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Pump Flow Testing

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With a little ingenuity, firefighting personnel can determine the flow rate of a pump using equipment on hand (a short piece of pipe, a tape measure, a level, and a plumb bob) and at almost no cost. Knowing how to go about this can be very handy since accurate flow meters are not often immediately available for firecrew use. This method of determining pump flow rate is very accurate and needs no calibration. It is based on the principle that when an object is released it falls at a given rate, independent of its horizontal velocity. So when water is released from a pipe that is at a given height from the ground, it always hits the ground in the same time.

As explained in detail below, how far away from the pipe exit that the water hits the ground is directly proportional to the water's horizontal velocity as it exits the pipe. Further, the horizontal velocity is directly proportional to the amount of water coming out of the pipe, and depends on the area of the pipe opening. Knowing this area, the height of the pipe exit above the ground, and the distance out from the pipe that the water hits the ground, the water flow rate can be accurately calculated using the formula given at the very end of this article.

For want of a better name I call this pump flow test method a "splash test." The steps to take to accomplish a splash test are:

(1) Couple a short length (three to five feet) of pipe of known <u>inside</u> diameter to the hose coming from the pump. (NOTE: In some cases, as flow rates approach maximum, hose ripple can occur. To prevent this, use either hard suction hose or a longer pipe.)

(2) Mount the pipe level, horizontally, at a convenient height ("h") above the ground. (NOTE: Select the height suggested in Table 1 below for the pipe size and flow <u>range</u> you are going to use to avoid having to do a sequence of calculations.)

(3) Run the pump and have the water splash on the ground.

(4) Measure the distance ("D") along the ground from the end of the pipe to where the water hits the ground (Figure 1). At the time of the measurement, the hose must be running full of water. Let a plumb bob hang from the pipe exit down to the ground—this locates where to start measuring "D."

How far out from the end of the pipe that the water hits the ground depends on the horizontal velocity as the water exits the end of the pipe. The higher the exit velocity, the higher the "D," i.e., "D" is directly proportional to water flow velocity. Knowing "D" and the height of the pipe ("h") above the ground, the velocity of the water out of the pipe can be determined. From this and the pipe exit area, the flow rate can be calculated.

To obtain the flow rate in gpm for the pipe size being used, when employing the height suggested in the table, multiply "D" by the gpm per inch found in the final column of the table. NOTE: Be sure to check the inside diameter of the pipe being used to see if it is as listed in Table 1; if it is not, the flow formula, presented following the table, must be used—as would be the case for any setup (pipe size or height) that is not presented in the table.

Mounting the pipe on a forklift is a very convenient way to hold the pipe (Figure 2), since now the pipe can easily be adjusted either horizontally or vertically. And, if the test is conducted at a station or work center, a pipe can be mounted permanently on a stand or building, and permanent marks

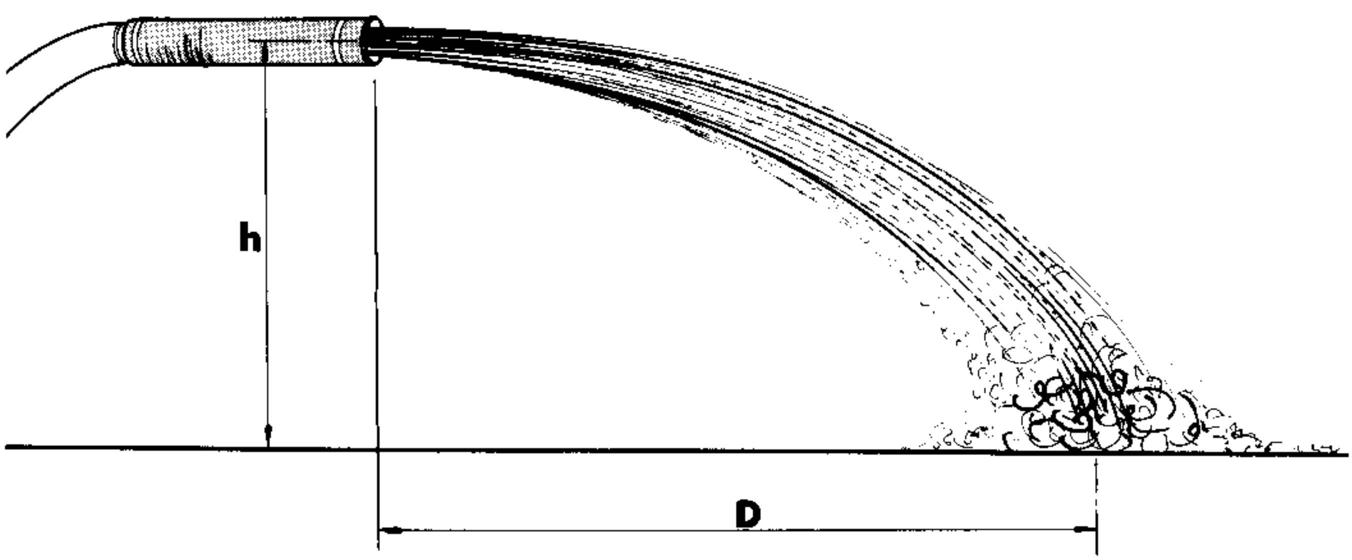

Figure 1.—Relation of pipe exit to "h" and "D."

placed on the ground (these can be in gpm). This would permit flow tests to be conducted very quickly and easily. Remember that a splash test determines only the gpm flow from the pump. To check pump performance, the pressure at which the water is flowing must also be known. The engine pressure gauge can be used to obtain this pressure by partially closing the overboard discharge valve to create a resistance for the pump.

Since there is a limited number of pipe sizes and practical heights for the water to fall from each of these pipes, the following table has been developed:

Table 1.—Splash Test Table.

Pipe size (in)	*Pipe ID (in)*	*Pipe opening area (sq in)*	*Flow range (gpm)*	*Suggested height (in)*	*Unit linear flow @ suggested height (gpm/in)*
0 - 1/2	0.62	0.30	2 - 10	18 - 3/4	0.25
0 - 3/4	0.82	0.53	5 - 20	29 - 7/8	0.35
1	1.05	0.86	10 - 40	38 - 9/16	0.5
1 - 1/4	1.38	1.50	20 - 100	45 - 13/16	0.8
1 - 1/2	1.61	2.04	40 - 150	54 - 1/4	1.0
2	2.07	3.36	60 - 250	65 - 3/8	1.5
2 - 1/2	2.47	4.79	100 - 400	74 - 3/4	2
3	3.07	7.39	150 - 600	79 - 1/8	3
4	4.03	12.73	200 - 900	84 - 1/2	5
5	5.05	20.01	300 - 1200	81 - 1/2	8
6	6.07	28.89	400 - 1600	108 - 3/4	10

For pipe IDs or heights not in the table, the flow rate can be calculated using the following formula:

Flow (gpm) = $3.61 \times AD/(h)^{1/2}$ [$(h)^{1/2}$ = square root of h]

where:

A = Area (in square inches) of the pipe opening = (3.14) x (r^2)
[r = 1/2 of pipe ID (in)]

D = Distance along ground (in inches) from the pipe exit to the midpoint of where the main body of water splashes.

h = Height above ground (in inches) of the midpoint of the pipe exit.

3.61 = Constant that adjusts answer for measurement units used in formula.

Figure 2.—Splash test with 1-1/2 in pipe at suggested height of 54-1/4 in; the calculated flow rate was 84 gpm.

Inching Our Way to Metrics

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Background

Section 5164 of the Omnibus Trade and Competitiveness Act of 1988 (Public Law 100-418) designates the metric system as the preferred system of weights and measures for the United States, trade and commerce. The intent is to stimulate this nation's conversion to the metric system, thus making us more competitive in the world market. Today, the United States is the only industrially developed country that remains on the inch-pound system. With the recent changes in Europe and the push to establish a European common market by 1992, it is critical for United States industries to convert to metrics.

The law requires all Federal agencies to use metrics in procurements, grants, and other business-related activities by the end of Fiscal Year 1992, except where not practical or efficient to do so, e.g., where the industry has not yet converted to the metric system. "Other business-related activities" is defined as "measurement sensitive" commercial- or business-directed transactions or programs. For example, in standards, specifications, publications, or regulations where any sort of measurement would be specified, the metric system would be shown. Also, Federal agencies are to encourage and support an environment conducive to the transition to metrics, while considering the impact on industry, in particular, small businesses. Offers or bids submitted in response to procurement solicitations using metric measurements will be acceptable and considered.

The Department of Commerce has been designated as the lead agency in implementing the law. Committees and subcommittees, e.g., Interagency Council on Metric Policy (ICMP) and the Metrication Operating Committee (MOC), have been formed to coordinate and establish policy for the Government's transition to metrics. Commerce's "Metric Conversion Policy for Federal Agencies" was published in the Federal Register on January 2, 1991.

The General Services Administration (GSA) has issued a proposed acquisition supplement on metrics that provides direction on introducing metrics into the world of contracting (55 Federal Register 208, October 26, 1990). The supplement references GSA's Metric Transition Plan which provides a good description of GSA's comprehensive program on incorporating metrics into its operations (55 Federal Register 67, April 6, 1990). Basically, GSA direction states that GSA's personnel are to consider the use of metrics in acquisition planning stages, that offers submitted in metric units or metric products are acceptable, that specifications and procurement descriptions be stated exclusively in metric units (hard metric) whenever metric is the accepted industry standard, and that when metric is not the accepted standard in a particular industry, a dual, hybrid, or soft metric system is to be used during the transition period. Since the law is applicable to all Federal agencies, a revision to the Federal Acquisition Regulations (FAR) has been issued as well (56 Federal Register 72, April 15, 1991). The language in the FAR is very general and requires Federal agencies to begin using metrics in procurements where practical and to establish guidelines on implementing this policy for acquisitions.

In the hard metric system, measurements are stated only in metric units. In the soft system, inch-pound measurements have been converted to metrics, but the physical dimensions are not changed. The dual system uses both systems: the inch-pound measurement is provided with a soft metric conversion shown in parentheses for information or comparison. The hybrid system uses both hard metric and the inch-pound values; this system would be used when a component of an end item is given in metric measurements but other components are given in inch-pound values.

Forest Service Comments

Metric conversion was discussed with staff representatives here in the Regional Office (RO) and at the Technology and Development Center in San Dimas. Staffs contacted were Engineering (Road and Bridge engineers and Working Capital Fund (WCF) manager), Lands (surveyor), Timber (sale administrator; silviculturists), and Aviation & Fire Management (air manager, and planning and systems manager).

These conversations were very enlightening. Some people interviewed experienced a feeling of deja vu when asked about the impact of metric conversion in our operations. When the Metric Conversion Act of 1975 was passed, their jobs had been impacted in various ways. The Washington Office (WO) Engineering staff issued specific direction on the use of metrics in specifications and standards, and task forces that included members of industry, as well as the Federal Government, were formed in response to the Act. This initial effort died due to strong protests from industry (too costly to implement a conversion) and a general lack of enthusiasm in the Government. Also, unlike Public Law 100-418, the Act established no deadline for the Government to accomplish the conversion.

Most of the staffs saw no real problems in introducing metrics in our specifications, provided it was phased in using a dual system. With the dual system, little impact is made on the contractors' operations; if measurements were in metrics only, problems would definitely occur.

Timber

One Forest has experimented in using the dual system in their silvicultural contracts for one of the Districts since May 1989. According to the Contracting Officer (CO), this has generated little to no reaction at all from contractors. The solicitations give the inch-pound measurement with the soft metric conversion following. The contract states that in the event of a conflict between the two, the inch-pound system governs. The rationale of showing the metric value in the contract is explained to the contractor at the pre-works.

The Forest envisions using this form of the dual system until 1992, then showing the metric value with the inch-pound conversions following in parentheses, until a move to the hard metric system can be made.

Timber stated that it is in the process of changing to cubic measures in timber sale contracts. Timber estimates this conversion will be accomplished in approximately four years. Using the dual system after this change would be fairly easy to compute. However, since there is no equivalent for board feet in metrics, conversion at this time would be difficult, even using a dual system. Evidently, there is no move in the timber industry to change to metrics at this time; the focus now is on changing to cubic.

Lands

Using a dual system would have minimal impact on cadastrals. It has been a requirement of some contracts in the past to have survey results provided in both systems. This is standard practice. There are so few surveying instruments made in the United States, that most of the equipment is geared for metric measurements already. It is relatively easy to produce results in both systems. Contractors are using the same equipment as we are for the most part. County agencies, however, are not using metric measurements on maps. This would require some adjustments, but should not pose any major problems.

Engineering

The topic of metrics came up at the National Wildfire Conference held in November 1990. A representative from GSA stated at this meeting that all specifications must now include metric equivalents. This created quite a bit of confusion for the Technology and Development Center attendees since the Forest Service has issued no such direction. Many of the specifications developed in 1975 at the Technology and Development Center included a dual system in response to the Metric Conversion Act and to do so again would not pose a big problem. Many of the standards used are international standards and are already showing both the inch-pound and metric measurements, e.g., Standard Automotive Engineer (SAE) and National Fire Protection Association (NFPA) standards.

The area of construction presents the largest problems. The construction industry has not converted to metrics due to major expenses involved in doing so, e.g., retooling and redesigning all hardware. While we can include the dual system in our specifications without much trouble and have done so in the past, the use of metrics exclusively cannot be realized until industry makes the change. The materials must match the plans and dimensions. Most of the engineers were unconcerned about the possibility of discrepancies occurring when using the dual system. They felt that only minor consequences would result and the impact would be minimal for the types of projects we do.

The automotive industry has adopted metrics, so this is one area that easily lends itself to using the metric system. Specifications for heavy equipment, usually manufactured by large businesses such as John Deere and Caterpillar, could easily employ the hard metric system. However, procurements involving the fabrication of components, such as fire engines and utility bodies, would have to use the dual system. Contractors usually bidding on these types of solicitations are small businesses who are still buying four-foot sheet metal.

One problem area cited by road, bridge, and Technology and Development Center engineers is how to handle plans and drawings. With the use of special computer-aided design (CAD) software (which we do not own to date), the engineers thought the actual conversion would not be too difficult. Generating plans and drawings for each measurement system would be time-consuming and very costly. Trying to put both the inch-pound and metric measurement on the same drawing would be much too confusing and consume too much space. Of course, the question of funding for all of this arises.

Aviation and Fire Management

Ground visibility at some airports is now reported to pilots in meters and feet. This is about the only step toward metrication in this area. Instrumentation, maps, aeronautical charts, handbooks, etc., are all in the inch-pound system. Changing to metrics would be very expensive. One would think this industry would have converted to metrics long before now, considering that so much aircraft made in the United States is exported.

Steps Needed for Implementation

(1) Issue direction and establish timeframe to implement use of metrics. Time is needed to revise specifications and prepare personnel for the change.

(2) Proceed with phasing-in the use of metrics to meet the intent of the law. Where industry has converted to metrics, use the hard metric system in all specifications, e.g., purchase of heavy equipment. Use dual system in <u>all</u> other specifications (service, supply, and construction) where measurements appear. Include a statement that in the event discrepancies exist, the inch-pound measurement will govern. Retain use of drawings and plans in the inch-pound system in deference to cost.

(3) Educate our personnel. Include presentations and training on the metric system at National, Regional, and Forest meetings. GSA has developed some formal courses.

(4) Inform contractors about the renewed interest in metrics by the Federal Government. Advise them that metrics will be used in our procurements and operations and that they are strongly encouraged to begin considering the use of metrics in their operations as well.

It is doubtful that the Government's use of metrics in specifications and internal operations will provide the impetus for all industries to "bite the bullet" and switch to metrics. While it is essential for contractors dealing in the international market to make the conversion, it is important that our domestic industries take the first steps in this direction as well. Use of the dual system in our contracts will help to initiate the change. The awareness level of contractors and our own employees will be heightened. This will be beneficial in achieving the long-range, ultimate goal of everyone using and "thinking in" metrics.

Metric System

Length

Unit	Number of Meters	Approximate U.S. Equivalent
Myriameter	10,000	6.2 Miles
Kilometer	1,000	0.62 Miles
Hectometer	100	109.36 Yards
Dekameter	10	32.81 Feet
Meter	1	39.37 Inches
Decimeter	0.1	3.94 Inches
Centimeter	0.01	0.39 Inch
Millimeter	0.0001	0.04 Inch

Area

Unit	Number of Square Meters	Approximate U.S. Equivalent
Square Kilometer	1,000,000	0.3861 Square Mile
Hectare	10,000	2.47 Acres
Are	100	119.60 Square Yards
Centare	1	10.76 Square Feet
Square Centimeter	0.0001	0.155 Square Inch

Volume

Unit	Number of Cubic Meters	Approximate U.S. Equivalent
Dekastere	10	13.10 Cubic Yards
Stere	1	1.31 Cubic Yards
Decistere	0.10	3.53 Cubic Feet
Cubic Centimeter	0.000001	0.061 Cubic Inch

Capacity

Unit	Number of Liters	Approximate U.S. Equivalent (Cubic)
Kiloliter	1000	1.31 Cubic Yards
Hectoliter	100	3.53 Cubic Feet
Dekaliter	10	0.35 Cubic Foot
Liter	1	61.02 Cubic Inches
Deciliter	0.10	6.1 Cubic Inches
Centiliter	0.01	0.6 Cubic Inch
Milliliter	0.001	0.06 Cubic Inch

Capacity

Unit	Number of Liters	Approximate U.S. Equivalent (Dry)
Hectoliter	100	2.84 Bushels
Dekaliter	10	1.14 Pecks
Liter	1	0.908 Quart
Deciliter	0.10	0.018 Pint

Capacity

Unit	Number of Liters	Approximate U.S. Equivalent (Liquid)
Dekaliter	10	2.64 Gallons
Liter	1	1.057 Quarts
Deciliter	0.10	0.21 Pint
Centiliter	0.01	0.338 Fluidounce
Milliliter	0.001	0.27 Fluidram

Mass and Weight

Unit	Number of Grams	Approximate U.S. Equivalent
Metric Ton	1,000,000	1.1 Tons
Quintal	100,000	220.46 Pounds
Kilogram	1,000	2.2046 Pounds
Hectogram	100	3.527 Ounces
Dekagram	10	0.353 Ounce
Gram	1	0.035 Ounce
Decigram	0.10	1.543 Grains
Centigram	0.01	0.154 Grain
Milligram	0.001	0.015 Grain

Other SI Conversion Factors

To Convert From	To	Multiply By
Board Foot	Cubic Metre	2.359 737 x 10^{-3}
Btu (Heat)	Joule	1.055 056 x 10^{3}
Btu (Power)	Watt	2.930 711 x 10^{-1}
Ft-lbf (Work, Energy)	Joule	1.355 818
Ft-lbf/min (Power)	Watt	2.259 697 x 10^{-2}
Horsepower (electric) (Power)	Watt	7.460 000* x 10^{+2}
Pound-force (lbf) (Force)	Newton	4.448 222
Pound (lb avoirdupois) (Mass)	Kilogram	4.535 924 x 10^{-1}
Lbf/in^2 (psi) (Pressure)	Pascal	6.894 757 x 10^{3}

*Exact.

Mexico/USDA Forest Service Road and Bridge Design Workshop

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Preface

During the month of May 1990, four persons from different Regions of the Forest Service met in Chihuahua, Mexico to conduct a Road and Bridge Design Workshop for the government of Mexico. Jose Martinez, although not participating in the actual workshop, was its coordinator and planner for the Forest Service. The four participants from the Forest Service who served as instructors explain their perceptions of the workshop and Jose explains how the workshop came about in the introduction.

Introduction - Jose Martinez

Mexico-SARH/USDA Forest Service

Memorandum of Understanding

Technology Transfer

The first meeting of the joint forestry working group under the umbrella of the Memorandum of Understanding was held in El Paso, Texas in October 1985. Prior to this meeting, specific training in transportation systems was requested and coordinated between Jaime Gonzales, Jefe del Programa Forestal Y de la Fauna; Jack Frost, Regional Engineer, Region 3; and Jose Martinez, Structural Engineer, Region 3. The intent of this technology transfer request was to display standards and techniques in transportation planning, road location, field design, route design, classification of roads, cost estimating procedures, and road maintenance. Another objective was to perform an on-the-ground review of the proposed transportation plan for the "Gran Vision" road development.

The next visit was in 1986. Several Forest Service participants with varied backgrounds were involved. Those participating included transportation planners, silviculturist, timber harvest specialist, sawmill maintenance technologist, civil engineers, and tree nursery management personnel. Some of the topics and areas of field visitation included chip and pulp mill operations, sawmill maintenance and operations, timber cut methods, debarking operations, bandsaw maintenance, transportation planning, cable systems (logging), road location, and haul-versus-skid cost. During this visit, the World Bank was reviewing the State of Chihuahua project request. We had the opportunity to discuss our proposals and recommendations with the World Bank representatives and Jaime Gonzales.

The next few visits by Charlie Fudge, Jose Martinez, Bruce Meinders, and Ben Del Villiar to the State of Chihuahua were to assist in reviewing the World Bank proposal. This proposal was approved in 1989. Two of the programs addressed in the project are training and technology transfer.

In October 1990, Jose Martinez organized and coordinated a two-day technology transfer on the Lincoln National Forest. Topics included integrated resource management, geographic information systems, global positioning system, reforestation management, road design using Lumberjack software, and spotted owl survey and inventory. Based on the results of scheduled activities the following individuals met to program technology transfer and workshops for our counterparts: Dave Jolly, R-3 Regional Forester; Jaime Gonzales, Regional Forester-State of Chihuahua; Al West, Deputy Chief, State and Private Forestry; Emilio Zamudio, Deputy Chief, Mexico; Charlie Fudge, R-2 Director of Timber Management; Jose Martinez, Forest Engineer, Lincoln National Forest; and Tom Schmeckpeper, R-3 Director of Pest Management.

The objective of this meeting was to plan and coordinate the programs for Fiscal Year 1990 and tentatively schedule the 1991 program. Workshops were programmed with the timber/transportation working group taking the lead. The working group coordinators were Charlie Fudge and Jose Martinez and since Charlie's retirement, Marlin Hughes, R-3 Timber Management Director. The following workshops were scheduled: bandsaw filing - coordinated by Charlie Fudge; integrated resource management - initial coordination by Jose Martinez and implemented by Delbert Griego, Gila National Forest; spotted owl surveys and investigation - coordinated and implemented by Jose Martinez; road and bridge design - coordinated and implemented by Jose Martinez with technical assistance by Richard Solheim (R-6), Harold Valdez (R-2), Duane Yager (R-1), and Charlton Lewis (R-8).

The Road and Bridge Design Workshop was implemented in May 1990 and was a success.

Transportation Planning

Charlton Lewis

Years ago I participated in a detail on another forest, but it was in the National Forest system and working there was not a lot different from working on the forest to which I was assigned at the time. Sure, it had different terrain, different vegetation and was in a different state, but the work was similar to what I had been doing, and the administrative environment and culture were basically the same. But last winter when I saw the notice about this Road and Bridge Design Workshop in Mexico, I anticipated a different situation from that on the Cherokee National Forest here in Tennessee. And I was right.

I was fortunate enough to be chosen among several applicants to participate in the Workshop in the area of Transportation Planning. Beginning with the purpose of transportation planning and how it fits into overall land and resource management, I continued on into area planning and project level planning. Objectives that transportation planning hopes to achieve, criteria that need to be met, and constraints that need to be addressed were all covered. Development of an area plan with general corridors and subsequent project level plans for specific timber sales based on the area plan was presented. The idea was to present the material much as we would do here for the Forest Service and let the participants use what was applicable to their own situations.

At first, there was the usual nervousness about being in a new situation with unfamiliar faces and surroundings. In addition, there was a different language and different culture. But considering all that, the presentation went fairly smoothly. There were some difficulties to overcome in the field exercise in order to present a working example of the principles being taught in the classroom. These basically included the lack of good maps and aerial photographs early enough to be able to prepare adequately beforehand and a change in the location of the exercise. However, with some adjustments, we were able to plan a road that turned out to be a good example for location, survey, and design.

Some of my observations about the cultural setting of the workshop included some negative, some neither negative nor positive, just different, and some definitely positive.

Obviously, since I spoke only English, the language barrier was a problem. But I considered that my problem and not theirs. I wish I did speak Spanish and if I should ever have a similar opportunity again, I hope to develop some Spanish-speaking skills beforehand. It was still challenging and fun to pick up a few words and phrases. We were very fortunate to have Harold Valdez along who very ably served as translator many times.

Having a different time schedule also took some adjustment on my part. The 8-to-5 USA schedule is hard to break. Generally, a typical day might be:

8:00 am eat breakfast
8:30 am leave motel for training facility
9:00 am - 2:00 pm classroom training
2:00 pm - 4:00 pm break for lunch
4:00 pm - 7:00 pm classroom training

Actually, this schedule was not too difficult to get use to; the difficulty was that we didn't always start on time. Getting in a hurry was not usually done except on the street!

More specifically, other negative things included unanticipated changes in such areas as:

— workshop location (we stayed longer in the City of Chihuahua than we had anticipated)
— number of participants (the number attending was more than the number of handouts we were told to prepare for)
— schedule (Pope John Paul's arrival caused a holiday which meant we had to make some adjustments in our timeframe)
— field exercise location (the town was changed and the specific area for the exercise was changed also, making it difficult to be prepared).

Also, there were not enough maps and good aerial photographs available early enough to prepare for the field exercise for transportation planning.

One difference in the setting of the workshop that was neither negative nor positive, but just different, was obviously the different terrain and climate from Tennessee. It was much hotter and drier than it is on the Cherokee National Forest.

The organization of the Mexican government was different from that of the US Forest Service. Equivalent positions and procedures did not always exist. There was no "government" vs "private" land and consequently no need for rights-of-way. The land was "public" and assigned to the different native Indian families for their use and for them to live on, even though the government still "managed" it.

The cost of performing road construction as well as other activities is very different because of the high use of labor. It is a very labor-intensive society, which means not only a lower cost but also a less certain construction schedule.

There were no timber sales as we know them. Although we saw some areas cleared of timber, there were others that had only a few trees cut at the time. These were cut by hand without the use of power saws; in fact, they were cut by ax. Therefore, the harvesting methods are different. No large logging trucks are used, just mostly tandem.

However, in spite of these differences, there definitely were some very positive aspects. The Mexican people were very cordial and hospitable. We could not have had better hosts. Although I felt I already knew the meaning of Southern Hospitality, I learned a new meaning to the phrase. The coordinators made up to us for all the things that might have been lacking in materials or advance preparation. That is not to say that there had not been preparation; there certainly had been, but there were a few things that they probably didn't know that we would need.

One of the most exciting and rewarding things was the eagerness of the participants to learn. It was obvious that they were there not just to "get out of the office," but they were willing to learn and in fact, were very capable of learning. Some of them could speak some English, and it didn't take much effort on our part to realize that they were overcoming the language barrier and learning very well. Their enthusiasm was very evident during the field exercise when they ran up and down the slopes while taking cross sections.

The instructors all worked well together to adapt to the variable schedule and to the adjustments that had to be made during the field exercise.

Overall, it was a very rewarding experience and the appreciation shown by the coordinators of the workshop and the participants was very evident in how they made us feel welcome and in how they made us know they were thankful for the services that we rendered.

I was personally enriched by having participated in a new culture, experiencing new sights, sounds, and smells. I tasted new food, met new friends, and saw new places. I had experiences that cannot be captured by words and gained memories that will last a lifetime. I was made to feel welcome and appreciated and was treated royally for simply sharing part of the skills and knowledge of my job with the Forest Service.

Road Design

Richard Solheim

This was my first work detail outside the United States, and I accepted the assignment with enthusiasm and excitement. The thought of going to Chihuahua to teach road design was a once-in-a-lifetime opportunity. I had been assigned as assistant instructor for the three-week USFS Road Design session in November 1989, and I sensed that this was going to be a lot different. From the minute I got off the plane at Chihuahua to the minute I got back on when my detail was over, I was constantly aware that everything was so different, the lifestyles, the cultures, time schedules, and food. The fourth day we were there classes were cancelled because of the arrival of El Papa Juan Pablo (Pope John Paul). Two million people watched and listened to him speak that day.

The next day I began my program with the principles of road location, P-line survey, note reduction, and an overview of the design process. I taught the basic manual geometric road design method using the standard USFS Road Design Handbook. On Monday morning we departed for Creel, Chihuahua in the Sierra Madre Mountain Range to do our field work. Creel is a small village north of Copper Canyon, in a valley inhabited by the cliff dwellers and surrounded by the most magnificent rock formations anywhere.

Here, using what we had taught the past week, we applied it to a real situation, planning the transportation system, locating and surveying it. Now we were ready to return to Chihuahua for the design portion, but first, the feast! Our hosts prepared a barbecue banquet for us at the Governor's mansion by his private lake. This was their way of saying "thank you."

The road design session was not so easy as the field portion because of the language barrier. Technical terms are very hard to translate. Our two interpreters were stymied at times trying to relay a concept. It is much easier in the field because you can demonstrate if you cannot express it verbally. We were fortunate to have in attendance Andres De La Rosa, a Professor in Civil Engineering and Rigoberto Carballo, a Professor in Forestry Sciences, both from the University of Chapingo, near Mexico City. Andres and Rigo both spoke some English so they were able to use their teaching skills to help when necessary.

The next two weeks were filled with design applications. The students were divided into teams and each team did its design. It was a workshop atmosphere, with about two hours of lecture followed by a design period to apply the concepts. We went as far as one redesign to balance the earthwork to show the method for achieving the best as well as the most economical design. We used the Region 3 cost guide for estimating purposes.

If we had more time, we were to go back to Creel to set construction stake on the project. As time was short, we were limited to a classroom lecture on the staking principles.

I really enjoyed my detail to Chihuahua, and would return to repeat it if the opportunity comes up. I know now what to expect and would be better prepared, mainly with more visual aids, and a class in conversational Spanish. About the time I was able to converse reasonably well, the detail was over. I made a lot of friends there, friends with whom I keep in contact even now. I hope our Forest Service counterparts in Mexico have learned as much from me as I haved learned from them.

Road Maintenance

Harold Valdez

"Entrenamiento sobre caminos forestales"

* Proceso del manejo de mantenimiento*
(Road maintenance process)

In presenting the road maintenance portion I began with the Maintenance Management process, including definitions on Maintenance, Forest Development Roads, and the Maintenance Management System. The Maintenance Management System implementation included the scope of responsibility and the source of information. I identified the Road Objectives and Service Levels describing the primary purpose of the road and described the significant traffic characteristic and operating conditions. This in turn determined the maintenance levels that would be required to meet the objectives and service levels of the road. I reviewed maintenance activities and standards on specified types of work related to major activity groups and outlined the work involved for each activity, work method, production rate, and expected result.

I described and showed how to develop an Annual Maintenance Plan that would accomplish a total maintenance job including performance by others (i.e., commercial users and non-commercial users) and cooperation of local authorities including possible transfer of jurisdiction. The Plan included establishing a base year, maintenance frequency, and estimated cost in order to develop a maintenance budget.

I reviewed developing out year budgets and current year budget allocations in relation to budget needs. I reviewed 1900-4's that would identify maintenance work required. In identifying the work required I identified the scheduling of work either by contract versus force account, objective and service level, type, location, crew size, etc. In the final part of this instruction I reviewed the performance and work accomplishments.

In presenting the maintenance portion of the workshop, the instructors and I agreed to present the maintenance portion right after Charlton Lewis's Transportation Planning presentation in order to establish the need and reasons why good road location and design can contribute to less maintenance and lower costs. I also presented a slide program that showed the type of maintenance problems on my Forest and the type and to what degree of maintenance was required to correct and protect the investment that we had on our roads. The slide presentation included maintenance of level I, II, III and IV roads with slides on snow removal during winter logging operations.

The biggest challenge for me in helping present the Road and Bridge Design Workshop was in the interpretation. Even though I am able to speak Spanish, it was hard at the beginning due to the type and fluency of the Spanish that is spoken in that region. To make matters more complicated, the two professors were from Mexico City (approximately 800 miles South of the city of Chihuahua) and they spoke more rapidly and combined words and used words that I had never heard. In order to explain and show the comparison and the humor, it was like trying to listen to Charlton's Southern accent which required me to listen intently and consequently would require me to have him slow down and repeat a word or all that he had said.

One of the professors could speak some English as he had studied Forestry at Colorado State University for two-and-one-half years during the middle of the 1980's. This helped some, but the professor needed to refresh his English skills just as I had to refresh my Spanish skills. The professor would listen to the English presentation and he would translate to Spanish; this would go on until a question would arise or more clarification was needed. I had to listen very intently to the questions from the students and then translate them into English for the instructor. The instructor would then give his answer and I would listen to the professor's Spanish translation of the instructor's response to try to determine if what he was conveying in his interpretation and translation was in the correct context as presented by the instructors. At times during the instruction the students and the professor would get into discussions that required interpretation and translation from me to the instructors then back to the professor and the students and then back to the instructors. This would go on until instructors, professor, and students were satisfied with the answer or they understood the steps in a problem. During the second week when we had the field exercise on transportation planning, road location, and survey the professor who spoke English left for Mexico City and I was left with all the translation as we did the practical exercise in the field. This presented a real challenge as I had no one to help me translate the technical terms from English into Spanish. This forced me to discuss and learn the technical terms in Spanish and give the instructions with the help of the other professor who was an engineer but did not speak English. It also brought me and the instructors closer to the students in that we were all working on a project together regardless of the language barrier.

I agree with Charlton and his comments on the detail and that it was an enriching and rewarding experience. I made new friends with whom I am still in contact and with whom I will visit in the future.

Bridge Design

Duane Yager

This was my first time at teaching with a language barrier. When teaching with no language barrier, an instructor can determine from body language and the wording of the question if there is a misunderstanding of a concept. This is lacking in this training environment.

One of the first areas of training was terminology of a bridge design. These terms caused some confusion because the students and translator were not familiar with bridge terminology. An instructor needs to be careful to use only one term for a similar object, i.e., beam, stringer, girder.

The training then was developed to take an individual through the design of a road structure from the location, hydrology, and hydraulics. At this stage alternatives for the crossing were discussed. Since I did not have any cost for local structures and for that matter what materials were available, it was difficult to discuss actual cost of alternative structures.

The advantages and disadvantages of three different types of structures were discussed. Metal culverts were the first structures discussed. Design aids and specifications were given to the students. The design aids covered corrugated metal round and pipe arches. Also, drawings for structural plate pipe up to an 18-foot span were used. I found out that very few metal culverts were used in construction. The primary culvert used is stone masonry construction.

Two different bridges were discussed: Log and Treated Timber.

First, two different designs of log bridges were discussed: Alaskan Log and Region One. The Alaskan log bridge uses logs for the support and crushed rock for the deck. A design manual was used to determine the size of logs to be used for different clear spans of bridges.

The Region One design uses eight logs and a sawn plank deck. A drawing was distributed showing size of log to be used for different span and species. The species on the drawings were for logs used in Montana and Idaho.

Construction techniques and construction specifications were discussed for installing these bridges. Some common construction problems were discussed as well as the advantages and disadvantages of the two different log bridge constructions. The design of sawn or glued laminated beam treated timber bridges was not discussed. Drawings for glued laminated beam bridges were used for discussion. Again, the specifications were for timber from the Northwestern United States.

The last area discussed during the six days of training was scour protection for structures. Riprap sizing and installation was presented. A chart for sizing riprap dependent upon previous hydraulics computations was distributed. Gabions were discussed not only for scour protection but also as retaining walls.

In six days, an attempt was made to familiarize the trainees with some of the basic information for small road structures. No attempt was made to get into the structural design of members, i.e., stress, strain, deflection, etc. The sizes and species of members were shown on drawings provided. This information needs to be converted to local species and material available.

The students were eager to learn. In the future it would be better to cover limited areas and not try to cover a broad spectrum. In addition, the bridge design instructor needs to know what materials are available for use in construction. No attempt was made to get into the design of reinforced concrete or prestressed concrete bridges for longer span structures. From the discussion with other instructors, road equipment management, retaining walls, and foundation engineering might be areas that would be beneficial in improving timber harvesting in Mexico.

I am thankful for the opportunity to experience training with a language barrier. It gave me a better understanding of how important it is to make sure there is a clear understanding of terminology before any discussion is started. I am sure that I learned more from this training than did the students.

Field Testing of Roto Trimmer Mobile Rock Crusher

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Mechanical Engineer
San Dimas Technology and Development Center

Introduction

One of the major dilemmas faced by road managers is how to recondition worn-out native surface roads. Usually, the fine-grained particles needed for a smooth road surface are lost through dusting, erosion, improper blading, etc. What remains is an extremely rough and impossible-to-maintain roadbed composed of cobbles and boulders.

Until now, most managers relied on two options: rip and re-lay the roadbed or cover the oversized material with either aggregate or borrow. Both can be quite costly, especially if a suitable borrow or aggregate source is not available. Attempts at ripping and re-laying worn-out and rocky segments often result in an unsightly windrow of boulders which either has to be hauled away or fragmented and incorporated into the road prism. Ideally, an acceptable material should be produced from that available in the road surface. Grid-rollers, hammermills, and mobile crushers have all been tried but, depending on material type and conditions, each has had limited success.

Equipment

The Roto Trimmer Mobile Rock Crusher (Figure 1), a machine developed in Alaska to break up permafrost, was recently used on an experimental basis to recondition 23 miles of road on the Lolo National Forest, R-1. The Roto Trimmer, which resembles a giant roto-tiller, consists of a two-component kit: a front rotary drum attachment and a rear power pack. This kit mounts on any suitable loader or grader. The rotary drum is 3 feet in diameter by 10 feet wide and has 184 carbide teeth attached to it. These teeth rip up the roadbed and auger the material into the trimmer housing where it is further fractured and blended.

The Roto Trimmer Mobile Rock Crusher is described in the San Dimas Technology and Development Center's Equip Tip 9177 1301, January 1991. The following information details the test results subsequent to the publishing of this Equip Tip. The current price of a Roto Trimmer unit is $176,500 and is manufactured by Crude Tool Works of Kenai, AK.

Processing

Since the contractor (Triple Tree Inc., Missoula, MT) was not familiar with the equipment or its capabilities, considerable experimentation was necessary

Figure 1.—Roto Trimmer mounted on a wheeled loader.

early in the project to determine the most efficient method of operation. After trying various procedures, the contractor found that best results were achieved by processing each lane with two passes of Roto Trimmer. This was followed by smoothing with a road grader, watering, and then rolling with a steel-wheeled vibratory roller. Experimenting demonstrated that two 4-inch passes were faster and less costly than one 6-inch pass. Generally, processing deeper than four inches caused excessive wear on the ripper teeth and machinery.

Productivity

The estimated productivity rate using the above method was 20 to 30 ft/min of road surface completed on a standard 14-foot wide road or approximately one and one-half lane miles per 10-hour shift, depending on the material encountered. Grading and rolling is included in this rate.

Sampling

A large portion of the contracted 23 miles included very rough, worn-out roads with excessive rock and little or no fine material. To evaluate the Roto Trimmer's performance, samples were taken of the roadbed before and after processing. The selection of sample sites was based on rock type and the amount of large rock present in the roadbed. Initially, the Roto Trimmer was touted as being able to produce a suitable road surface in almost any rock type, regardless of size. Therefore, to test the ultimate capabilities of this machine, sample sites were located in segments containing excessive amounts of cobbles, boulders, and protruding bedrock. Processing these "worst case" areas by conventional methods would have been particularly difficult and costly.

Five sample sites were chosen in rock types common on the Lolo National Forest and with well-known construction characteristics. Except for small, infrequent igneous intrusions, all rock within the project area is derived from Precambrian Belt metasediments. Three sites were located in Wallace Formation limestone/dolomite, one in Mount Shields Formation quartzite, and the last in an igneous intrusion.

Test Procedure

Four of the five sites were sampled before and after processing by digging a 6-inch deep by 1-foot wide trench across the processed portion of the road. The samples were submitted to a private materials testing laboratory where material from each site was tested for: P.L./L.L. (plastic and liquid limit - AASHTO T-89), P.I. (plasticity index - AASHTO T-90), L.A.A. (abrasion - AASHTO T-96), S.A. (sieve analysis - AASHTO T-11 & T-27), and durability (durability index - AASHTO T-210). Values for the MOHS hardness scale and the Unified Rock Classification System (URCS) were assigned in the field. "After" samples were tested for gradation only; see Figures 2 through 5.

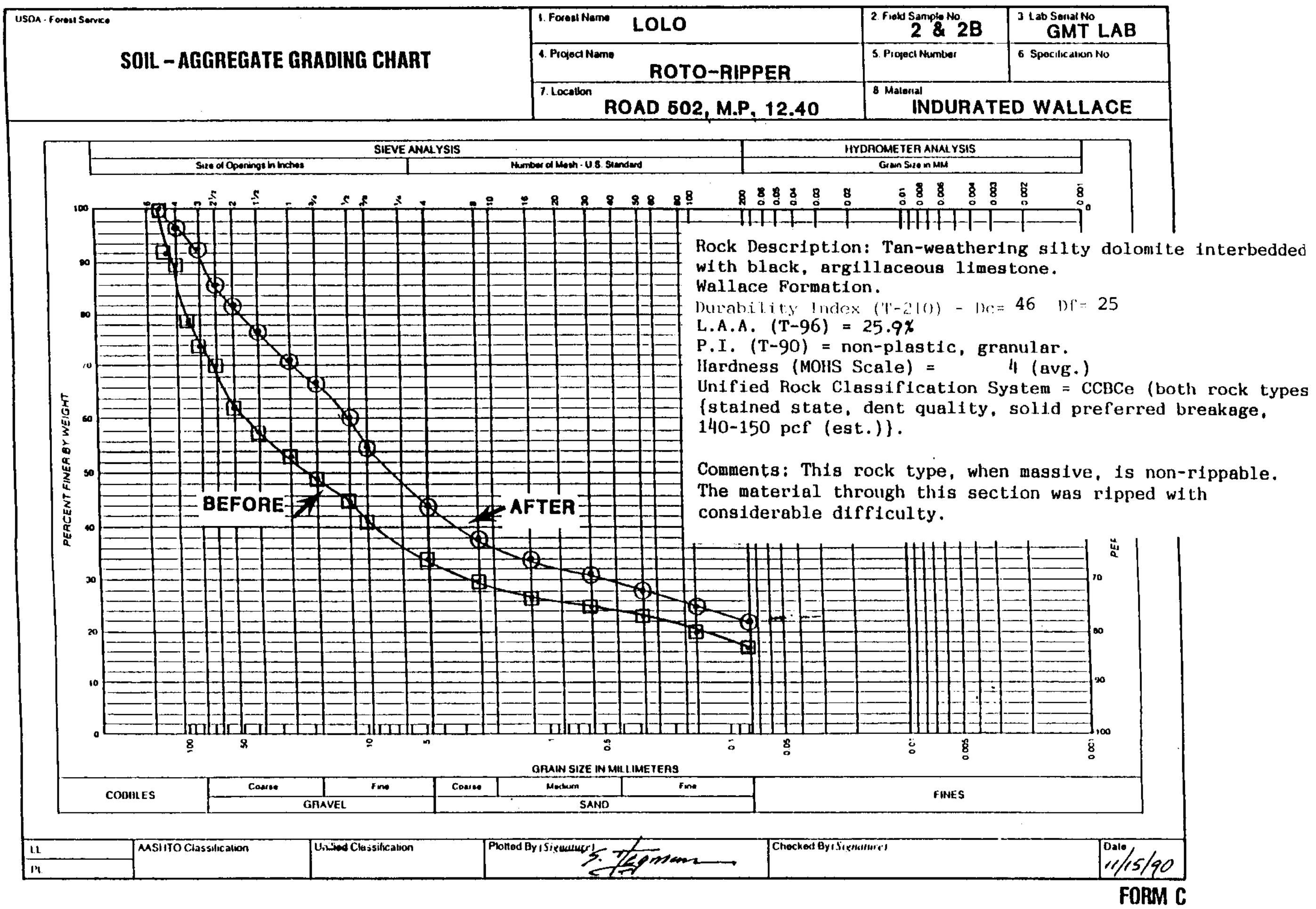

Figure 2.—Site 2: Soil-aggregate grading chart.

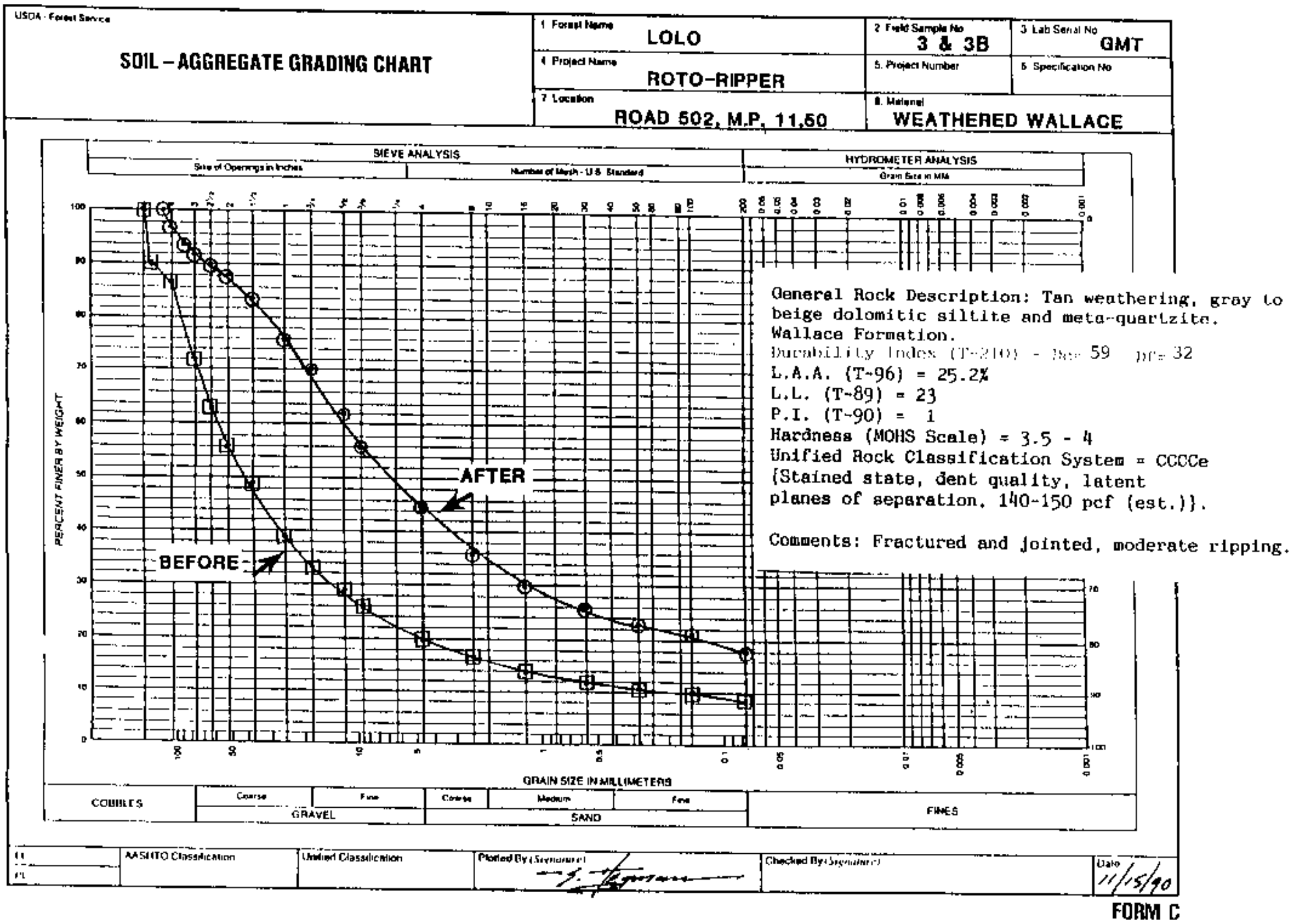

Figure 3.—Site 3: Soil-aggregate grading chart.

Test Site Descriptions

Test Site #1, Road #502, M.P. 12.80 (Wallace Formation: massive). This site lies in a section containing massive, grey to dark-grey limestone/dolomite cutslope outcrops. Solid bedrock extends 2 feet across the inside shoulder with several large, desk-sized boulders protruding 3 to 6 inches above the surface. Few fractures of planes of separation exist within the rock mass. This rock type is relatively common on the Forest and generally requires blasting when massive outcrops or large boulders such as these are encountered.

Because of the large boulders and bedrock, this section could not be effectively sampled prior to processing. Instead, a visual estimation was made of the gradation within a 50-foot segment. The rock in this section proved too hard for the Roto Trimmer to process. Consequently, no follow-up samples were taken.

Test Site #2, Road #502, M.P. 12.40 (Wallace Formation: fractured). The material is similar to Site #1 but more argillaceous and fractured; some parting occurs along the bedding planes. This site is situated on the uphill

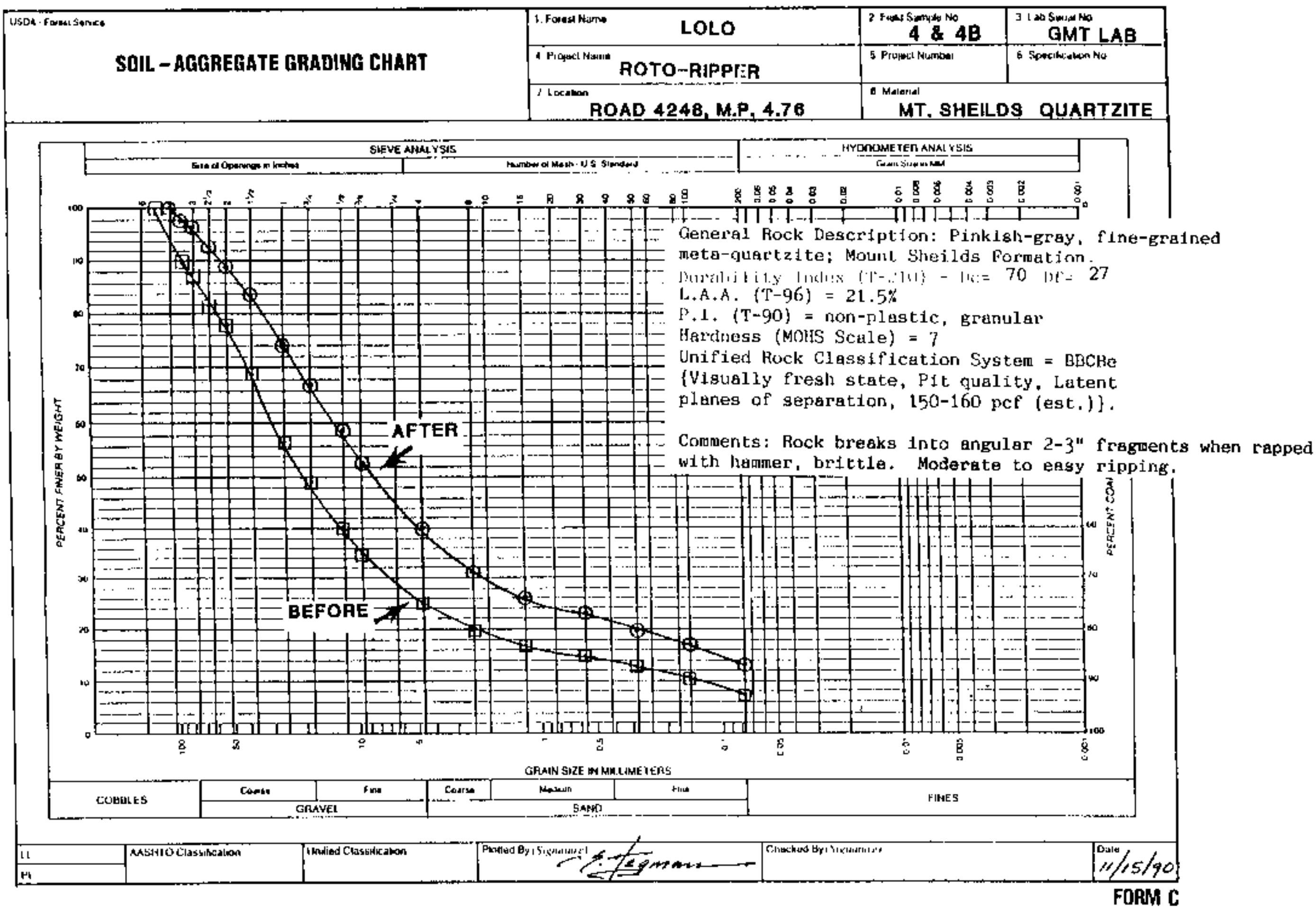

Figure 4.—Site 4: Soil-aggregate grading chart.

side of a newly constructed switchback. The contractor experienced considerable difficulty in ripping this material with a D8-K dozer.

The rock ripped out in brittle, 3 to 5 inch thick, by 6 inch square blocks. Since the roadbed rock was still loose from ripping and small enough to pull into the trimmer mechanism, test results showed a significant reduction in particle size across all sieves. The most dramatic change occurred between the 2- and 3/8-inch sieves where the amount of material passing through each sieve increased 16 to 18 percent.

Test Site #3, Road #502, M.P. 11.50 (Wallace Formation: fractured and weathered). Similar to the material in Site #2 but fractured, weathered, and somewhat softer. This site was selected to determine the Roto Trimmer's ability to process weathered and extremely fractured materials. The roadbed before processing was rocky and rough. Several rocks 6 to 12 inches across were loosely embedded in the road (see Figure 6).

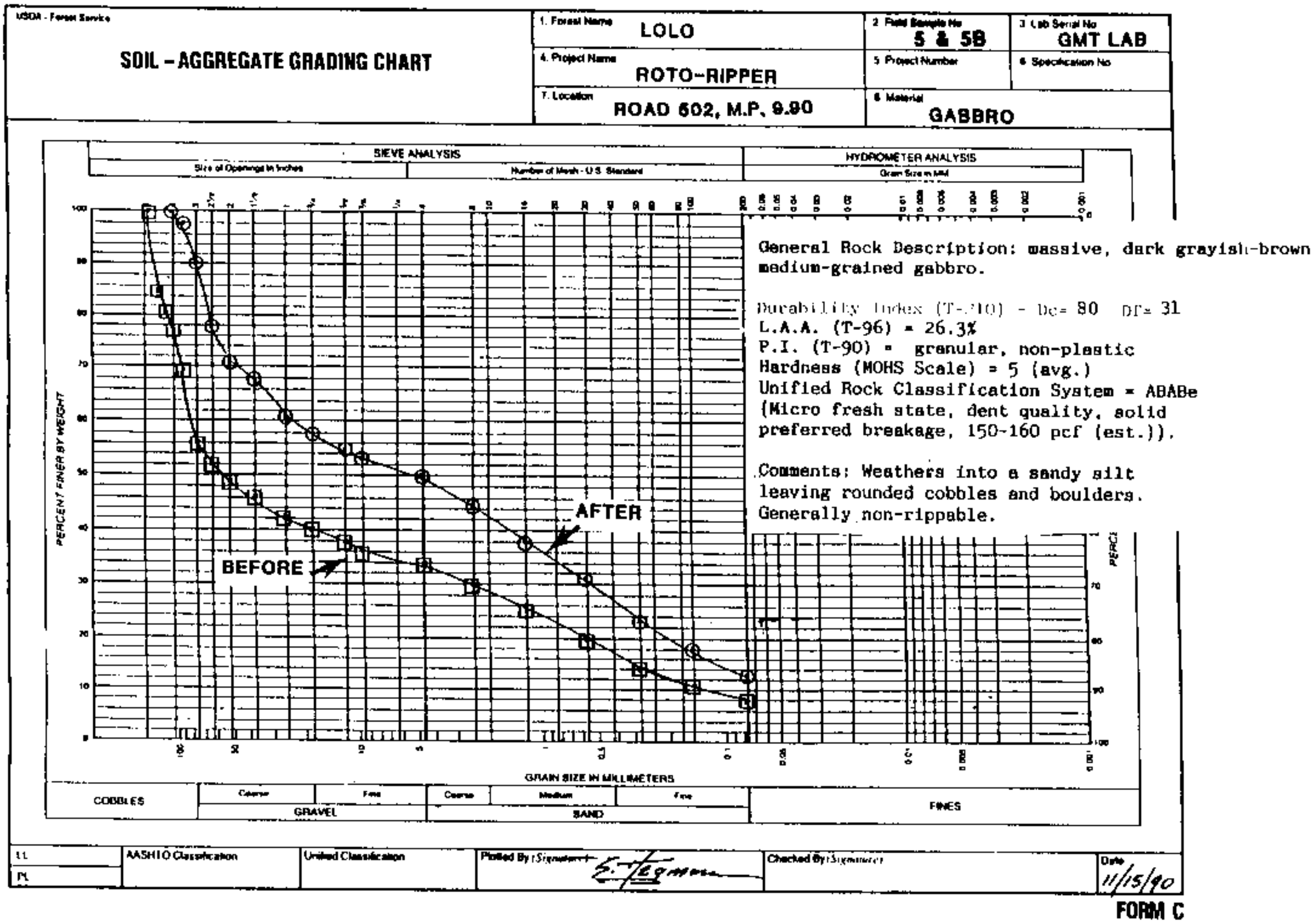

Figure 5.—Site 5: Soil-aggregate grading chart.

Most of the rock larger than 6 inches was successfully broken down to fragments less than 4 inches. The amount of material passing the 1-1/2 inch sieve jumped from 49 percent to 84 percent and the percent of material passing the Number 4 sieve increased from 20 percent to 45 percent. Similarly impressive results were recorded across almost all of the sieves. However, because this material had been weathered and contained internal fracturing, the vibratory roller also caused surface fragmentation. Since the samples were taken before processing and after rolling, it was difficult to determine exactly how much breakage can be attributed to the Roto Trimmer (see Figure 7).

Test Site #4, Road #4248, M.P. 4.76 (Mt. Shields Formation: meta-quartzites). The site is located in very fractured, brittle, fine-grained meta-quartzite which is moderately rippable with D8 dozer. This rock type has been an excellent source of crushed and grid-rolled, pit-run aggregates. Site #4 was selected to determine if the Roto Trimmer could manufacture a product similar to the grid-rolled, pit-run aggregates. Due to large, loose cobbles, this site was almost too rough to drive prior to processing.

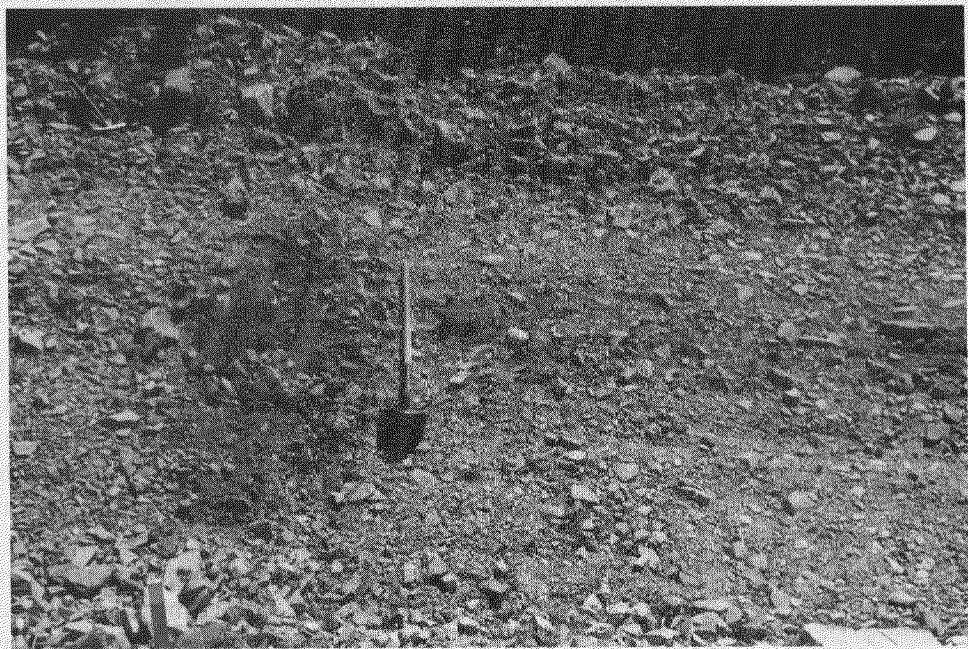

Figure 6.—Site No. 3 before processing.

After processing, this segment appeared as if crushed aggregate had been applied.

Test Site #5, Road #502, M.P. 9.90 (gabbro dike). This site is located in a massive, medium-grained, gabbro dike. Although gabbro intrusions are not a common occurrence on the Forest, this segment was selected to test the Roto

Figure 7.—Site No. 3 after processing.

Trimmer's performance on igneous rocks. Much like Site #1, this area contained large, solid boulders and shelf rock protruding up to 6 inches above the road. The Roto Trimmer attempted to chew the tops off the protruding rocks but the teeth wore out faster than the rock.

If the machine was able to pull the rock into the trimmer housing, it was usually fractured smaller than 4 inches. Except for the large boulders and bedrock, the material was effectively processed and the results were similar to the other sites.

Synopsis

Of the tests conducted, the sieve analysis proved to be the most informative. A comparison of "before" and "after" sieve analyses showed significant improvements in gradation and a substantial reduction in rock greater than 3 inches. According to the sieve analyses, the Roto Trimmer not only fragmented the over-sized rock but also manufactured appreciable "fines." Visual inspections of all areas indicated a thorough mixing of the processed material, which tends to reduce pot-hole development. Pockets of rock or fines were virtually nonexistent. Of the 23 miles of road that were reconditioned, only a very few isolated sections had noticeable oversized material. Even these exhibited a significant improvement in gradation.

Rock hardness did not seem to be a factor; the Roto Trimmer was able to break any rock pulled into the trimmer housing. Rocks that displayed weathering, internal fracturing, or jointing showed the greatest improvement in gradation. A certain degree of material breakdown may be attributed to rolling but, because the samples were taken after rolling, the exact amount is unknown. The fragmentation due to rolling appeared to be limited to areas of softer, more weathered rock. Segments of very hard shelf rock or large boulders may require blasting or ripping prior to processing.

Modifications

Subsequent to this testing and the distribution of the San Dimas Equip Tip, the Roto Trimmer has been modified by the manufacturers and the owners to remove some basic design "bugs" and to increase its efficiency. These changes include:

Installed two additional metal fracture boards to ensure better fragmentation, to decrease outcast of larger rocks, and to protect the machinery.

Increased thickness of trimmer housing from 1/2 to 5/8 inches for extra strength.

Added trimmer housing support brackets to allow rotary drum attachments to be changed from a forward to a reverse position by removing only the lift arm, pins, and hydraulic hoses.

Added a 1/2-inch steel replaceable inner liner for the trimmer housing.

Installed two 20-inch truck wheels with an adjustable axle height in front to increase maneuverability and to maintain a level trimming elevation.

Added a locking valve to maintain hydraulic pressure and to ensure uniform trimming depth.

Installed a leveler on back of machine to smooth processed material.

Added 1,000 pounds for improved stability.

Added extra set of gears to ease direction change of rotary drum.

Established a 1-inch clearance between teeth and fracture boards to break rock into smaller fragments.

Switched to teeth with higher carbide content for longer wear.

(NOTE: The contractor recently purchased a Cat 250 SS soil stabilizer, a machine similar to a scraper, to carry the trimmer unit. This will enable the operator to proceed in a forward direction. When mounted on a front-end loader, as it now is, the loader must operate in reverse.)

Conclusion

Because the Roto Trimmer is a unique piece of equipment and its owners are still experimenting with various operating methods, time and cost comparisons to more conventional procedures were difficult to determine. Operating costs and production rates appear to be reasonably close to conventional methods. Unfortunately, comparative test results from conventional processing methods do not exist. The current Forest Service specification, Section 306, "Reconditioning Existing Road," establishes only the minimum depth of scarification and maximum rock size allowed. Since there are no gradation requirements, no sampling is necessary.

The Lolo National Forest is continuing to evaluate the Roto Trimmer on other road reconditioning projects. These roads will include a variety of material types: granitic boulders, washed alluvium, glacial tills, extrusive volcanics, and various sedimentary formations. Once the evaluation process is completed, and if the results are as impressive as the initial tests, minimum gradation specifications can be established for future reconditioning projects. This will ensure a more consistent product and provide an easier-to-maintain road surface.

The limited sampling and testing accomplished so far shows that the Roto Trimmer can produce a suitable road surface by pulverizing oversized rock into a relatively well-graded material. In most cases, this cannot be achieved by conventional processing. More monitoring and testing need to be done in a wider range of materials to determine the Roto Trimmer's full capabilities, productivity, and efficiency. But, based on the results from this initial project, it appears to be a viable tool for reconditioning worn-out native surface roads.

Information Sources Since this is a developing piece of machinery, for updates, you can contact:

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Crude Tool Works
P.O. Box 1725
Kenai, Ak 99611
(907) 283-9696

Mr. Bob Greil
Triple Tree Inc.
6205 Pine Grove Lane
Missoula, MT 59802
(406) 258-6273

Using GPS in Fire Fighting on the Shorts Fire (Okefenokee Swamp Fire)

Douglas Luepke
Cartographer
Region 8

On October 12, 1990, an overview of Trimble's Global Positioning System (GPS) Pathfinder capabilities was presented to the Fire Management Team in the Regional Office of the Southern Region. The Team decided to mobilize the Pathfinder on the Shorts Fire which had been burning for approximately one month. The fire was under control at this stage and mop-up was the principal activity. This presented an excellent opportunity to integrate GPS into the operation.

The first use of the GPS unit on the fire was on a flight with an infrared detection mission to locate hot spots along the fire perimeter. The infrared (IR) interpreter sat in the back seat of the helicopter with a hand-held forward looking infrared scanner (FLIRS) unit. The Pathfinder operator was in the copilot's seat with the Pathfinder lying on the floor between his feet, and the polycorder (recorder/display unit) on his lap. The antenna was fastened on top of the pilot's control panel with duct tape. As the flight began, the Pathfinder was turned on and began reading position fixes. Once the helicopter reached the fire edge, the Pathfinder was set in the "data logging" mode. The data logging interval was set at one point per second. The pilot flew slowly at treetop level, following the sinuosity of the fire perimeter while the Pathfinder logged a position in a file every second.

In the back seat with the IR interpreter was a MOUSETRAP operator. The MOUSETRAP is a location device used to record a position every two seconds based on the Loran C Navigation System. As the helicopter slowly moved along the fire perimeter, the IR interpreter would acknowledge a hot spot and the MOUSETRAP operator would press a computer function key to identify the location in the data file being recorded. At the same time, the GPS operator would document the time being displayed by the polycorder and, if time permitted, the latitude and longitude on a pad of paper.

After two hours, using the above described methods, the east and south side of the fire had been mapped. Upon returning to camp, the data in the polycorder were downloaded to a laptop computer. The flight of the IR mission was then plotted using an HP7475 plotter at 1:24000 scale. The plot consisted of a series of dots depicting points along the line of flight. Precise registration of the plot with a United States Geological Survey (USGS) 7 1/2 minute quad map is accomplished by aligning the 2 1/2 minute tick marks produced on the plot with the 2 1/2 minute ticks on the USGS quad.

The entire file was then graphically displayed on a computer monitor. Using the Pathfinder software, PFINDER, the hot spots as acknowledged by the IR interpreter were located in the file by matching the time tag of each position with the times recorded by the GPS operator. The latitude and longitude of these points were recorded on a pad of paper. Using the "Locator" command, the operator can move a pointer around freely on the screen with a mouse. As the pointer is moved, the latitude and longitude are displayed in the upper portion of the screen. The pointer is moved around until the exact latitude and longitude of each previously recorded hot spot appear on the screen. As this is done, the pointer indicates on the graphic screen where that hot spot is located relative to the fire perimeter. This point is then visually transferred from the screen to the plotted 1:24000 scale fire line map overlay.

With the hot spots located on the overlay, it was determined which spots were easily accessible by engines and which required water bucket drops.

During the detection flight it was noted that one hot spot was relatively small and not smoking. It was near a fire break recently constructed with bulldozers. Considering the Pathfinder's navigating capability, it was decided to try to locate this spot with an engine crew using GPS.

The first step in locating this hot spot was to enter the recorded location into the Pathfinder's waypoint file. The engine crew drove as close as they could to the spot, navigating with the USGS quad map and the overlay plot. The Pathfinder was then used to navigate to the final location. With the Pathfinder position at the engine known, the navigate program was executed. This program calculates the azimuth and distance from the user to the previously entered coordinates of the waypoint (hot spot). The polycorder displays the azimuth and distance from the current position to the hot spot. A compass was used to direct the crew toward the hotspot. As the engine crew approached the position, the distance displayed on the polycorder continued to decrease. When the distance decreased to zero indicating the location of the hot spot had been reached, there was no visible evidence of a hot spot. This confirmed the observation during the detection flight that this spot was not smoking. As the search for the hot spot narrowed, a pile of debris pushed up by the dozers was noticed. Using the cold touch method, heat was detected coming from this pile. This was it, and within 10 to 15 feet of where the GPS unit had zeroed out. Mission accomplished.

Another task was to calculate the area of the fire. Because helicopter time was in high demand, it took the next three days to complete the remaining portions of the fire perimeter. Although the flights were not at ideal satellite visibility times, the data were collected as if this were a working fire situation and information was needed immediately. Due to antenna location within the helicopter and minimum satellite visibility, portions of the perimeter had to be flown in different directions to get adequate satellite signals. The PFINDER software has the capability to calculate area if all data are flown in the same direction. It was understood that flying portions of the perimeter in opposite directions would require additional steps to calculate the area.

Using the Pathfinder software, the data acquired during the three days were merged into one file using the utility program MULTISSF. This file was graphically displayed on the computer monitor. All overlapping data from each of the individual flights were then removed with the DELETE command. The final product was a single, clean file, depicting the fire perimeter of the Shorts Fire. Next, the utility program GISGENX was used to convert these data into Autocad DXF format.

An Autocad drawing file was then created and the data collected by the GPS unit were added by using the Autocad command, DFXIN. All points in the file were placed on Layer 0. Using the POLYLINE command, a line was drawn on a separate layer over the existing GPS points. It took about 30 minutes to do this. Once this line was closed on itself, the AREA command was used to calculate the acreage. The total area measured was 20,079 acres with a perimeter of 49.5 miles. This was less than the total fire area of 20,779 acreage because the small burn areas outside the main burn on the southern perimeter were not included in the GPS measurements. If these areas had been measured, the calculation would likely have been very close.

Conclusions

This fire situation provided an excellent opportunity to introduce GPS to the fire fighting procedures. Although the activity of the fire was not intense, there was a real chance for this fire to take off and run. It was proven that GPS can be used effectively in a helicopter. However, it was noted that the location of the antenna within the helicopter is critical. In some cases the loss of signal from one or more satellites created data gaps ranging from 50 to 200 feet. This was not critical because the detail of the fire perimeter was not lost.

The process used to record hot spots, download the data, and locate these spots on the map was a bit cumbersome. Future versions of the software will reportedly provide the capability to tag points by pressing a key similar to the procedure used by the MOUSETRAP.

One more valuable feature of the GPS software was the ability to produce a plot with 2 1/2' tick marks which allows easy registration with the USGS quads. This eliminated the need for "rubber sheeting" the fire map to make it fit.

The navigation ability of the GPS unit can play a major role in fire fighting. The new, low cost, lightweight, Pathfinder Basic now available seems to be an excellent tool to locate recorded hot spots. An individual in a spotter helicopter can record hot spots and transfer the information by radio to a ground crew for immediate response. Imagine the spotter directing 10 or more engine crews to hot spots and also directing water drops all at the same time using GPS.

Several people suggested flying the perimeter of the fire at a higher altitude. In this way, a less detailed but acceptable perimeter could be defined in less time. This would have eliminated the additional steps and software used for area calculations. However, this provided an opportunity to demonstrate another way to calculate area and the flexibility of PFINDER in converting data into Autocad format.

Additional Comments

One of the activities associated with the fire was the consideration of an existing facility for a combination fire camp and incident command post. The Pathfinder was used to create a quick as-built plan of the existing features including roads, parking areas, and existing supply and motor pool locations. These data were collected, downloaded, and a 1"=40' plot provided to the planning team in less than two hours.

Getting There and Back—Program Strategy

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Washington Office

John Quenoy
Forest Engineer
San Juan National Forest, Region 2

Goal

One goal is to develop and operate a Forest Service road and trail system that provides safe, environmentally sound and efficient access to all Forest resources. An additional goal is to reach the point where access decisions made as part of Forest Plans, are clear and rational to the customers being served.

Situation

Getting There and Back (GTB) is a focus on the operation and management of the existing road system, and the future access needs to meet Resource Planning Act (RPA) and Forest Plan objectives. Most of the business, administration, and uses of the National Forests are dependent on the road system for access. Many of the roads were initially constructed to serve forest uses such as timber harvesting, livestock grazing, and mineral mining, but these roads are now vital for administration and access to all the forest resources as well.

The management of access is every Forest manager's responsibility. To accomplish the goals set forth in the Forest Plans, appropriate and safe access is an essential component of implementing these goals.

There are many types of roads which, in turn, require different levels of care and upkeep. The upkeep of these roads must be consistent with Forest Plans and overall management objectives. Road upkeep and development require continuous financing, both through commercial haulers and general appropriations. The general appropriation funding is politically vulnerable because arguments over the merits of roads tend to lead the public to believe that forest roads are almost entirely associated with timber access. Discussions that focus on the construction of new roads, primarily for timber harvest, should not be permitted to dilute the importance of the management and restoration of the existing system—which serves all forest programs.

The following factors have, or are, contributing to the so-called "roads debate":

(1) Perception that the Forest Service constructs more roads than were planned, with no increase in funding.

(2) Perception that roads contribute greatly to environmental damage.

(3) Inability to adequately articulate that the construction, reconstruction, maintenance, closure and obliteration of roads are needed to serve all resource programs.

(4) Lack of public acceptance that travel and access decisions are made in Forest Plans and subsequent project plans, and that they are made to support all future resource activities.

(5) Failure to eliminate unneeded roads in a reasonable timeframe.

(6) Failure by the Forest Service to adapt to changing user desires and values, and then incorporate these changes in management decisions.

(7) Perception that there are too many engineers who overbuild roads.

(8) Perception that the agency has too much road money.

(9) Lack of priority within the Forest Service for adequate management of the road system.

Market Segments

Market Segments are the individuals and groups who have some sort of stake in policy and decisions. These are the individuals and groups for which the strategies and actions are developed.

(1) Internal
Agency Line Officers
Staff Directors
Resource Staff Members
Agency Spokespersons

(2) External Federal Government
Department of Agriculture Managers
Office of Management and Budget
Other Federal Agencies
Members of Congress and their Staffs

(3) External Other
Local Citizens
State and Local Governments
Users and Tourists
Organized Groups
- General Users
- Specific Interests, Age/Type of Use
- Forest Industries and Mining Interests
- Concessionaires
- Conservation Organizations and Special Interest Groups

Strategies/Actions

Strategies are portrayed as goal-type statement (A through G), followed by a series of actions that could help to attain the strategy. Actions are then related to the market segments that would most benefit (listed in parentheses).

A. *Incorporate Diverse Public Involvement:* Solicit, involve, and listen to users, special interest groups, and individuals about transportation issues.

(1) Sponsor a National Access/Travel Management Conference inviting a wide variety of users and special interest groups. This meeting will concentrate on developing a dialog among the users, Forest officials, and congressional staffs. (Market Segments 1, 2, 3)

(2) Sponsor meetings at the Regional and Forest levels to talk and listen to users, special interest groups, and individuals and incorporate the input into Road Management Objectives (RMOs). (Market Segments 1,3)

(3) Solicit road users and special interest groups to participate in the consideration of access and travel management during the National Environment Policy Act (NEPA) scoping for all resource projects. (Market Segment 1)

(4) Utilize the input from the Forest Planning effort, which has already had public involvement. (Market Segment 1)

(5) Utilize appropriate input from other agency initiatives such as the Federal Highway Administration (FHWA) "20-20" process and Department of Interior Legacy 99 infrastructure promotion. (Market Segments 1, 3)

(6) Actively participate with congressional and special interest groups on the ground, to show what is being proposed, what has been done, and to provide them with accurate and pertinent information on associated access and travel management issues. (Market Segments 1, 3)

(7) Develop a network to share the successes, and failures, of transportation partnerships that are underway and on-going. This network should include Forest Service people, other governmental agencies, special interest groups, and other interested and influential individuals. (Market Segments 1, 2, 3)

(8) Take steps to assure that the Washington Office is able to collect, track, and disperse accurate and timely information for the entire road program. This would assure that consistent and accurate information is always available to the public, congressional people, and Forest Service employees. (Market Segments 2, 3)

B. *Resource Decisions Include Transportation Decisions:* Link travel and access to all resource programs.

(1) Consider augmenting the existing road functional classifications. The terms arterial, collector, and local road are well institutionalized, but expansions in the definitions could be more descriptive of the use of and need for the road. (Market Segments 1, 2, 3)

(2) Clearly link travel and access with initiatives that are ongoing within the different resource programs, such as Change on the Range, Recreation Strategy, Rise to the Future, and New Perspectives. (Market Segments 1, 2, 3)

(3) Consider a Forest Service special road program which would complement the Bureau of Land Management's Backcountry ByWays initiative. Interpretative signing and publications would be used to "show and tell" the use opportunities as well as the multiple resources that the road serves. (Market Segment 3)

(4) Provide information to the public, on access and travel management, containing meaningful statistics and examples of the wide variety of uses that are available. (Market Segment 3)

(5) Continue to urge completion of the road management objectives, using a full interdisciplinary team that includes Forest users. (Market Segments 1, 3)

(6) Support the ongoing consideration of the financing policies that would fund transportation as part of the resource appropriation they serve. (Market Segments 1, 3)

(7) Strengthen the budget narratives to show the impacts of varying levels of financing. (Market Segment 2)

C. *Transportation Decisions Have a Broad-Based Acceptance:* Develop a higher level of trust, understanding, acceptance and support for roads, both internally and externally.

(1) Each unit develop key contact lists of users, special interest groups, and individuals who have transportation interests. Make the commitment to keep these people informed and involved. Go to them so that they don't have to come to us. (Market Segment 3)

(2) Utilize partnerships and cooperative agreements in all conceivable aspects of development, operation, maintenance, travel management, and information distribution concerning roads and trails. (Market Segments 2, 3)

(3) Identify and develop coalitions for quality management of travel and access. (Market Segments 1, 3)

(4) Provide meaningful information that satisfies the Forest users and special interest group desires. (Market Segments 3)

(5) Acquire quality, credible pictures of roads and users, for use in our reports and displays. (Market Segments 2, 3)

(6) Write Forest Service reports in terms that are more readily understood by the public. (Market Segments 2, 3)

(7) Promote the adopt-a-road program and give the adopting organization or interest group the credit and publicity. (Market Segment 3)

(8) Make efforts to participate with various road user groups and motor vehicle enthusiasts. (Market Segments 1, 3)

D. *Access and Travel Management Decisions Satisfy the Customer's Needs:* Apply the philosophy that the customer comes first.

(1) Continue to emphasize quality maps and signing that are meaningful and that will confidently lead the users to their destination and back. (Market Segment 3)

(2) Acquire an understanding of what users expect to find when using the National Forests. (Market Segment 3)

(3) Incorporate the contribution of roads to resource management as part of the Scenic Byway interpretation. Provide opportunities and show case roads that meet the users expectations through the New Perspectives. (Market Segment 3)

(4) Conduct on-site surveys to determine how and where people get their information on roads. Use the survey to make an assessment of likes, dislikes, and expectations. (Market Segment 3)

E. *Minimize the Environmental Impact of Roads*: Incorporate visual and environmental technology in the planning, construction, and maintenance of roads.

(1) Continue to incorporate state-of-the-art technology to minimize environmental impacts from roads, including variable tire inflation. (Market Segments 1, 3)

(2) Incorporate visual quality management objectives into the planning, design, construction, and maintenance of forest roads. (Market Segment 3)

(3) Correct the backlog of road structural damage and drainage problems in roads that are contributing to environmental damage. (Market Segment 1)

(4) Continue to make it common practice to renovate the existing roads as a way to avoid constructing new roads. (Market Segments 1, 2, 3)

(5) Find effective ways to make resource managers, and the public, more aware of road maintenance needs and financing. Show the needs through examples of real situations that are causing environmental damage and the consequences and costs. (Market Segments 1, 2, 3)

F. *Manage Roads for Safety and Efficiency:* Assure that the development, operation, and maintenance decisions incorporate adequate safety, and contribute to management efficiency.

(1) Continue to develop, operate, and maintain roads to the standards necessary to safely handle the intended use. (Market Segments 1, 3)

(2) Design, construct, and maintain roads to meet management objectives. Avoid overbuilding, as well as underbuilding, and maintain the roads for the intended use and protection of the investment, no more and no less. Use analysis to accomplish this goal. (Market Segments 1, 2, 3)

(3) Monitor the use on the roads, and adjust management for that use where possible. (Market Segment 1)

(4) Provide enough signing so that users will not be led into unsafe and hazardous situations. (Market Segment 3)

(5) Generously provide pertinent information about opportunities and driving tips on forest roads. (Market Segment 3)

(6) Maintain the roads to safely handle the use, or take action to reduce conflicts. (Market Segment 3)

(7) Utilize the pavement management system in the design of asphalt and graveled roads. (Market Segment 1)

(8) Develop a credible model to predict maintenance investments to avoid future reconstruction.

G. *Interface Forest Roads with Other Public Transportation Systems:*

(1) Emphasize the contribution of forest roads to the President's Rural Economic Development Initiative, especially those routes that significantly contribute to recreation, tourism, hunting, and fishing. (Market Segments 2, 3)

(2) Expand partnerships with counties and other government agencies for construction and maintenance. (Market Segments 2, 3)

(3) Aggressively obtain rights-of-way that restrict access to National Forest land. (Market Segment 3)

(4) Make the forest recreation opportunities more visible to the public through publications, and better informational/interpretative signing on the transportation system. (Market Segment 3)

(5) Expand the scenic byway concept to additional selective, high value forest development roads to enhance the driving-for-pleasure recreation experience. (Market Segment 3)

(6) Gain consistency on road standards with the federal, state, and county agencies. Various road agencies tend to set their own standards and often they are out-of-sync with each other. (Market Segment 2)

Errata to the "Where is First and How Far is Second—GPS" Article in the January-February 1991 Issue

An equation was omitted from page 14 of the January-February 1991 issue of "Engineering Field Notes." The corrected information appears below:

SO #1

34 pts	8.73' error
223 pts	11.63' error

SO #2

44 pts	27.36' error
134 pts	11.93' error

SO #3

146 pts	15.10' error

SO #5

32 pts	1,219.39' error
34 pts	156.83' error

SO #7

69 pts	25.55' error
287 pts	23.58' error

SO #8

34 pts	13.06' error
98 pts	18.51' error

SO #9

42 pts	106.12' error
148 pts	30.26' error

$$\text{Error} = N^2 + E^3$$
$$= \sqrt{N^2 + E^2}$$

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