Appendix 2C
Engineering Design Criteria

APPENDIX 2C

Engineering Design Criteria

1.0 Civil Engineering Design Criteria

1.1 Introduction

This section summarizes the codes, standards, criteria, and practices that will be generally used in the design and construction of civil engineering systems for the Rice Solar Energy Project (RSEP). More specific project information will be developed during execution of the project to support detailed design, engineering, material procurement specification, and construction specifications.

1.2 Codes and Standards

The design of civil engineering systems for the project will be in accordance with the laws and regulations of the federal government, the State of California, and the Riverside County Code of Building Regulations. The current issue or edition of the documents at the time of filing this Application for Certification (AFC) will apply, unless otherwise noted. In cases where conflicts between the cited documents exist, requirements of the more conservative document will be used.

1.3 Civil Engineering Codes and Standards

The following codes and standards have been identified as applicable, in whole or in part, to civil engineering design and construction of power plants and related offsite improvements.

- American Association of State Highway and Transportation Officials (AASHTO) – Standards and Specifications
- American Concrete Institute (ACI) – Standards and Recommended Practices
- American Institute of Steel Construction (AISC) – Standards and Specifications
- American National Standards Institute (ANSI) – Standards
- American Society of Testing and Materials (ASTM) – Standards, Specifications, and Recommended Practices
- American Water Works Association (AWWA) – Standards and Specifications
- American Welding Society (AWS) – Codes and Standards
- Asphalt Institute (AI) – Asphalt Handbook
- Riverside County Flood Control and Water Conservation District – Hydrology Manual
- State of California Department of Transportation (CALTRANS) – Standard Specification

- State of California Department of Transportation (CALTRANS) – Highway Design Manual
- American Railway Engineering and Maintenance-of-Way Association (AREMA) – Manual for Railroad Engineering
- California Energy Commission – Recommended Seismic Design Criteria for Non-Nuclear Generating Facilities in California, 1989
- Concrete Reinforcing Steel Institute (CRSI) – Standards
- Factory Mutual (FM) – Standards
- National Fire Protection Association (NFPA) – Standards
- California Building Code (CBC) 2007
- Steel Structures Painting Council (SSPC) – Standards and Specifications

1.4 Engineering Geology Codes, Standards, and Certifications

Engineering geology activities will conform to the applicable federal, state, and local laws, regulations, ordinances and industry codes and standards.

1.4.1 Federal

None are applicable.

1.4.2 State

The Warren-Alquist Act, PRC, Section 25000 et seq. and the California Energy Commission (CEC) Code of Regulations (CCR), Siting Regulations, Title 20 CCR, Chapter 2, require that an AFC address the geologic and seismic aspects of the site.

The California Environmental Quality Act (CEQA) and the CEQA Guidelines require that potential significant effects, including geologic hazards, be identified and a determination made as to whether they can be substantially reduced.

1.4.3 City

California State Planning Law, Government Code Section 65302, requires each city to adopt a general plan, consisting of nine mandatory elements, to guide its physical development. Section 65302(g) requires that a seismic safety element be included in the general plan.

The site development activities will require certification by a Professional Geotechnical Engineer and a Professional Engineering Geologist before, during and following construction, in accordance with the California Building Code (CBC), Chapters 17 and 18. The Professional Geotechnical Engineer and the Professional Engineering Geologist will certify the placement of earthen fills and the adequacy of the site for structural improvements.

2.0 Mechanical Engineering Design Criteria

2.1 Introduction

This section summarizes the codes, standards, criteria, and practices that will be generally used in the design and construction of mechanical engineering systems for the RSEP. More specific project information will be developed during execution of the project to support detailed design, engineering, material procurement specification, and construction specifications.

2.2 Codes and Standards

The design of the mechanical systems and components will be in accordance with the laws and regulations of the federal government, state of California, Riverside County ordinances, and industry standards. The current issue or revision of the documents at the time of the filing of this Application for Certification (AFC) will apply, unless otherwise noted. If there are conflicts between the cited documents, the more conservative requirements shall apply.

The following codes and standards are applicable to the mechanical aspects of the power facility.

- California Building Standards Code, 2001
- American Society of Mechanical Engineers (ASME) Boiler and Pressure Vessel Code
- ASME/ANSI B31.1 Power Piping Code
- ASME Performance Test Codes
- ASME Standard TDP-1
- American National Standards Institute (ANSI) B16.5, B16.34, and B133.8
- American Boiler Manufacturers Association (ABMA)
- American Gear Manufacturers Association (AGMA)
- Air Moving and Conditioning Association (AMCA)
- American Society for Testing and Materials (ASTM)
- American Society of Heating, Refrigerating, and Air Conditioning Engineers (ASHRAE)
- American Welding Society (AWS)
- Cooling Tower Institute (CTI)
- Heat Exchange Institute (HEI)
- Manufacturing Standardization Society (MSS) of the Valve and Fitting Industry
- National Fire Protection Association (NFPA)
- Hydraulic Institute Standards (HIS)
- Tubular Exchanger Manufacturer's Association (TEMA)

2.3 Mechanical Engineering General Design Criteria

2.3.1 General

The systems, equipment, materials, and their installation will be designed in accordance with the applicable codes; industry standards; and local, state, and federal regulations, as well as the design criteria; manufacturing processes and procedures; and material selection, testing, welding, and finishing procedures specified in this section.

Detailed equipment design will be performed by the equipment vendors in accordance with the performance and general design requirements to be specified later by the project. Equipment vendors will be responsible for using construction materials suited for the intended use.

2.3.2 Materials

Asbestos will not be used in the materials and equipment supplied. Where feasible, materials will be selected to withstand the design operating conditions, including expected ambient conditions, for the design life of the plant. It is anticipated that some materials will require replacement during the life of the plant due to corrosion, erosion, etc.

2.3.3 Pumps

Pumps will be sized in accordance with industry standards. Where feasible, pumps will be selected for maximum efficiency at the normal operating point. Pumps will be designed to be free from excessive vibration throughout the operating range.

2.3.4 Tanks

Large outdoor storage tanks will not be insulated except where required to maintain appropriate process temperatures or for personnel protection.

Overflow connections and lines will be provided. Maintenance drain connections will be provided for complete tank drainage.

Manholes, where provided, will be at least 24 inches in diameter and hinged to facilitate removal. Storage tanks will have ladders and cleanout doors as required to facilitate access/maintenance. Provisions will be included for proper tank ventilation during internal maintenance.

2.3.5 Heat Exchangers

Heat exchangers will be designed in accordance with Heat Exchange Institute (HEI) standards. Some heat exchangers will be provided as components of mechanical equipment packages and may be shell-and-tube or plate type. Heat exchangers may be designed in accordance with TEMA or manufacturer's standards. Fouling factors will be specified in accordance with TEMA.

2.3.6 Pressure Vessels

Pressure vessels will include the following features/appurtenances:

- Process, vent, and drain connections for startup, operation, and maintenance
- Materials compatible with the fluid being handled
- A minimum of one manhole and one air ventilation opening (e.g., handhole) where required for maintenance or cleaning access
- For vessels requiring insulation, shop-installed insulation clips spaced not greater than 18 inches on center
- Relief valves in accordance with the applicable codes

2.3.7 Piping and Piping Supports

Stainless steel pipe may be Schedule 10S where design pressure permits. Underground piping may be high-density polyethylene (HDPE) or polyvinyl chloride (PVC) where permitted by code, operating conditions, and fluid properties. In general, water system piping will be HDPE or PVC where embedded or underground and carbon steel where aboveground. Appropriately lined and coated carbon steel or ductile iron pipe may alternately be used for buried water piping.

Threaded joints will not normally be used in piping used for lubricating oil. Victaulic, or equal, couplings may be used for low-energy aboveground piping, where feasible.

Piping systems will have high-point vents and low-point drains. Drains with restricting orifices or steam traps with startup and blowdown drains and strainers will be installed in low points of steam lines where condensate can collect during normal operation.

Steam piping systems and steam drain lines in the plant will typically be sloped in the direction of steam flow. Condensate collection in piping systems will be avoided by installing automatic drain devices and manual devices as appropriate.

Steam lines fitted with restricting devices, such as orifices in the process runs, will include adequate drainage upstream of the device to prevent condensate from collecting in lines.

Hose and process tubing connections to portable components and systems will be compatible with the respective equipment suppliers' standard connections for each service.

Stainless steel piping may be used for portions of the lubricating oil system downstream of the filters. Carbon steel piping may be used elsewhere.

2.4 Valves

2.4.1 General Requirements

Valves will be arranged for convenient operation from floor level where possible and, if required, will have extension spindles, chain operators, or gearing. Hand-actuated valves will be operable by one person. Gear operators may be provided on manual valves 8 inches or larger.

Valves will be arranged to close when the handwheel is rotated in a clockwise direction when looking at the handwheel from the operating position. The direction of rotation to close the valve will be clearly marked on the face of each handwheel.

The stops that limit the travel of each valve in the open or closed position will be arranged on the exterior of the valve body. Valves may be fitted with an indicator to show whether they are open or closed; however, only critical valves will be remotely monitored for position.

Valve materials will be suitable for operation at the maximum working pressure and temperature of the piping to which they are connected. Steel valves will have cast or forged steel spindles. Seats and faces will be of low-friction, wear-resistant materials. Valves in throttling service will be selected with design characteristics and of materials that will resist erosion of the valve seats when the valves are operated partly closed.

Valves operating at less than atmospheric pressure will include means to prevent air in-leakage. No provision will be made to repack valve glands under pressure.

2.4.2 Drain and Vent Valves and Traps

Drains and vents in 600-pound class or higher piping and 900 degrees Fahrenheit or higher service will be double-valved. Drain traps will include air cock and easing mechanism. Internal parts will be constructed from corrosion resistant materials and will be renewable.

Trap bodies and covers will be cast or forged steel and will be suitable for operating at the maximum working pressure and temperature of the piping to which they are connected. Traps will be piped to drain collection tank or sumps and returned to the cycle where feasible.

2.4.3 Low Pressure Water Valves

Low-pressure water valves will be the butterfly or gate type of cast iron construction. Ductile iron valves will have ductile iron bodies, covers, gates (discs), and bridges; the spindles, seats, and faces will be bronze. Fire protection valves will be Underwriters Laboratories (UL)-approved valves meeting NFPA requirements.

2.4.4 Instrument Air Valves

Instrument air valves may be the ball type of bronze construction, with valve face and seat of approved wear-resistant alloy.

2.4.5 Non-return Valves

Non-return valves for steam service will be in accordance with ANSI standards and properly drained. Non-return valves in vertical positions will have bypass and drain valves. Bodies will have removable access covers to enable the internal parts to be examined or renewed without removing the valve from the pipeline.

2.4.6 Motor-Actuated Valves

Electric motor actuators will be designed specifically for the operating speeds, differential and static pressures, process line flow rates, operating environment, and frequency of operations for the application. A hand wheel and declutching mechanism will be provided to allow hand wheel engagement at any time except when the motor is energized. Actuators will automatically revert back to motor operation, disengaging the hand wheel, upon energizing the motor. The motor actuator will be placed in a position relative to the valve that prevents leakage of liquid, steam, or corrosive gas from valve joints onto the motor or control equipment.

2.4.7 Safety and Relief Valves

Safety valves and/or relief valves will be provided as required by code for pressure vessels, heaters, and boilers. Safety and relief valves will be installed vertically. Piping systems that can be over-pressurized by a higher-pressure source will also be protected by pressure-relief valves. Equipment or parts of equipment that can be over-pressurized by thermal expansion of the contained liquid will have thermal relief valves.

2.4.8 Instrument Root Valves

Instrument root valves will be specified for operation at the working pressure and temperature of the piping to which they are connected. Test points and sample lines in systems that are 600-pound class or higher service will be double-valved.

2.5 Heating, Ventilating, and Air Conditioning (HVAC)

HVAC system design will be based on site ambient conditions specified for the site. Except for the HVAC systems serving the control room, maintenance shop, lab areas, and administration areas, the systems will not be designed to provide comfort levels for extended human occupancy.

Air conditioning will include both heating and cooling of the inlet-filtered air. Air velocities in ducts and from louvers and grills will be low enough not to cause unacceptable noise levels in areas where personnel are normally located.

Fans and motors will be mounted on anti-vibration bases to isolate the units from the building structure. Exposed fan outlets and inlets will be fitted with guards. Guards will be specified for belt-driven fans and arranged to enclose the pulleys and belts.

Air filters will be housed in a manner that facilitates removal. The filter frames will be specified to pass the air being handled through the filter without leakage.

Ductwork, filter frames, and fan casings will be constructed of mild steel sheets stiffened with mild steel flanges and galvanized. Ductwork will be adequately supported. Duct joints will be leak tight. Grills and louvers will be of adjustable metal construction.

2.6 Thermal Insulation and Cladding

Parts of the facility requiring insulation to reduce heat loss or afford personnel safety will be thermally insulated. Minimum insulation thickness for hot surfaces near personnel will be designed to limit the outside lagging surface temperature.

The thermal insulation will have as its main constituent calcium silicate, foam glass, fiber glass, or mineral wool, and will consist of pre-formed slabs or blankets, where feasible. Asbestos-containing materials are prohibited. An aluminum jacket, blanket or suitable coating will be provided on the outside surface of the insulation. Insulation system materials, including jacketing, will have a flame spread rating of 25 or less when tested in accordance with ASTM E 84.

Insulation at valves, pipe joints, steam traps, or other points to which access may be required for maintenance will be specified to be removable with a minimum of disturbance to the pipe insulation. At each flanged joint, the molded material will terminate on the pipe at a distance from the flange equal to the overall length of the flange bolts to permit their removal without damaging the molded insulation.

Outdoor aboveground insulated piping will be clad with textured aluminum of not less than 30 mil thickness. At the joints, the sheets will be sufficiently overlapped and caulked to prevent moisture from penetrating the insulation. Steam trap stations will be “boxed” for ease of trap maintenance.

Design temperature limits for thermal insulation will be based on system operating temperature during normal operation.

Outdoor and underground insulation will be moisture-resistant.

2.7 Testing

Hydrostatic testing, including pressure testing at 1.5 times the design pressure, or as required by the applicable code, and will be specified and performed for pressure boundary components where an in-service test is not feasible or permitted by code.

2.8 Welding

Welders and welding procedures will be certified in accordance with the requirements of the applicable codes and standards before performing any welding. Records of welder qualifications and weld procedures will be maintained.

2.8 Painting

Except as otherwise specified, equipment will receive the respective manufacturer's standard shop finish. Finish colors will be selected from among the paint manufacturer's standard colors.

Finish painting of un-insulated piping will be limited to that required by OSHA for safety or for protection from the elements. Piping to be insulated will not be finish painted.

2.9 Lubrication

The types of lubrication specified for facility equipment will be suited to the operating conditions and will comply with the recommendations of the equipment manufacturers.

The initial startup charge of flushing oil will be the equipment manufacturer's standard lubricant for the intended service. Subsequently, such flushing oil will be sampled and analyzed to determine whether it can also be used for normal operation or must be replaced in accordance with the equipment supplier's recommendations. Rotating equipment will be lubricated as designed by the individual equipment manufacturers. Where automatic lubricators are fitted to equipment, provision for emergency lubrication will also be specified. Where applicable, equipment will be designed to be manually lubricated while in operation without the removal of protective guards. Lubrication filling and drain points will be readily accessible.

3.0 Control Engineering Design Criteria

3.1 Introduction

This section summarizes the codes, standards, criteria, and practices that will be generally used in the design and installation of instrumentation and controls for the RSEP. More specific project information will be developed during execution of the project to support detailed design, engineering, material procurement specification, and construction specifications.

3.2 Codes and Standards

The design specification of all work will be in accordance with the laws and regulations of the federal government, the State of California, and local codes and ordinances. A summary of general codes and industry standards applicable to design and control aspects of the power facility follows.

- American National Standards Institute (ANSI)
- American Society of Mechanical Engineers (ASME)
- The Institute of Electrical and Electronics Engineers (IEEE)
- Instrumentation, Systems, and Automation Society (ISA)
- National Electrical Manufacturers Association (NEMA)
- National Electrical Safety Code (NESC)
- National Fire Protection Association (NFPA)
- American Society for Testing and Materials (ASTM)

3.3 Control Systems Design Criteria

3.3.1 General Requirements

The Plant Control System will be a Distributed Control System that is fully integrated, flexible, and expandable microprocessor-based control and data information management system will be provided to monitor, control, display, alarm, record and trend all assigned plant inputs and outputs as described below. The plant control system will have a distributed architecture comprised of currently commercially available technology field bus technology. Each of the system functional processors will be a configurable unit programmed to execute a specific dedicated task using the most advanced applications software available.

Windows-compatible stations for operator interface in the control room, including keyboard pointing devices, printers, and color graphic monitors. Additional operator interfaces will be capable of being placed in local control centers, supervisor's offices, etc. The stations will be provided with a commercially available, Windows operating system with real-time extensions. In addition, Windows-compatible software development stations will consist of color graphic monitors with keyboards, printers, removable and fixed disks. The software development station will also support all operator station functions

Independent process controllers utilizing intelligent devices, intelligent process I/O hardware, terminations, and signal conditioning as required. The process controllers will be capable of being distributed to local control centers or other remote concentrations of I/O throughout the plant, and will perform the necessary continuous, logic, and sequential control and data acquisition functions. Remote I/O will be available with all of the features provided by local I/O including placing serial communications modules/ports supporting PLC, RTU, etc. interfaces with remote I/O.

Process communication among process controllers, operator and software development stations will be over a high reliability network suitable for mission critical applications. Variables in the system-wide global database are updated a minimum of once per second, with the capability of updating critical variables every 1/10 second to all process controllers in the system. The network will communicate at 100 megabits per second and be capable of updating process data at the above rates, on all points as required for system operation. Redundancy features and extensive diagnostic procedures will be provided to ensure error-free performance. This network will include the capability for transmitting file-type data and plant informational data messages. This network will be based on an industry-standard, open-protocol capable of easily incorporating third-party products. These third-party devices will have access to process and file data through appropriate and available interfaces.

Each system process controller will be designed such that the failure of any controller will not affect the operation of any other controller except for the loss of data from the failed controller. The same controller hardware provided for data acquisition functions will also be capable of performing local and coordinated modulating control and sequential logic. This same controller hardware will be capable of performing coordinated modulating control and sequential logic in all power plant process areas, including but not limited to molten salt controls, steam drum level controls, steam turbine controls and balance of plant controls. This system will be expandable and flexible, able to be configured for a wide range of process applications and easily upgradeable in the field via engineer-oriented, fill-in-the-blanks software.

The system will be capable of control in the system controller or intelligent field device. To enhance reliability, the control loops will be functionally distributed. The system will include redundant controllers with automatic failover. Controller redundancy will be provided in a one-to-one arrangement no more than one microprocessor will be backed-up by the redundant processor. A processor failure will be alarmed on the operator's station.

3.3.2 Pressure Instruments

In general, pressure instruments will have linear scales with units of measurement in pounds per square inch, gauge (psig). Pressure gauges will have either a blowout disk or a blowout back and an acrylic or shatterproof glass face. Pressure gauges on process piping will be resistant to plant atmospheres.

Siphons will be installed on pressure gauges in steam service as required by the system design. Steam pressure-sensing transmitters or gauges mounted above the steam line will be protected by a loop seal.

Pressure test points will have isolation valves and caps or plugs. Pressure devices on pulsating services will have pulsation dampers.

3.3.3 Temperature Instruments

In general, temperature instruments will have scales with temperature units in degrees Fahrenheit. Exceptions to this are electrical machinery resistance temperature detectors (RTDs) and transformer winding temperatures, which are in degrees Celsius. Temperature elements will be protected by thermowells except when measuring gas or air temperatures at atmospheric pressure. Temperature test points will have thermowells and caps or plugs.

RTDs will be 100-ohm platinum, 3-wire type. The element will be spring-loaded, mounted in a thermowell, and connected to a cast type head assembly.

Thermocouples will be Type J or K dual-element, grounded, spring-loaded, for general service. Materials of construction will be dictated by service temperatures. Thermocouple heads will be the cast type with an internal grounding screw.

3.3.4 Level Instruments

Reflex-glass or magnetic level gauges will be used. Level gauges for high-pressure service will have suitable personnel protection.

Gauge glasses used in conjunction with level instruments will cover a range that includes the highest and lowest trip/alarm set points.

3.3.5 Flow Instruments

Flow transmitters will typically be the differential pressure-type with the range similar to that of the primary element. In general, linear scales will be used for flow indication and recording. Magnetic flow transmitters may be used for liquid flow measurement below 200 degrees Fahrenheit.

3.3.6 Control Valves

Control valves in throttling service will generally be the globe-body, cage type, with body materials, pressure rating, and valve trims suitable for the service involved. Other trim and valve bodies may be used when suitable for the intended service.

Valves will be designed to fail in a safe position.

Control valve body size will not be more than two sizes smaller than line size, unless the smaller size is specifically reviewed for stresses in the piping.

Control valves in 600-Class service and below will be flanged where economical. Where flanged valves are used, minimum flange rating will be ANSI 300 Class.

Critical service valves will be defined as ANSI 900 Class and higher in valves of sizes larger than 2 inches. Severe service valves will be defined as valves requiring anti-cavitation trim, low noise trim, or flashing service, with differential pressures greater than 100 pounds per square inch (psi).

In general, control valves will be specified for a noise level no greater than 90 decibel A-rated (dBA) when measured 3 feet downstream and 3 feet away from the pipe surface.

Valve actuators will use positioners and the highest pressure, smallest size actuator, and will be the pneumatic-spring diaphragm or piston type. Actuators will be sized to shutoff against at least 110 percent of the maximum shutoff pressure and designed to function with instrument air pressure ranging from 80 to 125 psig.

Hand wheels will be furnished only on those valves that can be manually set and controlled during system operation (to maintain plant operation) and do not have manual bypasses.

Solenoid valves supplied with the control valves will have Class H coils. The coil enclosure will normally be a minimum of NEMA 4 but will be suitable for the area of installation. Terminations will typically be by pigtail wires.

Control valve position feedback will be provided to the DCS for display.

3.3.7 Instrument Tubing and Installation

Tubing used to connect instruments to the process line will be stainless steel for primary instruments and sampling systems.

Instrument tubing fittings will be the compression type. One manufacturer will be selected for use and will be standardized as much as practical throughout the plant.

Differential pressure (flow) instruments will be fitted with three-valve manifolds; two-valve manifolds will be specified for other instruments as appropriate.

Instrument installation will be designed to correctly sense the process variable. Taps on process lines will be located so that sensing lines do not trap air in liquid service or liquid in gas service. Taps on process lines will be fitted with a shutoff (root or gauge valve) close to the process line. Root and gauge valves will be main-line class valves.

Instrument tubing will be supported in both horizontal and vertical runs as necessary. Expansion loops will be provided in tubing runs subject to high temperatures. The instrument tubing support design will allow for movement of the main process line.

3.3.8 Pressure and Temperature Switches

Field-mounted pressure and temperature switches will have NEMA Type 4 housings or housings suitable for the environment. In general, switches will be applied such that the actuation point is within the center one-third of the instrument range.

3.3.9 Field-Mounted Instruments

Field-mounted instruments will be of a design suitable for the area in which they are located. They will be mounted in areas accessible for maintenance and relatively free of vibration and will not block walkways or prevent maintenance of other equipment.

Field-mounted instruments will be grouped on racks. Supports for individual instruments will be prefabricated, off-the-shelf, pipe stands. Instrument racks and individual supports will be mounted to concrete floors, to platforms, or on support steel in locations not subject to excessive vibration.

Individual field instrument sensing lines will be sloped or pitched in such a manner and be of such length, routing, and configuration that signal response is not adversely affected. Liquid level controllers will generally be the non-indicating, displacement-type with external cages.

3.3.10 Instrument Air System

Branch headers will have a shutoff valve at the takeoff from the main header. The branch headers will be sized for the air usage of the instruments served, but will be no smaller than 3/8 inch. Each instrument air user will have a shutoff valve, filter, outlet gauge, and regulator at the instrument.

4.0 Geologic and Foundation Design Criteria

4.1 Introduction

This section contains a description of the site conditions and preliminary foundation-related subsurface conditions. Geological evaluations were performed at the site by Terracon; the results are provided in a Preliminary Geotechnical Investigation Report, Titled "Preliminary Geotechnical Engineering Report, Rice Solar Energy Project", dated August 5, 2009

The information presented in this section is based on the results of the report by Terracon and reflects the codes, standards, criteria, and practices that will be used in the design and construction of site and foundation engineering systems for the facility. More specific project information will be developed during execution of the project to support detailed design, engineering, material procurement specification and construction specifications. This information will be included in a detailed geotechnical engineering study that will be used to support the detailed design. This report, if requested, will be provided to the CEC upon completion.

4.2 Scope of Work

The scope of services for the preparation of this section included an assessment of soils-related hazards, a summary of preliminary foundation and earthwork considerations, and preliminary guidelines for inspection and monitoring of geotechnical aspects of construction based on available published data as analyzed in the report prepared by Terracon.

4.3 Site Location

The Project is located in north eastern Riverside County along the California SR-62 corridor, approximately 75 miles east of Twenty Nine Palms, CA and approximately 32 miles west of Parker, Arizona.

4.4 Site Subsurface Conditions

4.4.1 Stratigraphy

The site surface soils generally consist of silty sand and poorly graded sand. The underlying near surface and subsurface soils generally consiste of silty sand, poorly graded sand and poorly graded gravel with a significant amount of caliche cementation. The soils are moderately to strongly cemented with caliche in several locations across the site. The soils generally had high blow counts; however, the soils exhibited a tendency for hydrocompaction (collapse) when wetted and subjected to foundation pressures. Groundwater was not encountered in any test boring at the time of drilling.

4.4.2 Seismicity/Ground-Shaking

The project site lies within a moderate seismic region. The site is within the influence of several fault systems, which are considered to be active or potentially active.

4.4.3 Ground Rupture

Ground rupture is phenomenon associated directly with faulting. No faults are located on or near the site, and ground rupture at the site is not likely.

4.4.4 Liquefaction Potential

Liquefaction is the phenomenon where saturated soils develop high pore water pressures during seismic shaking and lose their strength characteristics. This phenomenon generally occurs in areas of high seismicity, where ground water is shallow and loose granular soils or hydraulic fill soils are present. The State of California has not yet mapped the region that the property is located in for Seismic Hazard Zones. Groundwater at the site was measured to be approximately 360 feet below ground surface. Based on the relative densities of the soils encountered in the borings, and the depth of groundwater at the site, the liquefaction potential of site soils is considered to be low.

4.4.5 Groundwater

The available information from boring records for on site wells indicates groundwater is approximately 360 feet below ground surface.

4.5 Assessment of Soil-Related Hazards

4.5.1 Liquefaction

Refer to 4.4.4, above.

4.5.2 Expansive Soils

Expansive soils shrink and swell with wetting and drying. The shrink-swell capacity of expansive soils can result in differential movement beneath foundations. Based on the geotechnical report, expansive soils were not encountered at the site.

4.5.3 Collapsible Soils

Collapsible soils are generally defined as soils that have potential to suddenly decrease in volume upon increase in moisture content, even without increase in external loads. Soils were found on the site that "hydro-compacted" and had a tendency to collapse under loaded conditions.

4.6 Preliminary Foundation Considerations

4.6.1 General Foundation Design Criteria

For satisfactory performance, the foundation of any structure must satisfy two independent design criteria.

First, it must have an acceptable factor of safety against bearing failure in the foundation soils under maximum design load. Second, settlements during the life of the structure must not be of a magnitude that will cause structural damage, endanger piping connections, or impair the operational efficiency of the facility. Selection of the foundation type to satisfy these criteria depends on the nature and magnitude of dead and live loads, the base area of the structure and the settlement tolerances. Where more than one foundation type satisfies these criteria, then cost, scheduling, material availability and local practice will probably influence or determine the final selection of the type of foundation.

Based on the information presented in the Terracon report, construction of the foundations for the project is feasible using shallow spread foundations, mat foundations and pier foundations for the various structures.

4.6.2 Shallow Foundations

Shallow foundations are considered feasible for use at the site following earth work recommendations as noted in the Terracon report. Allowable bearing pressures will include a safety factor of at least three against bearing failures. Settlements of footings are expected to be limited to allowable settlements for the foundations (typically one inch maximum); tanks can usually undergo somewhat larger allowable settlements.

Minimum footing sizes and depths will use building code minimums. Refer to Terracon report for more details.

4.6.3 Deep Foundations

Compressible soils are not expected based on information in the Terracon report. However, if compressible soils are present at the project site, which would preclude use of shallow foundations mentioned above, deep foundations could be needed. This foundation selection would come later in final design.

Drilled piers may be used for support of the solar arrays due to ease of construction. Most likely a drilled pier on the order of 24 inches could be used for support of most pipe racks and heliostats.

4.6.4 Corrosion Potential and Ground Aggressiveness

Corrosivity tests were conducted as part of the preliminary geotechnical evaluations. Detailed results are presented in the Terracon report.

4.7 Preliminary Earthwork Considerations

4.7.1 Site Preparation and Grading

At the time of the field exploration, a light growth of desert shrub occupied the site. The density of surface vegetation varies significantly and could change substantially prior to the time of grading. Surface vegetation will need to be removed where grading activities are planned, or where heliostats will be installed. It is anticipated stripping of brush and seasonal vegetation will not be required over much of the site (for heliostat installation). Grubbing, if required, should include removal of bush root balls and isolated roots greater than 0.5 inch in diameter.

Following site stripping, grubbing and/or any required over-excavation, some working of soils will be required. In most areas this will entail moisture conditioning and compaction.

4.7.2 Temporary Excavations

All excavations should be sloped in accordance with Occupational Safety and Health Act (OSHA) requirements. Sheet piling could also be used to support any excavation. The need for internal supports in the excavation will be determined based on the final depth of the excavation.

4.7.3 Permanent Slopes

Cut and fill slopes shall be 2:1 (horizontal to vertical) maximum unless otherwise engineered.

4.7.4 Backfill Requirements

All engineered fill soils should be nearly free of organic or other deleterious debris and less than three inches in maximum dimension. The native soil materials, exclusive of debris, may be used as engineered fill provided they contain less than three percent organics by weight (ASTM D2974). Recommended requirements for any imported soil to be used as engineered fill, as well as applicable test procedures to verify material suitability are provided in the Terracon report.

Engineered fill will be compacted to at least 95 percent of the maximum dry density as determined by ASTM D 1557 when used below footings or mats or structures. In general or yard areas, fill will be compacted to 90 percent of the maximum dry density as determined by ASTM D 1557. Initially, engineered fill will be placed in lifts not exceeding 12-inches loose thickness. Thicker lifts may be used pursuant to approval based on results of field compaction performance. In general, the moisture content of compacted fill will fall within three percentage points of the optimum moisture content measured by ASTM D 1557.

4.8 Inspection and Monitoring

A California-registered Geotechnical Engineer or Engineering Geologist, or their representative, will monitor geotechnical aspects of foundation construction and/or installation and fill placement. At a minimum the Geotechnical Engineer/Engineering Geologist will supervise inspection of the following activities:

- Surfaces to receive fill will be inspected prior to fill placement to verify that no pockets of loose/soft or otherwise unsuitable material were left in place and that the subgrade is suitable for structural fill placement.
- Fill placement operations will be monitored by an independent testing agency. Field compaction control testing will be performed regularly and in accordance with the project specifications.
- The Geotechnical Engineer will supervise inspection of drilled shaft installation as required.

4.9 Site Design Criteria

4.9.1 General

The RSEP will be located in the Rice Valley on approximately 1,410 acres in eastern Riverside County, California. The site is bounded by State Route 62 to the north, and undeveloped land to the east, west, and south. Railroad tracks operated by the California-Arizona Railroad run east/west north of SR 62, north of the site. The project includes construction of a solar plant, which will generate electricity using concentrating solar-thermal technology. In conjunction with the solar plant, an administration building, a warehouse, and a paved access road from State Route 62 to the central power block will be constructed.

The site slopes from north to south at less than 2%. There are some very minor existing structures associated with a previous use of the site that will be removed from the site prior to the beginning of project construction.

4.9.2 Datum

The site elevation ranges from approximately 750 to 900 feet (amsl), based on the U.S. Geological Survey (USGS) Quad Map information. Final site grade elevation will be determined during detail design.

4.10 Foundation Design Criteria

4.10.1 General

Reinforced concrete structures (spread footings, mats, and deep foundations) will be designed consistent with the Structural Engineering Design Criteria in this section. Allowable soil bearing pressures for foundation design will be in accordance with this section and the detailed geotechnical investigation for the site.

4.10.2 Groundwater Pressures

Hydrostatic pressures due to groundwater or temporary water loads will be considered.

4.10.3 Factors of Safety

The factor of safety for structures, tanks, and equipment supports with respect to overturning, sliding, and uplift due to wind and buoyancy will be as defined in the Structural Engineering Design Criteria in this section.

4.10.4 Load Factors and Load Combinations

For reinforced concrete structures and equipment supports, using the strength method, the load factors and load combinations will be in accordance with the Structural Engineering Design Criteria In this section.

4.11 References

"Preliminary Geotechnical Engineering Report, Rice Solar Energy Project," by Terracon, Dated August 5, 2009.

5.0 Structural Engineering Design Criteria

5.1 Introduction

This section summarizes the codes, standards, criteria, and practices that will be generally used in the design and construction of structural engineering systems for the Rice Solar Energy Project. More specific project information will be developed during execution of the project to support detail design, engineering, material procurement specification and construction specifications.

5.2 Codes and Standards

The design of structural engineering systems for the project will be in accordance with the laws and regulations of the federal government, the State of California, Riverside County ordinances, and the industry standards. The current issue or edition of the documents at the time of filing of this Application for Certification (AFC) will apply, unless otherwise noted. In cases where conflicts between the cited documents exist, requirements of the more conservative document will be used.

The following codes and standards have been identified as applicable, in whole or in part, to structural engineering design and construction of power plants.

- California Building Code (CBC), 2007 Edition
- American Institute of Steel Construction (AISC):
  - Manual of Steel Construction—13th Edition
  - Specification for Structural Steel Buildings—AISC 360-05
  - Specification for Structural Joints Using ASTM A325 or A490 Bolts
  - Code of Standard Practice for Steel Buildings and Bridges –AISC 303-05
  - Seismic Provisions for Structural Steel Buildings – AISC 341-05
- American Concrete Institute (ACI):
  - ACI 318-05, Building Code Requirements for Structural Concrete
  - ACI 301-05, Specifications for Structural Concrete
- American Society of Civil Engineers (ASCE):
  - ASCE 7-05, Minimum Design Loads for Buildings and Other Structures
- American Welding Society (AWS):
  - D1.1—Structural Welding Code—Steel
  - D1.3—Structural Welding Code—Sheet Steel
- Code of Federal Regulations, Title 29—Labor, Chapter XVII, Occupational Safety and Health Administration (OSHA).
  - Part 1910—Occupational Safety and Health Standards.
  - Part 1926—Construction Safety and Health Regulations
- National Association of Architectural Metal Manufacturers (NAAMM)—Metal Bar Grating Manual.
- Hoist Manufacturers Institute (HMI), Standard Specifications for Electric Wire Rope Hoists (HMI 100).
- National Electric Safety Code (NESC), C2-1993

- National Fire Protection Association (NFPA Standards).
  - NFPA 850 Fire Protection for Electric Generating Plants.
- OSHA Williams-Steiger Occupational Safety and Health Act of 1970.
- Steel Deck Institute (SDI)—Design Manual for Floor Decks and Roof Decks.

5.3 CEC Special Requirements

Prior to the start of any increment of construction, the proposed lateral-force procedures for project structures and the applicable designs, plans and drawings for project structures will be submitted for approval.

Proposed lateral-force procedures, designs, plans, and drawings shall be those for:

- Major project structures
- Major foundations, equipment supports, and anchorage
- Large, field-fabricated tanks
- Switchyard structures

5.4 Structural Design Criteria

5.4.1 Datum

Site topographic elevations will be based on an elevation survey conducted using known elevation benchmarks.

5.4.2 Frost Penetration

The site is located in an area free of frost penetration. Bottom elevation of all foundations for structures and equipment, however, will be maintained at a minimum of 12 inches below the finished grade.

5.5 Design Loads

5.5.1 General

Design loads for structures and foundations will comply with all applicable building code requirements.

5.5.2 Dead Loads

Dead loads will consist of the weights of structure and all equipment of a permanent or semi-permanent nature including tanks, bins, wall panels, partitions, roofing, drains, piping, cable trays, bus ducts, and the contents of tanks and bins measured at full operating capacity. The contents of the tanks and bins, however, will not be considered as effective in resisting structure uplift due to wind forces; but will be considered as effective for seismic forces.

5.5.3 Live Loads

Live load will consist of uniform floor live loads and equipment live loads. Uniform live loads are assumed equivalent unit loads that are considered sufficient to provide for movable and transitory loads, such as the weights of people, portable equipment and tools, small equipment or parts, which may be moved over or placed on the floors during maintenance operations, and planking. The uniform live loads will not be applied to floor areas that will be permanently occupied by equipment.

Lateral earth pressures, hydrostatic pressures, and wheel loads from trucks, will be considered as live loads.

Uniform live loads will be in accordance with ASCE Standard 7, but will not be less than the following:

- Roofs: 20 pounds per square foot (psf)
- Floors and Platforms (steel grating and checkered plates): 100 psf. In addition, a uniform load of 50 psf will be used to account for piping and cable trays, except that where the piping and cable loads exceed 50 psf, the actual loads will be used.

  Furthermore, a concentrated load of 5 kips will be applied nonconcurrently to the supporting beams of the floors to maximize stresses in the members, but the reactions from the concentrated loads will not be carried to the columns.
- Floors (elevated concrete floors): 100 psf. In addition, elevated concrete slabs will be designed to support an alternate concentrated load of 2 kips in lieu of the uniform loads, whichever governs. The concentrated load will be treated as a uniformly distributed load acting over an area of 2.5 square feet, and will be located in a manner to produce themaximum stress conditions in the slabs.
- Control Room Floor: 150 psf
- Stairs, Landings, and Walkways: 100 psf. In addition, a concentrated load of 1 kip will be applied nonconcurrently to the supporting beams for the walkways to maximize the stresses in the members, but the reactions from the concentrated loads will not be carried to the columns.
- Pipe Racks: 50 psf. Where the piping and cable tray loads exceed the design uniform load, the actual loads will be used. In addition, a concentrated load of 8 kips will be applied concurrently to the supporting beams for the walkways to maximize the stresses in the members, but the reactions from the concentrated loads will not be carried to the columns.
- Hand Railings. Hand railings will be designed for either a uniform horizontal force of 20 pounds per linear foot (plf) applied in any direction, or a 200-pound concentrated load applied at any point and in any direction, whichever governs.
- Slabs on Grade: 250 psf
- Truck Loading Surcharge Adjacent to Structures: 250 psf
- Truck Support Structures: AASHTO-HS-20-44
- Special Loading Conditions: Actual loadings.

Laydown loads from equipment components during maintenance and floor areas where trucks, forklifts or other transports have access, will be considered in the design of live loads.

Live loads may be reduced in accordance with the provisions of CBC.

Posting of the floor load capacity signs for all roofs, elevated floors, platforms and walkways will be in compliance with the OSHA Occupational Safety and Health Standard, Walking and Working Surfaces, Subpart D. Floor load capacity for slabs on grade will not be posted.

5.5.4 Earth Pressures

Earth pressures will be in accordance with the recommendations contained in the project-specific geotechnical report.

5.5.5 Groundwater Pressures

Hydrostatic pressures due to groundwater or temporary water loads will be considered.

5.5.6 Wind Loads

The wind forces will be calculated in accordance with CBC 2007, Chapter 16 with a basic wind speed of 85 miles per hour (mph), an Importance Factor of 1.15 and an exposure category of "C."

5.5.7 Seismic Loads

Structures will be designed and constructed to resist the effects of earthquake loads as determined in CBC 2007, Section 1613 and applicable sections of ASCE 7-05. The occupancy category of all the structures is III. The Importance Factor (I) is 1.25 for all the structures except those related to fire safety and hazardous materials; the importance for these structures is 1.50. Other seismic parameters will be obtained from the geotechnical report.

5.5.8 Snow Loads

Snow loads will not be considered.

5.5.9 Turbine-Generator Loads

The steam turbine-generator loads for pedestal and foundation design will be furnished by the equipment manufacturers, and will be applied in accordance with the equipment manufacturers' specifications, criteria, and recommendations.

5.5.10 Special Considerations for Steel Stacks

Steel stacks will be designed to withstand the normal and abnormal operating conditions in combination with wind loads and seismic loads, and will include the along-wind and across-wind effects on the stacks.

The design will meet the requirements of ASME/ANSI STS-1-1992, "Steel Stacks," using allowable stress design method, except that increased allowable stress for wind loads as permitted by AISC will not be used.

5.5.11 Special Considerations for Structures and Loads during Construction

For temporary structures, or permanent structures left temporarily incomplete to facilitate equipment installations, or temporary loads imposed on permanent structures during construction, the allowable stresses may be increased by 33 percent.

Structural backfill may be placed against walls, retaining walls, and similar structures when the concrete strength attains 75 percent of the design compressive strength (f'_c), as determined by sample cylinder tests. Restrictions on structural backfill, if any, will be shown on the engineering design drawings.

Design restrictions imposed on construction shoring removal that are different from normal practices recommended by the ACI Codes will be shown on engineering design drawings.

Metal decking used as forms for elevated concrete slabs will be evaluated to adequately support the weight of concrete plus a uniform construction load of 50 psf, without increase in allowable stresses.

5.6 Design Bases

5.6.1 General

Reinforced concrete structures will be designed by the strength design method, in accordance with the California Building Code and the ACI 318, "Building Code Requirements for Structural Concrete." Steel structures will be designed by the working stress method, in accordance with the California Building Code and the AISC Specification for the Design, Fabrication, and Erection of Structural Steel for Buildings.

Allowable soil bearing pressures for foundation design will be in accordance with the "Final Subsurface Investigation and Foundation Report" for the Facility.

5.6.2 Factors of Safety

The factor of safety for all structures, tanks, and equipment supports will be as follows:

- Against Overturning: 1.50
- Against Sliding: 1.50 for Wind Loads
- Against Uplift Due to Wind: 1.50
- Against Buoyancy: 1.25

5.6.3 Allowable Stresses

Calculated stresses from the governing loading combinations for structures and equipment supports will not exceed the allowable limits permitted by the applicable codes, standards, and specifications.

5.6.4 Load Factors and Load Combinations

For reinforced concrete structures and equipment supports, using the strength method, the strength design equations will be determined based on CBC 2007 and ACI-318-05. The Allowable Stress Design load combinations of CBC 2007 will be used to assess soil bearing pressure and stability of structures per CBC 2007.

Steel-framed structures will be designed in accordance with CBC 2007, Chapter 22 and the AISC Specification for the Structural Steel Buildings. Connections will conform to Research Council on Structural Connections of the Engineering Foundation Specification for Structural Joints.

5.7 Construction Materials

5.7.1 Concrete and Grout

The minimum design compressive strength (f'_c) of concrete and grout, as measured at 28 days will be as follows:

- Electrical ductbank encasement and lean concrete backfill: 500 psi
- Structural concrete: 3,000 psi
- Grout (Class G-1): 5,000 psi
- The classes of concrete and grout to be used will be shown on engineering design drawings or indicated in design specifications.

5.7.2 Reinforcing Steel

Reinforcing steel bars for concrete will be deformed bars of billet steel, conforming to ASTM A 615, Grade 60.

Welded wire fabric for concrete will conform to ASTM A 185.

5.7.3 Structural and Miscellaneous Steel

Structural and miscellaneous steel will generally conform to ASTM A 36, ASTM A 572, or ASTM A992 except in special situations where higher strength steel is required.

High strength structural bolts, including nuts and washers, will conform to ASTM A 325 or ASTM A 490.

Bolts other than high-strength structural bolts will conform to ASTM A307, Grade A.

5.7.4 Concrete Masonry

Concrete masonry units will be hollow, normal weight, non-load bearing Type I, conforming to ASTM C129.

Mortar will conform to ASTM C 270, Type S.

Grout will conform to ASTM C 476.

5.7.6 Other Materials

Other materials for construction, such as anchor bolts, shear connectors, concrete expansion anchors, embedded metal, etc., will conform to industry standards and will be identified on engineering design drawings or specifications.

6.0 Electrical Engineering Design Criteria

6.1 Introduction

This section summarizes the codes, standards, criteria, and practices that will be generally used in the design and construction of electrical engineering systems for the Rice Solar Energy Project. More specific project information will be developed during execution of the project to support detailed design, engineering, material procurement specification, and construction specifications.

6.2 Codes and Standards

The design of the electrical systems and components will be in accordance with the laws and regulations of the federal government and the State of California, Riverside County ordinances, and industry standards.

The current issue or revision of the documents at the time of filing this Application for Certification will apply, unless otherwise noted. If there are conflicts between the cited documents, the more conservative requirement will apply.

The following codes and standards are applicable to the electrical aspects of the power facility:

- American National Standards Institute (ANSI)
- American Society for Testing and Materials (ASTM)
- Anti-Friction Bearing Manufacturers Association (AFBMA)
- California Building Standards Code 2001
- California Electrical Code 1998
- Insulated Cable Engineers Association (ICEA)
- Institute of Electrical and Electronics Engineers (IEEE)
- Illuminating Engineering Society (IES)
- National Association of Corrosion Engineers (NACE)
- National Electrical Code (NEC)
- National Electrical Manufacturers Association (NEMA)
- National Electrical Safety Code (NESC)
- National Fire Protection Association (NFPA)
- Underwriters Laboratories, Inc. (UL)

6.3 Switchyard and Transformers

6.3.1 Switchyard

The Rice Solar Energy Project consists one solar concentrating power plant which will tie into an onsite switchyard. The plant has a steam turbine generator that will connect to the switchyard via a generator step-up transformer (GSU), a generator circuit breaker, and a high voltage switchyard breaker. The generator and generator circuit breaker will conform to IEEE C50.13 and IEEE C37.013 respectively. A disconnect switch will be included with the generator circuit breaker for generator disconnect and transformer maintenance. Isolated phase bus duct will connect the generator to the generator circuit breaker and the generator circuit breaker to the generator step-up transformer. High-voltage disconnect switches and bus will conform to IEEE C37.32-2002.

The switchyard will be located near the generator step-up transformer and will require an overhead line for connection to the GSU. The high voltage circuit breaker and switchyard protection scheme will conform to IEEE C37 standards. All instrument transformers associated with BSEP will comply with IEEE 57.13. The design and construction of the plant switchyard will conform to all applicable codes and standards including, but not limited to IEEE 1127, 1267, 1427, and 1527 and the NESC.

A grounding grid will be provided to control step and touch potentials in accordance with IEEE Standard 80, Safety in Substation Grounding. Metallic equipment, structures, and fencing will be connected to the grounding grid of buried conductors and ground rods will be installed as required for personnel safety. The substation ground grid will be tied to the plant ground grid.

Lightning protection will be provided by shield wires or lightning masts and surge arrestors. The lightning protection system will be designed in accordance with IEEE 998 guidelines.

All faults will be detected, isolated, and cleared in a safe and coordinated manner as soon as practical to ensure the safety of equipment, personnel, and the public. Protective relaying will meet IEEE C37 requirements for each piece of equipment and will be coordinated with the utility.

Revenue metering will be provided on the 161/230 kV switchyard bus to record net power to or from the Rice switchyard. Meters and a metering panel will be provided. Metering will conform to IEEE C51.1 and utility standards.

6.3.2 Transformers

The generator will be connected to the 161/230 kV switchyard through a GSU transformer, and the plant auxiliary transformers will supply the plant loads. These transformers will be designed in accordance with ANSI C57 standards.