Saguache Solar Energy Project

Site Characteristics Investigation for the Grading and Drainage Design

Saguache County

Colorado

October 26, 2010

Submitted to:

SOLARRESERVE

Prepared By:

WorleyParsons

resources & energy

NOTICE

The information presented in this document was compiled and interpreted exclusively for the purposes of this Site Characteristics Investigation for the Grading and Drainage Design for Saguache Solar Energy Project. WorleyParsons provided this report for Saguache Solar Energy, LLC for the purpose noted above.

WorleyParsons has exercised reasonable skill, care, and diligence to assess the information acquired during the preparation of this report, but makes no guarantees or warranties as to the accuracy or completeness of this information. The information contained in this report is based upon, and limited by, the circumstances and conditions acknowledged herein, and upon information available at the time of its preparation. The information provided by others is believed to be accurate but cannot be guaranteed.

WorleyParsons does not accept any responsibility for the use of this report for any purpose other than that stated above and does not accept responsibility to any third party for the use in whole or in part of the contents of this report. Any alternative use, including that by a third party, or any reliance on, or decisions based on this document, is the responsibility of the alternative user or third party.

No part of this publication may be reproduced, stored in a retrieval system or transmitted, in any form or by any means, electronic, mechanical, photocopying, recording or otherwise, without the prior permission of WorleyParsons.

SAGUACHE SOLAR ENERGY PROJECT – SITE CHARACTERISTICS INVESTIGATION FOR THE GRADING AND DRAINAGE DESIGN

REV	DESCRIPTION	DATE
0	Issued for Use	26-October-2010

TABLE OF CONTENTS

1. INTRODUCTION 3
2. SITE LOCATION 3
3. REGIONAL AND LOCAL CHARACTERISTICS 3
3.1 CLIMATOLOGY 3
3.2 TOPOGRAPHY 4
3.3 LAND USE 4
3.4 GEOLOGY AND SOILS 5
3.5 SURFACE WATERS AND FLOODPLAINS 6
3.6 HYDROGEOLOGY 7
4. RECOMMENDATIONS/CONCLUSSIONS 8
5. REFERENCES 8

LIST OF FIGURES

FIGURE 1: REGIONAL MAP
FIGURE 2: LOCATION MAP
FIGURE 3: SITE CONDITIONS
FIGURE 4: AERIAL SITE MAP
FIGURE 5: SITE MAP – SOILS
FIGURE 5.1: SITE MAP – SOILS LEGEND

1. INTRODUCTION

The proposed Saguache Solar Energy Project (herein "SSEP" or "Project') is a 200 MW Solar Thermal Power Generating Project to be built in south-central Colorado (refer to **Figure 1**). The SSEP will be constructed as two 100 MW units with each unit containing a circular solar array field containing heliostats, power block, administration/warehouse buildings, evaporation ponds and associated linear facilities (transmission lines, access roads etc).

The aim of this report is to evaluate existing grading and drainage patterns associated to aid the future detail design of the SSEP, and to verify that drainage for the site can be designed to detain and treat storm water in accordance with the Urban Drainage Stormwater Manual. This is undertaken by investigating the local environment that impacts the grading and drainage patterns which are climate, topography, land use, geology, soils, surface waters, flood plains and hydrogeology.

2. SITE LOCATION

The SSEP will be located in unincorporated Saguache County, Colorado, situated west of State Highway 17, south and east of State Highway 285 and north of State Highway 112. Access to the site is off Country Road G, which is located north of the site.

The Project site is approximately 145 miles south-west of Denver and approximately 5 miles northeast of the town of Center. There are no permanent residents in the near vicinity of the project site.

3. REGIONAL AND LOCAL CHARACTERISTICS

3.1 CLIMATOLOGY

The San Luis Valley is an arid cool desert with extreme daily temperature changes, but generally characterized by cold winters, moderate summers and tremendous amounts of sunshine in all seasons (Emery 1979 and Baumann 2001).

The closest Western Regional Climate Center meteorological station to the Project is *Centre 4 SSW (051458)* which is 9 miles southwest. Based on data records from 1941 to 2009, the average annual maximum temperature is 58.4°F, with a peak of 80.5°F recorded in July. The average annual minimal temperature is 24.3°F with the low of -0.9°F recorded in January. The average total annual precipitation is 7 inches, ranging from a monthly high of 1.25 inches (recorded in August) to a low of 0.2 inches (recorded in February). The average total annual snowfall is 25 inches, ranging from a monthly high of 4.8 inches (recorded in December) to a low of 0 inches (recorded June through August). Average annual evaporation in the Project area, based on published evaporation pan data at the San Luis Lakes (approximately 15 miles southeast of the Project site), is 56 inches, of which all occurs between March and October.

The detailed drainage design will address the precipitation and snow melt conditions on the site, however it is anticipated that there will be no major drainage design issues based on these reported annual average values.

3.2 TOPOGRAPHY

The Project site is located in the San Luis Valley, which is identified as the States best solar resource area. It is an extensive valley that covers approximately 8000 square miles from Colorado to New Mexico. The Project site is surrounded by mountain ranges with the Great Sand Dunes Park to the east and the Rio Grand National Park to the west of the Project site (refer **Figure 1)**. The average elevation of the San Luis Valley is approximately 7,700 feet above mean seal level (amsl) and over 14,000 feet amsl in surrounding mountain peaks (Emery 1979).

The SSEP is located at approximately 7555 to 7590 feet amsl, gently sloping southwest to northeast at approximately a 0.1% grade (refer **Figure 2** and **3**). Due to the flat topography, drainage channels will need to be designed as wide and shallow to provide the appropriate grade.

3.3 LAND USE

The Project will be developed on approximately 6,200 acres of privately owned land of which the SSEP facilities would be established on approximately 3,000 acres of this land. The current land use in the Project area is primarily irrigated crop land (refer **Figure 1** and **4**). Generally, the land is covered by cropland (mainly barley, oats, hay, potatoes and other vegetables), irrigated with large center-pivot irrigation systems, separated by dirt roadways (refer to **Photo 1**). There is an existing 230 kilovolt (kV) transmission line that runs through the Project area and connects with the San Luis Valley substation, located approximately 6 miles south.

Photo 1: Roadway between two crop circles, Site Visit (07/06/2010)

The entire property is within the unincorporated Saguache County and all zoned Agriculture Use, unless otherwise specifically designated by the County. The current draft of the Saguache County Master Plan recognizes that solar energy development is a priority within the County.

Due to the flat topography/surface for cropping, major grading works will not be required to create a level surface for the SSEP, however vegetation will require removal to maximize solar potential and minimize fire hazards. There will be an increase in impervious area around the power block, buildings and access road, as these portions of the project will be on impervious surfaces, rather than the exposed soil. This can be mitigated by the use of a detention / retention basin to ensure the post development flow rates are at or less than the pre development flow rates. Therefore there does not appear to be any major impediments to overcome with the grading and drainage design based on the current land use site conditions.

3.4 GEOLOGY AND SOILS

The San Luis Valley sits on top of the Rio Grande Rift, which is a split in the crust of the earth, where the sides are pulling away from each other. As the mountains have eroded over time, the hole has been filled with rock, sand, clay and earth, and it's estimated that up to 12,000 feet of this material underlies the valley (Emery, 1979). The alluvial deposits are coarse and permeable near the mountains and grade to fine-grained, less permeable deposits towards the centre of the valley (Emery, 1979). The United States Department of Agriculture (USDA), Natural Resources Conservation Services (NRCS) has classified the soils in the Project area as generally fine loam which portions of coarse loam and clay loam (refer **Figure 5** and **5.1**). Based on site visits, the surface soils are appear to be well drained after irrigation water is supplied.

The Colorado Department of Agriculture, Center Conservation District was established in 1944 and has the mission statement of "the prudent use and adequate treatment of all land, water, and

related resources within it's boundaries, to sustain the use of these resources for future generations and to restore that portion of these resources damaged through improper use" (Colorado Department of Agriculture 2010). The SSEP is within this District and will be addressing their requirements by controlling soil erosion, protecting the water quality and quantity and preventing the spread of noxious weeds through design of Best Management Practices (BMPs) and operational procedures.

A geotechnical investigation will be undertaken as part of the SSEP design process to determine the requirements of the design based on the soil and underlying geological conditions, however there does not appear to be any major hurdles to overcome with the grading and drainage design based on the current geological and soil site conditions.

3.5 SURFACE WATERS AND FLOODPLAINS

The Project site is within the Rio Grand River Basin watershed (refer **Figure 1**). Surface water flows into the San Luis Valley from the surrounding mountains however generally it percolates into the ground or is diverted through irrigation canals and the only surface water to leave the valley is via the Rio Grande River, 20 miles south of the Project site. The Rio Grande River forms in the San Juan Mountains and flows eastward towards the centre of the valley, and then southward towards New Mexico, and subsequently forms a border between Texas and Mexico before flowing into the Gulf of Mexico (Sangres 2010 and Baumann 2001) (refer **Figure 1**).

The surface water is a major source of water for irrigation, therefore a system of canals and laterals have been established, having an aggregate length exceeding 150 miles (Emery 1979) (refer **Figure 3**). More than 70 percent of the surface water inflow is sourced from snowmelt (between April and June), with the remaining water sourced from precipitation through of the year (July to March) (Emery 1979). There are several irrigation canals on the Project site which include the Gibson Ditch, North Lateral and North Central Lateral (**refer Figure 3**). The irrigation canals will require rerouting or removal for the SSEP with consideration to surrounding users of the canals.

The Federal Emergency Management Agency (FEMA) has not issued historic, current or future maps for the Saguache County, therefore have not analyzed if there is a flood hazard in this region. The Colorado Water Conservation Board (CWCB) Flood Protection Program performs technical reviews for CWCB designation and approval of flood plain studies. The USGS, in cooperation with the Colorado Department of Transportation and the Bureau of Land Management, undertook a study in 2000 to assess the magnitude and frequency of flooding in Colorado (Vaill 2000). The CWCB recommends using this USGS study to approximate peak flows in the Rio Grande Basin (Colorado Water Conservation Board 2004). However, as the Rio Grande River is 20 miles southeast from the Project site, at an elevation of 7645 feet amsl, flowing southwest (away from the site) in an established floodplain, it is not expected to cause a flooding impact to the Project Site.

Figure 1 and **2** indicates a lake / wetland / river area north and north east of the Project site. Russell Creek, north of the Project site, which is downstream of Russell Lakes (containing Davey Lake, Trites Lake, Island Lake) flows to the Mishak Lakes area and then merges with Werner Arroyo Creek, La Garita Creek, Saguache Creek and all flow into the San Luis Creek to the north

east of the project site (at an approximate elevation of 7545 feet amsl). There is intermittent flow from the San Luis Creek, through a series of small lakes (approximately 15 miles east of the Project site) down to Bachelor Lake and San Luis Lakes at an elevation of 7515 feet amsl. Flooding of the project site from the San Luis Creek is not expected.

The surface water runoff from the Project site, that is not infiltrated to groundwater, will follow natural contours to the north east and towards the San Luis Creek region, which is classified as a freshwater emergent wetland area on the United States Fish and Wildlife Services National Wetland Inventory (refer **Figure 1**).

As outlined in **Section 3.3**, stormwater flows may be mitigated on the SSEP site to ensure there is no impact to downstream properties due to the development. The Colorado Department of Public Health and Environment (CDHE) is responsible for administering the states stormwater management plan, which are mirrored after the federal NPDES program, requiring that stormwater be treated to the maximum extent practicable (Regulatory Database 2010). Therefore Saguache Solar Energy LLC will obtain permit coverage under Colorado's NPDES program for construction and operation of the SSEP.

Based on the current site conditions, there are no apparent major hurdles to overcome with the grading and drainage design.

3.6 HYDROGEOLOGY

Groundwater occurs in both unconfined and confined aquifers in the San Luis Valley (Emery 1979). The aquifers are recharged by infiltration of a variety of sources which include the irrigation water applied to land, surface waters from the mountains, precipitation, and from canal leakage. Groundwater is generally removed from the aquifers by pumping well extraction (generally used for irrigation) and evapotranspiration. Within the San Luis Valley unconfined aquifers, groundwater can be found at less than twelve feet from the surface, while the confined aquifers occur in the upper 6,000 feet of the sediment (Baumann 2001). Hot springs occur along the eastern and northeastern sides of the San Luis Valley due to the formation of natural artesian wells, which occur when groundwater has been heated deep within the earth and can flow upward to the surface under natural pressure.

Historically, surface flood irrigation was the primary method of distributing water to the agriculture fields form the 1890s to the early 1960's. As the Rio Grande River flowed out of the San Juan Mountains and into the centre of the valley, the sediment accumulated and caused the water from the unconfined aquifer to rise to the surface and even seep onto the surface (Baumann 2001). In addition, there were elevated nitrogen concentrations in the groundwater during this period due to all the agriculture practices (Stogner 1997). However now there are nutrient and pest management programs in place to optimize the management of water, nutrients and pesticides and decrease the transportation of agriculture fertilizers and pesticides to the groundwater (Stogner 1997). Data from the Colorado Division of Water Resources show that the depth of existing groundwater wells on site ranges from 32 feet to over 1000 feet.

Based on the current site conditions, the groundwater will be sufficiently below the ground surface to not interact with the grading and drainage design.

4. RECOMMENDATIONS/CONCLUSSIONS

The scope and scale of the grading and drainage design is contingent on the regional and local site conditions. A review of the climate, topography, land use, geology, soils, surface waters and hydrogeology has identified that no major design difficulties are expected. It is concluded that the Saguache Solar Energy Project can be designed and built to detain all flows leaving the site at historic levels and locations, and that all runoff can be treated for quality per the Urban Drainage Stormwater Manual (produced by DRCOG).

5. REFERENCES

Baumann, Prof Paul R (2001), Dry land and Water, San Luis Valley, CO, State University of New York, http://employees.oneonta.edu/baumanpr/geosat2/Dry_Land_Water/Dry_Land_Water.htm

Colorado Department of Agriculture (2010), http://www.colorado.gov/cs/Satellite/Agriculture-Main/CDAG/1178305637278

Colorado Water Conservation Board (2004), Guidelines for Determining 100-year Flood Flows for Approximate Floodplains in Colorado, Version 6.0, Department of Natural Resources, Flood Protection Program, Colorado, June 2004.

Emergy (1979), http://www.nps.gov/grsa/naturescience/upload/Trip2023.pdf

Regulatory Data base (2010), http://204.202.251.206/regulatory_data/state.aspx?id=125

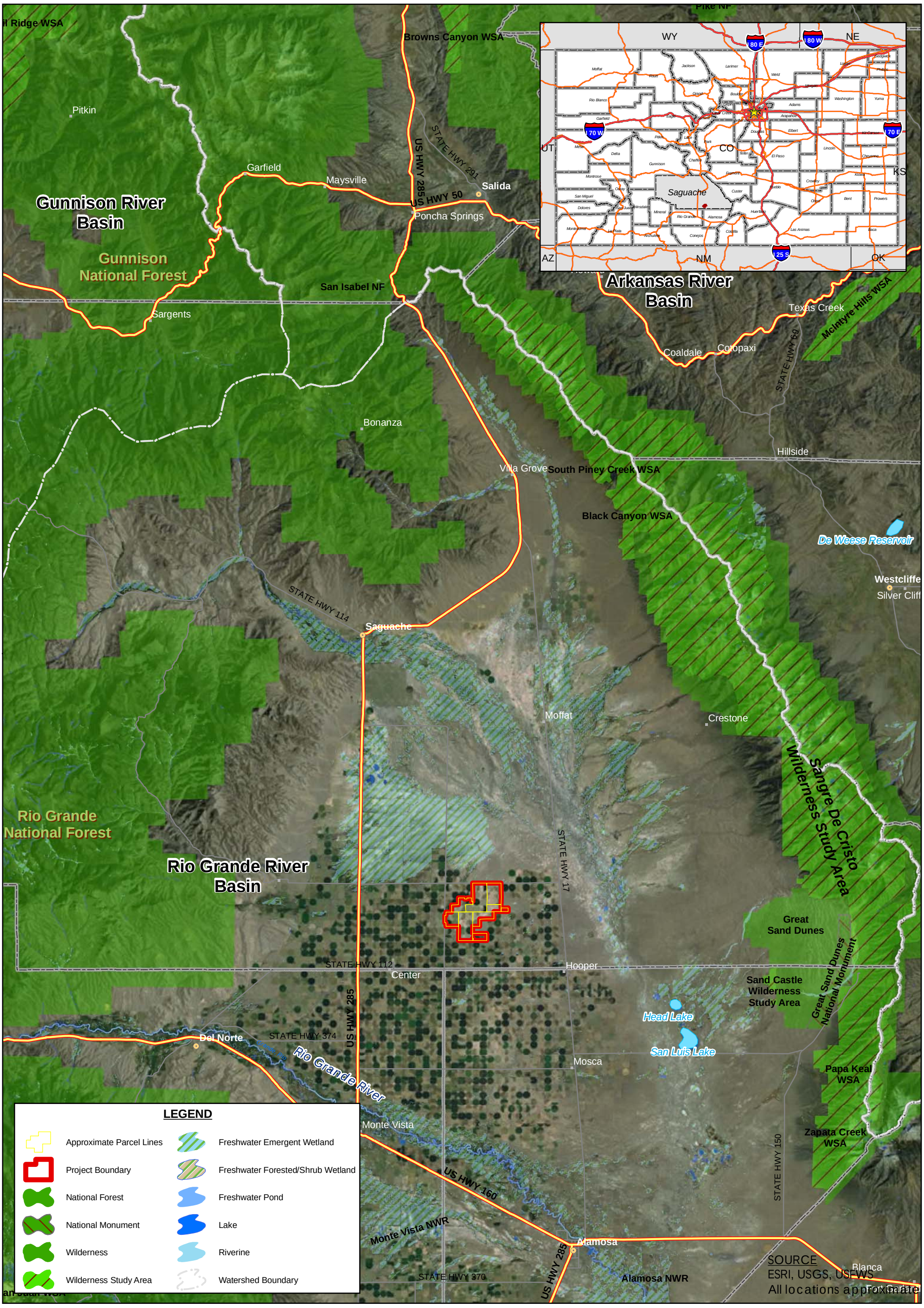
Sangres (2010), http://www.sangres.com/colorado/slv.htm

Stogner, Robert Snr (1997), Variability of Nitrate Concentrations in the Shallow Ground Water in a Selected Area of the San Luis Valley, South-Central Colorado, US Department of the Interior-US Geological Survey, Fact Sheet FS-004-97, March, http://pubs.usgs.gov/fs/fs004-97/pdf/fs004-97.pdf

Western Regional Climate Center (2010) Climate Data: http://www.wrcc.dri.edu/cgi-bin/cliMAIN.pl?co1458 and http://www.wrcc.dri.edu/htmlfiles/westevap.final.html#COLORADO

Vaill, J.E (2000), Analysis of the Magnitude and Frequency of Floods in Colorado, US Department of the Interior-US Geological Survey, Water Resources Investigation Report 99-4190,

FIGURES



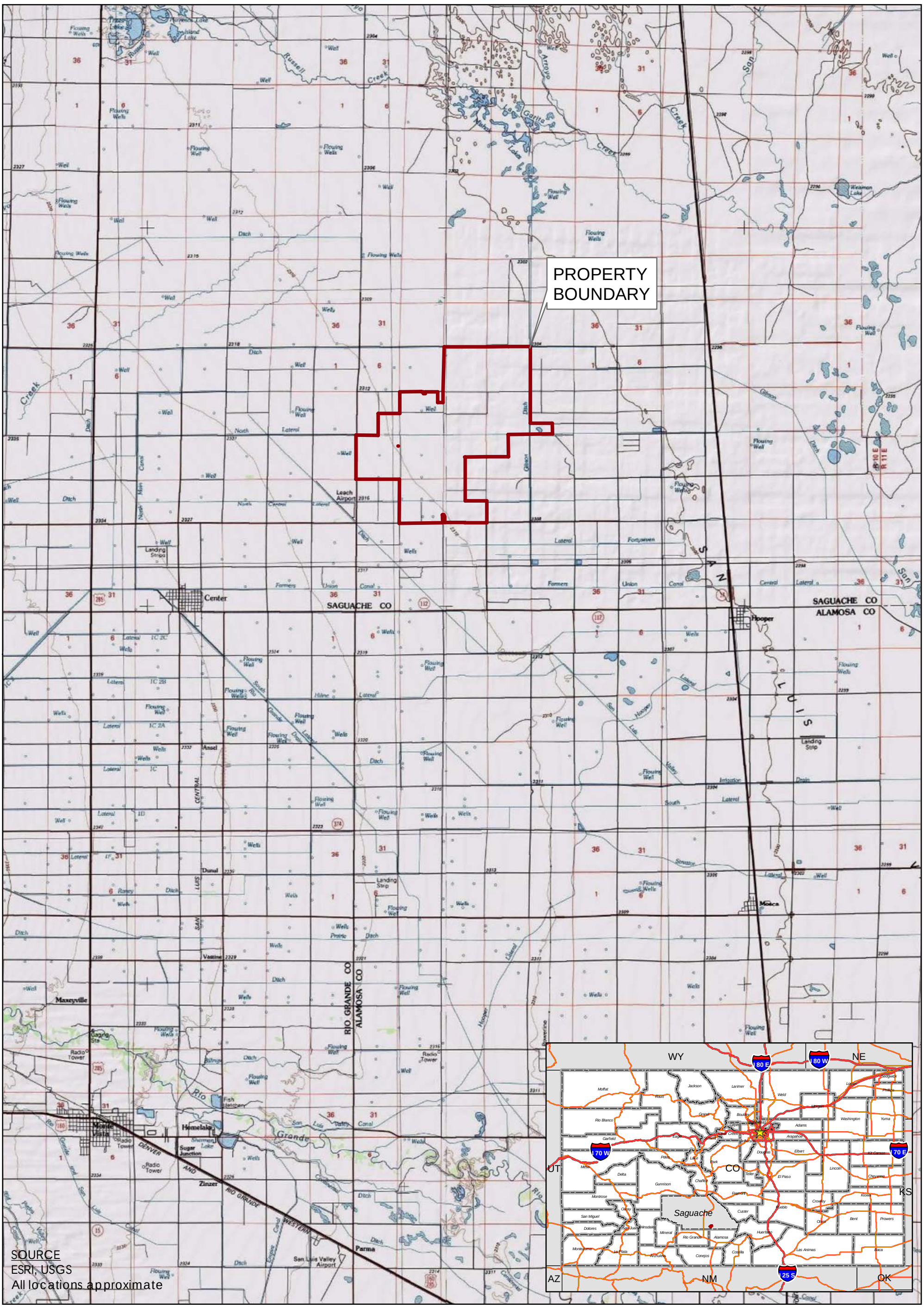
N
W E
S
0 15
Miles

SOLAR RESERVE LLC.
SAGUACHE SOLAR ENERGY PROJECT

WorleyParsons
resources & energy

REGIONAL MAP

SWL	JF	8/2010
108010-00270		1



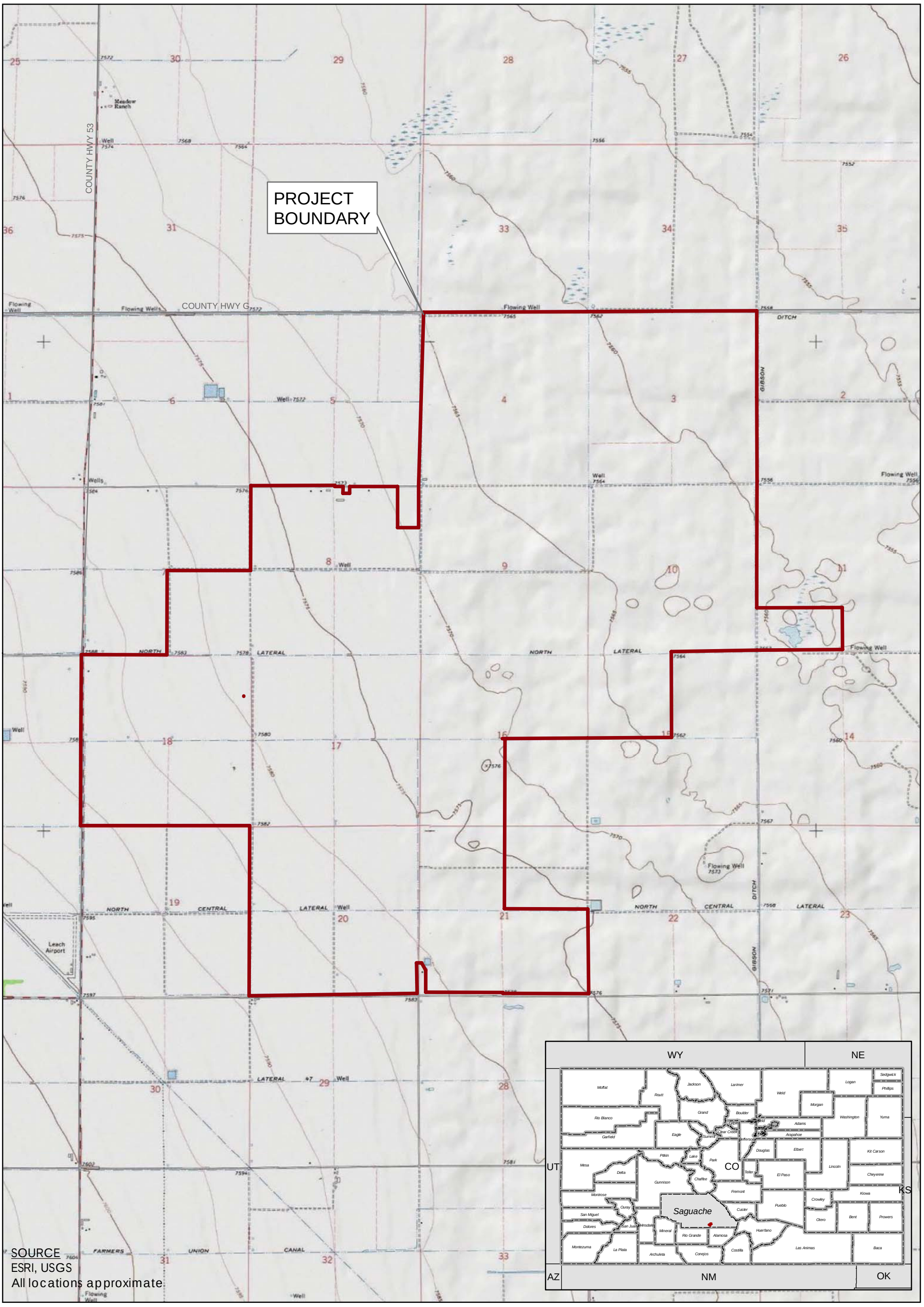
N
W E
S
0 5
Miles

SOLAR RESERVE LLC.
SAUGUACHE COUNTY, CO

WorleyParsons
resources & energy

LOCATION MAP

SWL	JF	8/2010
108010-00270		**2**



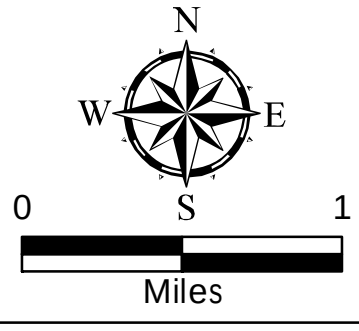
N
W E
S
0 3,500
Feet

SOLAR RESERVE LLC.
SAUGUACHE COUNTY, CO

WorleyParsons
resources & energy

SITE CONDITIONS

SWL	JF	8/2010
108010-00270		3

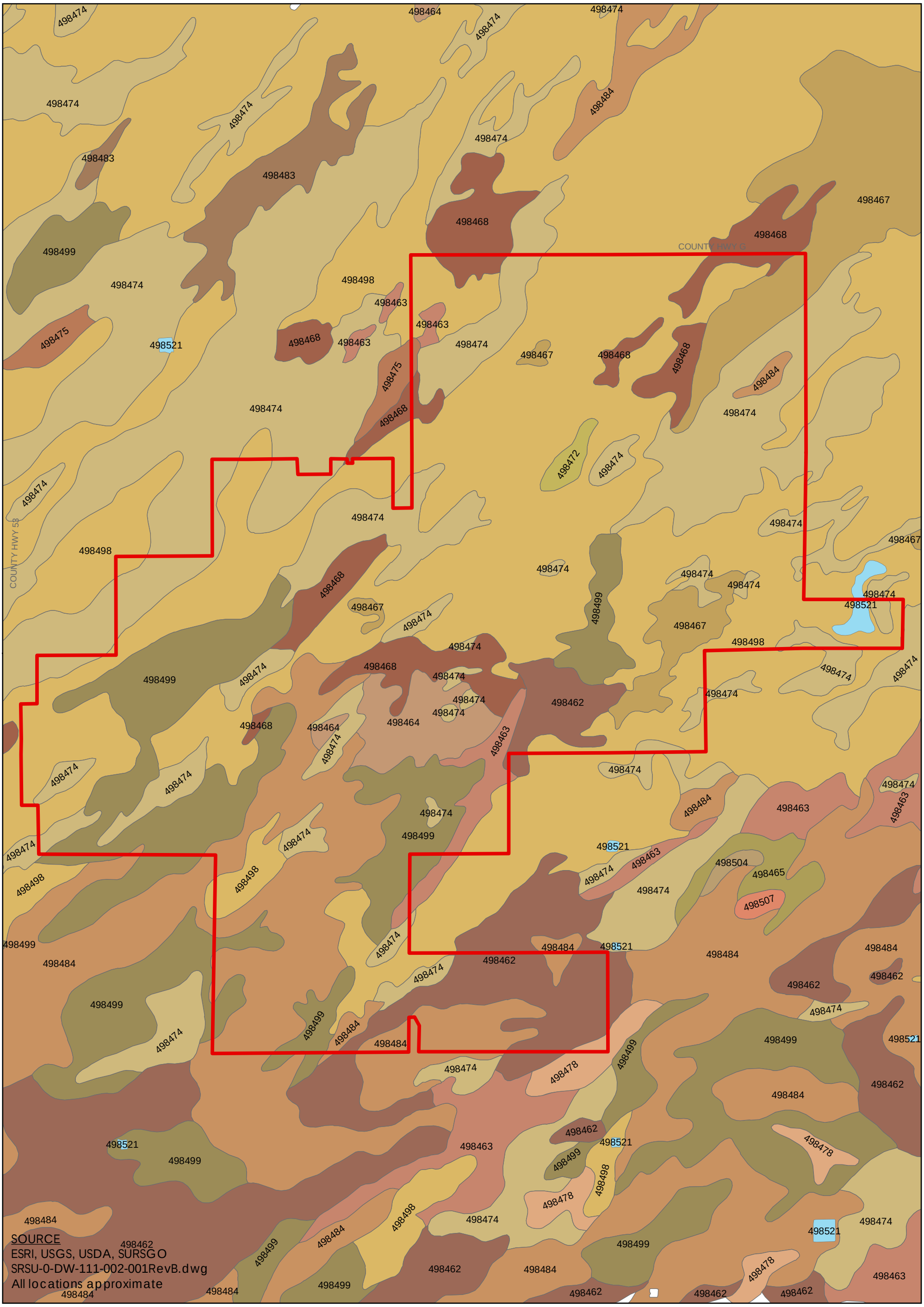


SOLAR RESERVE LLC.
SAUGUACHE COUNTY, CO

WorleyParsons
resources & energy

AERIAL SITE MAP

SWL	JF	8/2010
108010-00270		4



N
W E
S
0 1
Miles

SOLAR RESERVE LLC.
SAUGUACHE SOLAR ENERGY PROJECT

WorleyParsons
resources & energy

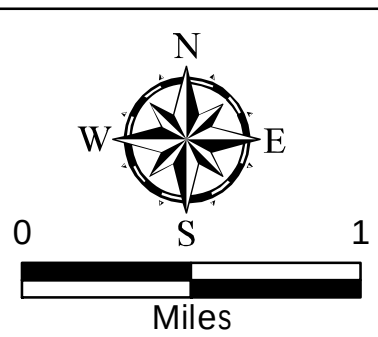
SITE MAP - SOILS

SWL	JF	8/2010
108010-00270		5

Legend

- 498462, Mixed, frigid Typic Psammaquents
- 498463, Mixed, frigid Typic Psammaquents
- 498464, Fine-loamy, mixed (calcareous), frigid Typic Fluvaquents
- 498465, Fine, montmorillonitic, frigid Aridic Natriborolls
- 498467, Clayey over sandy or sandy-skeletal, montmorillonitic, frigid Typic Natrargids
- 498468, Clayey over sandy or sandy-skeletal, montmorillonitic, frigid Typic Natrargids
- 498472, Fine-loamy, mixed, frigid Aquentic Durorthids
- 498474, Coarse-loamy, mixed, frigid Aquic Natrargids
- 498475, Fine-loamy, mixed (calcareous), frigid Typic Torrifluvents
- 498478, Coarse-loamy, mixed, frigid Typic Calciorthids
- 498483, Clayey over sandy or sandy-skeletal, montmorillonitic, frigid Aquic Natrargids
- 498484, Coarse-loamy, mixed, frigid Typic Natrargids
- 498486, Loamy-skeletal, mixed (calcareous), frigid Aquic Ustorthents
- 498497, Fine-loamy over sandy or sandy-skeletal, mixed, frigid Typic Haplargids
- 498498, Fine-loamy over sandy or sandy-skeletal, mixed, frigid Aquic Natrargids
- 498499, Fine-loamy over sandy or sandy-skeletal, mixed, frigid Aquic Natrargids
- 498504, Fine-loamy, mixed, frigid Pachic Haploborolls
- 498506, Mixed, frigid Typic Torripsamments
- 498507, Mixed, frigid Typic Torripsamments
- Water

SOURCE
ESRI, USGS, USDA, SURSGO
SRSU-0-DW-111-002-001RevB.dwg
All locations approximate



SOLAR RESERVE LLC.
SAUGUACHE SOLAR ENERGY PROJECT

WorleyParsons
resources & energy

SITE MAP - SOILS LEGEND

SWL	JF	8/2010
108010-00270		**5.1**