ORNL/LTR-2024/XXX

Summary of Siting Analyses for the Texas Public Utility Commission

O. A. Omitaomu
R. J. Belles

May 2024

OAK RIDGE National Laboratory

ORNL IS MANAGED BY UT-BATTELLE LLC FOR THE US DEPARTMENT OF ENERGY

ORNL/LTR-2024/XXX

CRADA/NFE-23-09638

SUMMARY OF SITING ANALYSES FOR THE TEXAS PUBLIC UTILITY COMMISSION

O. A. Omitaomu
R. J. Belles

May 2024

Prepared by
OAK RIDGE NATIONAL LABORATORY
Oak Ridge, TN 37831
managed by
UT-BATTELLE LLC
for the
US DEPARTMENT OF ENERGY
under contract DE-AC05-00OR22725

ABSTRACT

The Texas Public Utility Commission (PUC) requested that Oak Ridge National Laboratory (ORNL) staff evaluate existing and recently retired coal sites in Texas using the Oak Ridge – Siting Analysis for power Generation Expansion (OR-SAGE) tool. The US Department of Energy (DOE) Gateway for Accelerated Innovation in Nuclear (GAIN) provided funding for the site reviews. This letter report documents an overview of the analyses results. Individual data packages for each site are provided separately.

1. INTRODUCTION

1.1 BACKGROUND

This work summarizes siting evaluation assistance provided to the Texas PUC for suitability of advanced nuclear technologies to meet siting criteria from the Nuclear Regulatory Commission (NRC) and associated guidance documents including the Electric Power Research Institute (EPRI) siting guide and other proprietary datasets. Existing and recently retired coal sites in Texas based on a recent DOE coal-to-nuclear study[1] were evaluated for this report.

The Texas PUC is interested in reducing the risk of nuclear deployment decisions by creating a portfolio of deployment locations that meet site selection requirements for the future deployment of new nuclear technologies. The unique OR-SAGE tool and existing data is applied to support the Texas PUC goal to evaluate potential brown field sites.

The OR-SAGE tool is designed to use industry-accepted practices in screening sites and then employ the proper array of data sources through the considerable computational capabilities of geographic information system (GIS) technology available at ORNL. The tool was developed to screen potential sites on a national and regional basis. However, because of the tool granularity, it is often focused specifically on user sites of interest.

More than 60 data sets have been collected and processed by ORNL to develop exclusionary, avoidance, and suitability criteria for screening sites for a variety of power generation types, including nuclear power plants. Available site evaluation parameters include population density, slope, seismic activity, proximity to cooling-water sources, proximity to hazard facilities, avoidance of protected lands and floodplains, susceptibility to landslide hazards, and many others. All siting parameters should be considered as flags to inform siting decisions and should not be used to rule in or rule out any site.

The OR-SAGE process is very versatile. Essentially, OR-SAGE is a visual, relational database. The database partitions the contiguous United States, a total of 7.2E8 hectares (~1.8 billion acres), into 100- by 100-m (1 hectare or ~2.5 acre) cells. The database is tracking just under 700 million individual land cells. Successive suitability criterion is applied to each cell in the database. User-specified thresholds can be applied to each siting parameter data layer. In this manner, a variety of scenarios can be quickly and thoroughly evaluated. Data can be added and/or revised within OR-SAGE to address user interests.

1.2 METHODOLOGY

OR-SAGE is essentially a dynamic visualization database that has matured with support from EPRI and the DOE Office of Nuclear Energy (NE). Specifically, the DOE-NE Systems Analysis and Integration

[1] J. Hanson, et al., *Investigating Benefits and Challenges of Converting Retiring Coal Plants into Nuclear Plants*, INL/RPT-22-67964, Rev. 1, September 13, 2022.

(SA&I) Campaign enabled additional functionality and supported a broad application of OR-SAGE to the potential for backfit of advanced reactors at aging coal plants.[2] This report demonstrated the versatility of OR-SAGE and serves as a good reference for the OR-SAGE methodology. This report summarizes the application of the OR-SAGE tool to the potential placement of an advanced non–light-water reactor (non-LWR) at industrial sites for power generation.

Power reactor siting in the United States is based on limiting dose to individuals on the site exclusion area boundary and on the boundary of a low-population zone as defined in Title 10 to the Code of Federal Regulations, Part 100 (10 CFR 100). There is also well-defined regulatory guidance[3] for siting a nuclear power plant (NPP) in the US in NRC Regulatory Guide 4.7 (RG 4.7), "General Site Suitability Criteria for Nuclear Power Stations." Furthermore, the EPRI siting guide[4] for Nuclear Energy Generation Facilities, provides siting criteria for consideration and is updated periodically. Approximately 50 potential site selection evaluation criteria (SSEC) are identified in the various sources related to public health and safety, environment, socioeconomic, and engineering factors. The selected advanced non-LWR siting factors for a nominal small NPP provide a high level of discrimination and readily available data. The default advanced non-LWR siting criteria used in this study are as follows:

- Land with a population density greater than 500 people per square mile (including a 4-mile buffer) is excluded. The cap at 4 miles is based on vendors demonstrating small source terms that meet the 10 CFR 100 dose requirements at or near the NPP exclusion area boundary.
- Wetlands and open water are excluded.
- Protected lands (e.g., national parks, historic areas, wildlife refuges) are excluded.
- Land with a moderate or high landslide hazard susceptibility is excluded. This is a flag based on broad-based risk assessments by the US Geological Survey (USGS) and is not a substitute for in-depth geological evaluations at the site.
- Land that lies within a 100-year floodplain is excluded.
- Land with a slope greater than 12% (~7°) is excluded. This is an economic consideration regarding site preparation.
- Land located in proximity to hazardous facilities (airports, military facilities, missile generating or toxic gas generating facilities) is avoided. This is a flag based on a broad consideration for risk and RG 4.7 guidance. Meeting this avoidance criterion is not a substitute for an in-depth risk assessment.
- Land too close to the identified fault lines is excluded; the length of the fault line determines the required standoff distance per 10 CFR 100, Appendix A.
- Land with safe shutdown earthquake (SSE) peak ground acceleration (2% chance in a 50-year return period) greater than 0.3 g is excluded. This can be adjusted based on individual technology design specifications. For example, smaller technology designs with limited piping may be able to demonstrate robustness at higher g-forces.

[2] Ibid.

[3] NRC, *General Site Suitability Criteria for Nuclear Power Stations*, RG 4.7, Revision 3, March 2014.

[4] A. Sowder (Project Manager), *Advanced Nuclear Technology: Site Selection and Evaluation Criteria for New Nuclear Energy Generation Facilities (Siting Guide)*, 3002023910, 2022 Revision, EPRI, 2022.

For comparison, the following large light water reactor parameters are considered in place of or alongside the above parameters:

- Land with a population density greater than 500 people per square mile (including a 20-mile buffer) is excluded. The cap at 20 miles is based on RG 4.7 guidance.

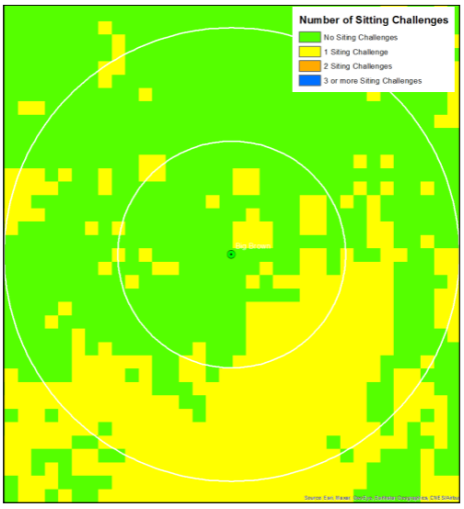
- Land areas that are more than 20 miles from cooling water makeup sources with at least 135,000 gallons per minute are excluded for nominal large LWR plant applications. It is assumed that advanced non-LWRs will not need this resource.

The siting criteria are combined using an algebraic approach. The algebraic approach employed by OR-SAGE is summarized in Appendix A of a report on backfitting nuclear plants at Tennessee Valley Authority (TVA) sites.[5] Based on preliminary design information and expert judgment, it is assumed that a small, advanced reactor, as defined by multiple vendors, can easily be accommodated on a 50-acre footprint. Many proposed advanced reactor NPP technologies have even smaller proposed footprints. Microreactors may require a footprint of only a few acres.

1.3 DATA PACKAGES

Applying these parameters to each Texas site resulted in two analyses for each site including the desired look at a small, advanced technology such as the XE-100 reactor[6] and a comparison for a large LWR. A data package has been prepared for each Texas coal site evaluated in the 2022 DOE study. The data packages will be provided separately from this letter report. Each site data package includes 9 pages of relevant figures. The first figure in each data package is simply a satellite view of the area around the site center followed by a table of the parameters applied for small, advanced reactor technology siting. This is followed by a color-coded composite map like that shown in

Figure 1 demonstrating the algebraic combination of the advanced reactor criteria.



[5] R. Belles, O. Omitaomu, and A. Worrall, *TVA Coal-Fired Plant Potential for Advanced Reactor Siting*, ORNL/TM-2021/2158, September 2021.

[6] XE-100 is an example of a small, advanced reactor technology. The XE-100 reactor is an 80 Mwe pebble-bed, high-temperature, gas-cooled reactor (HTGR) designed by X-Energy. There are numerous small, advanced reactor designs in development. ORNL is not endorsing any specific technology.

Figure 1. Sample composite map for a site.

The white concentric circles on the composite map in

Figure 1 sweep an area with a 0.5-mile radius and a 1-mile radius, respectively. This equates to areas of about 500 acres and 2,000 acres.

This composite map is followed in each data package by small individual parameter maps for each of the criterion. A subsequent composite map is provided in each data package for a large LWR application. Two additional individual parameter maps for this large LWR evaluation are also provided to round out each data package.

2. SITE EVALUATIONS

2.1 BIG BROWN POWER PLANT

The site center is located on the north end of Fairfield Lake in Freestone County, Texas. The site is approximately 9 miles northeast of the town of Fairfield, TX. The OR-SAGE evaluation process was applied around the provided site center point[7] and the composite results are shown in Figure 2. The evaluation radii are depicted as white circles on the map.

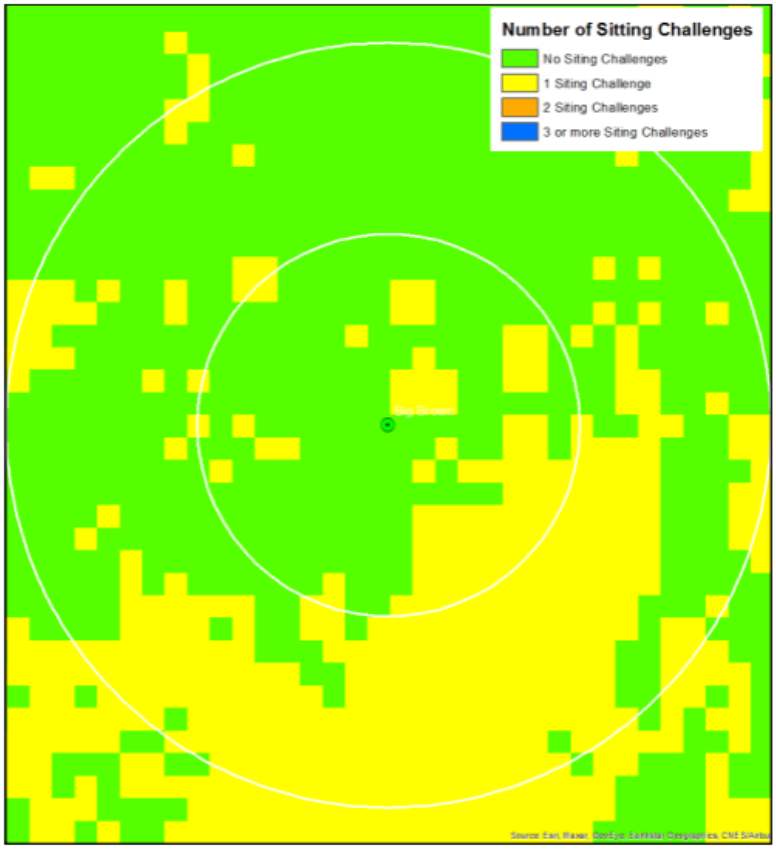


Figure 2. Big Brown Power Plant advanced reactor composite map.

[7] Center points provided by the DOE Energy Information Administration.

Population density within 4 miles is not an issue as Fairfield lies well outside the evaluation radius. The only flag for this site is associated with the site ponds and Fairfield Lake. Significant tracts of land that meets all the OR-SAGE screening criteria (shown in green) are available within the 0.5-mile and 1.0-mile radii. The large LWR composite map is similar.

2.2 COLETO CREEK POWER STATION

The site center is located next to the Coleto Creek Cooling Basin in Goliad County, Texas. The site is approximately 13 miles southwest of Victoria, TX. The OR-SAGE evaluation process was applied around the provided site center point and the composite results are shown in Figure 3.

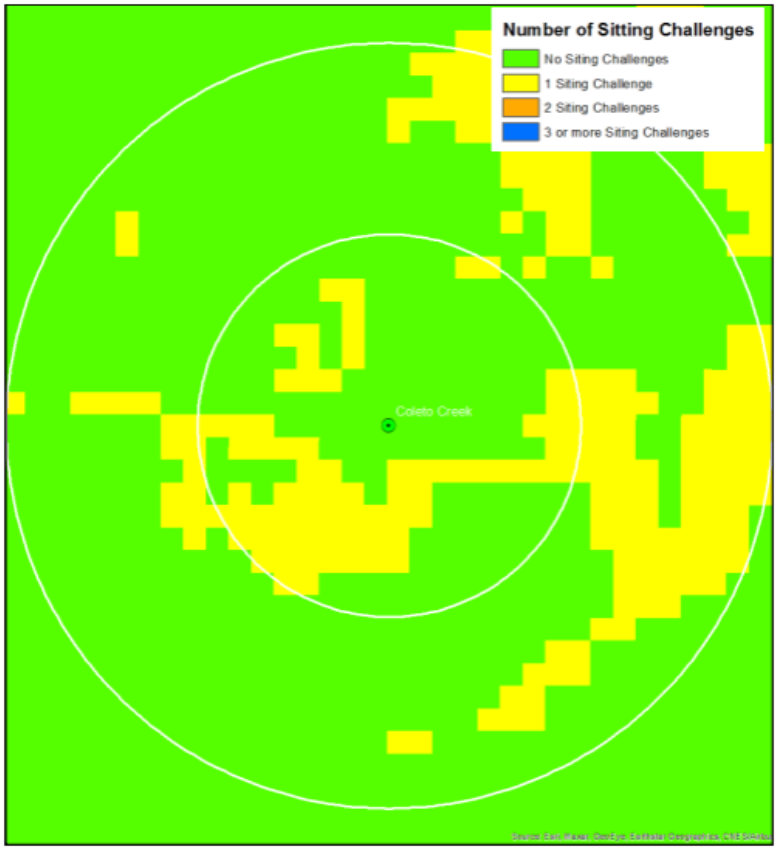


Figure 3. Coleto Creek Power Station advanced reactor composite map.

Population density within 4 miles is not an issue. The only flag for this site is associated with the site ponds and the cooling basin. Significant tracts of land that meets all the OR-SAGE screening criteria (shown in green) are available within the 0.5-mile and 1.0-mile radii. The large LWR composite map is similar.

2.3 FAYETTE POWER PROJECT

The site center is located next on the southwest corner of the Fayette County Reservoir in Fayette County, Texas. The site is approximately 7 miles east of the town of La Grange, TX. The OR-SAGE evaluation process was applied around the provided site center point and the composite results are shown in Figure 4.

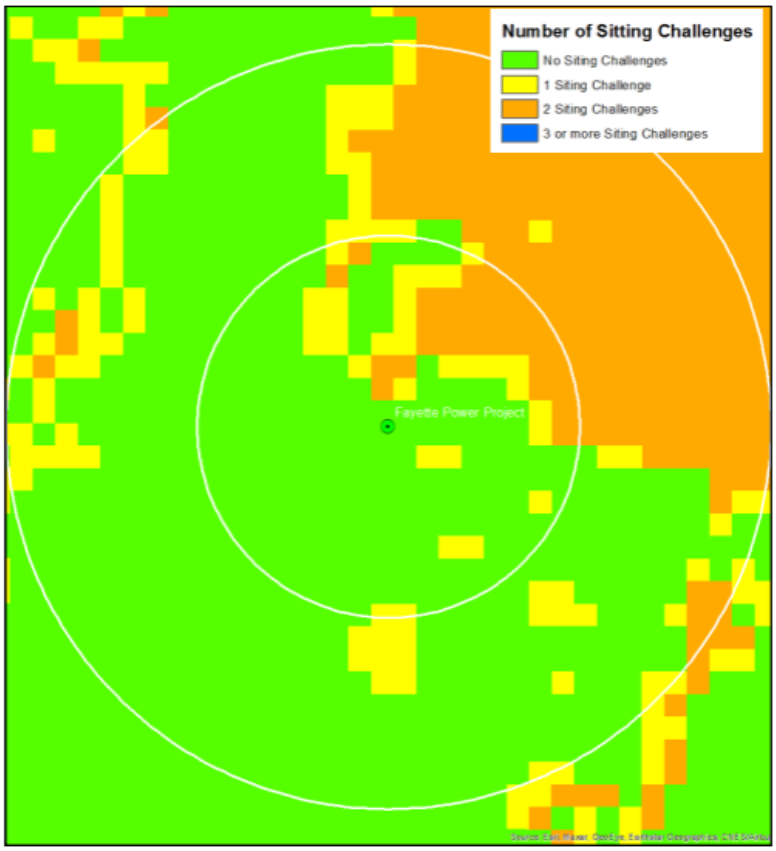


Figure 4. Fayette Power Project advanced reactor composite map.

Population density within 4 miles is not an issue. The only flags for this site are associated with the site ponds, the Colorado River, and the county reservoir. There are floodplains associated with some of these areas. This accounts for the orange color on the composite map. Significant tracts of land that meets all the OR-SAGE screening criteria (shown in green) are available within the 0.5-mile and 1.0-mile radii. The large LWR map is defined by a lack of makeup cooling water.

2.4 GIBBONS CREEK POWER PLANT

The site center is located next on the west edge of the Gibbons Creek Reservoir in Grimes County, Texas. The site is approximately 13 miles east of College Station, TX. The OR-SAGE evaluation process was applied around the provided site center point and the composite results are shown in Figure 4.

Population density within 4 miles is not an issue. The only flag for this site is associated with the site ponds, the reservoir, and associated waterways. Significant tracts of land that meets all the OR-SAGE screening criteria (shown in green) are available within the 0.5-mile and 1.0-mile radii. The large LWR composite map is similar.

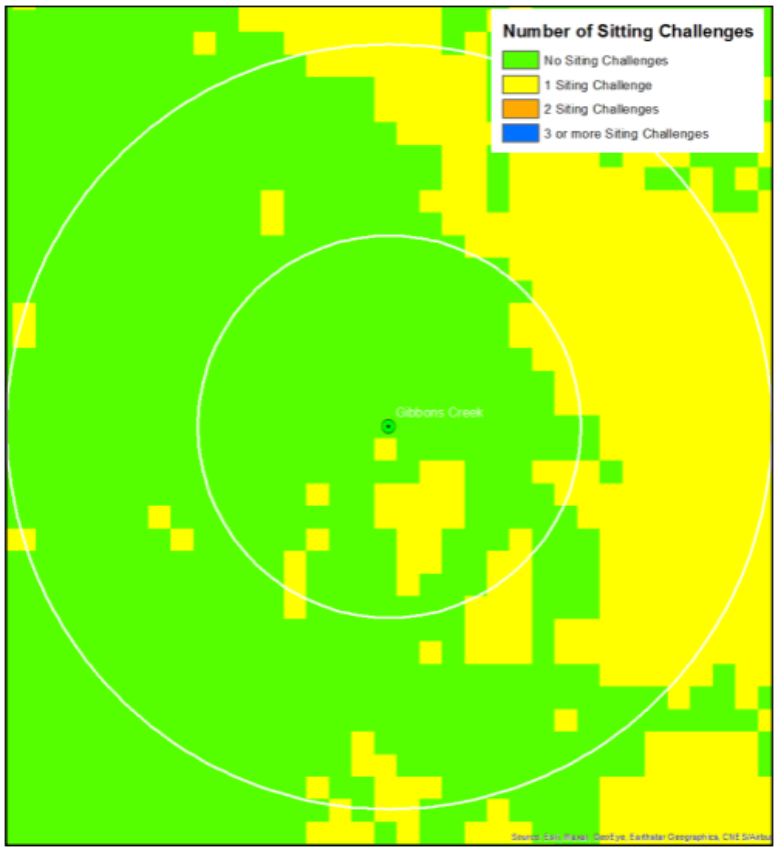


Figure 5. Gibbons Creek Power Plant advanced reactor composite map.

2.5 HARRINGTON STATION

The site center is in Potter County approximately 6 miles northeast of Amarillo, TX. The OR-SAGE evaluation process was applied around the provided site center point and the composite results are shown in Figure 6.

Rick Husband Amarillo International Airport is within 10 miles of the evaluation radius for the site. This accounts for the yellow color associated with the entire composite map. This is simply flagged as a risk factor that should be evaluated per guidance provided in RG 4.7. The airport is about 5 miles from the site center and the main runway is parallel to the site. Given the runway orientation, distance and selection of technology, this risk factor may prove to be negligible.

Population density within 4 miles is not an issue. The only other flag for this site is associated with the site ponds. If the airport risk is deemed acceptable, then the composite map for this site could possibly improve (i.e., yellow areas become green and orange areas become yellow). The large LWR composite map is similar.

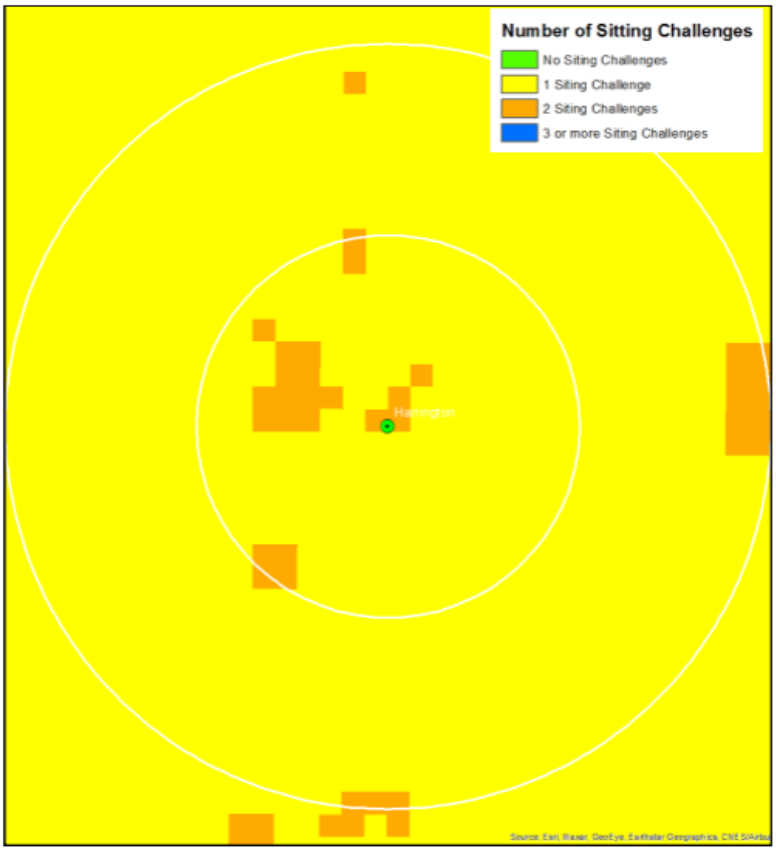


Figure 6. Harrington Station advanced reactor composite map.

2.6 J K SPRUCE STATION

The site center is surrounded by Calaveras Lake in Bexar County, Texas. The site is approximately 20 miles southeast of downtown San Antonio, TX. The OR-SAGE evaluation process was applied around the provided site center point and the composite results are shown in Figure 7.

Population density within 4 miles is not an issue. The major flag for this site is associated with the site ponds and Calaveras Lake. Parkland across the lake from the plant infringes slightly on the edge on the 1-mile radius. This accounts for the small, orange-colored areas on the composite map. Significant tracts of land that meets all the OR-SAGE screening criteria (shown in green) are available within the 0.5-mile and 1.0-mile radii. The large LWR composite map is impacted by population within 20 miles and inadequate makeup cooling water.

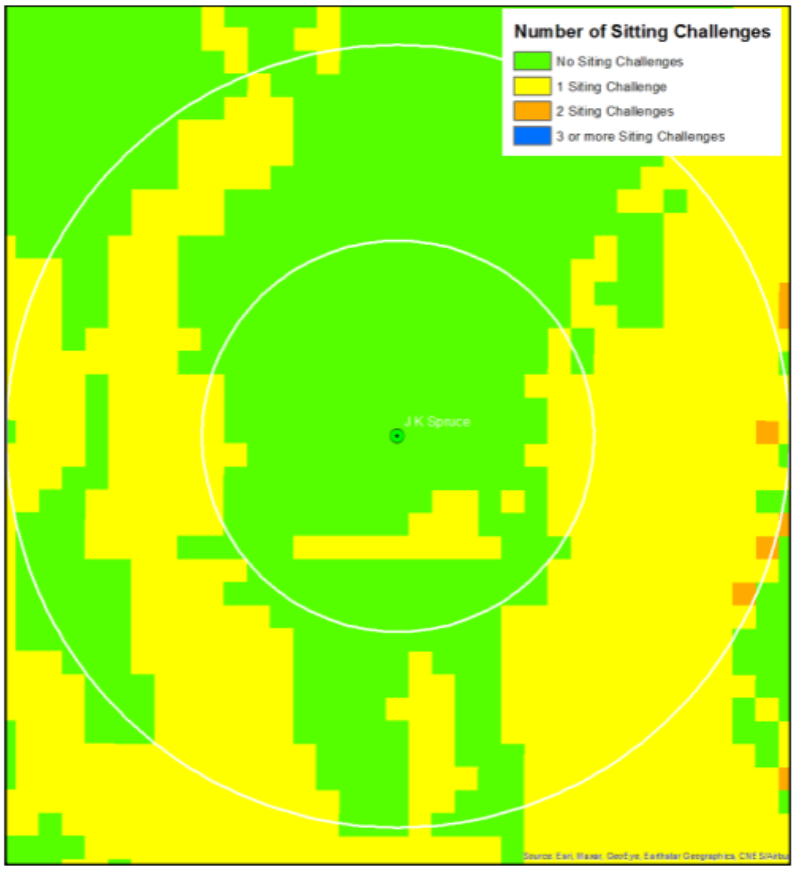


Figure 7. J K Spruce Station advanced reactor composite map.

2.7 J T DEELY POWER PLANT

The J T Deely Power Plant is immediately adjacent to the J K Spruce Station. The composite map is essentially the same as that shown in Figure 7.

2.8 LIMESTONE GENERATING STATION

The site center is approximately 2 miles east of Lake Limestone and 11 miles west of Buffalo, TX in Limestone County. The OR-SAGE evaluation process was applied around the provided site center point and the composite results are shown in Figure 8.

Population density within 4 miles is not an issue. The only flag for this site is associated with the site ponds. Significant tracts of land that meets all the OR-SAGE screening criteria (shown in green) are available within the 0.5-mile and 1.0-mile radii. The large LWR composite map is similar.

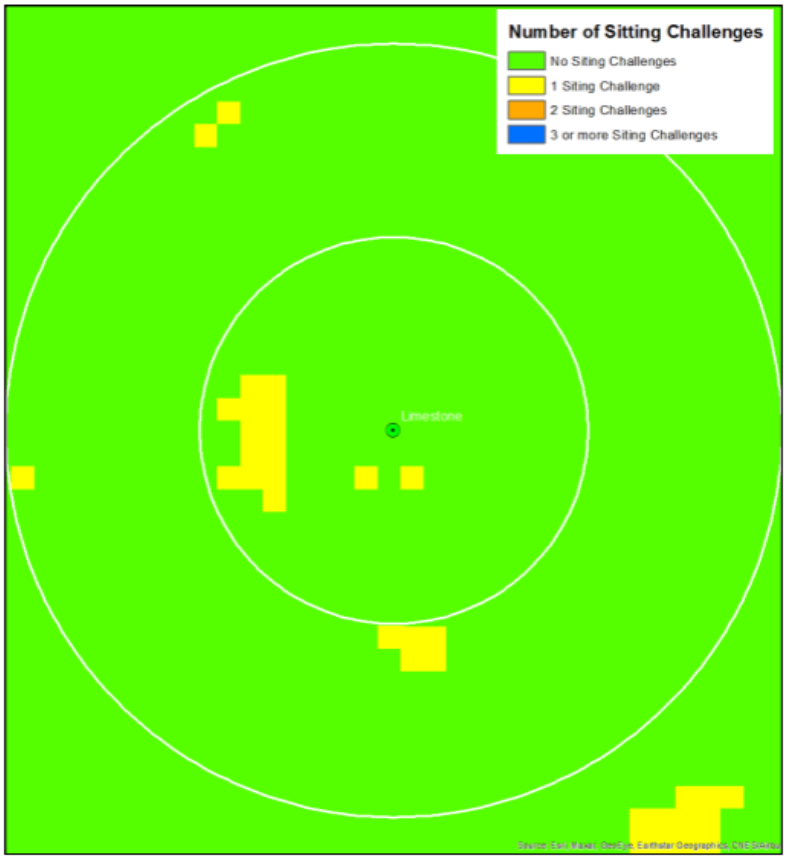


Figure 8. Limestone Generating Station advanced reactor composite map.

2.9 MAJOR OAK POWER STATION

Also known as Twin Oaks Power Station, the site center is between Bremond, Calvert, and Franklin, TX in Robertson County. The closest of these towns is Bremond at 5 miles. The site is 5 miles east of the Brazos River. The plant is 13 miles west of the Oak Grove Steam Electric Station. The OR-SAGE evaluation process was applied around the provided site center point and the composite results are shown in Figure 9.

Population density within 4 miles is not an issue. The only flag for this site is associated with the site ponds. Significant tracts of land that meets all the OR-SAGE screening criteria (shown in green) are available within the 0.5-mile and 1.0-mile radii. The large LWR composite map is impacted by a lack of makeup water in sufficient quantities.

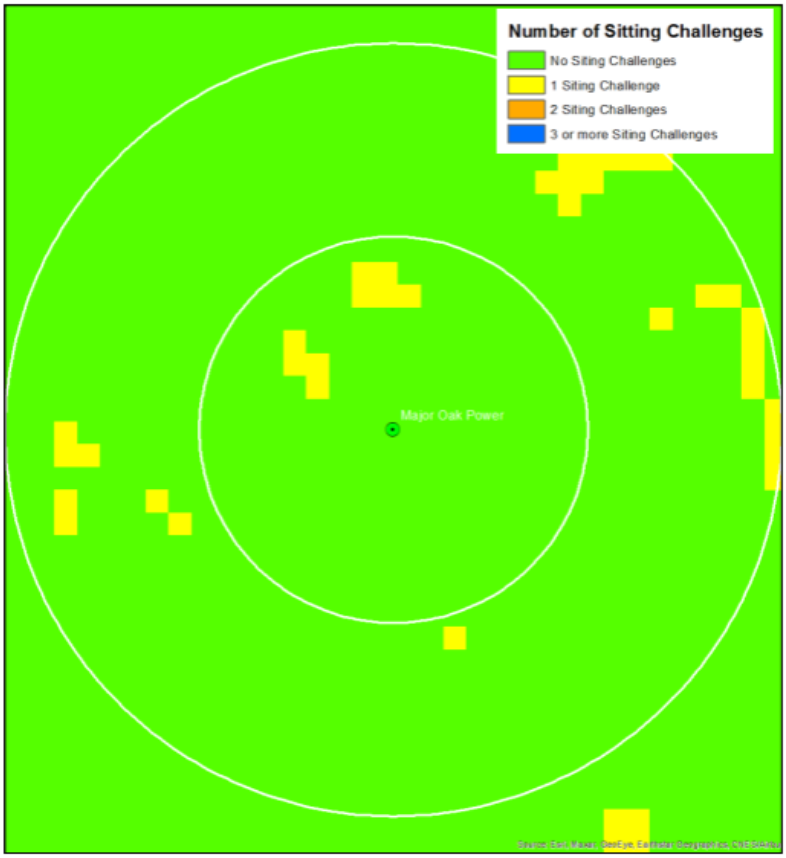


Figure 9. Major Oak Power Station advanced reactor composite map.

2.10 MARTIN LAKE STEAM STATION

The site is surrounded by the north end of Martin Lake in Rusk County between Carthage and Henderson, TX. Both towns are about 15 miles away. The OR-SAGE evaluation process was applied around the provided site center point and the composite results are shown in Figure 10.

Population density within 4 miles is not an issue. The only flag for this site is associated with Martin Lake and the site ponds. Significant tracts of land that meets all the OR-SAGE screening criteria (shown in green) are available within the 0.5-mile and 1.0-mile radii. The large LWR composite map is similar.

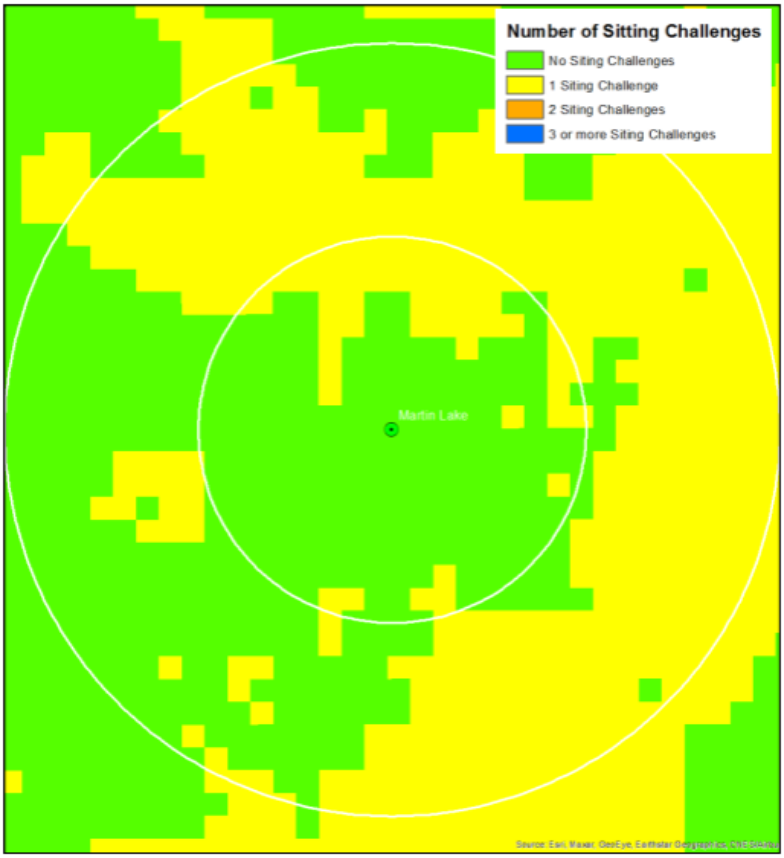


Figure 10. Martin Lake Steam Station advanced reactor composite map.

2.11 MONTICELLO STEAM STATION

The site sits on a peninsula in Lake Monticello in Titus County 5 miles southwest of Mount Pleasant, TX. The plant is 11 miles west of the Welsh Power Plant. The OR-SAGE evaluation process was applied around the provided site center point and the composite results are shown in Figure 11.

Population density within 4 miles is not an issue. The only flag for this site is associated with Lake Monticello and the site ponds. Significant tracts of land that meets all the OR-SAGE screening criteria (shown in green) are available within the 0.5-mile and 1.0-mile radii. The large LWR composite map is similar.

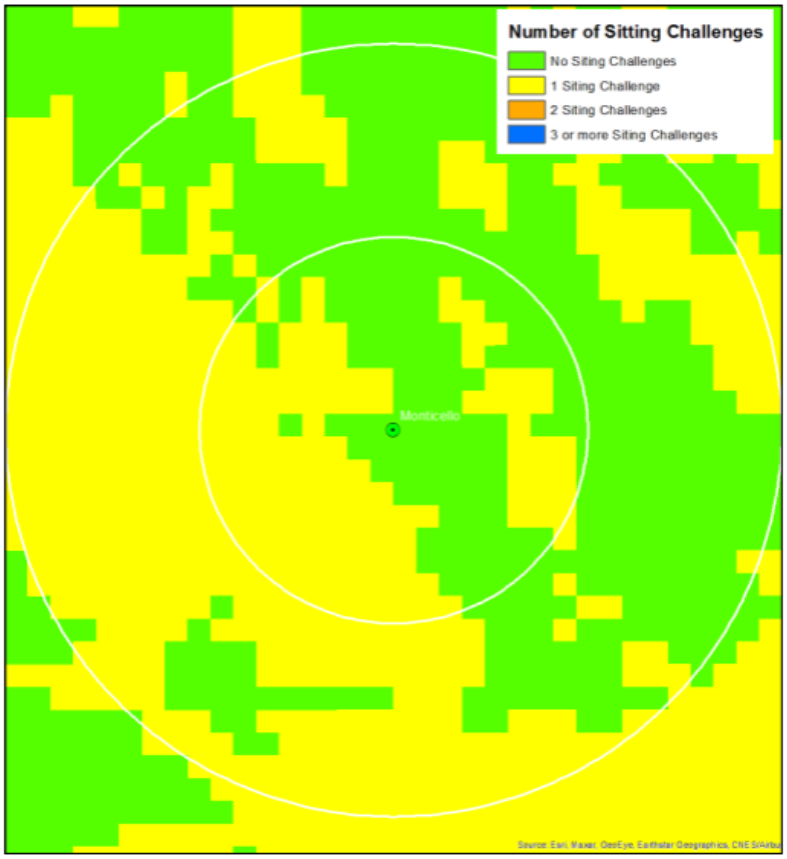


Figure 11. Monticello Steam Station advanced reactor composite map.

2.12 OAK GROVE STEAM ELECTRIC STATION

The site sits on the southern edge of the Twin Oak Reservoir in a rural area of Robertson County 10 miles north of Franklin, TX. The plant is 13 miles east of the Major Oak Power Station. The OR-SAGE evaluation process was applied around the provided site center point and the composite results are shown in Figure 12.

Population density within 4 miles is not an issue. The only flag for this site is associated with the Twin Oak Reservoir and the site ponds. Significant tracts of land that meets all the OR-SAGE screening criteria (shown in green) are available within the 0.5-mile and 1.0-mile radii. The large LWR composite map is similar.

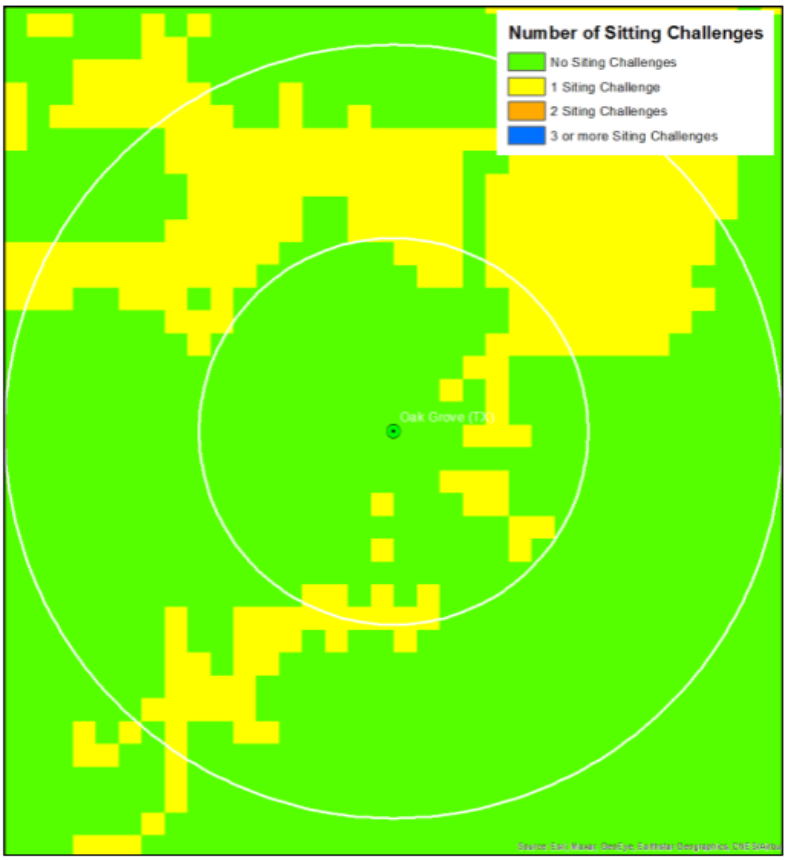


Figure 12. Oak Grove Steam Electric Station advanced reactor composite map.

2.13 OKLAUNION POWER STATION

The site center is approximately 7 miles southeast of Vernon, TX in Wilbarger County. The OR-SAGE evaluation process was applied around the provided site center point and the composite results are shown in Figure 13.

Population density within 4 miles is not an issue. The only flag for this site is associated with the site ponds. Significant tracts of land that meets all the OR-SAGE screening criteria (shown in green) are available within the 0.5-mile and 1.0-mile radii. The large LWR composite map is impacted by a lack of makeup water in sufficient quantities.

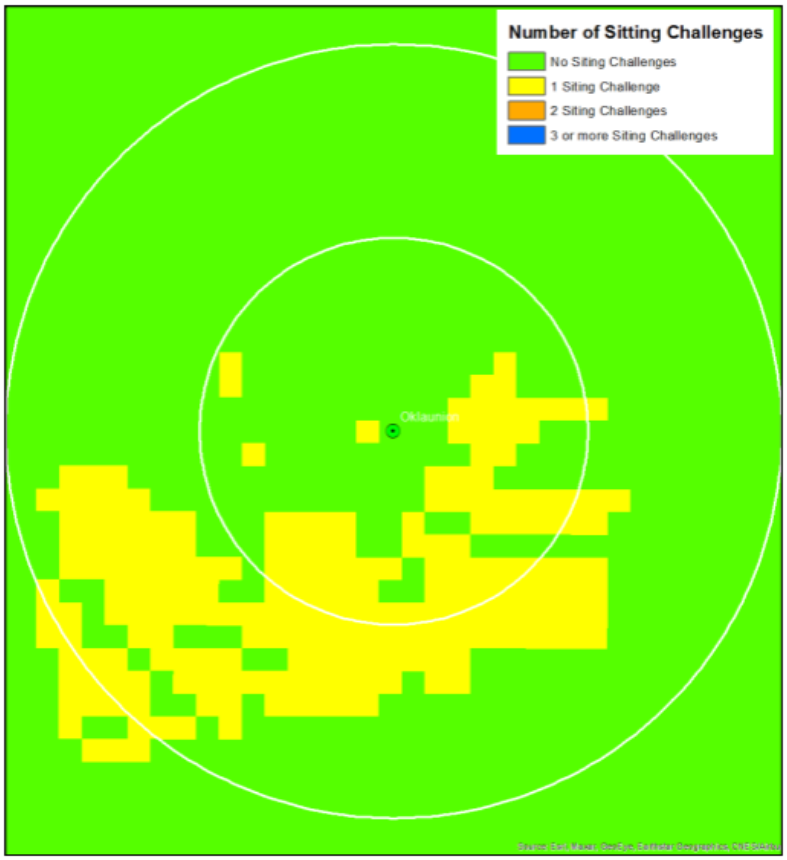


Figure 13. Oklaunion Power Station advanced reactor composite map.

2.14 PIRKEY POWER PLANT

The site sits on the northern edge of the Brandy Branch Reservoir in Harrison County 5 miles southeast of Hallsville, TX. The OR-SAGE evaluation process was applied around the provided site center point and the composite results are shown in Figure 14.

Population density within 4 miles is not an issue. The only flag for this site is associated with the Brandy Branch Reservoir and the site ponds. Significant tracts of land that meets all the OR-SAGE screening criteria (shown in green) are available within the 0.5-mile and 1.0-mile radii. The large LWR composite map is similar.

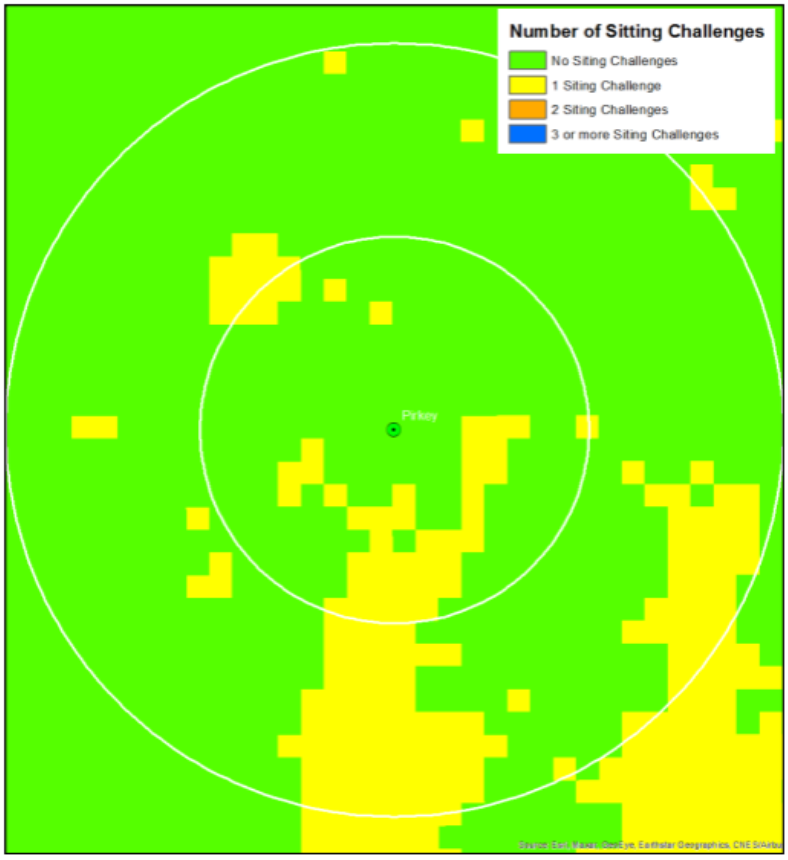


Figure 14. Pirkey Power Plant advanced reactor composite map.

2.15 SAN MIGUEL POWER PLANT

The site is in a rural area of Atascosa County 17 miles south of Pleasanton, TX and 15 miles north of the Choke Canyon Reservoir. The OR-SAGE evaluation process was applied around the provided site center point and the composite results are shown in Figure 15.

Population density within 4 miles is not an issue. The only flag for this site is associated with the site ponds. Significant tracts of land that meets all the OR-SAGE screening criteria (shown in green) are available within the 0.5-mile and 1.0-mile radii. The large LWR composite map is similar.

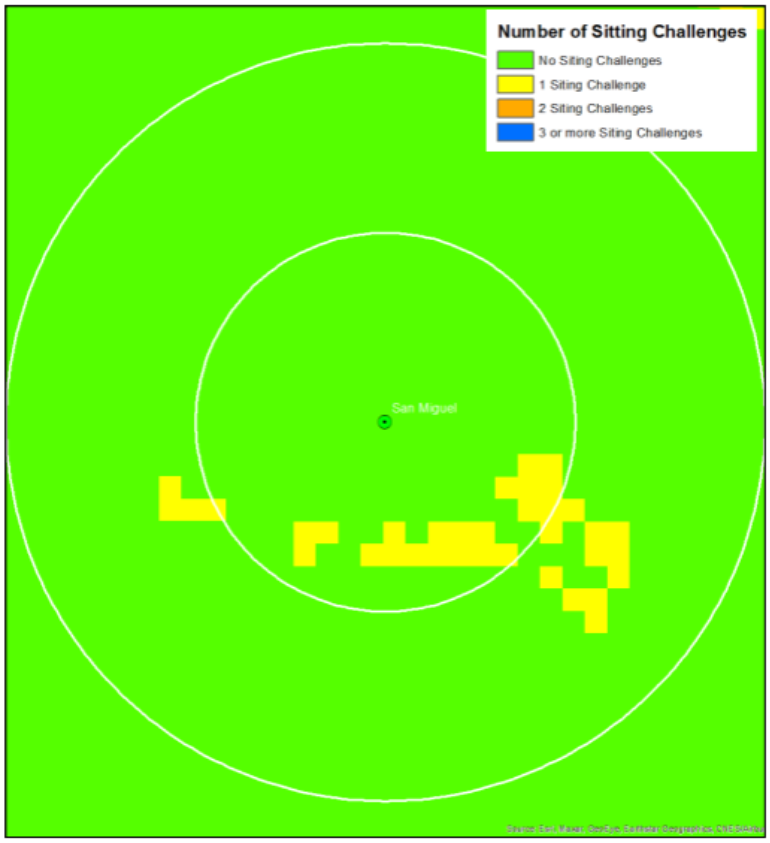


Figure 15. San Miguel Power Plant advanced reactor composite map.

2.16 SANDOW POWER PLANT

Units 4 and 5 sit on the southern edge of Alcoa Lake in Milam County 7 miles southwest of Rockdale, TX. The OR-SAGE evaluation process was applied around the provided site center point and the composite results are shown in Figure 16.

Population density within 4 miles is not an issue. The only flag for this site is associated with the site ponds. Significant tracts of land that meets all the OR-SAGE screening criteria (shown in green) are available within the 0.5-mile and 1.0-mile radii. The large LWR composite map is similar.

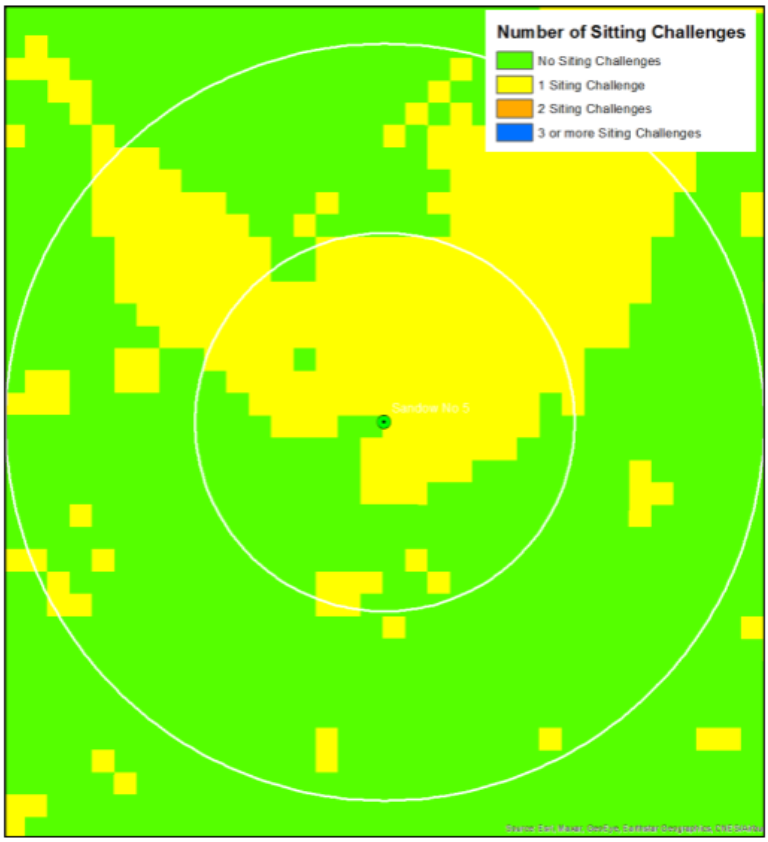


Figure 16. Sandow Power Plant advanced reactor composite map.

2.17 SANDY CREEK ENERGY STATION

The site center is in McLennan County 11 miles southeast of Waco, TX and 2.5 miles east of the Brazos River and 1 mile east of Lake Creek Lake. The OR-SAGE evaluation process was applied around the provided site center point and the composite results are shown in Figure 17.

Population density within 4 miles is not an issue. Two flags are associated with this site. The three yellow stripes across Figure 17 are predominantly associated with the 100-year floodplain. The orange areas are associated with wetlands off Lake Creek Lake. Significant tracts of land that meets all the OR-SAGE screening criteria (shown in green) are available within the 0.5-mile and 1.0-mile radii, especially in the center and eastern area. The large LWR composite map is similar.

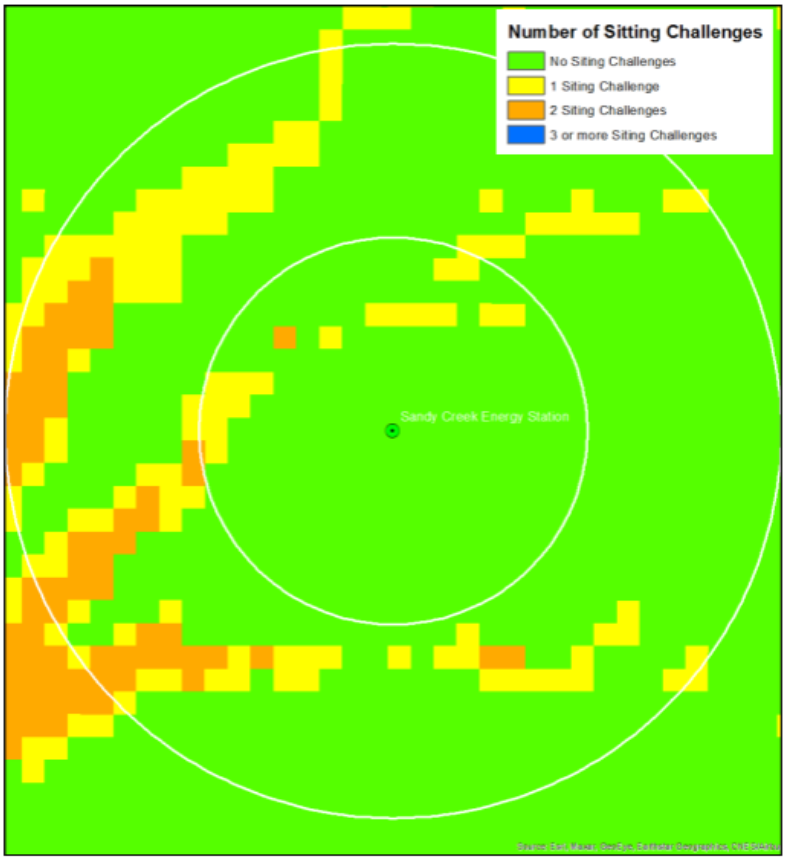


Figure 17. Sandy Creek Energy Station advanced reactor composite map.

2.18 TOLK STATION

The site center is in a rural area of Lamb County 9 miles southeast of Muleshoe, TX. The OR-SAGE evaluation process was applied around the provided site center point and the composite results are shown in Figure 18.

Population density within 4 miles is not an issue. The only flag for this site is associated with the site ponds. Significant tracts of land that meets all the OR-SAGE screening criteria (shown in green) are available within the 0.5-mile and 1.0-mile radii. The large LWR composite map is impacted by a lack of makeup water in sufficient quantities.

Figure 18. Tolk Station advanced reactor composite map.

2.19 W A PARISH GENERATING STATION

The site center is on the southern edge of Smithers Lake in Fort Bend County 6 miles southwest of Houston, TX. The OR-SAGE evaluation process was applied around the provided site center point and the composite results are shown in Figure 19.

Population density within 4 miles is not an issue. The only flag for this site is associated with Smithers Lake and the site ponds. Significant tracts of land that meets all the OR-SAGE screening criteria (shown in green) are available within the 0.5-mile and 1.0-mile radii, particularly to the south of the site center. The large LWR composite map is impacted by the population density associated with nearby Houston and a lack of makeup water in sufficient quantities.

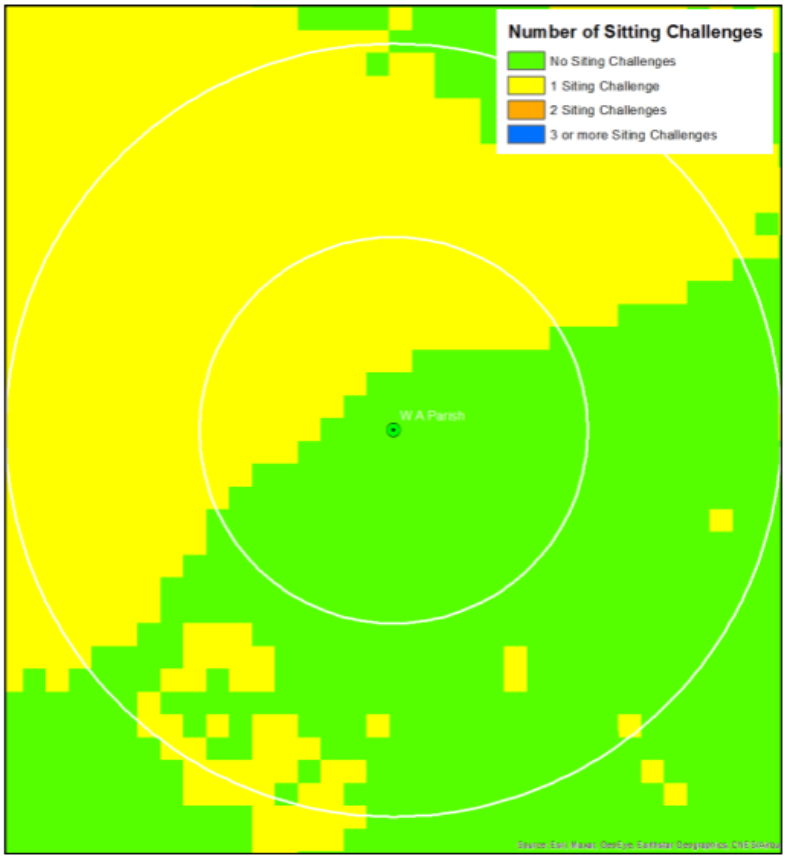


Figure 19. W A Parish Generating Station advanced reactor composite map.

2.20 WELSH POWER PLANT

The site center is on the western edge of the Welsh Reservoir in Titus County between Pittsburg and Daingerfield, TX. The plant is 11 miles east of the Monticello Steam Station. The closest of these towns is Daingerfield at 6 miles. The OR-SAGE evaluation process was applied around the provided site center point and the composite results are shown in Figure 20.

Population density within 4 miles is not an issue. The only flag for this site is associated with the Welsh Reservoir and the site ponds. Significant tracts of land that meets all the OR-SAGE screening criteria (shown in green) are available within the 0.5-mile and 1.0-mile radii. The large LWR composite map is similar.

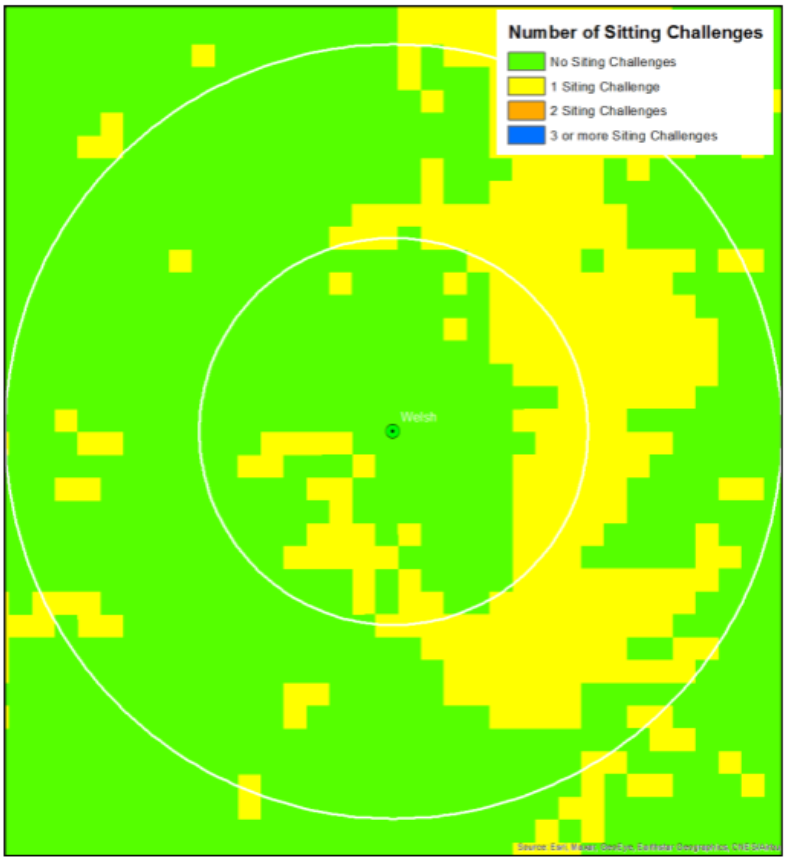


Figure 20. Welsh Power Plant advanced reactor composite map.

3. SUMMARY

The OR-SAGE analyses do not provide an alternative for the detailed site analyses required by the NRC. However, the siting data visualization provided by OR-SAGE does indicate where siting issues may exist. Of the 21 sites evaluated, 20 appear to be amenable to consideration for advanced reactor siting. The 21st plant, Harrington Station, must consider the risk associated with a nearby airport and, after analysis, may well be amenable to consideration for advanced reactor siting. This is consistent with the 2022 DOE *Coal-to-Nuclear* report where 15 of these plants scored highly for advanced reactor siting based on a very high level numeric scoring review. This more specific visual review of the Texas plants shows improved results over the 2022 report. All of these results are subject to the selection of a specific reactor technology.

As of August 2021, when the data for the 2022 DOE *Coal-to-Nuclear* report was pulled, 6 of these plants were retired. This includes Big Brown, Gibbons Creek, Monticello, Oklaunion, Sandow 4, and Sandow 5. Infrastructure status of these shutdown facilities will need to be considered for any economic advantage to a nuclear backfit. Planned retirements will also need to be coordinated to best maintain infrastructure for a nuclear backfit.

Twelve of these facilities are also amenable to consideration of a large LWR backfit. Large LWRs are more sensitive to population density and sufficient makeup water cooling.

Figure 21 shows the locations of the plants evaluated as red pins on a Google Map for Texas. For reference, current nuclear power plants at Comanche Peak and South Texas are shown with a green pin.

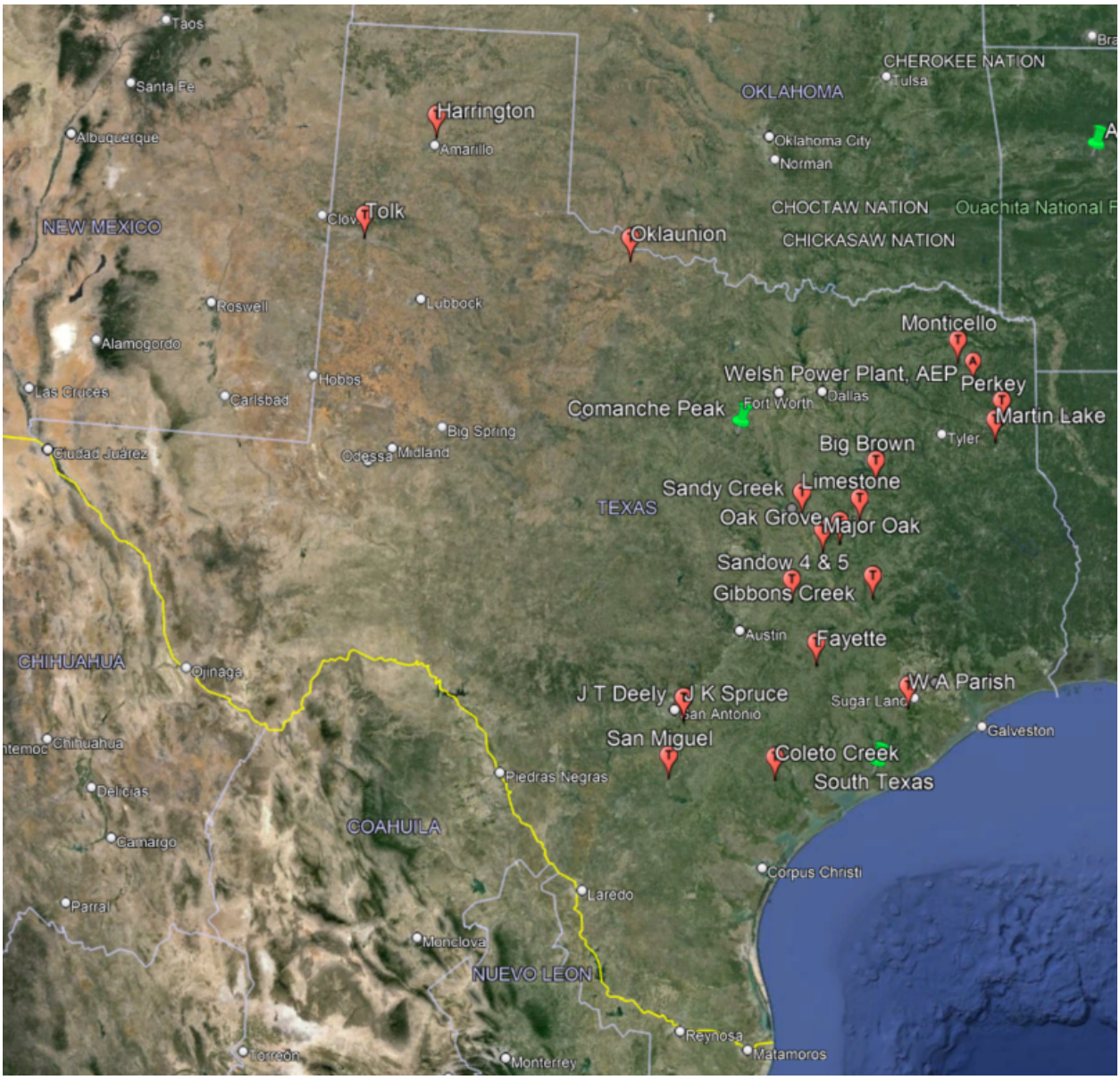


Figure 21. Google Map rendering of coal plant locations (red pins) and the existing nuclear plants in Texas (green pins)