



Engineering Field Notes

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Vision of Opportunity

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Introduction

These are exciting times for Engineering. We face some of the biggest challenges and the greatest opportunities at any time in the history of the Forest Service. Our actions in the next couple of years will not only set the course for the future of engineering in the Forest Service, but also determine how successful the Forest Service will be and how our engineering services will be used.

I believe our skills are critical to the future of the agency and that the roles we will play will be vastly different from those we have played in the past. We are at the apex of key issues being faced by the agency: roads, recreation, healthy forests and grasslands, and watershed restoration. In order for the Forest Service Natural Resource Agenda to thrive, engineering ideas, creativity, and technical skills are needed.

In many ways, we have already begun to face challenges and recognize opportunities. The fiscal management and deferred maintenance reports prepared by the agency for Congress are just one example of the significant contributions you made this past year. The reports are a high-priority issue critical to the agency. Thank you for your outstanding efforts in getting in the November 1998 and January reports. I realize that some of you had to give up leave and most of you rearranged schedules and programs of work. The bottom line is that we got the reports in and they are having a significant effect on our business. For the first time, we can talk about our total need with some degree of certainty. I thank you.

In this issue of *Engineering Field Notes*, I wanted, as your new national Director, to share with you a vision of opportunity available to help the agency meet its mission of caring for the land and serving people. Although all of the work we do in Engineering is important, this vision focuses on four areas. By focusing on these four areas, we can make short- and long-term impacts:

1. Buildings and Facilities
2. Geospatial Data
3. Watershed Restoration
4. Forest Roads

We always seem to direct most of our attention to roads. While they are a significant part of our work load, road work is not all we do. So, I will first address several other areas that are just as important and in need of our attention.

Buildings and Facilities

There are more than 25,000 buildings, not including recreation facilities, in the Forest Service. Most of these buildings are more than 30 years old. Many of these buildings are beyond their useful life, are obsolete, do not meet current codes and accessibility standards, have been neglected or abandoned, and are simply no longer needed. Despite the hard work of caring folks in facilities, we have simply not managed our facilities in a businesslike manner. The program as a whole is broken. Because of the magnitude of the problem, the current situation is not manageable. This situation is reflected in the funding we receive. At current budget levels, we are able to replace our offices on a 300-year rotation schedule. We have sufficient Fire, Administrative, and Other (FA&O) maintenance to meet only 12 percent of the yearly need.

We need to correct the situation. Making a difference in how facilities are managed and funded is a top priority for me and for my staff. We are working hard to provide additional authorities for local managers to surplus and sell unneeded buildings and property and use the proceeds to acquire new, functional facilities in locations where they are best suited. We are working to capitalize our facilities, which means bringing them under the principles of the Working Capital Fund (WCF) for maintenance and replacement. Initially, this process will be done on a pilot basis for specific projects, forests, and regions. I am asking the Chief for successive increases in each of the next 5 years in FA&O facilities construction.

I need your help too. With additional funding and authorities will come additional responsibilities. Facilities Master Plans will have to be revised and kept current. We must reenergize the value analysis program. We must be able to demonstrate to Congress and the public that we can responsibly and consistently manage our facilities with the public interest in the forefront. Our buildings must meet health and safety standards; be accessible, attractive, and cost effective; and have the full cost of operation and maintenance accounted for. We must identify what our needs are and have incentives to dispose of inventory we can no longer justify. My goal is to get our replacement cycle down to 50 years with adequate funding for maintenance.

Geospatial Data

The information technology “revolution” is rapidly and fundamentally changing the way governments, corporations, institutions, and individuals go about their work. This change is especially true with the widespread use of geospatial information and geospatial technologies in a growing array of applications—from retail site location and crime analysis to community development, transportation modeling, and, of course, natural resource management. These technologies and applications are becoming embedded in everyday life. Maturing hardware and software, improved telecommunications, and information technology standards, along with common data and applications, are making this happen on local, national, and global scales. Clearly, information is the fuel. The lack of information or flawed information is unacceptable in today’s world.

Within the Forest Service, Engineering has been a key player in providing geospatial information and related technical support services through its Geospatial/Geometronics and Remote Sensing programs. When folks need high-quality, reliable geospatial information and technical support, they

come to Engineering. Our ability to gather, manage, and provide useful information is being tested as it never has been before. The Geospatial Service and Technology Center (formerly Geometronics Service Center), the Remote Sensing Applications Center, the Washington Office Geospatial Service and Technology and Remote Sensing groups, and the regional Geospatial/Geometronics units are taking the necessary steps to prepare for the future. We are responding. We can do more. It is my belief that Engineering can continue to provide the focus and collaborative leadership necessary to support the geospatial information needs of the Forest Service.

Watershed Restoration

The third area in which we can make an impact and which needs Engineering support is watershed restoration. It is important that we provide cost-effective support to restoration needs. Restoration support that we should provide in association with our road system includes the following:

- Planning to determine which roads are no longer needed and have the greatest risk to the environment.
- Cost-efficient decommissioning of those unneeded roads.
- Repairing environmental damage caused by roads through retrieving unstable side-cast material, restoring fish passage, reconnecting cut-off side-channels and oxbows, and relocating roads out of riparian areas.
- Upgrading roads to be more environmentally friendly by armoring and draining surfaces and ditches and using open-box low-water fords and bioengineered reventments.
- Geotechnical and hydrogeologic services.

We also have the skills needed to add value to many other restoration projects underway. These projects include the design and anchoring of fish structures, the design and stabilization of fish habitat side-channels, the construction and placement of berms and culverts for wetland enhancement, the design and construction of energy-dissipating drop structures, and restoration of stream sinuosity. Many structures, in-channel stream work, and earth work end up being temporary or high-maintenance features because simple engineering principles were not incorporated into the project. We can be of service, achieve greater benefits, and save the agency money.

Forest Roads

The fourth area is, of course, roads. Over the past few years, many questions have been raised about roads: How many roads should there be? How should they look? How has their use changed? How can they be funded? How can we restore environmental conditions that have been adversely affected by roads?

Given that the commodity haul on Forest Service roads is now estimated at 2 percent of road use and most Forest Service road use is by our recreating public, isn't it time we recognize the high-use passenger car roads for what they are? They are public roads. The vast majority of drivers on national

forest roads pay Federal and State gas taxes, but none of that tax money is available to reconstruct or maintain those roads. We need to:

- Identify public-use roads.
- Identify the funding needed to make public roads safe, environmentally sound, and mission critical.
- Secure adequate funding to repair and maintain our deteriorating roads.

For far too long we have used commodity projects to subsidize our road system. As our management emphasis has shifted to ecosystem management and recreation, the old funding sources simply cannot keep up. As a result, we have a rapidly deteriorating road system. We must work together to turn this situation around. What we have been doing in the past no longer works. We cannot depend on timber sale appropriations to bail us out. In this area, doing nothing is more risky than trying something different. The national trend is clear—the user must help pay. My staff and I are working to get our high-use passenger car roads recognized as a separate funding category under the Federal Highway Trust Fund. A precedent has been set by several other agencies such as the National Park Service and National Wildlife Refuges.

However, this funding source will not solve the entire problem. We are aggressively pursuing additional maintenance funding to meet our “critical” annual road and bridge maintenance needs. This effort will mean a doubling of our current maintenance budget. Again, I need your help. We need to demonstrate our ability to manage public-use roads through cost-effective demonstration projects that have local community support and are environmentally friendly. I also need your help in making sure we can fulfill our accountability responsibilities—we need an accurate inventory that can hold up to audit scrutiny. We also need deferred maintenance data figures that are based on sound engineering costing and are accurate and timely. We have a very short timeframe in which we can demonstrate performance in this area. In the upcoming year, we will need all of our passenger-car roads inventoried—roughly just over 80,000 miles. In addition, we will need a statistical sample of our high-clearance vehicle roads. I realize this task is a big one for the regional, forest, and district offices but the information is crucial to gaining constituent and congressional support. Our credibility, our very existence, depends on us.

Our Chief has identified roads and road policy as one of the four areas of our Natural Resource Agenda. He has been very clear and direct about what he wants from roads—to ensure appropriate public access to national forests, minimize the environmental impact associated with roads, and reduce the size of the road system to a level we can financially sustain and maintain. I am confident we can meet that challenge. When we do, there will be higher user satisfaction, less environmental degradation, more secure wildlife habitat, and more available fish habitat.

Conclusion

The following four articles provide a more detailed vision description for each of these areas. These four areas provide us with a vision and a challenge for the future. Are you up to the challenge? I am. So, let's get going!

The National Forest Service

Facility Infrastructure

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Overview

The Forest Service owns more than 25,000 administrative buildings (figure 1) with a replacement value of more than \$3 billion. The Forest Service leases more than 650 buildings at an annual cost of more than \$63 million. We have an additional 14,000 recreation buildings and more than 900 research buildings. Current appropriations provide maintenance for less than 1 percent of asset value compared with the industry standard of 2 to 4 percent. A large number of our facilities do not meet our needs for location, size, safety codes, accessibility, and so forth.

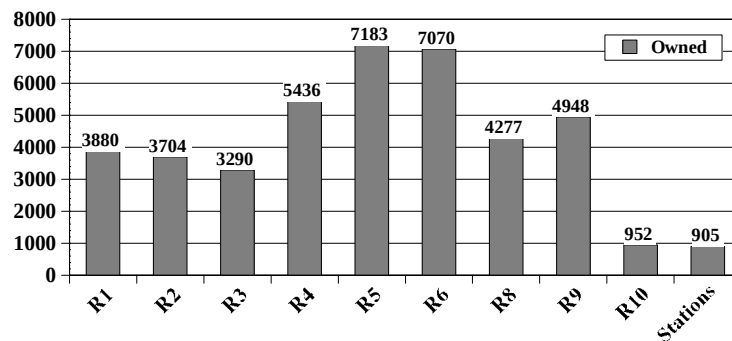


Figure 1. Number of Forest Service buildings.

Forest Service facilities provide resource program support and public service by providing work and meeting space, storage and repair areas, visitor information, operational bases, communications, and employee housing. Adequate facilities have the following benefits:

1. Quality of work-life (affects productivity, recruitment, and overall employee well-being).
2. Safe and healthy environment for employees and the visiting public.
3. Effective use of space.
4. Service to the public (public image of the Forest Service is based on visitor contact).
6. Protection of investment.

7. Ability to meet key administrative goals and initiatives such as accessibility and energy conservation.
8. Operational support to critical programs such as fire suppression and communications.

The Forest Service is changing. Changing programs have resulted in changed needs for facilities in function and location. Changes in public laws and codes, as well as unfunded mandates, affect the cost of facilities. Changes in personnel levels, working budgets, and operating methods and the need to reduce facility costs affect the current mix of facilities needed for Forest Service management.

When new facilities are needed, most forests have no option but to commit to long-term, high-cost leases. Existing facilities are often obsolete in function and difficult to maintain without major renovation to meet current policy, codes, and functional needs.

The Problem: Administrative Facilities That Are Aging and in Disrepair

Forest Service facilities are in desperate need of maintenance, replacement, and repair. Why has this occurred? Some indicators of the problem include the following:

- Approximately 60 percent of the owned facilities are more than 30 years old (figure 2). Many were built in the 1930's by the Civilian Conservation Corps (CCC). These historic structures often no longer serve administrative needs because of inadequate space, improper location, high maintenance costs, and inability to meet current codes and requirements without major renovation. Consolidation of offices and administrative sites has changed the size and location requirements for our infrastructure.

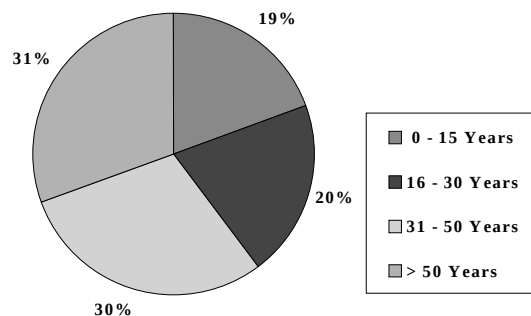


Figure 2. Building gross square footage distribution by age.

- More than half of the existing facilities have exceeded their design or useful life, suffer from inadequate maintenance, and are in need of major renovation. Figures 3 to 6 are examples of office and housing facilities that do not meet functional needs.
- Funding for replacements and renovation through the facilities construction program has not kept pace with the need. Replacement intervals for the \$3 billion replacement value exceed 300 years at historical funding levels (current average of \$10 million).



Figure 3. Older building no longer meets functional needs.



Figure 4. Attic space used as an office.



Figure 5. Reception area—inadequate visitor service.

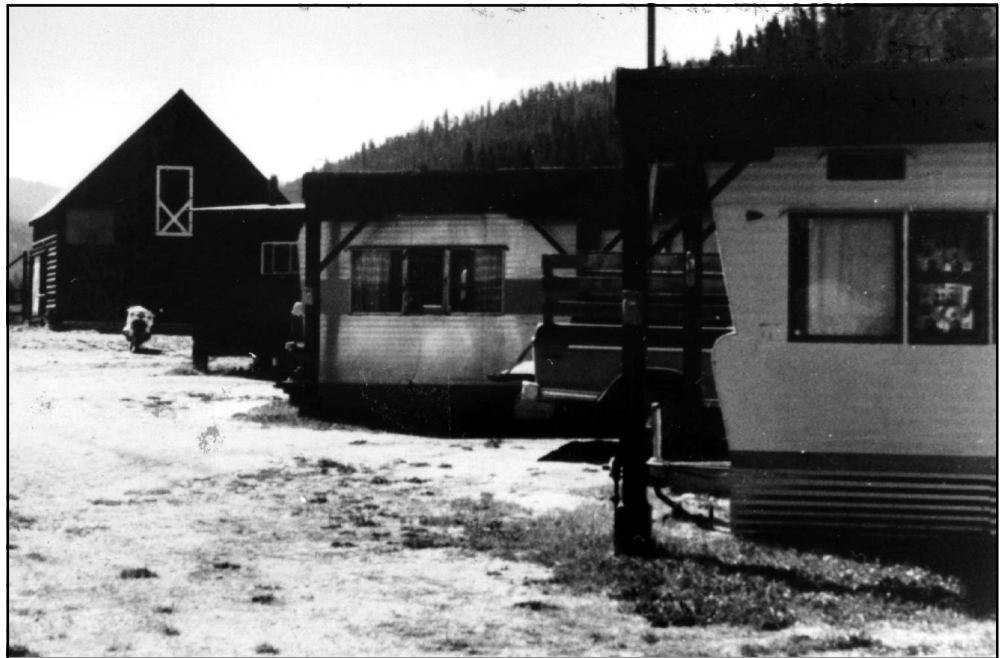


Figure 6. Employee housing at remote sites is often old trailers, never intended for long-term use.

- The 1989 report to Congressman Volkmer identified \$60 million of annual replacements necessary to keep the backlog of facility construction from growing. By 2010, more than half our buildings will be older than 50 years and obsolete unless we make plans today for their future use. See figures 7 to 9.
- Funding for maintenance has not kept pace with needs. The backlog in deferred facility maintenance grows while funding remains static. This is highlighted in the 1998 Fiscal Report on deferred maintenance and is illustrated in figures 10 and 11.
- Local offices must rely increasingly on high-cost leases to address facility needs as replacement funding is not sufficient. Lease costs are increasing as real estate values increase in mountain communities and cities. See figures 12 and 13.

Disrepair can mean a loss of public confidence in our ability to manage our assets. As illustrated in figure 14, it does not project a professional image to the public. The disrepair also contributes to safety issues for our employees and the public. It does not serve our employees or the public or demonstrate our commitment to their well-being.

Line officers and managers need incentives to dispose of properties in excess of our needs and the flexibility to realign facility space around current and projected staffing. Our facilities management should be operated in a fiscally accountable, financially sound, and businesslike manner.



Figure 7. *Bunkhouse more than 50 years old.*



Figure 8. Bunkhouse is a combination of two buildings with an addition built in the attic. Original buildings were moved from other sites.



Figure 9. Unsafe sidewalk at bunkhouse.

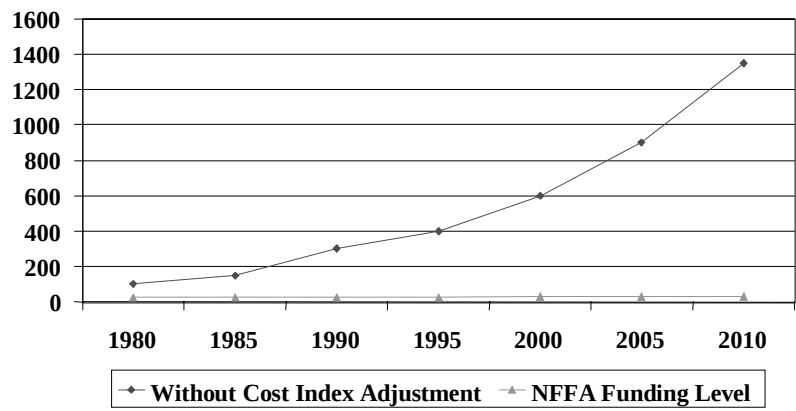


Figure 10. Budget history—CNFA (\$ in thousands)

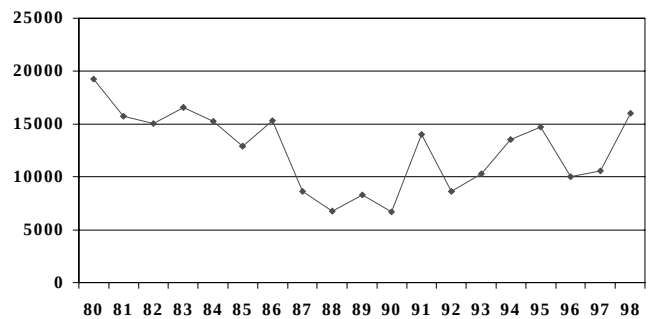


Figure 11. Backlog—NFFA maintenance (\$ in millions).



Figure 12. High-cost leased building.

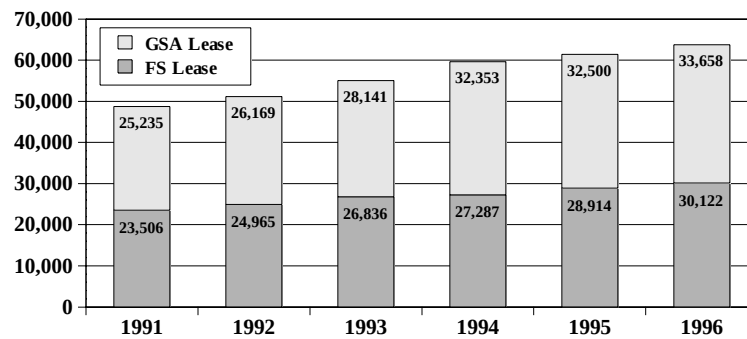


Figure 13. Lease costs (\$ in thousands)

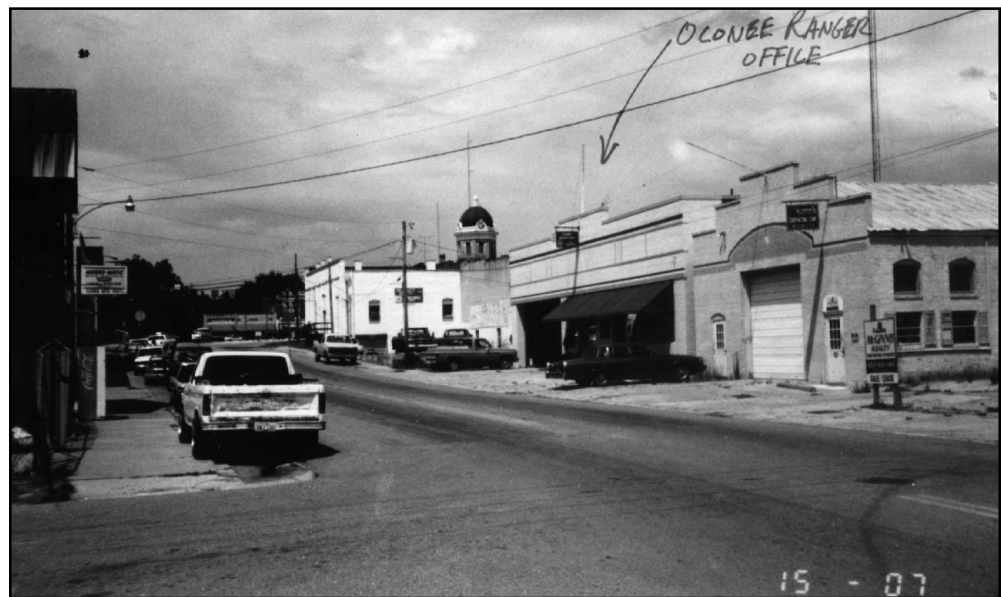


Figure 14. Lack of identity.

A Recovery Strategy

Significant delays in renovation, replacement, and maintenance are costly. The current backlog is growing at an alarming rate. Postponing investment results in a disproportionate increase in repair costs. Over time, the rate of deterioration increases, so that continued delays can cost many extra dollars and possibly result in the need for total replacement.

The Forest Service has relied on attempts to increase appropriations to address this need without significant success. While this approach must be continued, a new strategy for facilities improvement is essential. The agency facilities strategy includes the following:

- Support for new legislation to improve business practices, such as authorities to sell unneeded facilities (land and improvements), and to enhance partnerships and colocation opportunities.

- Expansion of existing authorities such as the Working Capital Fund (WCF).
- An increase in funding for facility construction to replace obsolete buildings.

The “New” Approach We are not seeking additional funding with this proposal. However, to begin the process of capitalizing existing facilities and improving management, we must be able to dispose of excess facilities and utilize the salvage value. We believe that currently proposed General Services Administration (GSA) legislation may provide the needed authority to accomplish this step.

For years the Forest Service has operated a Working Capital Fund (WCF) to secure and manage fleet, aircraft, and nursery facilities. The Secretary of Agriculture is authorized to establish new WCF operations for facilities. It is time to use existing authority to begin the process of capitalizing our administrative facilities into a Fire, Administrative, and Other (FA&O) WCF account. Such authority would enable the Forest Service to collect replacement and maintenance funds.

Replacement and maintenance funds would be collected from operating appropriations that directly benefit from the use of the facility, much as lease costs are currently collected. This approach focuses accountability to local line officers for a major part of their fixed costs. The Forest Service would be in a position to pay itself to properly manage its assets, much like the GSA does on all its leased facilities. This ability provides incentive for improved accountability of real property and accurately reflects the fixed costs of our facilities. The need to pursue high-cost leases would diminish, and the capitalizing of older facilities would allow for essential replacement, renovation, and maintenance. The new approach would give line officers an incentive to dispose of facilities that are no longer needed and the flexibility to use the funding to consolidate and replace offices. This incentive is critical to reduce the number of buildings that are no longer needed and are costly to maintain, and to minimize expenditures on facilities not of critical importance.

Appropriations for current FA&O Construction and Facilities Maintenance should not be decreased because replacement and maintenance of facilities that are not capitalized still must be enabled.

A pilot approach to beginning an FA&O WCF account is proposed to test the concept and to set in place proper business practices for operating it. The auspices of the National Performance Review effort may aid in this process. An inventory of facilities and an estimate of annual, deferred, and improvement needs based on a 5-percent sampling process was completed in fiscal year 1999. The National Facilities Review Team assessed the current facilities management practices, analyzed the inventories, and provided several recommendations to improve facilities management. A follow-up task group is working on developing a business plan to implement the recommendations. By 2001, replacement projects may be initiated, with Service-wide implementation possible by 2003.

Engineering Geospatial Program

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Introduction

The Engineering Geospatial Program consists of two major program areas: Geospatial Service and Remote Sensing. Both programs have a long history of providing geospatial products and services to Forest Service managers, scientists, and resource specialists. Field demand for base geographic data products, maps, remotely sensed imagery products, and related technical support services, including technology transfer, is increasing at an enormous rate. This increased demand is partly due to the recent implementation of the corporate hardware and software platform, which includes the geographical information system (GIS) ARC/Info and ArcView. In addition, a national image processing procurement currently underway will provide basic image processing tools to all employees. Imagery and other digital geospatial data bases used by field scientists and resource specialists are primarily provided through Engineering's Geospatial Program. But merely providing data is not enough—Engineering provides the geospatial community with extensive training and technology transfer opportunities on the many types of digital data used every day for land management purposes.

Program Areas

Geospatial Service Program

The Geospatial Service Program includes the Washington Office (WO) Engineering Geospatial Service Group, the WO Engineering Technical Center—Geospatial Service and Technology Center (GSTC), nine regional geometronics groups, and geospatial personnel located at forest supervisor and district offices. (In April 1999, the term “geometronics” was changed to “geospatial” to more accurately define the scope of the program.) The overall Geospatial Service Program mission is to provide managers, scientists, and resource specialists with maps, base geospatial data products, and related technical support services. The Geospatial Service Program includes:

- **Mapping.** The program produces base maps, which are essential for forest planning, resource inventories, search and rescue, fire suppression, communicating management proposals to the public, and other administrative purposes. They are also used to generate derivative products such as forest plan maps, wilderness maps, habitat maps, and recreation maps such as forest visitor maps. Forest visitor maps provide essential recreation and travel management information to forest visitors.
- **Geospatial Data Development and Maintenance.** The program produces and maintains digital geographic data, such as features, elevations, and imagery. The data are used to support the production of base maps and other products and are essential to the Forest Service mission. Nearly all land management decisions made within

the Forest Service are influenced by geography—the location and characteristics of things on or about the surface of the Earth. These data provide the geographic foundation for Forest Service GIS data bases and serve as the spatial tie with several national data base development efforts, such as Infrastructure (INFRA), Automated Lands Project (ALP), and Natural Resource Information System (NRIS) data base modules. These data support a wide range of GIS activities, including forest planning, landscape assessments at a number of different scales, protecting and restoring ecosystems, range management, fisheries research, recreation planning, boundary management, fire modeling, water quality assessment, infrastructure management, and many others.

- **Technical Services.** Technical support services are provided to users of geospatial data and geospatial technologies. These services include technical assistance, training and technology transfer, and applications and tools development. Through a data clearinghouse activity, the program also manages the dissemination of geospatial data to both Forest Service units and non-Forest Service customers—public and private.
- **Collaboration.** A variety of collaborative activities have been developed through cooperation with other Federal agencies in various GIS, mapping, geospatial data development, and shared technology activities. The program is managed and coordinated in a manner supporting Federal Geographic Data Committee (FGDC) programs and initiatives; National Spatial Data Infrastructure (NSDI) protocols; and Executive Order 12906, Coordinating Geospatial Data Acquisition and Access: The National Spatial Data Infrastructure (April 1994). Within the Forest Service, the Geospatial Service Program is closely coordinated with the Ecosystem Management Coordination (EMC), Information Resources Management (IRM), Lands, and Recreation programs.

As a national technical center, the Geospatial Service and Technology Center provides a suite of geospatial products and related technical support services to the Forest Service geospatial community (from its Salt Lake City, UT, location). Traditionally, GSTC's programs have been coordinated and delivered through regional geospatial groups. Today, with a growing, more demanding customer base, GSTC often works closely with field units. Also, direct collaboration with WO staffs such as EMC, IRM, Lands, Watershed and Air, and Fire and Aviation Management has become routine. Externally, GSTC maintains collaborative relationships with other Federal agencies such as the U.S. Geological Survey (USGS) and the Bureau of Land Management (BLM). Several Memorandums of Understanding and Interagency Agreements have been established over the years to coordinate programs, conduct investigations, share products and services, and leverage resources. For more information about the GSTC, please visit its website at <http://fsweb.gsc.fs.fed.us>

In 1996, the Deputy Chief of the National Forest System appointed the GSTC Steering Committee to review and validate nationally significant geospatial work that is accomplished at GSTC. Committee recommenda-

tions are made through the Director of Engineering. The Steering Committee is made up of the chairperson, executive secretary, and 9 to 11 members-at-large. The members-at-large represent a broad cross-section of users of geospatial information from all Forest Service regions and organizational levels. The committee monitors program priorities and program/project timelines and recommends funding levels to accomplish the work. In addition, the committee has the following tasks:

- Ensures that nationally significant regional geospatial and GSTC programs are planned for compatibility.
- Provides oversight of the GSTC Program of Work and supporting technical services.
- Evaluates program accomplishments.
- Identifies and evaluates future roles for GSTC on the basis of Forest Service business-driven requirements.
- Reviews requests for significant special project work and ensures they will not inappropriately affect national Program of Work assignments.

Remote Sensing Program

Engineering's Remote Sensing Program consists of the WO Remote Sensing Group, the WO Engineering Technical Center—Remote Sensing Applications Center (RSAC), and various remote sensing specialists located in the regions, stations, and areas. The overall mission is to provide the Forest Service with remote sensing products and support in technology evaluation and training and technology transfer.

From its location in Salt Lake City, RSAC provides support in technology evaluation, development, training, and technology transfer in the use of remote sensing, GIS, image processing, and GPS for all natural resource applications. RSAC is organized into four program areas: (1) Integration of Remote Sensing, (2) Liaison and Special Projects, (3) Training and Technology Awareness, and (4) Operations. The program of work that RSAC performs is determined by field units and staffs that sponsor specific technical support and training projects. The Integration of Remote Sensing Program is sponsored by the Remote Sensing Steering Committee, which includes members representing the staff areas of the National Forest System, Research, and State and Private Forestry. Funding for steering committee projects is provided by National Forest System staff areas. For more information about RSAC, please visit its website at <http://rsac.gsc.wo.fs.fed.us>

Future Engineering Geospatial Service Program Activities

Work loads at the Geospatial Service and Technology Center and at the Remote Sensing Applications Center are evolving to provide additional products and services required by the geospatial community. A synopsis of a draft GSTC/RSAC business plan outlining seven major emphasis areas is listed below. Both current and projected activities are included to highlight the changing requirements being placed upon GSTC and RSAC.

Data Acquisition, Preparation, and Integration

Current—Includes production and maintenance of base geospatial data, control information, and related derivative products; conversion of feature data to current specifications; and the Service-wide procurement of multiresolution, multitemporal satellite imagery. Products include Cartographic Feature Files (CFF's), 30- and 10-meter Digital Elevation Models (DEM's), Digital Orthophoto Quads (DOQ's), ground control coordinates, and remotely sensed imagery. Derivative data include Primary Base Series (PBS) text, Softcopy PBS, and LT4x (Linetrace) contour data in unedited Tagged Vector Contour (TVC) format.

Projected—Includes the above, plus (1) acquisition, preparation, and integration of resource data (themes and layers) meeting the Forest Service GIS Core Data Standard, including the spatial components of NRIS modules, ALP, INFRA, and other national data bases; (2) salvage and reformatting of existing and historic data to meet the Core Data Standard and needs of other applications; (3) data validation and certification; (4) production of Image Derived Products (IDP's); and (5) acquisition and integration of data developed, produced, or otherwise held by sources outside the Forest Service (other Federal, State, commercial, etc.).

Clearinghouse

Current—Includes the data dissemination activities of GSTC's Data Library. Includes retrieval of data from existing archives and writing data onto magnetic or optical media for distribution.

Projected—Transition to an on-line spatial data clearinghouse, complete with metadata and compliant with NSDI, FGDC, Executive Order 12906, and electronic Freedom of Information Act requirements. The clearinghouse will support searches for and browsing of data holdings (current and historic), evaluating suitability of data, and acquiring data. As needed, the clearinghouse will accommodate other data and metadata beyond current and future GSTC and RSAC data products such as GIS Core Data, other nationally consistent resource information, and remotely sensed imagery. Links to other data holdings external to the Forest Service, and "historical" and "snapshot" data archives will be provided. As needed, the clearinghouse will support data transactions at the individual feature level. These transactions will be supported by feature-level metadata. Externally, the clearinghouse will function as an official node of the NSDI and have direct access to the spatial data holdings of other Federal, State, and commercial sources.

Technical Assistance

Current—Includes (1) technical assistance provided to users of GSTC data products; (2) data preparation needed under the Region 3 GIS Core Data initiative; (3) support for field use of remote sensing, image processing, GIS, and GPS technologies; (4) GIS and remote sensing project design consultation; and (5) technical support for cartography and photogrammetry applications and special projects.

Projected—Expanded from above to include (1) broad assistance in GIS and remote sensing applications and the use of all forms of spatial data; (2) project consultation and support; and (3) administration of the National Geospatial Applications Helpdesk, jointly managed by GSTC and RSAC. The National Geospatial Applications Helpdesk will specifically address geospatial applications and data use issues. Depending on the needs of

requesting units, on-site assistance will be provided by qualified GIS or remote sensing specialists. Costs for on-site support would be shared or fully reimbursable. The range of services will include preparing and formatting data, troubleshooting GIS data problems, processing imagery, preparing data for map outputs, linking spatial information to Oracle data bases, and so forth. Units will also have the option of sending project employees to GSTC or RSAC to work on projects and engage in one-on-one technology transfer.

Cartographic Publishing

Current—Includes printed hardcopy base maps, produced manually or digitally for high-volume film-based lithographic printing, and softcopy Primary Base Series map images.

Projected—Includes the above, plus (1) softcopy Secondary Base Series maps; (2) Web-enabled mapping, which is the ability to compose a map product interactively using standard tools and geospatial data available over the FS Web or the Internet; (3) intelligent maps on interactive media; (4) print/publish-on-demand capabilities; and (5) standard or customized (non-Web) GIS data base viewers. The purpose of this business area is to continue to provide consistent cartographic, maplike “views” of geographic information—in hardcopy form or other—as technology and user needs advance.

Technology Assessment and Applications and Tools Development

Current—Includes development and implementation support for (1) GSTC production systems and data handling environments; (2) cartographic symbol sets for field use; (3) remote sensing, image processing, and GIS field applications; (4) Web-served geospatial applications; and (5) evaluating and, when appropriate, proposing the implementation of advanced GIS, remote sensing, image processing, mapping, data handling, and related technologies.

Projected—Includes the above, as well as support for building, testing, modifying, and implementing GIS and remote sensing/image processing applications, including specific tools and capabilities of national or corporate scope. GIS and remote sensing applications guidelines will be produced and maintained as part of this activity. New developments in GIS and remote sensing/image processing technologies that have potential to improve the efficiency of data processing and integration required for GIS Core Data implementation and maintenance will be evaluated. Technology assessment will be conducted and managed as a nationally recognized program.

Training and Technology Transfer

Current—Includes remote sensing, image processing, GIS, GPS, and cartographic courses offered by RSAC and GSTC. Technology transfer includes publishing reports and conference proceedings, conducting workshops and conferences, and supervising technical content on the GSTC and RSAC FS Web sites.

Projected—Includes above, plus (1) determining Forest Service needs for integrated, sustained geospatial-related training; (2) establishing core competencies (principles, sciences, technologies, and applications; (3) designing course content; and (4) expanding the methods of training delivery and expanding Web site content.

Standards

Current—Includes (1) maintaining standards for GSTC data products (collaborating with USGS and BLM as needed); (2) preparing the national data dictionary for the GIS Core Data standard; and (3) IREMCG-sponsored guidelines, or standards describing the use of remotely sensed data to prepare consistent products and resource information for large area assessments and forest plan revisions.

Projected—Includes the above, plus (1) serve as the national Forest Service clearinghouse for all geospatial data standards; (2) collaboratively administer the maintenance of geospatial standards; and (3) coordinate the review and implementation of these standards. Standards and guidelines addressing emerging technologies will also be developed to provide direction to field users on how to appropriately apply new technology and produce and manage geospatial information effectively.

Engineering Is Supporting Watershed Restoration

John Fehr

**San Dimas Technology and Development Center Manager
Washington Office**

There are a couple of obvious reasons why it is important for all Engineering personnel to be involved in the restoration of watersheds. First, watershed restoration and health are one of the four key areas of the Natural Resource Agenda. Second, restoring watersheds is essential to meeting the commitments we have in the Clean Water Action Plan. However, the most fundamental reason for us to be involved in watershed restoration is that healthy watersheds are essential for sustainable forests and as Engineering personnel we have skills and abilities that are needed to help restore watersheds. One of the main reasons many of us chose to work for the Forest Service was our expectation that we would be using our skills to preserve and improve the health of forests. Now we can have an essential role in doing this by helping to restore watersheds. In many watersheds that are in need of restoration work, roads have contributed to the degradation of the watershed by such consequences as changing drainage patterns and restricting the passage of fish. We have the opportunity to help change the adverse impacts of the road system and to move out from the roads into the entire watershed to help in restoration.

We have many partners to work with in improving the roads, two of the most important of which are biologists and hydrologists. To utilize engineering skills most effectively, we must cooperate with biologists and hydrologists and use their skills most effectively. Those who do not value and use the skills of all three disciplines will reduce the effectiveness of restoration work they are involved in. These are not the only disciplines that will be involved in watershed restoration, but they are essential. In the book *Watershed Restoration: Principles and Practices*, edited by Chief Dombeck, Chris Wood, and Jack Williams, the point is made very clearly about the importance of cooperation in watershed restoration. Genuine, respectful cooperation between engineers, biologists, and hydrologists is absolutely necessary for the success of the efforts we are all going to make to improve watershed health. Cooperation will help us to recognize more of the impacts that are degrading watersheds, to prioritize situations that need to be corrected, and to maximize the effects of the resources we commit to restoration.

I expect that in many watersheds, reducing the negative effects of roads on the watershed will be one of the highest priorities for restoration efforts. It may be helpful to think of the roads as the beachhead where we will start our efforts to improve the entire watershed. There will be many reasons for using roads as a starting point, but some important ones that you may not immediately think of include the ease of maintaining any structures or

other work you do for watershed restoration; often, adequate maintenance has been a major factor in determining how successful watershed restoration efforts have been. We already maintain our roads, and with creativity and training we can change our road maintenance practices to include much of the maintenance effort needed to sustain the restoration work. The people doing the road maintenance work on your unit can become important partners in your restoration efforts.

Another reason for using roads as a starting point is that we know what we need to do to reduce many of the negative effects of roads on watersheds. The Water/Road Interaction Technology Series prepared through the Technology and Development Program contains a wealth of information on how we can effectively reduce the negative effects. To help accelerate the use of this information, we will conduct two training sessions in September: one will be in Nashville, Tennessee, from September 14 to 16, and the other session will be in Reno, Nevada, from September 21 to 23. Each of these sessions will be presented for 100 Forest Service employees. We hope there will be a good mix of engineers, biologists, and hydrologists. Each session will also have room for up to 50 participants from other agencies. The Federal Highway Administration is providing the funding to support their training. Having other agencies at the training will help give us different perspectives and it will help to improve road maintenance that is outside our boundaries but may still be within the watersheds we are restoring.

We are now ready to use our engineering skills to improve our road system and we will have the opportunity to take our creativity and our skills in design and contract administration out into all portions of the watersheds to work with biologists, hydrologists, and others. We will actively work to restore meadows, uplands, riparian areas, and channels to produce stable watersheds. Engineering in the Forest Service has the reputation of being a group that is good at implementing a plan, and now we have the chance to enhance that reputation by implementing the Clean Water Action Plan and restoring watersheds.

The National Forest Road System: An Engineering Emphasis Item for the 21st Century

John Bell

**Road System Operation and Maintenance Program Manager
Washington Office**

Introduction

There is probably no single issue concerning the national forests that affects as many people, as many resources, and as many programs as the deteriorated state of the Forest Development Road System (FDRS) today. The content of the Forest Service Natural Resource Agenda certainly points out the importance of the roads issue. Roads is specifically identified as one of the four focus issues of the agenda. The goals of the other three agenda issues—Recreation, Clean Water, and Sustainable Forest Management—can never be reached unless the current problems of the road system are addressed and resolved.

Background

Construction of the road system began with an Act of Congress in 1916 and has gone on intermittently—funded with general Treasury appropriations—ever since. Construction peaked during the Great Depression, which sounds wrong until you realize that much of the work done during that time was accomplished by the Civilian Conservation Corps.

The 1960's also saw high levels of construction. Harvesting timber provided financing, and a permanent forest road system became available for multiple uses with minimal need of appropriated funds. Construction of timber-financed roads continued into the 1980's, resulting in much of the road system as we know it today.

By the 1990's, things changed. The American public began to place more importance on wildlife and watersheds relative to commodity production than it had for a generation. Federal Treasury expenditures were restricted by a desire to sustain spending on social programs, balance the budget, and cut taxes. Finally, scientists became aware of previously unrecognized adverse effects on resources—many of them cumulative in nature—of extensive road systems. As we now head “back to the future,” the level of timber harvest and associated road construction has dropped dramatically.

Current Situation

We estimate there are between 400,000 and 500,000 miles of roads in the national forests. The currently inventoried mileage of the FDRS is 386,000 miles. States, counties, and private individuals own tens of thousands of miles of roads on approved easements in the forests. At any given time there are thousands of miles of temporary roads that will be decommissioned upon completion of the task for which the roads are authorized. Finally, there are at least 50,000 miles of other roads that we call many terms including “Non-System,” “Ghost,” “Unclassified,” “Two-Track,” and

“Unauthorized.” We don’t have a good inventory on these at this time. They were created by various means such as cross-country vehicle travel or failure to decommission temporary roads for resource projects.

All system roads are required to exist for at least one specific forest management purpose. As the purposes vary greatly, the roads have been constructed to a variety of standards. A total of 85,000 miles of roads are currently in Maintenance Level 1 (blocked to all traffic for a period of at least 1 year between uses). The remaining 295,000-plus miles of roads are used regularly, although snow is rarely plowed and some roads are restricted by gates. Much of the 295,000 miles are in Maintenance Level 2, where use by high-clearance vehicles is accepted and use by passenger cars is discouraged. Only about 86,000 miles of roads are intended for use by prudent drivers in passenger cars.

In spite of the wide variety of standards and purposes, the FDRS is an integral part of the rural transportation system in America. Much of the economic activity in rural areas would not exist without the access to recreation, private inholdings, and resource commodities provided.

Use of the FDRS today is primarily for recreation. More than 90 percent of all traffic is recreation related. The Forest Service Recreation Staff estimates that more than 800 million recreation visits are made to the forests annually. They further estimate that recreation use is growing by 2 to 3 percent annually. The remainder of traffic on the FDRS is local, administrative, or commercial in nature. Timber sale traffic is now less than 1 percent of the total, a big change from the 1970’s.

The problems of the FDRS are as big as its size. More and more we hear about bridges being closed or posted with weight limits, landslides blocking roads that have not been repaired, and roads that should be available for general recreation users in passenger cars being barely passable to high-clearance vehicles. The public’s access to their national forests is deteriorating.

Only recently have we obtained definitive data on the problem. As part of the Interior and Related Agencies Appropriations Bill for FY 1999, Congress required the Forest Service to submit a report on its annual maintenance, deferred maintenance, and capital improvement needs with the President’s FY 2000 budget request to Congress. We developed standard protocols based on Federal Accounting Standards Advisory Board standards and on protocols in effect in the Interior Department. Field data were collected on a random sample comprising more than 2 percent of all road miles. The data confirmed that there is a big problem. The backlog of deferred maintenance and capital improvement needs is \$8.4 billion. Of that amount, \$2.7 billion is determined to be “critical.” (Critical needs are those that, if not met, constitute an “immediate threat” to health and safety, resources, or accomplishment of the agency’s mission. The amounts include indirect costs at FY 1998 rates.)

The congressional report also indicates how fast this backlog is growing. In its simplest form, deferred maintenance is just regular maintenance that was not done when it was supposed to be. The report indicates that the

Forest Service needs more than \$560 million annually to operate and maintain our roads. Of that, \$197 million is either “critical” annual maintenance need or unavoidable road system operational need. With congressional appropriations for road maintenance at \$99 million in fiscal year 1999, the backlog grows at least \$300 to \$400 million a year.

Failure to do maintenance when it should be done is not the only form of deferred maintenance. Deferred maintenance also includes investments necessary to bring roads into compliance with current standards. Roads are required to meet “Best Management Practices” to comply with the Clean Water Act. Road culverts are required to provide for fish passage. The watershed and fishery values on the national forests are a treasure, yet noncompliance with applicable standards established to protect them from road impacts is common. The recent report to Congress indicates resource-related deferred road maintenance is \$2.6 billion, with \$900 million of that amount being critical.

The numbers in the report display one aspect of the problem. They show the costs and needs to the agency, but the roads aren’t there for the agency. They’re there for the users. As noted above, more than 90 percent of road users are recreationists. What happens to those 90 percent-plus of users who come to recreate? The answer is self-evident. Their vehicles suffer more wear and tear than necessary and it takes longer to get to their destinations than it should.

Recreationists are not the only parties affected by poorly maintained roads. The costs proliferate in rural America. Water treatment plants are required to remove sediment that should not have entered the waterways. Reservoirs fill with silt. Fish spawning beds are smothered. Commercial users waste time on poor roads getting from point A to point B, and to them time is money. Yes, the harmful effects are endemic.

Solutions

In their simplest form, the problems of the FDRS boil down to a disconnect between the number of roads on the system and the funds available to maintain them at a level that provides necessary public access and complies with applicable standards for environmental protection and public safety. The recent report to Congress indicates current road maintenance needs are more than \$560 million per year. Current road maintenance funding is \$99 million per year.

As described in the document *Charting Our Future ... A Nation’s Natural Resource Legacy*, we need sufficient funding to restore necessary roads to a safe, environmentally sound condition and to close and stabilize unnecessary roads. We need to protect and manage cautiously the relatively few remaining roadless lands. Primary actions that will be taken to improve access for all forest road users while protecting healthy ecosystems include:

- 1) Determine the best way to provide all Americans with access to the national forests. Based on sound science, we will develop new tools and analytical procedures to use in deciding when—or if—new roads are needed.

- 2) Accelerate the pace of decommissioning unneeded substandard roads that damage the environment.
- 3) Selectively upgrade forest roads. We will restore and improve the key roads needed for recreation, rural access, and a sustainable flow of goods and services.
- 4) Seek additional funding sources for the transportation system.

No matter what happens in the arena of new laws and appropriations, one thing will not change—our ongoing partnerships with State and local governments providing coordination, planning, development, and maintenance of the shared rural transportation system in America. Most national forests have cooperative road agreements with counties in their area. Forest engineers and forest road managers are on a first-name basis with their counterparts in State and local government. We have a successful method for investing in public agency roads needed for national forest management through the Forest Highway Program. These are long and successful partnerships. If funding is obtained from the Highway Trust Fund for a system of “Public” Forest Development Roads, we do not want that funding to come at the expense of these partnerships or at the expense of the Forest Highway Program. (That program has at least a 50-year backlog of reconstruction needs at current levels of appropriations that must also be addressed.)

Implementing our new agenda for forest roads will improve service to users, protect environmental values, enhance public safety, mitigate environmental impacts, promote viable local communities, diminish annual debate over Forest Service road appropriations, and boost the public credibility of our natural resource management.

These are exciting times for Forest Service roads engineers. The roads remain controversial, but the controversy has shifted. A consensus is building that a system of roads meeting applicable standards is essential for providing public access to the national forests. The consensus recognizes that much is wrong with the roads as they exist today. The fact that the FDRS is one of the four items in the Natural Resource Agenda clearly demonstrates that concern. Solutions will be found. We are in a position to help shape and implement those solutions.

1999 Forest Service Engineers of the Year

From the list of excellent candidates, the winners of the 1999 Engineer of the Year awards were selected. Congratulations to the following winners:

- Managerial—Robert Sutton from the Sierra National Forest in Region 5.
- Technical—Belinda Walker from the San Bernardino National Forest in Region 5.
- Engineering Technician—Greg Bohls from the Black Hills National Forest in Region 2.

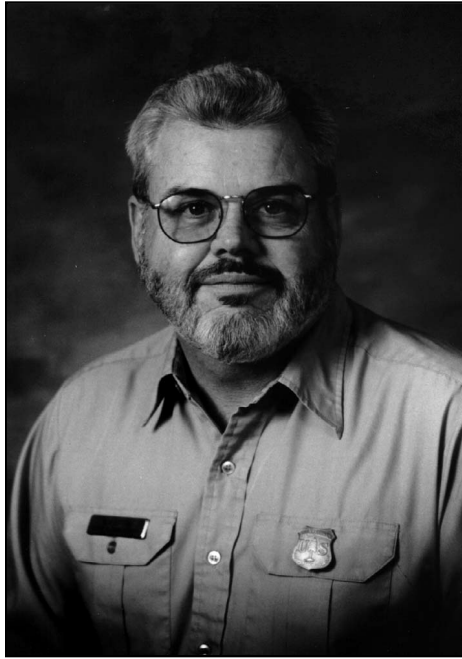
In recognition of their achievements, the Director of Engineering presented each with a special plaque and cash award at a ceremony in Washington, DC, on April 8, 1999. Members of the executive leadership team and the winners' families were among those who attended the ceremony. A summary of the winners' accomplishments is included on the following pages.

Congratulations to those who were selected to represent their regions as candidates for the 1999 Forest Service Engineers of the Year. The following are the finalists in all of the categories:

Managerial	Technical	Engineering Technician
Earl Applekamp	Susan Colyer	Larry Shepherd
Suzanne Buntrock	Kurt Kretvix	Tim Rollins
Terry Warhol	Jeffery Gabardi	Shane Belliston
Kevin Korman	Lawrence Chitwood	Billy Ellis
David Dercks	William Sullivan	Charles Warren
		Larry Felts
		Terry Poe

Robert Sutton

Managerial Engineer of the Year



As the Forest Engineer on the Sierra National Forest, Robert (Bob) Sutton is recognized as an integral member of the forest management team. Bob is an exceptional manager who provides leadership in many areas, including technology use and development, facilities management, and local and regional initiatives. His commitment and dedication have been recognized with numerous awards from the Sierra and Region 5, including being selected as Regional Engineer of the Year in 1995 and 1998.

Bob has provided consistent leadership in technology use and development by encouraging the use of new systems and products. After a bridge approach was washed out and a wall

failed in the 1997 flood, Bob advocated the use of “Terramesh” to stabilize the bridge approach and the placement of a unique drainage system behind the reconstructed wall. He has provided direction in the development of a new facility to help disabled persons get into boats. This unique access ramp is now being considered at boat ramps throughout Region 5. Bob’s continued support of the use of AutoCad has resulted in the Sierra being recognized for its AutoCad capabilities. When the Federal Highway Administration (FHWA) needed a detailed inventory of forest highways, Region 5, in part, relied on the Sierra to develop and implement an AutoCad method of collecting and displaying the data. Bob has also provided leadership in the development of a number of unique and innovative designs that provide accessible recreation facilities and the construction of a trail bridge that uses stringers salvaged from a failed road bridge.

Bob’s leadership in facilities management is reflected in the type and quality of many of the Sierra National Forest buildings. Examples of his efforts to acquire quality structures include the following:

- The Supervisor’s Office: When the Federal Building in downtown Fresno no longer had room for the Sierra, Bob was in charge of finding a location for the new Supervisor’s Office. After difficult political negotiations, the Sierra office ended up in an excellent location in a leased facility that continues to meet the needs of its employees and customers.
- The Fresno Air Attack Base: When the Sierra was notified by the City of Fresno that the air base facilities were a “blight on the landscape,” Bob headed the team that sought to replace the World War II-vintage

structures. The team—which included personnel from the City of Fresno and the State of California Department of Forestry—put together a plan to build a new state-of-the-art facility that has served as a model for others.

- The Minarets Ranger Station: When the historic Minarets Ranger Station burned to the ground on a Saturday morning, Bob was one of those who responded. By Monday, he had a package together that included a replacement cost estimate. He guided the project through the planning, design, and construction phases. The district now has a new ranger station that blends into the historic compound and provides a modern and productive work environment for the Minarets District.

The following contributions to the Sierra management team demonstrate areas in which Bob has provided exemplary leadership:

- Providing active and positive leadership during the current reorganization of the Sierra. Bob has championed reorganizing in an effort to reduce fixed costs while maintaining as high a level of service as possible. He has organized several key meetings to initiate the plan and led the reorganization presentation at the Regional Office.
- Supporting the Sierra's human resource and civil rights efforts, including chairing the Human Resource Committee for 5 years and serving as an instructor for civil rights training.
- Providing direction in the reorganization of the administrative function for the Southern Sierra Province. A three-forest operations team was established to handle a majority of the administrative work load. While serving as Acting Administrative Officer, Bob provided direct oversight in this reorganization and received a Certificate of Merit for his efforts. The Regional Forester praised this team as the best example in Region 5.
- Serving as the longest standing member of the forest safety committee and providing employees with a safe and positive work environment.
- Organizing recovery efforts after the January 1997 flood. This effort included not only the typical engineering areas such as roads and facilities, but also other areas such as trails, meadows, and archeological, and other resource areas.

In addition to his efforts on the Sierra, Bob has also demonstrated leadership at the regional level. When Region 5 wanted to institute a new process to manage the Capital Investment Program, Bob volunteered to lead the committee and make the presentation to the Regional Forester. As a result of his leadership, a new system was designed and implemented. The success of the program is measured not only in the dramatic decrease in carryover construction funds, but also in the tremendous understanding and acceptance by those involved throughout the Region. It now serves as a model process that another region is looking to adopt.

Bob was also a key member of the committee that put Engineering Skills Plan for the year 2000 (ESP2000) together. ESP2000 has encouraged skill sharing across forest boundaries. It has led to the retention of key engineering skills during downsizing. It has been a very successful program that is being looked at as a model for skill sharing in other functional areas.

Bob's leadership is best reflected in the engineering work force on the Sierra. Despite losing eight employees to the buyout in 1998, all of Engineering's key objectives were met including a broad variety of projects that added up to approximately \$4 million under contract. Projects included Emergency Relief for Federal Owned projects (ERFO), timber sales, boating ramps, a campground, trails and trailheads, building roofing, forest ecosystem restoration and maintenance, and other flood recovery projects. In addition to contracting, Bob also coordinated skill sharing with the neighboring forests to accomplish the work. These results have been produced with excellent fiscal management. Despite the ever-changing fiscal climate, Engineering routinely closes the year without deficits and with strict observance to fiscal integrity.

The accomplishment of the program of work can also be tied to the strong working relationships Bob has established with his employees and other Federal, State, and local agencies. Bob has consistently encouraged his employees to advance their careers through education. As a result of Bob's encouragement, a significant number of engineering employees who have served on the Sierra under Bob's tenure have seen their careers progress to the Regional Office or Washington Office level. Others have become District Rangers or Forest Engineers.

Bob has been very active in the local community throughout the years. He worked on a committee helping to put together a master plan for State Center Community College District that will serve as a guiding document for the junior colleges in the local area. Bob also participated in the job-shadowing program for Commencement 2000 and is active in parent programs at both Cal Poly at San Luis Obispo and Menlo College.

In addition to his community support at the college level, Bob has coached both baseball and soccer and served as a soccer referee, supported Clovis High School by serving as a chaperone for the band and participating in numerous fundraisers, and served as a judge for the science fair for the Fresno Unified School District. Bob has helped out with some of the special education classes including donating and helping with two computers. He also provided civil rights training for Clovis High's human resource crew.

Bob received a Bachelor of Science degree in Civil Engineering from Cal Poly at Pomona in 1971. He returned to college and received a Master of Science degree in Transportation Engineering from the University of California at Berkeley in 1976. Bob has kept abreast of current engineering practices through training sessions and workshops. He also has completed HAZMAT training via the Internet.

Bob is a proven leader who has demonstrated both professional and managerial skills. His contributions range from the local and regional to national levels.

Belinda Walker

Technical Engineer of the Year



Belinda Walker provides technical expertise as a staff engineer at the San Bernardino National Forest, a technical specialist in environmental engineering on a shared services basis in Southern California, and a consultant to other forests and units statewide and regionally on a case-by-case basis. She has been recognized by many forests and other agencies for her expertise in various aspects of specialized engineering. In 1997, Belinda was recognized by the Forest Service and the U.S. Department of Agriculture (USDA) as the Environmental Engineer of the Year, and in 1998 she was an Honorable Award Winner of the Annual Federal Environmental Engineer of the Year.

Belinda was also instrumental in the recognition of the San Bernardino National Forest as the recipient of Region 5's Forest Hazardous Materials Program Award in 1997. In 1996, Belinda was selected from a candidate pool that included environmental professionals from 18 national forests in California to be the recipient of the Individual Hazardous Materials Program Leadership Award.

As demonstrated by her many awards, Belinda is recognized as a regional expert in many aspects of environmental engineering. She has written or reviewed many environmental engineering specifications and is a strong advocate for having good technical and economic analysis in the design process as a basis for decision making. She has particularly stressed the integration of environmental engineering concepts into Forest Service engineering practices.

Belinda has assisted forest engineering, ecosystem, watershed, and resource projects. She has demonstrated her expertise in the following areas:

- Abandoned Mines—Conducting site discoveries, assessing and reporting on site hazards and natural resource damage assessment, and prioritizing sites for reclamation/remediation.
- Hazardous Materials Management—Providing guidance in hazard communication compliance, transportation of hazardous materials, storage of hazardous materials, use of hazardous materials, and hazardous materials management inspections.

- Hazardous Waste Management—Giving instruction in hazardous waste storage, hazardous waste transportation, and hazardous waste disposal; developing site-specific contingency plans for hazardous waste storage areas; and performing hazardous waste management inspections, on-scene coordination of chemical spill cleanups, and assessments of brownfields and other property slated for exchange.
- Emergency Response—Developing forest contingency and emergency response plans for hazardous materials on National Forest System lands, including acting as a liaison with local and State emergency response commissions and designing response actions at uncontrolled hazardous waste sites.
- Comprehensive Environmental Response, Compensation, and Liability Act (CERCLA)—Performing preliminary assessments and site inspections of hazardous waste sites and removal/remedial actions and natural resource damage assessments, and assisting the Office of General Counsel in pursuing cost recovery.
- Federal Facilities Compliance—Implementing the Interstaff Federal Facilities Compliance Program Action Plan; developing and maintaining budget; and developing the Federal Agency Pollution Abatement and Prevention Project Plan and surface water treatment plants, asbestos and lead management/abatement, and storm water monitoring programs and plans.

Belinda serves as the Contracting Officer's Representative for Professional Environmental Services contracts. In this function she initiates corrective action to achieve compliance with applicable Federal, State, and local laws; assists inspectors Region-wide in the interpretation of difficult contractual problems; and provides guidance for negotiations, change orders, work orders, and general contractor relations as well as recommending changes to existing contracts to provide conformance to good engineering and environmental practices. Belinda assists the Region in the development of specifications for requests for proposals for environmental services contracts and subsequent evaluations and selection of environmental engineering contractors. Belinda has been selected 2 years in a row by her peers to serve as the chairperson of two selection panels to evaluate and select contractors for Region-wide environmental contracts.

Belinda constantly works with the public and other agencies on many issues, including requests for environmental information, contracts, restoration of property that the Forest Service is acquiring, land exchanges, county liaison, emergency responses to the release of hazardous substances, and watershed repairs and studies. She deals with other agency representatives both on a project and program management level and on a daily working level with technical specialists on design details.

Shared services positions covering multiple forests have been set up to provide services with the limited resources available in Region 5. As one of a few environmental engineers in Region 5, Belinda performs shared services project work for the Southern California province, the Regional Office, and

other forests that may require assistance. The following are examples of major projects for which she has provided technical leadership.

During the early 1990's, both the Office of Inspector General and USDA conducted audits of USDA's agencies to determine their compliance with environmental laws and regulations. On both occasions, it was recommended that the Forest Service develop and implement Regional Office oversight on the forests, with adequate frequency and depth to ensure program performance and success. Belinda volunteered to become a member of Region 5's Environmental Auditing Subcommittee and subsequently developed the training manual and inspection guide that is currently being used by Region 5 forests to conduct audits of the Environmental Engineering Programs. In addition to this, Belinda trained all 18 Region 5 forests on the implementation of the auditing program and serves as member of the Region 5 inspection team when annual forest oversight visits are performed. The inspection manual will be used by other regions and possibly the National Park Service in development of their environmental engineering compliance audits. Cost savings (a result of the program, manuals, and training being prepared and performed by Belinda) of more than \$100,000 have enabled this requirement to become a reality.

With the recent rounds of base closures, surplus military property has become increasingly available. In keeping with the true spirit of recycling, Region 5 has requested and received buildings and land to replace currently leased office space. Belinda has consistently taken the lead on interpretation of environmental restoration documentation and clean-up issues (using the latest technology) at four Superfund sites and has rapidly become recognized as the Region's expert in this arena. Belinda has prepared reports for the Office of General Counsel, U.S. Navy, and the City of San Bernardino documenting the requirements for technology to be used to make these properties usable. Cost savings from these evaluations and subsequent development of contract specification performed by Belinda have been estimated at more than \$200,000 for these four sites.

The Cleveland, Los Padres, and San Bernardino National Forest asbestos and lead programs, managed by Belinda, include well over 500 structures that require inspection, reinspections, and abatement. Inspection surveys were performed in-house due to her insistence that to be confident in the evaluation of the cost and techniques used to abate the hazards, you must observe the hazards firsthand. Completion of the asbestos inspections programs as well as preparation of the required survey reports, management plans, and contract specifications for abatement were accomplished by Belinda at a cost savings estimated at more than \$250,000. Belinda was instrumental in ensuring that all team members had the required State certification, training, baseline physicals, and the necessary protective personnel equipment.

The San Bernardino National Forest has a very large surface water source that serves 15 developed sites. Belinda interpreted the California Surface Water Treatment Rule and designed/developed contract specifications and performed oversight for construction and installation of a state-of-the-art microfiltration/chlorination system that has since become a standard

design for other municipal water treatment plants. This project was applauded by the local water regulatory agency as fully meeting the intent of the Surface Water Treatment Rule and for including in the design various contingencies to ensure protection of the public health. The system was designed to operate without the continued presence of a plant operator, to alert a remote location of system failure, and to prevent delivery of untreated water to the public in the event of system failure. As a result of a process that neutralizes backwash water, no hazardous wastes are generated at this site.

In addition to providing training on environmental compliance auditing, Belinda has conducted training to many forests and in regional training sessions in Region 5 on underground and aboveground storage tank installation and management; siting, location, design, and management of hazardous material storage facilities; emergency response to chemical spills; and storage and management of chemicals and remediation techniques for hazardous waste sites. She has provided more than 200 hours of classroom and hands-on training to Region 5 engineers and technicians and assisted other regions with their training format and classroom materials.

She is a mentor in the Forest Service career development program and is working with a local university to provide volunteer opportunities for students in their environmental engineering co-op education program.

Belinda has been chairperson of many committees and workshops, including the Environmental Services Contract Selection Committee and regional training workshops. Belinda is also the Region 5 representative on the National Technology Development Committee for Engineering and Roads.

In addition to being the chairperson of her neighborhood watch association committee, Belinda contributes to her community by supporting the recycling committee, Girl Scouts, and a local elementary school. Belinda has been involved both with Forest Service and local area recycling issues for years. She is the Cleveland and San Bernardino Forest's Recycling Coordinator and has been instrumental in setting up programs geared toward recycling toner, computer printer cartridges, alkaline batteries, and ammonia from blue-line machines. Belinda is currently working with her daughter's Girl Scout troop and has supported the troop through donations of time, supplies, and funding. Belinda was recognized this past summer by the troop leaders at her daughter's bridging ceremony as one of the troop's strongest supporters. She is an active member and volunteer at her daughter's school. Helping to offset the high cost of education and related expenses, Belinda has donated time and supplies to every event from the school's annual carnival to the graduation ceremony for the eighth grade students.

Professional development and maintaining proficiency in environmental engineering is an ongoing concern for Belinda. She shares her knowledge with others and actively promotes continued education for her co-workers. Belinda received a BS in Civil Engineering from the University of Alabama in 1981. To continue to meet the demands of the increasingly stringent environmental engineering field, Belinda has pursued and completed the University of California's certificate program in Environmental Engineer-

ing Management. Belinda maintains State certification in Asbestos Inspection, Asbestos Risk Management Planning, Lead-Based Paint Inspection, and Lead-Based Paint Risk Assessments and has worked with and encouraged other environmental professionals to obtain and maintain their certifications. Belinda is also an active participant in the San Bernardino County District Attorney's Environmental Crimes Task Force.

Belinda continuously exceeds in accomplishing her regular program of work as well as a wide variety of extra projects. She is often asked to provide assistance to other functional areas, helping with design, planning, and execution of watershed, ecosystem restoration, and resource projects. She leads by example through her willingness to accept and accomplish numerous assignments.

Greg M. Bohls

Engineering Technician of the Year



Greg M. Bohls is an outstanding engineering technician on the Black Hills National Forest in Region 2. He has been consistently recognized for his performance and has made significant contributions at all levels of the organization.

Some of Greg's specific accomplishments follow:

- Providing contract administration on five timber sales, three Emergency Relief for Federal Owned (ERFO) (flood repair) projects, one stream stabilization project, and two National Guard summer projects in 1998. In addition to these activities, Greg planned, designed, and prepared contracts for the five timber sales; performed preconstruction activities for an ISTEA parking lot and two ERFO projects; and assisted in the completion of the Mickelson Trail.
- Planning, designing, and constructing a trailhead, camping facility, and trail system on the Black Hills. Because the facility was constructed in a semiprimitive, nonmotorized environment, new and innovative design techniques were used to allow for maintenance-free use. Many designs related to horse corrals and other facilities have been requested and used throughout Region 2 and the Nation.
- Serving as the leader for the Black Hills' cost estimating team. In this capacity, he is a proven expert in cost estimation and has provided leadership in converting the cost guide to metric units and in making it accurate and easy to use.
- Receiving numerous awards including a Certificate of Merit for Outstanding Performance and a Perfect Safety record under an exceptionally heavy work load in 1998.
- Providing technical guidance in the development and construction of the Cook Lake Recreation Area. This was a \$450,000 reconstruction/construction campground project that included constructing facilities and drilling three water wells.
- Completing data entry for more than 100 bridge inspection reports while on detail to the Supervisor's Office. During this detail, he also prepared photo reports for facilities and tallied information of existing building structures from 1937 to 1987.

In addition to these accomplishments, Greg is recognized for his technical expertise in many areas, including:

- Erosion control methods and geotextiles. He is often consulted for reviews, material selection, and advice concerning geotextiles and geogrids for construction purposes, erosion control methods, repair work for watershed projects, and slope stability projects. In order to enhance his expertise in this area, Greg is pursuing certification in Land Management and Erosion Control and Geotechnical Engineering Technology.
- Engineering Drafting. He participated in a major effort in standardization for the Black Hills of typical engineering drawings and the application of standard computerized AutoCad drawings. Greg has trained and advised other engineers and technicians throughout the region on a variety of drafting topics.
- Photography. As a still photographer, Greg has photographed infrared aerial images of wild land burn areas used to determine tree stress. He has also extensively used his skills for construction documentation, public presentations, and training.

Keeping up with new technology and professional development are priorities for Greg. Since 1982, he has been taking U.S. Army engineering courses and has accumulated 220 hours of coursework related to engineering. He is currently pursuing the requirements for the construction engineer course. Greg is also enrolled in the South Dakota Department of Transportation Roads Scholar program and has taken a variety of transportation and management courses. He recently completed the requirements for the Junior Level Roads Scholar program and received a certificate of excellence. He is also preparing for the NICET's Certified Civil Engineering test.

Greg has also received high scores on his construction certification examinations and has helped train many individuals for these exams as well as for other technical and contract administration courses. He is currently certified in all construction certification categories.

Greg has also sought opportunities to share his expertise with others. Examples include writing an article for *Engineering Field Notes* and participating in organizations that provide training experiences. Greg also serves as an advisory committee member for the Lake Area Vocational Technical School for the Engineering/Architectural Drafting Technology program. He has also served as the coordinator for the Southern Africa Manpower Development project and provided supervision and training to an engineering student from Botswana as part of the program.

Examples of Greg's technical expertise are also evident in the leadership roles he has undertaken. Greg has served as an acting Project Team Leader and expert panel member for an Advanced Contract Administration Workshop. In addition, he has volunteered for assignments as the Bearlodge District Engineer and the North Zone Safety Officer. As the District Engineer, he was a Division Group Supervisor responsible for emergency repair of Forest Service roads damaged by extraordinary floods.

The repair work included working with the Federal Highway Administration to obtain ERFO road funds. Efforts resulted in approximately \$1,400,000 to be used for repairs. As the District Engineer, he also prepared a contract for geotechnical drilling, design, and repair of several of the flood-damaged areas. As the North Zone Safety Officer, he was responsible for rewriting the zone safety plans and job hazard analyses. He also was an active participant on a team that rewrote the forest safety plan.

In addition to his work on the advisory committee for the Lake Area Vocational Technical School, Greg is very active in his community. He has volunteered his time to many projects including the following:

- Providing leadership in his church as the teacher for the first and second grade youth education program, youth activities director, historian, meeting recorder, and treasurer. He is currently involved with a program for new members of the church and has been a facilitator for a healing process program, for divorced, widowed, and separated individuals.
- Constructing part of the City of Spearfish's bike trail.
- Coaching Little League baseball teams, supporting the South Dakota Special Olympics Program, and participating in numerous fundraisers for various organizations, including the American Cancer Society.
- Cutting firewood for Native Americans on the Pine Ridge and Rosebud reservations who were running out of wood for heat during a winter when the temperatures were 40 to 50 degrees below zero.
- Speaking as a guest lecturer at the Black Hills State University Photography Workshops.

Greg Bohls is a dedicated individual with a wide variety of experience. He accepts additional challenges with a positive attitude and commitment to provide the highest quality of engineering services available.

Reducing Aggregate Surfacing Maintenance

Steve Monlux
Materials Engineer
Region 1

In 1997 and 1998, Region 1 evaluated the benefits of adding bentonite clay and calcium chloride flake to in-place aggregate surfacing. This evaluation was done by comparing results of short test sections on two projects. Prior to treatment, one project had serious washboarding that required blading three times per year and only provided a safe riding surface for several days after each blading. The other project had a history of serious pothole development on bridge approaches shortly after blading.

Field comparison tests show that either bentonite clay or calcium chloride flake reduce blading maintenance by significantly reducing washboard and pothole development. The addition of these products to the existing aggregate provides significant improvements in the safety and riding comfort of the surface and has the potential for reducing costs by reducing the frequency of road surface blading. Other benefits include less aggregate loss, less surface erosion from freshly bladed surfacing, and less airborne dust.

Copies of the reports are available from Steve Monlux, through IBM (smonlux/r1) or e-mail (smonlux/r1@fs.fed.us).

RoadEng™—Road Survey and Design Software

Sam Carlson
Transportation Development Group Leader
Region 6

Chuck Vantoorn
Marketing Representative
Softree Technical Systems, Inc.

The following article is provided as an example of the type of software being developed for low-standard road design. This software is being used by Region 6 and other regions. This article is provided for information only. Engineering Field Notes does not endorse or approve any product or service to the exclusion of others that may be suitable.

Several regions have adopted RoadEng™ for low-standard road design. RoadEng™ has similarities to Forest Service road design software such as FLRDS and RDS. Working in cross-section, it allows horizontal and vertical offsets from P-line stations. It will calculate cross-sections, catch points, earthwork quantities, and mass balance. Geometric design is optional.

RoadEng™ operates in Microsoft Windows™ and prints hardcopy without using CAD software. It allows both English and metric units and can convert between the two.

The following example illustrates the use of RoadEng™ for forest road survey and design.

Entering P-line Survey and Cross Sections

Field notes, consisting of P-line data and perpendicular side shot(s), are entered in the survey/map module. Stream locations can be entered for culvert design and ground types for slopes and earthwork calculations (the user defines cut/fill angles and expansion/compaction for each ground type). Surveys can be done by compass, chain, and clinometer; EDM; or theodolite.

The computer screen illustration in figure 1 shows a typical chain and compass road centerline survey with single side shots.

Creating a Road Template

A road template needs to be defined before beginning a design. This definition is done by specifying road width, ditch parameters, surfacing depth, and cut/fill slopes. Figure 2 has metric units and in this case the cut and fill slopes are automatically determined from the ground types specified in the survey notes.

Designing the Horizontal Alignment

The next step is horizontal alignment (for lower standard roads this step is not necessary; the road centerline is assumed to be the P-line). As with RDS and FLRDS, offsets can be produced numerically from P-line stations in cross-section.

Survey/Map - [T130.DB1]

File Edit Station Coordinates View Module Window Help

Station	Typ	Fore Azim	H.D.	S.D.	Slp.(%)	SSL Slp.(%)	SSR Slp.(%)	GND	CRK	Label
	FS	54.0	39.9	40.0	8					
173.9						-67/..	55/..	OB		
	FS	33.0	24.0	24.0	-1					
149.9						-60/..	50/..	OB		
	FS	344.0	39.0	39.0	-5					
110.9						-64/..	55/..	OB		Reference Point (0+36
	FS	356.0	36.0	36.0	3					
74.9						-60/..	58/..	OB		
	FS	354.0	34.0	34.0	5					
49.7						-68/..	60/..	OB	600	600 mm metal pipe
	IFS	354.0	8.8	10.0	-55					
41.0						-68/..	60/..	OB		
	FS	358.0	41.0	41.0	3					
* 0.0						-72/..	63/..	OB		

For Help, press F1

NUM

Figure 1.

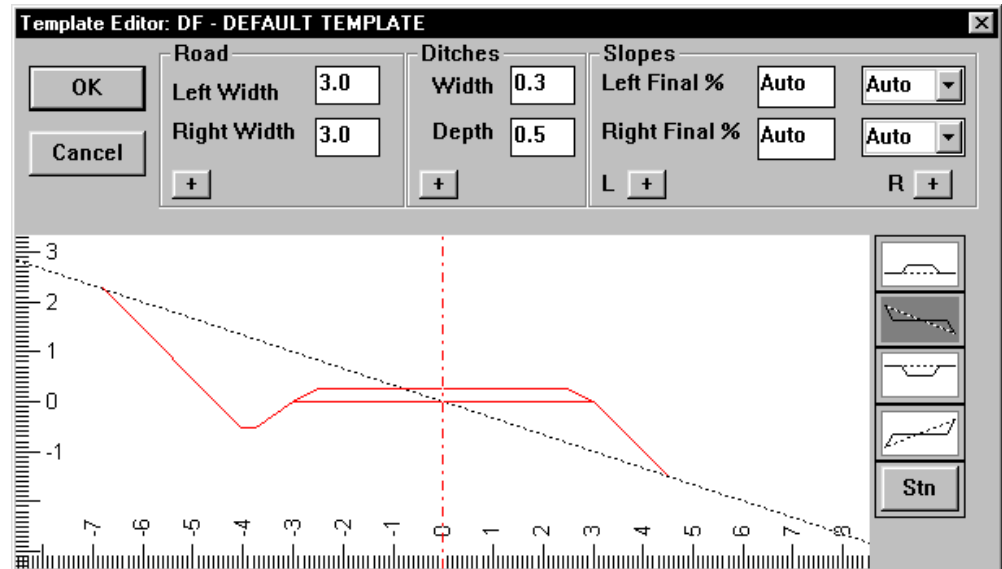


Figure 2.

Alternatively, using the mouse in plan view, intersection points (IP's) can be inserted anywhere from the P-line (even skipping several P-line stations). This is an interactive type of design where mouse actions result in automatic numerical and graphical feedback such as offset distances and cut/fill limits. In cross-section, the road prism shifts relative to the topography after the IP is moved in plan. See figure 3.

Curves can be added and the positions of the begin/end curve (BC/EC) are determined automatically from the curve radius. The position of the

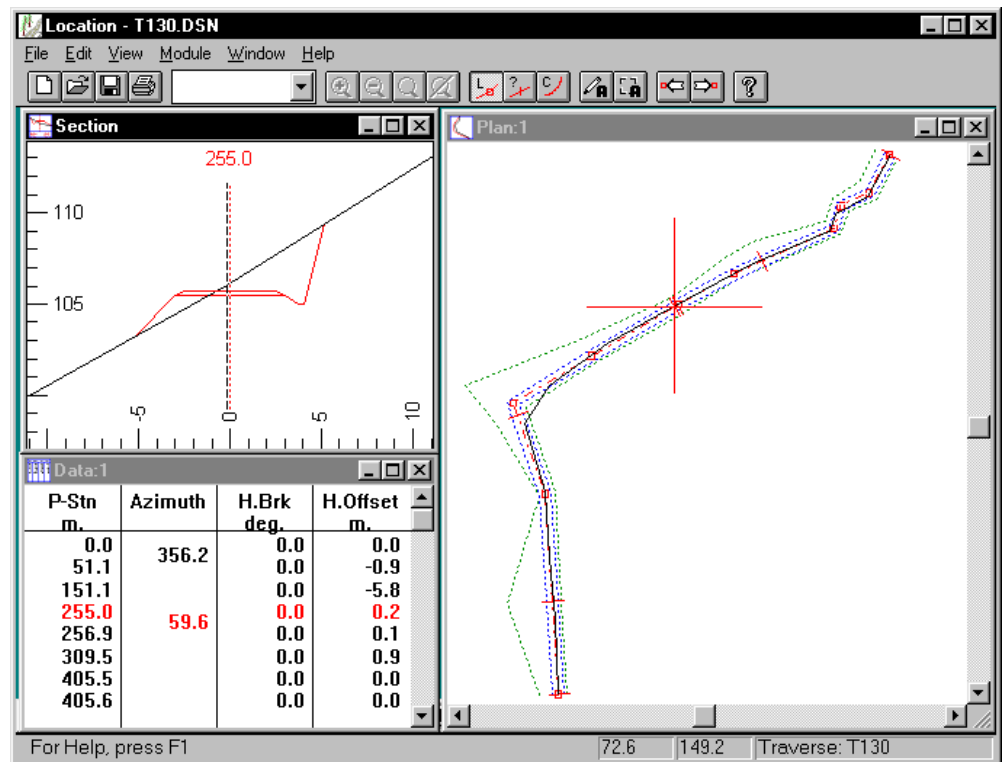


Figure 3.

catchpoints is automatically calculated and can be displayed numerically and graphically.

Figure 4 shows the road centerline (dash-dot) and edges (inside dot) as a 40-meter radius curve and the P-line (solid) as straight tangents. The cut and fill catchpoint limits are the dotted lines outside the road edges.

Designing the Vertical Alignment

Similar to the options for horizontal alignment described above, the vertical alignment can be designed, by keyboard or by mouse, in either the cross-section or the profile window. Grades, grade breaks, and cut/fill depths are also calculated and displayed whenever the alignment is changed. See figure 5.

A vertical curve can be added at an IP point by specifying a radius or K value.

A mass-haul diagram can be included at the bottom of the profile window for balancing cuts and fills. Along this profile there are several transitions from embankment to excavation; the haul diagram displays balance points at 175 and 400. See figure 6.

Reporting Earthwork and Slope Stake Information

Volumes are calculated and reported in the data window and can be exported to a spreadsheet for further analysis. See figure 7.

Figure 8 shows a slope stake report in the RoadEng™ data window. The data window can be customized.

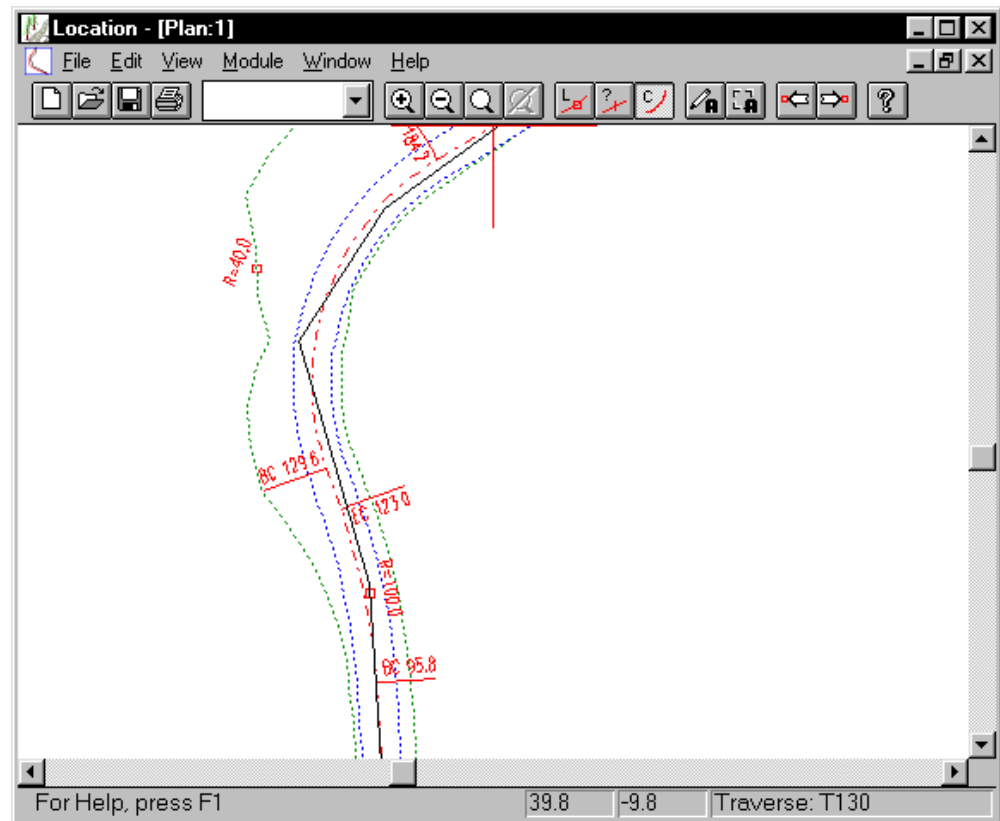


Figure 4.

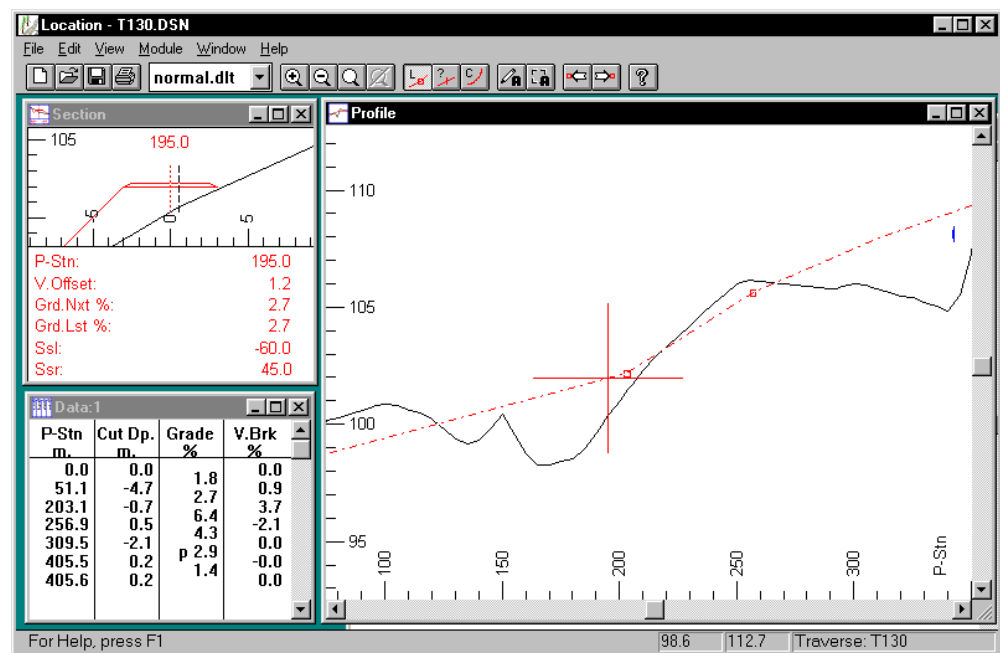


Figure 5.

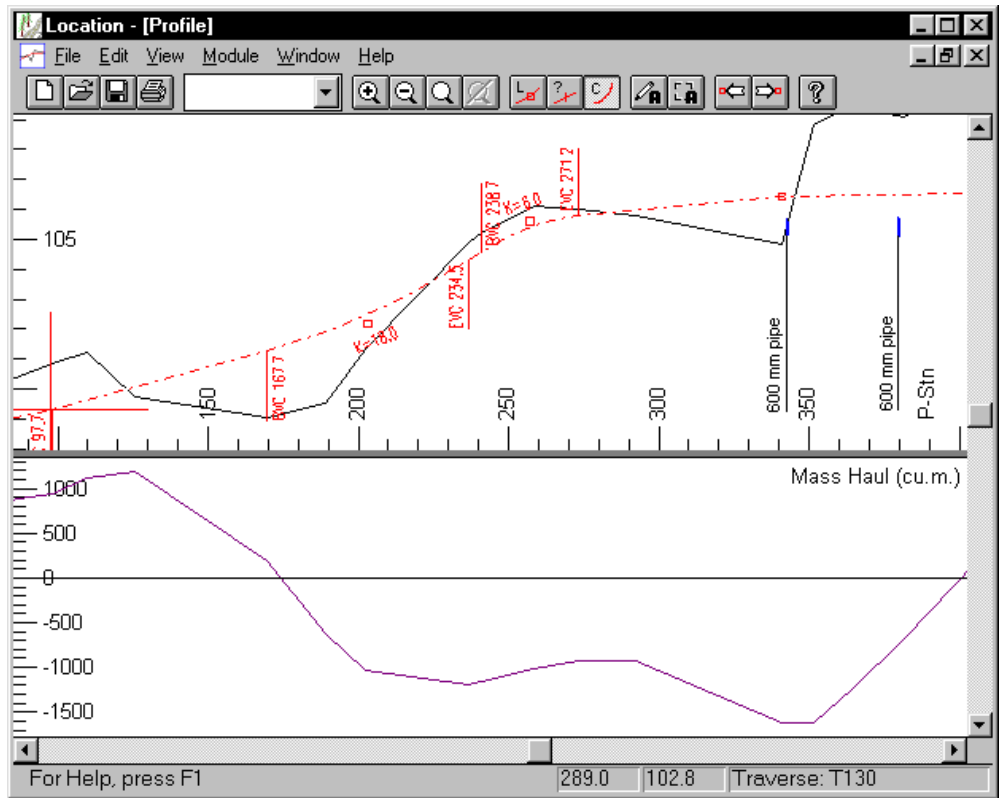


Figure 6.

Creating Construction Drawings

Plans, profiles, and cross-sections as well as various tables and legends can be sized and arranged into any customized layout. Plotting can be done directly from RoadEng™ without CAD software (output to CAD software is available using the DXF format). Figure 9 shows the Fed-Aid format with the plan, profile, and haul diagram following the stationing from left to right.

For more information, contact:

Softree Technical Systems Inc.
 (206) 628-6454
www.softree.com/mail@softree.com

Microsoft Excel - Book1

File Edit View Insert Format Tools Data Window Help

Sheet1 Sheet2 Sheet3

	A	B	C	D	E
1	P-Stn	Cut V.	Fill V.	Strip V.	Mass H.
2	m.	cu.m.	cu.m.	cu.m.	cu.m.
3	0	175.3	2922	0	0
4	51.1	457.8	3014.3	0	-2746.7
5	109.5	189.1	169.3	0	-5303.3
6	129.8	59.4	242.1	0	-5283.5
7	151.1	52	1077.4	0	-5466.2
8	185	6.9	643.8	0	-6491.5
9	202.3	300.7	579.3	0	-7128.4
10	255	18.8	4.5	0	-7407
11	256.9	9.7	3	0	-7392.7
12	257.9	157.9	389.3	0	-7386

Figure 7.

Location - [Data:1]

File Edit View Module Window Help

report.dlt

P-Stn m.	Cut Dp. m.	Grade %	H.Offset m.	Stk L m.	Stk R m.	Ssl %	Ssr %
351.6	-0.6	p 2.2	1.8	7.2	5.2	-45.0	55.0
355.0	0.3	p 2.9	1.6	5.6	6.3	-48.0	45.0
360.0	1.9	p 3.4	1.3	6.1	6.6	-48.0	45.0
364.1	-0.4	p 2.0	-2.5	6.7	5.7	-48.0	45.0
365.0	-0.5	p 2.6	-2.4	7.3	5.8	-48.0	45.0
370.0	-1.0	p 2.4	-2.1	10.0	5.9	-54.0	56.0
375.0	-1.5	p 2.3	-1.8	11.1	5.6	-54.0	56.0
379.6	-1.9	p 2.5	-1.6	11.2	3.7	-54.0	56.0
380.0	-1.9	p -10.2	-1.5	9.3	3.7	-54.0	56.0
381.6	-1.2	p 1.7	-0.3	9.6	5.7	-54.0	56.0
385.0	-1.0	p 2.0	-0.3	9.9	6.0	-54.0	56.0

For Help, press F1

38.7 -31.7 Traverse: T130

Figure 8.

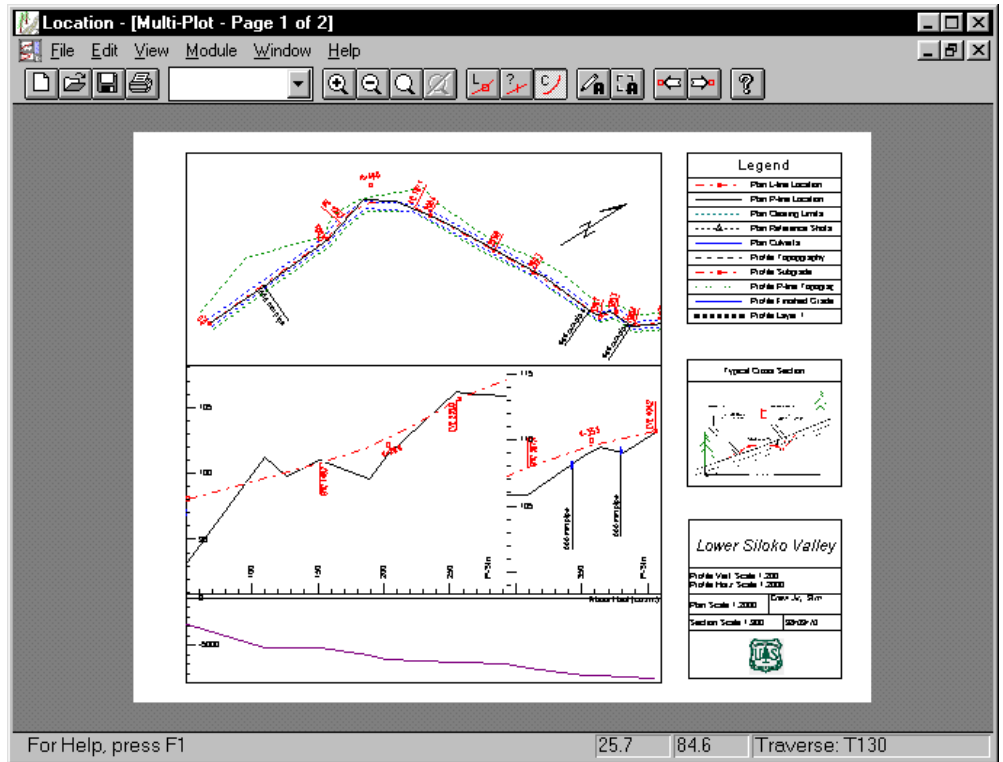


Figure 9.

Solar-Powered Water System Operation and Maintenance

John Janson
Civil Engineer
Region 9, Superior National Forest

Introduction

Solar-powered water pumping and supply systems have been in use on the Superior National Forest since the first one was installed in 1992. The system was installed near Grand Marais, Minnesota, at Kimball Lake Campground by Tim Norman of the Gunflint Ranger District and Gary Hoshide of the San Dimas Technology and Development Center (SDTDC). We are currently operating 12 of these systems at various campgrounds and are planning to install more. We feel they are a superior replacement for the hand-pump system at a cost of approximately \$3,500. Although they require some technical skill to install and maintain, the advantages far outweigh the disadvantages.

Solar-powered water systems have been extremely successful. They provide barrier-free, sanitary water on demand from easy-open, self-closing spigots, without the need for significant physical exertion. Instead of the hammering sound of hand pumps, water is supplied almost soundlessly. The smooth pumping operation and the settling capability of the tank have greatly reduced the sediment load from wells that originally had problems.

In the 7 years they have been in operation, only one solar-powered water system installation has tested positively for coliform bacteria. The problem was identified as dead bugs in the venting of the tank and was solved by proper screening. The new tanks now have a ball breather valve. One other solar-powered water system failed because of a lightning strike.

Sanitary surveys have detected no deficiencies in these systems. System siting does need to include provisions for disposing excess runoff and proper sealing against potential contaminants around the surface of the well and casing.

The operation and maintenance costs have been calculated, as required for Forest Service deferred maintenance reporting, and are included at the end of this article.

Solar Pump System Description

The photovoltaic system consists of two 24-inch × 28-inch, 16-volt, 60-watt solar collection modules, wired in series, converting solar energy into 32 volts of electricity, powering a small 24-volt submersible pump located in the water well, delivering water through a 3/4-inch-diameter standpipe to a 220- to 300-gallon plastic tank. The reason for the 16-volt panels is that over time they gradually lose power as they wear out. Rarely do we get a full 32 volts of direct sun. The control box regulates power down to 24 volts so the pump does not burn out. A float switch system activates and deactivates the pump. See figures 1 to 5 for details.

Pumping during daylight hours provides the reserve needed to supply the evening and early morning water needs of the site. One or two 240- to 300-gallon tanks are located inside a 5-foot × 8-foot pumphouse building. The bottom of the tank is elevated to the height of the spigot and water is supplied from a wall-mounted spigot located outside the building at the elevation of the bottom of the tank. Water delivery from the tank is by gravity.

Operation

Operation consists of annual startup and shutdown, monthly bacteriological sampling and testing, annual nitrite/nitrate sampling and testing, annual cleaning, and a weekly operational check. The systems are in operation from May through September.

Sampling and Testing

Water sampling and testing is done at the spigot on a monthly basis for coliform bacteria and annually for nitrate/nitrite. Samples for coliform bacteria are collected by the site operator. The hydrologic technician in Ely conducts the laboratory tests and notifies the operator within 48 hours of the sample collection if a problem is identified and the system needs to be shut down. Sanitizing is performed according to startup procedures if a bacterial problem arises.

Startup

The systems are opened for operation in May of each year. To prepare the system, the spigot must be reconnected and the solar panels on the roof reinstalled. The switch in the control panel is turned to the “on” position. The tank, piping, and all connections must be shock chlorinated with a solution of 100 mg/liter chlorine. For 300 gallons of water, approximately three-fourths of a pound of chlorine (HTH) compound is needed and must be completely mixed. The spigot is opened until the chlorinated water comes out. To ensure that the system is inoperable, the spigot is removed and capped or locked. After 24 hours, the tank is drained and flushed thoroughly with fresh water from the well. The spigot should be replaced and uncapped or unlocked so that the system is operable. The system should be checked for leaks and full operation, including float valves. Before opening the system to public use, the water must be sampled and tested and the building locked.

Shutdown

The systems are normally shut down in September of each year. To shut down the system, the control box switch must be turned to the “off” position and the tank, piping, and all connections drained. The spigot is removed and stored inside the building. In areas of high incidence of vandalism or thievery, solar panels from the roof should be removed and stored in a safe location, either in the building or at the local district office warehouse. The pumphouse building should be locked.

Maintenance

To ensure effective operation of the system, the following items should be maintained:

- A drainageway for wastewater away from the well casing.
- A sanitary well seal and a protective concrete slab around the well casing.

Additional maintenance actions include:

- The system should be disinfected whenever it is opened—annually and after any replacement of water piping or storage components.
- The system should be inspected and/or cleaned weekly.
- A set of all components should be kept on the forest in the event of failure of any component.
- The building should be stained every 4 years.
- A sanitary survey should be conducted every 5 years by a hydrologist, engineer, and operator.
- An annual condition survey should be conducted by the operator.

Operation and Maintenance Costs

The life of the solar pump, building, piping, electrical supplies, and solar panel is estimated at 15 to 20 years, after which a replacement cost of approximately \$3,500 needs to be budgeted.

Operation

Total Operation Cost = \$235 per water system per year (estimated 3/30/99)

1. Monthly bacti sampling and testing:
 $(4 \text{ days/month} \times 6 \text{ months} \times \$128/\text{day}) / 58 \text{ wells}^1 = \53
2. Annual nitrite/nitrate sampling and testing:
 $(4 \text{ days/year} \times \$126/\text{day}) / 58 \text{ wells}^1 = \9
3. Weekly operational check:
 $(2 \text{ hours/week} \times 4 \text{ weeks} \times 6 \text{ months} \times \$13/\text{hour} \times 5\%) = \32
(This is an estimated 5 percent of overall campground operational inspection time for the operator. The operator will be inspecting other components of the campground the rest of the time.)
4. Testing supplies and test (no cost on nitrite/nitrate by State) bacti, chlorine, and bottles = \$5
5. Startup and shutdown of solar system:
 $(2 \text{ hours} \times \$13/\text{hr} \times 2 \text{ events}) = \52
6. Drain tank in autumn and fill/chlorinate tank in spring:
 $(2 \text{ hours} \times 2 \text{ events} \times \$13/\text{hr}) = \$52$
7. Clean building, vents, and drainageway annually:
 $(1 \text{ hour} \times \$13/\text{hour}) = \13
8. Vehicle: $(\$.32/\text{mile} \times 30 \text{ miles/trip} \times 40 \text{ trips} \times 5\%) = \19

Maintenance

Total Maintenance Cost = \$167 per water system per year (estimated 3/30/99)

1. Annual condition surveys:
 $(5 \text{ days/year} \times \$128/\text{day})/58 \text{ wells}^1 = \11
2. Five-year sanitary surveys:
 $(12 \text{ days}/5 \text{ years} \times (\$128 + \$242 + \$276))/58 \text{ wells}^1 = \27
3. Stain building: $[(8 \text{ hours} \times \$13/\text{hour}) + \$10 \text{ material}]/4 \text{ years} = \29
4. Replace controller (lightning strike) once per 5 years =
 $[\$300 + (4 \text{ hours} \times \$13/\text{hr})]/5 = \$71$
5. Vehicle: $(\$0.32/\text{mile} \times 30 \text{ miles}/\text{trip} \times 3 \text{ trips}/\text{year})^1 = \29

Notes

1. There are 58 water systems on the Superior. Inspection costs have been approximated for all the wells on the Forest and then divided by the number of wells. Vehicle mileage has been reduced accordingly.

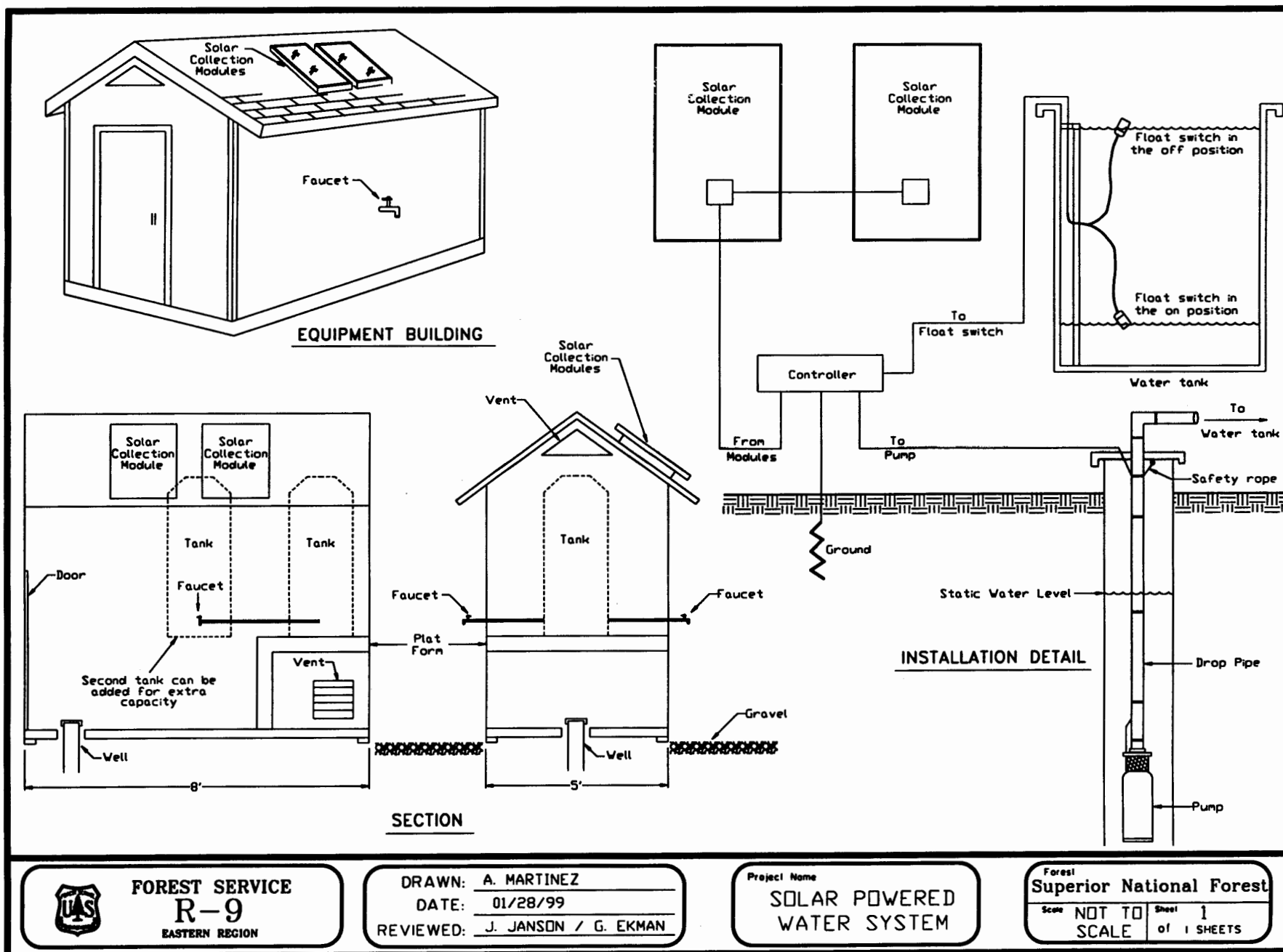


Figure 1. Information about each culvert is input here.



Figure 2.



Figure 3.



Figure 4.



Figure 5.

FishXing: New Software Under Development To Assist in the Analysis of Fish Passage Through Culverts

Fish Crossing Development Team:

Mike Furniss, Rocky Mountain Research Station

Tom Moore, WO Engineering—San Dimas Technology and Development Center

Mike Love and Thomas Dunklin, Six Rivers National Forest

Bob Gubernick, Tongass National Forest

Susan Firor, Margaret Lang, Terry Roelofs, and Bill Trush, Humboldt State University

Culverted road-stream crossings sometimes function as upstream migration barriers to fish. Culverts can block migration of resident and anadromous fish if the culverts have excessive water velocities during high flows, inadequate water depth during low flows, or excessive drops at the outlet. The design of new culverted crossings and the analysis of the performance of existing culverts on historic fish-bearing streams requires input from professionals with backgrounds in engineering, fisheries, and hydrology. A thorough analysis of the culvert hydraulics relative to fish swimming and jumping abilities throughout the range of fish migration flows can be difficult and time consuming. This analysis lends itself to computer applications assistance.

A software application for Windows 95/Windows NT called FishXing (pronounced “fish crossing”) is being developed by the Fish Crossing Development Team under the direction of Mike Furniss. Engineer-in-training Mike Love and programmer/mathematician Susan Firor of the Fish Crossing Development Team have done the primary design and programming. Professors Bill Trush, Terry Roelofs, and Margaret Lang of Humboldt State University are providing technical review and advice as the program develops. Additional design and applications support are being provided by Bob Gubernick, geotechnical engineer of the Tongass National Forest.

The Forest Service Engineering Technology and Development Program and the Federal Highway Administration (FHWA) Coordinated Technology Program are the primary sponsors of the project. The project design is being coordinated at the Six Rivers Watershed Center while beta testing, production, and distribution of the software will be handled by the San Dimas Technology and Development Center. Other sponsors who provide funding or in-kind support include the Stream Systems Technology Center, Rocky Mountain Research Station; the Forest Service Fish Habitat Relations Program; Forest Service Soil, Water, and Air Technology and Development Program; the National Marine Fisheries Service; and the Humboldt State University Institute for River Ecosystems.

The Objective

The objective of this project is to integrate the biology, hydrology, and hydraulics components of fish passage into a single software product that analyzes the passability of proposed and existing culvert installations. FishXing integrates the latest biological and physical science involving fish passage through culverts into one easy-to-use software package. FishXing does not allow for evaluation of baffles, weirs, and other in-stream obstructions commonly used to facilitate fish passage.

FishXing is intended to assist engineers, fish biologists, and hydrologists in designing and analyzing culvert hydraulics for determining fish passability. It is a user-friendly package with easy-to-understand output.

Program design emphasizes the interdisciplinary nature of the problem, incorporating the essential considerations from fisheries biology, hydrology, culvert and open-channel hydraulics, and engineering. The program is specifically designed to be easy to use but not to obscure the complexity of the problem or to substitute for sound professional judgment where this is called for.

Literature Review

An extensive collection of literature concerning fish capabilities and fish passage through culverts exists, and several State and Federal agencies have produced guides for solving fish passage problems. The U.S. Department of Transportation and the Forest Service (Baker and Votapka 1990) summarized current information on fish passage through culverts and created an annotated bibliography. The information is grouped by discipline and includes engineering requirements and biological criteria for fish passage. Evans and Johnston (1990) produced a similar guide for the Forest Service that includes a checklist and outline for reviewing proposed and existing culvert installations.

The general guidelines for designing a new stream crossing or analyzing an existing culvert begin with fish biological information. The fish biologist must identify the “design fish or fishes” and their migration capabilities. This means that for all fish species and age-classes of concern, the period of year that migration occurs and the swimming and leaping abilities of each species and age-class must be determined and specified in sufficient detail. The capabilities of a variety of species have been reported in numerous publications (Bell 1990; Watts 1974; Powers and Orsborn 1985) but the published literature is often incomplete and needs local adaptation.

Because it is usually not practical to design culverts to pass fish 100 percent of the time, acceptable design flows—high-flow and low-flow limits—need to be defined. The design flows serve as cut-off values. Within the design flow limits, the culvert should be passable to fish. In the West, the high-flow limit has commonly been selected as the discharge that is equaled or exceeded 10 percent of the time during the period of migration (for example, October through April). The use of a flow-duration approach was first presented by the California Department of Transportation (Kay and Lewis 1970), and has been adopted by State agencies responsible for fisheries in California, Oregon, and Washington. In regions with long-duration high flows, such as where snowmelt dominates the flow regimes, the high flow limit is often selected based on both duration and frequency of the flow (that is, the 2-year 3-day high flow) (Ashton and Carlson 1984).

Defining a low-flow limit is more ambiguous, but is usually selected based on similar magnitude-frequency approaches and an examination of the stream channel and its passability at low flows.

Once the biological constraints have been determined, the hydraulics of the proposed or existing culvert should be examined throughout the range of fish-passage flows to determine if the culvert performs as a migration barrier. Powers and Orsborn (1985) present a thorough analysis of culverts as physical barriers to upstream migration.

At the upper design-flow limit, culverts frequently present velocity barriers. The factors affecting this problem are the fish swimming ability and the size, length, and gradient of the culvert. Several options are available to reduce excessive velocity in proposed culverts. Using a pipe arch, or increasing the culvert size and decreasing the gradient, can reduce water velocities. Recently, many new culverts have been oversized and then sunken below the stream bed, creating a natural stream bottom and increasing the bottom roughness (White 1996). Other options include using an open-bottom arch or backwatering the culvert by placing a boulder or log weir downstream of the outlet. Mitigating excessive velocities in existing culverts is more difficult, but can be done by backwatering the culvert with weirs or placing baffles in the culvert.

Low-flow barriers exist when the water depth in the culvert is insufficient for adult fish passage. Several publications, including Bjornn and Reiser (1991), suggest required minimum water depths for several classes of fish. The solutions available for reducing velocities usually also increase the water depth.

Culverts with perched or hanging outlets are often vertical barriers to fish at all flows. The leaping abilities of the fish should be compared to the horizontal and vertical distance the fish must leap to enter the culvert. New stream crossings should never be installed with a perched outlet, and outlet velocities should be minimized to ensure that scouring and channel downcutting will not occur. At existing perched outlets, the most common solution is to use a series of weirs to create step-pools that raise the fish to within leaping distance of the culvert outlet.

Analyzing the passability of culverts and creating design solutions for passability problems are complex. When designing a new crossing or remediating an existing passability problem, a multitude of possible design combinations exist. Each combination requires numerous calculations. Because of the nature of the problem, it is well-suited for computer applications.

Existing Culvert Software

A guide to computer software for designing and analyzing culverts (Moore et al. *in press*) examined 24 different software products. Only one software product, FishPass, evaluates fish passage through culverts. This DOS program is hard to use and has very limited applicability. Most existing culvert design software is designed to be used for culvert sizing for passing peak flows. Many produce erroneous results when analyzing hydraulics within the range of fish passage flows. HEC-RAS can be used effectively to determine culvert hydraulics, but is difficult to learn and use and does not integrate fish performance and site hydrology.

Many of the user-friendly software tools do not yield water velocities and hydraulic jumps throughout the length of the culvert. Also, most of them fail to offer the user the option of sinking the culvert below stream grade or using an open-bottom arch.

FishXing—in its current state—contains the following features:

- The user is able to save each stream crossing in a project folder to facilitate the evaluation of groups of culverts (for example, all culverts on fish-bearing streams within a watershed). An identification number, location, and comments may be assigned to each crossing. Each project can hold up to 100 culverts. The preliminary culvert data input screen is shown in figure 1.
- The user is able to select from a menu, or enter, the fish species and age class. Default values from the literature for the swimming and leaping ability of the fish are automatically filled in. The values may be edited by the user. Other biological inputs include the period of migration and the average fish length.
- The user can enter the high-flow and low-flow limits for fish passage, which helps define the range of flows analyzed by the software.

The screenshot displays the 'FishXing - culvert3.pas' application window. The menu bar includes 'File', 'Tailwater Methods', 'Options', 'View', and 'Help'. The toolbar contains icons for file operations and navigation. The main window is titled 'Culvert Information' and features a 'Samples' section with the following fields and controls:

- Input Units:** Radio buttons for 'English' (selected) and 'Metric'.
- Culvert ID:** Text box containing '3'.
- Culvert Name:** Text box containing 'Smith's Culvert'.
- Road:** Text box containing 'Driveway'.
- Milepost:** Text box containing '0.0'.
- Stream Name:** Text box containing 'Anker Creek'.
- Latitude:** Text box containing '122.45,21.20'.
- Longitude:** Text box containing '42.32,21.08'.
- Length of historical upstream habitat:** Text box containing '2200 ft'.
- Upstream Barrier Information:**
 - ☒ Upstream Barriers Exist
 - Number of upstream barriers: Text box containing '1'.
 - Distance to next barrier: Text box containing '350 m'.
- Downstream Barrier Information:**
 - ☐ Downstream Barriers Exist
 - Number of downstream barriers: Empty text box.
 - Distance to next barrier: Empty text box.
- Comments:** A large text area containing:
 - +Anker Creek is tributary to Lindsey Creek.
 - + Two culvert barriers downstream make access nearly impossible for salmonids. Old-time residents commented that Steelhead spawned in this section of creek prior to construction of the Anker Road county culvert (downstream).

Navigation buttons include '> Next' and '< Back'.

Figure 1. Preliminary culvert data input screen.

- The user can choose from three options for defining the tailwater (water surface) elevation downstream of the outlet. The options include:
 - A constant tailwater elevation (useful when a weir or other type of downstream control exists).
 - A user-defined tailwater elevation—discharge rating curve.
 - A user-created downstream cross-section, which allows the computer to generate a tailwater elevation—discharge rating curve using Manning's equation.
- The user can choose from a wide variety of culvert shapes and sizes, including circular, pipe arch, open-bottom arch, and box culverts. In order to obtain a natural stream bottom, the user can also sink the culvert below the stream gradient. Figure 2 shows the primary data input screen.

The software quickly computes the results and allows the user to view them on screen or export them to a spreadsheet as a worksheet and charts. Both uniform flow and gradually varied flow are calculated. For uniform flow, the results include the water depth and velocity in the culvert, critical depth, the water surface elevation of the pool at the outlet, and the vertical and horizontal distance the fish must leap if the outlet is perched. These values are plotted against a user-defined range of flows. See figures 3 and 4 for examples of the tabular and graphical outputs.

The screenshot displays the 'FishXing - culvert3.pas' software window. The title bar includes 'File', 'Tailwater Methods', 'Options', 'View', and 'Help'. Below the title bar is a menu bar with icons for file operations, calculation, and help. The main window is titled 'Culvert Input Sheet for Smith's Culvert'. It contains several input fields and sections:

- Culvert Information:** Culvert Number: 3, Road: Driveway, Smith's Culvert, Mile Post: 0.0, Stream Name: Anker Creek.
- Fish Information:** Species: Greeneye, Age Class: Adult, Fork Length: 600 mm.
- Migration Period:** From: November, to: March.
- Swimming Ability:**
 - Use Prolonged (selected) or Use Burst.
 - Max Swim Speed: 13.7 ft/s (Prolonged) / 26.6 ft/s (Burst).
 - Time to Exhaustion: 10 min (Prolonged) / 15 s (Burst).
 - Max Leap Speed: 13.7 ft/s.
 - Fish Condition: 0.75.
 - Minimum Water Depth: 0.6 ft.
- Hydrologic Criteria:** Low Passage Flow: 3 cfs, High Passage Flow: 19.5 cfs.
- Culvert Design:**
 - Shape: Circular.
 - Construction: CMP (2 2/3 X 1/2 in corr.).
 - Installation: At Grade, Sunken Depth: 0 ft.
 - Culvert Diameter: 66 in.
 - Culvert Span: [] ft, Height: [] ft.
 - Culvert Rise: [] ft, Width: [] ft.
 - Roughness Coefficient for Culvert (n): 0.024.
 - Roughness Coefficient for Natural Bottom: [].
 - Culvert Length: 32 ft.
 - Inlet Bottom Elevation: 46.30 ft (selected).
 - Culvert Slope: 1.25 %.
 - Outlet Bottom Elevation: 45.9 ft.
 - Inlet Head Loss Coefficient: 0.9.

At the bottom, there are buttons for 'Tailwater Options', 'Profile Flows', '< Back', and 'Calculate'.

Figure 2. Input data screen.

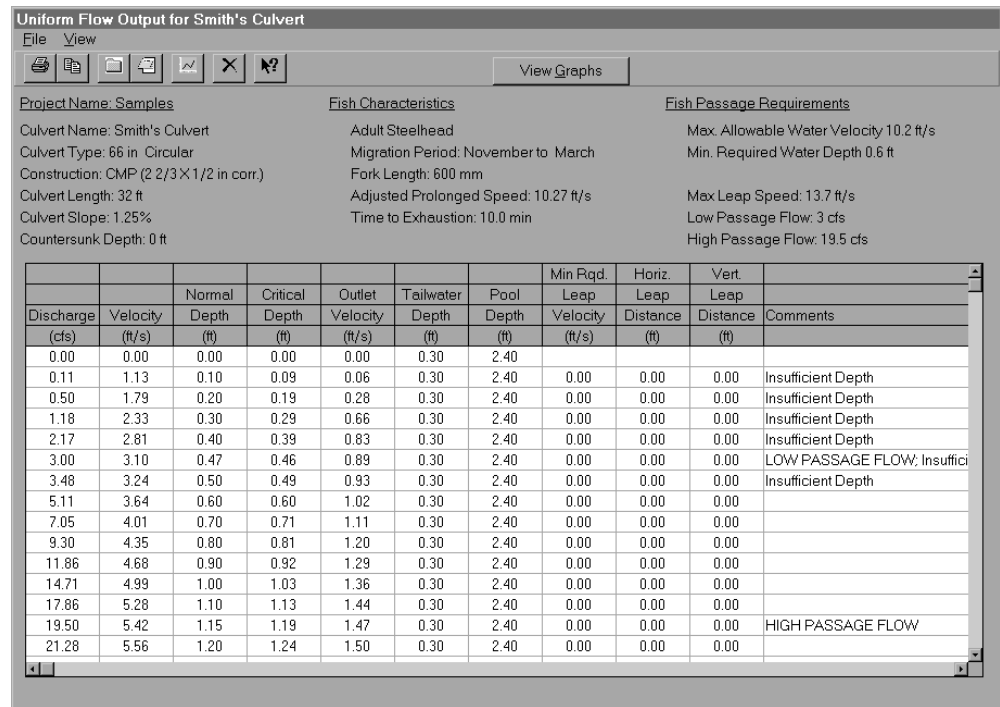


Figure 3. Tabular results from uniform flow calculations.

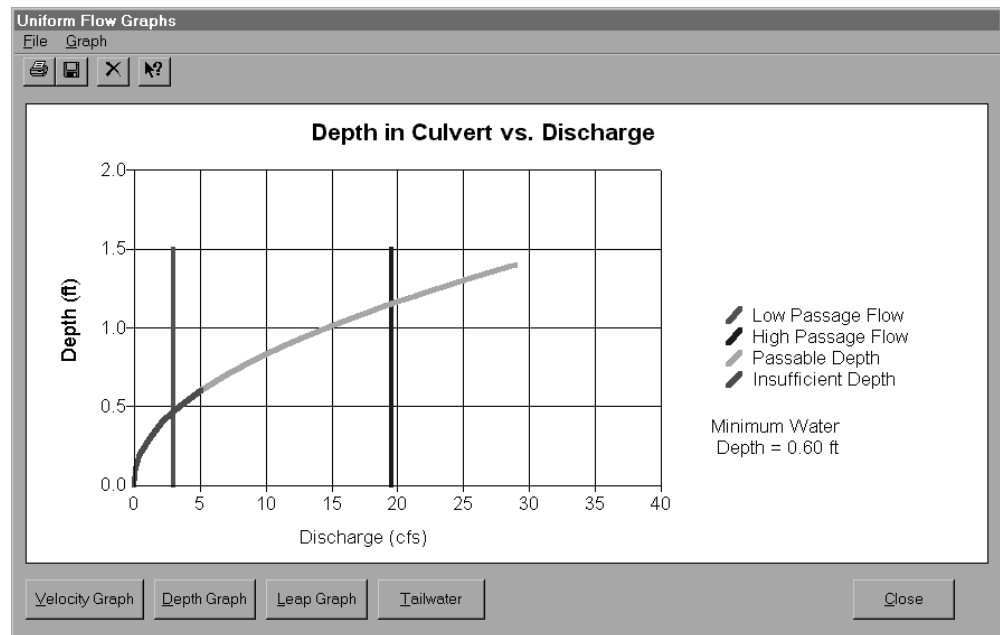


Figure 4. Graph of depth vs. discharge output for uniform flow calculations. Graphical displays are also available for velocity, minimum required fish-leaping velocity, and a tailwater rating curve.

For gradually varied flow, the output plots water level, normal depth, and critical depth along the length of the culvert. Any predicted hydraulic jumps and headwater and tailwater elevations are shown for a profile of user-defined flows. Examples of the output of these results are shown in figures 5 and 6.

The software also uses the fisheries inputs to estimate the maximum water velocity the fish can swim against for the length of the culvert and alerts the user when velocities are excessive, the water depth is insufficient, the leap is too far, or the outlet pool is too shallow for the leap. A text-format report that summarizes the results for each site can be generated.

The final product will be a powerful software tool that engineers, fish biologists, and hydrologists can use to analyze the passability of existing and proposed crossings on fish-bearing streams. The software could also be used to assess various design options on proposed crossings and to find feasible solutions to remediate existing fish passage problems.

Note: The software is expected to be available by late fall of 1999. It is not yet available, but those seriously interested in beta testing may contact Tom Moore at (909) 599-1267 to volunteer. A beta-test version of the program can be found at <http://www.stream.fs.fed.us./fishxing>

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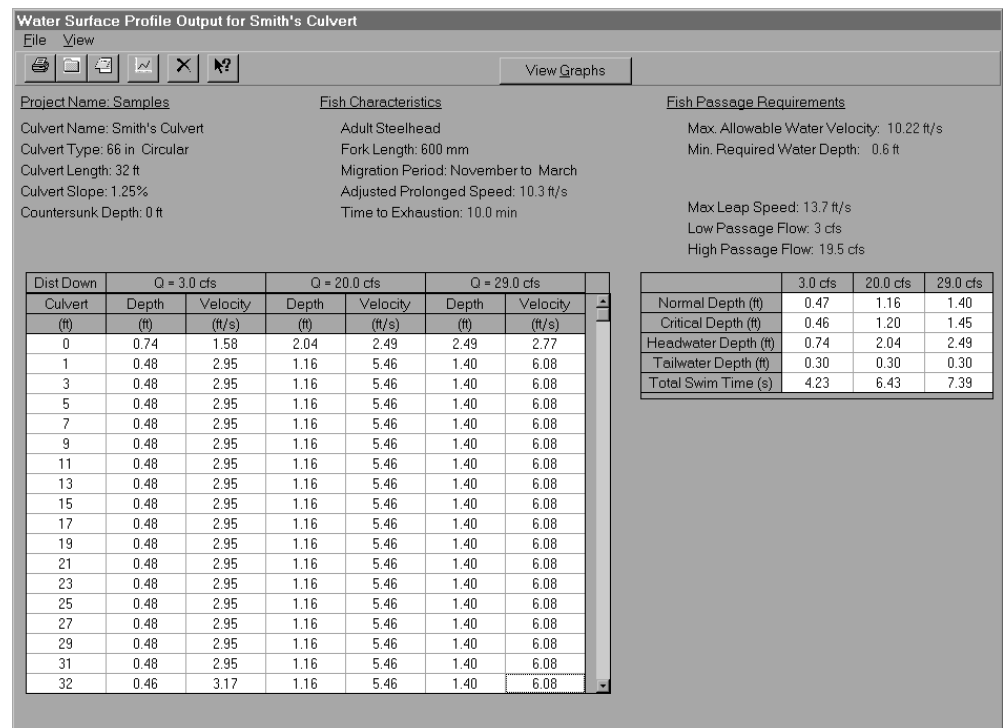


Figure 5. Tabular output from gradually varied flow calculations.

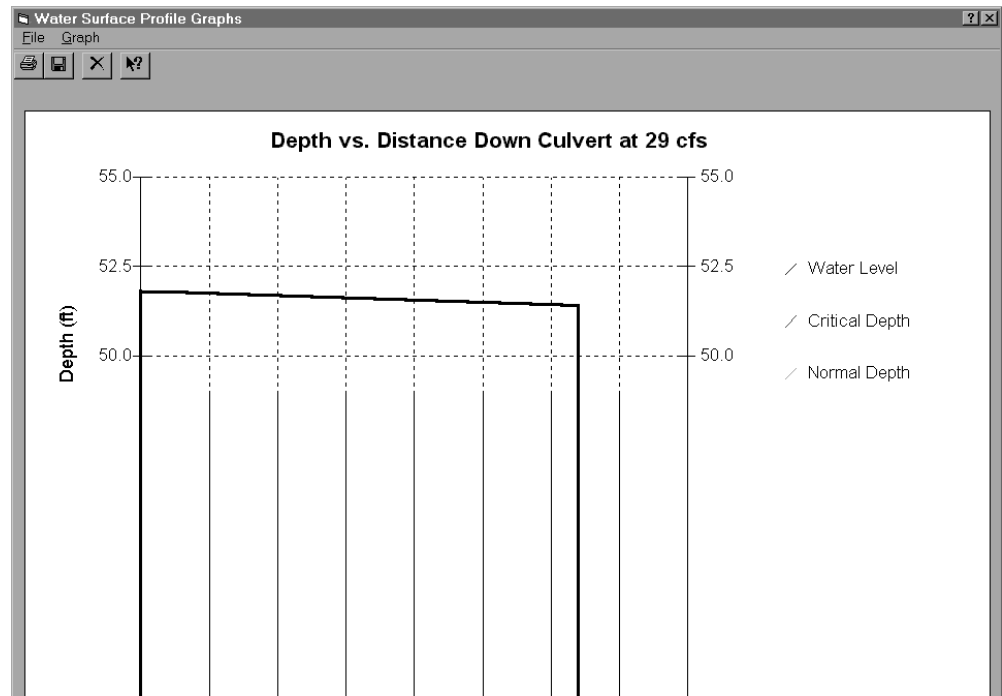


Figure 6. Graphical output from gradually varied flow calculations, for a specified flow: 29 cfs.

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1998 *Engineering Field Notes* Article Awards

Special thanks to each of our authors and readers who made 1998 another great year. Articles related to global positioning systems, inspecting and repairing bridges, low-volume road systems, and Federal recreation symbols were among those shared. Through *Engineering Field Notes* (EFN), we continue to provide a way for Forest Service engineers, at all levels and from all regions, to share their knowledge and experiences. During this time of heavy work loads and decreased staff, we applaud each of you, especially the authors, for your support in fostering an environment where information and experience are viewed as valuable resources and are shared accordingly.

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