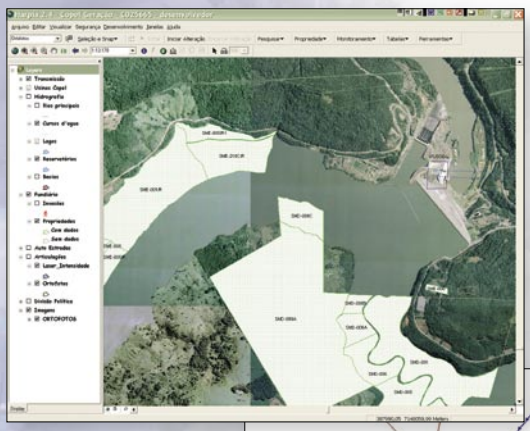
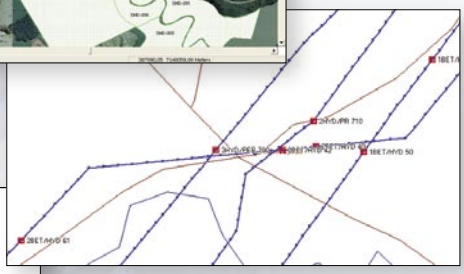
GIS Solutions for Power Generation and Transmission Services

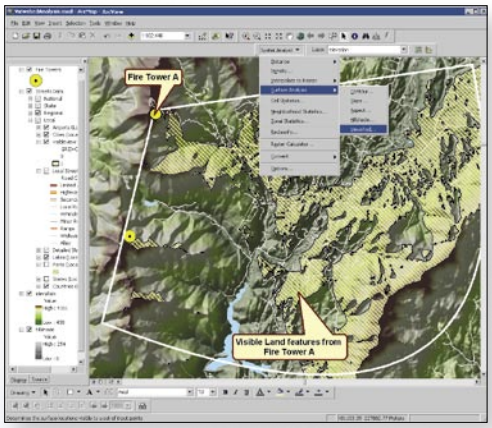
Asset Management
Engineering
Environmental Studies
Grid Analysis
Land Management
Logistics
Market Assessment
Regulatory Compliance
Right-of-Way Management
Site Selection
Vegetation Management





ESRI

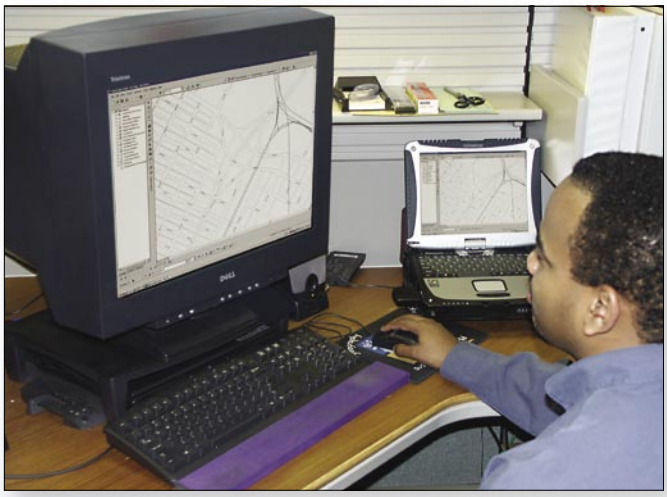
GIS Solutions for Power Generation and Transmission Services



Balancing the need to develop new markets, improve system reliability, and reduce operation costs is the greatest challenge for today's utility decision makers—a challenge that is successfully met with ESRI's geographic information system (GIS) software. GIS provides solutions across the entire enterprise for applications in business, engineering, environmental management, and other disciplines necessary for comprehensive and effective power generation and transmission management.

GIS is used for planning and monitoring power generation resources. Sophisticated spatial analysis is useful for determining optimum generation potential, formulating what-if scenarios, studying environmental impact, and managing facility assets. GIS is used to spatially analyze network congestion, consider growth opportunities for renewable energy sources, determine site feasibility, and create energy resource market scenarios.

Power companies can intelligently plan, build, monitor, and manage their transmission networks using ESRI® technology. The ArcGIS® geodatabase is a key component for maintaining and managing accurate transmission asset data such as substations, lines, and associated structures. Use GIS to assess grid reliability levels and formulate plans for improving reliability, meet compliance requirements, site and manage transmission corridors, inventory and schedule right-of-way maintenance, and analyze load growth or changes in load shape or strain on substation capacities.

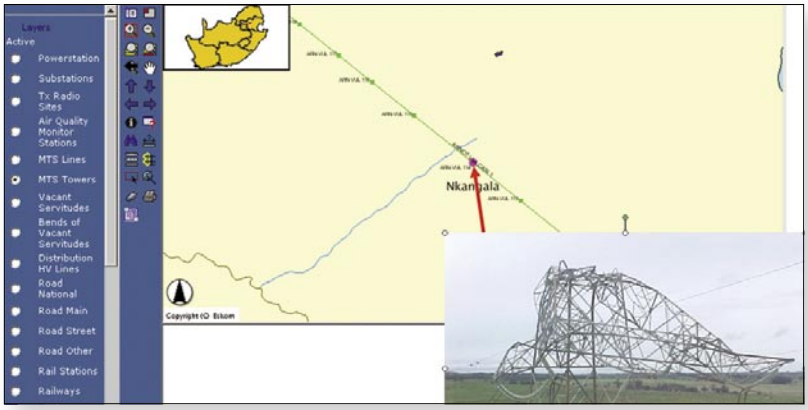


An enterprise ArcGIS implementation for utility companies provides spatial query and geographic visualization to virtually every employee. Interoperability built into ESRI's GIS software enables the utility company's core business systems to work in harmony with GIS, providing corporate-wide, integrated solutions. This brochure offers real-world case studies that demonstrate how ESRI's GIS software is being used for generation and transmission purposes.

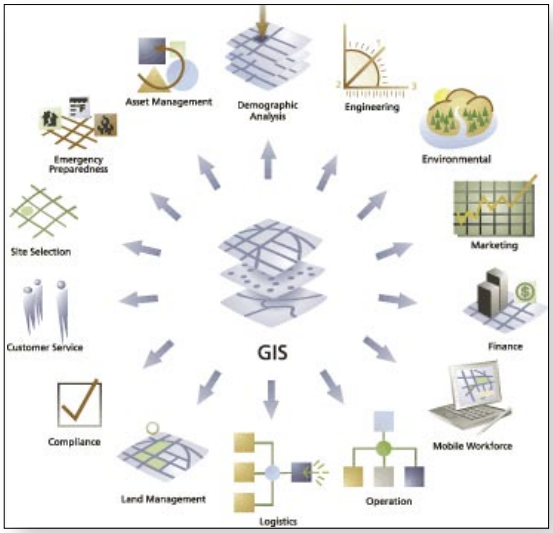
Using ESRI's GIS technologies, generation and transmission companies improve their business operations by

- Analyzing market potential
- Reducing maintenance costs
- Optimizing assets
- Monitoring environmental impacts
- Automating processes
- Streamlining work procedures
- Improving earning potential
- Integrating business systems

GIS Solutions for the Enterprise



Eskom employees in South Africa log on to the company intranet and use GIS mapping tools to view extensive transmission line data. This customized Map Viewer tool shows the location of a downed transmission tower and a photo. Employees can add other layers of information or access other maps relevant to their jobs.



Power companies around the world are using new business strategies to better manage and improve service. GIS offers generation and transmission organizations a method of quickly accessing and producing maps, leveraging database information, and automating work processes. ESRI's GIS software is an open system conforming to information technology standards and therefore can be used throughout the enterprise for a variety of business processes. Integrating ArcGIS into corporate systems streamlines daily workflow and improves decision making and collaborative efforts for sound business management.

ArcGIS Data Models for the Utility Industry

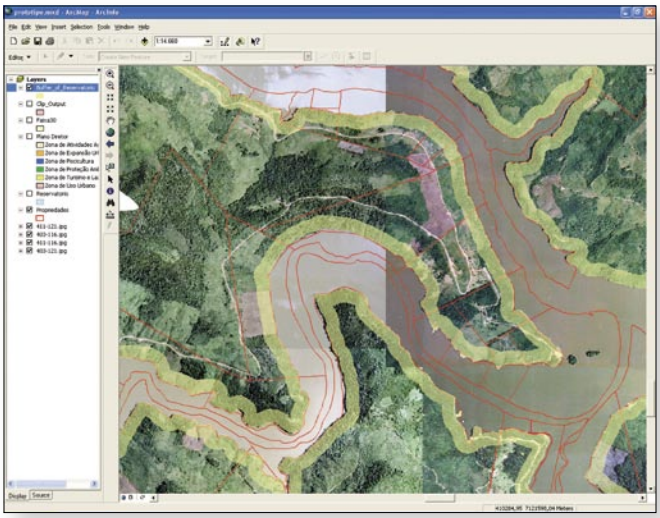
Electric Distribution
Electric Transmission
Gas Distribution
Energy Utilities MultiSpeak
Land Parcels
Pipeline
Telecommunications

Site Selection and Evaluation

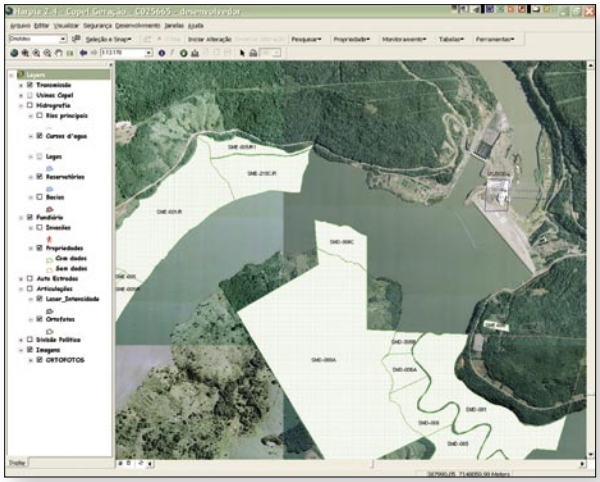
Generation site placement studies are supported using GIS. For example, building a hydropower station requires thorough studies of geological lithologies, water drainage patterns, surface, and subsurface structures. The geological, structural configuration is essential to understand the strengths and weaknesses of the area so the project can be implemented in suitable terrain. GIS is used to process this data to show, for example, the hydropower potential of an area. Using information, such as spot height topographic maps and digitized data about elevation contours, ArcGIS can generate digital elevation models (DEMs). GIS is used to layer additional data on the DEM such as catchment boundaries, drainage networks, and location of major habitation and environmental factors.

Companhia Paranaense de Energia

Brazilian forests and environmental efforts are of national concern and the focus of international scrutiny. The Companhia Paranaense de Energia (Copel) implemented an environmental management system (EMA) to plan the environmental preservation of the region it serves. EMA incorporates GIS applications that are used to manage the power company's environmental compliance. Copel supplies electricity to three million consumers with 6,800 km of transmission lines. It owns 18 power plants of which 17 are hydroelectric power plants. Copel decision makers use EMA, which is built on ArcGIS 8, to consider a number of sustainable and environmental factors in determining facility placement and the ensuing consequences such as health benefit and threat, socioeconomic effects, and environmental impacts of constructing generation facilities such as dams.



GIS shows the effects of a planned reservoir.



Orthophoto image and GIS layers depict environmental impact.

EMA uses a geodatabase composed of alphanumeric and cartographic registration data to devise comprehensive environmental preservation plans. The system allows Copel to support the legality of its real estate registrations. It is also used to provide relocation plans for families whose properties are affected by the construction of reservoirs.

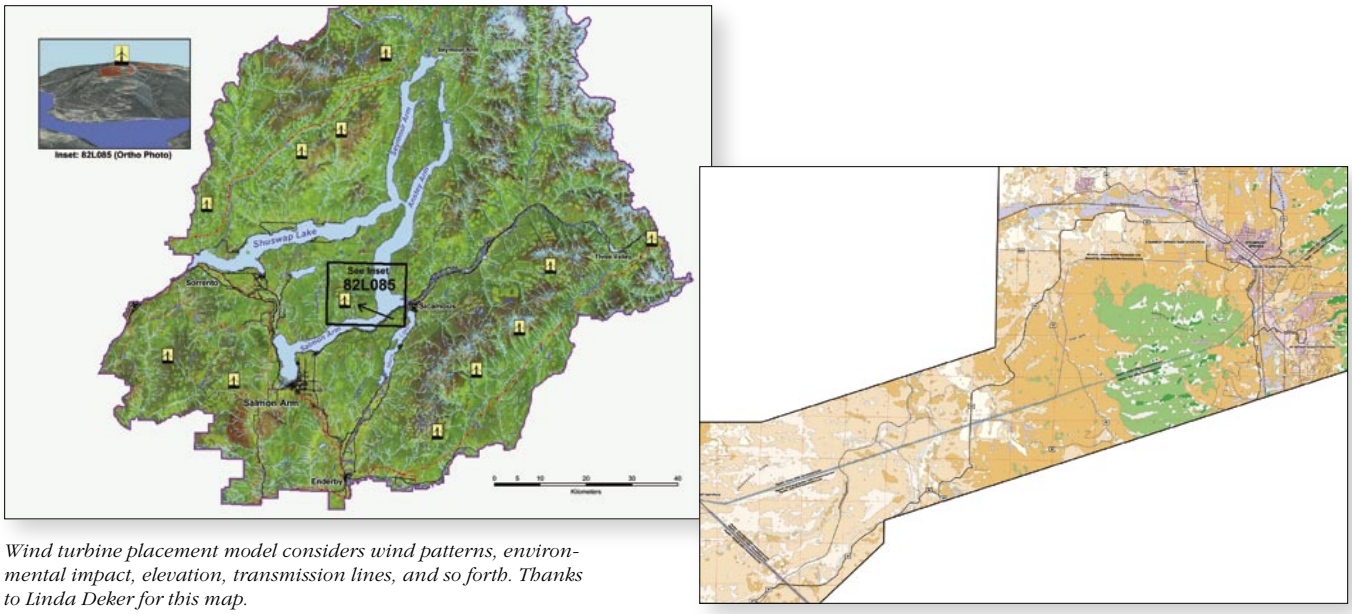
Site Selection and Evaluation

The system was put to the test when Copel constructed its Salto Caxias power plant. The construction impacted 600 families in the 19,000 hectares of land to be flooded. Copel covered all relocation costs. The enormity of this project attracted international attention, and the company could not afford mistakes. All contingencies had to be considered; therefore, Copel divided the project's use of EMA into several subsystems including water management, contingency planning for floods and damages to the dam, and relocation of expropriated people as a result of the construction of reservoirs. Other related GIS applications were developed for handling environmental licenses, recovery of degraded areas, zero effluents and waste caused by the power plant's maintenance process, and agrarian management including production of seedlings. For example, one application takes into consideration multiple factors to present spatial reports such as the limits of the state's municipalities, the main rivers of Paraná, and data about Copel's transmission lines.

North Sea Wind Parks Location Selection

Nuon, one of the largest energy companies in the Netherlands, is planning wind parks on the continental shelf of the Dutch North Sea. A GIS application will assist the company in its quest for suitable locations. A myriad of factors complicates the actual selection process, ranging from density of shipping traffic and the proximity of drilling rigs to bird migration patterns and military restrictions. Each factor has its own weight in the decision-making process. Superimposing the data that has been charted on separate maps helps in the selection of suitable locations. On the new interactive and multilayered map, the weight of each factor can be adjusted and a sensitivity analysis can be executed for all concerned parties.

Site Selection and Evaluation



Wind turbine placement model considers wind patterns, environmental impact, elevation, transmission lines, and so forth. Thanks to Linda Deker for this map.

Salmon Arm Forest District

Accurate wind turbine placement requires geographic and environmental analysis that includes multiple variables, which can be computed and displayed with GIS. GEM Mapping and Design developed a wind tower site analysis model that was used to determine the most ideal locations for establishing wind turbines in the Salmon Arm Forest District, British Columbia, Canada, primarily in areas where there are fairly steady wind patterns with the least impact on the environment and neighboring communities. The determination of the best turbine locations was based on the following criteria: close to transmission lines and existing roads, in areas of moderate elevation, away from wetlands, and away from mature tree stands.

ArcView®, ArcInfo®, and ArcGIS 3D Analyst™ were used for the project. A five-meter resolution colored orthophoto was surface draped over the DTM model of a 1:20,000-TRIM map sheet to show a close-up of an ideal location, and a 15-meter resolution colored satellite image was used for the entire district. Programs were written to create the TIN grid, draw relationships for the tree heights database information, and create the buffers and union coverages for the entire district. This project covered approximately 65 map sheets.

Yampa Valley Electric Association

Yampa Valley Electric Association (YVEA) serves approximately 12,000 customers in Steamboat Springs, Colorado, and the surrounding area from Xcel Energy's Steamboat Springs Substation. A 230-kilovolt electric transmission line from the Wolcott Tap supplies the Steamboat Springs Substation. YVEA also has a 69-kilovolt transmission line running to the Steamboat Springs Substation from the Mt. Harris Substation. The 69-kilovolt line can only provide a limited amount of backup power. Without an additional high-voltage source of power, the Steamboat Springs area is at risk during an outage of the existing 230-kilovolt line. The risks are greater if the outage occurs in the winter when access to the line is limited and repair time is impaired by snow. There are various options for bringing additional electricity to the Yampa River Valley. Any of these options will create a looped or dual transmission supply to the existing electric system.

The vegetation and geologic hazards maps are part of a series of 42 maps prepared by EDAW for Xcel Energy. EDAW mapped various environmental factors to assist Xcel Energy in the siting of a transmission line. The maps and graphics were prepared for two public meetings and used in filing applications. This was EDAW-Denver's first project to extensively use ArcGIS, geodatabase annotations, and group layers.

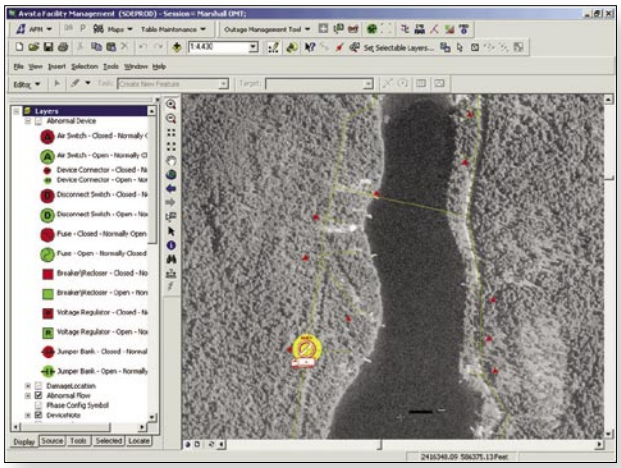
Map reprinted with permission from Xcel Energy.

Plant Licensing

Utilities generating power are required by federal regulation to license or relicense their facilities. A large number of environmental studies are conducted during this process, and GIS tools aid in efficient and comprehensive results. The studies require a wide variety of data from governmental and other sources including ecological, engineering, recreational, cultural, and socioeconomic content. Examples of GIS-related tasks used for relicensing are analysis of data, capture and display of changes over time, two- and three-dimensional surface/bathymetry models, elevation models, and the presentation and reporting of the studies for meetings as well as ongoing monitoring after a license is granted.

Avista Corporation

The Federal Energy Regulatory Commission has the exclusive authority to license all nonfederal hydroelectric projects that are located in navigable waterways or federal lands. New licenses are issued for a period of 30 to 50 years, and power companies must meet requirements for relicensing application. Because of a wide range of issues involved, such as meeting the requirements of the National Environmental Policy Act, the Clean Water Act, the Endangered Species Act, and several portions of the Federal Power Act, the relicensing process is complex.



Avista Utilities' collaborative approach to relicensing includes interagency data sharing dependent on standardization and interoperability of systems.

Avista Utilities generates, transmits, and distributes electricity in the Pacific Northwest. Avista's relicensing initiative requires much collaborative effort in administration and technologies including GIS. Interagency relationships include formal agreements between public and private agencies. Standardization of ArcGIS and interoperability of systems makes data sharing possible between organizations. Land base data is shared by a consortium of counties, cities, water districts, and highway districts. Avista has worked out cost allocation agreements with these agencies for sharing datasets—agreements that have saved the power company 65 percent of information costs. Land base datasets that the consortium shares are orthophotography, topography, street centerlines, and parcels.

The company's revolutionary approach to hydroelectric project relicensing has been held up as an industry model. In fact, the company has received the National Hydropower Association's Hydro Achievement Award for Stewardship of Water Resources for four straight years as a result of its collaborative approach to relicensing and for accomplishments in river protection and enhancement.

Network Viewing Solutions

Intelligently building a transmission line network requires precise planning, costing, scheduling, and so forth. Use GIS for selecting suitable areas, finding the optimum path, creating the profile analysis, engineering design of towers and wires, surveying support, and estimating costs.

Bonneville Power Administration

The Bonneville Power Administration (BPA) is a federal agency with the U.S. Department of Energy that serves 10 million people in the Pacific Northwest. BPA markets and transmits the power from the generation facilities owned by the U.S. Army Corps of Engineers and Bureau of Reclamation on the Columbia River. BPA's geodatabase contains data on 800,000 transmission towers.

To make this data available for applications, BPA created an Internet tool for viewing its geographic transmission data. TView2, which is built on ArcIMS®, allows personnel to access and display asset data such as tower location, operating name of line, tower type, and the conductor elevation attachment point. The map displays a network representation, and the Identifier tool indicates the assets on a specific tower. Users can search layers such as roads and rivers, service area boundaries of cooperatives and public utility districts, landownership, and threatened and endangered species data.

BPA's information systems group built the tool using Visual Basic® and ESRI's MapObjects®. All the data is managed with ArcSDE®, which is an application server that facilitates storing spatial data in a relational database management system.

TView2 is currently loaded on approximately 700 workstations on the BPA computer network and has a wide range of uses. For example, if there is an outage on the transmission system and the location of the problem is known, a dispatcher can reference it on TView2 and give maintenance crews exact information about how to get to the trouble spot for repairs.

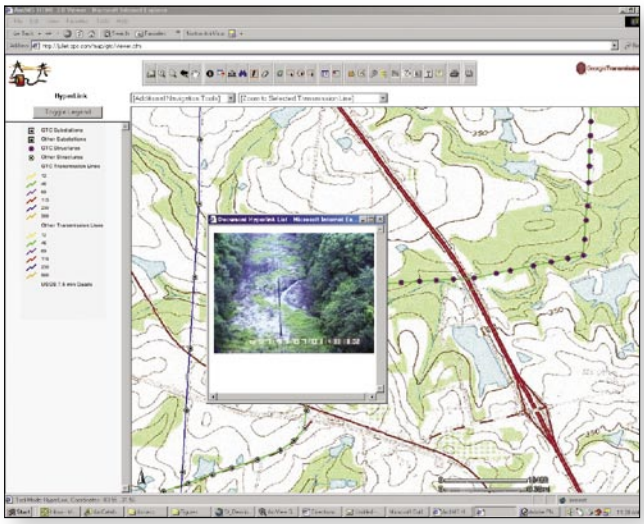
BPA's Transmission Business Line (TBL) ensures that the service region has a safe and reliable electric grid and energy is served at a competitive rate. TBL relies on its GIS to provide customers and constituents a visual of its transmission systems in their areas. TBL uses GIS for transmission system planning, design, construction, and maintenance activities. It is an important tool used to help site transmission lines and facilities, to identify property features, and to conduct studies that require analysis of the geographic distribution of data.

Transmission line project proposal map available for public viewing on BPA Web site

The information systems group is in the process of testing a mobile version of TView2, which runs on a laptop. Field personnel will use this tool when they are doing vegetation treatments on the access roads. It will be connected to the BPA network on a daily or weekly basis for updates.

Another tool developed by the group is the Internet Mapping Framework (IFM) that works in conjunction with ArcIMS Internet mapping software. This tool provides GIS developers with a fast method for building Web-based applications in-house. IFM helps designers add functionality and data layers to applications for specific work tasks. The framework concept allows the user to use XML code to quickly change the buttons and the layers available within the application.

Network Viewing Solutions



GTC integrates its maps, databases, and image files—located in separate areas of the company—into a single, common interface by using an ArcIMS Web application called GTCView.

Georgia Transmission Corporation

At Georgia Transmission Corporation (GTC), using GIS-based Web applications is part of the daily routine of employees throughout the company. GTC is a not-for-profit cooperative owned by and serving 39 electric membership corporations in Georgia.

Because GTC has been using GIS for several years, it has accumulated a wealth of geographic data including orthophotography, parcel data, and systems data for the state of Georgia. The company uses Web-based applications that enable it to make this data more easily accessible to a greater number of company employees.

By implementing an ArcIMS Web application called GTCView, GTC integrates its maps, databases, and image files, which are located in separate areas of the company, into a single, common interface. GTCView was designed in collaboration with Idea Integration, the consulting and system integration solutions unit of MPS Group. Idea partnered with Photo Science, Inc., the primary GIS contractor for GTC, to develop this Web application that provides browser-based user access to information. Integration of GTC's GIS and the existing corporate database into a common application interface increases the practical use of information across the organization.

One of the goals in designing GTCView was to take information and characteristics about the location of facilities and integrate them with other attribute databases. GTCView links four relational databases for GIS use. Its primary feature is an interactive map from which the user can make textual queries and access relational databases, allowing for map design.

For example, the planning department is asked to supply energy to a target area by building a new facility and routing electricity to it. Obviously, it is more cost-effective to build a facility that is in close proximity to the target area. If the planning department wants to determine the load need for a new area, it can access databases through GTCView. The user enters the location of the new area and performs a distance query such as the location of all 115-kilovolt transmission lines within 50 miles of the site. GIS produces both a map and a list of those transmission lines.

Software users even access unusual data with GTCView. For instance, GTC has a database of video images photographed from aircraft flyovers of transmission lines. These images are linked to GPS at the time of capture. Using the GTCView application, a company employee selects a transmission line, then clicks a button that looks like a video camera to actually see the video of the line. The user can also click directly on a tower and see a photo of the structure. The tool extends the benefit of the data-gathering investment.

The Web-based application allows the user to create custom maps without being a cartographer. The symbology is available and easy to use, a map template sets the stage, and the employee creates the map. More than 100 employees are using GTCView. The tool makes users self-sufficient in producing maps and GIS-empowered to do more with them. With a geographic perspective, employees put GIS to work from fulfilling a request order to getting a budget approved.

Wholesale Power Markets

PJM Interconnection

PJM Interconnection operates the world's largest competitive wholesale electricity market and the largest centrally dispatched territory in North America. This regional transmission organization (RTO) ensures the reliability of the high-voltage electric power system serving 51 million people in Delaware, Illinois, Kentucky, Maryland, Michigan, New Jersey, North Carolina, Ohio, Pennsylvania, Tennessee, Virginia, West Virginia, and the District of Columbia. PJM has more than doubled in size in the past year and a half, making it critical to take advantage of decision support tools, such as GIS, to optimize and streamline current and planned business enterprise practices.

Integral GIS is working with PJM to build the foundation for an enterprise GIS on a platform of ESRI's ArcGIS and ArcSDE software and Microsoft® SQL Server 2000. Analysts use GIS to create powerful visualizations for planning, markets, and operations with a focus on supporting planning activities related to PJM's Regional Transmission Expansion Plan (RTEP).

Planning

PJM's RTEP is a sophisticated process for planning regional transmission expansion to assure future electric reliability and to accommodate the connection to the grid of new electric generation. The Interconnection Planning Department developed its System Planning GIS to allow it to see the geographic relationships between facilities distributed over PJM's system. New power plant projects come through a queuing process. The planning department studies these projects to analyze the effects on the electric grid. Queues of projects and their accompanying attributes are entered into GIS to create a tool for analyzing how transmission relationships are affected. A decision made in queue A can significantly affect queues B and C. Depending on what effect those queues have on the transmission system, an upgrade to the system could be required. For example, a planning engineer's review of a proposed 1,000-megawatt coal-fired generation plant may determine that certain parts of the transmission grid will need to be upgraded to accommodate the new plant interconnection and additional power. The GIS would be used to visualize any planned modification to the bulk power system. In addition, GIS tracks construction status on the electric grid.

Planning engineers are also working toward a GIS interface with a load flow program, the Power System State Estimation, which creates better visualizations of resultant contingencies on the system caused by new generation, new transmission, generation retirements, and other changes.

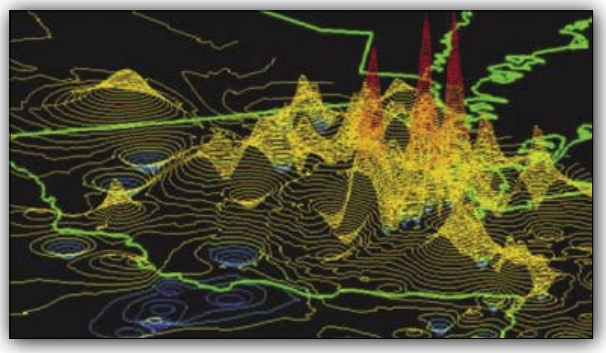


Figure 1. A marketing price map indicates the market price fluctuations on PJM RTO's transmission system.

GIS is used for various reports to stakeholders such as the Federal Energy Regulatory Commission, state agencies, and state regulatory commissions. GIS-generated reports show the status of the transmission grid and the status of construction on the system in the next five and ten years.

Collaboration with the many transmission owners within PJM's 19 zones is a highly coordinated effort. PJM has been establishing standards within its dataset and data models for quality and accessibility. Although most of the transmission owners use GIS in their operations, their information goals, such as outage and asset management, are different from PJM's planning goals; therefore, data models are different. Diagrams for generation and transmission projects are submitted to PJM in many formats. For consistency's sake, PJM GIS analysts are working with the transmission owners to collaborate on a GIS transmission data model. The idea of collaborative efforts for data sharing is gaining acceptance. PJM is already setting the foundation for data sharing by standardizing GIS databases within its own organization.

Markets

PJM uses locational marginal pricing (LMP) to establish a unique price for each node or location on the transmission system. If there is no congestion in the transmission system, the LMP level is the same throughout the transmission grid. If the grid is congested, LMP has different values (figure 1).

As a proof of concept, the GIS was used to display market data using interpolated surfaces of actual LMP data within PJM's system. It provides a view of the direction of grid congestion affecting LMP. An effective LMP method should incorporate real-time operation characteristics for the system into the pricing and market response. PJM has thousands of LMP points in the

system that are assigned a dollar value that is updated every five minutes. Analysts tie price points from the market data into the GIS, which interpolates its surface. ArcView and the software extension ArcScene™ are used to create a three-dimensional map with a colorized gradient surface to indicate price range variations across the entire system (figure 2). This enables analysts to see the points where there is a lot of congestion and the LMP is high (shown on the map as a peak) and where the LMP is low. This regional perspective of the energy pricing on the system will advance economic planning on the transmission system.

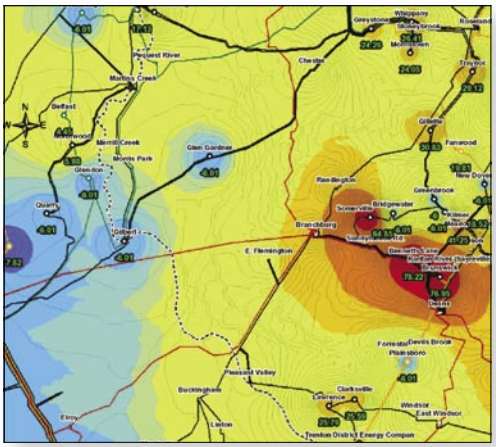


Figure 2. Price dynamics are displayed three dimensionally.

Operations

PJM's System Operations is responsible for maintaining a reliable transmission system. Weather has an effect on the system because of changes in energy demand based on temperature and outages. PJM is streaming real-time weather data from Meteorlogix into its GIS to be displayed on a section of PJM's control room screen. The screen is a matrix of 56 high-definition screens, 14 screens wide by 4 screens high, which displays critical information related to the reliability of the grid. One quadrant of the screen displays Meteorlogix® real-time weather data across the PJM system, streamed in and refreshed every five minutes from an FTP server.

Weather data is integrated into ArcView to create an overlay of weather on the transmission system and area basemaps. PJM uses the weather data to anticipate how the load will change. For example, if a warm front is moving into the region and a high of 95 degrees is forecasted for southern New Jersey, PJM anticipates a greater demand for power in that region. If a thunderstorm is moving through an area or hurricane direction is predicted, then, based on historical analysis, PJM can prepare for outages and anticipate dispatch needs to maintain system reliability.

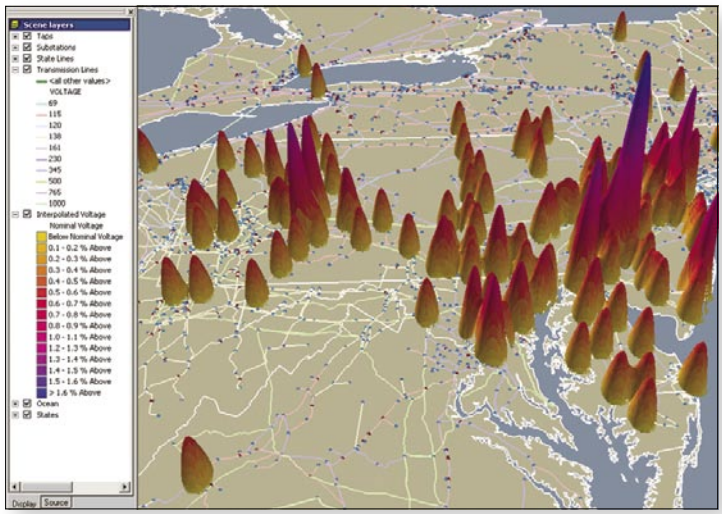


Figure 3. Three-Dimensional Voltage Map

In addition to real-time weather, analysts use ArcView and ArcScene to create 3D gradient surfaces of voltage use across the transmission system (figure 3). PJM plans to stream data in real time for instant voltage activity on the grid in order to quickly and precisely identify any severe voltage conditions in the system from a regional perspective.

PJM's innovative GIS applications will help meet its goal of managing the bulk power grid efficiently. With an eye on the future, the organization is developing goals to create collaborative plans that support effective decision making for those transmission companies it serves.

PJM control room maps display transmission grid and other information including real-time weather data.

Right-of-Way Solutions

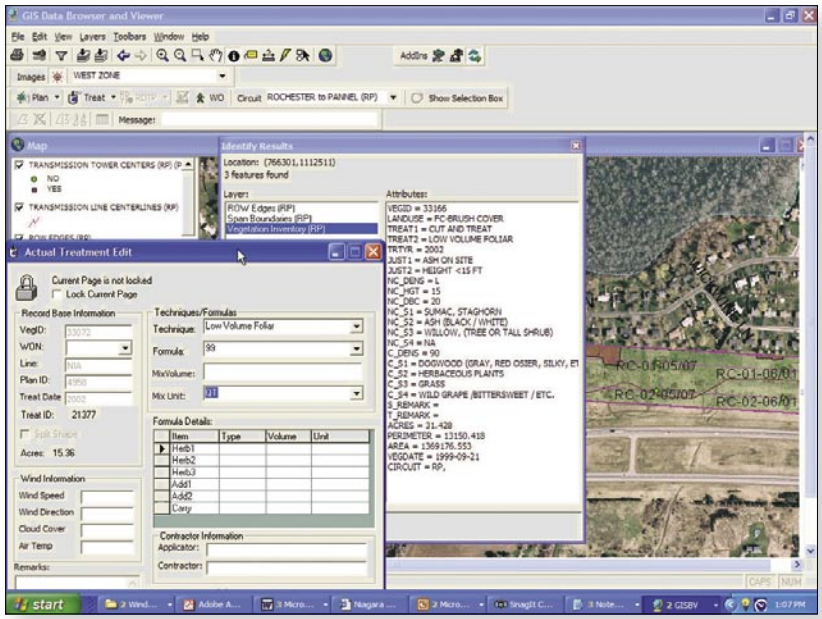
GIS is used to manage right-of-way activities including planning and management, property appraisal, property acquisition, property/asset management, asset relocation, vegetation management, and corridor preservation. Use GIS to buffer and overlay right-of-way requirements for tower placement, query features to identify property owners and other land information, and perform geospatial analysis to direct tree-trimming efforts. GIS provides a myriad of opportunities to streamline right-of-way processes from facility management to market assessment.

The New York Power Authority

The New York Power Authority (NYPA) vegetation management program maintains approximately 16,000 acres of right-of-way (ROW). The program's principal goal is to provide safe and reliable transmission of electric power in an economic and environmentally compatible manner. Therefore, the authority has designed an integrated vegetation management computer application called the ROW Application, which is built on ESRI's ArcGIS.

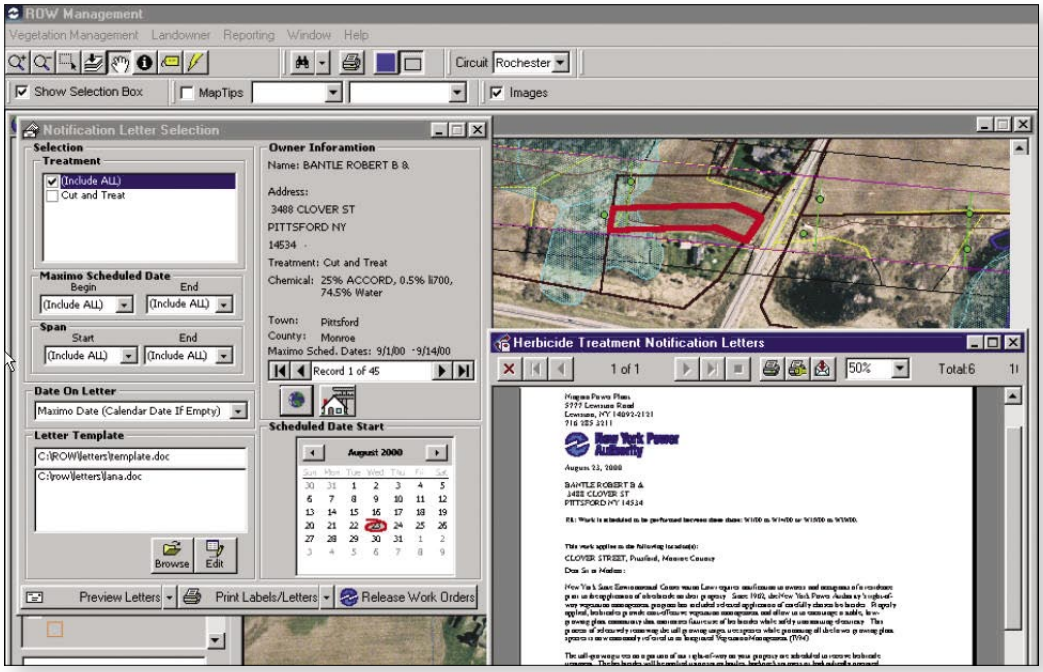
NYPA is the United States' largest state-owned power organization and one of the largest producers of electricity in New York state. The power is produced at 17 generating facilities and distributed by approximately 1,400 circuit miles of high-voltage transmission lines. The enterprise-wide ROW Application is linked to the land management, equipment maintenance, and environmental and engineering data, which is necessary to efficiently and effectively manage the authority's facilities and also to comply with all relevant regulations.

NYPA partnered with the URS Corporation of Buffalo, New York, to develop a GIS-integrated vegetation management (IVM) application that provides easy access to data. The IVM has a simple interface and can perform relatively complex tasks such as creation of treatment plans that ensure compliance with all regulatory mandates and landowner agreements. Using ArcSDE, NYPA maintains all vector and tabular data at its central data center. The center provides all parties with access to the most current information. Image data (digital orthophotos and document scans) are maintained on local servers at each NYPA site.



GIS provides access to geographic data so IVM treatment techniques can be examined, taking into account conditions such as wetlands, landowner issues and agreements, site access, regulatory commitments, and security.

Right-of-Way Solutions



NYPA's notification system is integrated with GIS. The user defines the vegetation treatment area and herbicide treatment notification letters are automatically printed and sent to landowners in the target area.

This combination of centralized and distributed data storage provides the best possible response times across NYPA's wide area network. Central data access also ensures data security control.

The ROW Application helps ROW managers evaluate current vegetation conditions. It provides access to geographic datasets so vegetation management treatment techniques can be examined in a way that includes factors such as wetlands, landowners' issues/agreements, site access, regulatory commitments, security, and dangerous tree-trimming sites. The application also has a function that serves the treatment plan review process and another function that creates work orders through MAXIMO®.

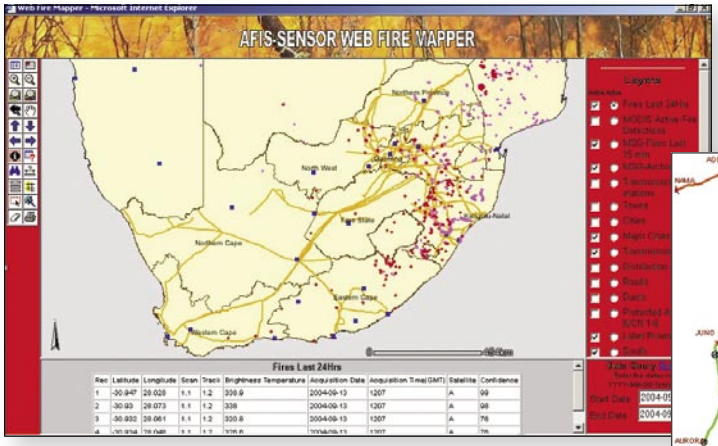
The IVM program incorporates a balance of cultural, physical, biological, and chemical tactics to control the targeted tall-growing tree species. It also works to enhance the abundance of all lower-growing, desirable vegetation. A regular inventory and documentation of maintenance activities allow for analysis, evaluation, and continuous improvement in the overall ROW management program.

The IVM workflow is a smooth process from scheduling treatments to evaluating effectiveness. Field inventories are annually conducted for the ROW scheduled for treatment the following year. NYPA's system forestry staff reviews the inventories and treatment recommendations, accepting or modifying the recommendations as they deem necessary.

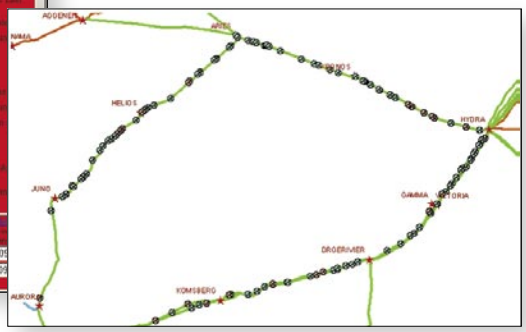
Once the actual fieldwork begins, the treatment plan and related data are downloaded onto field computers for use by NYPA inspectors. These inspectors track the actual treatment in the field, then upload the data to the central server for future use. This data supports contract change orders, regulatory reporting, information for seeking bids, and other reporting needs. After the next field inventory of the same ROW is completed, NYPA uses the as-treated data to analyze how well the previous treatment cycle worked.

Using the IVM application, NYPA had a 60 percent noncompatible vegetation reduction. Because of its IVM program, NYPA expects to be using a fraction of the herbicides and manual effort it has previously used. The solution is saving the company money and is having ecologically positive results.

Right-of-Way Solutions



Fire information is served on a GIS-enabled Web site.



Bird nests influence line integrity. ArcView displays bird nest transmission tower survey data.

Eskom, South Africa

The Republic of South Africa's government utility, Eskom, is the seventh largest electric company in the world in terms of generating capacity and sales. It provides more than 98 percent of South Africa's electrical requirements and more than 50 percent of the electricity produced in Africa. Eskom is involved in the generation, transmission, and distribution of electricity.

Eskom's Transmission Division's Transmission Spatial Information System (TxSIS) is built on ESRI's ArcGIS software and supports GIS across the enterprise. TxSIS provides support for strategic maintenance planning, line fault investigations, and real-time system operations. The geodatabase is managed with ESRI's ArcSDE spatial data engine software. The system includes an Internet mapping service on the TxSIS intranet site, which is accessed by approximately 200 transmission users on a monthly basis. ArcIMS distributes online maps that show the transmission network relative to its natural, physical, and legal environment and other technical transmission information.

The administrative process of obtaining servitude (right-of-way) rights for new transmission line projects is managed through GIS. This includes the total process, from notification management for the public participation during the environmental impact assessment for a new line project, to eventual negotiation with registered landowners about the terms of the servitude rights. TxSIS generates instructions to the contractors involved in the construction of the line as communicated by the landowners.

For example, GIS is used to create option sketches for obtaining servitude rights on a 100-kilometer new line. This process, which once took two to three weeks by hand, only takes 10 to 15 minutes with GIS. GIS is also used to track progress with the legal registration of the right-of-way. Furthermore, it is used in the performance management of employees involved in the registration process. Managing these processes with GIS has considerably improved workflow.

Line faults in South Africa are primarily caused by birds, lightning, and fires, which are all tracked with GIS. Annual raptor nest surveys are used to track trends, monitor risk, and evaluate the effectiveness of nest relocation initiatives and bird guard installations. Real-time lightning information, weather forecasts, and real-time weather data is processed in GIS. The integrated system shows where lightning is prevalent along sections of transmission lines and how maintenance efforts can best be directed for improving the network. Fire location data is automatically derived from satellite services. From this data, a fire incident map is posted on the Web Fire Mapper Web site.

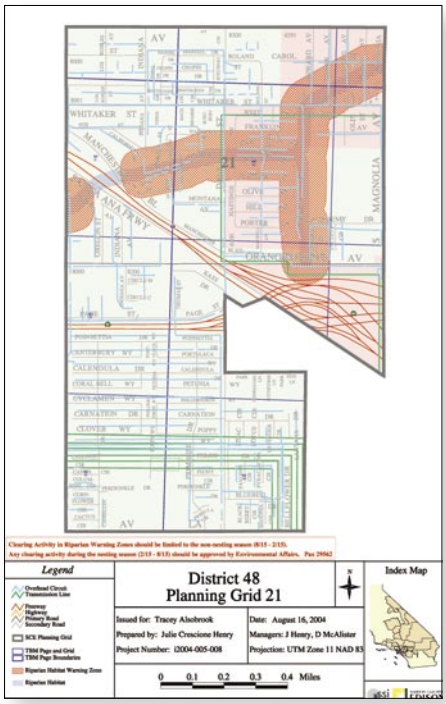
Right-of-Way Solutions

Southern California Edison

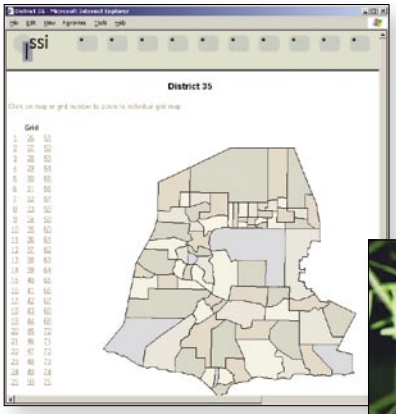
Southern California Edison (SCE) manages line clearing for safety, reliability, and regulatory purposes. The company's 4.2 million customer accounts are spread over a 50,000-square-mile service territory, encompassing a range of climates including desert, high mountains, coast, and plains. Fire prevention is important in Southern California, and SCE uses GIS as a tool to combat the risk of wildfire.

Clearing the vegetation around distribution circuits and transmission lines is one of SCE's leading safety concerns. SCE is also concerned that riparian habitats close to company structures be preserved. Many of these sites are suitable habitats for endangered species. In an effort to identify riparian habitat areas, SCE turned to GIS and Integrated Spatial Solutions Incorporated (ISSI) of Whittier, California, for assistance.

ISSI used GIS techniques, integrating various datasets from multiple sources. Data was drawn from Thomas Bros. Maps®, the Teale Data Center, and corporate databases within SCE. More than 700,000 circuit line features were converted from SCE's outage management system, M3i export format, and target regions were displayed using the Buffer tool in ESRI's ArcView software. These were combined with transmission line buffers to show areas of interest for the line-clearing process.



Electric line-clearing activities are buffered by 300 feet and are defined as riparian warning zones.



Interactive GIS Web map provides zone identification area for line-clearing action.

Least Bell's vireo habitat information is included in SCE's database.

Ecological and hydrological datasets were then obtained to identify those areas close to the company's electrical infrastructure. Least Bell's vireo critical habitat, southwestern willow flycatcher critical habitat data, and estuaries data from Thomas Bros. Maps were buffered and combined with hydrological data from the Teale Data Center. This data aggregation was defined as riparian habitat.

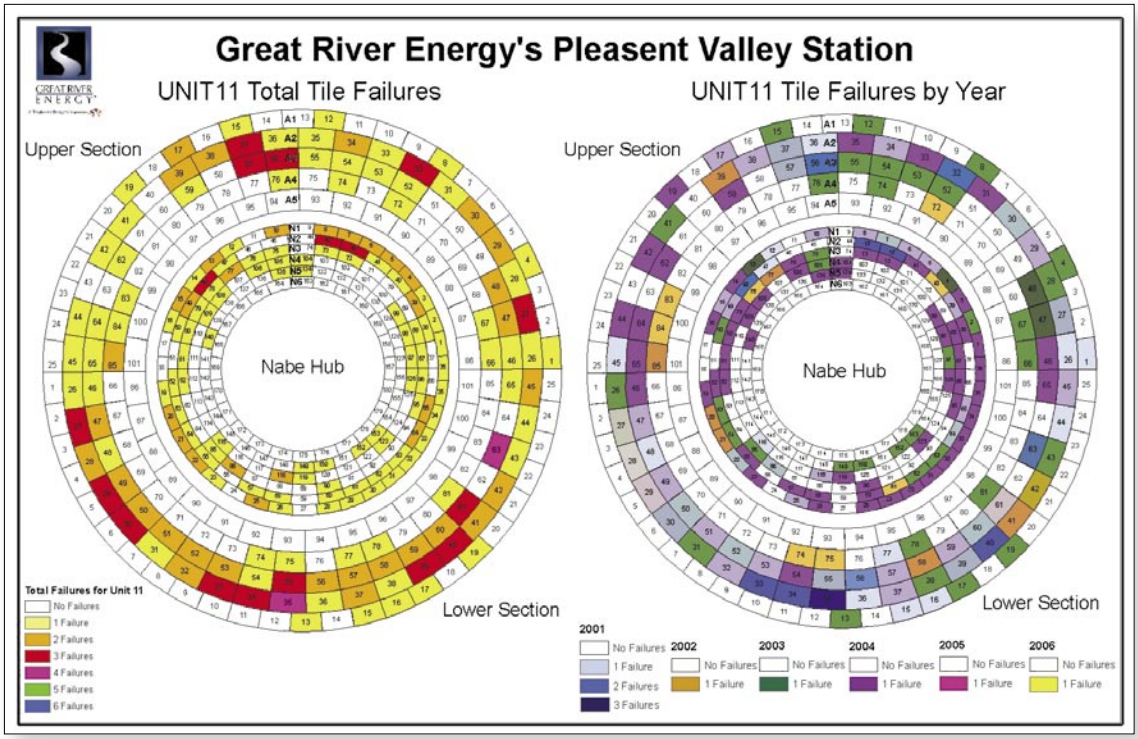
The final overlay was the riparian habitat on top of the area of interest for line clearing. The points of intersection were buffered by 300 feet and defined as riparian warning zones. The only manual intervention required was the changing of paper rolls and cutting of maps.

The project was a multidepartmental effort within SCE that included transmission and distribution, corporate real estate, and regulatory policy and affairs departments. ISSI produced more than 4,000 11-by-17-inch custom maps at varying scales, covering the entire SCE service territory. The maps were organized by SCE's planning grids and bound in books by district. The mapping effort encompassed 430 cities and communities and took four weeks to complete.

The maps were also made available to users in PDF format via an internal Web site. The SCE district shapefiles were converted to HTML polygon image maps and linked to individual 11-by-17-inch planning grid PDFs. These PDFs were made available for downloading and printing to all SCE personnel involved in line-clearing efforts.

SCE and ISSI are currently involved in a similar project that includes the mapping of fire hazard severity zones as well as historical resource warning zones.

Asset Management Solutions



GIS is used to map the heat-producing portion of a generating station and represents the location of each heat tile. Color coding is based on maintenance activities. The map serves to highlight problematic areas and suggest resolution activities (e.g., tile replacement of a different strength).

By providing a geographically oriented view of the electric generation and transmission structures, devices, and network, ESRI's ArcGIS helps electricity generation and transmission utility managers visualize, analyze, and understand their facilities.

Great River Energy

Great River Energy is using ESRI's ArcGIS software for mapping its transmission facilities. In addition, the generation department uses ArcGIS for tracking maintenance history of equipment in generating facilities.

Illustrated above is an example of using ArcGIS to track failure rates for heat shield tiles in combustion turbine generators. United Services Group, a department of Great River Energy, developed this application by re-creating the manufacturer's drawings of the heat shield tile locations using ArcGIS. The tile failure data is then located in an ArcGIS personal geodatabase and published as an ArcReader™ document.

Using ArcReader as a visual tool to present multiple years' worth of inspection data, Great River Energy can establish trends in failure rates of the tiles inside the combustion turbine. This graphic information is then used to assist with decisions on modifications to the turbine to reduce the cost of maintenance.

Asset Management Solutions

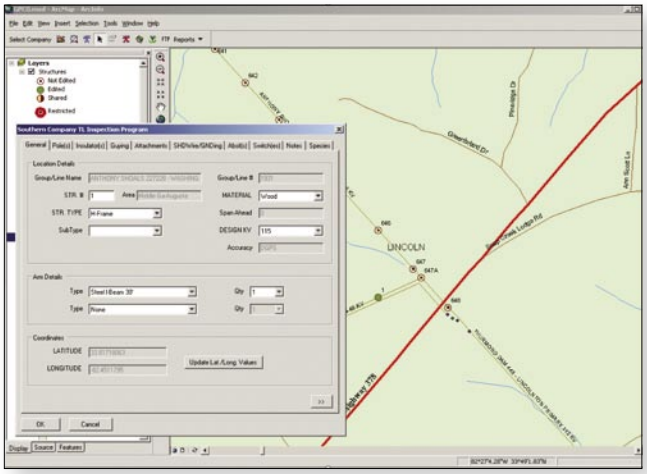
Southern Company

Transmission companies must perform transmission and inspection of lines to keep the power flowing. The two most important aspects of any transmission inspection system are the quality of the data and its usefulness. Inspection programs can vary greatly. Some programs are tedious, requiring paper forms, pen and ink, clipboards, and accordion files. Other designs are technologically smart and use digitized PC tablets that are uploaded to a central database. These portable, electronic inspection systems facilitate GIS, GPS, digital images, routing, inventory, and work order inventories.

Southern Company is one of the largest utility companies in the United States and is a leading generator of electricity. Its five individual operating companies have transmission line inspection crews that are independent of one another, and each operating company has different inspection requirements. Although the operating companies have used the same inspection contractor, corporate use of the contractor had not been centrally planned. This created personnel coverage gaps for the contractor, which resulted in inspector turnover and increased time spent on training.

The company identified four types of operations that would ultimately be incorporated into a Southern Company's Transmission Line Inspection System (TLIS): ground line treatment, aerial patrol, climbing, work orders, and general navigation. The first phase of the project addressed ground line treatment requirements.

ArcPad® software loaded on mobile laptops and PDAs provided a tool for climbing, aerial, and navigation inspection tasks. The field data was processed, uploaded, and processed in TLIS. ArcPad was combined with GPS, so field-workers could capture data about access road locations. The mobile application also displays documentation associated with current inspection work orders.



Transmission Line Inspection tool is used to collect asset data and provides detailed information such as coordinates and arm details.

A high-level plan proposed interactions between the compact terrain database and the TLIS. Next, interfaces between the compact terrain database and the TLIS applications were put in place. MESA Solutions customized ArcPad tools for capturing field inspection data.

TLIS allows inspection contractors to quickly gather information in the field using ruggedized computers. Once a set of inspection data is collected in the field, the contractor is able to package the data (using a special MESA-developed Work Complete function) and transfer the data to the appropriate Southern Company resource. By using the IT-developed transmission line management system application, the Southern Company resource group is able to integrate the collected data into the compact terrain database.

Inspection contractors and Southern Company personnel are able to more effectively and efficiently perform their inspections in the field and use this information to make the main set of equipment information more complete and reliable.

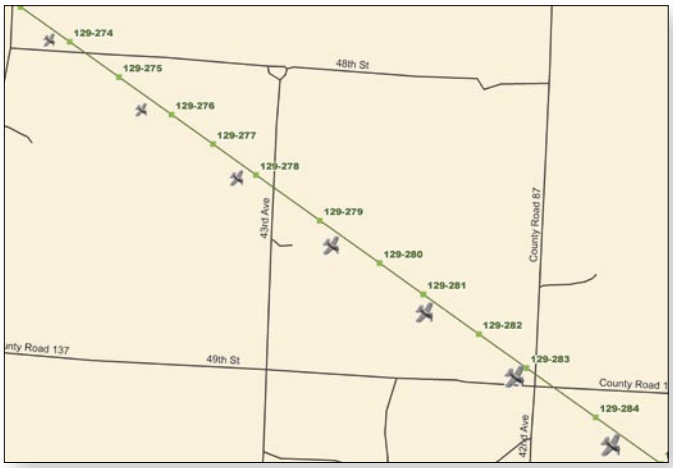
Asset Management Solutions

Basin Electric Power Cooperative

Basin Electric Power Cooperative is a regional wholesale electric generation and transmission cooperative serving 120 member systems that provide power and services to 1.8 million consumers in nine states. Small aircraft have proven very useful for gathering and maintaining data about this extensive power network.

Basin Electric uses small aircraft to fly over its transmission and generation facilities and capture data. Onboard telematic technology is used to transmit GPS coordinates to a server for recording the flight path of the aircraft. Telematics incorporates computers and wireless telecommunication technologies to create information solutions. Basin Electric's flight-tracking solution integration includes GPS, GIS, transceivers, and server applications.

Basin's Transmission Systems Maintenance office originally took phone calls from planes regarding location, time, and reports of network anomalies. The answering service was only available when an administrative assistant was at the desk to answer the phone. The cooperative wanted a broader plane-to-ground reporting system and moved the responsibility to its 24-hour security and response services section that manages the cooperative's dispatch service. The engineering and IT divisions established a GIS infrastructure several years ago. A pilot project combined transmission line locations and construction lists. In a joint effort to eliminate duplication, the GIS group initiated the project to use the existing GIS infrastructure and data.



Flight map tracks power company's aircraft during transmission inspection.

Basin Electric has been using ESRI technology including ArcInfo, ArcSDE, and ArcIMS for several years, so the foundation was set up for adding the solution. The flight-tracking application integrates SkyWave Mobile Communication GPS technology, an interactive Web site, and ESRI software. This combination allows technicians to map the current location of aircraft. Aircraft were retrofitted with SkyWave DMR-200 satellite transceivers that have low-elevation antennae. The DMR-200 is integrated with a GPS receiver. The internal GPS is used to generate aircraft position, altitude, airspeed, and direction of flight information.

The transceiver sends a signal to a satellite. The satellite sends data about latitude and longitude, speed, and direction to the SkyWave Web server. The system's reporting function relays latitude and longitude data at 2- to 10-minute intervals. The data drops into Microsoft SQL Server, then is automatically loaded into the geodatabase, which is managed by ArcSDE. Airplane data is geoprocessed in ArcInfo, then displayed on a Web-based map that employees access on the Internet. The system administrator can select the reporting intervals. The application refreshes data and redraws the map at 30-second intervals. An airplane symbol shows the plane's direction and time.

A dispatcher adds notes and sees other information related to the asset data such as photos, conductors, and maintenance histories. Another useful component of the solution is an ArcIMS image service, which uses a spatial data engine, ArcSDE, to reference the feature class file containing aircraft location. An HTML viewer user can select an aircraft feature and add comments. Adding comments invokes an automated process that updates the business table of the ArcSDE feature class. The user can also specify a start and end date and map the history of the aircraft's positions.

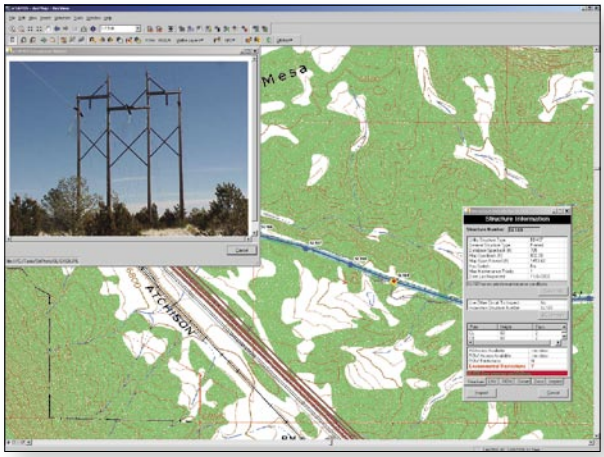
GIS provides the utility's service teams with parts lists, right-of-way data, parcel information, and access road locations. Field-workers can print a map of a specific corridor and have GIS create a route map to a selected asset.

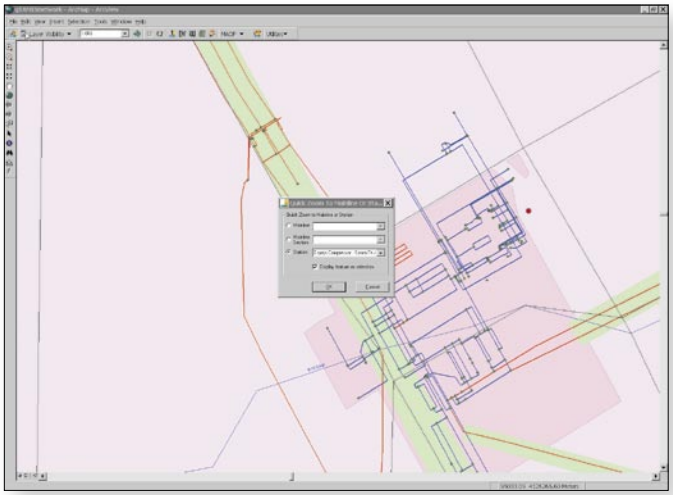
In addition to providing asset management data, the flight-tracking application supports the Basin Electric Power Cooperative's safety policies. It also creates documentation regarding low-elevation flight activity that can be used for Federal Aviation Administration audits and, if necessary, to support an incident investigation.

Asset Management Solutions

Public Service Company of New Mexico

Public Service Company of New Mexico (PNM) is the largest provider of electricity and gas in the state of New Mexico. It serves electricity to seven regional areas and gas service to approximately 100 communities. In addition, PNM sells electricity on the wholesale market. PNM's GIS staff changed the way GIS applications were managed at all levels of its organization for both individuals and departments and across the enterprise. PNM's vision was to create a single, centralized GIS repository where applications and data would be easily maintained and accessible. The results include streamlined business processes; more accurate, up-to-date asset and network management; and better regulatory compliance.



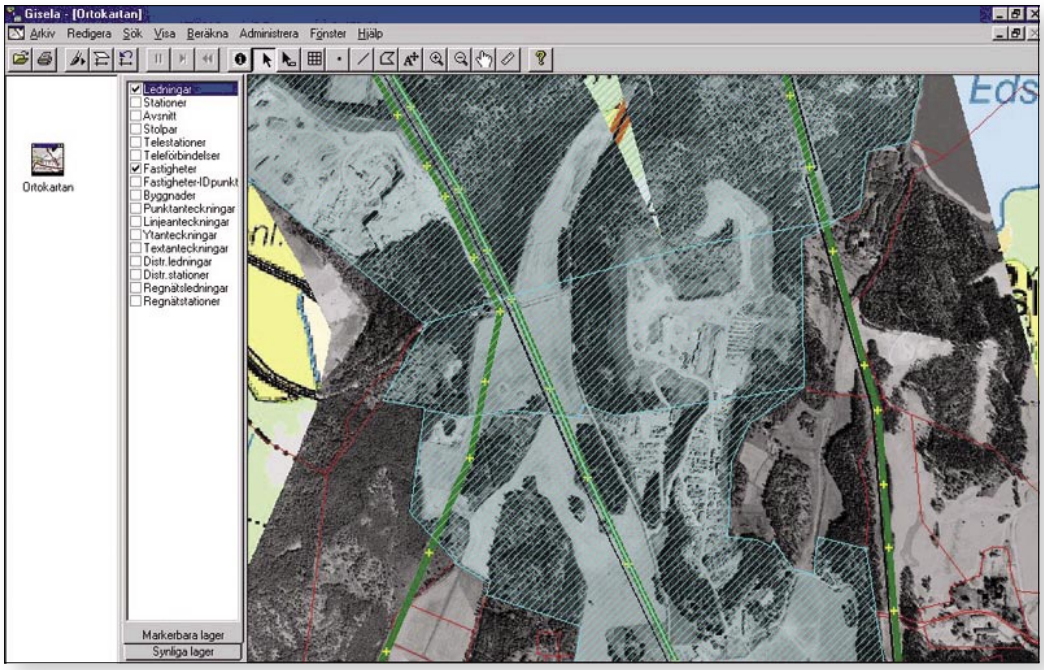


Public Service Company of New Mexico uses eTAMIS, a software application for online mapping. Included in eTAMIS are real-time routing, online analysis of structure information, a fault location tool, and more.

PNM and POWER Engineers, Inc., developed and implemented eTAMIS, a software application built on the ArcGIS platform, that supports high-voltage transmission line facilities management. This application, which can be connected to the network in the office or disconnected in the field, includes real-time routing and tracking, online analysis of structure information, a Fault Location tool, integration of several layers of base information, an inspection and maintenance module, and report functionality. The eTAMIS application also has the ability to display current environmental and landowner (right-of-way) data, computer-aided design drawings, and up-to-date scanned images of all utility drawings. Additionally, the application has custom data query and outage-routing capabilities.

This is but one example of how GIS provides PNM the strategies and solutions needed to turn data into information into knowledge and actions into results.

Asset Management Solutions



Transmission network data and land parcel data are overlaid on an aerial photography basemap.

Svenska Kraftnät

Svenska Kraftnät uses its Gisela system to document the Swedish national grid. The grid is portrayed in both a geographic and a schematic view. From the Gisela system, it is possible to reach information and drawings in a drawing system and component information in an asset management system. All employees at Svenska Kraftnät now have accurate maps on their computer screens and can easily search information in databases connected to the Gisela system.

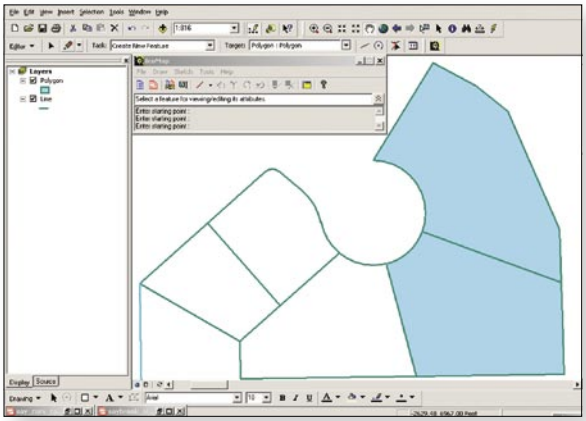
Land Management Solutions

Utility organizations that accumulate land must perform the accompanying records and land management duties. GIS supports land data storage and organization, surveying, mapping, and more. The result is fast access to maps, comprehensive data, and reduced costs.

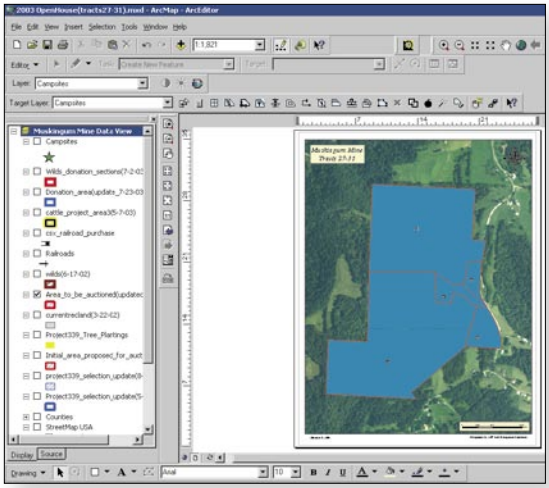
American Electric Power

Property is a major concern for American Electric Power (AEP) utility operations, and today GIS is helping the company manage these properties. American Electric Power is a large U.S. electricity generator with a generating capacity of more than 42,000 megawatts. AEP is also a large electric utility, serving approximately five million customers. Its 300,000 acres of land are used for power plants, oil and gas leases, mineral rights, and forestry.

Property plays a key role in AEP's operations, and revenue is generated by the way land is used. Accurate GIS maps help staff consider property potential and sell lands and properties. The company's real estate agents use GIS maps to fulfill land information requests by potential land buyers. AEP's legal department uses GIS maps as legal instruments that document property boundaries and land attributes such as acreage, soil type, elevation, and mineral content.



Field survey application IcoMap helps surveyors accurately map properties.



GIS organizes and displays property information for utility-owned lands.

The power company's Realtors use GIS for making land sales decisions. For example, if they are considering the sale of a piece of timberland, a field crew uses GPS and ESRI ArcPad to complete a field survey. The crew then maps the survey with UCLID's IcoMap® for ArcGIS.

IcoMap converts scanned documents into digital formats. By using IcoMap, workers can key in calls 50–75 percent faster. Time-saving quality assurance features allow users to edit individual lines and quickly correct mistakes. The software uses the survey measurements to draw coordinate geometry (COGO)-accurate maps. Because the program automatically enters the measurements, there is no risk of typing errors.

GIS is also an effective decision-making tool. For example, if AEP wants to build a new power plant, the site boundary is required to contain a defined proximity to water for cooling. Analysts use GIS to locate nearby streams and lakes and to create a data layer of environmentally protected areas. This helps analysts decide where to draw boundaries that meet generation needs without encroaching on protected areas.

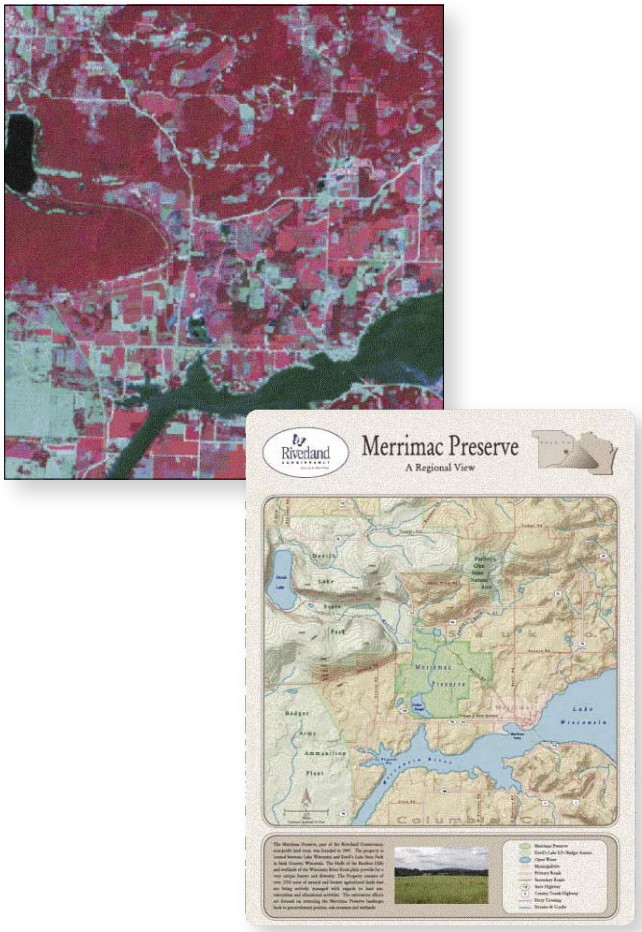
ArcIMS is used to make GIS accessible to staff via AEP's intranet. This gives other departments access to accurate information about the company's land.

Land Management Solutions

Alliant Energy

Conservation has come to the forefront in responsible utility management. Since its inception, GIS has been a large part of land management, natural resource management, and conservation management. Alliant Energy serves more than 1,000 communities in Iowa, Wisconsin, Minnesota, and Illinois. It is an excellent example of an organization using a large-scale GIS environment successfully. Alliant Energy found itself in the land trust business when it purchased land for a generation site. Because of market and economic constraints, it could not construct the facility originally envisioned. Instead, Alliant Energy became partners with Riverland Conservancy and converted an 1,800-acre site into the Merrimac preserve. Along with the conservancy, Alliant Energy actively manages the preserve's land use, restoration activities, and educational programs.

Alliant Energy measures the success of the project using GIS, remote sensing, and GPS. The GIS monitoring of the land trust project was set up in phases. The first phase was to provide a historical view of the landscape. Alliant's GIS team acquired aerial photography of the area for 1937, 1968, and 1992. This provided a geospatial history of the land. The next challenge was to orthorectify the historical photos. The team interpreted and digitized the land-use and land-cover data, then created maps and reports for historical analysis.



Aerial photography from decades past is useful for comparison analysis.

The second phase was to record and inventory the present characteristics of the landscape. This provided a comparison of changes from the past and a basis for monitoring future management tactics.

The third phase was to determine the best method for monitoring the future changes in the landscape.

The Merrimac preserve benefited, because once the government saw the technological skills in monitoring land preservation, it awarded a $500,000 Natural Resource Grant to support the project.

Alliant Energy benefited because demonstrating the company's commitment to the environment improved its public image. The project develops a common ground for partnerships with environmental groups at all levels of private and public sectors.

Business Partners

ESRI's business partners for the electric and gas industry bring ESRI software users the best applications available. Consultation support, extensions, and customization help you get the most out of GIS. Presented here is a list of business partners featured in the stories in this brochure.

EDAW
EDAW is a leading environmental planning and design firm with more than 65 years of experience in planning projects throughout the United States and the world. EDAW works with clients on projects that involve the development and delivery of energy-related commodities. EDAW balances environmental, social, economic, and regulatory considerations with project engineering objectives—all in a framework of informed decision making—to complete successful projects with its clients. Visit EDAW at **www.edaw.com**.

Idea Integration
Idea Integration provides a broad-based and diverse set of GIS services to a wide variety of vertical markets. Idea offers innovative solutions for the business-to-business and business-to-consumer market. Services include e-business strategy, creative design, customer relationship management, application development, business intelligence, and enterprise application solutions. Visit Idea Integration at **www.idea.com**.

Integrated Spatial Solutions Incorporated
Integrated Spatial Solutions Incorporated (ISSI) is a full-service GIS development agency. Its strategic development and consultation services range from innovative concepts and solutions to GIS design and development of desktop and Internet business solutions for utilities, IT, environmental agencies, public sector, and e-commerce clients. Visit ISSI at **www.issi-gis.com**.

MESA Solutions, Inc.
MESA Solutions, Inc., provides geospatial network management products, services, and solutions to electric, gas, water and wastewater, and UTelco companies. MESA Solutions provides best practices in project management, systems integration, and consulting services. Visit MESA Solutions, Inc., at **www.mesasolutions.com**.

Photo Science
Photo Science is a full-service photogrammetry, remote-sensing, and GIS services firm with staff exclusively devoted to the geospatial industry. Services include aerial imaging and data collection, photogrammetric mapping, GIS, remote sensing, and surveys. Visit Photo Science at **www.photoscience.com**.

Visit the Electric and Gas Industry Web site to learn more about ESRI's GIS solutions at www.esri.com/electricgas.

POWER Engineers, Inc.
POWER Engineers, Inc., provides a range of services that helps utilities design, build, operate, and maintain their facilities. Its services include data migration to the ArcGIS environment, application development, custom programming, needs assessment, field inventory, parcel mapping, data compilation and analysis, database design, and training. POWER Engineers currently implements asset management solutions using its Transmission Asset Management Information System (TAMIS) software application for electric and gas transmission facilities. Visit POWER Engineers at **www.powereng.com**.

UCLID Software
UCLID Software helps GIS managers quickly map parcels in ArcGIS. UCLID, an Extract Systems company, produces original equipment manufacturer (OEM) products for software developers and GIS software for end users. IcoMap for ArcGIS is a parcel mapping extension that helps mappers increase productivity by 84 percent on average. Title insurance companies, engineering firms, energy companies, utilities, and government GIS professionals use IcoMap. Many of the fastest growing counties rely on IcoMap to keep up with their workload. UCLID's patented technology is available to software developers in the Input Funnel Software Developer Kit (SDK). UCLID also provides professional services and workflow consulting. Visit UCLID at **www.uclid.com**.

United Services Group
United Services Group (USG), a business services unit of Great River Energy, uses ESRI software for providing AM/FM/GIS services to its member cooperatives. Great River Energy is a generation and transmission cooperative that serves 28 distribution cooperatives in Minnesota and Wisconsin. USG was established by Great River Energy as a shared services organization to provide engineering and technical services to cooperatives and municipalities in the Midwest. Visit United Services Group at **www.usgweb.com**.

URS Corporation
URS Corporation is a multidiscipline, professional consulting firm that provides full-service engineering, architecture, planning, environmental, GIS, and IT solutions. Visit URS Corporation at **www.urscorp.com**.

For more than 35 years ESRI has been helping people manage and analyze geographic information. ESRI offers a framework for implementing GIS technology in any organization with a seamless link from personal GIS on the desktop to enterprise-wide GIS client/server and data management systems. ESRI GIS solutions are flexible and can be customized to meet the needs of our users. ESRI is a full-service GIS company, ready to help you begin, grow, and build success with GIS.

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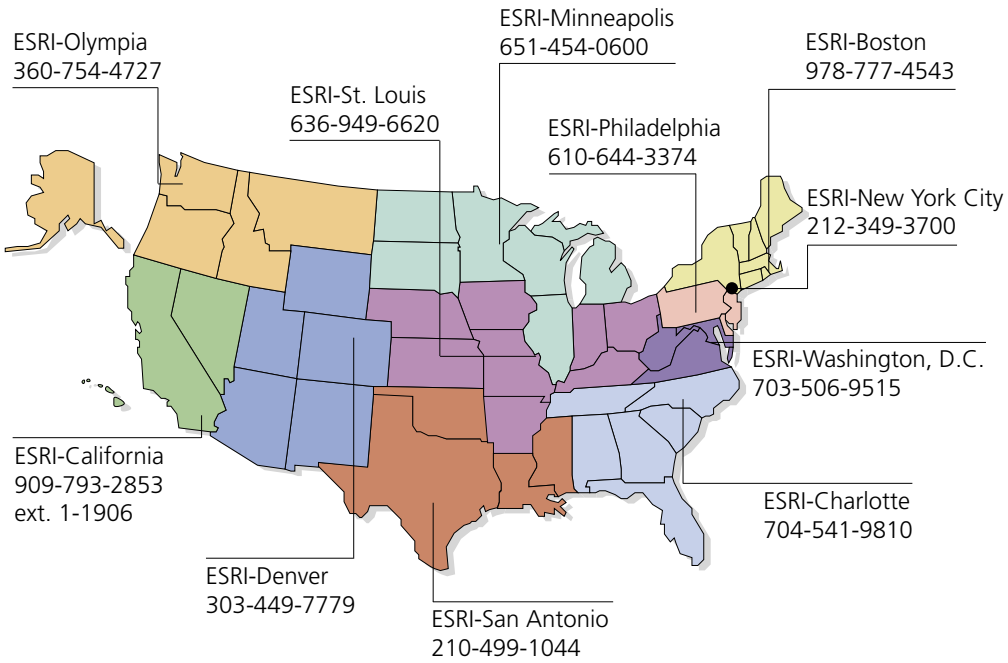

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