





2
✓ DOE/OR--01-1255
(ES/ER/TM-115)

**Remote Sensing
and Special Surveys Program
Annual Report
January - December 1993**

**S. R. Conder
A. D. King
W. E. Doll
R. C. Durfee
C. A. Gabrielsen
P. D. Parr**

RECEIVED
APR 07 1994
OSTI

Remote Sensing and Special Surveys Program Annual Report January - December 1993

| | |
|------------------|--------------|
| S. R. Conder | A. D. King |
| W. E. Doll | R. C. Durfee |
| C. A. Gabrielsen | P. D. Parr |

Environmental Restoration Program
P.O. Box 2003
Oak Ridge, Tennessee 37831-7298

Date Issued—March 1994

Prepared by
Health Sciences Research Division
Oak Ridge National Laboratory

Prepared for
U.S. Department of Energy
Office of Environmental Restoration
and Waste Management
under budgeting and reporting code EX 20

MARTIN MARIETTA ENERGY SYSTEMS, INC.
managing the

| | |
|------------------------------------|------------------------------------|
| Oak Ridge K-25 Site | Paducah Gaseous Diffusion Plant |
| Oak Ridge Y-12 Plant | Portsmouth Gaseous Diffusion Plant |
| Oak Ridge National Laboratory | under contract DE-AC05-76OR00001 |
| under contract DE-AC05-84OR21400 ✓ | |

for the
U.S. DEPARTMENT OF ENERGY

DISCLAIMER

This report was prepared as an account of work sponsored by an agency of the United States Government. Neither the United States Government nor any agency thereof, nor any of their employees, makes any warranty, express or implied, or assumes any legal liability or responsibility for the accuracy, completeness, or usefulness of any information, apparatus, product, or process disclosed, or represents that its use would not infringe privately owned rights. Reference herein to any specific commercial product, process, or service by trade name, trademark, manufacturer, or otherwise does not necessarily constitute or imply its endorsement, recommendation, or favoring by the United States Government or any agency thereof. The views and opinions of authors expressed herein do not necessarily state or reflect those of the United States Government or any agency thereof.

MASTER

875

CONTENTS

| | |
|---|-----|
| ACKNOWLEDGEMENTS | v |
| EXECUTIVE SUMMARY | vi |
| FORWARD | vii |
| 1. INTRODUCTION | 1 |
| 2. MAJOR SURVEILLANCE INITIATIVES | 1 |
| 2.1 THE OAK RIDGE RESERVATION AERIAL SURVEY | 1 |
| 2.1.1 Multispectral Imaging, Radiological Mapping, and Aerial Photography . . . | 1 |
| 2.1.2 Airborne Geophysical Surveys | 2 |
| 2.2 OAK RIDGE RESERVATION BASE MAPS | 3 |
| 2.3 PORTSMOUTH GASEOUS DIFFUSION PLANT RADIOLOGICAL SURVEY | 4 |
| 2.4 ENVIRONMENTALLY SENSITIVE AREAS SURVEY | 4 |
| 2.4.1 Threatened and Endangered Plant Species Survey | 4 |
| 2.4.2 Threatened and Endangered Animal Species Survey | 4 |
| 3. SPECIAL PROJECTS | 5 |
| 3.1 LASER INDUCED FLUORESCENCE FIELD TEST | 5 |
| 3.2 ENVIRONMENTAL TASK FORCE | 6 |
| 3.3 MINIATURIZED REMOTE SENSING PLATFORMS | 6 |
| 4. PUBLICATIONS | 7 |
| 4.1 REPORTS | 7 |
| 4.2 PRESENTATIONS | 7 |
| 4.3 CONFERENCE ACTIVITIES | 8 |

ACRONYMS and ABBREVIATIONS

| | |
|----------------|--|
| AEM | Airborne Electromagnetic Methods |
| AGL | Above Ground Level |
| AGU | American Geophysical Union |
| DOE | United States Department of Energy |
| EM | Electromagnetic |
| Energy Systems | Martin Marietta Energy Systems, Inc. |
| ER | Environmental Restoration |
| ERWM | Environmental Restoration and Waste Management |
| ETF | Environmental Task Force |
| GIS | Geographic Information System |
| GPS | Global Positioning System |
| IR | Infrared |
| MSS | Multispectral Scanner |
| NDVI | Normalized-Difference Vegetative Index |
| NOAA | National Oceanic and Atmospheric Administration |
| NTM | National Technical Means |
| OREIS | Oak Ridge Environmental Information System |
| ORNL | Oak Ridge National Laboratory |
| ORR | Oak Ridge Reservation |
| PORTS | Portsmouth Gaseous Diffusion Plant |
| SERDP | Strategic Environmental Research and Development Program |
| SOW | Statement of Work |
| VLF | Very Low Frequency |

ACKNOWLEDGEMENTS

A number of individuals have been instrumental in directing and participating in the developments discussed in this document. Special recognition and appreciation are given to the following key contributors.

D. M. Carden
N. Hendrix-Ward
L. P. Beard
J. E. Nyquist
J. L. Smyre

Author and Contributor Affiliations

S. R. Conder is a subcontractor with the University of Tennessee, Knoxville, Tennessee; A. D. King is a member of the Health Sciences Research Division, Oak Ridge National Laboratory; W. E. Doll, C. A. Gabrielsen, P. D. Parr, and J. E. Nyquist are members of the Environmental Sciences Division, Oak Ridge National Laboratory; R. C. Durfee and J. L. Smyre are members of the Computing Applications Division, Oak Ridge National Laboratory; D. M. Carden and N. Hendrix-Ward are members of the Department of Energy, Oak Ridge Operations; L. P. Beard is a post-doctoral student with the Environmental Sciences Division, Oak Ridge National Laboratory.

EXECUTIVE SUMMARY

The Remote Sensing and Special Surveys Program has been established to provide environmental site characterization data, change data, and trend data to various Environmental Restoration and Waste Management (ERWM) programs. The data are acquired through several different types of survey platforms. During the calendar year of 1993, a variety of surveys were conducted through the Remote Sensing and Special Surveys Program. The aerial surveys included geophysical, radiological, false color infrared (IR) photography, and natural color photography. Ground surveys were conducted to correlate data collected from the airborne platforms to data measured at ground level. Ground surveys were also conducted to determine the existence or absence of threatened and endangered plant species on the Oak Ridge Reservation. Some of the special surveys included laser induced fluorescence imaging, solar reflectance, and various remote sensing and ground control activities for the Strategic Environmental Research and Development Program (SERDP) initiative. Data analysis, management, and storage are also conducted by the Remote Sensing and Special Surveys Program to achieve the highest level of data useability possible. The data acquired through these surveys have provided and will continue to provide much needed information to ERWM programs.

FORWARD

This report does not attempt to explain program activities in detail. For further program information, contact David Carden, US Department of Energy Remote Sensing Program Manager at (615) 576-9262 or contact Amy King, Martin Marietta Energy Systems Remote Sensing and Special Surveys Program Manager at (615) 576-1509.

1. INTRODUCTION

The Environmental Restoration (ER) Remote Sensing and Special Surveys Program has been established to provide environmental site characterization data, change data, and trend data to Environmental Restoration and Waste Management (ERWM) programs at all of the five United States Department of Energy (DOE) facilities operated and managed by Martin Marietta Energy Systems, Inc. (Energy Systems). The Remote Sensing and Special Surveys Program can provide a great resource to these facilities through various survey activities. The data acquired from the surveys can be used to obtain screening level information for locating potential contamination sources; aid in site characterization efforts; establish baselines for comparison with future conditions; provide a data base of information for detailed analysis, comparisons, and integration with field measurements and map data; assist in remedial investigation planning; and aid in long-term monitoring of environmental improvements from restoration activities.

During the calendar year 1993, the Remote Sensing and Special Surveys Program conducted many exciting, innovative projects. Major surveillance initiatives and special projects are described below, along with listings of reports, presentations, and conference activities.

2. MAJOR SURVEILLANCE INITIATIVES

2.1 THE OAK RIDGE RESERVATION AERIAL SURVEY

2.1.1 Multispectral Imaging, Radiological Mapping, and Aerial Photography

This portion of the Oak Ridge Reservation (ORR) Aerial Survey included a high-resolution gamma radiation survey of approximately 80% of the ORR, and photography and multispectral scanner (MSS) missions of the entire ORR and several adjacent off-site areas. The radiological survey was conducted at 150 ft above ground level (AGL) providing the greatest spatial resolution and data sensitivity to date for this area. Multispectral scanner imagery (daytime and predawn), false color infrared (IR) photography, and natural color photography were obtained at various altitudes ranging from 3000 ft to 43,000 ft AGL. These surveys were conducted during 1992, however, much of the data analysis and manipulation was performed during 1993.

A final report on the radiological surveys of the ORR has been prepared by the DOE subcontractor. Digital gamma radiation contour data were received, converted, and loaded into workstations for further mapping and comparison with other imagery. A series of site specific and reservation-wide maps have been made of all the gamma data received so far. For selected areas, the gamma contours have been superimposed on scanned aerial photos in both 2-D and 3-D with the terrain surface underneath. These results have been studied to gain further understanding of possible sources, distributions, and relationships to surrounding terrain features.

Portions of the natural color and color infrared photography have been scanned and processed using special imaging systems at the Oak Ridge National Laboratory (ORNL). Rectified orthophotos and mosaics have been produced for each of the ORR facilities (ORNL, Y-12, and K-25) and the whole reservation by using digital elevation models and known ground control

points to geometrically correct the imagery. Some of the ground control has been acquired using accurate global positioning system (GPS) technology.

Radiometric techniques have been used to enhance and improve the color images to aid in map updates, terrain interpretation, and integration with other data. Multiple orthophotos have been mosaiced together to create composite images that can serve as a base on which to overlay all other types of geographic data for detailed interpretations. These images have been loaded into the Oak Ridge Environmental Information System (OREIS) for widespread use. A large variety of color hardcopy products have been produced to aid in a number of studies. The rectified photos have also been used as a base for real-time GPS data acquisition and mapping from vehicles traveling on the ORR. Some updates of map information is being made from low-altitude aerial photos.

Statistical imaging algorithms have been used to analyze the MSS imagery and compute land use and land cover patterns for portions of the ORR (e.g., ORNL). A color atlas of MSS images is being completed for the whole reservation. Work has been done to test rectification techniques on the MSS data which are much more difficult to correct than stereo photographs. A series of MSS image transforms have been applied to selected areas to study land cover patterns and vegetative growth and to create vegetation indices and simulated color IR. One such transform is the Normalized-Difference Vegetative Index (NDVI).

The pre-dawn thermal imagery has been transformed and analyzed for seeps and springs at ORNL, K-25, and Parcel A. Portions of the thermal data were rectified and digitally integrated with scanned color photos, map data, and seep field surveys to correlate the results. Thermal contour maps were also produced. Suspect seeps and springs were delineated and displayed on the computer with color hardcopy maps produced. Preliminary overlay of the seep field surveys and the thermal data show good correlations.

Sample videos from helicopter electromagnetic (EM) flyovers have been loaded onto laser video disks and integrated with digital workstations for selected browsing under locational control of a Geographic Information System (GIS). This has been done in both video and real-time digitized forms.

2.1.2 Airborne Geophysical Surveys

This portion of the Oak Ridge Reservation (ORR) Aerial Survey began in November of 1992. Testing and reconnaissance surveillance were completed in January 1993, with the high resolution survey scheduled for early 1994. The technologies that were used for this survey were originally designed for mineral prospecting, but were modified for environmental restoration purposes. The survey consisted of the simultaneous acquisition of magnetic, electromagnetic (EM), and gamma radiation data from a single helicopter platform. Both man-made (drums, trench boundaries, burn pits, well heads) and geologic (fractures, faults, karst features, geologic contacts) features were the targets for this survey.

Three stages of data acquisition constituted the elements of the airborne geophysical surveys. The three stages were testing, reconnaissance, and high-resolution data acquisition. The test stage data were acquired with two integrated electromagnetic/magnetic/radiometric systems. System A (Big Bird) was a conventional system, designed for surveying at altitudes of 100 ft AGL and

higher. System B (Little Bird) was designed specifically for ORR purposes, though it has subsequently been used for mining investigations over rugged high-elevation terrains. When compared to the Big Bird system, the Little Bird system is much lighter and more maneuverable, which allows for data to be collected at altitudes as low as 15 ft AGL. Test data were acquired at 5 reservation sites that were selected for their various known features. This allowed the sensitivity of the two systems to be determined for representative targets. Reconnaissance data were collected with the Big Bird system over the entire ORR using a flight line spacing of 150 ft and at an altitude of 100 ft AGL. This stage of the survey was designed for detection of large (metallic and non-metallic) man-made targets and for characterization of those geologic features that influence contaminant migration (e.g., faults and fractures). These data also provide baseline and regional information for subsequent localized studies. High resolution data acquisition using the Little Bird system is scheduled to begin in early 1994.

Examples of Preliminary Findings from the airborne geophysical surveys:

- ▶ Geologic features are very clearly imaged on three of the map sets acquired during the airborne geophysical surveys. The map sets are apparent resistivity maps derived from the EM data, very low frequency (VLF)-EM maps, and Potassium isotope maps derived from the gamma radiation data. These have been used to select sites for more intense geologic mapping and to identify anomalous features on the ORR that may be karst-related.
- ▶ Waste sites and other large cultural features appear as large anomalies on magnetic maps while geologic signatures are more subtle on these maps. Ground followup of some of these anomalies has been conducted, but no large unexplained anomalies have been identified to date.
- ▶ Test data indicate that these systems can reliably map the boundaries of many waste areas and can detect metallic targets composed of as few as 4 to 8 55-gallon drums.
- ▶ Comparisons between surface and airborne data are favorable, showing the expected loss in resolution with instrument height.
- ▶ Rapid anomaly identification can be accomplished by merging ortho-rectified aerial photographic images with geophysical data and by inspecting in-flight videotapes of the surface that were taken from the helicopter during the survey. These videotapes help to distinguish real anomalies from transient cultural objects (e.g. automobiles).
- ▶ Contemporaneous acquisition of multiple data sets is not only cost effective, but presents unique opportunities for data fusion that can be used to distinguish between different types of targets.

2.2 OAK RIDGE RESERVATION BASE MAPS

The Photogrammetry Branch of the National Oceanic and Atmospheric Administration (NOAA) conducted a photographic survey of the ORR and vicinity. The survey consisted of the acquisition of new aerial photographs (color and color infrared) adequate for future creation of digital ortho-rectified imagery, hardcopy orthophotographs, base map information and

environmental data at the scale of 1:2,400. These data were also acquired to assist the Environmental Restoration Program (ER) on the ORR and off-site areas. The survey was split into two phases. The first phase consisted of a survey of the entire reservation flown at an altitude of 6,000 feet AGL. Since higher resolution is required for the floodplain areas, a second phase, which consists of surveying floodplain areas at a lower altitude of 3,000 feet AGL, was scheduled. The second phase is scheduled for early 1994.

The first phase data acquisition was performed by a unique type of NOAA aircraft which incorporates real-time airborne global positioning system (GPS) technology. A GPS device on board the aircraft was interfaced in real-time to a GPS base station installed by NOAA at the McGhee Tyson airport. This GPS system aided in very accurate positioning of the aircraft during flight, in controlling the operation and timing of the camera exposures, and in collecting very precise geometric information on camera position, photogrammetric parameters, and ground control. Through use of GPS processing techniques, only a minimal number of preset ground control points were required for follow-on geometric rectification of the photography. This new process reduced the follow-on aero-triangulation and rectification processing.

2.3 PORTSMOUTH GASEOUS DIFFUSION PLANT RADIOLOGICAL SURVEY

A high resolution radiological (gamma) survey was conducted of the Portsmouth Gaseous Diffusion Plant (PORTS) by EG&G, Washington, D. C. Operations Office. The survey began on August 9, 1993 and was completed on August 17, 1993 following an informative outbriefing. The briefing included viewing the preliminary results, which suggest that no new radiological (gamma) concerns have arisen since the last radiological (gamma) survey conducted by EG&G in 1990. Final survey reports are expected from EG&G during early summer 1994.

2.4 ENVIRONMENTALLY SENSITIVE AREAS SURVEY

2.4.1 Threatened and Endangered Plant Species Survey

Surveys of threatened and endangered plant species are being conducted to insure compliance with the Endangered Species Act of 1973, as amended. The workplan for the threatened and endangered plant species task was approved by DOE and field surveys were initiated in the spring 1993. Rare plant information that was available for the Oak Ridge Reservation through 1992 has been compiled and published. Field surveys of the ER operable units were completed by the end of September 1993. Additional surveys were conducted in areas impacted by the southern pine beetle infestation prior to the initiation of forest cutting activities. Reports for each site surveyed have been prepared.

Ultimately, this project will provide needed information for enabling informed decisions regarding land use. These decisions, if made without this data, could result in the inadvertent extirpation of a threatened or endangered plant species. This project will provide necessary documentation for compliance with Federal and State regulations regarding threatened and endangered plantlife found on or around the ORR.

2.4.2 Threatened and Endangered Animal Species Survey

Assessment of threatened and endangered species is mandated by the Federal Endangered Species Act. To maintain compliance with this regulation, a workplan was developed and approved. The workplan for this project was completed in December 1993. Incorporated within the plan are milestones that track the progress of this project.

Lists of those threatened and endangered animals which do reside, could reside, forage/hunt or migrate through the ORR were also completed in December 1993. This information has been compiled from historical records, some of which are more than 10 years old. Field surveys will be initiated in the Spring of 1994 to confirm the presence or absence of the threatened and endangered animals identified on the lists. Resources are being identified and contracted to perform field surveys. Attendance at several classes/conferences are scheduled to insure that current methodologies are being used. These classes/conferences include: A Colloquium on the Conservation of Mammals, US Fish and Wildlife Services' Habitat Evaluation Procedures, Introduction to Arc Info, and US Fish and Wildlife Services' Habitat Suitability Indices.

Ultimately, this project will provide needed information for enabling informed decisions regarding land use. These decisions, if made without this data, could result in the inadvertent extirpation of a threatened or endangered animal species. This project will provide necessary documentation for compliance with Federal and State regulations regarding threatened and endangered wildlife found on or around the ORR.

3. SPECIAL PROJECTS

3.1 LASER INDUCED FLUORESCENCE FIELD TEST

As part of an EM-50 Office of Technology Demonstration project, EG&G Santa Barbara Operations Office visited the ORR on June 9-21, 1993 to test a newly developed laser-based remote fluorescence imaging system. The system was developed for monitoring surface uranium contamination and for identifying vegetative stress. During the visit, EG&G personnel chose several sites within the ORR to perform the field tests of their imaging system. Sites of interest at K-25 (formerly the Oak Ridge Gaseous Diffusion Plant) included the K-25 and K-27 buildings, and sites chosen at the Oak Ridge National Laboratory (ORNL) included the Global Change Research Facility (0800 Area) and the Walnut Grove Pine Tree Plantation. The K-25 sites were of interest in detecting surface uranium contamination, while the ORNL sites were chosen to identify vegetative stress.

The field tests conducted at K-25 were successful in identifying surface uranium contamination. In response to the successes experienced at the K-25 sites, development of a portable laser-induced fluorescence system is under discussion. This technology will inevitably aid in the characterization and remediation of surficial uranium contamination areas. While the studies conducted at ORNL afforded a laboratory-like atmosphere, further analyses of data from both ORNL sites need to be completed before results of those studies are interpretable. EG&G personnel continue to work with ORNL scientists to complete these analyses.

3.2 ENVIRONMENTAL TASK FORCE

A proposal was submitted to Vice President Al Gore's Environmental Task Force (ETF) for conducting analysis of National Technical Means (NTM) at the ORR. The proposal contained general information about the ORR facilities and the Environmental Restoration Program (ER). The proposal also contained detailed information about several ORR sites which were chosen as potential test sites for determining the relevance of using classified imagery for environmental restoration purposes.

As a result of the proposal, a statement of work (SOW) and ground truth acquisition plan were prepared for the initial data collection phase of the Strategic Environmental Research and Development Program (SERDP) initiative. Similar to the ETF, SERDP is interested in determining the relevance of using National Technical Means (NTM) remotely sensed data for environmental waste site characterization, monitorization, and remediation activities.

The SERDP Waste Site Study ground truth collection plan contained many data collection requirements. These requirements were designed to provide needed information for the image analysts who interpret the NTM data. Low altitude aerial photography, soil moisture readings, ground based photography and video of the chosen investigation areas, as well as meteorological data from the X-10, east and west Y-12, and K-25 towers have all been collected during periodic intervals throughout the later part of the year. Results of this study are expected to be determined within the first part of 1994.

3.3 MINIATURIZED REMOTE SENSING PLATFORMS

During 1993, EM-50 funded a new project that involves the investigation of the potential uses of radio-controlled aircraft for environmental site characterization. The first part of this project involves literature searches that includes communication with individuals at government agencies (national laboratories, military, the Remote Sensing Laboratory, NASA), universities (aeronautics and robotics programs), and private industries (radio controlled plane and helicopter manufacturers, global positioning system vendors, geophysical equipment vendors). A report that concisely summarizes the ongoing research and development in this area is currently being drafted and is expected to have a final release date in mid 1994.

The second part of this project involves the development of a radio-controlled aircraft designed for aerial photography and geophysical surveying. The aircraft has already demonstrated its photographic capabilities through the low altitude aerial photograph acquisition portion of the SERDP Waste Site Study.

4. PUBLICATIONS

4.1 REPORTS

Several reports were completed during 1993:

Doll, W.E., J.E. Nyquist, A.D. King, D.T. Bell, J.S. Holladay, V.F. Labson and L. Pellerin. 1993. *Aerial Remote Sensing Surveys Progress Report: Helicopter Geophysical Survey of the Oak Ridge Reservation*. EW/ER/TM-62. Martin Marietta Energy Systems, Inc., ORNL, Oak Ridge, Tennessee.

Durfee, R.C., R.A. McCord, J.E. Dobson, J.L. Smyre, P.R. Coleman, D.T. Bell, A.D. King, W.E. Doll, and J.E. Nyquist. 1993. *The Application of GIS and Remote Sensing Techniques for Site Characterization and Environmental Assessment*. Martin Marietta Energy Systems, Inc., ORNL, Oak Ridge, Tennessee.

King, A.D., W.E. Doll, R.C. Durfee, R.J. Luxmoore, S.R. Conder, and J.E. Nyquist. 1993. *Strategic Plan for the Utilization of Remote Sensing Technologies in the Oak Ridge Environmental Restoration Program*. ES/ER/TM-97. Martin Marietta Energy Systems, Inc., ORNL, Oak Ridge, Tennessee.

King, A.D., R.C. Durfee, D.T. Bell, S.R. Conder, and B.W. Moll. 1993. *A Proposal to Vice President Gore's Environmental Task Force, Use of Department of Energy Waste Sites from the Oak Ridge Reservation to Assess the Application of National Technical Means for Environmental Restoration*. Martin Marietta Energy Systems, Inc., ORNL, Oak Ridge, Tennessee.

Pounds, L.R., P.D. Parr, and M.G. Ryon. 1993. *Resource Management Plan for the Oak Ridge Reservation, Volume 30: Oak Ridge National Environmental Research Park Natural Areas and Reference Areas- Oak Ridge Reservation Environmentally Sensitive Sites containing Special Plants, Animals, and Communities*. ORNL/NERP-8. Martin Marietta Energy Systems, Inc., ORNL, Oak Ridge, Tennessee.

4.2 PRESENTATIONS

Several presentations were made during 1993:

Beard, L.P., J.E. Nyquist, and W.E. Doll. "Interpretation of AEM [Airborne Electromagnetic Methods] data at Oak Ridge Reservation."

- ▶ Presented by L.P. Beard at the 1993 American Geophysical Union (AGU) Fall Meeting, San Francisco, CA; December 9, 1993.
- ▶ Published in Eos, Trans. AGU, vol. 74, no. 43, p. 222.

Doll, W.E., J.E. Nyquist, and T.J. Gamey. "Noise Characterization in Airborne

Environmental Magnetic Surveys."

- ▶ Presented by Dr. W.E. Doll at the 1993 American Geophysical Union Fall Meeting, San Francisco, CA; December 9, 1993.
- ▶ Published in Eos, Trans. AGU, vol 74, no. 43, p. 220.

Doll, W.E., J.E. Nyquist, J.S. Holladay, V.F. Labson, and L. Pellerin. "Preliminary results of a helicopter-borne electromagnetic and magnetic survey of the Oak Ridge Reservation, Tennessee for environmental and geologic site characterization."

- ▶ Published in the Proceedings of the 1993 Symposium on the Application of Geophysics to Engineering and Environmental Problems, p. 281-295, 1993.

Environmental Quality Assessment Board.

- ▶ Dr. W.E. Doll presented the preliminary results of the airborne geophysical surveys of the ORR at the October 1993 Meeting.
- ▶ David M. Carden, DOE, presented the results of the 1992 Aerial Radiological Survey of the ORR at the November 1993 Meeting.

Lemiszki, P.J., J.E. Nyquist, and W.E. Doll. "Environmental Restoration Activities at the Oak Ridge Gaseous Diffusion Plant, East Tennessee: Surface Geologic and Airborne Geophysical Mapping."

- ▶ Presented by Dr. J.E. Nyquist as a poster presentation at the 1993 Geological Society of America Annual Meeting, Boston, Mass.; October 25-29, 1993.

Nyquist, J.E. and W.E. Doll. "Comparison of Surface and Aerial Geophysics for Characterizing a Hazardous Waste Site: A Case Study."

- ▶ Presented by Dr. J.E. Nyquist at the Society of Exploration Geophysicists 63rd Annual Meeting, Washington, D.C.; September 26-30, 1993.

Nyquist, J.E., W.E. Doll, J.S. Holladay, L. Pellerin, and V.F. Labson. "Environmental Characterization of the Oak Ridge Reservation Using Helicopter Geophysics."

- ▶ Presented by Dr. J.E. Nyquist at the International Workshop on Airborne Electromagnetic Methods, Tucson, Arizona; September 13-16, 1993.

4.3 CONFERENCE ACTIVITIES

Dr. W. E. Doll and Dr. J. E. Nyquist were invited to chair sessions at conferences in 1993:

Dr. W.E. Doll organized and chaired a workshop entitled "The Advancement of Environmental Geophysics" at the Society of Exploration Geophysicists 63rd Annual Meeting,

Washington, D.C.; September 26-30, 1993.

Dr. J.E. Nyquist chaired a session entitled "Case Histories" at the International Workshop on Airborne Electromagnetic Methods held in Tucson, Arizona; September 13-16, 1993.

DATE

FILMED

5/4/94

END

