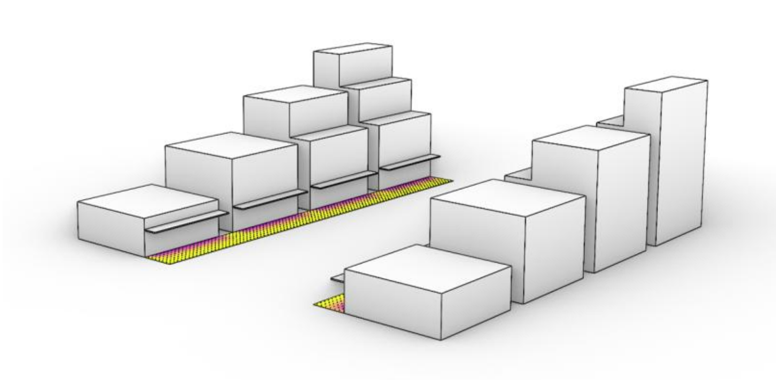
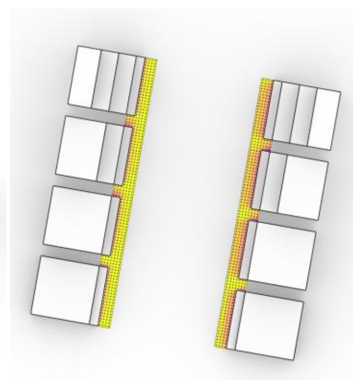
Micro-Grid Feasibility

St. Mary's & Darien, GA





Academic Project – Urban Design Studio - *consultation*

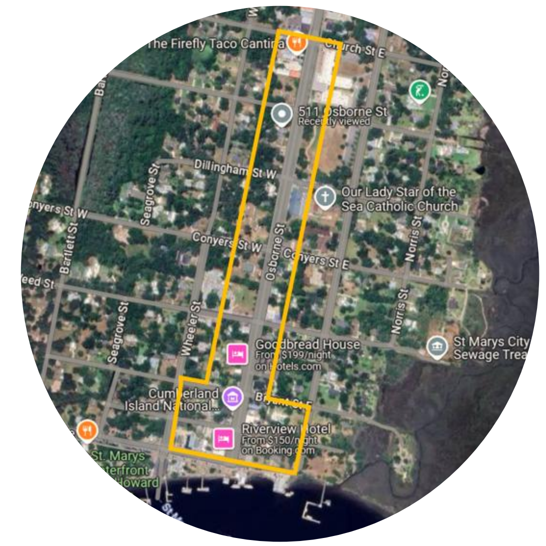
Location – Darien, USA

Software Used – Rhino, Climate Consultant, Ladybug and Honeybee Tools

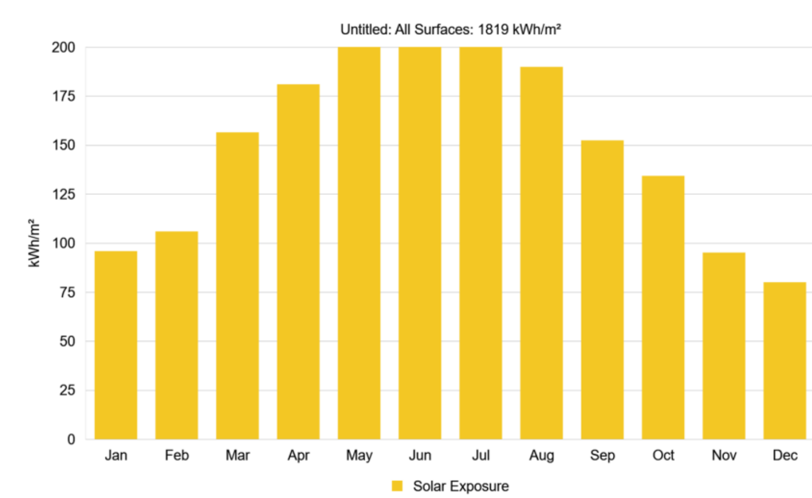
This project investigates the microgrid feasibility for St. Mary's and Darien, Georgia, focusing on resilience, solar energy potential, and sustainable community infrastructure. Conducted as a collaborative class effort between the Urban Design Studio and the High Performance Building Lab, the work combines site-specific solar potential assessment, energy demand analysis, cost modeling, and climate adaptation scenarios—including rainfall, outdoor comfort, and stormwater management. The integrated approach provides comprehensive recommendations for efficient microgrid design, renewable energy adoption, and climate-resilient urban planning tailored to the needs of these Georgia communities.

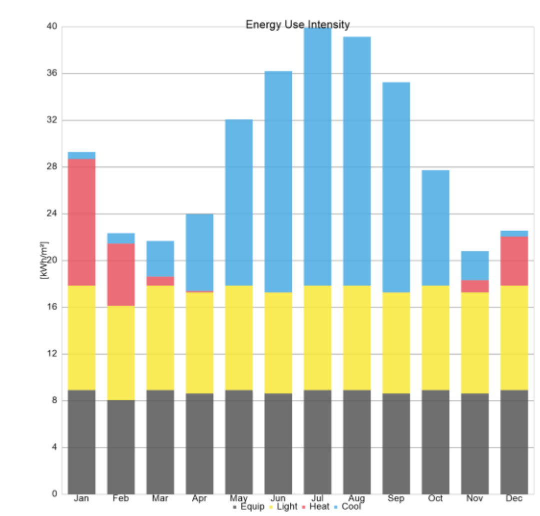
Solar Energy St. Marys

Osborne Microgrid – High Resilience



Annual Solar Radiation	1819 kWh/m2/yr
Total Roof Area	15897.64 m2
PV Panel Coverage	80%
Panel Efficiency	18%
Inverter Efficiency	96%





The solar panels produce 17625.6 kWh of electricity yearly
(1819 kWh/m2/yr x 15897.64m2 x 0.8 x 0.18 x 0.96 = 39,97,597.66 kWh)

Site EUI	148 kWh/m2/yr
Total Area	35744.54 m2

Projected target energy use: 1,25,46,333.54 kWh
Percentage covered by the PV system: 31.86%

COST BREAKDOWN (APPROX.) - EXAMPLE: ST MARYS

NREL PVWatts Calculator, NREL Solar Potential Resources

Total Roof Area: 15897.64 m²
PV Panel Coverage: 80%
Solar Radiation: 1819 kWh/m²/year
Panel Efficiency: 18%
Inverter Efficiency: 96%
Total Annual Solar Generation: 39,97,597.66 kWh
Projected Annual Energy Use: 1,25,46,333.54 kWh
PV Coverage: 31.86%

Effective system efficiency = 0.18 x 0.96 = 0.1728
1 kW PV system typically occupies ~6m² of roof space

Energy Yield per kW = Annual Radiation x System Efficiency x Area per kW
= 1819 kWh/m²/yr x 0.1728 x 6 m²/kW
= 1,885.93 kWh/kW-yr

Typical performance ratio is roughly 80% = 1,885.93 x 0.78 = **1,471kWh/kW-yr**

Description	Quantity	Unit Cost ($/W)	Cost (USD)	Source/Reference
PV System Size (kW)	~1,471 kW*	$2.00	$2,942,065	NREL & Solar Reviews

*Calculated: (2,094,223.38 kWh / 1,430 kWh/kW-yr approximate yield)

Average Daily Energy Use = (1,25,46,333.54 kWh/yr) / (365 days/yr)
= 34,373.51 kWh/day

A battery system typically does not aim to cover 100% daily use, but rather the most critical loads - assuming about 15% of daily energy use is critical (emergency lighting, refrigeration, IT systems, critical services)

Critical load/day = 34,373.51 x 0.15
= 5,156.02 kWh/day
= 5,000 kWh/day (approx.)

Description	Size	Unit Cost ($/kWh)	Cost (USD)	Source
Lithium-ion Battery Storage	5,000 kWh	$400.00	$2,000,000	NREL & BloombergNEF

Component	Quantity	Cost per unit	Total Cost (USD)	Source
Underground Cabling & Trenching	1.5 miles (~7920 ft)	$100/ft	$792,000	RSMeans Construction
Smart Switchgear & Microgrid Controls	1 central system	Lump Sum	$250,000	Schneider Electric
Smart Building Interface Controllers	20 units	$15,000 each	$300,000	Eaton & ABB

Average Daily Energy Use = (1,25,46,333.54 kWh/yr) / (365 days/yr) = **34,373.51 kWh/day**
Assuming the Osborne Street load profile with a 10-hour peak demand period:
Average Hourly Peak Demand = (34,373.51 kWh/day) / (10 hours/day) = **34,37.351kW**
Backup generators in microgrids typically cover critical peak loads, not full load of all buildings.
Assuming 25% of estimated peak demand as the critical load coverage = **34,37.35 kW x 0.25**
= 859.33kW = 800 kW

Description	Size	Cost per kW	Total Cost (USD)	Source
Natural Gas Backup Generator	800 kW	$900/kW	$540,000	Generac & CAT Power

Description	Percentage	Cost (USD)
Soft Costs (Eng., Legal, Mgmt.)	15%	$821,000
Project Contingency	5%	$302,000

Total Project Cost (approximate)

Category	Cost (USD)
Solar PV Installation	$2,942,065
Battery Storage	$2,000,000
Infrastructure	$1,342,000
Backup Generator	$5,40,000
Soft Costs & Contingency	$11,23,000
Total Project Cost	**$7,947,065**

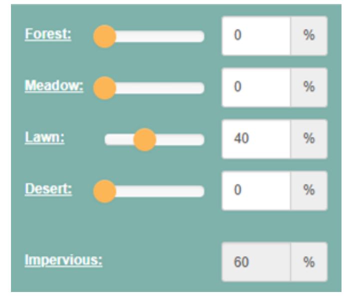
With Federal ITC @30% of (Solar PV Installation + Battery Storage) =
0.3 x (2,942,065 + 2,000,000) = $14,82,619.5

Final microgrid cost can be brought down to **$6,464,445.5 ($7,947,065 - $14,82,619.5)**

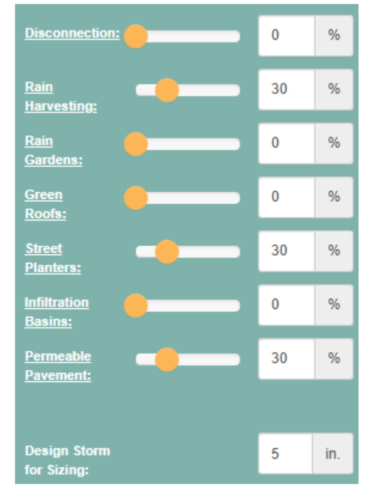
Cost per resident: **$1539.15 ($6,464,445.5/4,200 residents)**

CLIMATE CHANGE_DARIEN_ANNUAL EXTREME RAINFALL_ NEAR VS LONG TERM(2035 VS 2060)

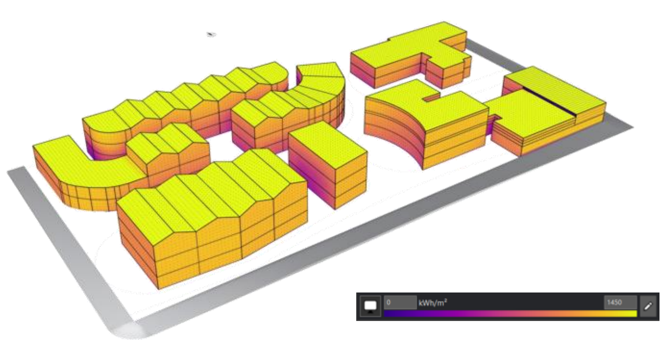
Land Cover

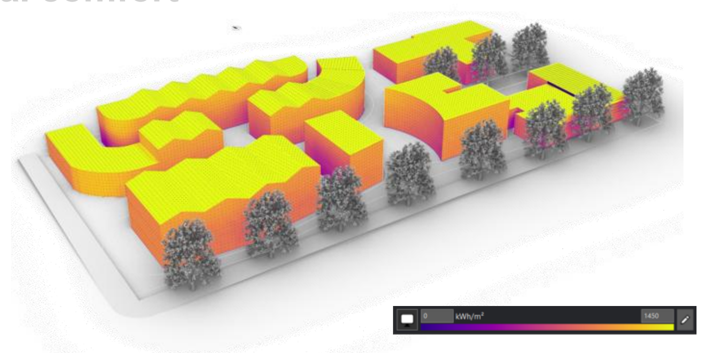


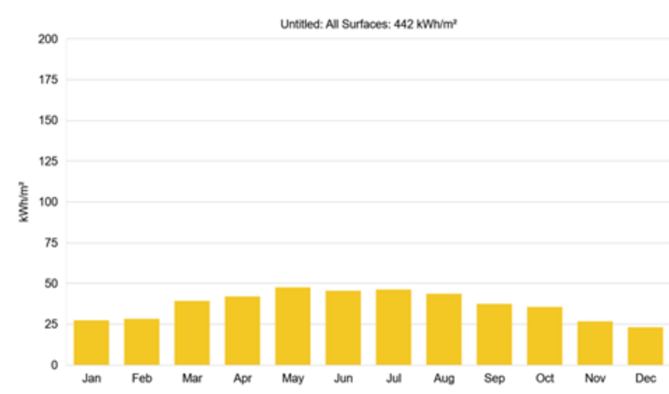
LID Controls

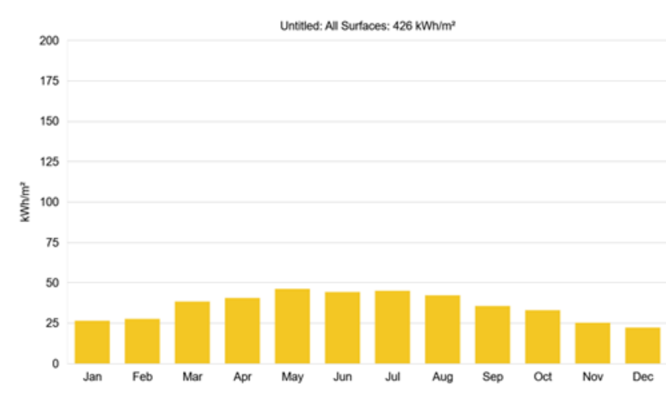


Option 1: Context Sensitive_Outdoor thermal comfort



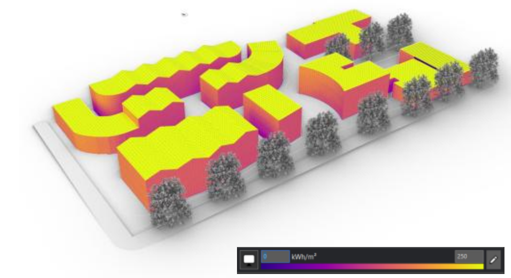


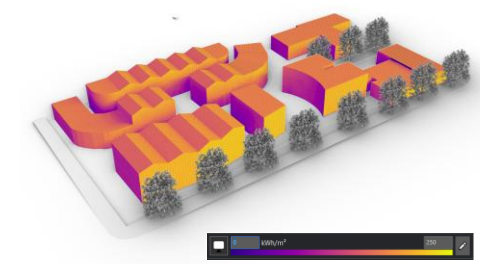


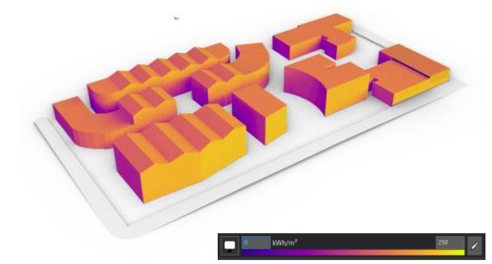


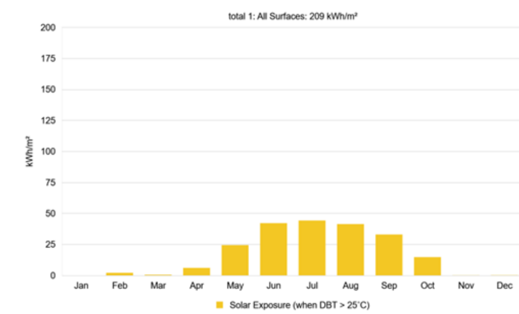
BASE CASE:
Annual, 06:00–20:00
Annual solar radiation of **442 kWh/m²/yr.**
Excess solar radiation on directly exposed south façade- requires shading device for fenestration , trees

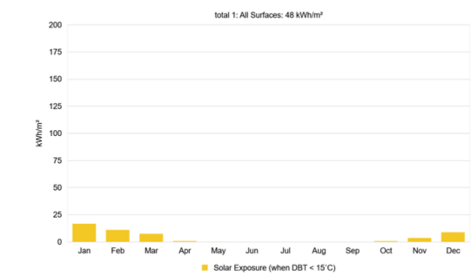
ITERATIVE CASE:
Annual, 06:00–20:00
Annual solar radiation of **426 kWh/m²/yr.**
Trees – 30' on the centre
Tall, medium density, Shed during fall

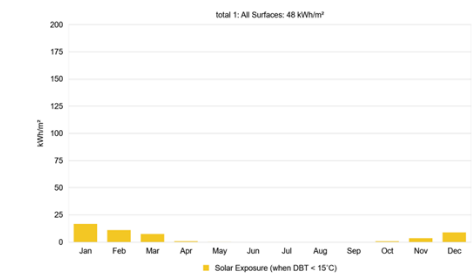










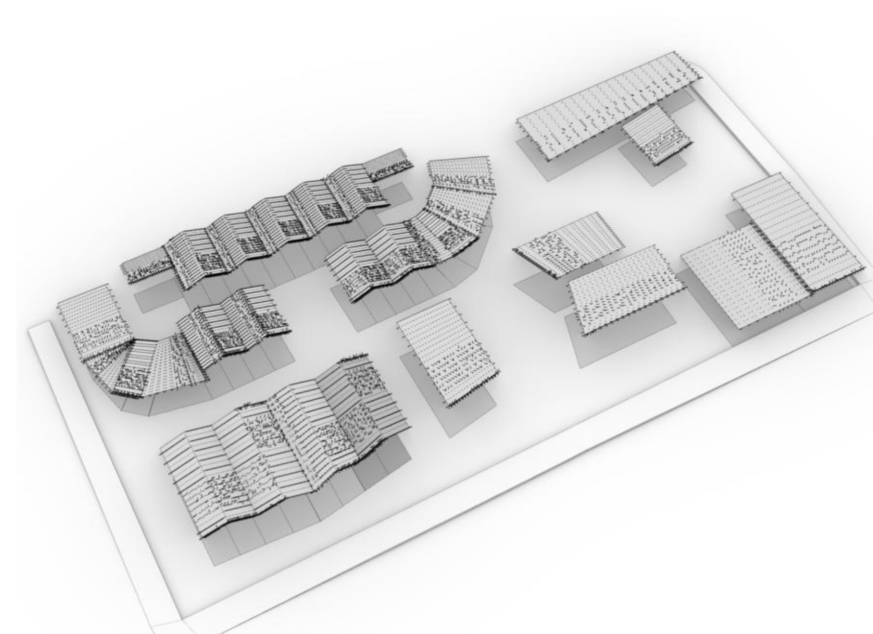


ITERATIVE CASE:
Annual, 06:00–20:00
Warm – Outdoor temp >25 deg cel
Annual solar radiation of 209 kWh/m²/yr
Comfortable range using shading.

ITERATIVE CASE:
Annual, 06:00–20:00
Warm – Outdoor temp <15 deg cel
Annual solar radiation of 48 kWh/m²/yr
With Trees
Requires more solar radiation during winters.

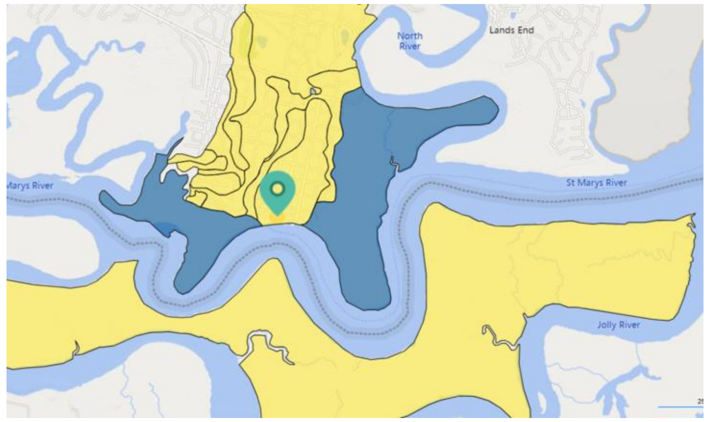
ITERATIVE CASE:
Annual, 06:00–20:00
Warm – Outdoor temp <15 deg cel
Annual solar radiation of 52 kWh/m²/yr
Without Trees - fall
Better alternative for comfortable indoors

HYDRAULIC FLOW FOR RAINWATER CATCHMENT AREA



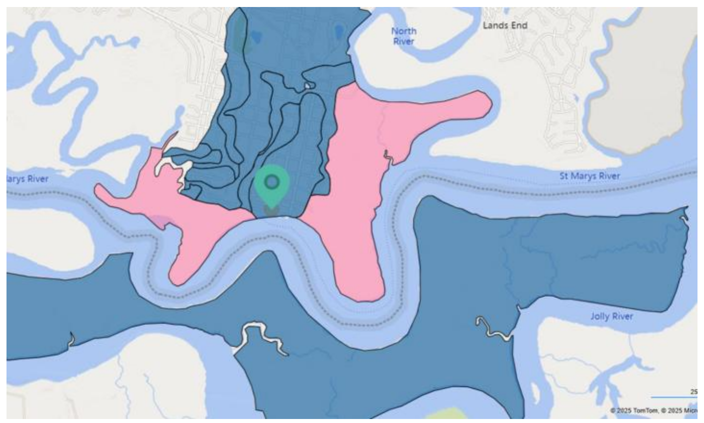
988415 gallons/year of rain water can be harvested.
15 circular cisterns of 24x20 feet would be required to storage

Calculation based on:
USA_GA_Stafford.AP-Cumberland.Island.Natl.Seashore.723210_TMYx.2004-2018.epw weather file



Soil type is identified by its Hydrologic Soil Group, a classification used by soil scientists to characterize the physical nature and runoff potential of a soil.

- Sand (Low Runoff)
- Sandy Loam (Moderately Low)
- Clay Loam (Moderately High)
- Clay (High Runoff)

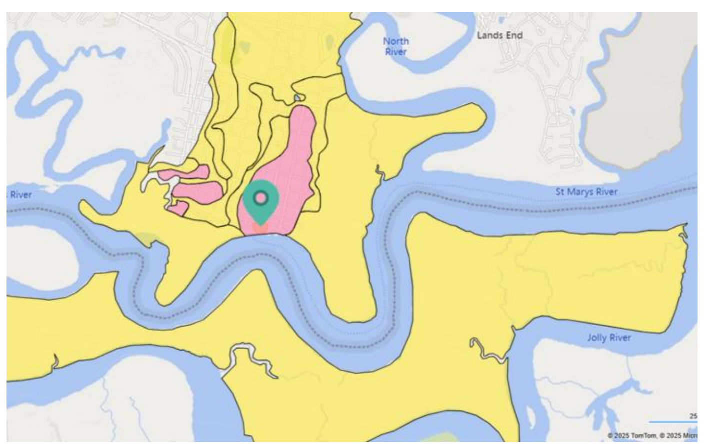


The rate at which standing **water infiltrates** into a soil is measured by its saturated hydraulic conductivity. Soils with higher conductivity produce less runoff.

- <= 0.01 inches/hour
- > 0.01 to <= 0.1 inches/hour
- > 0.1 to <= 1.0 inches/hour
- > 1 inches/hour

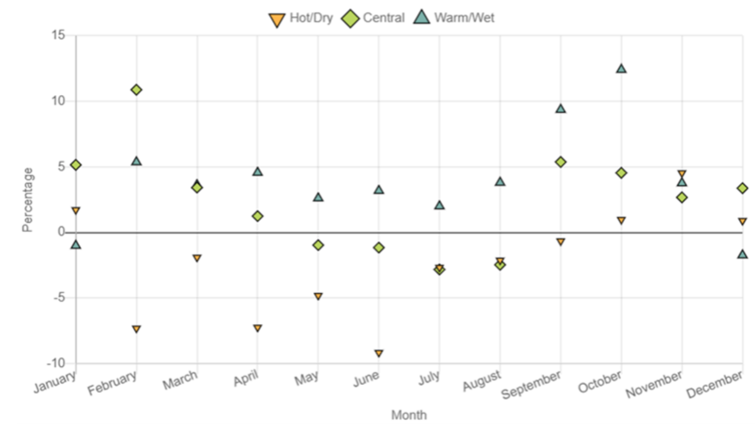
How fast does rainwater infiltrate pervious areas of your site (inches/hour)?

1.104

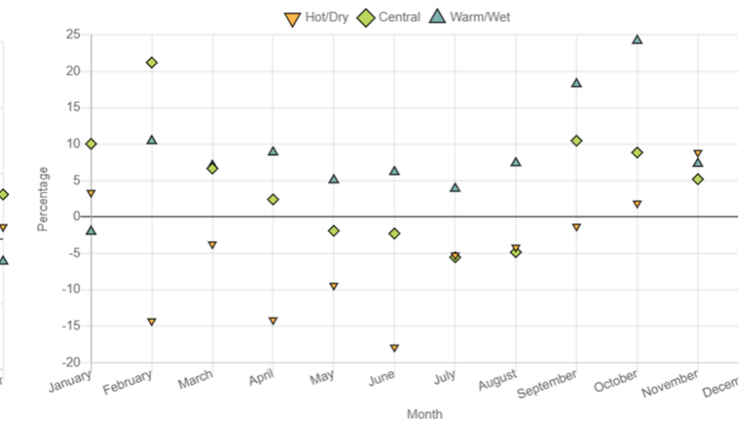


Site topography, as measured by surface slope (feet of drop per 100 feet of length), affects how fast stormwater will run off a site. Flatter slopes produce slower runoff flow rates and provide more opportunity for rainfall to infiltrate into the soil.

- Flat (2% Slope)
- Moderately Flat (5% Slope)
- Moderately Steep (10% Slope)
- Steep (Above 15% Slope)

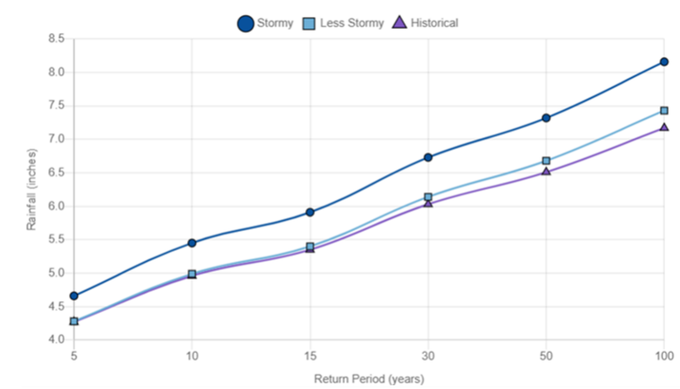


2035

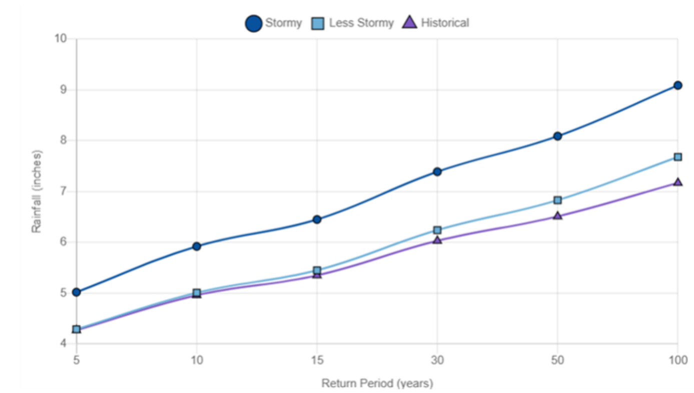


2060

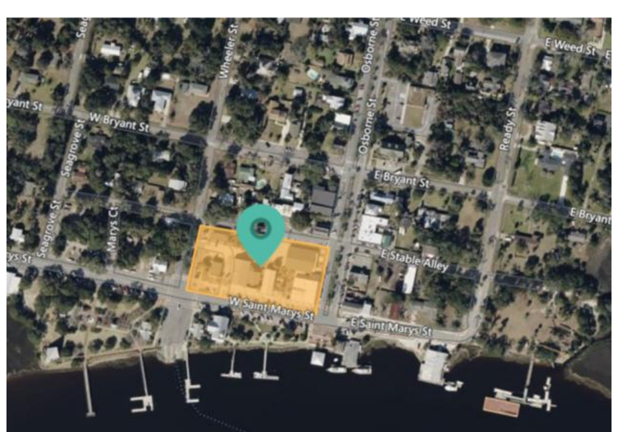
Percentage Change in Monthly Rainfall compares future monthly rainfall to the site's historical average for three different "storylines" of future climate: Hot/Dry, Central, and Warm/Wet. If a point is above the horizontal axis (zero change), it means that month is projected to become wetter compared to historical. If it's below the axis, it's projected to become drier. There is a range of possible futures (some in which rainfall decreases in certain months, and others in which it increases).

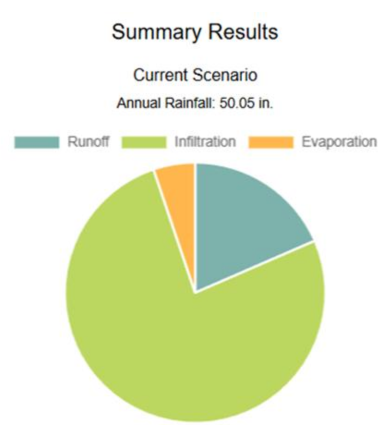


2035

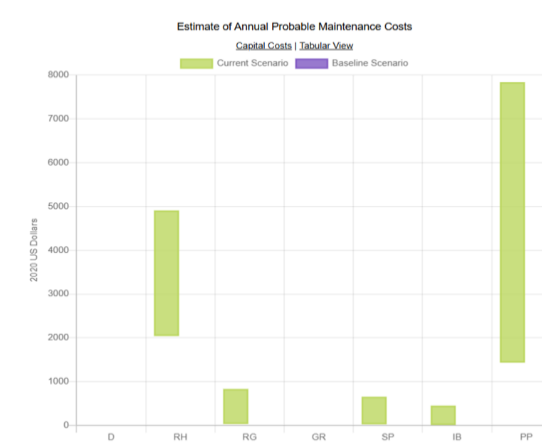


2060





Statistic	Current Scenario
Average Annual Rainfall (inches)	50.05
Average Annual Runoff (inches)	9.28
Days per Year with Rainfall	70.36
Days per Year with Runoff	19.79
Percent of Wet Days Retained	71.88
Smallest Rainfall w/ Runoff (inches)	0.42
Largest Rainfall w/o Runoff (inches)	1.03
Max Rainfall Retained (inches)	4.71



Note: site complexity variables that affect cost shown below:

	Current Scenario	Baseline Scenario
Dev. Type	Re-Development	NA
Site Suitability	Moderate	NA
Topography	Mod. Flat (5% Slope)	NA
Soil Type	A	NA
Cost Region	Atlanta(267 miles) 0.92	NA

Chart Key	
D - Disconnection	IB - Infiltration Basins
RH - Rain Harvesting	PP - Permeable Pavement
RG - Rain Gardens	
GR - Green Roofs	
SP - Street Planters	