1 EXECUTIVE SUMMARY

The purpose of this case study project was to develop model approaches and to document the procedures involved in the planning and conceptual design of a future wind energy facility in the State of New Mexico for the New Mexico Energy, Minerals & Natural Resources Department (EMNRD). Mesa Redonda (Quay County, 9 miles south of Tucumcari) was selected for this conceptual study because a preliminary assessment (also sponsored by the EMNRD) suggested that the mesa is an optimum location for an actual power plant. The scale of the wind farm chosen for this study consists of 27 - 1.5 MW wind turbines with a tower height of 213 feet (65 m) and a rotor diameter of 231 feet (70.5 m).

The case study project consisted of the following tasks:

Task 1 - Develop standards and procedures for conducting environmental assessments at potential wind power plant sites, including identification of applicable environmental permits at the federal, state and local government levels, as well as biological and cultural surveys.

A Phase I Avian Risk Assessment will be performed along with an initial biological resources screening, cultural resources overview and archeological reconnaissance survey. The project team will work with EMNRD staff to identify and document all required environmental permits at the federal, state and local government levels, including all applicable fees, filings, and scheduling requirements. Based on the results of the study and field research, the project team will identify any severe siting issues associated with the proposed Mesa Redonda site, and whether or not any portion of the site should be excluded from future consideration. The results of this task are documented in Sections 2, 3 and 4 of this report.

Task 2 - Develop standards and procedures for estimation of total construction costs, including professional soil analysis.

A professional soil analysis will be conducted consisting of soil sampling and laboratory testing. Laboratory testing will include grain size analyses, moisture content determinations, and corrosion tests. Field resistivity tests will also be conducted. A geotechnical evaluation and recommendation report will be prepared addressing the following with respect to the design and construction of the wind project structures:

- Subsurface conditions and geology encountered
- Settlement considerations
- Groundwater conditions for design (i.e., hydrostatic uplift, etc.)
- Dewatering requirement for construction
- Considerations and design parameters for lateral and uplift load resistance
- Soil resistivity interpretation for grounding system design
- Requirements for excavation and soil support systems
- Subgrade preparation for foundations and access roads
- Foundation construction considerations
- Backfill types and placement requirements
• Recommendations for earthwork control and testing frequency

The project team will develop estimates of total construction costs for the Mesa Redonda site, detailing every significant cost item and the basis for each estimate. The results of this task are documented in Sections 5, 7, and 10 of this report.

**Task 3 - Develop standards and procedures for statewide micro-siting plans based on prevailing wind direction and terrain including involvement of a professional meteorologist.**

An experienced wind energy meteorologist will review the wind data collected at Mesa Redonda and conduct a site visit for the purpose of documenting site conditions and identifying potential locations for wind turbines. Upon completion of the site visit, a preliminary turbine layout for the Mesa Redonda site will be developed using appropriate turbine spacing guidelines that consider wind direction and topography in developing a micro-siting plan for the site. This plan will provide the basis for the development of preliminary wind plant layouts/designs. WindFarmer, a leading industry software package for optimizing wind farm layouts, will be used to develop turbine layouts and energy production estimates taking into account topographical and surface roughness effects, calculated wake losses, setbacks, and noise, visual intrusion and other constraints. WindFarmer will also be used to produce a noise analysis for the Mesa Redonda site based upon source decibel levels typical of the GE Wind 1.5 MW wind turbine. The results of this task are documented in Section 6 of this report.

**Task 4 - Develop standards and procedures for estimating electric line extension and interconnection costs.**

The Mesa Redonda site is in close proximity to a 115 kV transmission line owned by the Southwestern Public Service Company (a subsidiary of Excel Energy) of Amarillo, TX. AWS will use the TRANSMISSION 2000® Transmission Access Information Library© developed by Commonwealth Associates to perform transmission line thermal screening and contingency analyses for the case study project. Cases to be examined will include the Southwest Power Pool’s (SPP) 2002 April Minimum, Summer Shoulder, Summer Peak, Fall Peak and Winter Peak Cases, and the 2003 Spring Peak Case.

The project team will also conduct a conceptual engineering study to define: a) where and how to connect the project site to the existing transmission line, and b) the basic design parameters of the interconnecting facilities (required capability, wire size, structure types, substation one-line arrangements, transformer sizes, etc.). The study will also include a first level cost estimate for the interconnection facilities.

In parallel with the conceptual engineering study, the project team will conduct a routing study. The purpose of the routing study will be to: a) recommend a proposed route for any new transmission facilities required to interconnect the project site to the existing transmission grid, b) identify legal and regulatory licensing issues, and c) identify which federal, state and local agencies are likely to be involved.

The results of this task are documented in Sections 8 and 9 of this report.
Task 5 - Develop standards and procedures for economic assessments of potential projects, including financial costs and benefits.

In this task, the detailed economics of the project will be investigated based on an assessment of currently available wind technology and the results of previous tasks (especially the assessment of infrastructure and wind energy resources). The project team will develop reasonable cost and financial assumptions in order to determine the expected annual and life cycle cost-of-energy estimates. The economic analysis will also consider any reasonably attainable cost offsets for the project. Realistic price estimates for the sale of power will then be developed. The results of this task are documented in Section 11 of this report.

1.1 The Project Team

AWS Scientific, Inc. (AWS) assembled a diverse team of experts to consult on this case study project, including six firms that have offices in New Mexico. In many areas, such as environmental, civil and electrical engineering, team members have complementary skills. The advantages of this team approach were twofold. One, it began the process of building a knowledge base among multiple in-state firms that will be necessary to support future wind development in New Mexico. Two, it provided an opportunity for peer review of all work products during the execution of this project, providing greater confidence in the results and the applicability of the standards and procedures to other areas of the state.

The members of the project team and their primary area of responsibility were as follows:

- Curry & Kerlinger, LLC (Cape May Point, NJ) – Avian Risk Assessment (Section 2)
- Animas Environmental Services - AES (Farmington, NM) – Biological Resources Screening (Section 3)
- SWCA Environmental Consultants (Albuquerque, NM) – Archaeological Reconnaissance and Cultural Resources (Section 4)
- Terracon (Albuquerque, NM) – Geotechnical Site Characterization (Section 5)
- AWS Scientific (Albany, NY) – Wind Plant Design (Section 6), Thermal Screening Analysis (Section 8), and Economic Analysis (Section 11)
- ASCG Incorporated (Albuquerque, NM) – Electrical Collection System Conceptual Design (Section 7)
- Peak Power Engineering, Inc. (Santa Fe, NM) – Transmission and Interconnection Facilities Conceptual Design (Section 9)
- The Louis Berger Group (Santa Fe, NM) – Civil Engineering (Section 10)
- enXco (North Palm Springs, CA) – Economic Analysis (Section 11)

1.2 Phase I Avian Risk Assessment

This report details a model Phase I Avian Risk Assessment for wind power development and serves as a case study in conducting such risk assessments. Curry & Kerlinger, LLC conducted a literature review, interviews with local and regional experts (agency staff, environmental organizations, and local birders), and site visits by an avian expert August 12 and
Mesa Redonda (about 5,100 feet [1,555 m] ASL) is elevated 300-400 feet (91-122 m) above the surrounding terrain, and consists of both private and public (state) lands. The topography within the site is relatively flat to gently rolling terrain, although immediately adjacent to where some turbines may be sited (near the rim) are steep hills and precipices. There are also several canyons that extend into the mesa for varying distances and promontories that project outward from the main mesa. The access road into the project will traverse steep hillsides. Vegetation is relatively sparse on top of the mesa. The habitat on site is mixed-grass prairie dominated by grasses, prickly pear cactus, yucca, as well as small 3-20 foot (1-6 m) juniper and pinyon pine. The pinyons and junipers form open forests in places. There are no wetlands on the mesa other than the dugouts made by the private landowner (rancher) to water cattle. There are very small creeks (mostly dry) at the bottom of the canyons off the mesa. Juniper and pinyon forest strips are in the valleys/canyons leading up to the mesa. Habitat surrounding the mesa for many miles is grassland/rangeland with juniper brushland on gently rolling hills or nearly flat land. The project site cannot be considered sensitive or rare habitat, nor is such habitat located within the project area or immediately adjacent to the project. There are no refuges, preserves, or sanctuaries within 10 miles (16 km) of the project site, nor does there seem to be significant habitat within this area.

Nothing in the literature or from interviews with experts suggested that the site is an important nesting or foraging area for federally threatened or endangered birds, or bird species proposed for listing (letters from U. S. Fish & Wildlife, New Mexico Game & Fish, and New Mexico Natural Heritage Program). The lesser-prairie chicken and mountain plover, both federally proposed listed species, may occur near the project site, but the habitat within the project boundaries is not suitable. No Audubon WatchListed species are likely to nest on or in the vicinity of the project site, and none are likely to spend much, if any, time on top of the mesa where turbines will be located. In addition, there was no evidence that the project site or lands adjacent to the site would attract significant concentrations of migrating or wintering waterfowl, shorebirds, songbirds, hawks, or other species. Site visits revealed no evidence of endangered or threatened species presence or use of the turbine sites, and the habitat did not appear to be suitable for such species. The site visit did not reveal significant prey availability that could attract large numbers of raptors to the mesa-top turbine locations. Soaring conditions along the edge of the mesa are excellent and the sides of the mesa are likely to attract some soaring birds.

A review of the available literature, site visits, and interviews with agency and environmental organization staff, as well as bird experts from the project area revealed that the proposed project site and adjacent areas support common nesting species. Because of the harsh conditions on the mesa top, relatively few species and numbers of individuals are likely to be present in any season. Turkey Vultures were numerous during the site visit and are likely to be the most common soaring bird on site. Small numbers of American Kestrels and Red-tailed

Executive Summary
Hawks will be present on site and it is possible that Prairie Falcons and Golden Eagles will visit the site from time to time, although their presence is likely to be limited because prey is scarce. In winter some raptors may also be present, but numbers of these species and use of the site are likely to be low.

Based on what is known about avian risk factors at wind power plants in North America and Europe, the species (type and numbers of individuals) that frequent the project site, and what was learned from the literature search, site visits, and interviews, there is no indication that the Mesa Redonda Wind Power Project will result in significant adverse impact to birds. From this Phase I Avian Risk Assessment there is also no indication that further study is needed prior to construction of the project.

1.3 Biological Resources Screening

Animas Environmental Services, LLC visited Mesa Redonda on August 14th, 2001, with representatives from the New Mexico Energy, Minerals, and Natural Resources Department as well as AWS Scientific and other project team members.

The project area was characterized as consisting of three distinct vegetative communities: plains-mesa grassland, montane scrub, and pinyon-juniper woodland. Approximately 400 different species of wildlife have been recorded in Quay County and could potentially occur at or in the vicinity of Mesa Redonda. This includes 36 mammals, 180 birds, 8 amphibians, 33 reptiles, 75 butterflies and moths, 4 dragonflies, 58 grasshoppers and crickets, and 8 molluscs. No crustaceans or fish would be expected at or in the vicinity of Mesa Redonda.

Of the plant and animal species that could potentially occur at Mesa Redonda or within the near vicinity, a total of two were identified as federal or state endangered or threatened species. Panhandle spurge, sandhill goosefoot and dwarf milkweed were identified as special status plant species, but none are federally or state protected. Federally or state protected mammal species include the black-footed ferret and least shrew. No federally or state protected bird species were identified as having potential habitat within or near the project area; however, the lesser-prairie chicken and mountain plover are federally proposed listed species, and both may have the potential to occur near the project area, but not within the project boundaries. No federally or state threatened or endangered amphibian, reptile, fish or mollusk species were identified as potentially occurring within or near Mesa Redonda.

Thirty-four federal, state, and local agencies, as well as private special interest groups were contacted by Animas Environmental Services, LLC regarding potential biological resources for the case study area. Correspondence, including project information and a project location map, was sent to these contacts along with a request for comments and concerns about biological resources issues and feedback regarding the biological screening process. Initial agency consultation revealed recommendations for equipment specifications (e.g., warning beacons), compliance with environmental permitting requirements, and a recommendation for implementation of a monitoring program to determine impact to bird populations.
If the Wind Power Project proceeds, regulatory agencies such as the United States Fish and Wildlife Service or New Mexico State Land Office could require that consultation to identify and mitigate impacts to biological resources be completed. This would likely require that formal field surveys for specific species listed as federal or state protected species be completed.

1.4 Archeaological Reconnaissance and Cultural Resources

In 2001, SWCA Environmental Consultants completed an archaeological reconnaissance of the top of Mesa Redonda, in Quay County, New Mexico. The purpose of this task was to generate realistic parameters for the costs and other challenges of building an actual wind-based power station at the site and to assess its potential impact on historic and culturally significant properties. It is important to emphasize that the study was only conceptual in nature, not an undertaking (i.e., no one was actually planning to go out and build a project). This is important to state explicitly, because if someone was actually planning to construct a project at the site, it would trigger the start of the review process under Section 106 of the National Historic Preservation Act -- and the State Historic Preservation Officer's first response would have been that a reconnaissance (as opposed to a survey of 100 percent of the area of potential effect) was inadequate.

The study included a files check for previously recorded archaeological sites on or near Mesa Redonda, plus a one-day archaeological reconnaissance. The estimated length of the reconnaissance is 6.4 km, including 3.0 km of N.M. State Trust Land and 3.4 km of private land. Applying a nominal transect width of 15 m, the survey included 9.6 ha (23.7 acres), including 4.5 ha (11.1 acres) of State Trust Land and 5.1 ha (12.6 acres) of private land.

No previously recorded archaeological sites were documented on or near Mesa Redonda. From the very limited reconnaissance conducted as part of this case study, the density of archaeological remains on the mesa top appears to be low. Cultural remains are most common within a few meters of the mesa rims, but most of those are isolated occurrences that are unimportant as sources of archaeological knowledge. The frequency of isolated occurrences in the interior of the mesa may be lower. On the whole, archaeological locales on the mesa appear to be few, small, and simple.

The reconnaissance on the mesa top did locate two sites (LA 134419 and LA 134420) that contained Native American and Euroamerican remains as shown in Figure 1. The Euroamerican remains—LA 134419—can mostly be associated with the livestock raising that has taken place on the mesa over the past century. None of the Native American remains—LA 134420—could be assigned to a specific period or culture. The remains—flaked stone tools and debitage—are consistent with occasional, short-term use of the mesa for hunting. Like the Native American remains, the observed Euroamerican remains are consistent with occasional, short-term use of the mesa.
Figure 1. Project location, reconnaissance route, sites, and isolated occurrences Based on the USGS Mesa Redonda, NM 7.5 minute quadrangle (1971 edition).
This is not to say that the mesa top lacks sites with evidence of intensive use by either Native Americans or Euroamericans—but at first glance, the mesa top was used only lightly. This probably reflects the difficult access to the top of the mesa, the general lack of water, and the lack of resources for economic pursuits other than hunting and grazing.

In any future development of Mesa Redonda, we recommend that LA 134419 be avoided. If avoidance is not practical, the site should be tested to determine its information potential (and thus its NRHP eligibility). We also recommend that LA 134420 be avoided. If avoidance is not possible, the site should be subjected to a program of archaeological data recovery. During any further archaeological studies on Mesa Redonda, this site should be revisited and more completely recorded.

While modern wind turbines are built on slender towers that are widely spaced, the required construction pads and construction access roads lead to extensive disturbance of intervening spaces. Much of this disturbance is temporary but unlike vegetation, archaeological sites do not grow back. Like other large construction projects, cultural resource managers should assume that wind generation projects involve extensive rather than localized ground disturbance, and that cultural resource surveys should examine the project area as a block rather than as a series of routes and construction pads.

Based on the results of the reconnaissance, any development of the mesa top should be preceded by an intensive (Class III) archaeological survey of the proposed development areas. As a preliminary estimate, 1.0 percent should be added to the total cost of a wind-powered generation facility at Mesa Redonda (or similar settings in eastern New Mexico), to cover the cultural resource component of environmental compliance.

### 1.5 Geotechnical Site Characterization

A geotechnical site characterization was conducted for the case study wind farm project on Mesa Redonda in Quay County, New Mexico by Terracon Consulting Engineers & Scientists to provide geotechnical engineering recommendations relative to:

- General subsurface soil and bedrock conditions,
- Anticipated construction challenges,
- Corrosion environment,
- General foundation types and their suitability for construction in this area, and
- General earthwork parameters.

The opinions presented are based upon the results of field and laboratory testing, engineering interpretation, and experience with similar soil conditions, structures and subcontractor Terracon’s understanding of the proposed project. The scope of the services performed for this study included a site reconnaissance by a geotechnical engineer, a limited subsurface exploration program, laboratory testing, and engineering interpretation of field and laboratory data.
A total of two hand auger borings were performed on October 23, 2001. The borings were advanced to approximate depths of 6 to 10 feet. At selected intervals, samples of the subsurface materials were taken by retrieving the cuttings from the hand auger. The samples were then sealed and marked and returned to the laboratory. Additionally, two rock samples were retrieved from outcroppings on the trail to the site for laboratory testing and visual classification.

Three 110-foot seismograph exploration lines and two field soil resistance surveys were also performed at these locations. The borings were located in the field near the seismic and electrical resistivity surveys for correlation of the results of the surveys to the actual soil conditions encountered in the near surface soils. The seismic survey was conducted utilizing a 12-geophone seismic response unit (Smartseis S12). The survey was conducted by locating the geophones along a straight line on a 10-foot spacing interval. The seismic data was then collected and the input source was moved to various locations along the line to better define the underlying subsurface conditions. Field measurements of apparent soil resistivity were performed using the Wenner Four-Electrode Method in general accordance with ASTM G 57 and ANSI/IEEE 81 in order to obtain measurements of apparent in-situ soil resistivity for the subject site. The soil resistivity measurements were performed using a Model 400 4-Pin Soil Resistance Meter manufactured by Nilsson Electrical Laboratory, Inc. Readings were taken at electrode spacing widths of 1, 2, 3, 4, 5, 10, 15, 20, and 25 feet.

Selected soil and rock samples were tested for the following engineering properties:

- Water Content
- Grain size
- Water Soluble Sulfate Content
- Plasticity Index
- Compressive Strength
- Resistivity
- Chloride Content

The test results were used for confirmation of the interpretation of the near surface soils as obtained by the electrical and seismic surveys, and the general site characterization. In addition, these results also provided useful information in developing opinions pertaining to construction issues and foundation type suitability.

**Test Results**

Near surface soils to depths of 6-10 feet consisted of lean clay with varying amounts of sand and silt. Bedrock from the outcroppings observed appeared to consist of massive limestone formation with lenses of silt/mudstone and some interbedded small sandstone layers.

Interpretation of the seismic and electrical resistivity surveys indicate that at the locations surveyed, the clayey soils varied in depth from about 20 feet below the existing ground surface to in excess of 40 feet. The surveys were done in the interior sections of the mesa and may not be indicative of areas near the edge of the mesa, where outcrops were observed. Interpretation of the data further indicates that the underlying bedrock layers were non-uniform with ledges and possible discontinuities, which would be consistent with the geological formations and their origin in the area. It should also be noted that the interface between the clayey soils and the
underlying bedrock was not well defined, which indicates that a decomposed or weathered layer
should be anticipated.

Laboratory test results of the clayey soils encountered in the hand auger borings are
indicative of soils that have the potential to undergo volume changes due to fluctuations in the
soil moisture content. The limestone bedrock is non-expansive; however, the weathered
formations that overlie the bedrock are likely expansive due to the clay content of the soils
formed by the weathering process. It should also be noted that there may be some cavities and
weakened areas (karst formations) from water seepage. Further exploration within the designated
sites for the turbines would determine to what extents (if any) karst type topography exists.
However, reconnaissance of the area during our exploration and site visits did not reveal
superficial features indicative of a karst environment.

Changes in resistivity measurements are indicative of a change of the underlying soil
profile. The field measurements combined with the laboratory testing of the soils indicate that
the soils are moderately corrosive to buried metals but not potentially detrimentally to buried
concrete.

Groundwater was not observed in the hand auger borings at the time of field exploration.
These observations represent relatively shallow groundwater observations and conditions at the
time of the field exploration, and may not be indicative of deeper depths, other locations along
the top of the mesa, or at other times of the year.

Site Characterization and Opinions

Based on information provided, it is anticipated that the Patrick & Henderson type
foundation system could be utilized for the support of all the turbines, and a conventional spread
footing foundation would be utilized for the support buildings. Therefore, it is our opinion that
the site appears suitable for the proposed construction. Potentially expansive soils and the
potential for materials which exhibit collapse upon elevation in moisture content will likely
require particular attention in the final design and construction of the project. Varying depths to
bedrock and the potential for weathered material overlying the bedrock may present some
problems in the excavation of the deep foundations. Although the surveyed locations indicate
that bedrock may be in excess of 40 feet below existing grade, it is anticipated that as the
perimeter of the mesa is approached, the depth to bedrock would decrease based on the outcrop
formations observed.

1.6 Wind Plant Design

AWS Scientific developed conceptual wind farm layouts for the 40.5 MW (27 – 1.5 MW
wind turbines) case study wind project at Mesa Redonda using WindFarmer.1 The key features
of WindFarmer used in this study were:

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1 WindFarmer is a fully integrated wind farm design and optimization package that allows wind farm developers to
maximize their energy yield while keeping environmental impacts to a minimum through the specification of
appropriate setback distances, maximum acoustical impact, and exclusion zones.
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- Optimization of wind farm layout,
- Energy capture calculations for wind farms and individual turbines,
- Sophisticated array loss model,
- Wind farm noise calculation, and
- Incorporation of site constraints.

Optimized turbine layouts were developed for two options: 1) a reduced area layout that considers the northeastern portion of the mesa an exclusion zone (Figure 2), and 2) a layout that allowed the program to site turbines anywhere on the eastern end of the mesa (Figure 3). This approach was chosen to examine whether or not the higher energy production estimates produced by Option 2 justify the incremental cost associated with the additional length of electrical cable and access roads between turbines.

Table 1 shows total gross and net energy production, average array loss, average total losses (estimated), average wind speed at 65 m hub height, and capacity factors for wind farm layout Options 1 and 2.

### Table 1. Energy Production Estimates.

<table>
<thead>
<tr>
<th></th>
<th>Option 1 (Reduced Area)</th>
<th>Option 2</th>
</tr>
</thead>
<tbody>
<tr>
<td>Gross Energy Production (MWh/yr)</td>
<td>125,192</td>
<td>131,985</td>
</tr>
<tr>
<td>Net Energy Production (MWh/yr)</td>
<td>106,701</td>
<td>114,534</td>
</tr>
<tr>
<td>Average Array Loss (%)</td>
<td>5.75</td>
<td>4.01</td>
</tr>
<tr>
<td>Average Total Losses (%)</td>
<td>14.80</td>
<td>13.30</td>
</tr>
<tr>
<td>Average Wind Speed at Hub Height (m/s)</td>
<td>7.71</td>
<td>7.93</td>
</tr>
<tr>
<td>Capacity Factor (%)</td>
<td>30.1</td>
<td>32.3</td>
</tr>
</tbody>
</table>

Since the closest residence to Mesa Redonda is approximately 3 miles away, noise is not expected to be an issue with any proposed development.

Finally, visual simulations of the case study project were developed from several vantage points, providing the reader and local residents with a sense of the visual impact of any proposed development of Mesa Redonda. If the project area is restricted to the eastern portion of Mesa Redonda, only a limited number of turbines would be visible from NM 209, if any. The reason for this is that due to the difference in elevation between the viewpoints and the top of the mesa, the western portion of the mesa obstructs any view of the turbines, even though the distance to the turbines is shorter than the distance from viewpoints along NM 278. Figure 4 shows a view of the case study project (Option 2) from NM 278.
Figure 2. Wind Plant Layout Option 1 – Reduced Area
Figure 3.  Wind Plant Layout Option 2
Figure 4. Photo Simulation of Case Study Project at Mesa Redonda from NM 278
1.7 Electrical Collection System Conceptual Design

A conceptual wind farm electrical collection system design was developed by ASCG Incorporated for turbine layout Options 1 and 2 discussed in the previous section.

A three phase 25 kV direct buried (U/G) triplex cable system was selected to avoid the visual impact associated with overhead lines within the project area. The cable would be run alongside the access road between turbines.

A loop configuration was chosen to provide for increased reliability/availability of the turbines. If the U/G cable were to fail between any two turbines, then all the turbines can be kept online via the loop. Base case voltage drop is expected to be less than 3%.

A Supervisory Control and Data Acquisition (SCADA) system using fiber optic cables would relay machine status along with breaker trip status back to a central receiver at the Mesa’s substation, and in-turn, would be relayed to the Wind Farm Operations Center.

The cost of Options 1 and 2 are estimated to be approximately $6.7 and $7.7 million, respectively. Cost estimates include the cost of insurance, overhead, a 15% contingency on construction costs, the General Contractor’s General Conditions plus overhead/profit, bonding, permits, and taxes.

As the location of the case study project is in Quay County, there is no local electrical permitting. Electrical permits are required from the State of New Mexico, however. A stamped set of electrical drawings will need to be submitted for plan check and permits to The State of New Mexico Construction Industries Division. In order to qualify to do the construction, the electrical contractor has to have EL 01 Certification to work on high voltage installations.

1.8 Thermal Screening Analysis

AWS Scientific conducted a thermal screening analysis for this case study project to determine whether or not the 115 kV line between the Tucumcari and Curry substations owned by Southwestern Public Service Company (SPS) of Amarillo, TX has the thermal capability to accept the output of a 40.5 MW wind project located at Mesa Redonda. The proposed interconnection point to the 115 kV Tucumcari-Curry line is approximately 3 miles east of Mesa Redonda, 15 miles southeast of the Tucumcari substation, and 60 line miles northwest of the Curry substation. Cases examined included the Southwest Power Pool’s (SPP) 2002 April Minimum, Summer Shoulder, Summer Peak, Fall Peak and Winter Peak Cases, and the 2003 Spring Peak Case. Contingency analysis was also performed for 9 single-line outages, with the resulting power flows monitored on 28 buses and 47 transmission lines.

The results of the analysis indicate that the SPS line between Curry and Tucumcari has sufficient thermal capability to accept the output of a 40.5 MW wind project located at Mesa Redonda under any seasonal condition with all lines in-service. Absent wind generation at Mesa Redonda, loading on the 115 kV line from Curry serves only to meet the low level of demand in
the Tucumcari area. Wind generation at Mesa Redonda would meet local demand in the Tucumcari area, with any surplus power flowing in the direction of the Curry substation. The results further suggest that the Mesa Redonda-Curry line may be able to handle much higher levels of new wind generation based on the power flow results and the line’s normal rating of 112 MVA. Lower limits may result however, based on changes in network configuration (generation and load changes) since the release of the FERC data used for this analysis, and/or the result of the SPP’s stability, short-circuit, and/or other interconnection and system reliability studies.

The results of the contingency analysis show that under April Minimum, Fall Peak, Winter Peak and Spring conditions, there are no line overloads or voltage violations in either the base case or the case with 40.5 MW of wind generation at Mesa Redonda under any outage scenario. Under 2002 Summer Shoulder conditions, an outage of Curry2 to Curry3 Circuit 1 results in an overload of Curry2 to Curry 3 Circuit 2, and vice versa, under both the base case and the wind generation case. The addition of wind generation at Mesa Redonda however, has no impact on the magnitude of the overloads resulting from these contingencies.

Under 2002 Summer Peak conditions, an outage of Curry2 to Curry3 Circuit 2 results in an overload of Curry2 to Curry3 Circuit 1, and an outage of Curry3 to Mesa Redonda or Mesa Redonda to Tucumcari results in an overload of the 115/13.2 kV Transformer at the Tucum1 bus. The addition of wind generation at Mesa Redonda has no impact on the magnitude of the overloads resulting from the outage of Curry2 to Curry3 Circuit 2 or Mesa Redonda to Tucumcari, however it does increase the overload on the 115/13.2 kV transformer at the Tucum1 bus resulting from an outage of the Curry3 to Mesa Redonda circuit by an additional 3.8% of its Normal Rating. Since the utility should have existing procedures to deal with potential overload conditions on the Tucum1 transformer, there should be no impact on the ability to interconnect 40.5 MW of wind generation at Mesa Redonda.

Also under 2002 Summer Peak conditions, the addition of wind generation at Mesa Redonda may result in undervoltage limit violations (<0.95 p.u.) at the FE-TUCU3, Tucumca3, and Mesa Redonda bus under certain outage conditions. This may require the installation of additional capacitor banks at the Mesa Redonda substation.

1.9 Power Transmission and Interconnection Facilities

Peak Power Engineering, Inc. developed a conceptual engineering design for the power transmission and interconnection facilities necessary to interconnect the case study project to the local transmission grid. Facilities required include a substation at the Mesa Redonda site, a new overhead transmission line leading from the top of the mesa to a 115 kV line owned by Southwestern Public Service Company located to the east of Mesa Redonda, and a utility interconnection (tap) facility.

A substation will be required on top of the Mesa to step up the collection system voltage of 25 kV to the transmission line voltage of 115 kV. An existing utility owned 115 kV transmission line is located approximately 2.6 miles east of the proposed Mesa Redonda project site. A new privately owned transmission line will be required to connect the substation at the
top of the mesa to the utility transmission line. The nominal length of this new transmission line is approximately 3 miles, with a 500-foot vertical drop from the top of the mesa to the terrain below. The remainder of the transmission line route is relatively flat.

The route proposed for the new transmission line (as shown on the next page) was selected based on identifying an accessible location for an intermediate structure. Use of an intermediate structure would limit the span to 1,500 feet and limit the vertical angle. Alternate routes directly to the east of the substation would have required spans of up to 2,500 feet and greater vertical angles.

The proposed transmission line structures are H-Frame, 60 – 70 feet in height wood construction. Three pole structures will be required for large angles and double dead end structures.

The utility interconnection facility should be located below and directly in line with the existing transmission line to minimize construction costs. The interconnection facility will likely be a basic two or three breaker station constructed similar to a transmission tap facility. Final design of the required interconnection facilities will need to be done to the interconnecting utility’s standards. Utility metering will also be included at the interconnection facility.

**Utility Interconnection Requirements**

The existing 115 kV transmission line is owned and operated by Southwestern Public Service Company (SPS) of Amarillo, TX (an Excel Energy Company). The developer will be required to make a request for interconnection to the existing line. The request for interconnect must be accompanied by a $10,000 initial payment for an interconnect study.

The interconnect study will be coordinated by the Southwest Power Pool in Little Rock, Arkansas and will consist of three phases:

1. A Feasibility Study,
2. A System Study, and
3. A Facilities Study

If the request for interconnect is approved, SPS will prepare a contract with the developer which includes the cost of design and construction for the interconnection and metering facilities.

**Government Agency Requirements**

The State of New Mexico has jurisdiction over the issuance of construction permits, licensing of contractors, and construction inspections. For construction permit applications, the developer will be required to submit structural and foundation drawings for the substation, as well as electrical drawings. All drawings will require a stamp from a New Mexico licensed engineer. A construction permit for the transmission line will require a licensed engineer’s calculations for structural design, load flow, fault currents, and losses. The developer must also submit a survey and staking plan for transmission line routing.
Based on conversations with the Quay County Clerks Office, the County does not have any development or land use ordinances outside of the City of Tucumcari. Therefore, it does not appear that the transmission line construction would be required to go through any local planning and development process or public hearing.

**Construction Costs**

The estimated cost of construction of the wind plant substation is $1,841,000. The estimated cost of new transmission line construction is $624,400. The estimated cost of utility interconnect facilities is $1,084,100.

### 1.10 Civil Engineering

The Louis Berger Group performed a conceptual investigation of the civil engineering works — access roads, site work and grading, and permitting requirements to construct a potential wind power project on Mesa Redonda. The proposed wind power project would require (1) access from the nearest developed road to Mesa Redonda, an access road to the top of the mesa, and circulatory access to each of the wind turbine locations, (2) site work and grading for the installation of wind turbines, (3) a service road for the overhead transmission line and substation facilities on the top of the mesa, and (4) permits from the New Mexico State Highway and Transportation Department (NMSHTD) to transport wind turbine nacelles, towers, blades, and other associated equipment across the state of New Mexico.

The work was based in part on the information and study results presented in previous sections of this report. In particular, the location of the access road between wind turbine locations was based on the two layout configurations described in Section 6. The “Transport Guidelines V80” by VESTAS, a major Danish wind turbine manufacturer, and AASHTO guidelines were used for the roadway design criteria. USGS 7.5-minute Quadrangle mapping, with a twenty-foot contour interval, provided the horizontal and vertical reference for the study of roadway alignments and profiles. The Geotechnical Site Characterization Study performed by Terracon and discussed in Section 5, provided some insight into the geotechnical conditions on top of the mesa. However, little data was available concerning the geotechnical conditions in the exact vicinity of the turbine locations or in the steep areas around the perimeter of the mesa. The alignment of the overhead transmission line described in Section 9 was used to establish the location and extent of the transmission line service road.

Mesa Redonda is located in Quay County east of NM 209 and west of NM 278. The top of the mesa is currently only accessible by four-wheel drive vehicle. At least two four-wheel drive roads from NM 209 reach the top of the mesa, one from the west and the other from the northwest. Another road linking with NM 278 approaches the mesa from the northeast. However, this road appears to terminate at the base of the steep side of the mesa continuing to the top only as a pack trail.

Limiting design criteria for the proposed access road were based on VESTAS V80 Transport Guidelines, and include a fourteen percent (14%) maximum grade, a 12-inch base course finishing surface, and horizontal curves to accommodate the 150-foot long transport...
vehicle with turnable rear wheels. In order to minimize environmental impacts as well as construction costs, an approach was adopted to consider utilizing an existing route up the mesa. Furthermore, strong consideration was given to the belief that the existing four-wheel drive roads were likely to be the easiest ways up the mesa.

All of the existing four-wheel drive routes to the top of the mesa have features that exceed the design criteria for the proposed access road. In particular, each of the existing routes have grades exceeding forty percent (40%) and utilize abrupt switchbacks at the steep upper slopes surrounding the entire mesa. The route that appears more appropriate than the others and thus chosen for more detailed study is the route that approaches the mesa from the northwest. This route, beginning at NM 209, appears to have the most gradual grades over a longer approach. Secondly, it has the least abrupt horizontal changes at switchback points. And lastly, it is likely to have the least visual impacts to the surrounding areas because the most severe road cuts occur within a deep nonlinear drainage valley not visible from developed areas.

A conceptual alignment and profile was then defined for the proposed access road. The alignment follows the existing road to the top of the mesa and continues around the proposed layout of the wind turbines. The road alignment chosen avoids sharp curves while passing directly by each of the turbine installation sites.

The two different wind turbine layout configurations studied necessitates two different circulatory access road alignments. The first road alignment, referred to as the Base Alignment, provides access to a reduced area, resulting in lower construction costs. The second option, referred to as the Alternate Alignment, services an enlarged area with turbines sited on the entire eastern portion of Mesa Redonda. The need for a longer access road results in higher construction costs for the alternate alignment.

The conceptual cost estimate for the 14.1-mile base alignment is approximately $4.7 million. The access road for the alternate alignment follows the base case alignment except for a 3-mile portion along the eastern side of the mesa. The alternate alignment results in a net 1.7-miles of additional road as compared to the base alignment. Thus the total cost estimate for the 15.8-mile alternate alignment is approximately $5.1 million.

Several unknowns still exist which could affect the estimated cost of the access road. First, it is not known if expansive soils exist along the proposed access road alignment. However, if such a situation does exist, additional costs may be required to blend or subexcavate such soils. Furthermore, portions of the alignment, which traverse steep terrain, are likely to require rock excavation and/or mechanically stabilized earth (MSE) retaining wall. The conceptual cost estimate assumes one third of the excavation through the steep areas requires rock excavation and utilizes MSE wall where the fill slope limits would otherwise be excessive. Lastly, the slope limits assumed in the typical section may need to be revised after a detailed geotechnical investigation is conducted.

The estimate for site work and grading of the 27 wind turbine installation sites is $757,031. This estimate was developed assuming a maximum existing 10% cross slope with no
occurrence of rock excavation. A pad size of one hundred feet square was assumed with a 12-inch base course surface. Grading away from the pad assumed a 3 horizontal to 1 vertical slope.

It is anticipated that a Patrick & Henderson foundation system would be employed for this project. The Patrick & Henderson foundation system is a patented deep foundation system. The system relies on excavating the soil to bedrock or a suitable bearing level and placing a circular form within the excavation and placing steel anchors within the form. Concrete is then placed inside the form and the form is removed and back-filled. Prior to design and construction, additional studies would be required to determine the actual depth to bedrock or bearing surface at the selected turbine locations since this could influence construction costs, depending upon the amount of excavation required and the materials to be excavated.

The estimated cost of foundation construction is $56,488 per turbine, or $1,525,176 for all 27 turbines. This estimate includes excavation, materials, labor, equipment, engineering, grounding, and transformer pad.

A twenty-two foot wide service road is proposed to parallel the transmission line from its intersection with a county road up to the beginning of the steep slopes of the mesa. From this point the transmission line spans from the base of the steep slopes to the rim of the mesa in one sweep. The service road is proposed to be discontinuous over the steep side of the mesa and then continue from the rim of the mesa to the proposed substation location. Access to the portion of the service road atop the mesa is by way of the Mesa Redonda access road. The total length of proposed service road is estimated to be 2.7 miles. No steep grades or difficult excavation is expected along the proposed alignment. The conceptual cost estimate for the overhead transmission line service road is $400,575.

Permit applications are analyzed for truck overloads by the New Mexico State Highway and Transportation Department (Mr. Jim Camp at 505-827-5532), and enforced by the New Mexico Motor Transportation Division of the New Mexico Department of Public Safety (Ernesto Pinon, 505-827-0321). In general the vehicle and loads shown in the Vestas Transport Guidelines are believed to be suitable for receipt of permit for transport on New Mexico highways. However, the permitting agencies recommend that an escort company conduct a route survey from the point of departure to destination so that the proper information may be made available to the agencies. The cost of the permit is less than $100, not including any licensing fees, taxes, or other unknown operating expenses.

1.11 Economic Analysis

Capital cost estimates developed for the two wind turbine layouts (Option 1 – Reduced Area, and Option 2 – No Exclusion Zones on the eastern portion of the mesa) are based on the conceptual cost estimates presented in Section 7: Electrical Collection System, Section 9: Power Transmission and Interconnection Facilities, and Section 10: Civil Engineering, and include the cost to complete an archaeological survey of the site.

Total installed costs for Option 1 are estimated to be approximately $57 million for a 40.5 MW wind project at Mesa Redonda, and include development, engineering, equipment
procurement and delivery, and construction pricing. Total installed costs for Option 2 are estimated to be $58.3 million.

O&M costs are estimated to be $14,000/MW/yr during the first year of operation, and then increase at inflation (3%/year) over the life of the project. O&M costs include operations staff labor, facilities maintenance, spare parts, consumables, wind turbine repair and contingencies, maintenance reserve additions, electricity consumption charges, substation O&M, interconnection maintenance, interconnection metering and telecommunications, fuel and vehicle maintenance, tools and safety equipment, site security, office utilities and supplies, meteorological tower maintenance, and wind plant control system maintenance. Experience shows that maintenance costs are generally very low while the turbines are new but increase over time as the turbines age. For the reduced area Option 1, this equates to a cost of 0.53 ¢/kWh.

Non-operating expenses include land lease payments, local taxes and insurance. Land lease payments are assumed to provide local landowners with an annual income of approximately $2,500 per MW for turbines installed on their property. The analysis assumes an annual property tax rate of 0.8% of total installed costs\(^2\) and an insurance rate of 0.52% of total installed costs.

The analysis assumes a debt term of 12 years for private power projects. The debt rate is assumed to be 8%. A grace period of six months is assumed during which only interest is paid. Following the grace period, equal principal payments are made on a quarterly basis over the term of the loan.

The study assumes that the project would be built before the end of 2003, and therefore the project developer/investor will be able to take advantage of the Production Tax Credit (PTC) which is scheduled to expire December 31, 2003. The PTC provides a 1.8 cents/kWh incentive in 2002 for wind energy projects for a period of 10 years (adjusted in future years for inflation).

Private power projects are expected to maintain a minimum Debt Service Coverage Ratio of 1.4, and provide a minimum Return on Equity of 18%. The Debt/Equity ratio for private power projects is assumed to be 70/30. The analysis also assumes 5-year Modified Accelerated Cost Recovery System (MACRS) tax depreciation for wind equipment (97% of total installed costs), and 15-year MACRS tax depreciation for non-wind related capital costs (3% of total installed costs), and an Effective Income Tax Rate of 39% (35% Federal and 7% State).

Net annual average energy production for Option 1 is estimated to be 106,701 MWh/year for an annual capacity factor of 30.1%, and 114,534 MWh/year for Option 2, resulting in an annual capacity factor of 32.3%. These estimates are developed in Section 6 of this report, and are based on the GE Wind 1.5 MW wind turbine power curve adjusted for site air density, and assume a 70.5 meter rotor diameter on a 65 meter tower.

The resulting levelized electricity sales price is 5.7 ¢/kWh for Option 1 and 5.39 ¢/kWh for Option 2, and is driven by the need to maintain the specified level of debt service coverage.

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\(^2\) Total property taxes assumed to equal 2.5% of assessed value. Assessed value assumed to equal 33.33% of market value (or total installed cost).
For Option 1, the cumulative net present value after-tax net equity cash flow is approximately $26.3 million, Return on Equity is equal to 22%, and the project has a payback period of 7 years. For Option 2, the cumulative net present value after-tax net equity cash flow is approximately $27.5 million, Return on Equity is equal to 23%, and the project has a payback period of 7 years.

The results indicate that the revenues received from the increase in energy production by capturing the more energetic winds projected for the northeastern rim of the mesa (Option 2) more than offset the increase in costs due to longer access roads, electrical cable and communication cable runs.

The resulting electricity prices are expected to be within 10% of the actual power sales price required by investors to develop the Mesa Redonda site. Lower construction costs, higher energy production, and/or a willingness on the part of investors to accept a lower Return on Equity, could reduce the price of future power sales to less than 5 ¢/kWh.

1.12 Conclusions and Recommendations

1.12.1 Conclusions

The following conclusions are drawn based on the results provided in previous sections of this report:

- The project site cannot be considered sensitive or rare habitat, nor is such habitat located within the project area or immediately adjacent to the project.
- Nothing in the literature or from interviews with experts suggested that the site is an important nesting or foraging area for federally threatened or endangered birds, or bird species proposed for listing (letters from U. S. Fish & Wildlife, New Mexico Game & Fish, and New Mexico Natural Heritage Program). No Audubon WatchListed species are likely to nest on or in the vicinity of the project site, and none are likely to spend much, if any, time on top of the mesa where turbines will be located. In addition, there was no evidence that the project site or lands adjacent to the site would attract significant concentrations of migrating or wintering waterfowl, shorebirds, songbirds, hawks, or other species. Site visits revealed no evidence of endangered or threatened species presence or use of the turbine sites, and the habitat did not appear to be suitable for such species. The site visit did not reveal significant prey availability that could attract large numbers of raptors to the mesa-top turbine locations.
- Based on what is known about avian risk factors at wind power plants in North America and Europe, the species (type and numbers of individuals) that frequent the project site, and what was learned from the literature search, site visits, and interviews, there is no indication that the Mesa Redonda Wind Power Project will result in significant adverse impact to birds.
- No federally or state threatened or endangered amphibian, reptile, fish or mollusk species were identified as potentially occurring within or near Mesa Redonda.
- An initial response from the New Mexico Forestry and Conservation Division indicated that it was unlikely that rare plant species would be impacted by the proposed project.
• From the very limited reconnaissance conducted as part of this case study, the density of archaeological remains on the mesa top appears to be low. Cultural remains are most common within a few meters of the mesa rims, but most of those are isolated occurrences that are unimportant as sources of archaeological knowledge. The frequency of isolated occurrences in the interior of the mesa may be lower. On the whole, archaeological locales on the mesa appear to be few, small, and simple.

• Based on information provided, it is anticipated that the Patrick & Henderson type foundation system could be utilized for the support of all the turbines, and a conventional spread footing foundation would be utilized for the support buildings.

• Varying depths to bedrock and the potential for weathered material overlying the bedrock may present some problems in the excavation of the deep foundations. Although the surveyed locations indicate that bedrock may be in excess of 40 feet below existing grade, it is anticipated that as the perimeter of the mesa is approached, the depth to bedrock would decrease based on the outcrop formations observed.

• If the project area is restricted to the eastern portion of Mesa Redonda, the project would not be visible from any residence on NM 209.

• Since the closest residence to Mesa Redonda is approximately 3 miles away, noise is not expected to be an issue with any proposed development.

• As the location of the case study project is in Quay County, there is no local electrical permitting. Electrical permits are required from the State of New Mexico, however. A stamped set of electrical drawings will need to be submitted for plan check and permits to The State of New Mexico Construction Industries Division. In order to qualify to do the construction, the electrical contractor has to have EL 01 Certification to work on high voltage installations.

• The results of the thermal screening analysis indicate that the SPS line between Curry and Tucumcari has sufficient thermal capability to accept the output of a 40.5 MW wind project located at Mesa Redonda under any seasonal condition with all lines in-service. The results further suggest that the Mesa Redonda-Curry line may be able to handle much higher levels of new wind generation based on the power flow results and the line’s normal rating of 112 MVA.

• The State of New Mexico has jurisdiction over the issuance of construction permits, licensing of contractors, and construction inspections for all transmission facilities. For construction permit applications, the developer will be required to submit structural and foundation drawings for the substation, as well as electrical drawings. All drawings will require a stamp from a New Mexico licensed engineer. A construction permit for the transmission line will require a licensed engineer’s calculations for structural design, load flow, fault currents, and losses. The developer must also submit a survey and staking plan for transmission line routing.

• Based on conversations with the Quay County Clerks Office it does not appear that transmission line construction would be required to go through any local planning and development process or public hearing.

• In general, vehicle dimensions and loads required to transport wind turbine nacelles, towers and blades are believed to be suitable for receipt of permit for transport on New Mexico highways.

• Revenues received from the increase in energy production by capturing the more energetic winds projected for the northeastern rim of the mesa (Option 2) more than

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offset the increase in costs due to longer access roads, electrical cable and communication
cable runs.
- The resulting levelized electricity sales price is projected to be 5.7 ¢/kWh for Option 1
  and 5.4 ¢/kWh for Option 2. Lower construction costs, higher energy production, and/or
  a willingness on the part of investors to accept a lower Return on Equity, could reduce
  the price of future power sales to less than 5 ¢/kWh.

1.12.2 Recommendations

The following recommendations are made based on the results provided in previous
sections of this report:

- Based on the results of the Phase I Avian Risk Assessment, there is no indication that
  further study of potential avian impacts is needed prior to construction of an actual wind
  project at Mesa Redonda.
- Initial agency consultation did reveal recommendations for implementation of a
  monitoring program to determine any resulting impact to bird populations from wind
  plant construction.
- If the Wind Power project proceeds, further consultation to fully determine the presence
  or absence of any federal or state protected biological species that has the potential to
  occur within the project area would be required. This consultation could result in the
  regulatory requirement that formal field surveys for specific protected species be
  completed. However, based on the agency consultation that was completed as part of
  this project, it is not likely that field surveys would be required.
- In any future development of Mesa Redonda, LA 134419 should be avoided. If avoidance
  is not practical, the site should be tested to determine its information potential (and thus
  its NRHP eligibility). We also recommend that LA 134420 be avoided. If avoidance is
  not possible, the site should be subjected to a program of archaeological data recovery.
- Based on the results of the reconnaissance survey, any development of the mesa top
  should be preceded by an intensive (Class III) archaeological survey of the proposed
  development areas.
- Potentially expansive soils and the potential for materials which exhibit collapse upon
  elevation in moisture content will likely require particular attention in the final design
  and construction of the project.
- A three phase 25 kV direct buried (U/G) triplex cable system is recommended to avoid
  the visual impact associated with overhead lines within the project area.
- The route that appears to be the most appropriate for access to the top of the mesa is the
  route that approaches the mesa from the northwest. This route, beginning at NM 209,
  appears to have the most gradual grades over a longer approach. Secondly, it has the
  least abrupt horizontal changes at switchback points. And lastly, it is likely to have the
  least visual impacts to the surrounding areas because the most severe road cuts occur
  within a deep nonlinear drainage valley not visible from developed areas.
- A detailed geotechnical investigation will need to be conducted to confirm or revise the
  slope limits assumed in the civil engineering analysis.
• The transportation permitting agencies recommend that an escort company conduct a route survey from the point of departure to Mesa Redonda prior to construction so that the proper information may be made available to the jurisdictional agencies.

• Additional short-term monitoring of site wind speeds should be conducted in the interior and at the northern rim of the mesa to confirm the wind resource estimates developed by the WAsP model.\(^3\)

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\(^3\) WAsP is a wind flow modeling software package for the vertical and horizontal extrapolation of wind climate statistics. It contains several models to describe the wind flow over different terrains and close to sheltering obstacles.