BEFORE THE
PUBLIC SERVICE COMMISSION
OF MARYLAND

In the Matter of the Application	**)**	
Of Cherrywood Solar I, LLC for a	**)**	
Certificate Of Public Convenience and	**)**	**Case No. 9477**
Necessity To Construct a 202 MW Solar	**)**	
Photovoltaic Generating Facility in	**)**	
Caroline County, Maryland	**)**	

DIRECT TESTIMONY OF DONALD E. STREBEL

ON BEHALF OF THE

MARYLAND DEPARTMENT OF NATURAL RESOURCES

POWER PLANT RESEARCH PROGRAM

December 13, 2018

PPRP Exhibit __(DES-1)
PSC Case No. 9477

Q. PLEASE STATE YOUR NAME, POSITION AND BUSINESS ADDRESS.

A. My name is Donald E. Strebel. I am a senior environmental consultant employed by Environmental Research Group, LLC (ERG). My business address is Versar, Inc., Suite 1, 9200 Rumsey Road, Columbia, MD 21045.

Q. WHAT ARE YOUR RESPONSIBILITIES IN THIS POSITION?

A. I am a subject matter expert working under contract for Versar, Inc. to provide environmental impact assessment expertise to the Power Plant Research Program (PPRP). In this position, I work with teams of topic-area experts to review the biological and ecological impacts of proposed power generating facilities and transmission lines and provide science-based environmental assessment reports, testimony, and mitigation recommendations to PPRP.

Q. WHAT IS YOUR PROFESSIONAL BACKGROUND?

A. I hold a Ph.D. in Applied Physics, conferred in 1980 by the Electrical Engineering and Computer Science Department of the University of California, San Diego. I also received a Master of Science degree from the same program in 1975 and earned both a Bachelor of Science degree in Physics and a Bachelor of Arts Degree in History from the University of Rochester in 1972. I worked for Versar, Inc. from December 1988 through January 2018 and joined ERG upon my retirement from Versar. Appendix A provides additional details of my education, employment, and professional qualifications.

Q. PLEASE DESCRIBE YOUR GENERAL EXPERIENCE IN SITE EVALUATION AND IMPACT ASSESSMENT FOR POWER FACILITIES.

A. I have worked on CPCN assessment tasks for PPRP for more than 20 years. As a

Versar employee, I managed the Linear Facilities Siting and Evaluation Program and served as the Deputy Program Manager for Versar's Biological Support contract with Maryland's Power Plant Research Program (PPRP). In these roles I led consultant teams that provided biological impact assessments, draft license conditions, and testimony for numerous generation and transmission CPCN cases in which PPRP intervened. These assessments included evaluating construction and operational impacts to rivers and streams, wetlands, forests, and wildlife, with specific emphasis on protected natural resources such as rare, threatened or endangered (RTE) species, scenic rivers, and Maryland's Green Infrastructure Network.

Q. PLEASE DESCRIBE YOUR SPECIFIC EXPERIENCE WITH RECENT CPCN CASES.

A. I provided Direct Testimony on behalf of PPRP in Case No. 9426 (Mason Dixon Solar Center). I have provided draft impact assessments to PPRP for Biggs Ford Solar Center (PSC Case No. 9439), and Casper Solar Center (PSC Case No. 9450), both of which are currently suspended while waiting for County action. I also provided an impact assessment for the Church to Steele 138 kV transmission line rebuild (PSC Case No. 9367), which is in the DPL ROW adjacent to the Cherrywood Solar Project and which is subject to environmental license conditions that may affect the Project.

Q. WHAT IS THE PURPOSE OF YOUR TESTIMONY TODAY?

A. The purpose of my testimony is to support certain findings and recommendations concerning the Application by Cherrywood Solar I, LLC for a CPCN to construct a 202 MW solar photovoltaic generating facility in Caroline County, Maryland. Specifically, I will evaluate potential individual and

cumulative environmental impacts to the ecological and biological resources that may be affected by the Project, including streams, wetlands, and forests. I will also describe the plants and animals that utilize the habitats that these resources provide. Based on my assessment of the potential impacts to these resources by the Project, I present conclusions and recommendations with respect to constructing and operating the generating facility and its transmission lead line.

Q. WHAT ELSE, IF ANYTHING, WILL YOU BE ADDRESSING IN YOUR TESTIMONY?

A. The reviewing State agencies have developed a number of Initial Recommended License Conditions to help minimize and mitigate environmental impacts associated with the proposed Project (included in PPRP Exhibit__(HS-2)). Based on the effects on natural resources of constructing and operating the facility, I am providing testimony as to why several of these Initial Recommended License Conditions are reasonable and necessary.

Q. HAVE YOU REVIEWED CHERRYWOOD SOLAR I, LLC'S APPLICATION AND OTHER FILINGS IN THIS PROCEEDING?

A. Yes. I have reviewed the Cherrywood Solar I, LLC CPCN application materials filed with the PSC on January 23, 2018. These materials include an Application and an Environmental Review Document (ERD) dated January 22, 2018 that was prepared by H&B Solutions, LLC. However, I used as my primary reference the revised version of the ERD dated May 25, 2018 that was included as Attachment C to the Direct Testimony of Dane S. Bauer, filed on June 1, 2018. I have also read the testimony that has been filed in the case by Cyrus Tashakkori and Dane S. Bauer.

Q. DO YOU HAVE ANY OTHER FAMILIARITY WITH THE POTENTIAL

ENVIRONMENTAL EFFECTS OF THE PROPOSED PROJECT?

A. Yes. I participated in a field review of portions of the Project site on June 28, 2018 and have reviewed all of Cherrywood Solar I, LLC's responses to PPRP's data requests pertaining to the environmental impacts of the Project. In addition, my team and I conducted an independent evaluation of the potential environmental impacts using data from a variety of sources. This evaluation assessed the potential effects of the Project on streams and nontidal wetlands; RTE species; forest resources and Maryland's Green Infrastructure Network; and land use and vegetation management in the relevant portions of Caroline County.

Q. ARE YOU INTRODUCING ANY EXHIBITS TO SUPPORT PPRP'S TESTIMONY?

A. No, I am not introducing any exhibits, but my testimony does support portions of exhibits introduced by PPRP Witness Helen Stewart. These exhibits include PPRP Exhibit__HS-2 (Initial Recommended License Conditions) and PPRP Exhibit__HS-3 (Project Assessment Report, or "PAR").

Q. **WHAT SECTIONS OF PPRP'S PROJECT ASSESSMENT REPORT WERE PREPARED BY YOU OR UNDER YOUR SUPERVISION?**

A. I was responsible for Section 3 (Biological Resources) and the related paragraphs of the Summary (Section 7).

Q. PLEASE DESCRIBE ANY LIMITATIONS OF THE ANALYSIS YOU ARE PRESENTING TODAY.

A. My review is limited by the completeness and accuracy of the information about the proposed configuration of the Project that Cherrywood Solar I, LLC provided

in its Application and its Environmental Review Document, as revised. Design changes and any other new information about planned construction activities or treatments may change my analyses or conclusions.

Environmental Infrastructure

Q. PLEASE CHARACTERIZE THE ENVIRONMENTAL FEATURES OF THE PROJECT AREA.

A. The proposed project comprises 18 parcels distributed in four non-contiguous clusters of several parcels each. The landscape matrix in which these clusters are embedded contains streams, wetlands, and forests that are part of Maryland's Green Infrastructure Network. These Green Infrastructure components support rare and sensitive species of plants and animals, as well as provide transportation corridors and high quality habitats for diverse aquatic, terrestrial, and avian populations. The surroundings also encompass Tier II streams, Wetlands of Special State Concern, and stream reaches in the Upper Choptank River Stronghold Watershed that provide abundant permanent wildlife habitat, including habitat for Federally-listed endangered species.

Q. WHAT IS THE GREEN INFRASTRUCTURE NETWORK AND WHY IS IT IMPORTANT?

A. The Maryland Department of Natural Resources developed the Maryland Green Infrastructure Assessment to identify ecologically important lands and define a network of large blocks of intact forests and wetlands, or hubs, connected by habitat corridors. Maryland's Green Infrastructure represents Maryland's highest priority lands for protection in order to preserve and protect reproducing populations of Maryland's vital forest species. Although the Applicant's ERD

characterizes the 18 parcels as agricultural fields, each of the four groupings of parcels contains substantial amounts of natural vegetation and Green Infrastructure areas.

Q. ARE THERE OTHER SENSITIVE OR PROTECTED RESOURCE AREAS NEAR THE PROJECT?

A. Yes, as I mentioned, the project surroundings include Wetlands of Special State Concern, Stronghold Watersheds, and Tier II streams. Wetlands of Special State Concern provide habitat for rare species and are protected under State law. Similarly, Tier II waters are stream segments in which water quality is better than minimum requirements; activities that have potential to affect the water quality of these segments are subject to anti-degradation review conducted by the Maryland Department of the Environment (MDE). Stronghold Watersheds are defined by DNR as watersheds with high biodiversity that are likely to provide habitat for rare and endangered fish, amphibians, reptiles, and mussels.

The Cherrywood Solar Project site also contains Biodiversity Conservation Network (BioNet) areas within all Project subareas. Maryland DNR's Natural Heritage Program developed the BioNet to identify and rank areas for both terrestrial and freshwater biodiversity conservation. The criteria used to define the BioNet focus on the most irreplaceable species and habitats, as well as on the habitats that concentrate larger numbers of rare species.

Q. WILL THE PROJECT AFFECT THESE RESOURCE AREAS?

A. Yes. The effects of a biologically instantaneous conversion of a significant portion of this area to an extensive industrialized surface are much larger than a simple sum of the lost area of wetlands or number of trees removed within the limits of

disturbance. Because of the size and the distributed nature of the solar facility, it will fundamentally transform the environmental character of the landscape and affect all of the interdependent species that use it.

Q. DOES THE PPRP PROJECT ASSESSMENT REPORT DESCRIBE THESE IMPACTS IN MORE DETAIL AND DISCUSS APPROPRIATE MITIGATION?

A. Yes, Section 3 of PPRP's PAR presents a complete assessment of the potential impacts of the proposed project on vegetation, wildlife, RTE species, wetlands, and streams. In the remainder of my testimony, I will briefly summarize the impacts to these resources and address the Initial Recommended License Conditions that the reviewing State agencies are recommending to mitigate these impacts. I will also comment on the generator interconnections, the cumulative impacts on the sensitive features of the surrounding landscape, and the requirements for forest conservation actions to balance the proposed development.

Vegetation Impacts

Q. PLEASE DESCRIBE THE EXISTING VEGETATION ON THE PROJECT SITE.

A. The vegetation on and around the project parcels and the underground interconnections is described in Section 3.1 of PPRP's PAR. In addition to farmed areas, these parcels include forests, wetlands, ditches and streams that support corridors of perennial grasses and scattered shrubs along their banks, and farmsteads with lawns and other residential landscaping. The interconnections between subsections of the project run adjacent to or beneath forested wetlands. Over 60% of the area within the 1,217 acre limit of disturbance is classified as

prime farmland, based on the soils present, and if uncultivated would be suitable for supporting a wide variety of vegetation cover types and productive ecosystems. However, there is currently little permanent vegetation within the areas proposed for solar panels, which are typically used for growing crops such as corn, soybeans, and wheat.

Q. WOULD CONSTRUCTION AND OPERATION OF THE PROJECT RESULT IN IMPACTS TO VEGETATION RESOURCES?

A. There will be minor impacts from removing some existing trees and other vegetation, e.g. at the edges of farm fields, to construct the facility. No direct forest clearing is anticipated. Construction of the solar panels would restrict the types of vegetation that could be allowed to grow during the operational lifetime of the solar facility, but would not have permanent detrimental effects on the soils or future use as farmland except where grading is required. In fact, the developer's plans to plant and maintain the array portion of the project parcels with a low-height cover grass would retain the soil in place and over time could replenish soil organic matter and essential plant nutrients.

Q. DO THE STATE AGENCIES RECOMMEND ANY LICENSE CONDITIONS WITH RESPECT TO VEGETATION MANAGEMENT?

A. Yes. The reviewing State agencies recommend a vegetation management program for the array portion of the project parcels that, while being consistent with the goals and purpose of the project, can preserve the natural resources of the site, create wildlife and pollinator habitat, and protect the streams and ditches that flow through the site. PPRP has recommended a license condition that specifies that the areas beneath and between the solar panels be planted with native, warm-season grasses and that a grounds management plan be developed

(Initial Recommended License Condition No. 13). The plan is to include a description of the species to be planted, the mowing schedule and grass height, a protocol for managing invasive species, and details of an Integrated Vegetation Management (IVM) regime for creating and maintaining 35-foot-wide buffer areas on either side of the streams and drainage ditches that run through the properties. Restricting mowing during some periods and maintaining grass height will also create nesting habitat for some birds and provide cover and food for other animal species found in a natural grasslands ecological community.

Wildlife Impacts

Q. IS THE PROJECT SITE ADJACENT TO WILDLIFE HABITAT OR USED BY WILDLIFE?

A. Yes. The types of wildlife habitat and wildlife found on and around the project parcels and the underground interconnections are described in Section 3.3 of PPRP's PAR (PPRP Exhibit__(HS-3)). The 18 property parcels that would be incorporated into the project contain an array of stream, wetland, and forest wildlife habitats as well as cultivated fields. The farmed areas provide open space and forage areas for animals that live in or visit the adjacent natural habitats, such as deer, skunks, foxes, and migratory birds.

The area is located in the seasonal bird migration route known as the Atlantic Flyway and contains important bird habitat that supports both resident birds and transients. An eagle's nest has been recorded in the forested area near Lake Bonnie. A raptor survey conducted for the Church-Steele Transmission Line Rebuild (CPCN Case 9367), found raptor nests in the ROW near the Cherrywood Solar Project. Forest Interior Dwelling Species (FIDS) habitat exists in the forests throughout the Project site, and a bird sanctuary is located across the Choptank

River in the Red Bridges area.

The numerous drainage ditches and wetlands across the Project site also provide habitat for a variety of wildlife, such as frogs, turtles, snakes, and gophers. Approximately 5.16 acres of wetland areas are inside the limits of disturbance. There are also approximately 20,000 linear feet (3.8 miles) of ditches or linear wetland features inside the limit of disturbance, and an additional 25,900 linear feet (4.9 miles) outside of this limit, but within the parcel boundaries.

Q. PLEASE DESCRIBE THE IMPACTS TO WILDLIFE THAT WOULD RESULT FROM CONSTRUCTION AND OPERATION OF THE PROJECT.

A. Construction of the solar panel arrays will cause changes in open space, forage availability, water retention, and runoff. Covering over 1,000 acres with structures, breaking up open areas with fencing, and changing vegetative cover will necessarily have an impact on many types of wildlife. These changes will create a more urbanized landscape and cause increases in some species and decreases in others. Both temporary and long-term changes to wildlife populations and species are likely.

At a minimum, the significantly reduced amount of open farmland in the local area will result in decreases in the sizes of wildlife populations for which the farmland is a limiting resource. It is also likely that there will be changes in the species present, e.g. birds adapted to the narrower, fragmented spaces offered by arrays of solar panels will replace birds that hunt over large open spaces. Border fences may hinder terrestrial species that use open spaces for travel between habitat patches.

The Applicant's plan to plant and maintain the site in low cover grasses with

wild flower seed mixes could benefit some wildlife, encouraging colonization or use by grassland species and supporting pollinator species. Further, the Applicant is proposing a 35-foot setback from wetland areas, ditches and streams. With proper vegetation management, a considerable amount of new wildlife habitat could develop in these areas.

Q. DO THE STATE AGENCIES RECOMMEND ANY LICENSE CONDITIONS WITH RESPECT TO WILDLIFE?

A. Yes. Based on the State's evaluation, Cherrywood Solar should exercise an abundance of caution in construction and operations because of the potential for disturbance to wildlife habitats on site and nearby habitats that support sensitive species. Therefore, the reviewing State agencies recommend several license conditions that are intended to protect wildlife habitat while directly addressing the impacts of: spills or leaks of contaminants (Initial Recommended License Condition No. 18); construction-caused erosion and sediment (Initial Recommended License Condition No. 10); construction in and near streams and drainage ditches (Initial Recommended License Condition No. 15); vegetation management (Initial Recommended License Condition No. 13); and construction during wildlife breeding seasons (Initial Recommended License Condition No. 14). With the specific objective of creating wildlife and pollinator habitat, the reviewing State agencies recommend a license condition that requires the use of an Integrated Vegetation Management approach in the 35-foot buffer around streams and drainage ditches (Initial Recommended License Condition No. 13.f). Also, to provide the information necessary to protect raptors, the reviewing State agencies recommend a license condition that requires a raptor nest survey before the start of construction (Initial Recommended License Condition No. 14.b).

RTE Species Impacts

Q. ARE THERE ANY KNOWN LISTED RARE, THREATENED OR ENDANGERED (RTE) SPECIES PRESENT ON OR ADJACENT TO THE SITE?

A. Yes. The RTE species habitat found on and around the project parcels and the underground interconnections is described in Section 3.4 of PPRP's PAR. The Maryland Department of Natural Resources Wildlife and Heritage Service (WHS) indicated in a November 30, 2017 letter that the project may provide habitat for multiple RTE species. A second letter dated May 24, 2018 addressed a parcel subsequently added to the project. I also reviewed the February 5, 2014 WHS letter prepared for the Church to Steele transmission line project (PSC Case No. 9367) which was constructed on the Delmarva Power right-of-way that runs through several of the parcels that are part of the Cherrywood Solar Project.

The Upper Section of the project is in the drainage area of the Crescent macrosite, a nontidal wetland complex that supports several State listed plants and amphibians. A State-listed endangered mussel and a State-rare forest plant have been recorded in areas that overlap some of the project parcels in this area. There are also records of State endangered plants, State rare insects, and a State endangered mussel near the Lower Section, which is in the Upper Choptank River drainage. This portion of the Upper Choptank River is known to support several RTE species, including a federally-listed endangered mussel in waters downstream of the project.

In general, agricultural fields themselves do not provide habitat for RTE species, but small streams, uncultivated roadside areas, forest patches, and drainage ditches in agricultural areas may still provide such habitat. This is a concern

throughout the Cherrywood Solar development area, given the extensive stream/ditch drainage system and the close proximity to known sensitive species locations. If appropriate habitat is present, the absence of a record of RTE species may only indicate that adequate surveys have not been conducted.

Q. ARE IMPACTS TO RTE SPECIES POSSIBLE FROM CONSTRUCTION AND OPERATION OF THE PROJECT?

A. Yes. RTE species in the Crescent macrosite and in the Upper Choptank River are highly sensitive to water quality. The dwarf wedge mussel, for example, is an extremely rare freshwater species that requires a stable, silt-free streambed and well-oxygenated water free of pollutants. Sediment or contaminants discharged from the site could be conveyed to sensitive locations downstream via tributary streams, ditches, and surrounding wetland areas. The WHS letters recommend avoiding any construction or operational practices that could have adverse impacts on hydrology or water quality.

In this regard, there are 8.7 miles of ditches or linear wetland features inside the project parcel boundaries, 3.8 miles of which are within the Project's limit of disturbance. Cherrywood Solar proposes to construct 51 culverts across these features to support a network of 20-ft-wide access roads that will cover approximately 53.4 acres. There is significant potential for this amount of construction directly in waterways to result in total sediment or contaminant releases that affect downstream water quality, even under the best conditions.

Additional potential sources of sediments or contaminants that could affect water quality include trenching and drilling for the underground power interconnections and the 81 liquid-insulated DC/AC transformers that will be installed on site. The project substation, with a utility-grade 34.5 kV to 230 kV

transformer, will be constructed in the area of the project closest to the Choptank River, where sediments and contaminants would flow less than ¼ mile through a short ditch/stream directly to the River.

Q. DO THE STATE AGENCIES RECOMMEND ANY LICENSE CONDITIONS WITH RESPECT TO RTE SPECIES?

A. Yes. For Cherrywood Solar to construct this project without RTE impacts, exceptional efforts will be necessary to protect water quality and minimize disturbance to RTE species. The reviewing State agencies recommend a license condition that requires the use of best practices and third-party monitoring during construction, avoidance of disturbance to wetlands and streams, and consultation with DNR WHS if additional RTE or sensitive species are encountered during planning, construction, operation, or maintenance of the facility (Initial Recommended License Condition No. 14).

In addition, license conditions that address certain other impacts while also protecting RTE species include: containing spills or leaks of contaminants (Initial Recommended License Condition No. 16); controlling construction-caused erosion and sediment releases (Initial Recommended License Condition No.10); maintaining culverts in streams and drainage ditches (Initial Recommended License Condition No. 15); containing inadvertent releases from directional drilling (Initial Recommended License Condition No. 18); and designing grading to minimize hydrological changes (Initial Recommended License Condition No. 9).

<u>Wetland and Stream Impacts</u>

Q. PLEASE DESCRIBE THE WETLAND AND STREAM RESOURCES ON OR

NEAR THE PROJECT SITE.

A. The wetland and stream resources on and around the project parcels and the underground interconnections are described in Section 3.5 of PPRP's PAR. The Cherrywood Solar site contains numerous streams, ditches, and wetland areas, and is adjacent to or upstream of several environmentally important features, including the Choptank River, the Crescent nontidal wetland macrosite, the Jackson Lane Wetlands of Special State Concern, a Tier II segment of Forge Branch, and the Upper Choptank River Stronghold Watershed. The project area drains either directly or through Broadway Branch, Oldtown Branch, and Forge Branch to a high-biodiversity section of the Choptank River that supports healthy fish communities and several endangered species.

There are wetland and stream features throughout the project site - in total, approximately 3.79 miles of protected channels and approximately 5.2 acres of protected wetlands have been identified inside the limit of disturbance. There are also networks of subsurface drainage tiles within the site that were constructed to drain additional wetland areas for farming purposes. The Lower Section of the project site contains a Delmarva Bay and over twenty identified wetland areas. Portions of this section drain to a Tier II (protected high-water quality) stream.

Q. WILL CONSTRUCTION AND OPERATION OF THE PROJECT BE LIKELY TO RESULT IN IMPACTS TO WETLANDS OR STREAMS?

A. Yes. As proposed, the project is likely to result in both positive and negative impacts. Cherrywood Solar proposes to maintain 35-foot buffers around streams, ditches, and wetlands within the limits of disturbance, which will avoid most direct interactions between the facility operations and these water features.

However, discharges to streams and ditches, or changes in hydrology from development, would affect both onsite and downstream water quality. In this regard, constructing the network of access roads for the project will require installing 51 culverts in the streams and ditches on the site. These culverts will replace open vegetation channels with concrete pipes. Sediment and contaminants may be released to the water during construction, improperly set culverts may result in erosion during operations, and the changed flow, temperature, and infiltration characteristics associated with these pipes will alter downstream conditions in the streams and ditches.

The permanent vegetation cover proposed will likely be beneficial in many locations by reducing surface evaporation and storm runoff peaks compared to an agricultural field. This will probably not be effective in areas of the site with poorly drained soils, where bare spots and stormwater ponding will develop. The project, as proposed, also includes construction of approximately 53.4 acres of hard-packed access roads, 1.6 acres of impervious area from footings and transformer pads, and an additional 2.1 acres of impervious area associated with the substation. Impervious surfaces, soil compaction associated with construction activities, and access roads will reduce the ability of soil to infiltrate rainfall, leading to increases in stormwater runoff, stream temperature, and erosion from these areas.

Q. DO THE STATE AGENCIES RECOMMEND ANY LICENSE CONDITIONS WITH RESPECT TO STREAM RESOURCES?

A. Yes. Given the sensitive and diverse biological communities downstream of the on-site streams, ditches, and wetlands, the State concludes that the Project will have to implement proper construction techniques, stormwater management,

and contaminant containment procedures to avoid possible negative impacts. The reviewing State agencies recommend license conditions that require: containing spills or leaks of contaminants (Initial Recommended License Condition No. 18); controlling construction-caused erosion and sediment releases (Initial Recommended License Condition No. 10); preserving water quality (Initial Recommended License Conditions No. 17); managing soil compaction (Initial Recommended License Condition No. 19); and designing grading to minimize hydrological changes (Initial Recommended License Condition No. 9). With the specific objective of protecting Tier II waters, the reviewing State agencies recommend a license condition that requires implementing enhanced best management practices for Tier II watersheds in the Lower Section of the Cherrywood Project during construction and post-construction biological monitoring of the Tier II segment (Initial Recommended License Condition No. 16).

Underground Interconnection Impacts

Q. PLEASE DESCRIBE THE ENVIRONMENTAL CONTEXT OF THE PROJECT INTERCONNECTIONS.

A. The resources that may be affected by the underground interconnections are described in Section 3.7 of PPRP's PAR. The Cherrywood Solar Project will require several interconnections between solar fields on the various parcels, as well as a new 230-kV substation that interconnects directly to the regional bulk transmission system via Delmarva Power's Keeney-Steele 230-kV circuit.

The 34.5-kV underground lines between parcels include two below a highway, one along a County road, and one below a lake. The proposed connection between Upper and Lower project sections will run parallel to Broadway Branch

in a forested wetland area, and then cross underneath Lake Bonnie, a jurisdictional wetland. A second underground connection runs along Bridgetown Road, parallel to Oldtown Branch and associated forested wetlands. This connection is in a Green Infrastructure Corridor and will also cross below an abandoned railroad track.

The proposed substation is located in a farm field adjacent to the DPL ROW, and will require a transmission interconnection at 230 kV. The ROW at this point is subject to an existing CPCN condition that, if farming ceases, would re-establish 100 feet of unmanaged vegetation between the DPL transmission line and the substation. The substation location is also adjacent to a short ditch/stream that flows directly into the Choptank River, approximately one mile upstream of a Wetland of Special State Concern, and within an area designated by the WHS Natural Heritage Program as "Critically Significant for Biodiversity Conservation".

Q. WHAT BIOLOGICAL IMPACTS COULD RESULT FROM CONSTRUCTION AND OPERATION OF THE PROJECT INTERCONNECTIONS?

The inadvertent release of drilling fluids from horizontal directional drilling beneath wetlands, the excavation of contaminated material from drilling below the railroad track, or the release of transformer insulating fluids could degrade sensitive habitats downstream of the interconnection facilities. These events are possible even under the best conditions.

The high-quality stream and wetland resources downstream of these facilities support endangered species that are especially susceptible to siltation, polluted runoff, and changes in hydrology. Potential impacts include significant detrimental effects on fish, benthic communities, and wetland plants.

Full information about the location and nature of the planned 230-kV interconnection between the project substation and the Keeney-Steele circuit is not available at this time. Engineering considerations may make it difficult to minimize some impacts while constructing this interconnection. The sensitive nature of the biological resources in the area will require careful attention during the remaining design stages to avoid impacts.

Q. DO THE STATE AGENCIESRECOMMEND ANY LICENSE CONDITIONS WITH RESPECT TO THE PROJECT INTERCONNECTIONS?

A. Yes. The reviewing State agencies recommend a license condition that requires Cherrywood Solar to meet the standards for construction, maintenance, or repair of underground utility lines in stream or wetland areas that are enumerated in the Maryland State Programmatic General Permit issued by the U. S. Army Corps of Engineers (Initial Recommended License Condition No. 20). Further, the reviewing State agencies recommend a license condition that would require the use of containment structures to prevent spills or leaks of transformer fluids from reaching streams, ditches, or wetlands (Initial Recommended License Condition No. 18).

Forest Conservation

Q. ARE THERE ANY OTHER ENVIRONMENTAL FACTORS THAT MUST BE CONSIDERED TO DEVELOP A SOLAR GENERATING FACILITY?

A. Yes. Maryland has made an evaluation of actions to protect and enhance forests a mandatory element of permitting development in the State. Section 5-1603(f) of the Natural Resources Article specifically requires the PSC to consider the need to minimize the loss of forest and the provisions for afforestation and

reforestation of the Forest Conservation Act (FCA; NRA 5-1601 through 5-1612) when reviewing CPCN applications.

Q. CHERRYWOOD SOLAR IS NOT REMOVING ANY FOREST. DOES THE FOREST CONSERVATION ACT STILL APPLY TO THE PROJECT?

A. Yes. The Forest Conservation Act establishes certain *minimum* forest cover requirements for land that is developed, even if no forest is removed by the project. These minimums are necessary to achieve the State's "No Net Loss of Forest" goals.

Q. WHAT, SPECIFICALLY, IS THE STATE'S NO NET LOSS OF FOREST STANDARD?

A. "No net loss of forest" means 40% of all land in Maryland is covered by tree canopy (NRA Section 5-101(i)). That is, the statewide total of forest losses and gains must be balanced to maintain the 40% cover objective. The Forest Conservation Act provides the mechanism for distributing those losses and gains among development projects to achieve the net balance. An individual project, such as the Cherrywood Solar project, is not evaluated directly against the no net loss standard.

Q. HOW DOES THE FCA WORK TO BALANCE LOSSES AND GAINS OF FOREST?

A. The evaluation approach used by the FCA, and its application to the Cherrywood project, is reviewed in Section 3.2 of PPRP's PAR. In general, projects on relatively heavily forested land (forest cover above the "Conservation Threshold") may be allowed to replace less than the amount of forest removed, while projects on relatively lightly forested land (forest cover below the

"Afforestation Threshold") are required to bring the property up to a minimum amount of forest cover. The two thresholds vary by land use class.

Q. IS THE PROJECT AREA LIGHTLY FORESTED?

A. Yes. Using the most current and accurate spatial data available from the State of Maryland and other reliable sources, PPRP determined that approximately 14.7% of the project parcels is forested. This is below the FCA afforestation minimum of 20% forest cover for agricultural lands, as well as below the Caroline County overall forest cover of approximately 32.1% and the statewide No Net Loss goal of 40% forest cover.

Q. IS THIS LOW AMOUNT OF FOREST ONE OF THE REASONS THAT DNR PROGRAMS HAVE IDENTIFIED THE AREA AROUND THE PROJECT AS A CONSERVATION PRIORITY?

A. Yes. A significant portion of the Project is within DNR Targeted Ecological Areas, which are lands and watersheds of high ecological value that are conservation priorities. As mentioned elsewhere in my testimony, the Project area also includes Green Infrastructure Network elements, Stronghold Watersheds, and BioNet biodiversity conservation areas. Conserving and enhancing the forests in this area will provide significant ecological benefits to the State and is consistent with the State's vision for enhancing the extent and condition of tree and forest cover in the Chesapeake Bay watershed and achieving the no net loss of forest objective (NRA 5-102).

Q. HAS PPRP DETERMINED THE AFFORESTATION THRESHOLD FOR THE CHERRYWOOD SOLAR PROJECT?

A. Yes. The material supplied by Cherrywood Solar was not adequate for FCA

mitigation evaluation. Therefore, PPRP independently compiled and analyzed the most current and accurate spatial data available from State of Maryland and other reliable sources to estimate the actual forest present and compare it to the afforestation threshold. This analysis determined that the existing forest on the parcels was 246 acres, or 14.7% forest cover, while the Afforestation Threshold was 333 acres, or 20% forest cover (PPRP PAR, Appendix D).

Q. ARE AFFORESTATION OPPORTUNITIES AVAILABLE ON THE PROJECT SITE?

A. Yes. PPRP has identified numerous opportunities for afforestation, reforestation, and conservation on the project parcels that meet the preferred mitigation options specified in the FCA, i.e. establishing or enhancing buffers adjacent to intermittent and perennial streams, establishing or increasing forest corridors, and establishing or enhancing forest buffers adjacent to critical habitats or on 100-year floodplains (NRA 5-1607(d)). For example, the cleared lands between the DPL Transmission Line ROW and the Choptank River will not be used for solar panels and could be reforested and put into Conservation easements to enhance the valuable habitat and natural resources of the Choptank Green Infrastructure corridor. The total area available for such afforestation at little to no impact to the Project would be at least 30 acres (PPRP PAR, Appendix E).

Q. DID CAROLINE COUNTY COMMENT ON THE FOREST CONSERVATION REQUIREMENTS FOR THE PROJECT?

A. Yes. In a letter dated May 30, 2018, the Caroline County Department of Planning & Codes indicated that the Project must obtain a CPCN issued by the PSC in accord with NRA 5-1603(f) in order to qualify for exemption from the County forest conservation regulations. That is, the County recognized that the PSC's

due consideration of the forest conservation requirements for the project, including reforestation and afforestation, will meet its local FCA requirements. The County exemption is consistent with NRA 5-1602(b)(5), which provides that after a utility is issued a CPCN, it may be granted an exemption from FCA requirements other than those contained in the CPCN conditions.

The County letter notes the intent of Cherrywood Solar to avoid removing any forest and to plant landscape buffers that may count as forest. It does not, however, provide any evaluation of the potential of these actions to meet the quantitative requirements of the FCA. Specifically, it is silent on the afforestation requirement of the FCA.

Q. HAS THE APPLICANT PROPOSED INCLUDING ANY FOREST CONSERVATION INTO THE PROJECT?

A. Yes. The Applicant has proposed that 29.92 acres of landscape buffers be used to address the State's FCA requirements.

Q. WHAT ARE THE RECOMMENDATIONS OF THE STATE AGENCIES WITH RESPECT TO FOREST CONSERVATION?

A. Considering all aspects of the Project, the DNR Forest Service has agreed that the Applicant's proposal to include 29.92 acres of forested landscape buffers as part of the project constitutes an acceptable contribution to the State's "no net loss of forest" afforestation goals. In addition, to meet the mitigation priorities of the FCA, the reviewing State agencies recommend that approximately 20 acres of existing forest areas on the properties owned by the Applicant be placed into conservation easements and be maintained in perpetuity as forests as defined by statue (NRA 5-1601(k)).

Therefore, the reviewing State agencies recommend a license condition that requires completion of a Forest Stand Delineation and development of a Forest Conservation Plan that includes not less than 29.92 acres of forest planting and landscape buffers, as well as approximately 20.21 acres of permanent Forest Conservation easements (Initial Recommended License Condition No. 12).

Conclusion

Q. PLEASE SUMMARIZE THE IMPACT OF THE CONSTRUCTION AND OPERATION OF THE PROJECT ON NATURAL RESOURCES.

A. Construction and operation of the proposed project may affect numerous sensitive natural resources, including wildlife, RTE species, and wetland and stream habitats. On the individual field or stream level, many of these impacts can be controlled or minimized by rigorous use of best management practices, and under the license conditions recommended by PPRP. However, because of the sheer scale of the project, spread over 18 parcels that lie within an area roughly 5 miles by 6 miles in size, the accumulated effects may still be significant.

Q. ARE THERE UNAVOIDABLE IMPACTS ASSOCIATED WITH THE PROJECT OR REQUIRED MITIGATION ACTIONS?

A. The potential cumulative effects of the Cherrywood Solar Project are described in Section 3.6 of PPRP's PAR. Even with adherence to best management practices, the Project has the potential to affect the environmental condition of neighboring properties, modify the ecological functioning of the landscape matrix as a whole, degrade future use of the land as farmland, or overwhelm the resilience of the environment by the accumulation of multiple small impacts. The proposed

facility is embedded, over an area of some 30 square miles, in a landscape teeming with sensitive habitats and natural resources. The area has been determined to contain watersheds of high ecological value, critical State forest resources, and biodiversity hotspots. The accumulated biological impacts of 1,073 acres of panel construction, including 51 new culverts on streams and ditches, are likely to be significant to surrounding and downstream environmentally sensitive areas. Of particular concern is the likelihood that the extensive, widespread land use conversion will cause irreversible degradation of the highly connected matrix of sensitive ecosystems in the Upper Choptank River landscape.

Q. WHAT IS YOUR RECOMMENDATION CONCERNING THIS PROJECT?

A. In my opinion, with adherence to the reviewing State agencies' Initial Recommended License Conditions provided in PPRP Exhibit__(HS-2), the proposed Project can be constructed and operated in accordance with applicable environmental laws and standards.

Q. DOES THIS CONCLUDE YOUR DIRECT TESTIMONY AT THIS TIME?

A. Yes.

PPRP Exhibit __(DES-1)
PSC Case No. 9477

APPENDIX A:

RESUME

for Donald E. Strebel, Environmental Consultant

EDUCATION:

Ph.D., Applied Physics, University of California, San Diego, 1980
M.S., Applied Physics, University of California, San Diego, 1975
B.S., Physics; B.A., History; University of Rochester, 1972

EXPERIENCE SUMMARY: *Versar 29 yrs* *Other 16 yrs*

Dr. Strebel is an Environmental Consultant at Environmental Research Group, LLC, serving Versar and other clients as a senior expert in environmental assessments of energy facilities, Geographic Information Systems, and Scientific Information Management. Prior to joining ERG, he was a Principal Environmental Scientist at Versar's Ecological Sciences and Applications Division in Columbia, Md. In that position he was responsible for developing, supervising, and performing consulting work in climate change, geographic information systems, environmental remote sensing, and ecological modeling. He managed the Transmission Line Siting and Evaluation Program and other client projects and programs as required. He also developed and managed the Division's Geographic Information Systems (GIS) activities. Prior to joining Versar, Dr. Strebel was employed with Science Applications Research as a Task Leader at NASA/Goddard Space Flight Center. He managed task members in research, data analysis, and scientific data management in support of large international remote sensing field experiments. He also has several years of college and university faculty experience in mathematics, statistics, and computer science.

Dr. Strebel's current technical concentrations include the impacts of and adaptation to climate change, environmental assessments of energy facilities, and practical applications of remote sensing imagery. For the last several years, he has worked with the Maryland Power Plant Research Program to develop and apply a carbon accounting model for use in forest and wetland carbon sequestration projects in the State of Maryland, such as those that qualify for offset allowances under the Northeast Regional Greenhouse Gas Initiative. Additional projects to address climate change impacts for this client have included developing land management options for climate change mitigation, assessing statewide carbon sequestration potential by land use class, and analyzing regulatory frameworks, sequestration protocols, and new technology.

Dr. Strebel has three decades of experience using aerial and satellite remote sensing imagery in a variety of areas, including identifying sensitive habitats, modeling terrestrial ecosystem processes and impacts, assessing stream health in watersheds, evaluating environmental impacts of power facilities and rights-of-way, and determining the accuracy of satellite-based land use classification.

He is also an expert in spatial data management and analysis and has provided advice on developing and implementing scientific information systems to a variety of clients, including EPA's Environmental Monitoring and Assessment Program (EMAP), and NASA's Earth Observing System Data and Information System (EOSDIS). He directed a project to enhance and modernize the Maryland Department of the Environment's Shellfish Program Data System. Examples of his other environmental work include conducting Natural Resource Damage Assessment (NRDA) pre-assessment studies, modeling non-point source contaminant inputs to estuaries, characterizing thermal pollution to waterways from power plants and from in-port discharges by ships, and using simulation models to map the atmospheric dispersion of dioxin emissions across the United States.

Previous work experience includes contract support at NASA/Goddard Space Flight Center (GSFC) and faculty positions at Wofford College and State University of New York at Binghamton. One of the tasks that he managed at GSFC was the design and implementation of the FIFE Information System, including establishing and maintaining operational procedures for receiving, ingesting, processing, and archiving large volumes of satellite and aircraft digital image data from a variety of current operational and experimental sensors. His faculty experience includes research on numerically inverting canopy reflectance models and teaching statistics at both undergraduate and graduate levels.

AREAS OF QUALIFICATION:

Physics, applied mathematics, climate change, carbon sequestration in terrestrial ecosystems, (ecological) non-linear dynamical systems, the effects of stochastic parameters on non-linear models, models of population growth and extinction, ocean fish population models, models of prey-predator dynamics, remote sensing, extraction of ecosystem parameters from satellite imagery, vegetation canopy reflectance modeling, acoustics, accelerated stress testing, CD-ROM design and publication, and data and information systems (including GIS).

CHRONOLOGICAL WORK HISTORY:

2/18 - present: Environmental Research Group, LLC, 9200 Rumsey Rd., Columbia, MD 21045.
Environmental Consultant.

On call consulting services as senior expert in environmental assessments of energy facilities, Geographic Information Systems, and Scientific Information Management.

12/88 – 1/18: Versar, Inc., ESM Operations, 9200 Rumsey Rd., Columbia, MD 21045.
Last Title: Principal Environmental Scientist.

Program manager and ecological systems modeler in Versar's Ecological Sciences and Analysis Division. Primary work areas were carbon sequestration by biological systems, electric power

transmission line siting and impacts, and the design, implementation, and operation of scientific information systems.

4/85 - 11/88: Science Applications Research, Lanham, MD.
Scientist.

Task leader at NASA/Goddard Space Flight Center. Performed and directed task members in research, data analysis, and scientific data management in support of remote sensing field experiments.

9/80 - 6/84: Wofford College, Spartanburg, SC. Assistant Professor of Mathematics and Computer Science. (On professional leave, 9/82 - 6/83: State University of New York at Binghamton. Visiting Asst. Prof of Systems Science.)

Taught courses in calculus, statistics, and computer science.

PUBLICATIONS:

Wieland, R.C. and D.E. Strebel. 2008. Valuing Timber and Carbon Sequestration in Maryland Using MD-GORCAM. Published by the Harry R. Hughes Center for Agro-Ecology. Queenstown, MD. HRHCAE Pub. 2008-01-B. Co-published by Maryland Department of Natural Resources as PPRP Technical Report PPRP-145. May, 2008. NTIS No. PB2009-111513.

Strebel, D.E., C,W. DeLisle, and J. Sherwell. 2007. Biological Strategies for Sustainable Energy Use. Proceedings of the Renewable Energy Symposium and Expo held at Frostburg State University, Frostburg, MD, September, 2007.

Wieland, R.C. and D. E. Strebel. 2007. Valuing Timber and Carbon Sequestration in Maryland Using MD-GORCAM. Joint Versar/Main Street Economics Technical Report prepared for the Maryland Power Plant Research Program and the Maryland Center for Agro-Ecology.

DeLisle, C. and D.E. Strebel. 2007. Carbon Management Options Guide: Biological Strategies for Maryland Power Producers and Consumers. Versar Technical Report prepared for the Maryland Power Plant Research Program.

Strebel, D.E., J.R. Dew, A. Brindley, and D. van Elburg-Obler. 2006. Enhancements to the MDE Shellfish Program Data System. Versar Technical Report prepared for the Maryland Department of the Environment.

Strebel, D.E. and D. van Elburg-Obler. 2004. Carbon Sequestration Potential of Maryland Wetlands. Versar Technical Report prepared for the Maryland Power Plant Research Program.

Vρlstad, J. H., N. E. Roth, G. Mercurio, M. T. Southerland, and D. E. Strebel. 2003. Using Environmental Stressor Information to Predict the Ecological Status of Maryland Non-Tidal Streams as Measured by Biological Indicators. Environmental Monitoring and Assessment, vol. 84, pp. 219-242.

Strebel, D.E., J. Kou, and D. van Elburg-Obler. 2002. Mitigating Cumulative Effects of Power Plants by Carbon Sequestration. Maryland Department of Natural Resources, PPRP Technical Report PPAD-02-1. July 2002.

Schreiner, S. P., T. A. Krebs, D. E. Strebel, and A. Brindley. 2002. Testing the CORMIX Model Using Thermal Plume Data from Four Maryland Power Plants. Environmental Modeling & Software, vol. 17, pp. 321-331.

van Elburg-Obler, D.M., D.E. Strebel, and A. Brindley. 2001. Smart Growth and Transmission Lines in Maryland. Versar Technical Report prepared for the Maryland Power Plant Research Program.

Strebel, D.E. and A. Brindley. 2000. Barnegat Bay GIS Data Set Report. Versar Technical Report prepared for U. S. Army Corps of Engineers.

Strebel, D.E., A. Brindley, and D. van Elburg-Obler. 2000. Barnegat Bay GIS Data Sets. CD-ROM archive of GIS data prepared for the U. S. Army Corps of Engineers.

Roth, N., D. Strebel, J. Kou, and T. Krebs. 2000. An Assessment of Land Cover Data Used in the Mid-Atlantic Landscape Atlas. Versar Technical Report prepared for the U. S. EPA.

Roth, N., D. Strebel, G. Mercurio, and A. Brindley. 1999. An Assessment of Selected Landscape Indicators Used in the Mid-Atlantic Atlas. Versar Technical Report prepared for the U. S. EPA.

Southerland, M., S. Harriott, and D. Strebel. 1999. Barnegat Bay GIS Study: Watershed Analysis and Restoration Site Selection Approach. Versar Technical Report prepared for the U. S. Army Corps of Engineers.

Schreiner, S.P., T.A. Krebs, D.E. Strebel, A. Brindley, and C.G. McCall. 1999. Validation of the CORMIX Model using Thermal Plume Data from four Maryland Power Plants. Maryland Department of Natural Resources, PPRP Technical Report PPRP-114.

Strebel, D.E., D.R. Landis, K.F. Huemmrich, J.A. Newcomer, B.W. Meeson. 1998. The FIFE Data Publication Experiment. Journal of the Atmospheric Sciences, vol. 55, pp. 1277-1283.

Meeson, B.W. and D.E. Strebel. 1998. The Publication Analogy: A Conceptual Framework for Scientific Information Systems. Remote Sensing Reviews, vol. 16, pp. 255-292.

Sellers, P.J., M.D. Heiser, F.G. Hall, S.J. Goetz, D.E. Strebel, S.B. Verma, R.L. Desjardins, P.M. Schuepp, and J.I. MacPherson. 1995. Effects of Spatial Variability in Topography, Vegetation Cover, and Soil Moisture on Area-Averaged Surface Fluxes: A Case Study using the FIFE 1989 data. J. Geophys. Research, Vol. 100, No. 012, pp. 25,607- 25,629.

Frithsen, J.B., S.P. Schreiner, D.E. Strebel, R.M. Laljani, D.T. Logan, and H.W. Zarbock. 1995. Chemical Contaminants in the Tampa Bay Estuary: A Summary of Distributions and Inputs. Tampa Bay National Estuary Program, Technical Publication #01-95. June 1995.

Strebel, D.E. and J.B. Frithsen. 1995. Scientific Documentation for EMAP Data: Guidelines for the Information Management Catalog. Versar Technical Report prepared for the U.S. EPA, Office of Research and Development.

Strebel, D.E. and J.B. Frithsen. 1995. Guidelines for Distributing EMAP Data and Information via the Internet. Versar Technical Report to U.S. EPA, Office of Research and Development.

Justice, C.O., G.B. Bailey, M.E. Maiden, S.I. Rasool, D.E. Strebel, and J.D. Tarpley. 1995. Recent Data and Information System Initiatives for Remotely Sensed Measurements of the Land Surface. *Remote Sensing Environ.*, Vol. 51, pp. 235-244.

Strebel, D.E., B.W. Meeson, and A.K. Nelson. 1994. Scientific Information Systems: A Conceptual Framework. Cpt. 5 in Environmental Information and Management and Analysis: ecosystem to Global Scales, W.K. Michener, J.W. Brunt, and S.G. Stafford, eds., Taylor & Francis, Ltd., London.

Strebel, D.E., Guest Editor. 1994. Selected Topics in Scientific Information Systems: Part I. *Remote Sensing Reviews*, Vol. 9, pp. 221-298.

Strebel, D.E., D.R. Landis, K.F. Huemmrich, and B.W. Meeson. 1994. Collected Data of the First ISLSCP Field Experiment. Vol. 1: Surface Observations and Non-Image Data Sets. Published on CD-ROM by NASA.

Meeson, B.W., D.E. Strebel, E.D. Paylor. 1993. Earth Science Information Systems: A Perspective from the Pilot Land Data System. *In*: Earth and Space Science Information Systems, A. Zygielbau, editor. AIP Conference Proceedings 283, AIP Press, New York. pp. 216-226.

Strebel, D.E., J.A. Newcomer, D.R. Landis, J.E. Nickeson, S.J. Goetz, B.W. Meeson, P.A. Agbu, J.M.P. McManus. 1993. Collected Data of the First ISLSCP Field Experiment, Vol. 5: Images Derived from Satellite, Aircraft, and Geographic Data. Published on CD-ROM by NASA.

Meeson, B.W., D.E. Strebel, D.R. Landis. 1993. Producing a CD-ROM: A Workbook. Technical Manual published by the NASA/Goddard Distributed Active Archive Center.

Newcomer, J.A. and D.E. Strebel. 1993. Lossless Compression of Image Data Products on the FIFE CD-ROM Series. *In*: Space and Earth Science Data Compression Workshop, J.C. Tilton, editor. NASA Conference Publication 3183. pp. 95-107.

Landis, D.R., D.E. Strebel, J.A. Newcomer, B.W. Meeson. CD-ROM Storage of Interdisciplinary Science Data. 1993. Proc. 9th Int. Conf. on Interactive Info. and Processing Sys. for Meteorology, Oceanography, & Hydrology, Am. Meteor. Soc. pp. 248-253.

Sellers, P.J., F.G. Hall, G. Asrar, D.E. Strebel, R.E. Murphy. 1992. An Overview of the First International Satellite Land Surface Climatology Project Field Experiment (FIFE). J. Geophys. Res., Vol. 97, No. D17, pp. 18345-18371.

Strebel, D.E., D.R. Landis, J.A. Newcomer, D. van Elburg-Obler, B.W. Meeson, and P.A. Agbu. 1992. Collected Data of the First ISLSCP Field Experiment. Vol. 2: Satellite Imagery 1987-1989. Published on CD-ROM by NASA.

Strebel, D.E., D.R. Landis, J.A. Newcomer, J.M.P. McManus, B.W. Meeson, and P.A. Agbu. 1992. Collected Data of the First ISLSCP Field Experiment. Vol. 4: ASAS & PBMR Imagery 1987 and 1989. Published on CD-ROM by NASA.

Strebel, D.E., D.R. Landis, J.A. Newcomer, S.J. Goetz, J.M.P. McManus, B.W. Meeson, and P.A. Agbu. 1992. Collected Data for the First ISLSCP Field Experiment. Vol. 3: NS001 Imagery 1987 and 1989. Published on CD-ROM by NASA.

Hall, F.G., K.F. Huemmrich, D.E. Strebel, S.J. Goetz, J.E. Nickeson, and K.D. Woods. 1992. Biophysical, Morphological, Canopy Optical Property, and Productivity Data from the Superior National Forest. NASA Technical Memorandum 104568, NASA Goddard Space Flight Center, July 1992.

Landis, D.R., D.E. Strebel, J.A. Newcomer, and B.W. Meeson. 1992. Archiving the FIFE Data on CD-ROM. Proc. IGARRS'92, Houston, May 1992. pp. 65-67.

Strebel, D.E., D.R. Landis, J.A. Newcomer, J. DeCampo, and B.W. Meeson. 1991. Collected Data of the First ISLSCP Field Experiment, Prototype volume. Published on CD-ROM by NASA, May, 1991.

Strebel, D.E. and J.B. Frithsen. 1991. Handling Supporting Information for EMAP External Data Sets. Draft EPA Technical Report, EPA/600/XXX/XXX, U.S. EPA, Environmental Monitoring Systems Laboratory, Las Vegas, December, 1991.

Hall, F.G., D.E. Strebel, J.E. Nickeson, S.J. Goetz. 1991. Radiometric Rectification: Toward a Common Radiometric Response Among Multidate, Multisensor Images. Remote Sensing of Environment, Vol. 35, pp. 11-27.

Hall, F.G., D.B. Botkin, D.E. Strebel, K.D. Woods, S.J. Goetz. Ecology, Vol. 72, No. 2, pp. 628-640, April 1991. Large-Scale Patterns of Forest Succession as Determined by Remote Sensing.

Murphy, R.E., P.J. Sellers, F.G. Hall, G. Asrar, B.L. Blad, E.T. Kanemasu, R.D. Kelly, B. Markham, D. Strebel, and J.R. Wang. 1991. An Overview of the Results of the FIFE-87 and FIFE-89 Campaigns. Adv. Space Research, Vol. 11, pp. 142-150.

Hall, F.G., P.J. Sellers, D.E. Strebel, E.T. Kanemasu, R.D. Kelly, B.L. Blad, B.J. Markham, J.R. Wang, and K.F. Huemmrich. 1991. Satellite Remote Sensing of Surface Energy and Mass Balance: Results from FIFE. Remote Sensing of Environment, Vol. 35, pp. 187-199.

Strebel, D.E., P.J. Sellers, and F.G. Hall. 1991. The FIFE Data. Cpt. 26 in *Land Surface Evaporation* T.J. Schmugge and J-C Andre, eds., Springer-Verlag, New York.

Strebel, D.E., J.A. Newcomer, J.P. Ormsby, F.G. Hall, P.J. Sellers. IEEE Trans. Geosci. and Remote Sensing, Vol. 28, No. 4, pp. 703-710, July, 1990. The FIFE Information System.

Hall, F.G., D.E. Strebel, S.J. Goetz, and J.E. Nickeson. Proc. IGARSS'90, pp. 165-168, May, 1990. Radiometric Rectification of Multi-Date, Multi-Sensor Satellite Images.

Strebel, D.E., S.G. Ungar, J.P. Ormsby, J.A. Newcomer, D. Landis, S.J. Goetz, K.F. Huemmrich, D. van Elburg-Obler, P.J. Sellers, and F.G. Hall. Symp. First ISLSCP Field Experiment, AMS preprint vol., pp. 140-147, February, 1990. The FIFE Information System: Support of Interdisciplinary Science.

Hall, F.G., P.J. Sellers, D.E. Strebel, E.T. Kanemasu, R.D. Kelly, B.L. Blad, B.J. Markham, J.R. Wang, and F. Huemmrich. Symp. First ISLSCP Field Experiment, AMS preprint vol., pp. 17-24, February, 1990. FIFE: Results Overview.

Sellers, P.J., F.G. Hall, D.E. Strebel, E.T. Kanemasu, R.D. Kelly, B.L. Blad, B.J. Markham, and J.R. Wang. Symp. First ISLSCP Field Experiment, AMS preprint vol., pp. 1-5, February, 1990. Experiment Design and Operations.

Sellers, P.J., M. Heiser, C.W. Walthall, F. Huemmrich, D.E. Strebel, and F.G. Hall. Symp. First ISLSCP Field Experiment, AMS preprint vol., pp. 117-120, February, 1990. A Comparison of Surface Biophysical Properties and Remotely Sensed Variables from FIFE.

Sellers, P.J., F.G. Hall, D.E. Strebel, G. Asrar, and R.E. Murphy. Cpt. 9 in *Remote Sensing of Biosphere Functioning*, R.J. Hobbs and H.A. Mooney, eds., Springer-Verlag, New York, 1990. Satellite Remote Sensing and Field Experiments.

Strebel, D.E., J.A. Newcomer, J.P. Ormsby, F.G. Hall, P.J. Sellers. Proc. IGARSS '89, vol. 1, pp. 42-45, July, 1989. Data Management in the FIFE Information System.

Newcomer, J.A., S.J. Goetz, D.E. Strebel, and F.G. Hall. Proc. IGARSS '89, vol. 3., pp. 1779-1782, July, 1989. Image Processing Software for Providing Radiometric Inputs to Land Surface Climatology Models.

Sellers, P.J., J.L. Dorman, C. Walthall, F.G. Hall, D.E. Strebel, B.L. Markham, J.R. Wang, R.D. Kelly, S.B. Verma, B.L. Blad, D.S. Schimel, R. Grossman, W. Brutsaert, R. Desjardins, L. Fritschen, R. Frouin, E. Kanemasu, and I. MacPherson. pp. 49-58 in Remote Sensing and Large-Scale Global Processes, A. Rango, editor, IAHS Publ. No. 186, IAHS Press, Wallingford, May, 1989. First ISLSCP Field Experiment: Experiment Execution and Preliminary Analyses.

Hall, F.G., P.J. Sellers, I. MacPherson, R.D. Kelly, S. Verma, B. Markham, B. Blad, J. Wang, and D.E. Strebel. Adv. Space Res., vol. 9, no. 7, pp. 275-293. (Proc. COSPAR meeting, July 1988). FIFE: Analysis and Results - A Review.

Hall, F.G., D.E. Strebel, and P.J. Sellers. 1988. Linking knowledge among spatial and temporal scales: vegetation, atmosphere, climate, and remote sensing. *Landscape Ecol*. 2:3-22.

Sellers, P.J., F.G. Hall, G. Asrar, D.E. Strebel, and R.E. Murphy. 1988. The First ISLSCP Field Experiment (FIFE). *Bull. Am. Meteorological Soc*. 69:22-27.

Strebel, D.E., S.J. Goetz, and F.G. Hall. 1987. Atmospheric correction of NS-001 data and extraction of multiple angle reflectance data sets. Proc. 21st Int. Symp. Rem. Sens. of Envir., pp. 939-948.

Hall, F.G., D.E. Strebel, S.J. Goetz, K.D. Woods, and D.B. Botkin. 1987. Landscape pattern and successional dynamics in the Boreal Forest. Proc. IGARSS'87 Symposium, pp. 473-483.

Otterman, J., D.E. Strebel, and K.J. Ranson. 1987. Inferring spectral reflectance of plant elements by simple inversion of bidirectional reflectance measurements. *Remote Sensing Environ*. 21:215-228.

Hallada, W.A., J.E. Nickeson, J.A. Newcomer, and D.E. Strebel. 1985. A comparison of MOMS and TM imaging systems. SAR Technical Report.

Strebel, D.E., N.S. Goel, and K.J. Ranson. 1985. Two dimensional leaf orientation distributions. *IEEE Trans. Geosci. & Rem. Sens*., GE-23:640-647.

Strebel, D.E. 1985. Environment fluctuations and extinction -- single species. *Theor. Popul. Biol*. 27:1-26.

Goel, N.S., and D.E. Strebel. 1984. Simple beta distribution representation of leaf orientation in vegetation canopies. *Agro. J*. 26:800-802.

Goel, N.S., D.E. Strebel, and R.L. Thompson. 1984. Inversion of vegetation canopy reflectance models for estimating agronomic variables. II. Use of angle transforms and error analysis as illustrated by Suits' model. *Remote Sensing Environ*. 14:77-111.

Goel, N.S., and D.E. Strebel. 1983. Inversion of vegetation canopy reflectance models for estimating agronomic variables. I. Problem definition and initial results using the Suits' model. *Remote Sensing Environ*. 13:487-507.

Strebel, D.E. 1980. Logistic growth in the presence of nonwhite environmental noise. *J. Theor. Bio*. 85:713-738.

Strebel, D.E. 1980. Population growth and extinction in stochastic environments. Ph.D. Dissertation, Univ. Calif., San Diego.

Strebel, D.E. 1979. Analog computer laboratory with biological examples. *Am. J. Physics* 47:612-618.

Strebel, D.E. 1975. Interspecific competition and a fluctuating environment: A preliminary investigation with applications to sardine and anchovy populations. M.S. Thesis, Univ. Calif., San Diego.

Strebel, D.E., and N.S. Goel. 1973. On the Isocline methods for analyzing prey-predator interactions. *J. Theor. Bio*. 39:211-239.