SH-12 PSPS MICROGRID SITE REVIEW

Last Updated: 2022-Nov-30

STUDY RESULTS

A territory-wide network screening was performed using SCE's network databases to look for viable locations to site a microgrid system to mitigate the impacts of Public Safety Power Shutoff (PSPS) events. The output metric used is a ratio of the value the microgrid provides to the cost of installing and operating the microgrid for a 15-year period. Over 1,400 sites surfaced as potential microgrid sites based on a set of ranking criteria, but only 13 of those sites had a substantially high value of service to justify further review for feasibility of installing a microgrid system. Additional analysis of those sites determined that the sites with high rankings in the screen had lower cost options, like targeted underground service (TUG), to meet the desired PSPS mitigations. No viable sites were identified by the screening methodology. To justify the use of microgrids to harden these sites, an economic model for valuing resiliency is required.

SUMMARY

The goal of the SH-12 Microgrid Assessment site review was to identify sites that would benefit from having a microgrid to mitigate the impact public safety power shutoff (PSPS) have on customers. The microgrid would be used to provide resilient backup power during a PSPS event so that customers would maintain service during the event.

To assess the viability of the microgrid, a screen was performed to identify clusters of customers that were affected by PSPS events that would also be safe to energize. To judge this, SCE's system was screened to identify clusters with underground (UG) service that were fed by long overhead (OH) lines. With a cluster of safe to energize customers identified, the benefit of the microgrid was determined by using the Value of Service (VOS) as described by the Nexant 2019 Value of Service Study presented in the 2021 General Rate Case (GRC)[1]. The sites of interest were communities, or groups of customers, fed by a stretch of overhead power lines in a high-wind area that would often be impacted by PSPS – or in a high wind exposure area. Roughly 1400 sites were identified as potential microgrid sites as part of the screening. A chart illustrating the cost for the entire spectrum of sites is shown in Figure 1, where just a handful of sites are close to breaking even with the VOS they could provide.

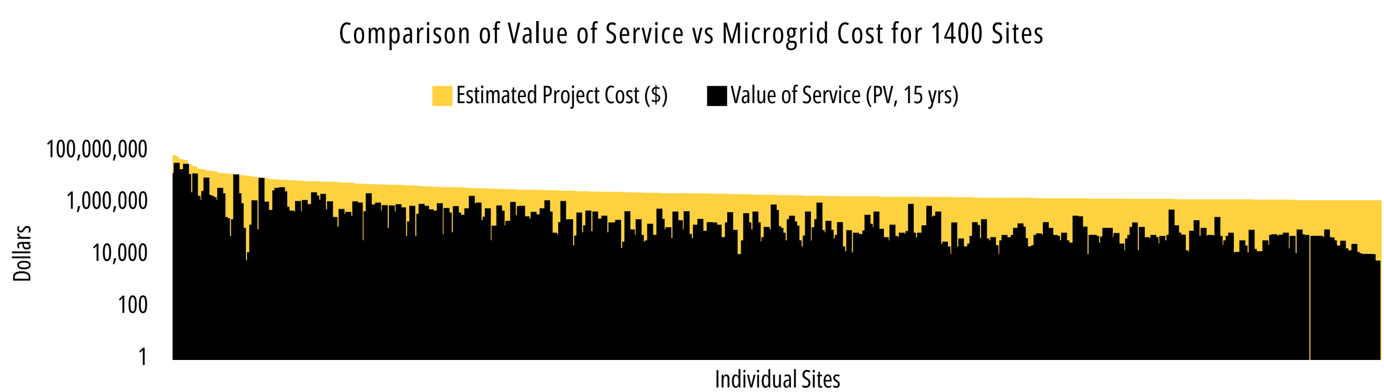

FIGURE 1 - PSPS VALUE OF SERVICE VERSUS MICROGRID COST AFTER 15-YEARS, ALL SITES

[1] Table 8-2 of Grid Modernization, Grid Technology, Energy Storage SCE-02 Volume 04, Part 01, Chapter II, Book A

The net cost for installing the microgrid was higher than the value of service it would provide to customers for most sites. Note that currently there is no accepted economic model to value the resiliency provided by a microgrid to help justify the implementation. For this study, $0.81per customer minute system-wide average cost was used to calculate the value of service. A more precise value of service may vary depending on the customer type. This system-wide average was used since often residential and commercial customers are intermingled within a community, so the system-wide average generalizes the value of service for all customers for simplicity. Regardless this assessment provides an estimate for valuing the resiliency enabled microgrids by comparing the microgrid deployment cost over its 15-year lifespan to a 15-year value-of-service it would provide to customers by mitigating the effects of PSPS events.

The 1,400 potential microgrid sites were filtered down to 13 sites in Table 1 using a variety ranking criteria that is later discussed in Table 3. A manual site review was performed to validate the feasibility of deploying the microgrid based on the configured network topology, high wind exposure area, and whether the impacted area was scoped for undergrounding. Five of the thirteen sites were already in scope for Targeted Undergrounding (TUG), and the remaining sites were not in scope for TUG, but TUG was estimated to be more cost-effective than a microgrid deployment based on a quick overhead line analysis using Cyme.

TABLE 1 - MICROGRID SCOPING SUMMARY

Benefit/Cost of Microgrid vs Value of Service	Site Name	15-yr Value of Service ($, millions)	Microgrid Project Cost ($, millions)	TUG Cost ($, millions)	TUG Length (miles)	Microgrid Recommendation
1.04	ACOSTA_201573752	$9.0	[redacted]	$1.8	0.46	Already in scope for TUG, and TUG recommended.
0.97	ACOSTA_94366516	$0.7	[redacted]	$3.0	0.75	Already in scope for TUG, and TUG recommended.
0.73	ACOSTA_167114014	$23.1	[redacted]	$1.3	0.32	Already in scope for TUG, and TUG recommended.
0.59	ENERGY_220356310	$6.6	[redacted]	$0.9	0.23	Already in scope for TUG, and TUG recommended.
0.55	ZONE_182277926	$6.7	[redacted]	$5.0	1.25	Not in-scope for TUG, but TUG recommended.
0.53	CASMALIA_207288687	$25.0	[redacted]	$0.7	0.19	Not in-scope for TUG, but TUG recommended.
0.55	CASMALIA_191032341	$9.7	[redacted]			
0.51	PETIT_13364021	$0.7	[redacted]	$3.0	0.75	Not in-scope for TUG, but TUG recommended.
0.51	TWIN_LAKES_42074340	$1.4	[redacted]	$5.8	1.45	Already in scope for TUG, and TUG recommended.
0.54	SAND_CANYON_23324285	$2.9	[redacted]	$7.3	1.82	Not in-scope for TUG, but TUG recommended.
0.48	SAND_CANYON_23323452	$9.4	[redacted]			
0.43	SWEETWATER_57590628	$2.7	[redacted]	$11.1	2.77	Not in-scope for TUG, but TUG recommended.
0.44	SWEETWATER_57590014	$14.2	[redacted]			

One challenge in analyzing the results produced by the microgrid scoping algorithm was that the identified locations for microgrids would only island a portion of a feeder impacted by PSPS outages. Acosta, for example, was one of the more cost-effective microgrids identified (in two separate locations) from Table 1, but after examining the physical location of the microgrid its part of a broader area that is disconnected during a PSPS event. Installing a microgrid at this single-family housing development will not mitigate the broader impact of PSPS for other customers downstream of this segment.

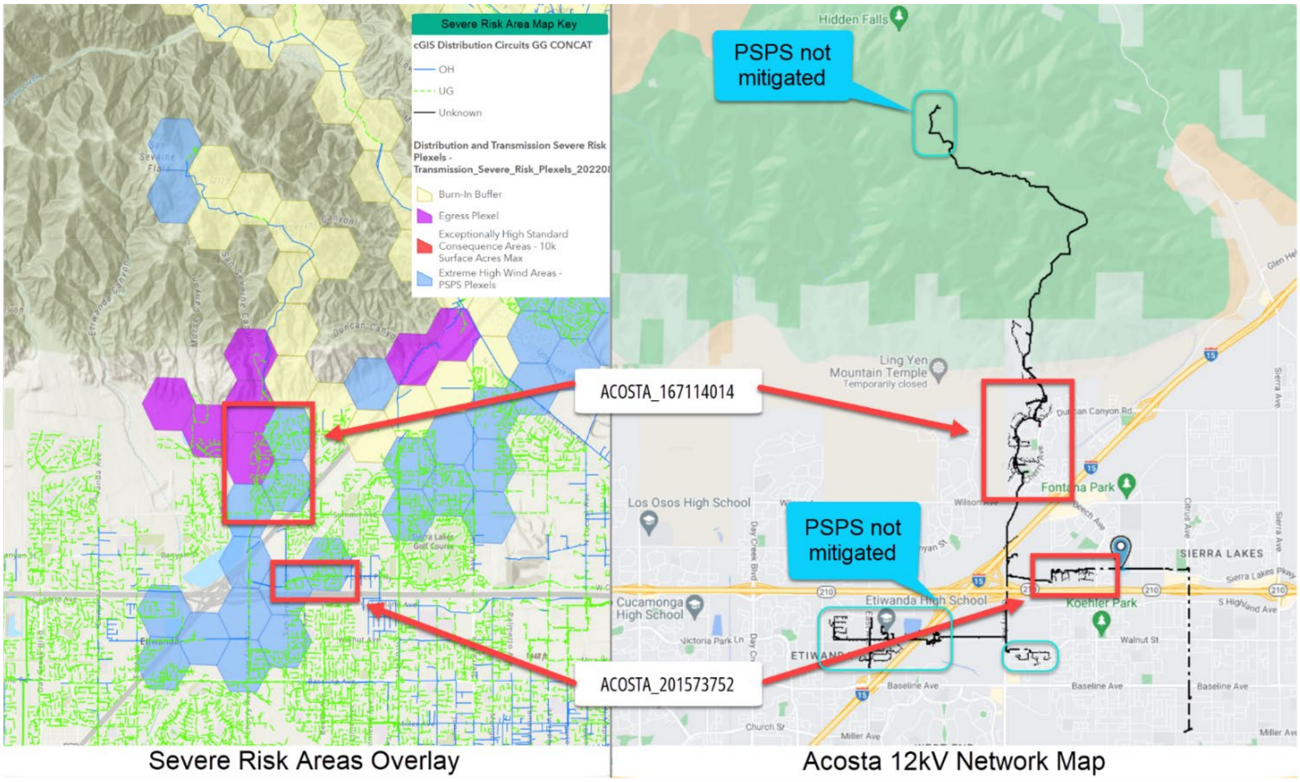

FIGURE 2 - MICROGRID LOCATIONS ARE OFTEN SUBSET OF CUSTOMERS IMPACTED BY PSPS

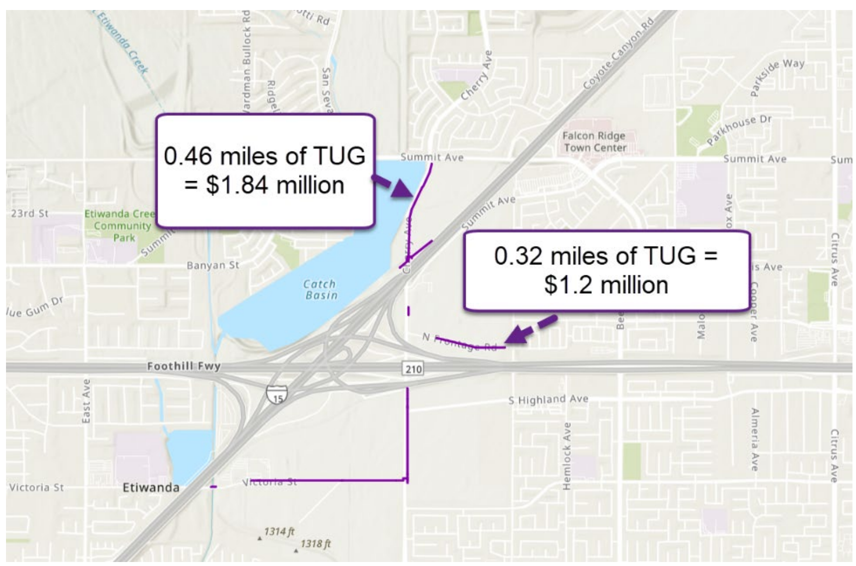

FIGURE 3 - TUG COSTS COMPARISON FOR ACOSTA 12KV SITES

One possible solution would be to install a larger microgrid to serve all customers impacted within the PSPS area. The blue encircled areas in Figure 2 had a benefit-to-cost ratio of 0.21, indicating that the proposed microgrid would be five times more costly than the value of service of those microgrids. This is where comparing the cable hardening costs for these sites to the microgrid deployment costs would be the deciding factor for whether to move forward with a microgrid solution. In this instance, the targeted undergrounding for the two top-segments of Acosta is $3.12 million (see Figure 3) versus [redacted] for the microgrid solution. This was often the trend in evaluating these sites, and based on this information, the Grid Edge Analytics and Controls team would not recommend pursing any of these sites when targeted undergrounding alternatives are more cost-effective. With that being said, the grid hardening group should evaluate these results, and verify that these TUG cost estimates are reasonable before this microgrid scoping study is finalized.

MICROGRID SITE SCOPING RESULTS

The site locations are shown in Figure 4, where the larger bubbles have a higher benefit-to-cost ratio. Most sites were in more sub-urban areas within the service territory (refer to Figure 5), which tend to have higher concentrations of high wind exposure areas impacted by PSPS.

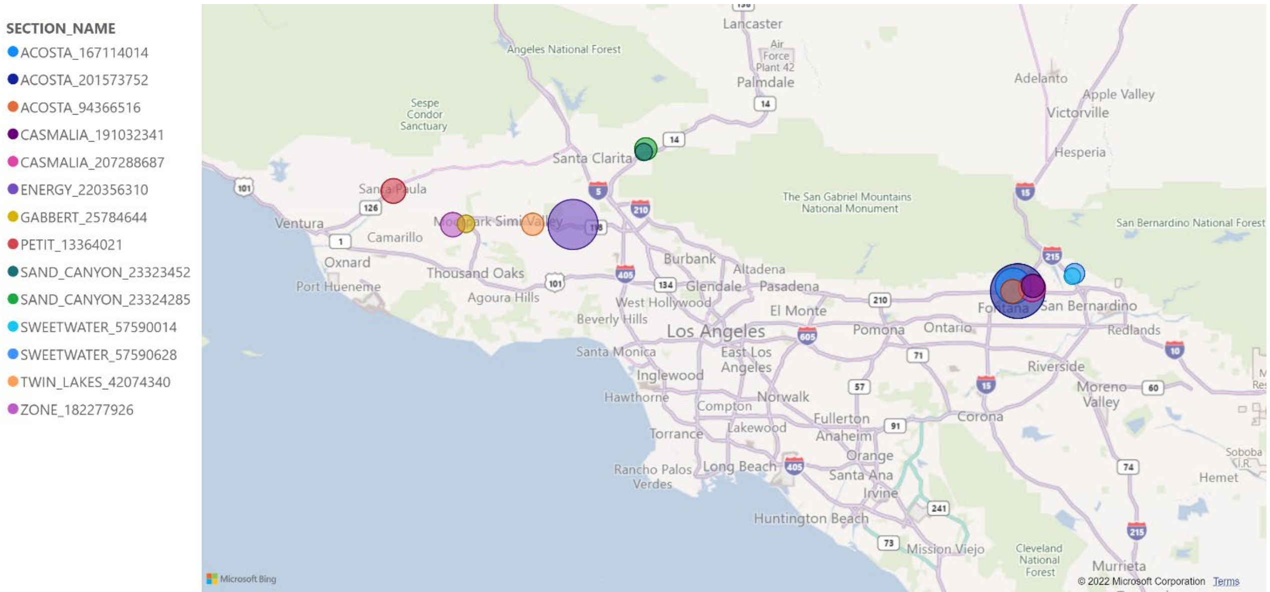

FIGURE 4 - TOP MICROGRID SITES

The severe risk area maps highlight several different categories of risk in Figure 5. Extreme high wind areas, the primary areas of focus in this microgrid scoping study, can see sustained winds of 40 miles-per-hour or higher, which would trigger a PSPS event for any overhead lines in that area. Burn-in buffer areas indicate that a fire event in this area may burn into the egress area thereby trapping the occupants. Egress areas have a lack of road availability and time to evacuate in the event of a fire. Exceptionally high standard consequence areas have a high fire growth potential, and a fire in this area may grow into 10,000 acres, or more, in 8 hours.

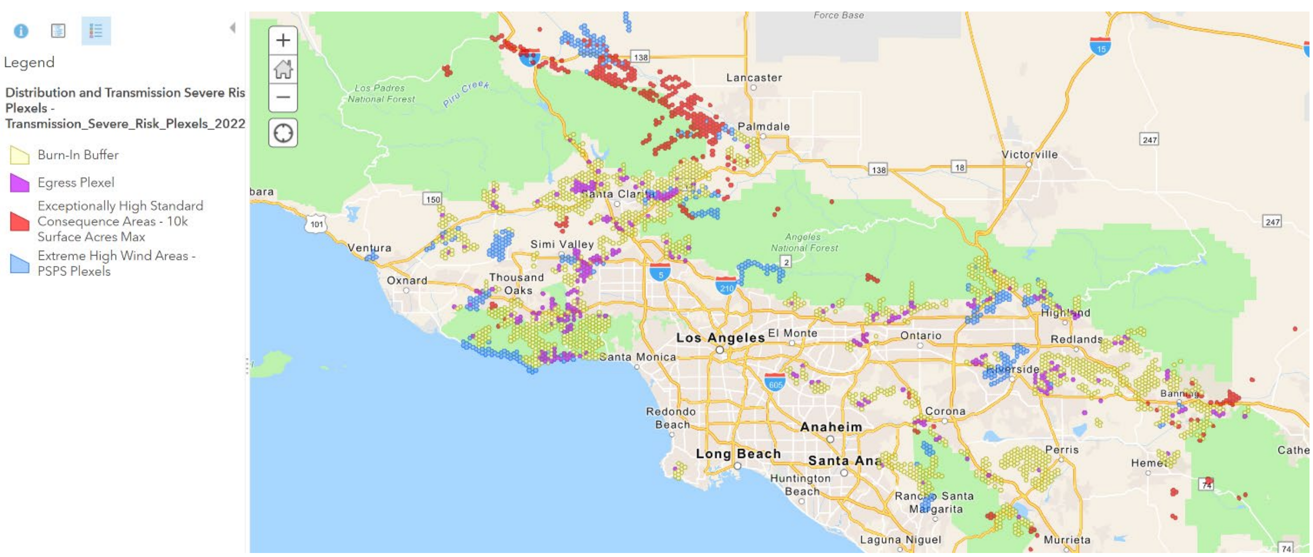

FIGURE 5 - SEVER RISK AREAS IN MICROGRID

The value of service for these potential sites was assumed to be $0.81 per customer minute of interruption, which is the system-wide average for Southern California Edison's service territory. The assets proposed for these microgrid sites would be a 6-hour battery energy storage system used as the primary islanding resource, and a backup internal combustion engine (ICE) generator if the PSPS duration exceeds the battery's 6-hour storage capacity.

CUSTOMER SITE PROFILE

The site-specific information for these scoped microgrids sites is shown in Table 2, and are ranked by their benefit-to-cost ratio. Higher benefit-to-cost ratios indicate that the value of service of avoiding PSPS outages for this site makes up for the cost of the microgrid after 15-years.

TABLE 2 - CUSTOMER SITE PROFILE

Benefit/Cost Ratio	SECTION NAME	Avg Daily Energy (kWh)	Peak Demand (kW)	Avg load (kW)	Line Segment ID	Latitude	Longitude	Community Resiliency Metric
1.04	ACOSTA_201573752	4712.1	1063.7	196.3	ND201573748$4623566E	34.1395151	-117.4747122	Not Found
0.97	ENERGY_220356310	3126.1	866.6	130.3	3005347E$GS8084-1	34.278987	-118.6026625	Not Found
0.73	ACOSTA_167114014	16225.0	4511.8	676.0	532E$GS6140-3	34.1502718	-117.4863256	Not Found
0.59	CASMALIA_207288687	26669.7	5679.8	1111.2	GS6179-4$4887274EPH	34.1458113	-117.4381486	Not Found
0.55	ZONE_182277926	6321.9	1701.6	263.4	2115918E$ND182277921	34.2786151	-118.9074122	27.8
0.53	CASMALIA_191032341	11990.1	2268.7	499.6	6123E$GS6024-5	34.1505351	-117.4360145	Not Found
0.55	PETIT_13364021	315.7	54.4	13.2	FD39135$BS2282-T	34.3491628	-119.058097	15.5
0.51	SAND_CANYON_23324285	2922.2	661.8	121.8	1123585E$23302949	34.4369901	-118.4178755	34.2
0.51	TWIN_LAKES_42074340	1342.4	219.7	55.9	1662574EPH$BS6651-1	34.2794913	-118.7047757	29.8
0.54	ACOSTA_94366516	291.8	29.9	12.2	ND94366525$598E	34.138854	-117.4877614	Not Found
0.48	SWEETWATER_57590628	3922.2	563.2	163.4	PMH4068-1$666E	34.1763936	-117.3303035	18.4
0.43	SAND_CANYON_23323452	16259.6	2407.9	677.5	4544201E$GS7835-3	34.4305585	-118.4230965	34.2
0.42	SWEETWATER_57590014	23191.3	4458.6	966.3	833E$GS1887-2	34.1706036	-117.3361246	20.5

RANKING METHODOLOGY

Roughly 9,500 sites identified and were then ranked based on the following line segment ranking criteria shown in Table 3. They were then filtered based on the number of downstream customers, years to break even on their value of service versus capital expenditure, and number of outages to break even for installing their battery. The number of downstream customers were filtered to have 15 or more customers to ensure that this microgrid was serving more than a handful of customers. Sites were also filtered such that their battery capital expenditure costs for the microgrid would break even with the value of service after 7 years to prioritize higher value sites. Finally, sites were filtered to have 10 outages or less for the battery capital costs to break even with the value of service to avoid selecting sites with an unrealistically larger number of outages required to make financial sense.

TABLE 3 - RANKING CRITERIA DESCRIPTIONS

Line Segment Ranking Criteria	• **UPSTREAM LENGTH:** Distance from substation (lollipop). Longer is better since radial power lines further from the substation increase the amount of exposure and therefore the probability the area will be impacted by PSPS. • **CIRCUIT OVERHEAD LENGTH:** Total overhead (OH) conductor on circuit. Longer is better UPSTREAM LENGTH. • **CUSTOMERS:** Number of customers fed by overhead lines. Higher is better since larger communities impacted by PSPS may benefit more in terms of value of service provided with a microgrid. • **NUMBER OF OUTAGES TO BREAKEVEN:** Number of 24-hour outages for Value of service to equal BESS Capital Expenditure. Lower is better since the return-on-investment period is lower on the battery. • **PSPS DURATION:** Total of PSPS outage durations. Higher is better since those are areas more impacted by longer, or more frequent PSPS outages.
Customer PSPS Filtering Criteria	• **Greater than 15 downstream customers** in the affected area • **Less than 7 years to break-even** on Value of Service versus battery capital expenditure • **Less than 10 outages required to break-even** on the cost of installing a battery

The individual line segment and PSPS metrics are shown in Table 4 for the top-sites, ranked by their benefit-to-cost ratio. The benefit-to-cost ratio is determined by dividing the 15-year value of service by the total project cost for the microgrid, which represents how much SCE would save customers keeping them online during a PSPS event.

TABLE 4 - PSPS IMPACT AND VALUE OF SERVICE PER SITE

Benefit/Cost Ratio	SECTION NAME	UPSTREAM LENGTH (ft)	Customers	No Outages Break Even	PSPS Duration (hrs)	Years to Break Even	Total Project Cost ($, millions)	15-year Value of Service ($, millions)
1.04	ACOSTA_201573752	14,162	204	15	119	3.0	[redacted]	$9.0
0.97	ENERGY_220356310	51,659	148	16	120	3.2	[redacted]	$6.6
0.73	ACOSTA_167114014	26,619	525	24	119	4.8	[redacted]	$23.1
0.59	CASMALIA_207288687	13,824	745	22	91	5.8	[redacted]	$25.0
0.55	ZONE_182277926	2,218	258	19	71	6.5	[redacted]	$6.7
0.53	CASMALIA_191032341	15,450	290	22	91	5.8	[redacted]	$9.7
0.55	PETIT_13364021	10,004	29	4	69	1.4	[redacted]	$0.7
0.51	SAND_CANYON_23324285	7,536	84	23	93	5.9	[redacted]	$2.9
0.51	TWIN_LAKES_42074340	3,971	129	6	28	5.1	[redacted]	$1.4
0.54	ACOSTA_94366516	21,722	15	6	119	1.2	[redacted]	$0.7
0.48	SWEETWATER_57590628	2,625	187	10	39	6.1	[redacted]	$2.7
0.43	SAND_CANYON_23323452	11,661	274	27	93	7.0	[redacted]	$9.4
0.44	GABBERT_25784644	30,519	131	9	35	6.2	[redacted]	$1.7
0.42	SWEETWATER_57590014	5,099	974	14	39	8.5	[redacted]	$14.2

DEPLOYMENT COSTS

The total microgrid costs for the top microgrid sites are shown in Figure 6, where the ENERGY_220356310 and ACOSTA_201573752 had the highest benefit-to-cost ratio of 0.97 and 1.04 respectively. The remaining sites had between a 0.4 to 0.7 benefit-to-cost ratio and were included since there may be a high margin of error for valuing the resiliency provided by a microgrid. All remaining sites had a less than 0.4 benefit-to-cost ratio.

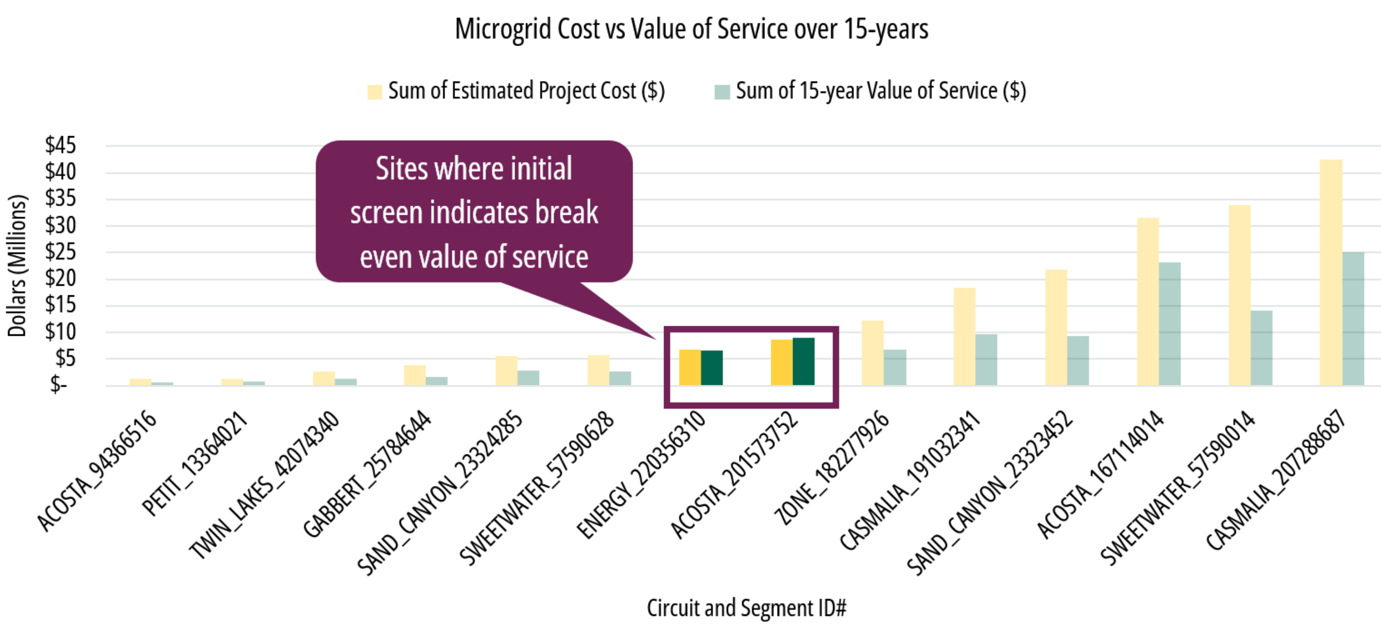

FIGURE 6 – TOP 10 MICROGRID SITES BASED ON FILTERING CRITERIA

Figure 7 shows that the driving factor to the high cost to deploy microgrids are the project deployment cost, which includes the added civil work, information technology (IT) costs, project management, and contingency costs. This project deployment cost is on average 76% higher than the overall capital expenditure and lifetime operations and maintenance cost of the microgrid. These costs can decrease over time as microgrid deployments become more standardized.

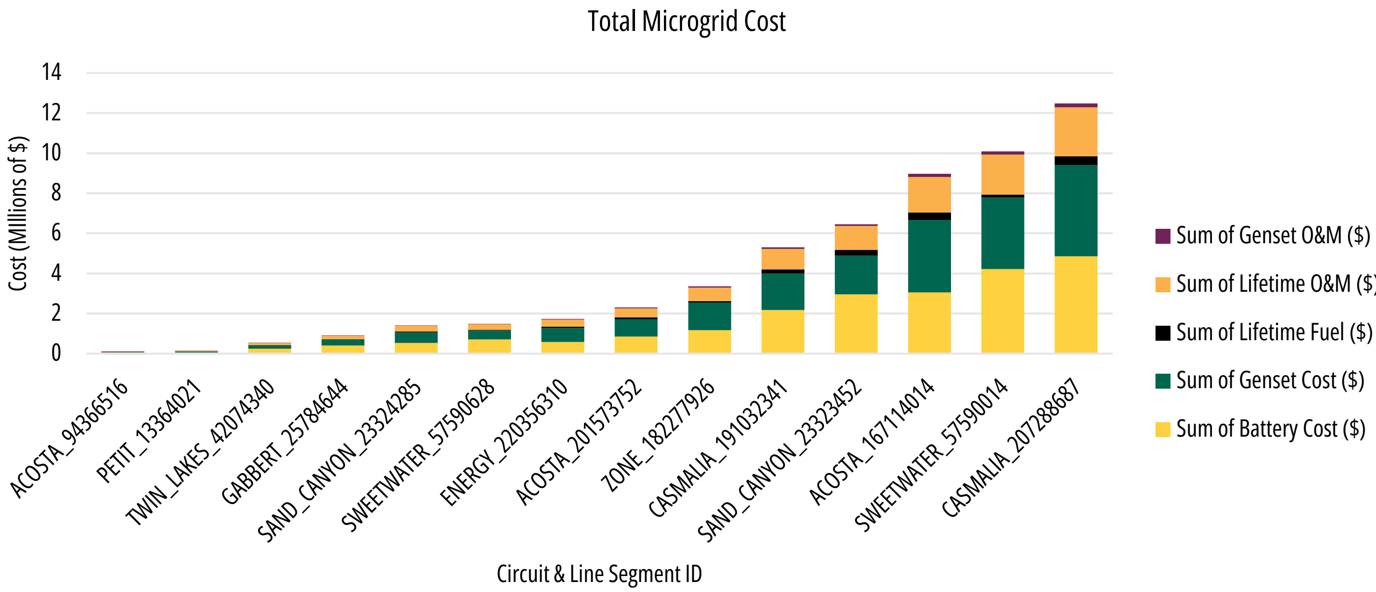

FIGURE 7 - TOTAL MICROGRID COST FOR TOP 10 MICROGRID SITES

Once the sites were identified the cost of deploying microgrid assets were calculated and compared to the value of service for eliminating the PSPS events experienced by customers at these sites. The battery deployment cost in Table 5 shows the battery energy and power capacity, land usage required to install the battery, battery cost operations and maintenance (O&M) cost over the lifetime of the battery, and finally the revenue the battery is projected to make if aggregated into a 100 kW, or larger, cluster of distributed energy resources. Providing services through the California Independent System Operator (CAISO) market were valued at $1,121 per kilowatt, which was calculated from the previous PSPS microgrid site proposal for 15-year NPV of BESS CAISO revenue at 10.5% discount rate. The general trend in Table 5 is that all deployment cost of the battery increases proportional to the average and peak demand at the site from Table 2.

TABLE 5 - BATTERY DEPLOYMENT COST

Benefit/Cost Ratio	SECTION NAME	Battery Energy (kWh)	Battery Land Use (sq-ft)	Battery Power (kW)	Battery Cost	Battery O&M Cost ($)	CAISO Revenue ($)
1.04	ACOSTA_201573752	1178.0	654.5	1178.0	$857,606	$21,440	$1,320,795
0.97	ENERGY_220356310	781.5	434.2	866.6	$588,346	$14,709	$876,249
0.73	ACOSTA_167114014	4056.3	2253.5	4511.8	$3,056,817	$76,420	$4,547,829
0.59	CASMALIA_207288687	6667.4	3704.1	6667.4	$4,853,892	$121,347	$7,475,461
0.55	ZONE_182277926	1580.5	878.0	1701.6	$1,178,211	$29,455	$1,772,019
0.53	CASMALIA_191032341	2997.5	1665.3	2997.5	$2,182,193	$54,555	$3,360,788
0.55	PETIT_13364021	78.9	43.8	78.9	$57,456	$1,436	$88,488
0.51	SAND_CANYON_23324285	730.5	405.9	730.5	$531,835	$13,296	$376,264
0.51	TWIN_LAKES_42074340	335.6	186.4	335.6	$244,312	$6,108	$81,795
0.54	ACOSTA_94366516	73.0	40.5	73.0	$53,110	$1,328	$1,099,388
0.48	SWEETWATER_57590628	980.6	544.8	980.6	$713,843	$17,846	$819,078
0.43	SAND_CANYON_23323452	4064.9	2258.3	4064.9	$2,959,242	$73,981	$4,557,517
0.42	SWEETWATER_57590014	5797.8	3221.0	5797.8	$4,220,820	$105,520	$6,500,468

Similarly, the deployment costs to install a backup diesel generator for these sites is also shown in Table 6, with the size, generator cost, fuel, and maintenance costs itemized.

TABLE 6 - DIESEL GENERATOR DEPLOYMENT COSTS

Benefit/Cost Ratio	SECTION NAME	Genset size (kW)	Genset Cost ($)	Fuel Annual ($)	Lifetime Fuel ($)	Genset O&M ($)
1.04	ACOSTA_201573752	1,064	$850,922	$14,218	$108,143	$37,228
0.97	ENERGY_220356310	867	$693,259	$9,530	$72,485	$30,330
0.73	ACOSTA_167114014	4,512	$3,609,443	$48,956	$372,365	$157,913
0.59	CASMALIA_207288687	5,680	$4,543,848	$60,297	$458,626	$198,793
0.55	ZONE_182277926	1,702	$1,361,303	$10,885	$82,792	$59,557
0.53	CASMALIA_191032341	2,269	$1,814,960	$27,108	$206,187	$79,404
0.55	PETIT_13364021	54	$43,528	$531	$4,038	$1,904
0.51	SAND_CANYON_23324285	662	$529,456	$6,786	$51,614	$23,164
0.51	TWIN_LAKES_42074340	220	$175,784	$803	$6,108	$7,691
0.54	ACOSTA_94366516	30	$23,906	$880	$6,697	$1,046
0.48	SWEETWATER_57590628	563	$450,594	$3,488	$26,531	$19,713
0.43	SAND_CANYON_23323452	2,408	$1,926,353	$37,758	$287,193	$84,278
0.42	SWEETWATER_57590014	4,459	$3,566,917	$20,625	$156,874	$156,053

Combining the battery, diesel generator, and other deployment costs together we can compare the lifetime microgrid costs to the value of service for mitigating PSPS events for these sites over the 15-year analysis period. The results are shown in Table 7, where the system cost (including O&M) of the battery and generator, and deployment cost of the microgrid, and estimated CAISO revenue equate to the total project cost. The 15-year net microgrid cost is the sum of the total project cost, potential CAISO revenue, and 15-year value of service.

TABLE 7 - TOTAL MICROGRID DEPLOYMENT COST

Benefit/Cost Ratio	SECTION NAME	System Cost ($)	Project Deployment Cost (PV, 15 years)	CAISO Revenue ($)	Total Project Cost ($)	15-yr Value of Service ($)	15-year ROI ($)
1.04	ACOSTA_201573752	$2,362,904	[redacted]	$1,320,795	[redacted]	$8,985,068	[redacted]
0.97	ENERGY_220356310	$1,796,659	[redacted]	$876,249	[redacted]	$6,582,406	[redacted]
0.73	ACOSTA_167114014	$8,920,985	[redacted]	$4,547,829	[redacted]	$23,123,335	[redacted]
0.59	CASMALIA_207288687	$12,391,382	[redacted]	$7,47b5,461	[redacted]	$25,001,124	[redacted]
0.55	ZONE_182277926	$3,399,340	[redacted]	$1,772,019	[redacted]	$6,730,021	[redacted]
0.53	CASMALIA_191032341	$5,322,245	[redacted]	$3,360,788	[redacted]	$9,731,981	[redacted]
0.55	PETIT_13364021	$230,432	[redacted]	$88,488	[redacted]	$740,395	[redacted]
0.51	SAND_CANYON_23324285	$1,490,221	[redacted]	$819,078	[redacted]	$2,890,336	[redacted]
0.51	TWIN_LAKES_42074340	$631,156	[redacted]	$376,264	[redacted]	$1,355,859	[redacted]
0.54	ACOSTA_94366516	$201,767	[redacted]	$81,795	[redacted]	$660,667	[redacted]
0.48	SWEETWATER_57590628	$1,576,650	[redacted]	$1,099,388	[redacted]	$2,720,091	[redacted]
0.43	SAND_CANYON_23323452	$6,476,519	[redacted]	$4,557,517	[redacted]	$9,428,001	[redacted]
0.42	SWEETWATER_57590014	$10,034,157	[redacted]	$6,500,468	[redacted]	$14,167,748	[redacted]

INDIVIDUAL SITE RESULTS

The section below is a summary of the manual site screening results of the top 13 sites and the rationale for not recommending the site for microgrid deployment. None of the sites were strong candidates for microgrids. All TUG estimates assume that it costs $4 million to underground 1 mile of overhead power lines.

ACOSTA_201573752, 167114014 AND 94366516

Already in scope for TUG, and TUG recommended instead of microgrid. Installing a microgrid at these single-family housing developments will not mitigate the broader impact of PSPS for other customers impacted on Acosta, as shown in Figure 2.

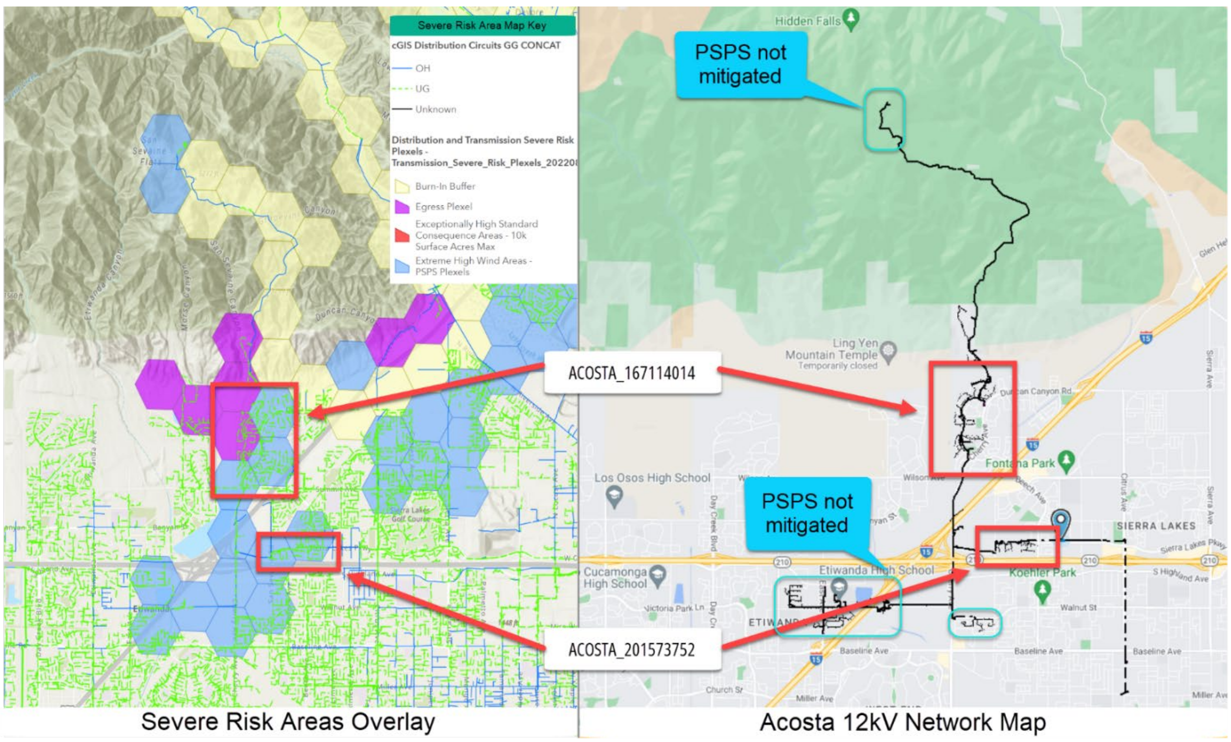

FIGURE 8 - MICROGRID LOCATIONS ARE OFTEN SUBSET OF CUSTOMERS IMPACTED BY PSPS

From Figure 9, the targeted undergrounding for the two top-segments of Acosta is $3.12 million versus [redacted] for the microgrid solution.

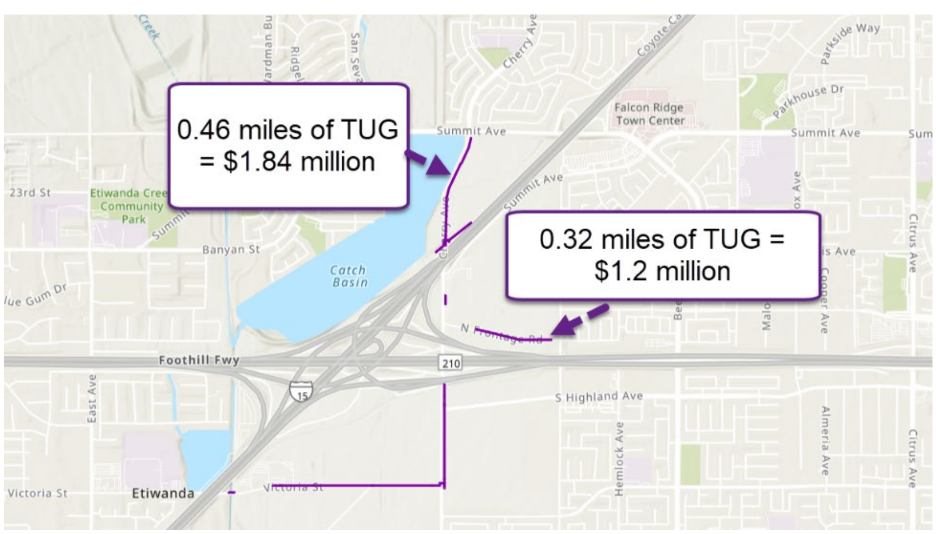

FIGURE 9 - TUG SEGMENTS OF ACOSTA 12KV

ENERGY_220356310

Already in scope for TUG, and TUG recommended instead of microgrid. Need clarification from grid hardening group as to whether TUG scope is supposed to address PSPS in on ENERGY_220356310 since this community is not within a high wind plexels. Regardless of its plexel location, there is an overhead line segment in scope for TUG which should address PSPS for this community as shown in Figure 10. This 0.23-mile length of overhead line is estimated to cost $920K to underground compared to [redacted] to deploy a microgrid, which means the TUG in scope should be more cost effective.

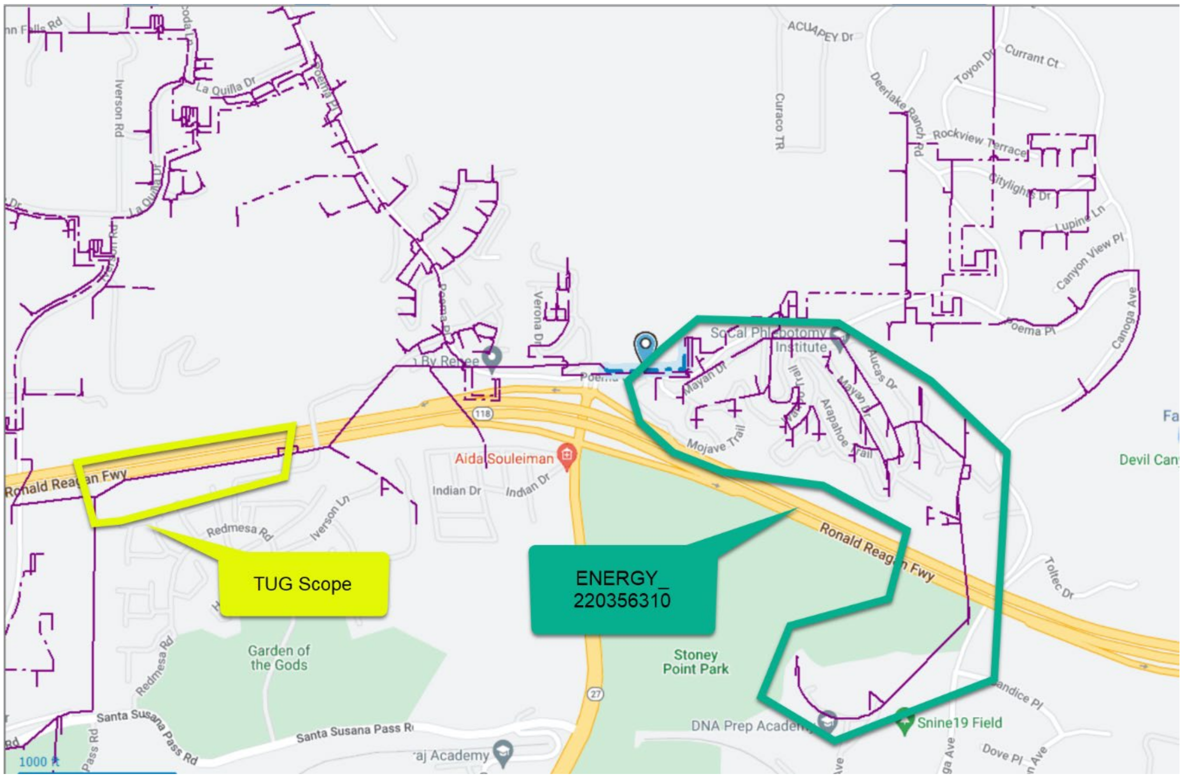

FIGURE 10 - NETWORK MAP OF ENERGY_220356310

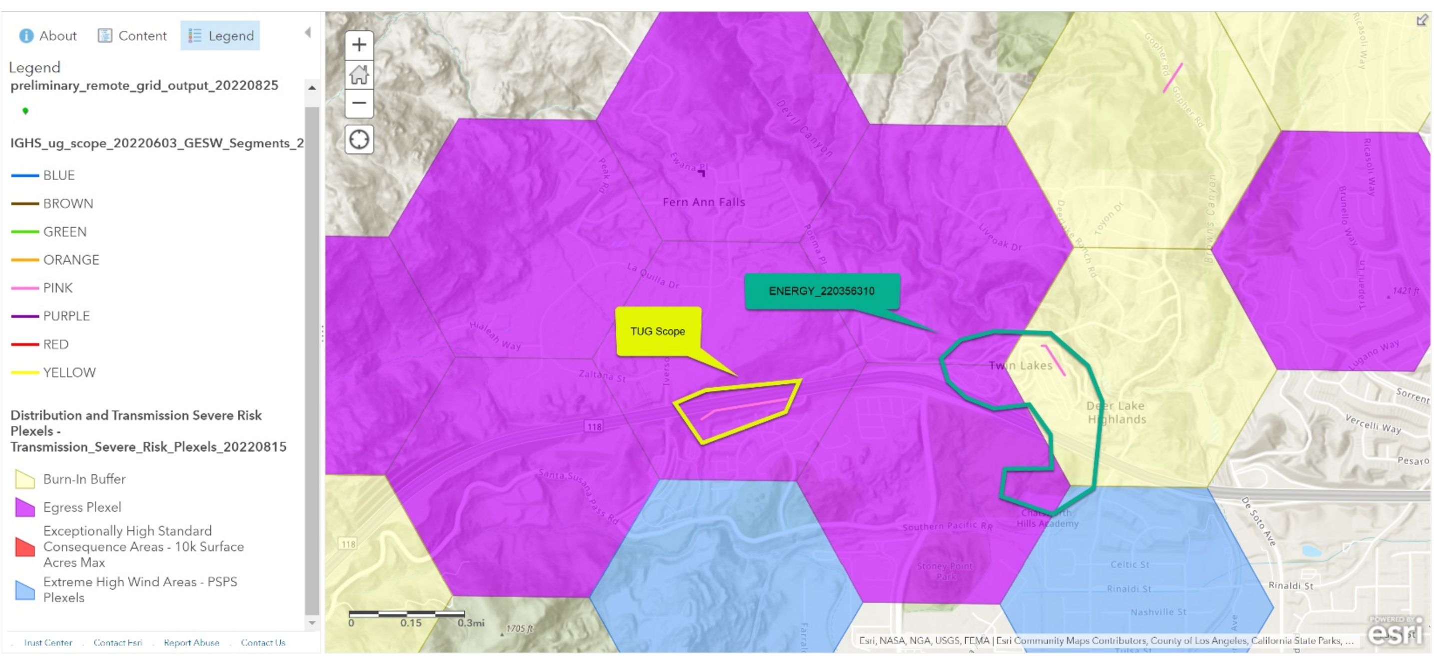

FIGURE 11 - SEVERE RISK MAP OF ENERGY_220356310

ZONE_182277926

Not in-scope for TUG, but TUG recommended instead of microgrid. Overhead lines feeding ZONE_182277926 end at this community, which happens to be within a single high-wind PSPS plexel. The estimated microgrid deployment cost is [redacted], but TUG could be a more cost-effective alternative at an estimated $5 million to underground the 1.25 miles of overhead line in this high wind plexel. This would also serve to benefit other customers outside the ZONE_182277926, but still within the high wind plexel. Note that TUG is not currently in-scope for this location.

FIGURE 12 - NETWORK MAP FOR ZONE_182277926

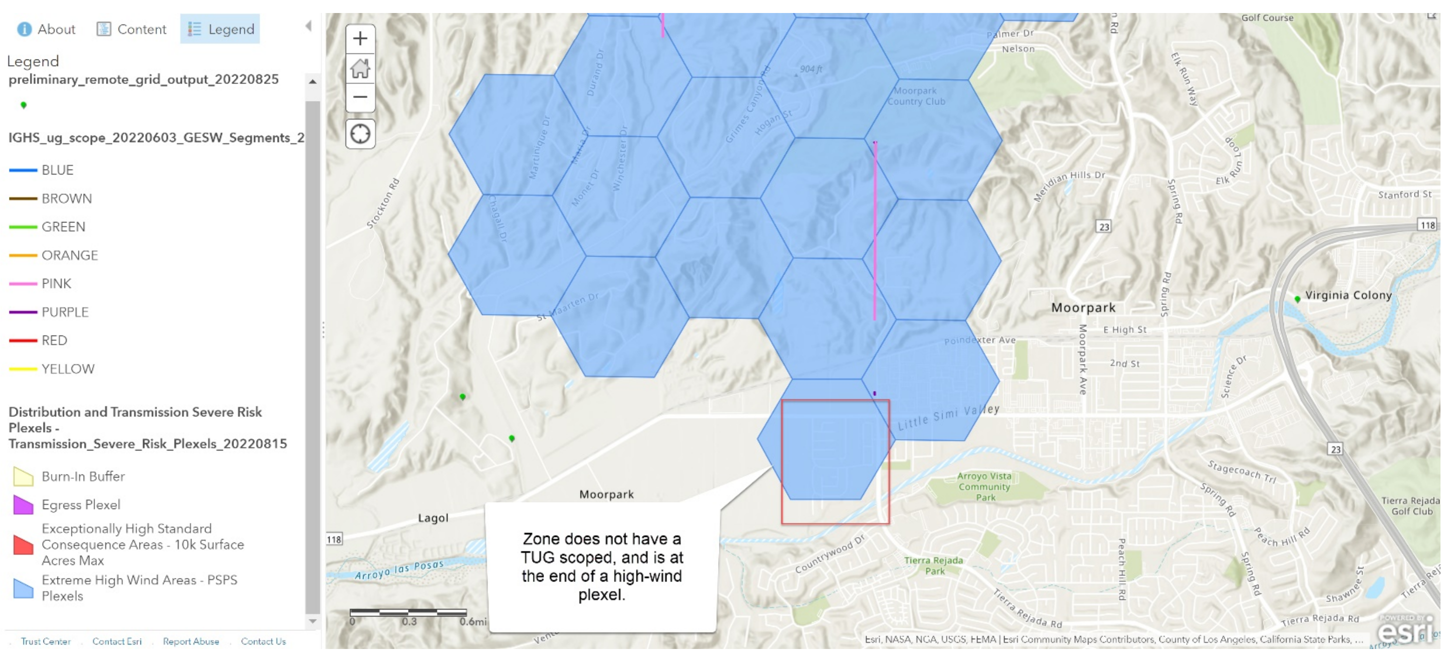

FIGURE 13 - SEVERE RISK AREA MAP FOR ZONE_182277926

CASMALIA_207288687 AND 191032341

Not in-scope for TUG, but TUG recommended instead of microgrid. Casmalia extends up into a high-wind area, and much of the infrastructure in these two microgrid areas are already undergrounded except for a few segments of the main line. No TUG is scoped for this area, so a microgrid would address PSPS for this undergrounded community. However, it appears that only 0.19 miles of TUG would be required and is estimated to cost $747,576 compared to [redacted] to deploy a microgrid making TUG a more cost-effective option.

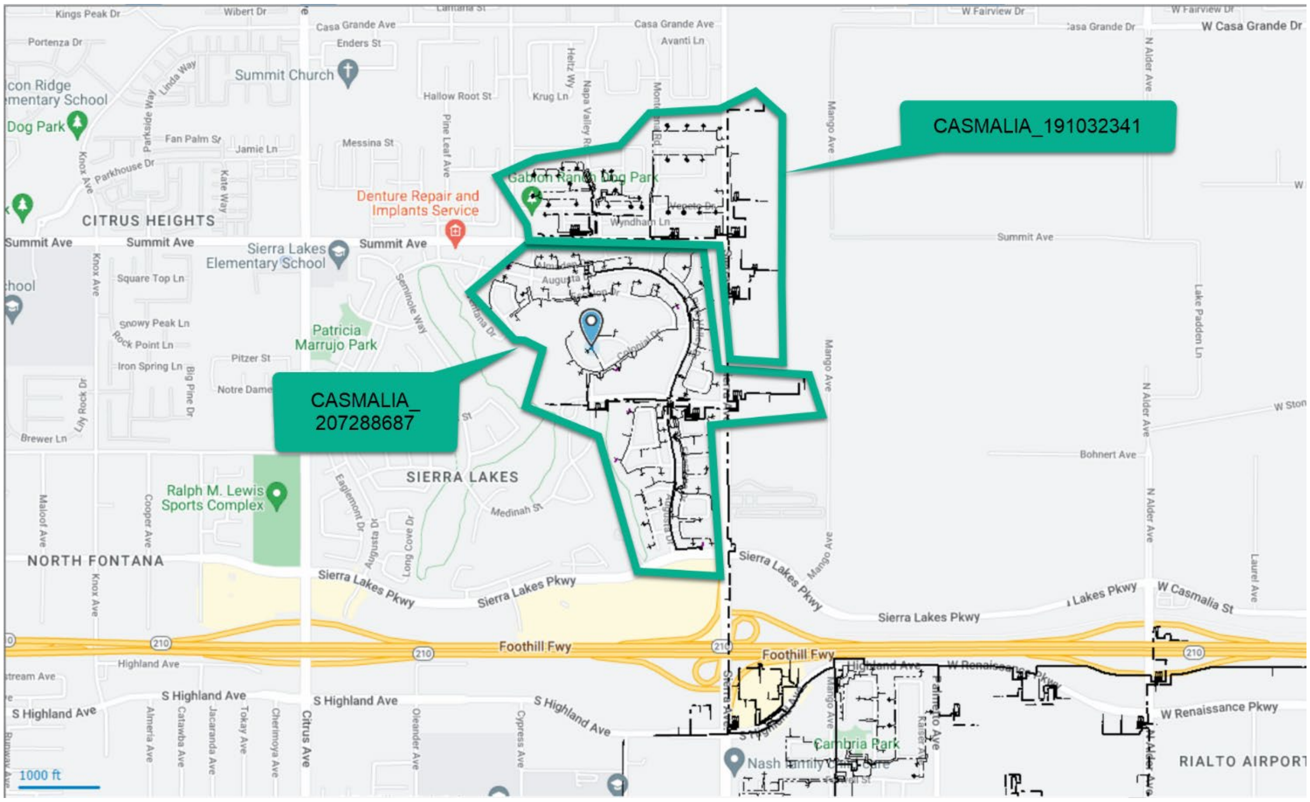

FIGURE 14 - NETWORK MAP OF CASMALIA

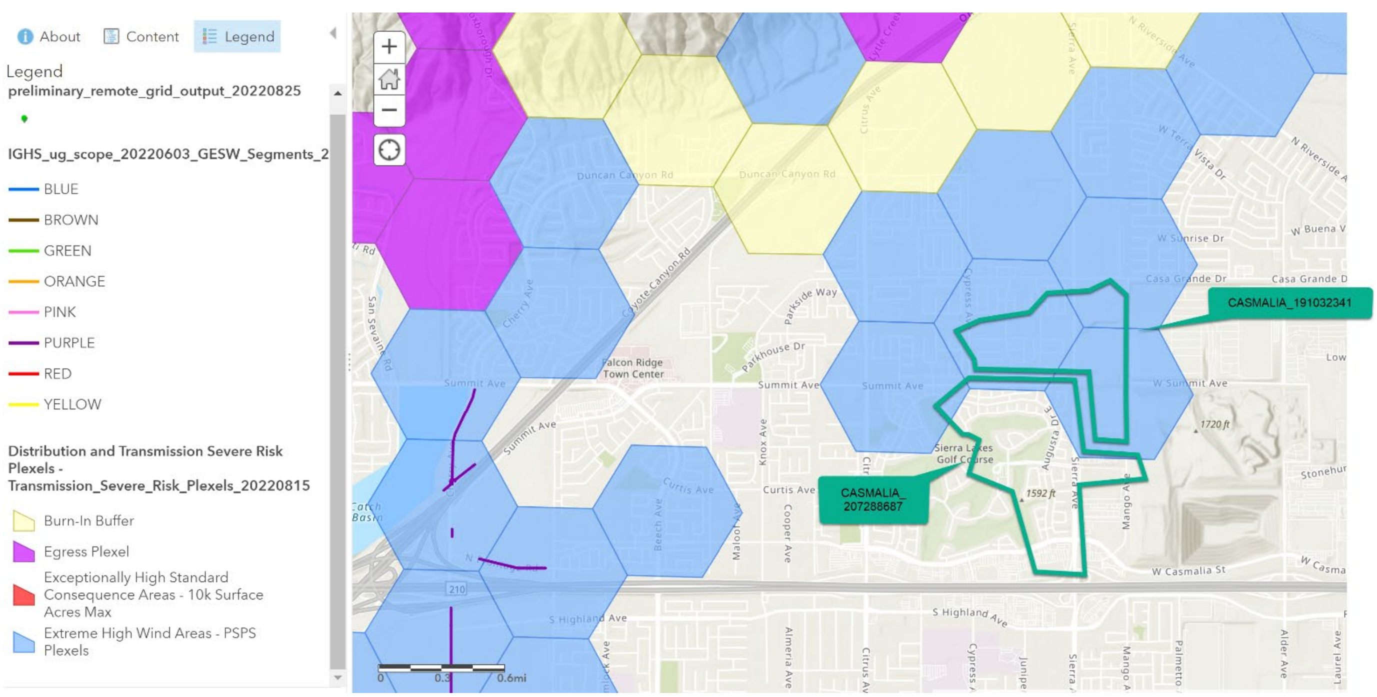

FIGURE 15 - SEVERE RISK AREA MAP OF CASMALIA

PETIT_1336402

Not in-scope for TUG, but TUG recommended instead of microgrid. PETIT_1336402 seems to be located within a high-wind area (Figure 17) that's not addressed by a targeted undergrounding; however, a microgrid at this location would not make much sense since the overhead line feeding this site has multiple customers connected along the way shown in purple in Figure 16. By comparison, the 15-year deployment cost at microgrid at PETIT_1336402 would be [redacted] whereas the estimated TUG cost for the entire main line within the two high-wind plexels is $3 million but would serve to mitigate PSPS for all impacted customers along the line segment highlighted in purple.

FIGURE 16 - NETWORK MAP OF PETIT_1336402

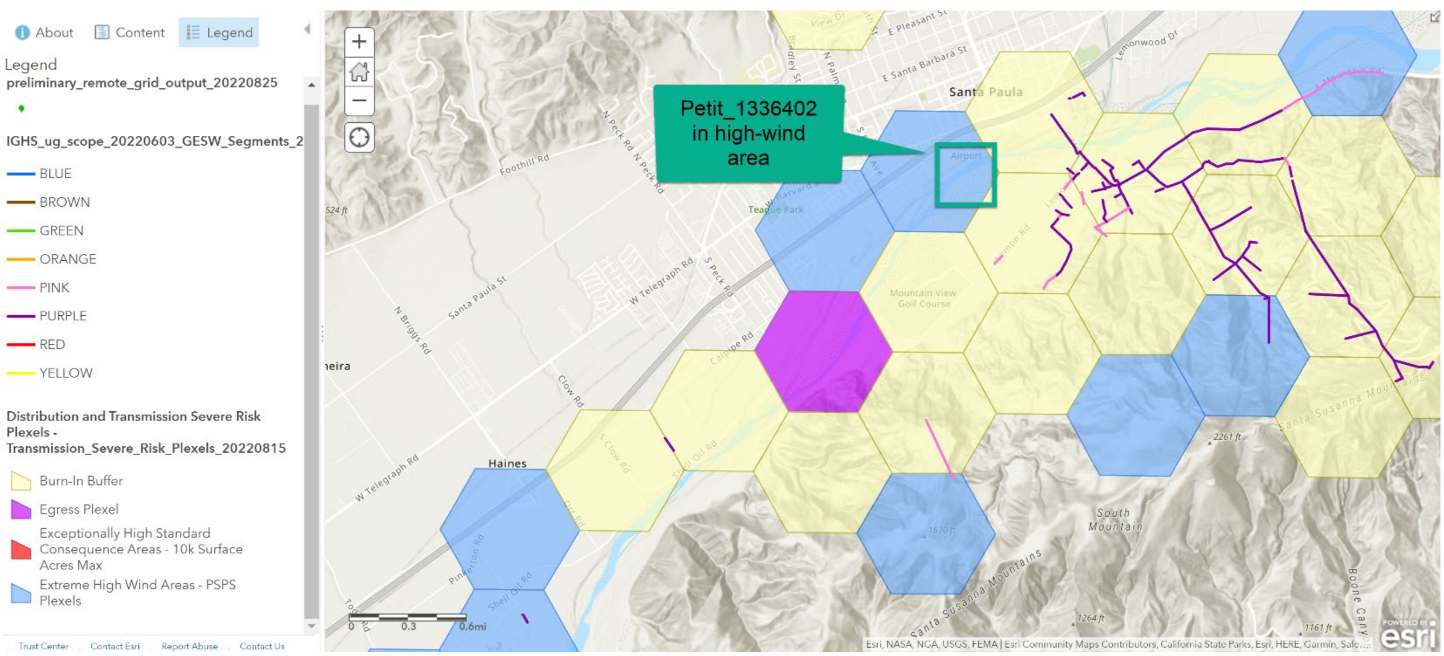

FIGURE 17 - SEVERE RISK AREA MAP OF PETIT_1336402

SAND_CANYON_23324285 AND 23323452

Not in-scope for TUG, but TUG recommended instead of microgrid. Sand Canyon microgrid sites are not within high wind areas but are within egress burn-in areas which may be mitigated with targeted undergrounding (need feedback from grid hardening group). A microgrid for these two sites are estimated to cost [redacted], whereas undergrounding all customers along the entire main line up to Mint Canyon Elementary School is estimated to cost $7.3 million.

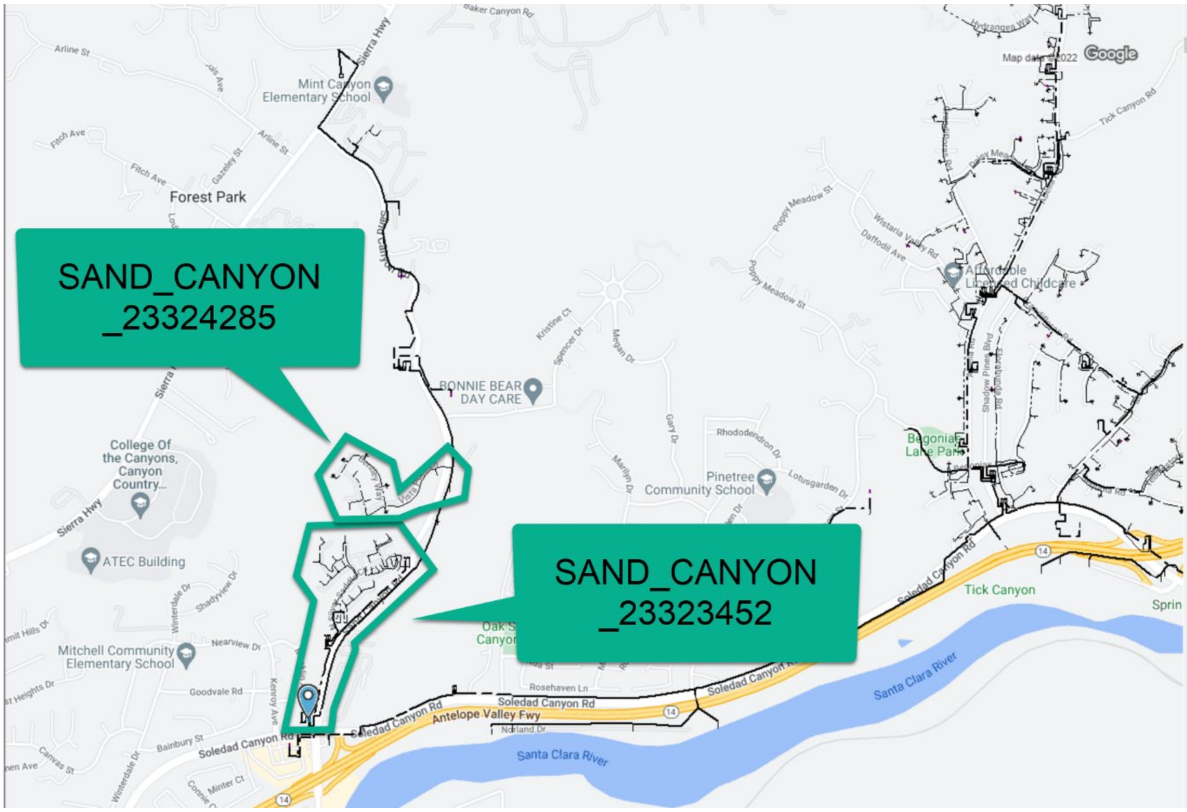

FIGURE 18 - NETWORK MAP OF SAND CANYON

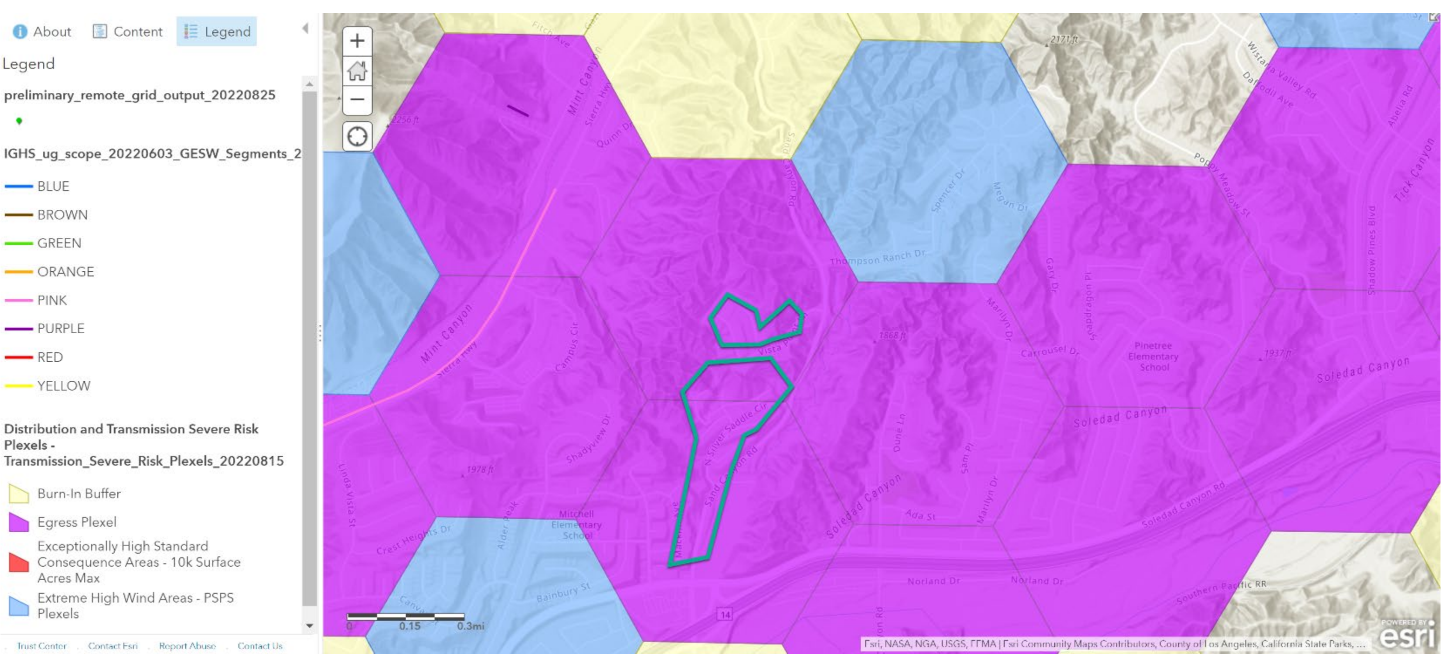

FIGURE 19 - SEVERE RISK AREA MAP OF SAND CANYON

TWIN_LAKES_42074340

Already in scope for TUG, and TUG recommended instead of microgrid. This Twin Lakes sites is already part of TUG scope from Figure 21. The cost for installing a microgrid for these 129 customers highlighted in Figure 20 would be [redacted], whereas undergrounding all cables shown in purple to avoid PSPS for this area is estimated to cost $5.8 million but would benefit all customers along this branch. The value of service would be much higher to underground all sections highlighted in purple in Figure 21.

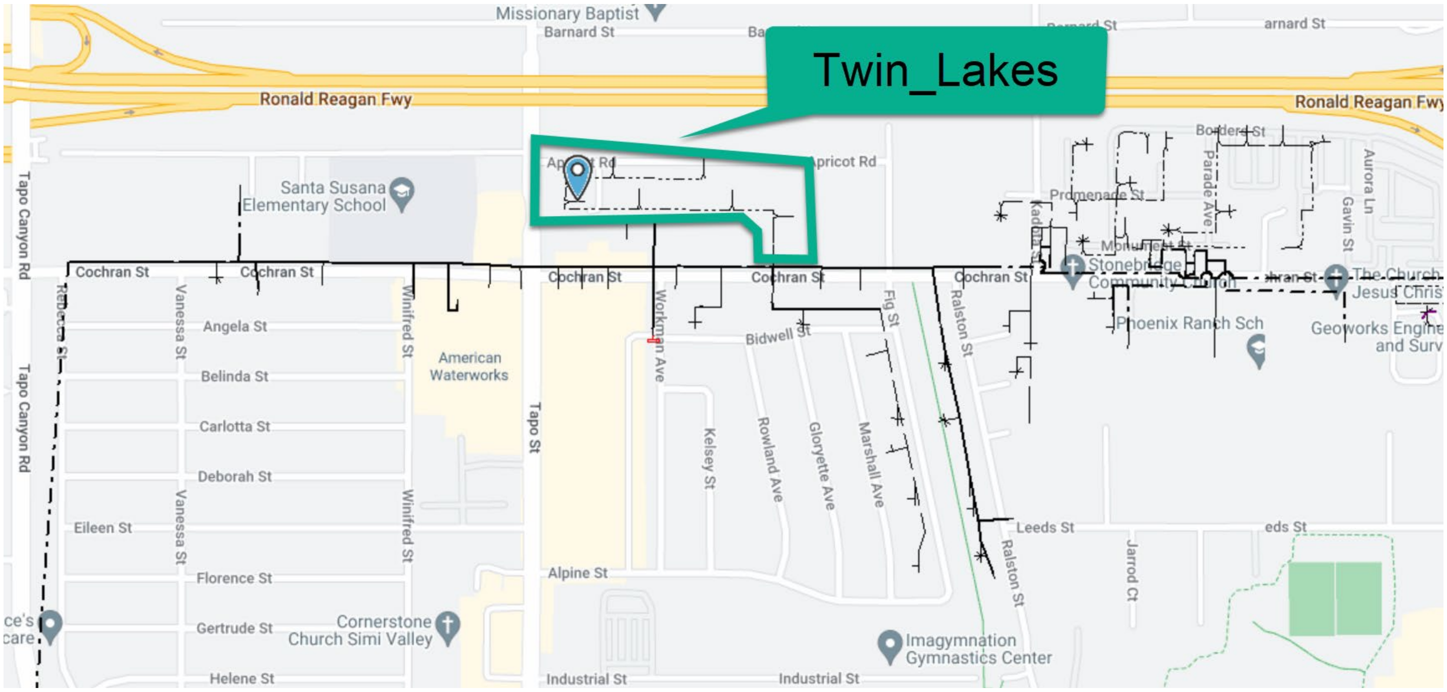

FIGURE 20 - NETWORK MAP FOR TWIN LAKES

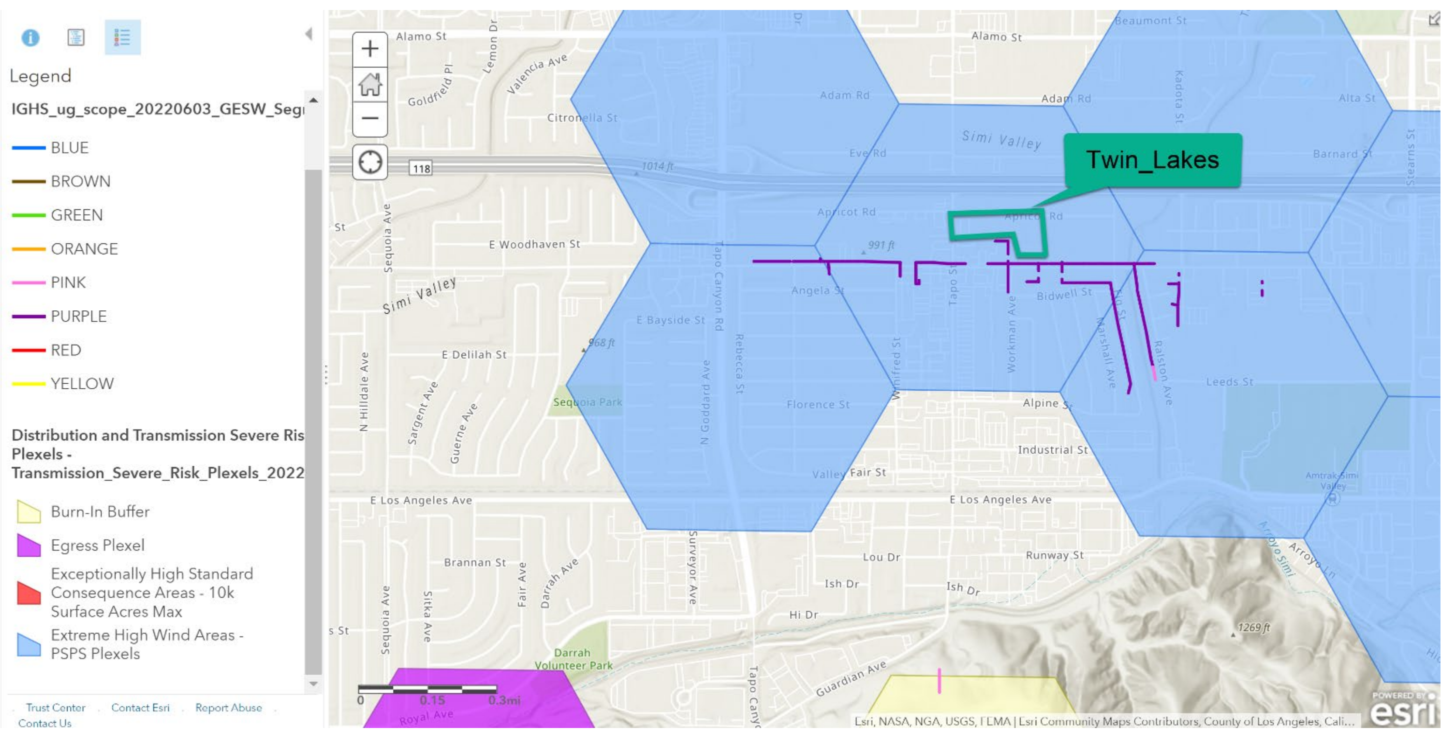

FIGURE 21 - SEVERE RISK AREA MAP FOR TWIN LAKES

SWEETWATER_57590628 AND 57590014

Not in-scope for TUG, but TUG recommended instead of microgrid. Although the two Sweetwater microgrids would address roughly half of the Sweetwater circuit, it would cost roughly [redacted] more to build these two microgrids at [redacted] than to underground all overhead lines on Sweetwater at $11 million. Only half of Sweetwater is within a high-wind area though, so this undergrounding cost would be around half, which would cost $5.5 million.

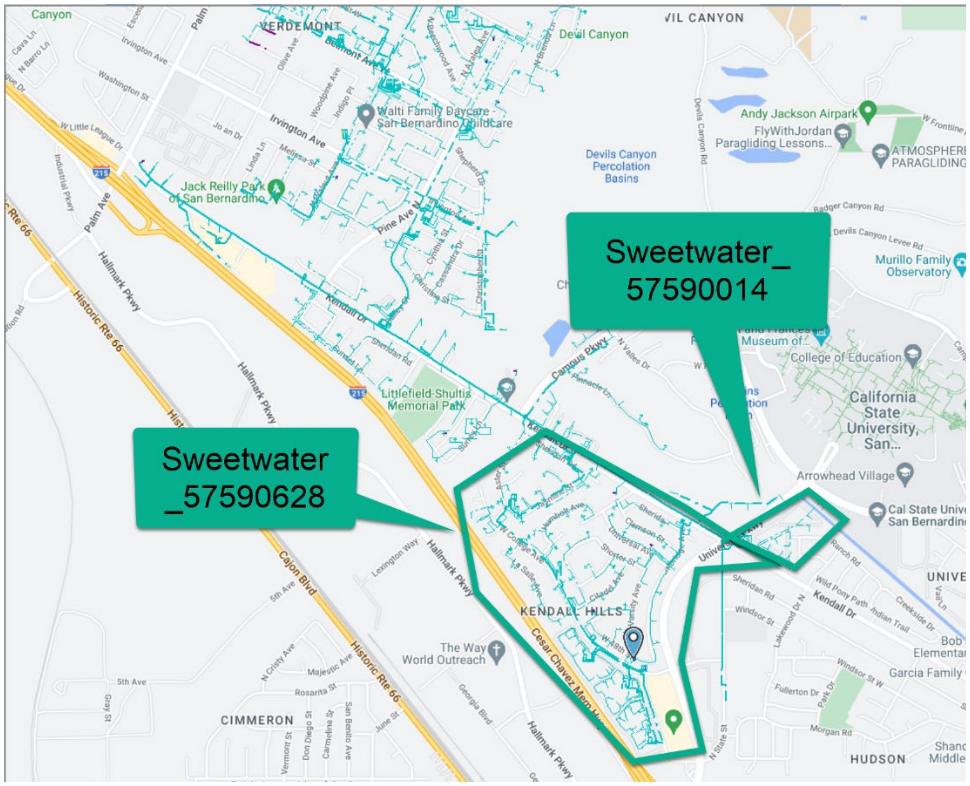

FIGURE 22 - NETWORK MAP FOR SWEETWATER

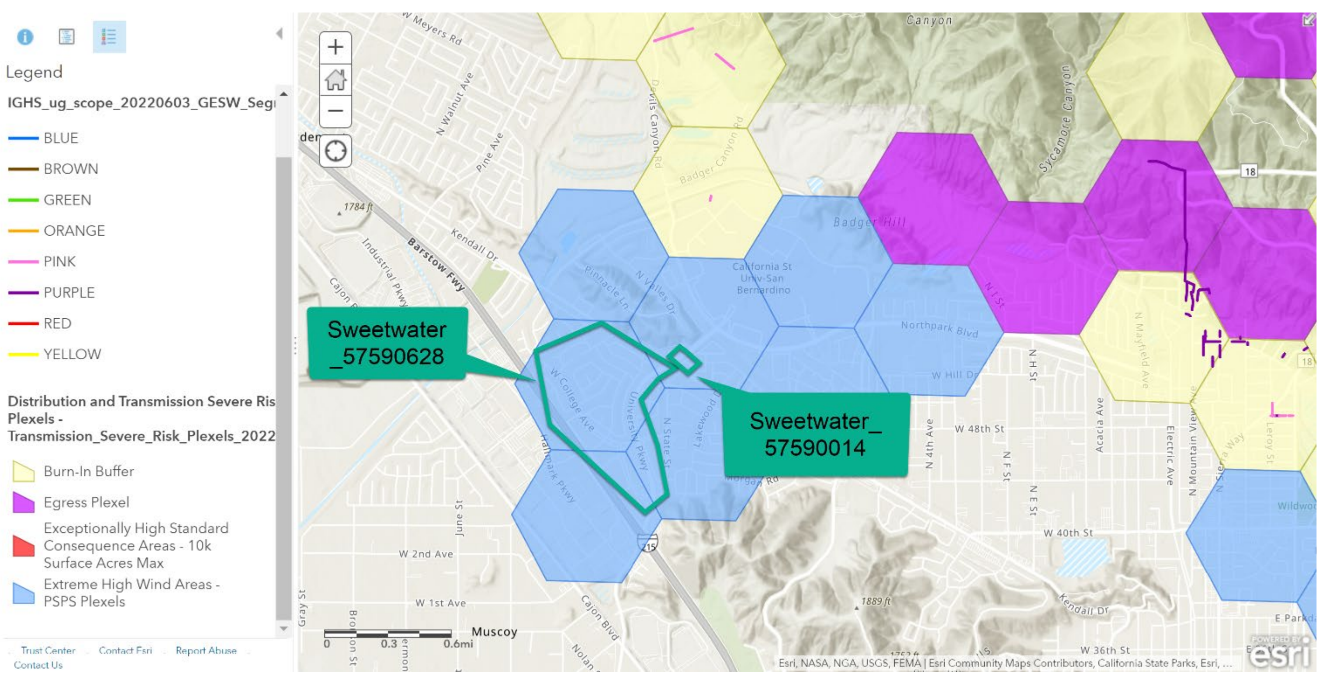

FIGURE 23 - SEVERE RISK AREA MAP FOR SWEETWATER