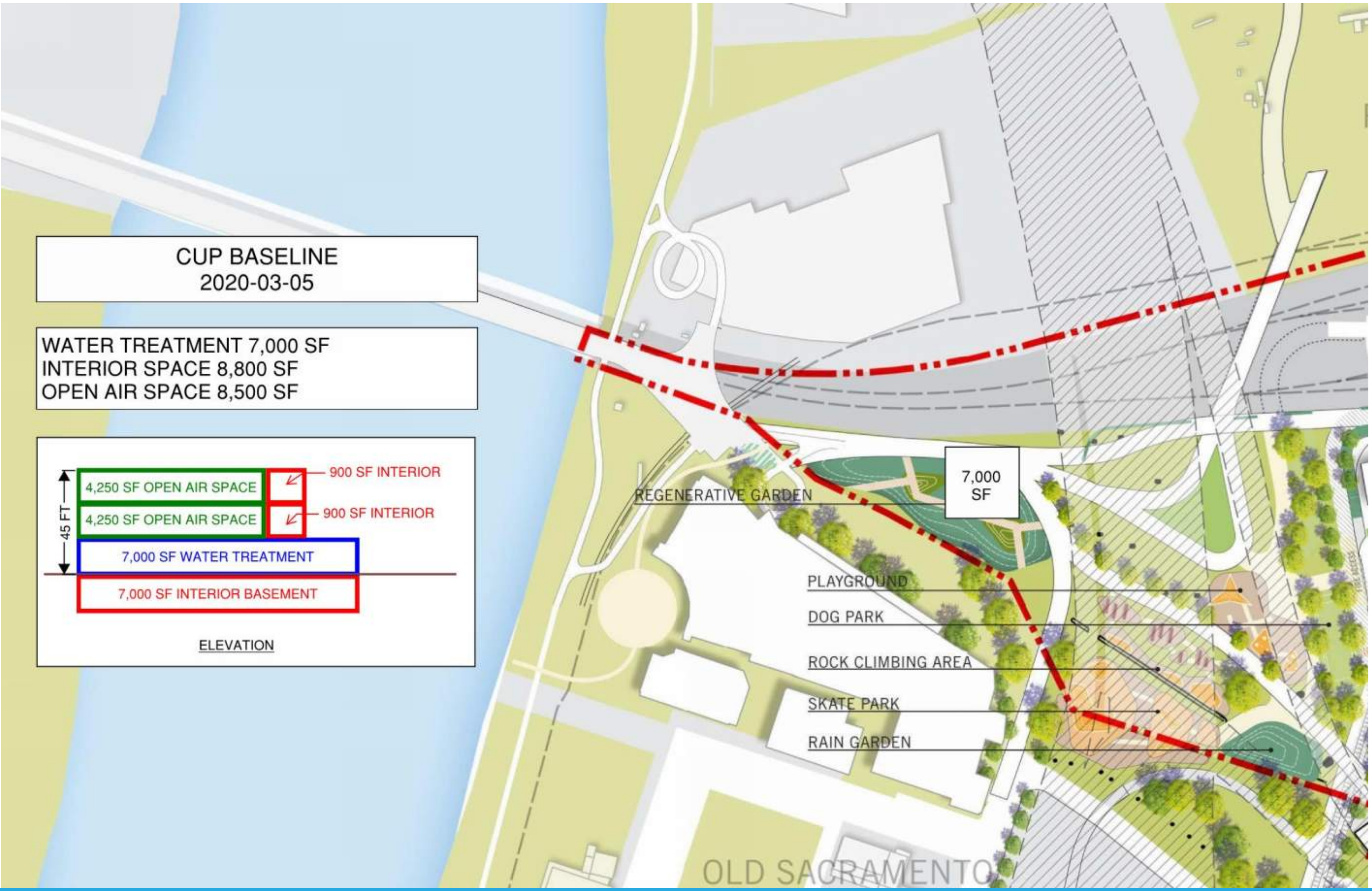


Summary of Findings: Base

	Scenario	Installed Capacity (MMBH)	Energy Use	Space Required
0: Business as Usual (Building by Building Systems	0A	Heating: 13.0 Cooling: 14 .0	1.60 GWh	Interior: 13.1K SF Roof: 12.7K SF
1: All-Electric Baseline CUP: Chillers, Towers, and Air Source Heat Pumps	1A	Heating: 11.0 Cooling: 12.4	0.98 GWh *(39% reduction)*	Interior: 8.8K SF Roof: 8.5K SF
4: All-Electric CUP + GSHP + Sewer Heat Recovery (iCUP) *(Still includes Chillers, Towers, Air Source Heat Pumps)*	4A	Heating: 12.3 Cooling: 12.1	0.85 GWh *(48% reduction)*	Interior: 10.5K SF Roof: 4.0K SF

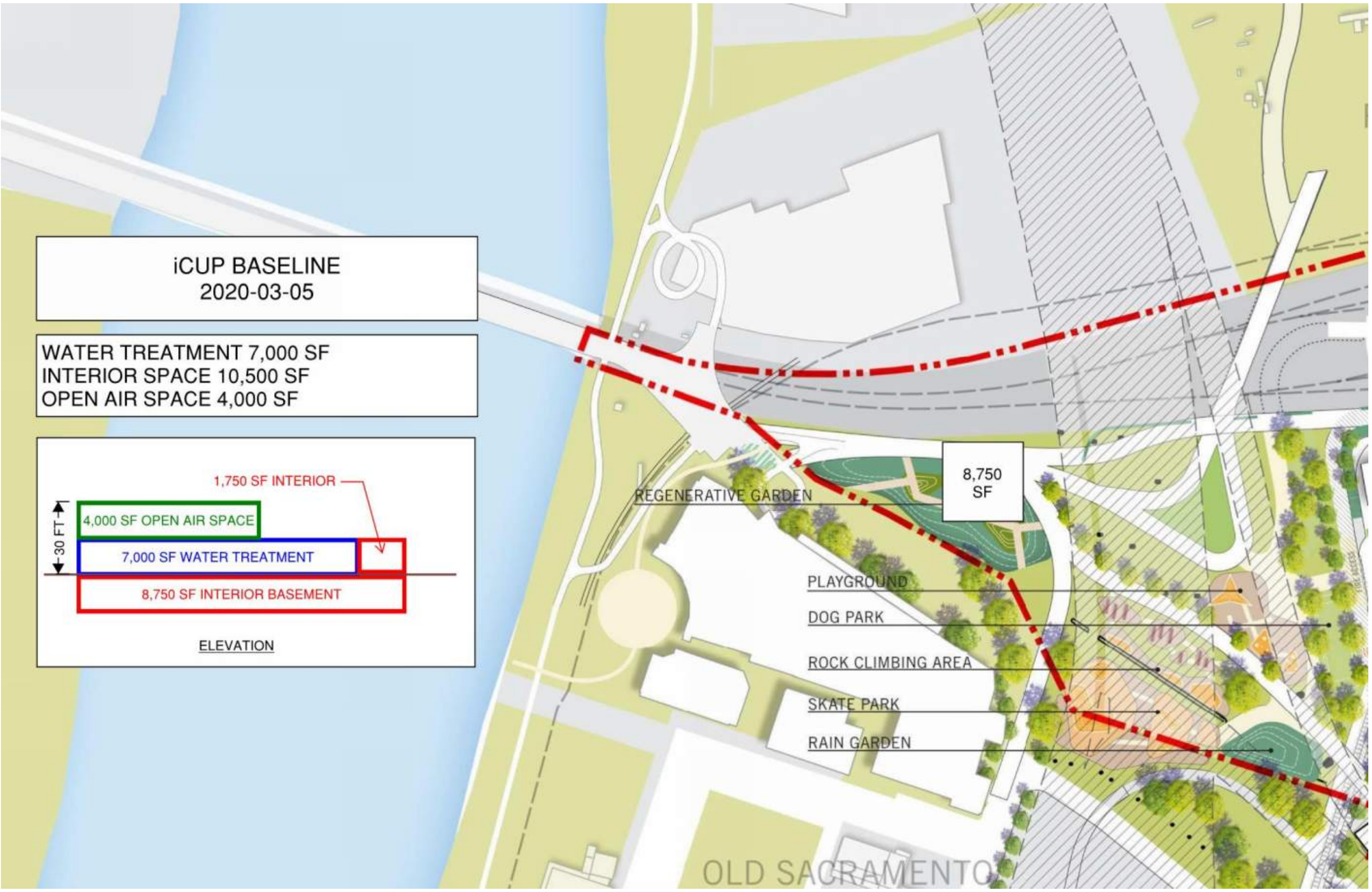
ARUP

Space: Baseline CUP



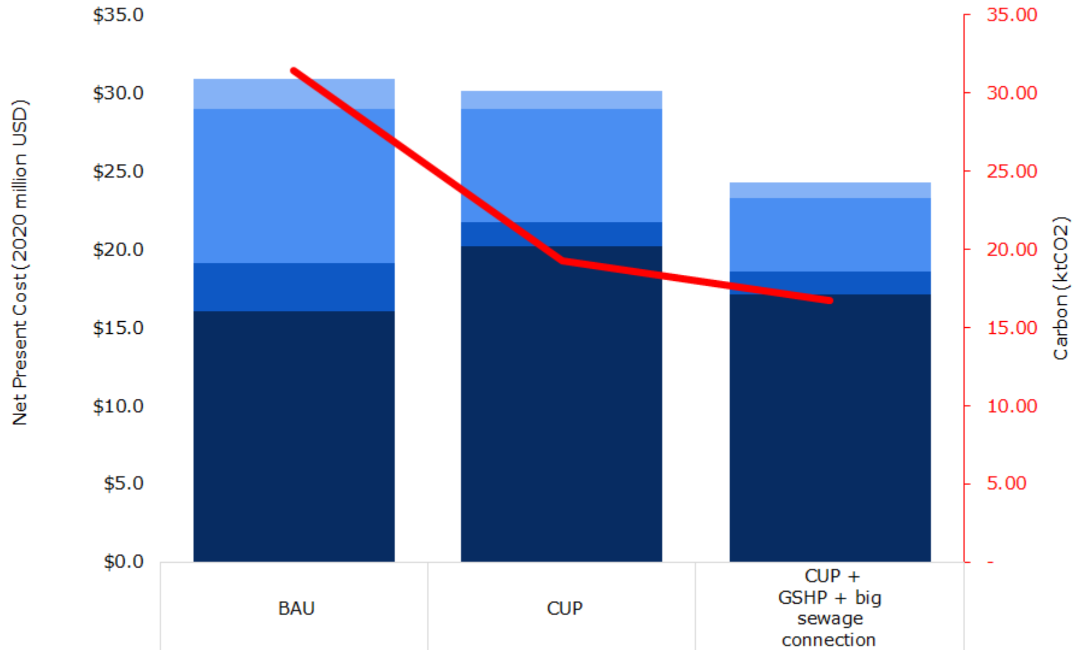
ARUP

Space: Innovative CUP (iCUP: GSHP + SHR)



ARUP

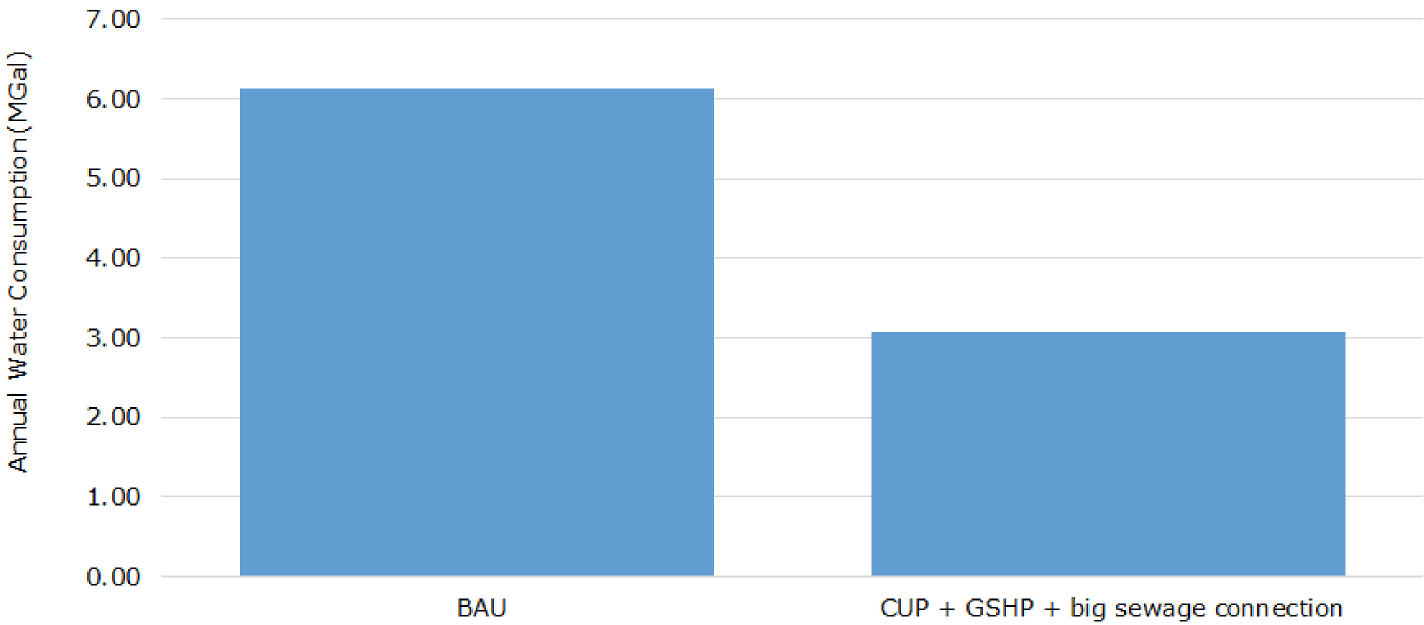
Life Cycle Cost



	BAU	CUP	CUP + GSHP + big sewage connection
Thermal elec fuel cost (NPC 2019 $)	$1.9	$1.1	$1.0
Total thermal operation costs (NPC 2019 $)	$9.9	$7.3	$4.7
Total annualised thermal REPEX (NPC 2019 $)	$3.1	$1.5	$1.5
Total thermal captial costs (NPC 2019 $)	$16.0	$20.2	$17.1
Carbon (ktCO2)	31.44	19.22	16.73

ARUP

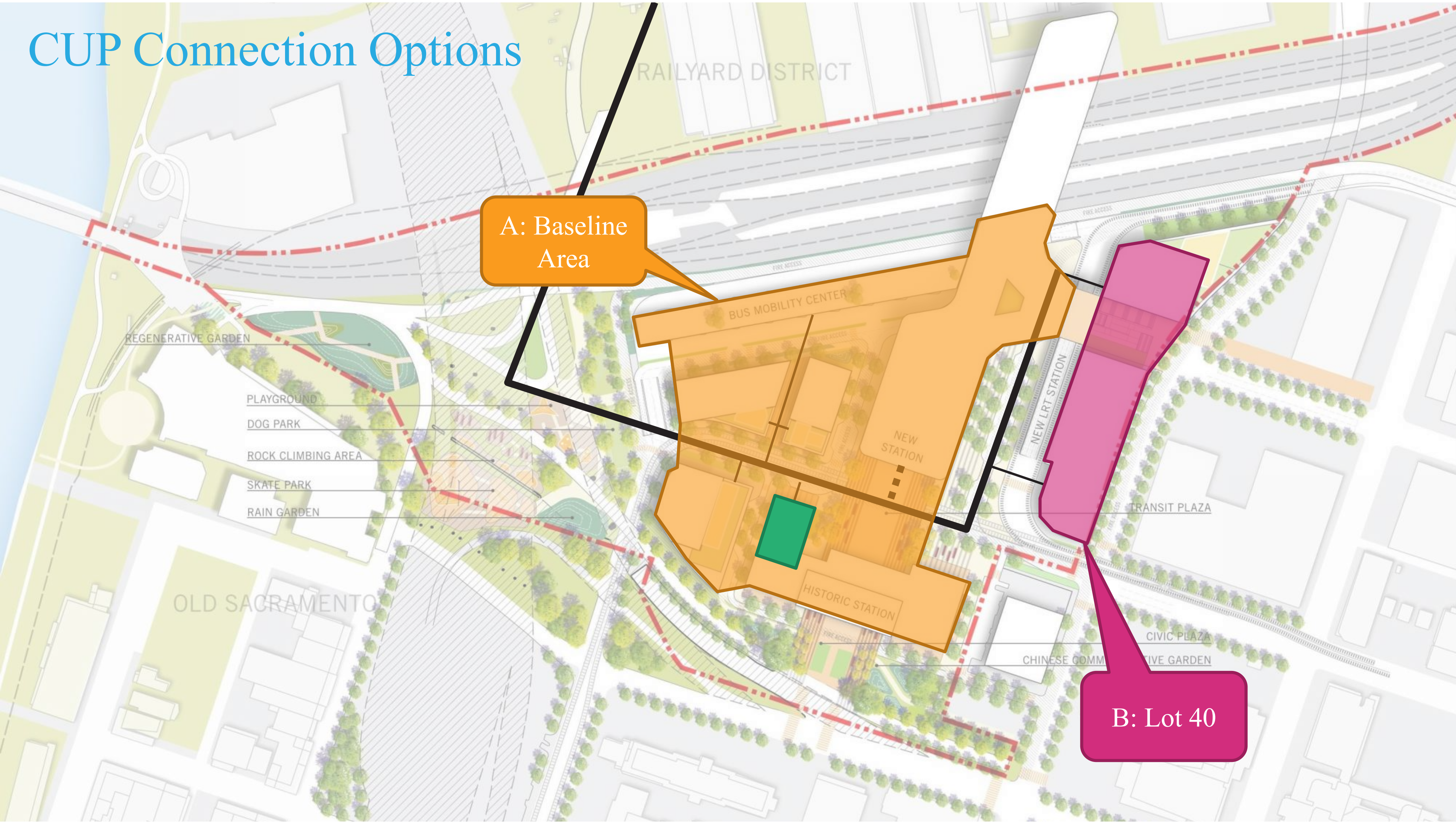
Water Consumption (Thermal Systems Only)



B Options: Including Lot 40

ARUP

CUP Connection Options

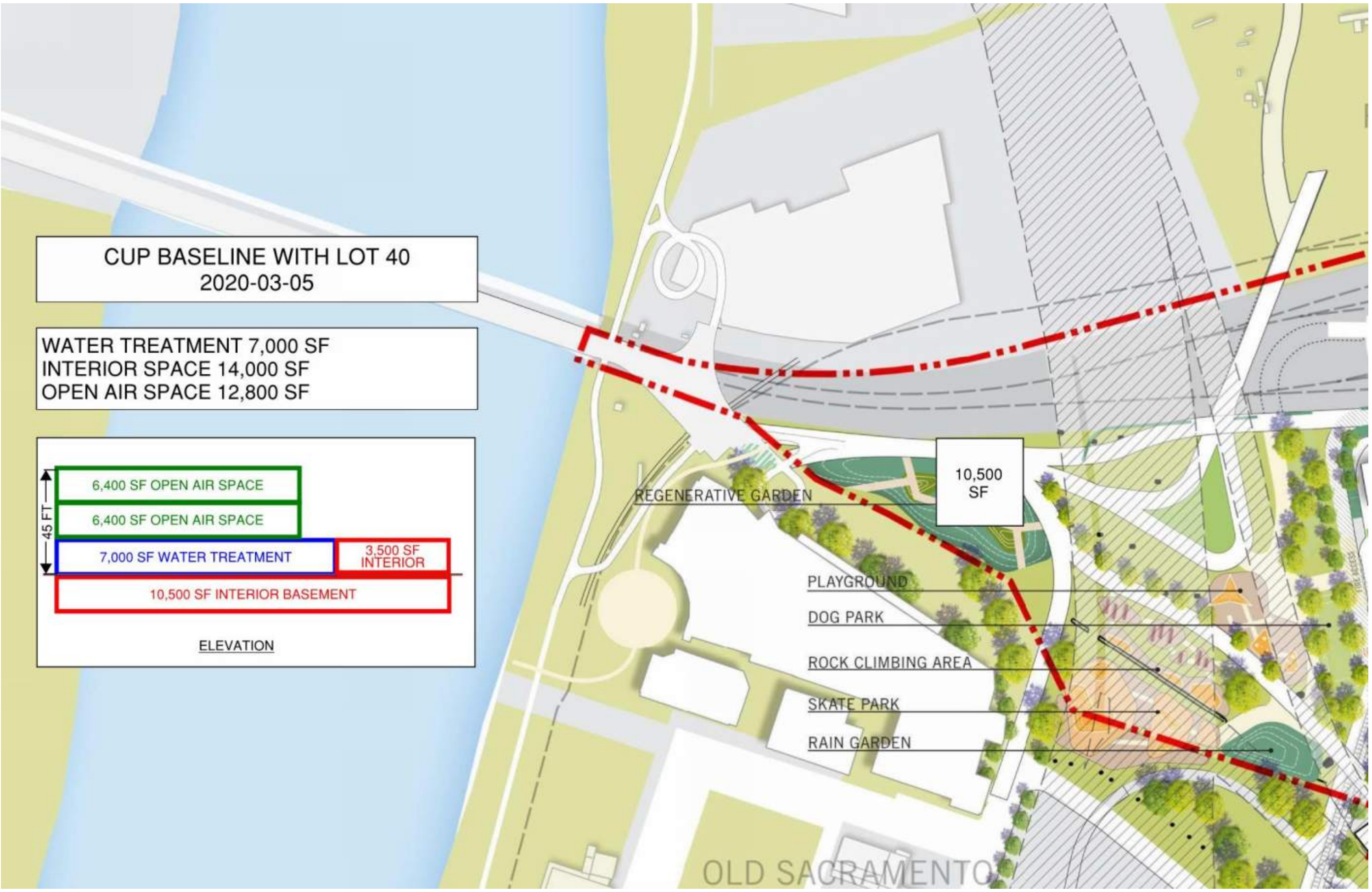


Summary of Findings: Base + Lot 40

	Scenario	Installed Capacity	Energy Use	Space Required
0: Business as Usual (Building by Building Systems	0A	Heating: 23.0 Cooling: 32.0	3.11 GWh	Interior: 22.3K SF Roof: 21.7K SF
1: All-Electric Baseline CUP: Chillers, Towers, and Air Source Heat Pumps	1A	Heating: 16.8 Cooling: 23.5	1.90 GWh *(39%)*	Interior: 14.0K SF Roof: 12.8K SF
4: All-Electric CUP + GSHP + Sewer Heat Recovery (iCUP) *(Still includes Chillers, Towers, Air Source Heat Pumps)*	4A	Heating: 16.6 Cooling: 23.5	1.65 GWh *(47%)*	Interior: 14.6K SF Roof: 7.4K SF

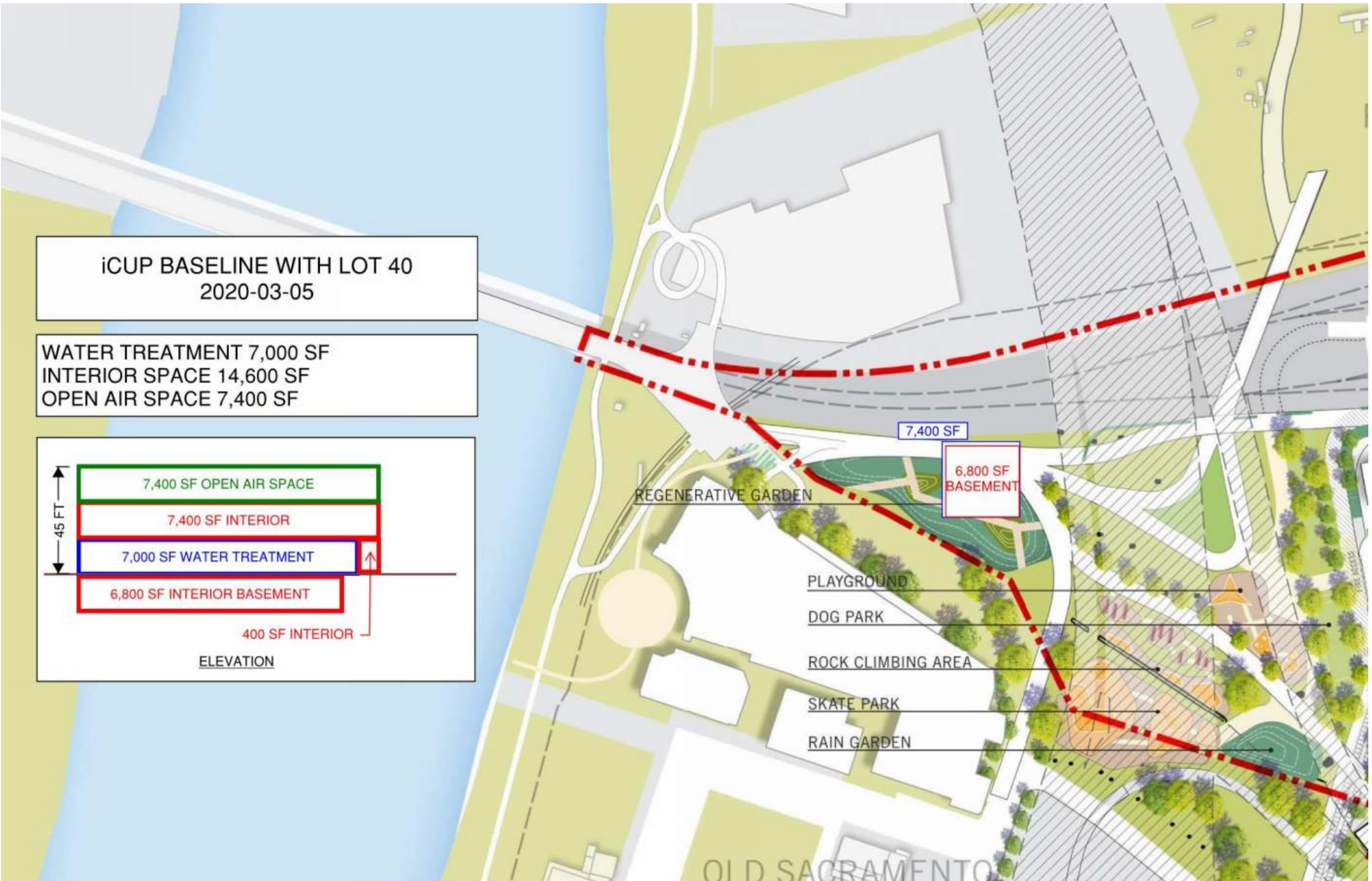
ARUP

Space: Baseline CUP



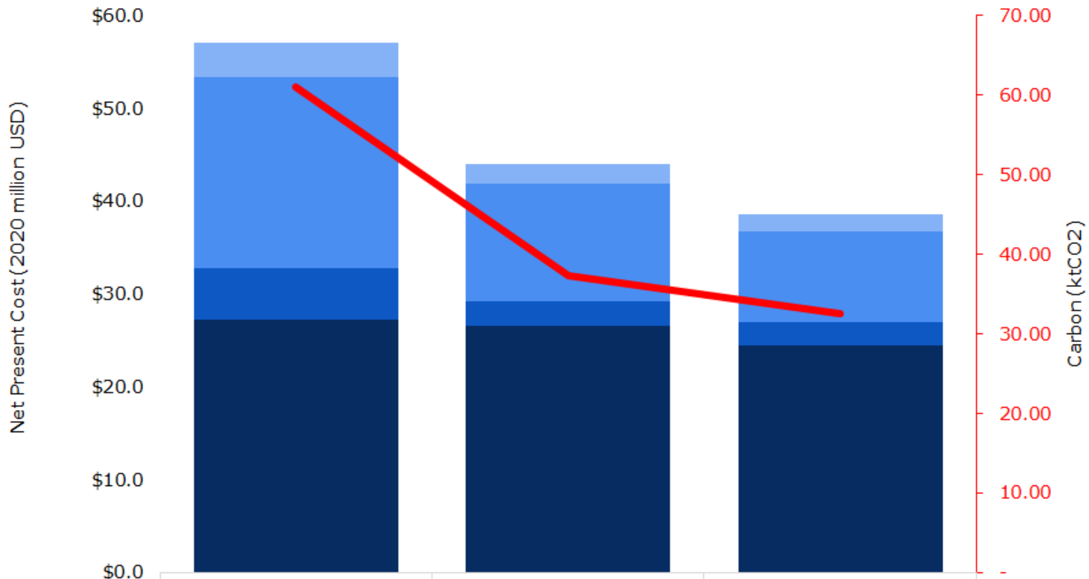
ARUP

Space: Innovative CUP (iCUP: GSHP + SHR)



ARUP

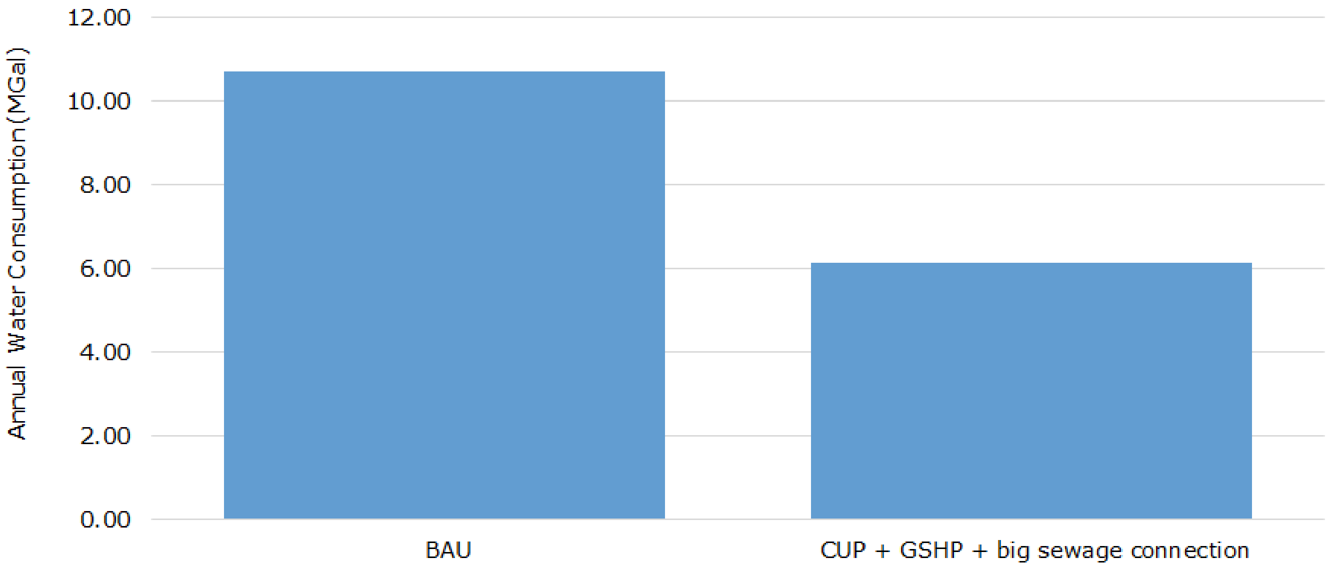
Life Cycle Cost



	BAU	CUP	CUP + GSHP + big sewage connection
Thermal elec fuel cost (NPC 2019 $)	$3.7	$2.1	$1.9
Total thermal operation costs (NPC 2019 $)	$20.6	$12.7	$9.7
Total annualised thermal REPEX (NPC 2019 $)	$5.5	$2.6	$2.6
Total thermal captial costs (NPC 2019 $)	$27.2	$26.6	$24.4
Carbon (ktCO2)	60.98	37.29	32.46

ARUP

Water Consumption (Thermal Systems Only)



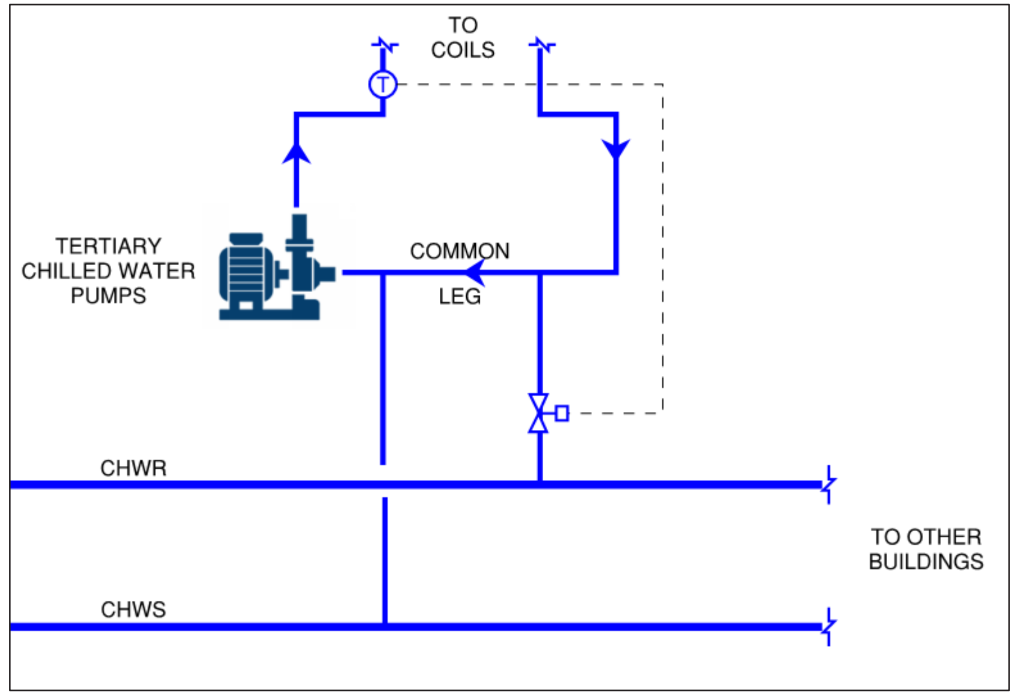
Benefits to SVS of Including Lot 40

- Higher diversity of heating and cooling across uses means greater use of CUP equipment
- Ground source heat pump and sewer heat recovery have better payback with added diversity due to greater annual use and heat recovery
- Operations cost is spread across greater floor area, reducing cost for Sacramento Valley Station operations (non-linear operations cost)

ARUP

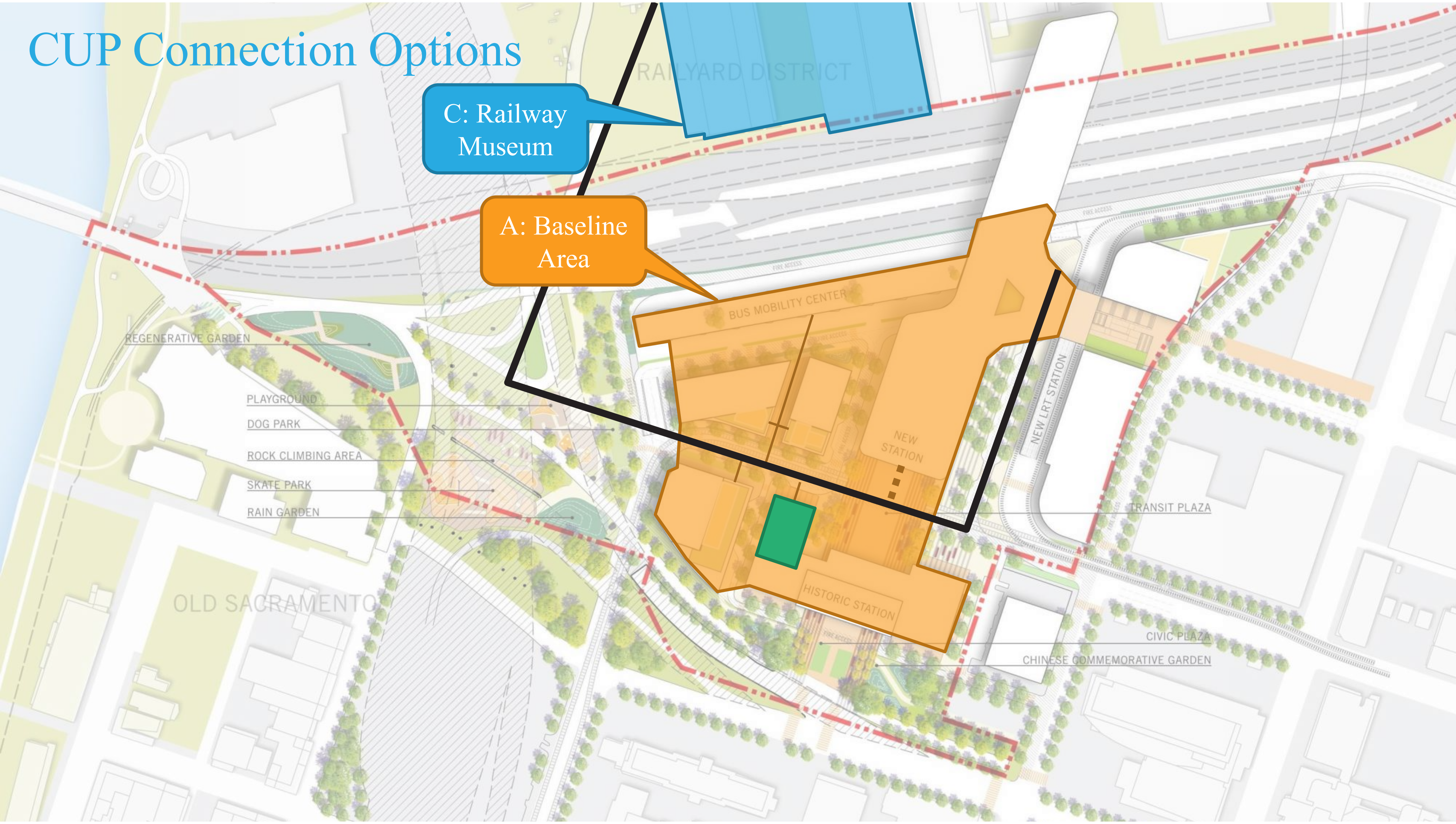
Connecting Lot 40

- Bring utilities to vault 5’ outside building floor plate
- Provide valves and cap within utility vault
- Connect into building at time of construction via either:
  - Heat exchangers at building (adds some loss to system)
  - Tertiary pumps with bypass
  - Btu meter (temperature + flow meter)



C Options: Including Railway Museum

ARUP


CUP Connection Options
C: Railway Museum
A: Baseline Area
RAILYARD DISTRICT
BUS MOBILITY CENTER
REGENERATIVE GARDEN
PLAYGROUND
DOG PARK
ROCK CLIMBING AREA
SKATE PARK
RAIN GARDEN
OLD SACRAMENTO
NEW STATION
NEW LRT STATION
TRANSIT PLAZA
HISTORIC STATION
CIVIC PLAZA
CHINESE COMMEMORATIVE GARDEN

Railway Museum Connection Concept

ARUP

Potential Value

- Additional diversity for CUP (especially without Lot 40)
  - Reduced total capacity of installed cooling and heating equipment

- Eliminate rooftop or interior mounted heating and cooling supply equipment for Railway Museum
  - Reduced structural cost
  - Increased interior space flexibility

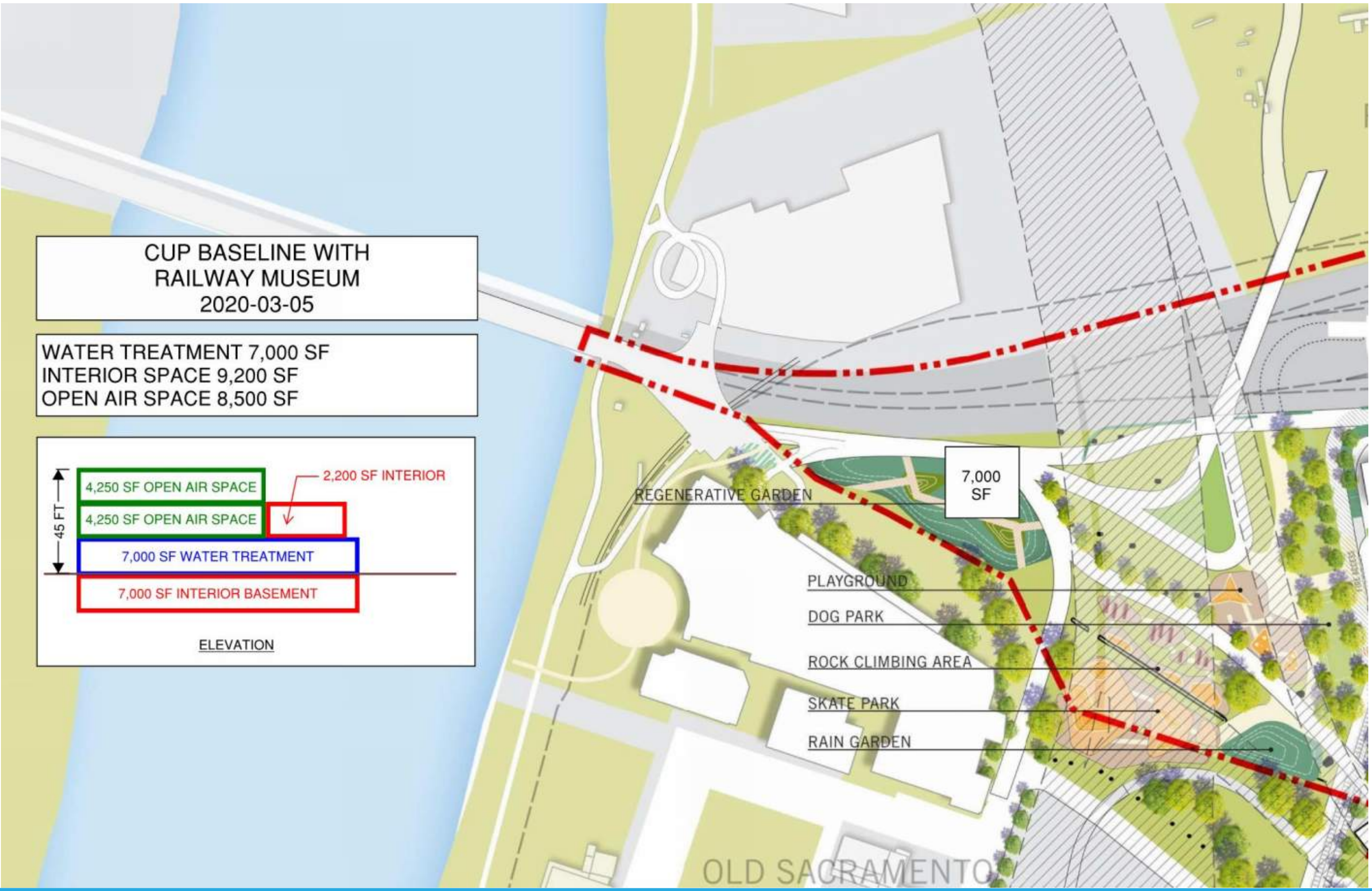
- Higher efficiency heating and cooling for Railway Museum
  - Reduced energy cost

Summary of Findings: Base + Railway Museum

	Scenario	Installed Capacity	Energy Use	Space Required
0: Business as Usual (Building by Building Systems	0A	Heating: 13.8 Cooling: 16.5	1.81 GWh	Interior: 14.8K SF Roof: 14.4K SF
1: All-Electric Baseline CUP: Chillers, Towers, and Air Source Heat Pumps	1A	Heating: 11.5 Cooling: 13.7	1.1GWh *(39%)*	Interior: 9.2K SF Roof: 8.5K SF
4: All-Electric CUP + GSHP + Sewer Heat Recovery (iCUP) *(Still includes Chillers, Towers, Air Source Heat Pumps)*	4A	Heating: 12.1 Cooling: 13.7	0.96 GWh *(47%)*	Interior: 10.8K SF Roof: 4.0K SF

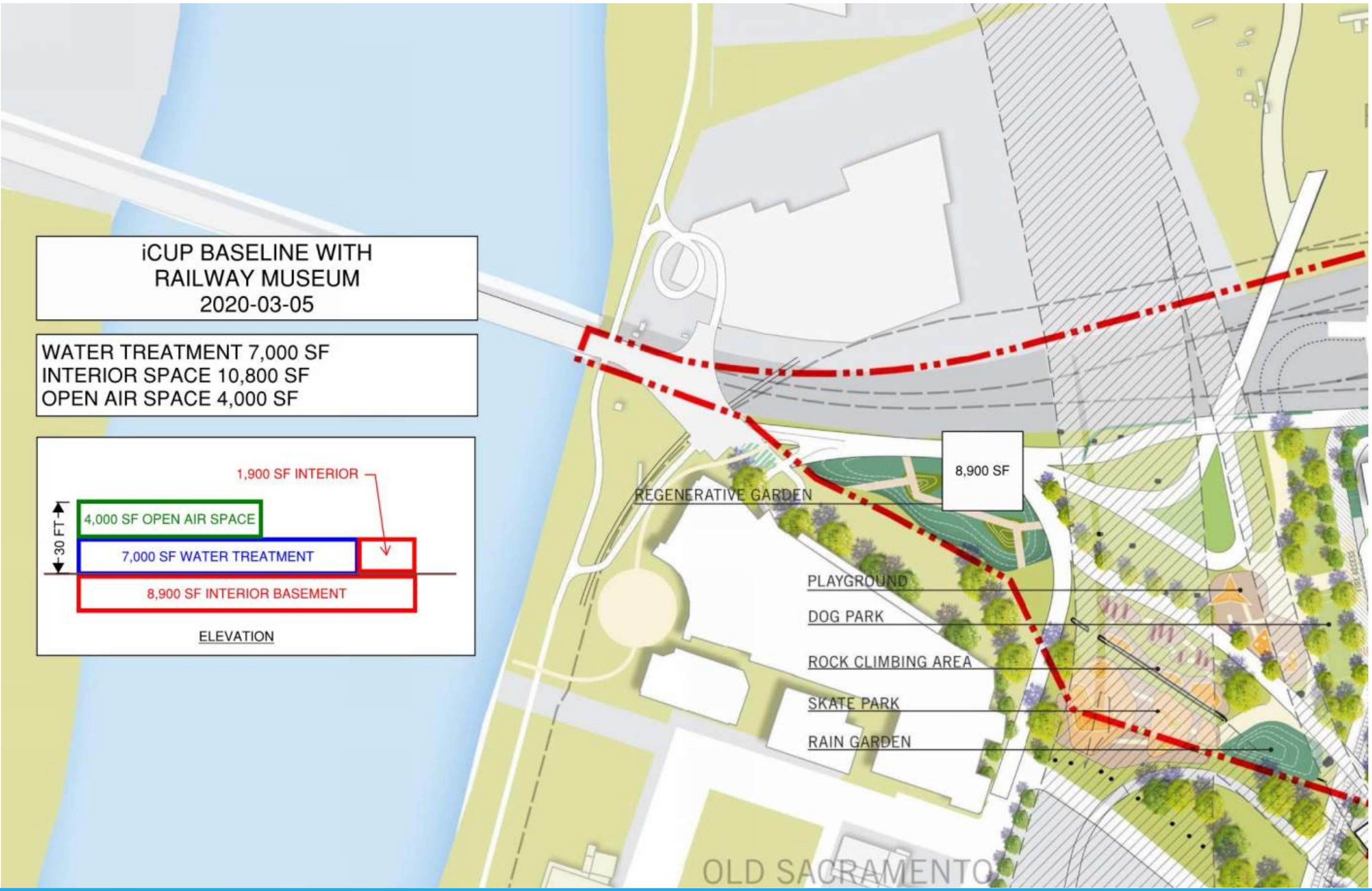
ARUP

Space: Baseline CUP



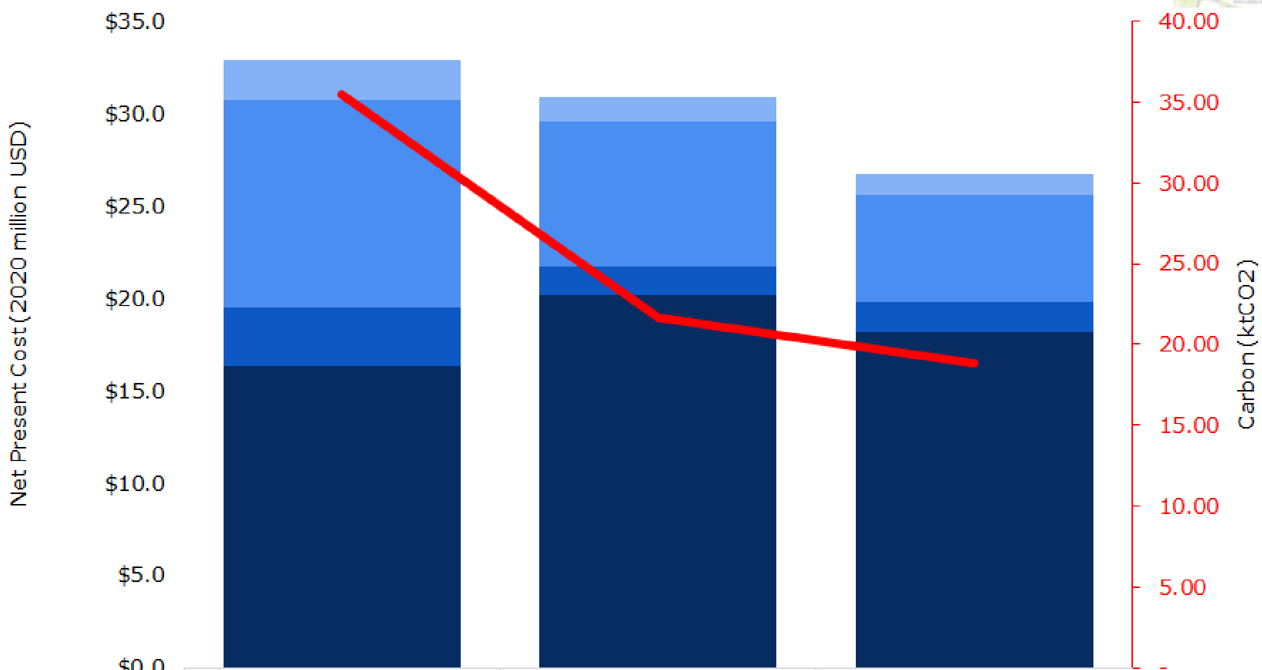
ARUP

Space: Innovative CUP (iCUP: GSHP + SHR)



ARUP

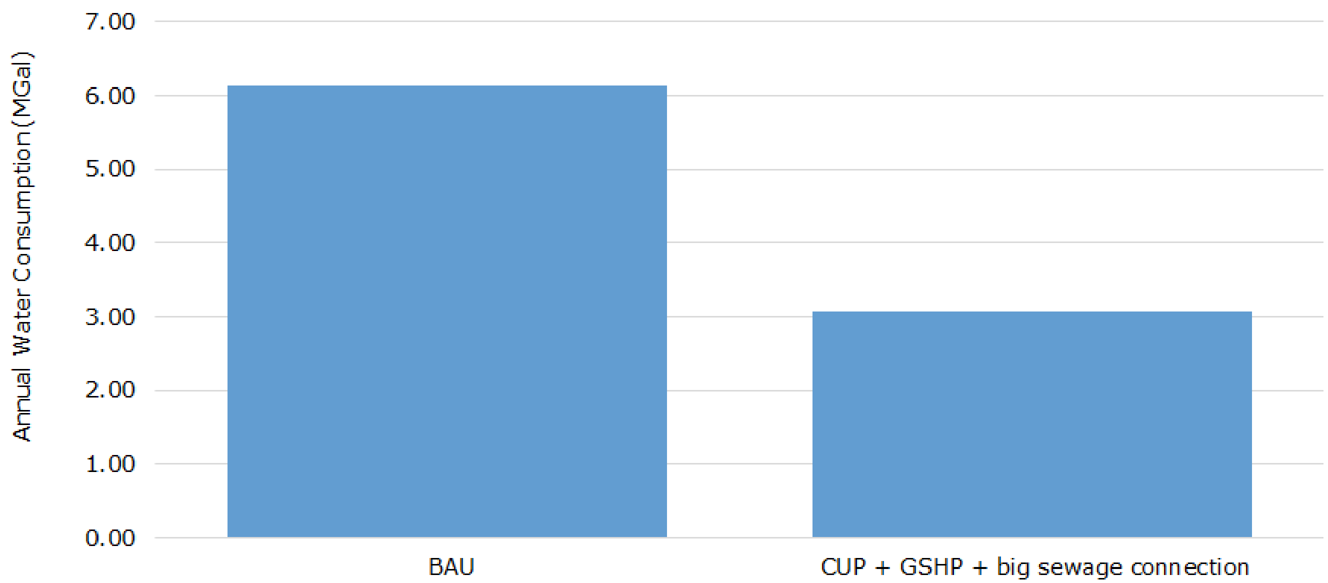
Life Cycle Cost



	BAU	CUP	CUP + GSHP + big sewage connection
Thermal elec fuel cost (NPC 2019 $)	$2.2	$1.3	$1.1
Total thermal operation costs (NPC 2019 $)	$11.2	$7.9	$5.8
Total annualised thermal REPEX (NPC 2019 $)	$3.2	$1.5	$1.6
Total thermal captial costs (NPC 2019 $)	$16.3	$20.2	$18.2
Carbon (ktCO2)	35.51	21.64	18.82

ARUP

Water Consumption (Thermal Systems Only)



Potential Value to SVS

- Additional diversity for CUP (especially without Lot 40)
  - Reduced total capacity of installed cooling and heating equipment
- Eliminate rooftop or interior mounted heating and cooling supply equipment for Railway Museum
  - Reduced structural cost
  - Increased interior space flexibility
- Higher efficiency heating and cooling for Railway Museum
  - Reduced energy cost

Responses to Questions

ARUP

Questions: CUP Space Organization Diagram

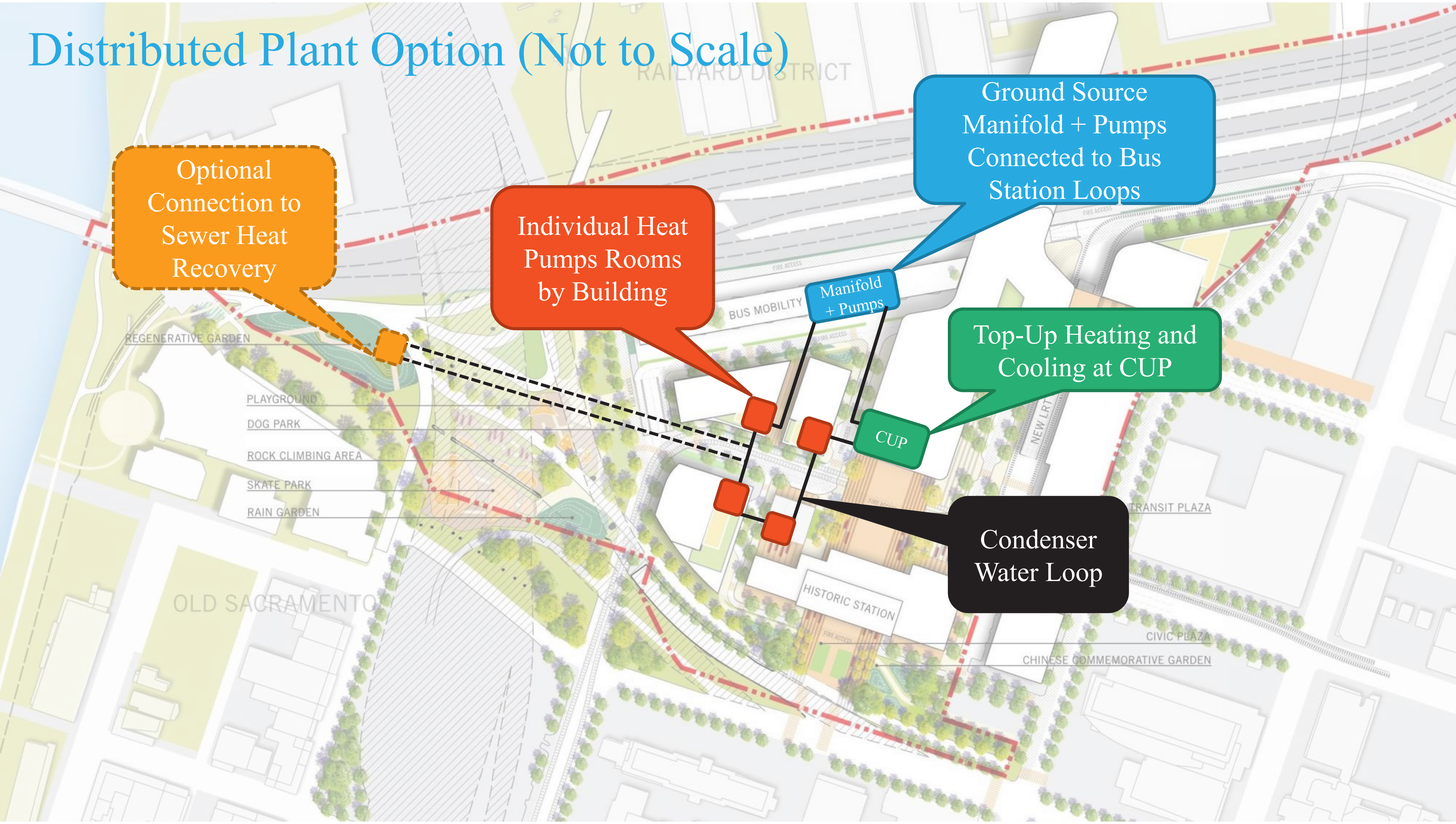
Space Take Diagrams	
Seeing this is combined system. However, this is looking quite big for this area	Agreed, it represents a worst-case spatial need; onsite heat/cool sourcing would reduce footprint. The CUP electrical room is also larger than it is likely to be.
In Grant's diagram, I see a below grade element and the above grade, are they both required?	At the moment, yes
Does the below grade element take the geothermal into consideration?	Not yet
Concern over the 75 ft height (higher than freeway)	Is there a maximum height we should target?

ARUP

Questions: Geothermal

Geothermal	
What is the heat/cool we get from it? Is it practical to place now, 10-15 years ahead of development?	Best to implement along with other infrastructure installation; disconnect between CAPEX/OPEX timing on capital recovery, can provide sensitivity analysis to right-size the payback;
Are we still looking at the horizontal loop? What is the pile system and is it more complicated?	Installing geothermal pipes with the piles, slightly more complicated installation, often has good payback; Rob is aware of local contractors
	Alternative manifold locations, either at the district center, or clusters at each building, with common condenser water loop; Day 1 installation of in-ground infrastructure, bringing to header, and distributing out;

ARUP



Distributed Plant Option (Not to Scale)
RAILYARD DISTRICT
Optional Connection to Sewer Heat Recovery
Individual Heat Pumps Rooms by Building
Ground Source Manifold + Pumps Connected to Bus Station Loops
Manifold + Pumps
BUS MOBILITY
Top-Up Heating and Cooling at CUP
CUP
NEW LRT
REGENERATIVE GARDEN
PLAYGROUND
DOG PARK
ROCK CLIMBING AREA
SKATE PARK
RAIN GARDEN
Condenser Water Loop
TRANSIT PLAZA
HISTORIC STATION
CIVIC PLAZA
CHINESE COMMEMORATIVE GARDEN
OLD SACRAMENTO

Questions: Sewer Heat Recovery

Sewage Heat Transfer	
What is the tap mechanism for transferring the heat? Probe? Circumferential jacket?	If tapping into the Bercut sewer, there are two products that can be used. One is a geopipe embedded in a replacement sewer line, which would involve replacing the sewer line (is there a CIP for this?). The other would be to tap into the line and pump sewage out of it, through a heat exchanger in the CUP, and then discharge back to the sewer.
What is the threshold for the first phase? Hotel?	From Bercut, the hotel would be a good threshold. For on-site WWTP, the size is small enough to be useful with any development.

ARUP

Questions: Railroad Museum/Lot 40

Railroad Museum/Lot 40	
Would this be a multi location plants, tied together? Implications	The intent would be a single central plant serving CHW and HHW to the museum, but alternatively, with GSHP and multiple heat pumps by building, you could do the same with the Railroad museum. In that case, it is building plants tied together.
What would be needed for physical connection?	Up to 8" CHWS/R lines through the tunnel, and up to 6" HHWS/R through the tunnel. There would need to be an agreement for the railway museum to buy from the plant, requiring a BTU meter (i.e., Onicon 10) on each line at the plant and a billing mechanism. At the building, the connection is either via a heat exchanger or isolation valves and a bypass (can add schematic if helpful).
Future Lot 40 tie-in -- what would need to be in place under ground level improvements?	Would need a means into the building, so a utility line capped and stubbed that Lot 40 could connect to, and a pathway to the building. If the slab is poured with the first phase of work, there may want to be a stub up into the building, but a utility vault 5' outside could suffice too. Would need to review the overall approach for getting into the buildings.

ARUP

Technology Appendix

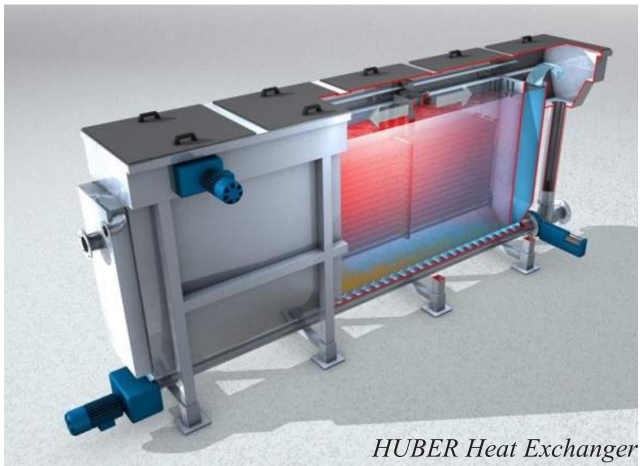
ARUP

Additional Detail: Sewer Heat Recovery

ARUP

Source: Building Wastewater

Example Product: Huber Technologies (HUBER Heat Exchanger RoWin)



HUBER Heat Exchanger

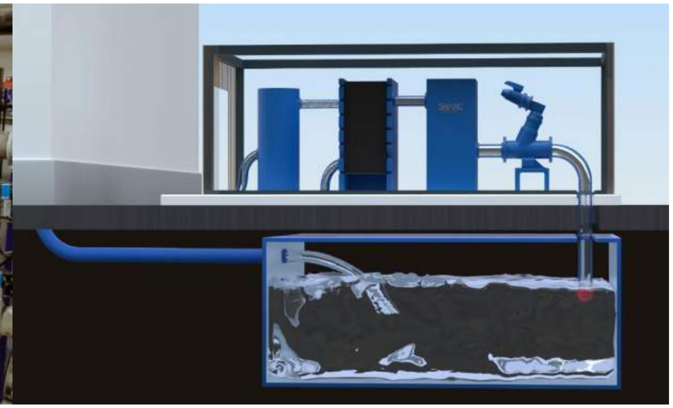
HUBER Heat Exchanger (tank version)

Source: Building Wastewater

Other products / manufacturers

Sharc Energy Systems

(Plate and frame)



KemcoSystems

(Shell and Tube)

Source: Building Wastewater

Example Product: Huber Technology (HUBER ThermWin)

Benefits

- Tanks and equipment installed above ground
- No modification of main sewer system (avoid additional underground tap)
- Design has control of which wastewater streams are directed to the system (e.g. could opt not to divert WC stream to recovery system, which could reduce filtration requirements)

Challenges

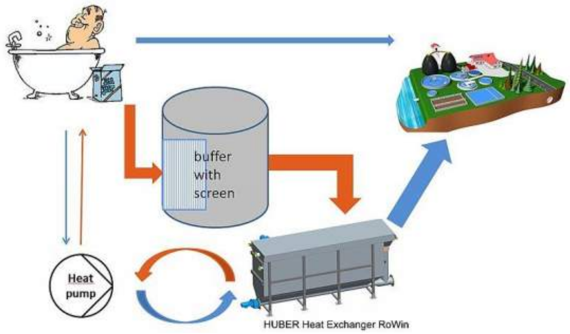
- Space/footprint requirements inside the building
- Heat loss between the plumbing fixture and heat recovery device; lower wastewater temperature than heat recovery at the plumbing fixture

Source: Building Wastewater

Example Product: Huber Technologies (HUBER Heat Exchanger RoWin)

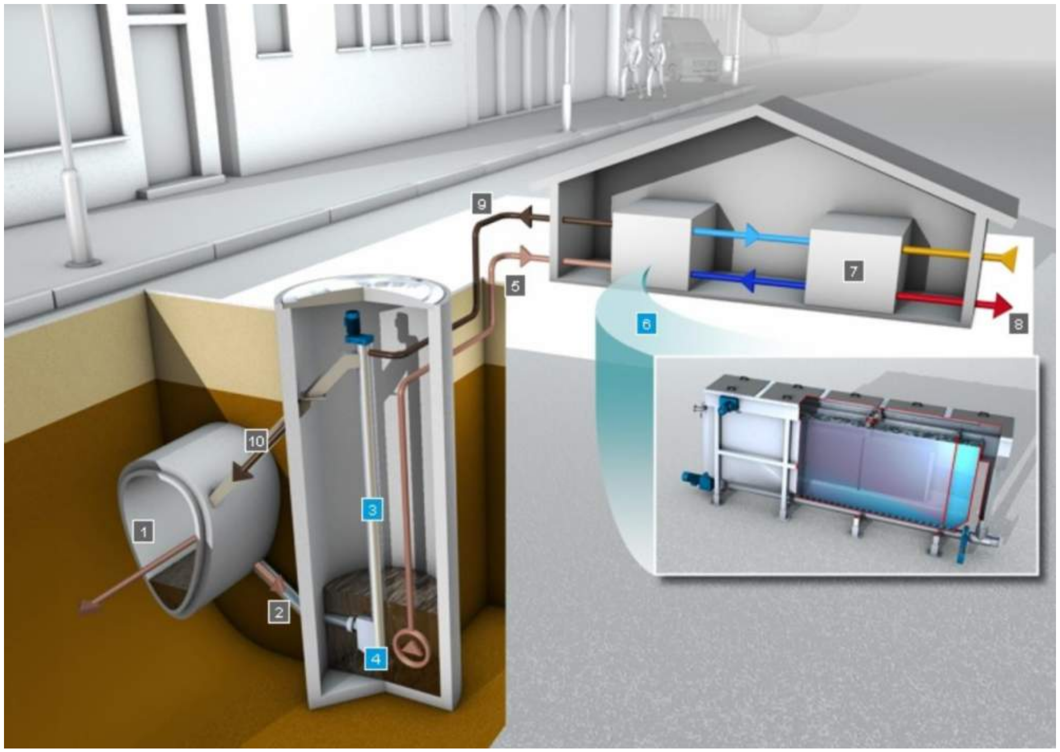
Case Study: Nursing Home Hofmatt (Münchenstein, Switzerland)

- Operating since 2012
- 4S HUBER RoWin heat exchanger; ROTAMAT® RoK 1 Storm Screen; additional heat pump and storage tank
- System operation
  - Wastewater at 23-25 deg C
  - Water inside the storage tank is allowed to stratify
    - Upper = 65C (service water)
    - Middle = 30-40C (heating)
    - Lower = 25C (additional cooling of liquefied cooling agent)



Source: Existing Sewers (Mains)

Example Product: Huber Technology (HUBER ThermWin)



1 sewer
2 sewage outflow
3 ROTAMAT® Pumping Stations Screen RoK 4
4 screen basket RoK 4
5 screened wastewater
6 compact HUBER Heat Exchanger RoWin
7 heat pump (+ heat storage tank)
8 heating water connection to consumers
9 cooled sewage return
10 screenings and sewage return into sewer

Applications

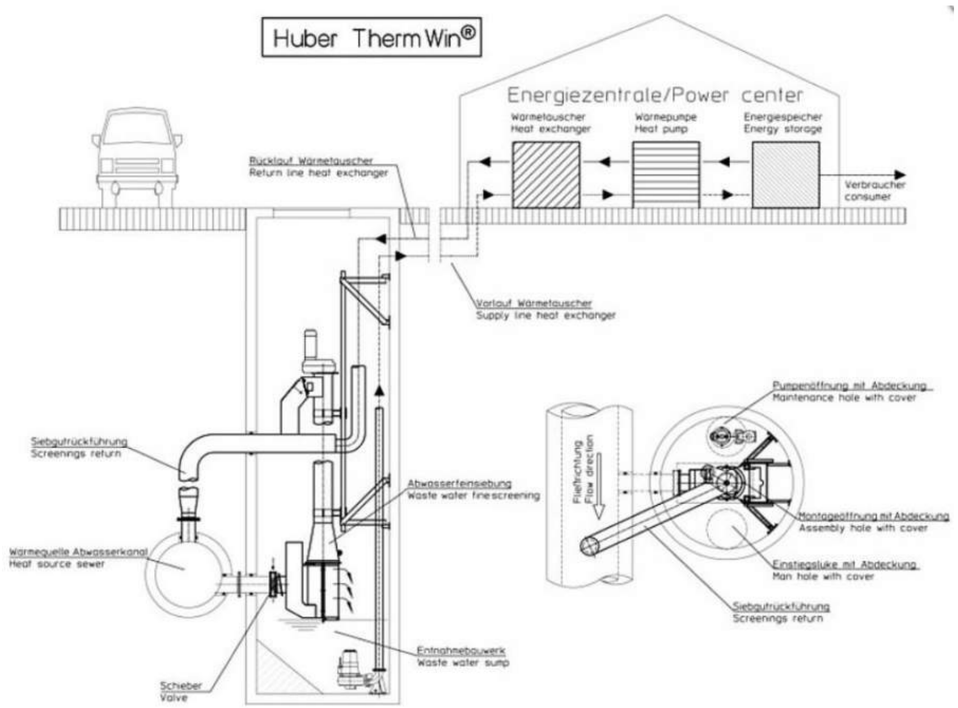
- Offices
- Nursing homes
- Hospitals
- Schools
- Sports Halls
- Other large buildings

Source: Existing Sewers (Mains)

Example Product: Huber Technology (HUBER ThermWin)

Guidelines

- dry weather flow at least 10 L/sec
- average temperature in winter should not fall below ~10 °C.
- Ideally a short distance between the sewer and the object to be supplied with the heat
- consider energy supply requirements during peak load periods



Schematic drawing of HUBER ThermWin system

Source: Existing Sewers (Mains)

Example Product: Huber Technology (HUBER ThermWin)

Benefits

- Local and free, decentralized heat source
- Minimal interference with existing sewers (drilling two holes)
- Negligible effect on wastewater treatment (sewage cooling by 1 – 2 °C only)
- Lower temperature could be more useful as a heat sink, if operation of the system for cooling is desired

Challenges

- Cost of replacing or modifying existing main sewer lines; coordination with AHJ
- Maintenance or replacement of underground connections, equipment, etc. (may be accessible via manhole, requiring a large diameter sewer)
- Most extreme filtration requirements, most susceptibility to fouling on heat exchanger, least control over the contents of the wastewater stream
- Variance in sewer water flow rates and temperatures (due largely to storm water flow)
- Lowest wastewater temperature, so least efficient heat transfer during heating

Source: Sewers (Main)

Example Product: Huber Technology (HUBER ThermWin)

Case Study: Wintower in Winterhur, Switzerland

- 28 stories, 22,000m^2 office space
- Huber Heat Exchanger RoWin (in the building basement); Huber Pumping Station Screen; Submersible pump (in shaft next to sewer)
- Heating with dry-weather flow:
  - 50 L/s removed and pre-treated
  - Removes 440 kW of heat from sewage
  - Heat pump generates 590kW heating energy using 150kW electrical power
  - Heat pump COP ~4.0
  - Delivers ~75% of heating energy demand
- Heat pump is reversed to provide cooling during the summer

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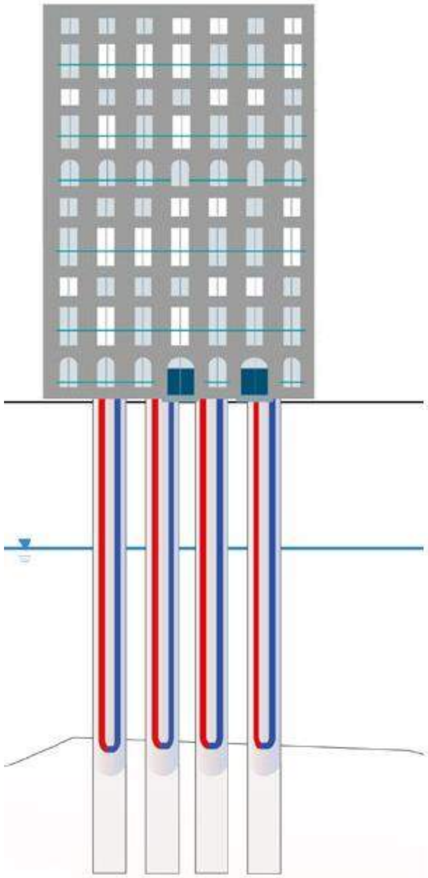
Additional Detail: Ground Source Heat Pump

ARUP

Energy Piles

Water is circulated through tubing arranged in loops installed within the building piles. Run in balance so that the total heat injected during the cooling season is equal to the heat extracted during the heating system. Performance is less dependant on geology than open loop systems.



Typical Depth: Pile depth (e.g. 100 ft)

Spacing: 20 ft or pile spacing

Installation Cost: Low

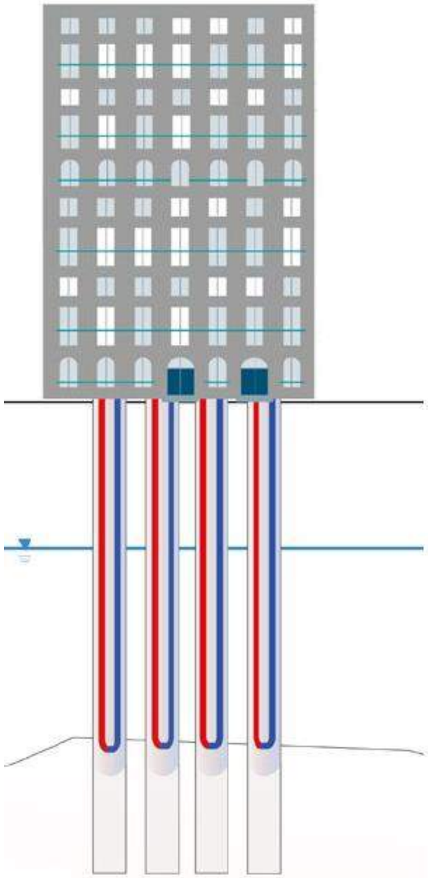
Testing: Thermal response test, optimally during pile load test

Thermal balance: Run in balance

Performance Risk: Low

Energy Piles+

Extending building piles beyond the required structural depth to benefit from greater thermal capacity. This option is cost effective because the piling rig is already required for the structure and therefore the added cost is for lengthening the piles (deeper drilling and additional material)



Typical Depth: Pile depth (e.g. 500 ft)

Spacing: 20 ft or pile spacing

Installation Cost: Low

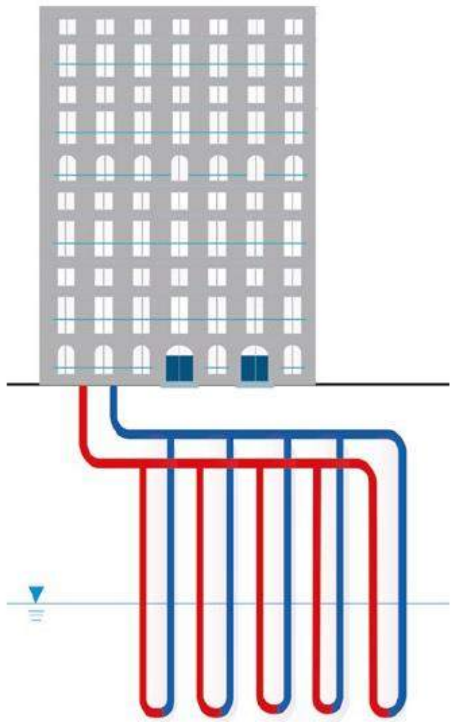
Testing: Thermal response test, optimally during pile load test

Thermal balance: Run in balance

Performance Risk: Low

Closed Loop Vertical Borings

Borings circulate water through tubing arranged in loops. Run in balance so that the total heat injected during the cooling season is equal to the heat extracted during the heating system. Performance is less dependant on geology than open loop systems. Operate in the same way as energy piles.



Typical Depth: 200 – 500 ft

Spacing: 20 ft between loops

No. of Loops: 30 - 100, or max possible

Installation Cost: $35,000 per loop

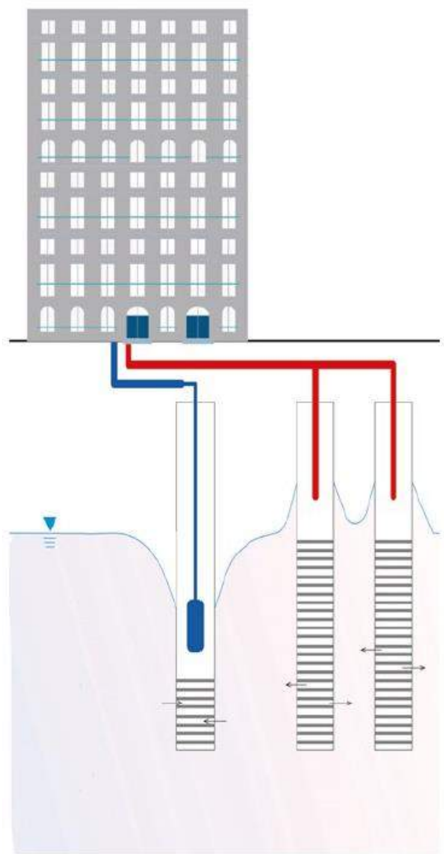
Testing: Thermal Response Test

Thermal balance: Run in balance

Performance Risk: Low

Open Loop Vertical Wells

Water is pumped from one well and heat energy transferred for heating or cooling before the water is reinjected into another well. More efficient and cost effective than closed loop systems. Only feasible in sufficiently productive aquifers and where sufficient spacing between wells can be achieved.



Typical Depth: 200 – 300 ft (related to permeability and thermal gradient)

Spacing: 250 ft between wells

Installation Cost: $1M per loop

Testing: Aquifer Test

Thermal balance: Can run out of balance

Performance Risk: High, until testing is performed – up front costs needed

iv. BMP sizing memorandum

To	Gregory Taylor, City of Sacramento	Date	May 11, 2020
Copies	Mathew Bamm, Arup	Reference number	252563-00
From	Maribel Gibson, Arup	File reference	04
Subject	SVS Stormwater Best Management Practices Sizing		

The masterplan framework for the Sacramento Valley Station (SVS) site includes Best Management Practices (BMPs) for treatment of the site's stormwater. The purpose of the BMPs are to collect, convey, and treat the site's stormwater before it either infiltrates into the ground or enters the city's stormwater system. The city utilizes the Sacramento Region *Stormwater Quality Design Manual* and Low Impact Development (LID) Credits Worksheet to determine what amount of BMPs are needed to adequately treat a site. See the attached SVS LID Credits Worksheet.

As design of the SVS site is still in its preliminary stages, high level estimates have been input to complete the worksheet. Assumptions are as follows:

- Step 1, Item 1b.d. – 30% of the total site is estimated to be landscape area/park.
- Step 2, Option 1 Porous Pavement – 1.5 acres are estimated to be porous pavement, with a conservative efficiency factor of 0.4.
- Step 3, Bioretention/Infiltration Credits – The preliminary design provides bioretention and infiltration areas within each drainage area, sized to be at minimum, 4% of the drainage area. Where feasible, these are intended to utilize infiltration, but where this is not possible due to site constraints, a bioretention area will be used. For this step, half of the total site's BMPs are assumed to be bioretention, and half are assumed to be infiltration.

Arup has reviewed the SVS LID Credits Worksheet through phone calls and emails with the City's Fernando Duenas, and he has confirmed that the 127.4 LID Credit total is compliant with the City's requirements.

Appendix D-2: Commercial Sites: Low Impact Development (LID) Credits and Treatment BMP Sizing Calculations

Name of Drainage Shed: Sacramento Valley Station Masterplan — Fill in Blue Highlighted boxes
Location of project: Sacramento

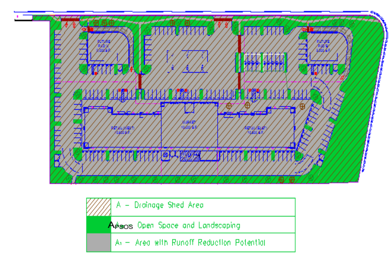
Step 1 - Open Space and Pervious Area Credits

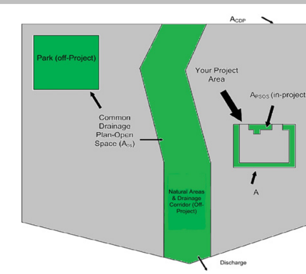
Is your project within the drainage area of a common drainage plan that includes open space? If not, skip to 1 b.

1 a. Common Drainage Plan Area	0	acres	A_{CDP}	
Common Drainage Plan Open Space (Off-project)	0	acres	A_{OS}	see area example below
a. Natural storage reservoirs and drainage corridors	0	acres		
b. Buffer zones for natural water bodies	0	acres		
c. Natural areas including existing trees, other vegetation, and soil	0	acres		
d. Common landscape area/park	0	acres		
e. Regional Flood Control/Drainage basins	0	acres		
1 b. Project Drainage Shed Area (Total)	28.00	acres	A	
Project-Specific Open Space (In-project, communal)**	8.40	acres	A_{PSOS}	
a. Natural storage reservoirs and drainage corridors	0.00	acres		
b. Buffer zones for natural water bodies	0.00	acres		see area example below
c. Natural areas including existing trees, other vegetation, and soil	0.00	acres		
d. Landscape area/park	8.40	acres		
e. Flood Control/Drainage basins	0.00	acres		

** Doesn't include impervious areas within individual lots and surrounding individual units. That is accounted for below using Form D-1a in Step 2.

Area with Runoff Reduction Potential	$A - A_{PSOS} =$	19.60	acres	A_T
Assumed Initial Impervious Fraction	$A_T / A =$	0.70		I
Open Space & Pervious Area LID Credit (Step 1)	$(A_{OS}/A_{CDP}+A_{PSOS}/A)x100 =$	30	pts	





Step 2 - Runoff Reduction Credits

Runoff Reduction Treatments	Impervious Area Managed			Efficiency Factor		Effective Area Managed (A_C)	
Porous Pavement:							
Option 1: Porous Pavement (see Fact Sheet, excludes porous pavement used in Option 2)	1.5	acres	x	0.4	=	0.600	acres
Option 2: Disconnected Pavement (see Fact Sheet, excludes porous pavement used in Option 1)	use Form D-2a for credits	→				0.00	acres
Landscaping used to Disconnect Pavement (see Fact Sheet)	0.0000	acres			=	0.00	acres
Disconnected Roof Drains (see Fact Sheet and/or Table D-2b for summary of requirements)	0	acres			=	0.00	acres
Ecoroof (see Fact Sheet)		acres			=	0.00	acres
Interceptor Trees (see Fact Sheet)	use Form D-2b for credits	→				0.00	acres
Total Effective Area Managed by Runoff Reduction Measures				A_C		0.60	acres
Runoff Reduction Credit (Step 2)				$(A_C / A_T)*100 =$		3	pts

Commercial

Table D-2a

Porous Pavement Type	Efficiency Multiplier
Cobblestone Block Pavement	0.40
Pervious Concrete/Asphalt	0.60
Modular Block Pavement &	0.75
Reinforced Grass Pavement	1.00

Table D-2b

Maximum roof size	Minimum travel distance
≤ 3,500 sq ft	21 ft
≤ 5,000 sq ft	24 ft
≤ 7,500 sq ft	28 ft
≤ 10,000 sq ft	32 ft

Form D-2a: Disconnected Pavement Worksheet

See Fact Sheet for more information regarding Disconnected Pavement credit guidelines

Effective Area Managed (A_C)

Pavement Draining to Porous Pavement

2. Enter area draining onto Porous Pavement	0.00	acres	Box K1
3. Enter area of Receiving Porous Pavement (excludes area entered in Step 2 under Porous Pavement)	0.00	acres	Box K2
4. Ratio of Areas (Box K1 / Box K2)	0.00		Box K3

5. Select multiplier using ratio from Box K3 and enter into Box K4

Ratio (Box D)	Multiplier
Ratio is ≤ 0.5	1.00
Ratio is > 0.5 and < 1.0	0.83
Ratio is > 1.0 and < 1.5	0.71
Ratio is > 1.5 and < 2.0	0.55

Box K4 value	1		Box K4
6. Enter Efficiency of Porous Pavement (see table below)			Box K5

Porous Pavement Type	Efficiency Multiplier
Cobblestone Block Pavement	0.40
Pervious Concrete Asphalt Pavement	0.60
Modular Block Pavement Porous Gravel Pavement	0.75
Reinforced Grass Pavement	1.00

7. Multiply Box K2 by Box K5 and enter into Box K6	0.00	acres	Box K6
8. Multiply Boxes K1,K4, and K5 and enter the result in Box K7	0.00	acres	Box K7
9. Add Box K6 to Box K7 and multiply by 60%, and enter the Result in Box K8	0.00	acres	

This is the amount of area credit to enter into the "Disconnected Pavement" Box of Form D-2

Form D-2b: Interceptor Tree Worksheet

See Fact Sheet for more information regarding Interceptor Tree credit guidelines

New Evergreen Trees

1. Enter number of new evergreen trees that qualify as Interceptor Trees in Box L1.		trees	Box L1
2. Multiply Box L1 by 200 and enter result in Box L2	0	sq. ft.	Box L2

New Deciduous Trees

3. Enter number of new deciduous trees that qualify as Interceptor Trees in Box L3.		trees	Box L3
4. Multiply Box L3 by 100 and enter result in Box L4	0	sq. ft.	Box L4

Existing Tree Canopy

5. Enter square footage of existing tree canopy that qualifies as Existing Tree canopy in Box L5.	0	sq. ft.	Box L5
6. Multiply Box L5 by 0.5 and enter the result in Box L6	0	sq. ft.	Box L6

Total Interceptor Tree EAM Credits

Add Boxes L2, L4, and L6 and enter it into Box L7	0	sq. ft.	Box L7
Divide Box L7 by 43,560 and multiply by 20% to get effective area managed and enter result in Box L8	0.00	acres	Box L8

This is the amount of area credit to enter into the "Interceptor Trees" Box of Form D-2

Commercial

Step 3 - Runoff Management Credits

Capture and Use Credits

Impervious Area Managed by Rain barrels, Cisterns, and automatically-emptied systems

(see Fact Sheet) - enter gallons, for simple rain barrels — 0.00 acres

Automated-Control Capture and Use System

(see Fact Sheet, then enter impervious area managed by the system) — 0.00 acres

Bioretention/Infiltration Credits

Impervious Area Managed by Bioretention BMPs

(see Fact Sheet)

Bioretention Area	24,000	sq ft	
Subdrain Elevation	6	inches	
Ponding Depth, inches	6	inches	4.11 acres

Impervious Area Managed by Infiltration BMPs

(see Fact Sheet)

Drawdown Time, hrs	12	drawdown_hrs_inf	
Soil Infiltration Rate, in/hr	0.50	soil_inf_rate	
Sizing Option 1: Capture Volume, acre-ft	0.00	capture_vol_inf	0.00 acres
Sizing Option 2: Infiltration BMP surface area, sq ft	24000	soil_surface_area	5.14 acres
Basin or trench?		approximate BMP depth 0.50 ft	

Impervious Area Managed by Amended Soil or Mulch Beds

(see Fact Sheet) Mulched Infiltration Area, sq ft — mulch_area — 0.00 acres

Total Effective Area Managed by Capture-and-Use/Bioretention/Infiltration BMPs — 9.24 A_{LIDC}

Runoff Management Credit (Step 3) — A_{LIDC}/A_T*200 = 94.3 pts

Total LID Credits (Step 1+2+3) — LID compliant, check for treatment sizing in Step 4 — 127.4

Does project require hydromodification management? If yes, proceed to using SacHM.

Adjusted Area for Flow-Based, Non-LID Treatment — A_T - A_C -A_{LIDC} = 9.76 A_{AT}

Adjusted Impervious Fraction of A for Volume-Based, Non-LID Treatment — A_{AT} / A = 0.35 I_A

Further treatment is required, see choose flow-based or volume-based sizing in Step 4

Step 4a Treatment - Flow-Based (Rational Method)

Calculate treatment flow (cfs): Flow = Runoff Coefficient x Rainfall Intensity x Area

Look up value for i in Table D-2c (Rainfall Intensity)	0.18	i
Obtain A_{AT} from Step 3	9.76	A_{AT}
Use C = 0.95	0.95	C
Flow = 0.95 * i * A_{AT}	1.67	cfs

Table D-2c

Rainfall Intensity		
Roseville	i =	0.20 in/hr
Sacramento	i =	0.18 in/hr
Folsom	i =	0.20 in/hr

Step 4b Treatment - Volume-Based (ASCE-WEF)

Calculate water quality volume (Acre-Feet): WQV = Area x Maximized Detention Volume (P_0)

Obtain A from Step 1	28.00	A
Obtain P_0: Maximized Detention Volume from figures E-1 to E-4 in Appendix E of this manual using I_A from Step 2.	0.18	P_0
Calculate treatment volume (acre-ft): **Treatment volume = A x (P_0 / 12)**	0.42	Acre-Feet

12 hrs — Specified Draw Down time

v06232012

Commercial

Mathew Bamm

From: Fernando Duenas <FDuenas@cityofsacramento.org>
Sent: Monday, April 20, 2020 11:04 AM
To: Maribel Gibson
Cc: Mathew Bamm
Subject: [External] RE: SVS_2018 Commercial LID CreditsPW (003).xlsx [Filed 20 Apr 2020 11:20]

If that is the case-then yes, the LID point total complies with the City's requirements. Please go ahead and add the LID spreadsheet in the any studies produced for the SVS. We will use it a reference document when the project comes across my section.

The project looks exciting and it will be a great addition to the downtown area. Thank you for reaching out to me and let me know if anything else comes up.

Fernando Dueñas, PE
Department of Utilities
Environmental Regulatory Compliance Section
1395 35th Ave, Sacramento, CA 95822
916-808-4953

From: Maribel Gibson <Maribel.Gibson@arup.com>
Sent: Monday, April 20, 2020 10:54 AM
To: Fernando Duenas <FDuenas@cityofsacramento.org>
Cc: Mathew Bamm <mathew.bamm@arup.com>
Subject: RE: SVS_2018 Commercial LID CreditsPW (003).xlsx

Thanks for this note, Fernando. The square footage numbers for biofiltration and infiltration areas are intentional. The sum of the two equal our total bioretention area, but how much is biofiltration vs. infiltration will be worked out at a later time. For now, we've made the assumption that it will be an even split between the two.

That being the case, do our numbers seem okay?

Thanks again.

Maribel Gibson PE
Senior Engineer | Civil

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Arup now has two offices in the Bay Area: San Francisco and Oakland. I am now working in the Oakland office.

From: Fernando Duenas <FDuenas@cityofsacramento.org>
Sent: Monday, April 20, 2020 10:47 AM
To: Maribel Gibson <Maribel.Gibson@arup.com>
Cc: Mathew Bamm <mathew.bamm@arup.com>
Subject: [External] SVS_2018 Commercial LID CreditsPW (003).xlsx

Hi Maribel: I had a chance to take a look at the LID worksheet and here are my comments. I noticed the square footage was exactly the same for the biofiltration areas (cell G165) and the infiltration area (cell G175)-these are two distinct BMP's and you may have inadvertently doubled-counted the biofiltration area. I took out the infiltration area value and I got an LID point score of 75. As an alternative, you can have some of the impervious areas drain into adjacent compost-amended soil areas. Amended soils can be used in areas set aside for landscaping and accept drainage from paved areas like parking lots or walkways and even roofs. The advantage of compost-amended soil is that you don't have to design a dedicated bioretention BMP and you can use the existing landscaping. This an excerpt from the Stormwater Quality design guide manual:

Compost-Amended Soil
The compost-amended soil BMP is an option in the BMP toolbox that has a smaller footprint than impervious surface disconnection. This BMP option is intended to be a less complex alternative compared to bioretention and engineered infiltration BMPs. Compost-amended soil is also ideal as a design feature in landscape and open space areas. The volume of water to be infiltrated is assumed to be captured within pore spaces of a simple, depressed bed of mulch and compost-amended soil that overlies the native soil (with no underdrain). The mulch and amended soil provide short-term storage for the water until it can infiltrate the native underlying soil. Refer to the Compost-Amended Soil BMP Fact Sheet for additional information.

I plugged an amended soil area of 26,000 square feet in the spreadsheet and I got a total of 99.3 points-this is sufficient for a master plan level document. According to the spreadsheet, up to 2.39 acres of hard surfaces can be drained into the amended soil areas and this can be distributed across the project site.

Please review the attached spreadsheet and let me know if you would consider the amended soil for SVS. I'll be available all day if you want to discuss further.

Fernando Dueñas, PE
Department of Utilities
Environmental Regulatory Compliance Section
1395 35th Ave, Sacramento, CA 95822
916-808-4953

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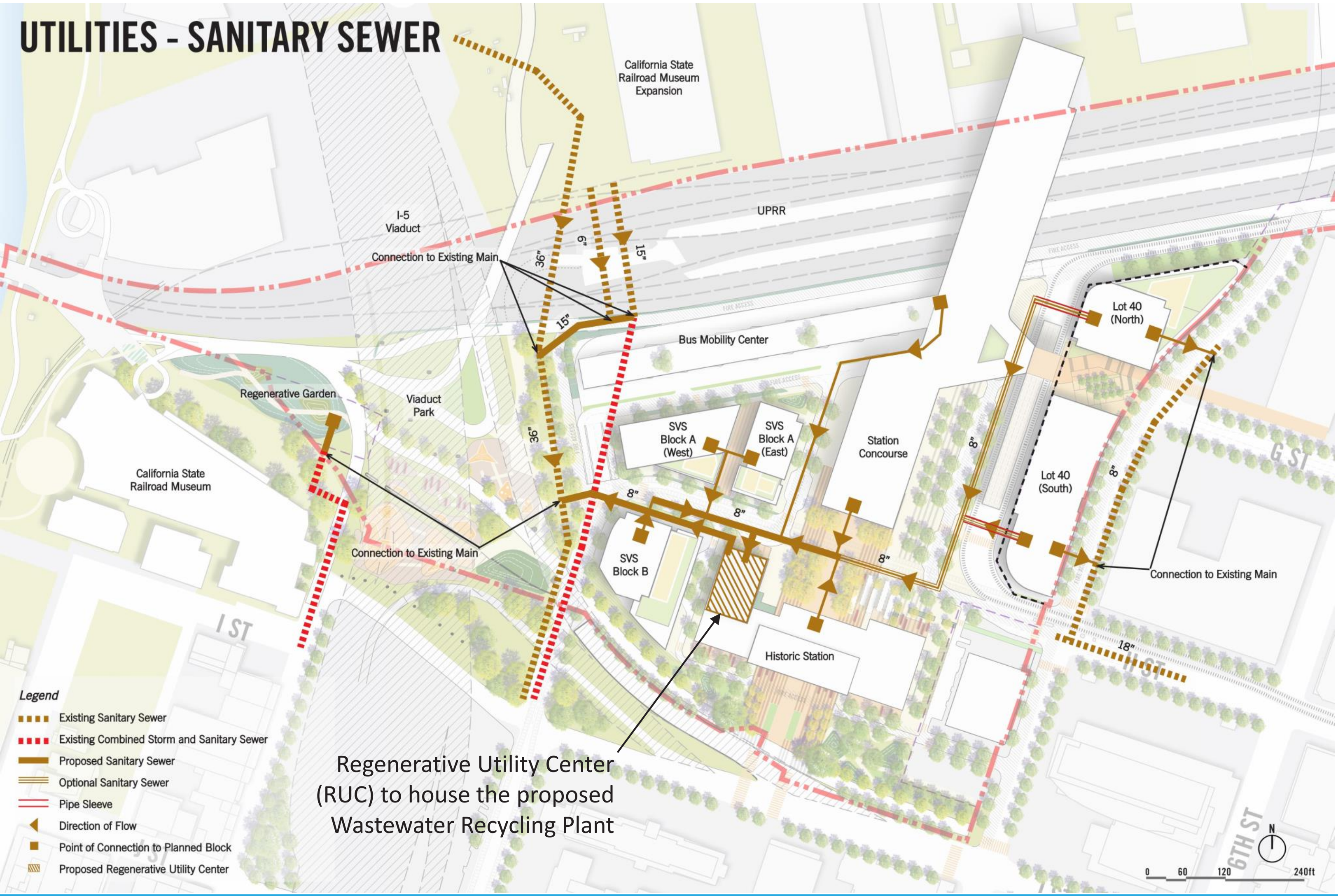
Sacramento Valley Station:
Wastewater Recycling Plant Executive Summary

Arup
May 12, 2020

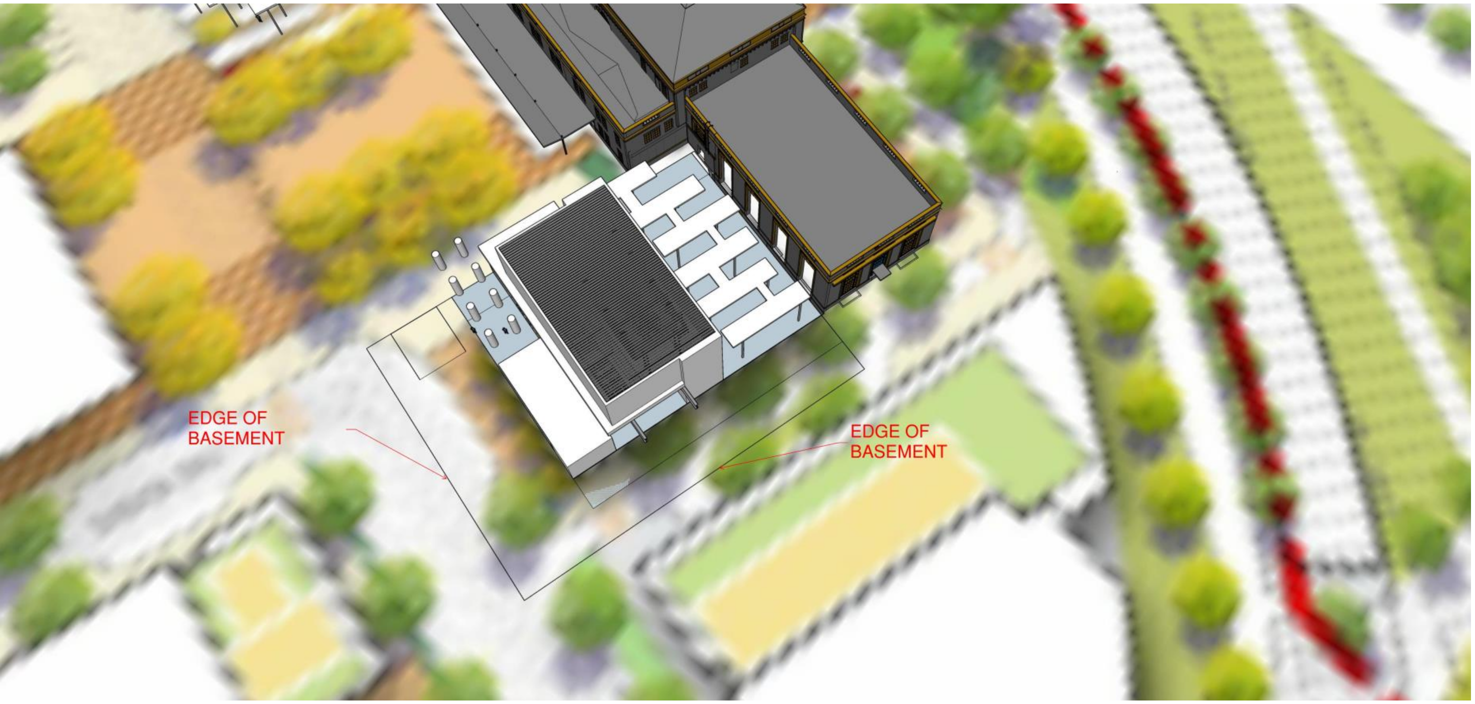
ARUP



- Gravity sewers drain toward the Regenerative Utility Center (RUC) located in the Historic Station Expansion
- Lot 40 optional (sleeves to be installed below RT rail and platforms)

PROPOSED SANITARY SEWER SYSTEM

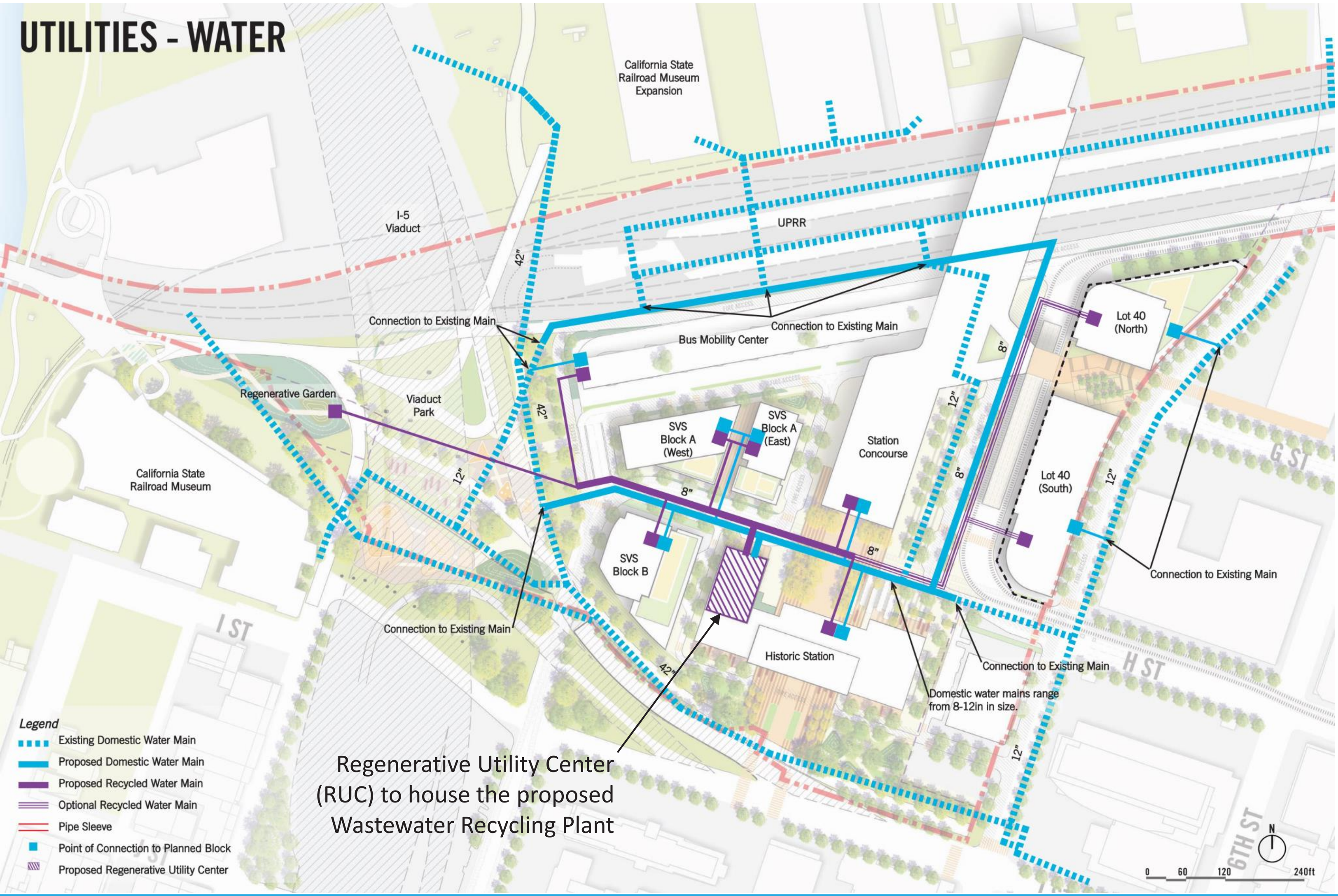
ARUP



- Compact wastewater recycling plant located in basement, but visible to the general public
- 100% wastewater treated to CA Title 22 recycled water standard
- Emergency overflow provided to 3rd Street sewer for temporary shutdown/maintenance
- Includes onsite sludge treatment; compost collected weekly
- Baseline 150,000 GPD with expansion capacity up to 250,000 GPD (to include Lot 40)
- Access from the west side includes gantry to install additional MBR units
- Recycled water storage tanks outside the building
- Consider starting with small pilot project by treating flow from nearby Bercut sewer

PROPOSED REGENERATIVE UTILITY CENTER (RUC)

ARUP



- Recycled water delivered to buildings and parks via purple pipe to supply flushing, irrigation and HVAC cooling demands
- Recycled water feeds wetland park at the Regenerative Garden
- Consider exporting recycled water to nearby projects and/or landscape areas
- Lot 40 optional (sleeves to be installed below RT rail and platforms)
- Infiltrate any unused recycled water to the ground or discharge to City sanitary sewer (as last resort)

PROPOSED WATER SUPPLY SYSTEM

ARUP

Projected Water and Wastewater Service Charges (Rates)

City of Sacramento Domestic Water Service Charges (Rates)
MONTHLY METERED WATER USE, PER 100 CF (CCF)

	2016	2017	2018	2019	2035	2040	2045	2050	(Projected)
	$ 1.0959	$ 1.2055	$ 1.3261	$ 1.4587	$ 4.3117	$ 6.0497	$ 8.4884	$ 11.9100	
				Rate Increase %	7.0083%	7.0083%	7.0083%	7.0083%	(avg from 1985-2020)

City of Sacramento Wastewater Service Charges (Rates)
MONTHLY METERED WASTEWATER USE, PER 100 CF (CCF)

	2016	2017	2018	2019	2035	2040	2045	2050	(Projected)
Unit Rate	$ 1.0002	$ 1.0902	$ 1.1883	$ 1.2953	$ 4.8529	$ 7.3327	$ 11.0796	$ 16.7411	
				Rate Increase %	8.6056%	8.6056%	8.6056%	8.6056%	(avg from 1985-2020)

Combined Water & Wastewater Service Charges (Rates), per 100 CF (CCF)

2016	2017	2018	2019	2035	2040	2045	2050	(Projected)
$ 2.0961	$ 2.2957	$ 2.5144	$ 2.7540	$ 9.1646	$ 13.3824	$ 19.5679	$ 28.6511	

Preliminary Payback Estimate on Water Treatment Plant Investment

Baseline: Treatment Demand (150,000 GPD)

150,000	GPD	Average Daily
54,750,000	gallons	Average Annual
7,319,519	cu.ft.	Average Annual
73,195	CCF	Average Annual
$ 6,000,000	CAPEX[1,2]	
$ 350,000	Annual OPEX[1,2]	
$ 13.20	Projected Service Charge ($/CCF)[3]	
$ 4.78	Service Charge for OPEX Only ($/CCF)[1]	
$ 8.41	Remaining Service Charge for CAPEX ($/CCF)	
9.7	Estimated Payback (Years)[4]	

Baseline + Lot 40: Treatment Demand (250,000 GPD)

250,000	GPD	Average Daily
91,250,000	gallons	Average Annual
12,199,198	cu.ft.	Average Annual
121,992	CCF	Average Annual
$ 8,500,000	CAPEX[1,2]	
$ 450,000	Annual OPEX[1,2]	
$ 12.13	Projected Service Charge ($/CCF)[3]	
$ 3.69	Service Charge for OPEX Only ($/CCF)[1]	
$ 8.44	Remaining Service Charge for CAPEX ($/CCF)	
8.3	Estimated Payback (Years)[4]	

- Preliminary CAPEX/OPEX estimates provided by NSU for two options:
  1) Baseline
  2) Baseline + Lot 40
- Recycled water rate assumed to equal the average of projected water + sewer rates over estimated payback period
- Projected water and sewer rates assume annual increase as seen over last 35 years (7.0% & 8.6%)
- Recycled water rate first covers OPEX, then remaining pays back the CAPEX
- Payback estimate assumes no operator markup
- DOU to negotiate connection fees

Notes
1) Year 2035 dollars
2) Per Natural Systems Utilities (NSU) preliminary estimate, March 2020
3) Average projected combined water & wastewater rate over the payback period starting in Year 2035
4) Assumes all generated recycled water is sold

PRELIMINARY PAYBACK ESTIMATE

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