Noise Technical Report and Evaluation of Compliance with the Colorado Noise Statute

Saguache Solar Energy Project

Saguache County, Colorado

Prepared for

SOLARRESERVE

2425 Olympic Boulevard, Suite 500E
Santa Monica, CA 90404

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Prepared by

CH2MHILL®

2485 Natomas Park Drive, Suite 600
Sacramento, California 95833

Contents

Section **Page**

Acronyms and Abbreviations ..... **v**

1. Introduction and Report Overview **1-1**
1.1 Project Overview 1-1
1.2 Noise Technical Report: Purpose and Contents 1-1

2. General Project Description **2-1**
2.1 Project Location 2-1
2.2 Project Description 2-1
2.3 Facility Description 2-2
2.3.1 Central Receiver/Tower 2-2
2.3.2 Power Block 2-3
2.3.3 Cooling System 2-3
2.3.4 Thermal Storage System 2-4
2.3.5 Major Electrical Systems and Equipment 2-4
2.3.6 Buildings and Enclosures 2-4
2.4 Project Schedule 2-5

3. Fundamentals of Acoustics **3-1**

4. Colorado Noise Statute **4-1**

5. Potentially Affected Environment **5-1**

6. Noise Impact Analysis **6-1**
6.1 Construction Noise 6-1
6.2 Operational Impacts 6-3
6.2.1 Plant Operational Noise Levels 6-3
6.2.2 Transmission Line and Switchyard Noise Levels 6-5
6.2.3 Periodic, Impulsive, or Shrill Noises 6-5

7. Conclusions **7-1**

8. References **8-1**

Tables

3-1 Definitions of Acoustical Terms
3-2 Typical Sound Levels Measured in the Environment and Industry

4-1 Maximum Permissible Noise Levels, dBA

6-1 Construction Equipment and Composite Site Noise Levels
6-2 Average Construction Noise Levels at Various Distances
6-3 Noise Levels from Common Construction Equipment at Various Distances
6-4 Sound Power Levels Used to Model Project Plant Operations

Figures

1 Vicinity Map
2 Process Diagram of CPS Technology
3 Site Layout
4 Parcels and Structures in the Project Area
5 Noise Contour Map – Both Facilities in Operation
6 Noise Contour Map – South Facility Only in Operation

Acronyms and Abbreviations

°C	degrees Celsius
°F	degrees Fahrenheit
BLM	Bureau of Land Management
CSP	Concentrating Solar Power
db	decibel(s)
dbA	A-Weighted Sound Pressure Level
EPA	U.S. Environmental Protection Agency
GDA	Generation Development Area
HTF	Heat Transfer Fluid
kV	kilovolt
L_{dn}	Day-Night Sound Level
L_{eq}	equivalent sound pressure level
MW	megawatt
Project	Saguache Solar Energy Project

SECTION 1.0

Introduction and Report Overview

1.1 Project Overview

SolarReserve is planning to build and operate two solar energy facilities adjacent to each other in a rural area approximately 6 miles northeast of the town of Center, in Saguache County, Colorado. The nominal rated electrical output of each of the two facilities is 100 megawatts (MW). The two combined facilities would make up the Saguache Solar Energy Project (Project). Each facility is a solar power plant of the concentrating type that will involve fields of heliostats, a solar receiver tower, and a steam turbine generator, similar to SolarReserve's Rice Solar Energy Project. The two facilities that make up the Project will be identical in design.

The Project will be subject to the State of Colorado Noise Statute. The State of Colorado limits the absolute noise levels that the Project can generate at locations 25 feet past the Project property line. The limits vary by the zone of the receiving property and by time of day.

1.2 Noise Technical Report: Purpose and Contents

This report presents an assessment of potential noise effects of the Saguache Solar Energy Project relative to compliance with the Colorado Noise Statute.

All of the property in the vicinity of the Project is zoned for agricultural use. Some of those properties include residences. The noise impact analysis is focused on the residential receptors that could be potentially affected by the noise level increases associated with the Project. Section 2 of this document includes a description of the Project. Section 3 discusses the fundamentals of acoustics. Section 4 presents a summary of the Colorado Noise Statute. Section 5 describes potential noise sensitive receptors. Section 6 provides an environmental analysis of the construction and operation of the solar energy facilities and associated facilities. Section 7 presents the conclusions.

SECTION 2.0

General Project Description

2.1 Project Location

The proposed Saguache Solar Energy Project is a 200-MW concentrating solar thermal energy facility to be located in Saguache County, Colorado. The Project will be developed within approximately 6,200 acres of privately owned land being optioned by SolarReserve in Saguache County in south-central Colorado. The Project site boundary includes approximately 4,000 acres of this land area and would contain the Project facilities. A vicinity map is shown in Figure 1 (all figures are in the Appendix). The Project site is located in the San Luis Valley, where the state's best solar resources exist. The San Luis Valley is identified as one of two solar power generation development areas (GDAs) in Colorado (RRGDATF, 2007).

2.2 Project Description

The Project is based on concentrating solar power (CSP) generation technology. Figure 2 shows a generalized process diagram of the CSP technology. The proposed CSP technology uses heliostats (tracking mirrors) to direct sunlight onto a central receiver erected on a concrete tower in the center of the solar field. A heat transfer fluid (HTF) is heated as it passes through the receiver and then circulated through a series of heat exchangers to generate high-pressure superheated steam. The steam is then used to power a conventional Rankine-cycle steam turbine-generator to produce electricity. The exhaust steam from the turbine is condensed and returned via feedwater pumps to the heat exchangers, where the high-pressure superheated steam is generated again. The 200-MW Project facility will be constructed in two 100-MW phases.

Each of the two tower facilities within the Project will have the following components:

- A solar array, a circular field with a radius of approximately 4,300 feet where the heliostats will be located
- A power block, a circle with a radius of approximately 400 feet, that will house the central receiver tower, storage tanks, steam turbine, cooling tower, transformers, heat exchangers, power block buildings, and other ancillary equipment
- An administration building, warehouse, and evaporation ponds that will be located along the outside perimeter of the solar array
- Associated linear facilities including transmission line, access road, and, potentially, an onsite water pipeline, all of which will be located within the Project boundary.
- An onsite switchyard (one that will be common to both Project facility phases) to connect the Project to the existing 230-kilovolt (kV) transmission line that crosses the Project site.

The Project will generate power from sunlight by focusing energy from a field of sun tracking mirrors, called heliostats, onto a central receiver. The HTF will be liquid salt, which is circulated through tubes in the receiver, collecting the energy gathered from the sun. The heated salt is then routed to an insulated storage tank where it can be stored with minimal energy losses. When electricity is to be generated, the "hot" salt is routed to a heat exchanger (or steam generator) and used to produce steam, which generates electricity in a conventional steam turbine cycle. After exiting the steam generator, the salt is sent to the cold salt thermal storage tank, and the cycle is repeated.

The salt is a combination of sodium nitrate and potassium nitrate with a melting temperature of 460 degrees Fahrenheit (°F). In the liquid state, the salt has the viscosity and an appearance similar to water. Salt is a heat storage medium that retains thermal energy very effectively over time. Once the salt is melted to a liquid form, it remains heated and in a liquid state throughout the plant's operating life, being reused again and again in the cycle. The salt that would be used is a technical-grade salt similar to commercial fertilizers.

The Project will deliver power to the grid at the existing 230- kV transmission line that runs through the Project site.

2.3 Facility Description

A solar power tower/central receiver system generates electric power from sunlight by focusing concentrated solar radiation on a tower-mounted receiver. Figure 3 shows the anticipated site layout. Figure 4 shows parcels and structures in the Project area. The system uses thousands of sun-tracking mirrors, called heliostats, which are arranged concentrically around the central receiver tower and reflect the sunlight onto the receiver. Each of the Project's two phases will consist of up to approximately 17,500 heliostats occupying a total of approximately 1,400 acres. Each heliostat will be approximately 670 square feet in size, yielding a total reflecting surface of nearly 12 million square feet. The heliostats will be 28 feet wide and 24 feet tall. Each heliostat will be mounted on a steel post at a height of about 13 feet, and each heliostat will have two-directional rotation to allow the heliostat to track the suns path across the sky. When the heliostat is in the vertical position, the bottom of the heliostat will be approximately 12 inches from the ground. For this reason, the vegetation around the heliostats will be cut, rolled, or removed to the ground surface. The spacing of the heliostats will allow access between the individual heliostats. The arrangement of the heliostats within the array will be optimized to maximize the amount of solar energy that can be collected by the field and arranged to avoid interference among heliostats as they track the sun during the day.

2.3.1 Central Receiver/Tower

The tower will be a concrete structure approximately 538 feet high, which will support a cylindrical receiver consisting of tube panels through which the liquid salt flows. The receiver will be approximately 105 feet tall and mounted on the top of the tower. The top of the receiver will therefore be at a height of approximately 643 feet. A 13-foot-tall maintenance crane will be mounted on top of the receiver, making the total structure height approximately 656 feet.

2.3.2 Power Block

The power block will include a steam turbine generator, the solar receiver tower, hot and cold salt tanks, a cooling tower, water treatment facilities and water storage tanks, and a step-up transformer. Steam will be generated at a temperature and pressure of 1,030°F and 1,685 pound-force per square inch absolute before entering the high-pressure section of the turbine. Steam exiting the high-pressure section of the turbine will be reheated to increase its temperature before entering the immediate-pressure section of the turbine. Exhaust steam from the turbine will be directed to the condenser. The turbine will drive a generator, which will deliver electrical power via a main step-up transformer in the onsite switchyard to the utility grid. Extraction steam from the steam turbine will be used to preheat the feedwater and for deaerating the feedwater.

This high-efficiency turbine is designed for reliable operation under conditions of daily startup and shutdown over the life of the plant. The solar field and power generation equipment typically will be started each morning after sunrise and in association with the buildup of solar energy. The solar field will shut down in the evening as the sun sets, although the integral thermal energy storage system will allow the steam turbine to continue operating.

The primary components of the power block will include:

- One "Hot" and one "Cold" Salt Tank – The "cold" salt will be pumped to the central solar receiver, where it will flow though the receiver, be heated by the sun's energy, and return as "hot" salt to the hot salt tank.
- A Central Solar Receiver – The central receiver, mounted on the tower, is where the sun's energy will be concentrated to heat the liquid salt.
- Solar Steam Generator System – The steam generator (STG), which is the core of the steam supply system for the power block, will be located in the steam generation building. Through the use of heat exchangers, the heat energy from the liquid salt will be used to produce steam.
- Steam Turbine—Once the pressurized steam has reached the optimum temperature in the superheater, it will flow to the steam turbine, which extracts thermal energy from the steam.

2.3.3 Cooling System

A dry cooling system will be employed at the site. The cooling system will consist of an air-cooled condenser, condensate tank, and condensate pumps. The system will receive saturated turbine exhaust, which is ducted from the steam turbine. It will enter heat exchangers in the air-cooled condenser where ambient air will be used to cool and condense the steam. The condensed steam will be gathered in a condensate tank and provided to the feedwater circuit through a condensate pump.

2.3.4 Thermal Storage System

The thermal storage system will make use of "hot" and "cold" liquid salt tanks to store solar heat energy for later steam generation as well as associated pumps and piping. Thermal storage will provide the Project facility with several operational enhancements. The solar field will be nominally sized to provide excess solar energy to the system and such sizing intentionally will result in collection of excess heat that cannot be utilized instantly by the power block. The thermal storage capability will allow the excess heat to be stored until utilized for power generation. Thermal storage can also extend the generation day of SolarReserve power plants. The heated salt can be stored in insulated tanks to provide a steam heating source after the sun sets, which will allow the Project facility to more closely satisfy the load demands of the electricity grid system, which may peak in the late afternoon and evening hours. While thermal losses in storage are low, the thermal storage system will include an auxiliary electric heat source to keep the salt in a molten state through protracted maintenance outages.

Although SolarReserve does not anticipate using any fossil fuels to maintain the salt temperature during the operational life of the plant, liquid propane or liquid natural gas may be used as fuel to melt the salt during plant commissioning.

2.3.5 Major Electrical Systems and Equipment

The bulk of the electric power produced by the Project will be transmitted to the electric grid under the control of Public Service Company of Colorado (PSCo), a division of Minnesota-based Xcel Energy, and Tri-State Generation and Transmission Association (TSGT). During operation, a small amount of electrical power will be used to power station auxiliary loads such as pumps and fans, control systems, and general Project facility loads including lighting, heating, and air conditioning, heliostat movement, and other uses. Additionally, electric power will be used to heat the HTF storage tanks, which will provide energy to maintain the salt in fluid state during protracted maintenance outages. Some power will be converted from alternating current (AC) to direct current (DC), which will be used as backup power for control systems.

The emergency power for the plant switchyard and other plant critical loads will be supplied by the 125-volt DC (VDC) station battery system. Emergency power to move the heliostats to the "stow position" in the event of a loss of power to the Project facility will be provided by emergency diesel generators.

2.3.6 Buildings and Enclosures

The following buildings and enclosures are planned as part of the Project:

- Steam Generation Building – This structure is planned to be located between the HTF storage tanks within the power block. The purpose of the building is to provide structural support and protection for the equipment associated with the heat exchange process.

- Steam Turbine Enclosure/Building – This structure will house the steam turbine generator and associated equipment and will be located within the power block at the Steam Turbine/Generator Area.
- Electrical Building – This structure will be located within the power block area and will house the switchgear, motor control centers, battery power supply, and other primary plant electrical components.
- Control and Operations Building – This building will be located within the power block and will house the plant control room and operations support.
- Water Treatment Building – This building will be located within the power block and will house the water treatment facilities.
- Administration/Maintenance Building – This building will serve as the center for support staff for the Project during operations. This facility is planned to be located outside the heliostat field, near the access road.
- Heliostat Assembly Building/Warehouse – This building will be used as a protected environment for the assembly/construction of heliostats during construction of each 100-MW facility. This facility will be converted to other uses at the completion of the construction of the Project.

2.4 Project Schedule

Construction of each of the 100-MW generating facilities, from site preparation and grading to commercial operation, is expected to take up to 30 months. Typically, construction will be scheduled to occur between 5:00 a.m. and 7:00 p.m. on weekdays and Saturdays. Additional hours may be necessary to make up schedule deficiencies or to complete critical construction activities (for example, pouring concrete at night during hot weather, or working around time-critical shutdowns and constraints). During some construction periods and during the startup phase of the Project, some activities may continue 24 hours per day, 7 days per week.

The Project will be constructed in two 100-MW phases. Each of the phases will include a tower, power block, and heliostat array. The first phase is proposed to be in the southwestern portion of the Project site, and the second phase is in the northeastern portion shown in Figure 3.

SECTION 3.0

Fundamentals of Acoustics

Acoustics is the study of sound, and noise is defined as unwanted sound. Airborne sound is a rapid fluctuation or oscillation of air pressure above and below atmospheric pressure creating a sound wave. Acoustical terms used in this section are summarized in Table 3-1.

The most common metric is the overall A-weighted sound level measurement that has been adopted by regulatory bodies worldwide. The A-weighting network measures sound in a similar fashion to the way in which a person perceives or hears sound. In this way, it generally provides a good measure for evaluating acceptable and unacceptable sound levels.

A-weighted sound levels are typically measured or presented as equivalent sound pressure level (L_{eq}), which is defined as the average noise level, on an equal energy basis for a stated period of time, and is commonly used to measure steady-state sound or noise that is usually dominant. Statistical methods are used to capture the dynamics of a changing acoustical environment. Statistical measurements are typically denoted by $L_{xx,}$ where xx represents the percentile of time the sound level is exceeded. The L_{90} is a measurement that represents the noise level that is exceeded during 90 percent of the measurement period. Similarly, the L_{10} represents the noise level exceeded for 10 percent of the measurement period.

Some metrics used in determining the impact of environmental noise consider the differences in response that people have to daytime and nighttime noise levels. During the nighttime, exterior background noises are generally lower than the daytime levels. However, most household noise also decreases at night, and exterior noise becomes more noticeable. Furthermore, most people sleep at night and are sensitive to intrusive noises. To account for human sensitivity to nighttime noise levels, the Day-Night Sound Level (L_{dn} or DNL) was developed. L_{dn} is a noise index that accounts for the greater annoyance of noise during the nighttime hours.

L_{dn} values are calculated by averaging hourly L_{eq} sound levels for a 24-hour period, and apply a weighting factor to nighttime L_{eq} values. The weighting factor, which reflects the increased sensitivity to noise during nighttime hours, is added to each hourly L_{eq} sound level before the 24-hour L_{dn} is calculated. For the purposes of assessing noise, the 24-hour day is divided into two time periods, with the following weightings:

- Daytime: 7 a.m. to 10 p.m. (15 hours) Weighting factor of 0 decibels (dB)
- Nighttime: 10 p.m. to 7 a.m. (9 hours) Weighting factor of 10 dB

TABLE 3-1
Definitions of Acoustical Terms

Term	Definition
Ambient Noise Level	The composite of noise from all sources near and far. The normal or existing level of environmental noise or sound at a given location. The ambient level is typically defined by the L_{eq} level.
Background Noise Level	The underlying ever-present lower level noise that remains in the absence of intrusive or intermittent sounds. Distant sources, such as traffic, typically make up the background. The background level is generally defined by the L_{90} percentile noise level.
Octave Band (or 1/1 Octave Band)	A frequency range with an upper limit that is twice the value of the lower limit of the range. Octave bands are typically identified by their center frequency.
1/3 Octave Band	A narrower range of frequencies than included in a full 1/1 octave band. Each full octave band is divided into three 1/3 octave bands.
Frequency	The number of times per second at which the sound pressure disturbance oscillates between positive and negative values relative to atmospheric. The frequency is measured in cycles per second, or hertz (hz).
Decibel (dB)	The decibel is the basic unit used to describe sound levels, including both sound pressure levels and sound power levels. The decibel is defined as 10 times the logarithm (to the base 10) of a ratio of a measured or calculated value to a reference value.
Sound Power Level (PWL)	A measure of the acoustic power emitted by a sound source. The PWL is defined as $10 \times Log\left(\frac{W}{W_0}\right)$, where W is the sound power emitted by the source (watts) and W_0 is the reference sound power (10^{-12} watt).
Sound Pressure Level (SPL)	A measure of the acoustic pressure at a specific location. The SPL is defined as $10 \times Log\left(\frac{p^2}{p_{ref}^2}\right)$, where p is the root mean square (rms) sound pressure being measured and pref is the reference rms sound pressure (2×10^{-5} newtons per square meter).
A-Weighted Sound Pressure Level (dBA)	The sound level in decibels as measured on a sound level meter using the A-weighted filter network. The A-weighted filter de-emphasizes the very low and very high frequency components of the sound in a manner similar to the frequency response of the human ear and generally correlates well with subjective reactions to noise. All sound levels in this report are A-weighted, unless stated otherwise.
Equivalent Noise Level (L_{eq})	The average A-weighted noise level, on an equal energy basis, during the measurement period.
Percentile (or Statistical) Noise Level (L_n)	The noise level exceeded during n percent of the measurement period, where n is a number between 0 and 100 (for example, L_{90})
Day-Night Noise Level (L_{dn} or DNL)	The average A-weighted noise level during a 24-hour day, obtained after addition of 10 decibels from 10:00 p.m. to 7:00 a.m.

The two time periods are then averaged to compute the overall L_{dn} value. For a continuous noise source, the L_{dn} value is easily computed by adding 6.4 dB to the overall 24-hour noise level (L_{eq}). For example, if the expected continuous noise level from the power plant were 60.0 dBA, the resulting L_{dn} from the plant would be 66.4 dBA.

The effects of noise on people can be listed in three general categories:

- Subjective effects of annoyance, nuisance, and dissatisfaction
- Interference with activities such as speech, sleep, and learning
- Physiological effects such as startling and hearing loss

In most cases, environmental noise produces effects in the first two categories only. However, workers in industrial plants may experience noise effects in the last category. No completely satisfactory way exists to measure the subjective effects of noise, or to measure the corresponding reactions of annoyance and dissatisfaction. This lack of a common standard is primarily due to the wide variation in individual thresholds of annoyance and habituation to noise. Thus, an important way of determining a person's subjective reaction to a new noise is by comparing it to the existing or ambient environment to which that person has adapted. In general, the more the level or the tonal (frequency) variations of a noise exceed the previously existing ambient noise level or tonal quality, the less acceptable the new noise will be, as judged by the exposed individual. Table 3-2 provides the relative A-weighted noise levels of common sounds measured in the environment and in industry for various sound levels.

TABLE 3-2
Typical Sound Levels Measured in the Environment and Industry

Noise Source at a Given Distance	A-Weighted Sound Level in Decibels	Noise Environments	Subjective Impression
Shotgun (at shooter's ear)	140	Carrier flight deck	Painfully loud
Civil defense siren (100 feet)	130		
Jet takeoff (200 feet)	120		Threshold of pain
Loud rock music	110	Rock music concert	
Pile driver (50 feet)	100		Very loud
Ambulance siren (100 feet)	90	Boiler room	
Pneumatic drill (50 feet)	80	Noisy restaurant	
Busy traffic; hair dryer	70		Moderately loud
Normal conversation (5 feet)	60	Data processing center	
Light traffic (100 feet); rainfall	50	Private business office	
Bird calls (distant)	40	Average living room library	Quiet
Soft whisper (5 feet); rustling leaves	30	Quiet bedroom	
	20	Recording studio	
Normal breathing	10		Threshold of hearing

Source: Beranek, 1998.

There are several mechanisms by which noise levels decrease as the distance between noise source and receptor increases. These include:

- Geometrical divergence
- Atmospheric absorption
- Ground effects
- Screening due to terrain or structures

These noise reduction effects generally increase as the frequency of the noise increases.

SECTION 4.0

Colorado Noise Statute

Offsite environmental noise is subject to the limits in Colorado Revised Statute (CRS), Title 25, Article 12 (Noise Abatement). Specific maximum permissible limits are found in CRS 25-12-103. The limits vary by type of zone of the receiving area and by time of day. The limits are shown in Table 4-1.

TABLE 4-1
Maximum Permissible Noise Levels, dBA

	Time Period	
Zone	**7:00 a.m. to next 7:00 p.m.**	**7:00 p.m. to next 7:00 a.m.**
Residential	55	50
Commercial	60	55
Light Industrial	70	65
Industrial	80	75

§25-12-103 (1) states, in part, that the limits apply to "Sound levels of noise radiating from a property line at a distance of 25 feet or more…" This appears to mean that the limit applies only to the noise from the sources on the Project property. However, §25-12-103 (9) states that "In all sound level measurements, consideration shall be given to the effect of the ambient noise level created by the encompassing noise of the environment from all sources at the time and place of such sound level measurement." It is not clear how the non-Project ambient noise is to be considered in the application of the limits to the Project noise. For the purposes of this evaluation, it will be assumed that the noise from the Project alone will not be allowed to exceed the limits noted above.

All of Saguache County is zoned as agricultural. There are no limits established in the Colorado Noise Statute for land zoned as agricultural. The definition of "industrial zone" in the statute specifically excludes agricultural operations.

To identify reasonable criteria to evaluate noise impacts, the residential zone limits will be used as guidelines for residential structures affected by Project noise.

The statute also states that periodic, impulsive, or shrill noises shall be considered a public nuisance when their noise levels are 5 dBA less than those listed in Table 4-1.

The Project equipment in the power block potentially will be able to operate 24 hours per day. Therefore, the nighttime limit of 50 dBA is the controlling criterion that will be used as a guideline for evaluating impacts at residences.

SECTION 5.0

Potentially Affected Environment

The Project is located in the San Luis Valley in south-central Colorado. Most of the Project area and the immediately surrounding area are currently being used for agricultural purposes. The Project is approximately 6 miles northeast of the town of Center, Colorado, and 19 miles south of the town of Saguache, Colorado. There are scattered residences and other structures on some of the land parcels in the area (Figure 4).

Current noise levels at the Project site are expected to be typical of an agricultural-rural area. According to results of studies presented by the Bureau of Land Management (BLM) in the document *Final Programmatic Environmental Impact Statement on Wind Energy Development on BLM-Administered Lands in the Western United States*, in a typical rural environment the "background noise is expected to be approximately 40 dBA during the day and 30 dBA at night" (BLM, 2005). Furthermore, according to information on noise levels presented by the U.S. Environmental Protection Agency (EPA), background noise levels are generally near 35 dBA L_{dn} in wilderness areas; near 40 dBA L_{dn} in rural residential areas; and near 44 to 45 dBA L_{dn} in agricultural cropland (EPA, 1978).

SECTION 6.0

Noise Impact Analysis

Operation of the Project will produce noticeable noise near the facility. Noise also will be produced at the site during the construction of the Project. Potential noise impacts from construction and operation activities are assessed in this section.

6.1 Construction Noise

Construction of the Project is expected to be typical of other power plants in terms of schedule, equipment used, and other types of activities. The noise level will vary during the construction period, depending on the construction phase. Construction of power plants can be generally divided into five phases that use different types of construction equipment. The five phases are demolition, site preparation, and excavation; concrete pouring; steel erection; mechanical; and cleanup (Miller et al., 1978).

The EPA Office of Noise Abatement and Control and the Empire State Electric Energy Research Company have extensively studied noise from individual pieces of construction equipment as well as from construction sites of power plants and other types of facilities (EPA, 1971; Barnes et al., 1976). Because specific information on types, quantities, and operating schedules of construction equipment is not available at this point in Project development, information from these documents for similarly sized industrial Projects will be used. Use of these data, which are more than 30 years old, is conservative because the evolution of construction equipment has been toward quieter designs to protect operators from exposure to high noise levels.

The loudest equipment types generally operating at a site during each phase of construction are presented in Table 6-1. The composite average or equivalent site noise level, representing noise from all equipment, also is presented for each phase.

TABLE 6-1
Construction Equipment and Composite Site Noise Levels

Construction Phase	Loudest Construction Equipment	Equipment Noise Level (dBA) at 50 feet	Composite Site Noise Level (dBA) at 50 feet
Demolition, Site Clearing, and Excavation	Dump Truck	91	89
	Backhoe	85	
Concrete Pouring	Truck	91	78
	Concrete Mixer	85	
Steel Erection	Derrick Crane	88	87
	Jack Hammer	88	
Mechanical	Derrick Crane	88	87
	Pneumatic Tools	86	
Cleanup	Rock Drill	98	89
	Truck	91	

TABLE 6-1
Construction Equipment and Composite Site Noise Levels

Construction Phase	Loudest Construction Equipment	Equipment Noise Level (dBA) at 50 feet	Composite Site Noise Level (dBA) at 50 feet

Source: EPA, 1971; Barnes et al., 1976.

Average or equivalent construction noise levels projected at various distances from the site are presented in Table 6-2. These results are conservative, because the only attenuating mechanism considered was divergence of the sound waves in open air. Additional attenuation will result from air absorption and ground effects. Table 6-3 presents noise levels from common construction equipment at various distances from divergence only.

TABLE 6-2
Average Construction Noise Levels at Various Distances

	Sound Pressure Level (dBA)			
Construction Phase	**50 feet**	**1,500 feet**	**1 mile**	**15 miles**
Demolition, Site Clearing, and Excavation	89	59	49	25
Concrete Pouring	78	48	38	14
Steel Erection	87	57	47	23
Mechanical	87	57	47	23
Cleanup	89	59	49	25

TABLE 6-3
Noise Levels from Common Construction Equipment at Various Distances

	Sound Pressure Level (dBA)			
Construction Equipment	**50 feet**	**1,500 feet**	**1 mile**	**15 miles**
Pile Drivers (20,000 to 32,000 ft-lbs./blow)	104	74	64	40
Dozer (250 to 700 hp)	88	58	48	24
Front End Loader (6 to 15 yd^3)	88	58	48	24
Trucks (200 to 400 hp)	86	56	46	22
Grader (13- to 16-foot blade)	85	55	45	21
Shovels (2 to 5 yd^3)	84	54	44	20
Portable Generators (50 to 200 kW)	84	54	44	20
Derrick Crane (11 to 20 tons)	83	53	43	19
Mobile Crane (11 to 20 tons)	83	53	43	19
Concrete Pumps (30 to 150 yd^3)	81	51	41	17

TABLE 6-3
Noise Levels from Common Construction Equipment at Various Distances

	Sound Pressure Level (dBA)			
Construction Equipment	**50 feet**	**1,500 feet**	**1 mile**	**15 miles**
Tractor (0.75 to 2 yd^3)	80	50	40	16
Unquieted Paving Breaker	80	50	40	16
Quieted Paving Breaker	73	43	33	9

Notes:
ft-lbs./blow = foot-pounds of work per blow
hp = horsepower
yd^3 = cubic yard(s)

Noise generated during the testing and commissioning phase of the Project is not expected to be substantially different from that produced during normal full-load operation. Starts and abrupt stops are more frequent during this period, but they are usually short lived.

A steam blow, with a noise level of 110 dBA at 1,000 feet, is an activity, rather than a piece of equipment. This activity is designed to clean scale and other debris from the boiler tubes and steam lines before admitting steam to the steam turbine where the foreign material would damage the blades. A temporary bypass line to the atmosphere is welded into the main steam line upstream of the steam turbine to divert the steam. Several short blows of approximately 2 minutes in duration each will be performed per day, and the entire process generally takes several weeks. Steam blow silencers can reduce noise levels by about 30 dBA, if necessary given the distance to sensitive receptors. Because the closest sensitive receptors are 12,000 feet away, the noise at that point will be reduced to 88 dBA, taking only geometric spreading into account. The Project will use steam blow silencers to reduce the noise at nearby residences.

Project construction activities may include early morning starts, evening work, and 24-hour operations. This may be required to maintain schedule, provide cooler periods to perform the work, perform 24-hour continuous operations, or may be due to other requirements. Noisy nighttime construction activities will be minimized to limit disturbance at residences.

6.2 Operational Impacts

6.2.1 Plant Operational Noise Levels

A noise model of the Project has been developed using source input noise levels derived from manufacturers' data, previous Projects with similar equipment, and information available in the technical literature. The noise emissions from the Project have been calculated at the property boundary and at points beyond. The noise levels presented represent the anticipated steady-state level from the plant with essentially all equipment operating. The Project was modeled for two scenarios: (1) both north and south facilities in operation, and (2) south facility only in operation.

Standard acoustical engineering methods were used in the noise analysis. The computer software noise model, CADNA/A by DataKustik GmbH of Munich, Germany, is very sophisticated and is capable of fully modeling complex industrial plants. The sound propagation factors used in the model have been adopted from International Organization for Standardization (ISO) 9613-2 *Acoustics – Sound Attenuation During Propagation Outdoors* and VDI 2714 *Outdoor Sound Propagation*. The model divides the proposed facility into a list of individual point and area noise sources representing each piece of equipment that produces a significant amount of noise. The sound power levels representing the standard performance of each of these components are assigned based either on field measurements of similar equipment made at other existing plants, data supplied by manufacturers, or information found in the technical literature. Using these standard power levels as a basis, the model calculates the sound pressure level that would occur at each receptor from each source after losses from distance, air absorption, ground effects, and blockages are considered. The sum of all these individual levels is the total plant level at the modeling point.

The A-weighted sound power levels for the major noise sources used in the model are summarized in Table 6-4. Some of the specific equipment to be used at the plant has not yet been determined. Therefore, typical noise levels for equipment associated with similar facilities have been assumed.

TABLE 6-4
Sound Power Levels Used to Model Project Plant Operations
Numbers of Equipment are Total for Both North and South Facilities

Plant Component	Sound Power Level, dBA
Large Cold Salt Pump, each of 6	112
Large Cold Salt Pump Motor, each of 6	116
Hot Salt Pump, each of 4	110
Hot Salt Pump Motor, each of 4	110
Small Cold Salt Pump, each of 2	108
Small Cold Salt Pump Motor, each of 2	100
Steam Turbine Generator, each of 2	110
Boiler Feed Pump, each of 4	105
Boiler Feed Pump Motor, each of 4	116
Air-cooled Condenser, each of 2	110
Fin Fan Cooler, each of 2	102
GSU Transformer, each of 2	101
Auxiliary Transformer, each of 2	90
Service Transformers, each of 4	82

Note:
GSU = Generator Step-Up

The maximum noise level attributable to normal Project operation with both facilities in operation at rated capacity at the nearest residence is estimated to be 46 dBA. The maximum property line noise level is estimated to be 49 dBA and will occur at the south property line. Contours of noise levels from the Project with both facilities in operation are shown in Figure 5.

The maximum noise level attributable to normal Project operation with only the south facility in operation at rated capacity at the nearest residence is estimated to be 44 dBA. The maximum property line noise level is estimated to be 49 dBA and will occur at the south property line. Contours of noise levels from the Project with only the south facility in operation are shown in Figure 6.

Project noise levels during nighttime operation would be lower than the expected daytime maximum levels described above. The cold salt pumps and cold salt pump motors would not operate at night. Also, the lower ambient temperatures at night should allow the air-cooled condenser to operate at lower fan speeds or with fewer fans in operation.

There is a potential for higher noise levels to be generated during periods when the steam turbine is bypassed. This situation is not expected to occur frequently and can be addressed in the design of the bypass valve system and the duct system that will convey the bypass steam to the air-cooled condenser.

6.2.2 Transmission Line and Switchyard Noise Levels

One of the electrical effects of high-voltage transmission lines is corona. Corona is the ionization of the air that occurs at the surface of the energized conductor and suspension hardware due to very high electric field strength at the surface of the metal during certain conditions. Corona may result in radio and television reception interference, audible noise, light, and production of ozone. Corona is generally a principle concern with transmission lines of 345 kV and higher. Noise is also generally associated with precipitation during foul weather conditions, which occurs infrequently in the Project area. The audible noise associated with the 230-kV lines in the area will be of the same magnitude upstream and downstream of the Project. Because the Project will be connected at 230 kV, it is expected that no corona-related design issues will be encountered, and any related impacts will be less than significant.

6.2.3 Periodic, Impulsive, or Shrill Noises

No significant periodic, impulsive, or shrill noises are anticipated at the closest noise sensitive receptors.

SECTION 7.0

Conclusions

Review of the Colorado Noise Statute indicates that none of the maximum permissible noise limits apply to land zoned for agricultural use. All property within Saguache County is zoned as agricultural. Although not technically applicable, the statute limits for residential use have been selected as guidelines for evaluating Project operational impacts at residences.

The noise levels generated by individual components of each of the two facilities that make up the Project have been estimated, based on information supplied by equipment suppliers and data available in the technical literature.

A computer model was used to estimate Project operational noise levels at multiple locations and to calculate a grid of noise levels at specific points to allow the generation of Project noise isopleths. The model results indicate that the maximum Project noise at any residence under normal conditions at maximum Project output with both facilities in operation is not expected to exceed 46 dBA. The model results also indicate that the maximum Project noise at any residence under normal conditions at maximum Project output with only the south facility in operation is not expected to exceed 44 dBA. The Project noise under either of these scenarios is less than the 50 dBA level used as a guideline. Additionally, nighttime Project noise levels will be lower, because the equipment used for collection will not be in operation; and the lower ambient temperatures will result in lower noise from the equipment used for cooling.

SECTION 8.0

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Appendix
Figures

FIGURE 1
Vicinity Map

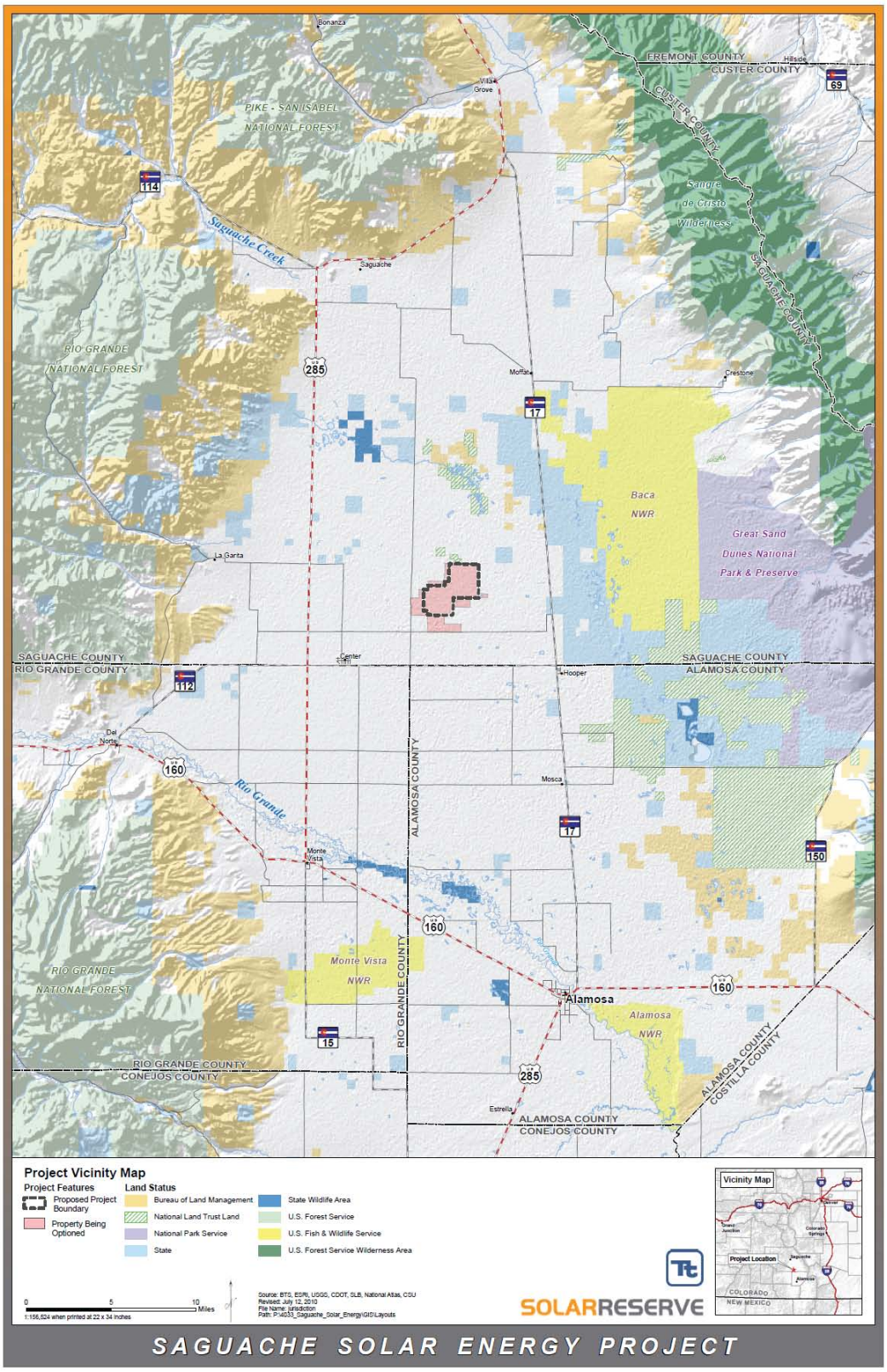
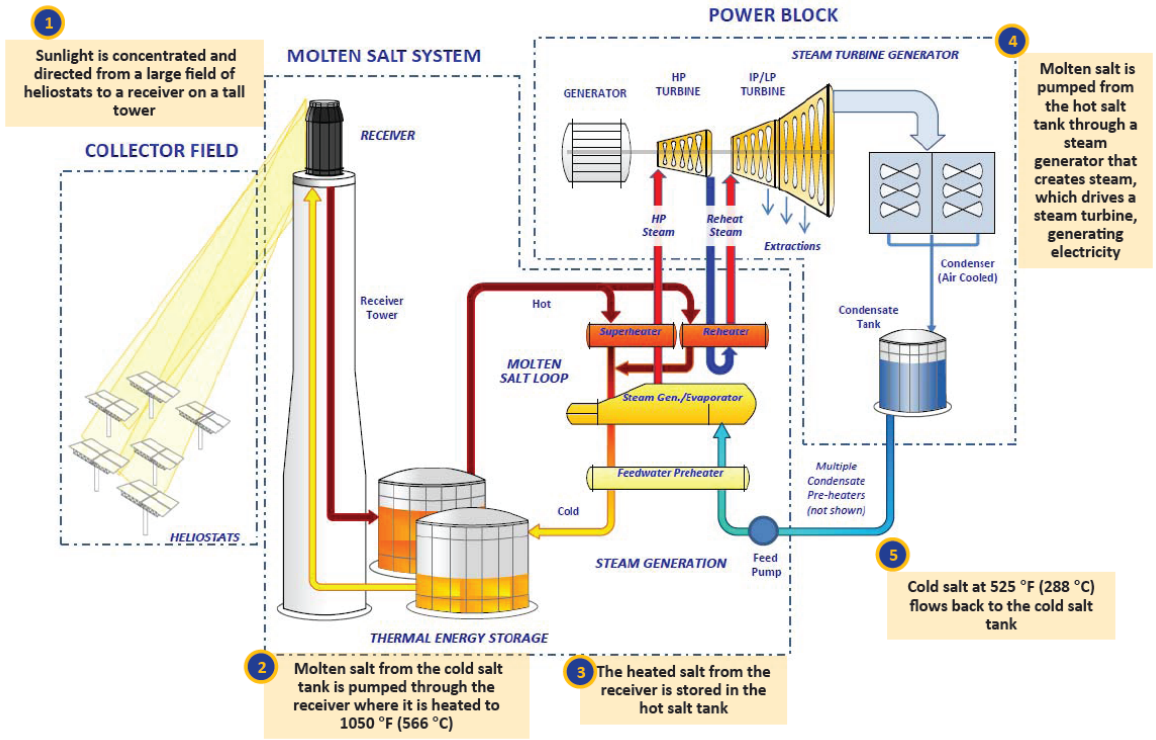


FIGURE 2
Process Diagram of CPS Technology



SOLARRESERVE

FIGURE 3
Site Layout

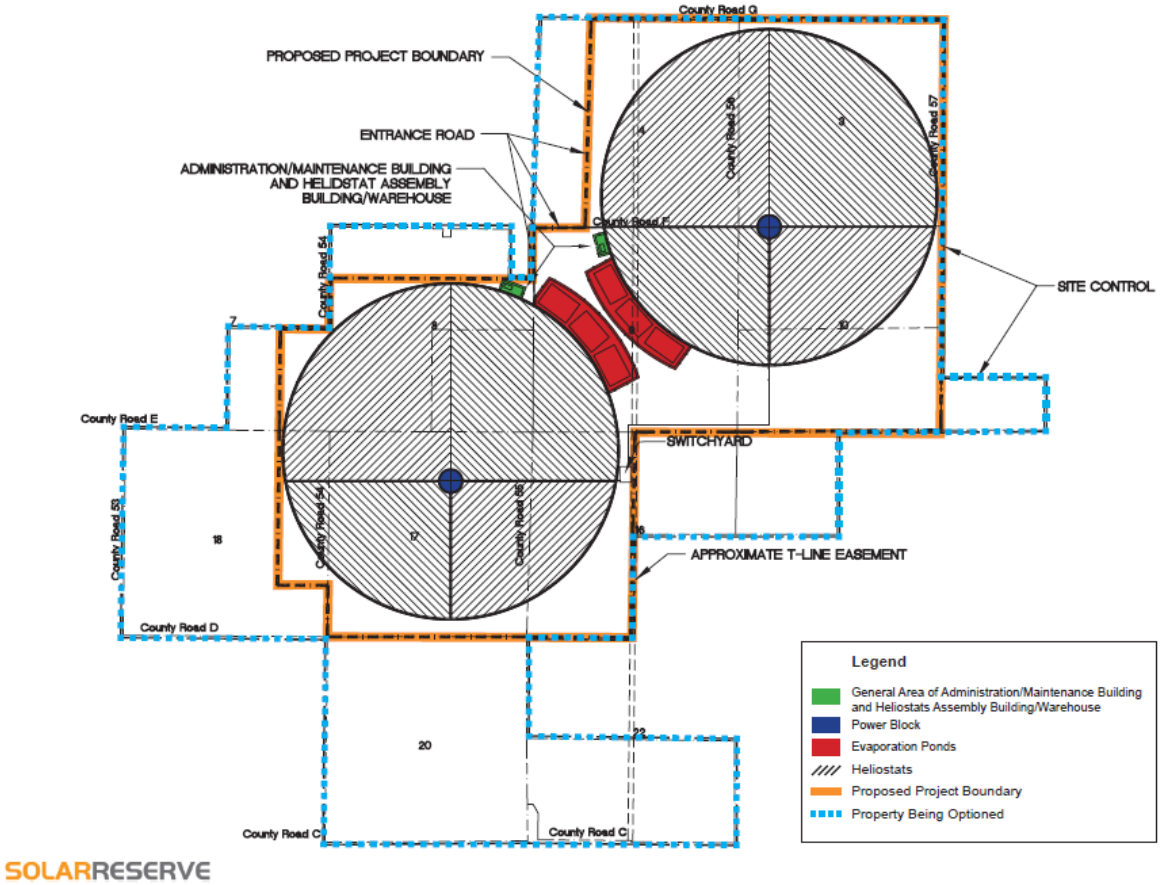
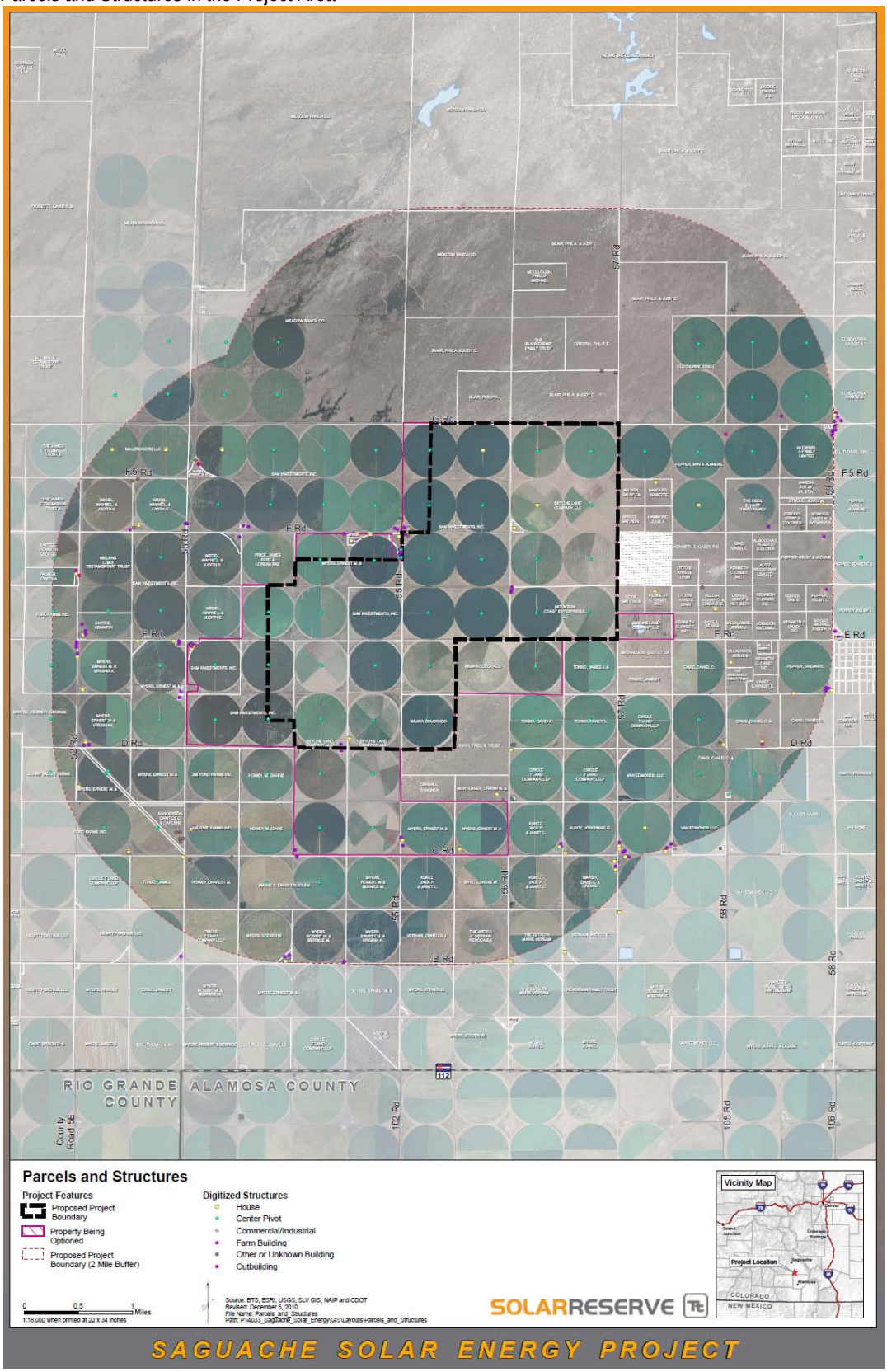
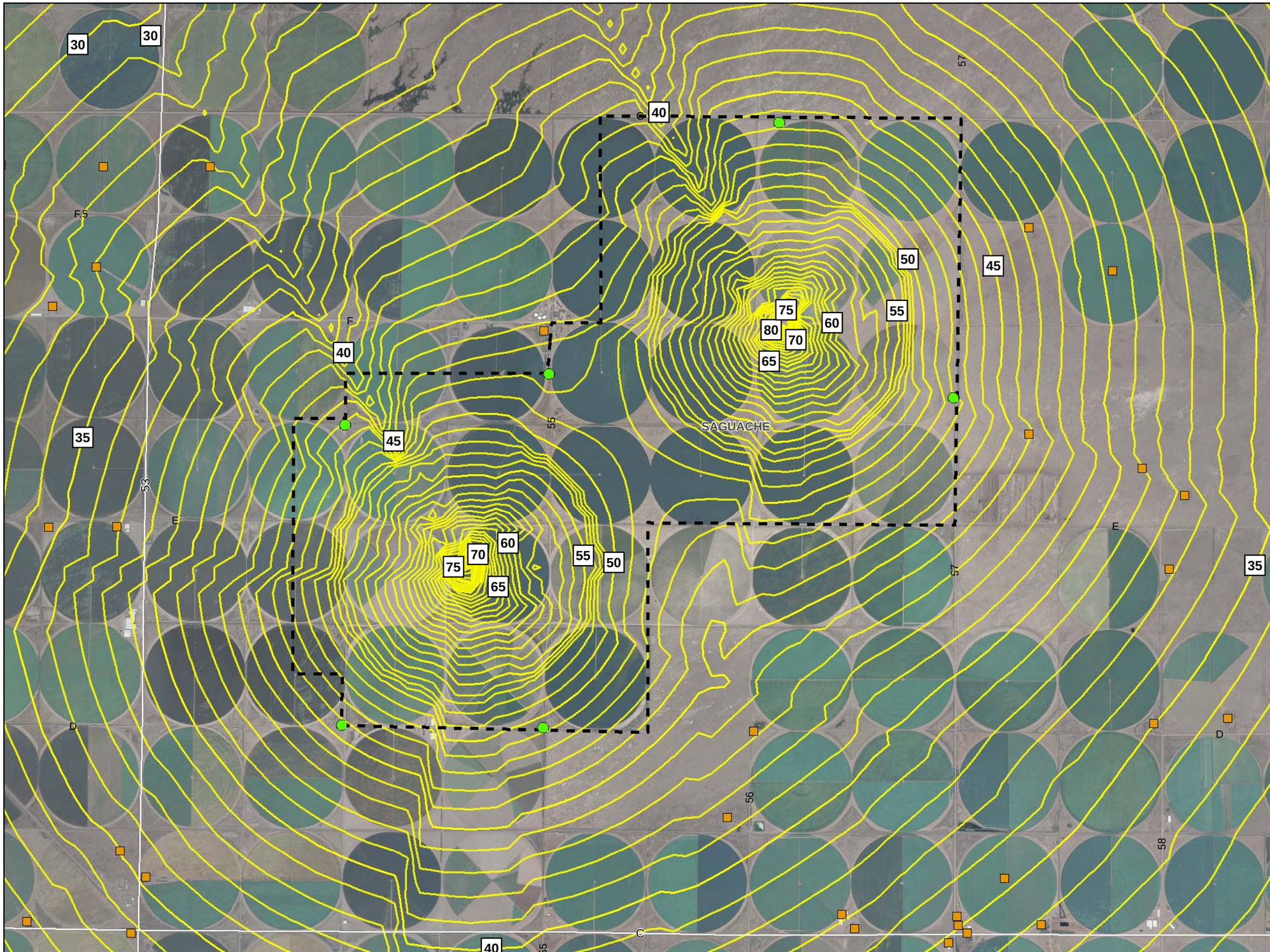


FIGURE 4
Parcels and Structures in the Project Area





Legend

- Property Line Receptor
- Residence
- Noise Contours
- Proposed Project Boundary

N

0 0.25 0.5 Miles

Figure 5
Project Noise Contours
Both Facilities in Operation

Solar Reserve
Saguache County, Colorado

Source: CDOT, NAIP 2009

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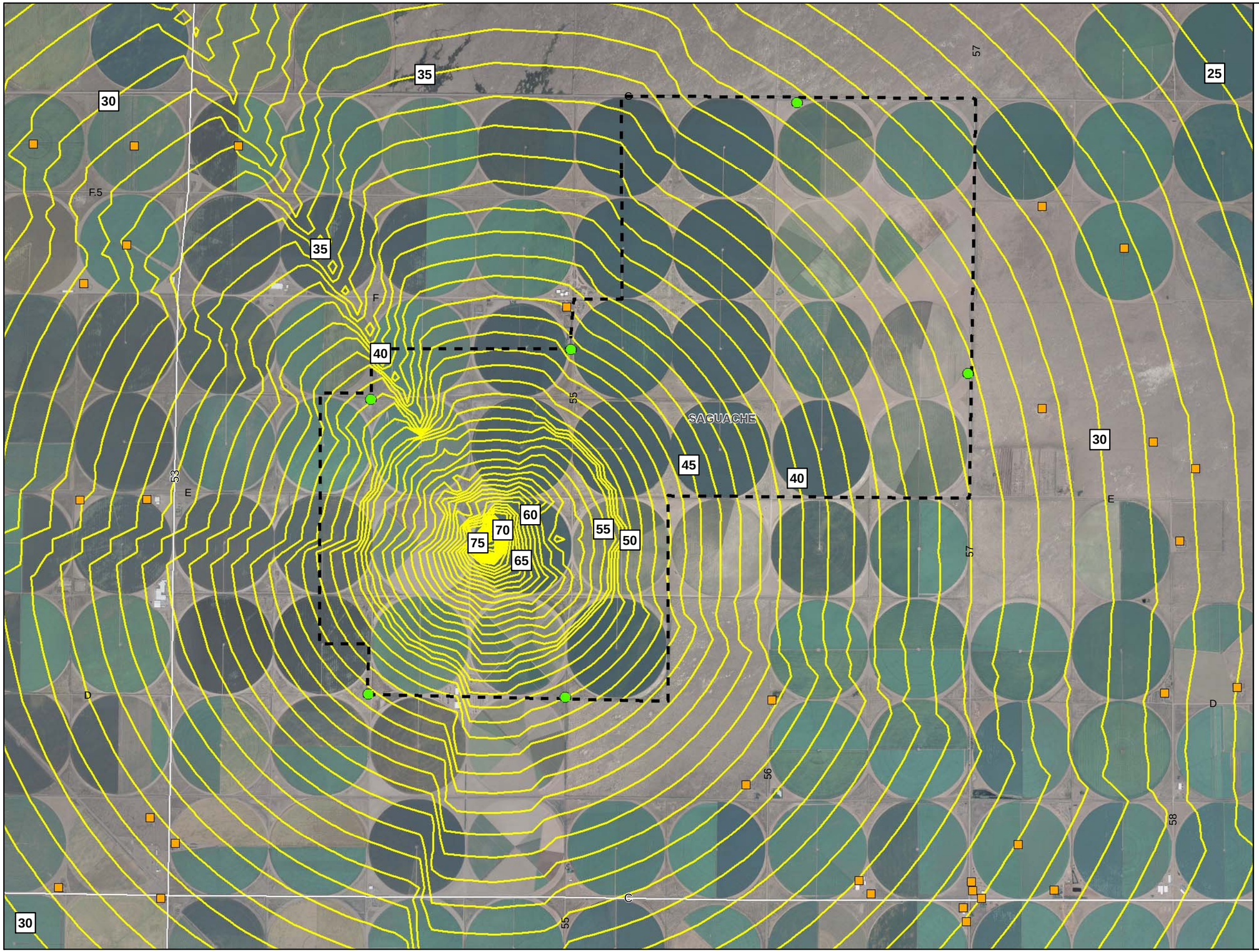

Legend

- Property Line Receptor
- Residence
- Noise Contours
- Proposed Project Boundary

N

0 0.25 0.5 Miles

Figure 6
Project Noise Contour
South Facility Only in Operation

Solar Reserve
Saguache County, Colorado

Source: CDOT, NAIP 2009

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