

# Road Maintenance Management Information System for Counties and Cities

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County highway departments in Indiana follow guidelines approved by the State Board of Accounts, mainly for highway resource accounting and not for maintenance activity costing. The existing Daily Work Report Form was modified to help maintenance activity costing with more precise reporting of road location, equipment, and material use and also for storage on a microcomputer data base. The Highway Extension and Research Project for Indiana Counties and Cities (HERPICC) at Purdue University tested the recommended procedures in a pilot project with White County Highway Department in Indiana. A user-friendly program was developed using the R-Base 5000 data base software for maintenance activity accounting; this program has been recommended for use by county highway and city street departments in Indiana. In addition, organizational requirements such as maintenance staff training, requirements for road inventory and road section demarcation, and special considerations for unpaved road maintenance activities such as dragging, grading, spot regravelling, and the required reports are described.

County highway departments, in general, spend more than 50 percent of their annual budgets on maintenance and repair programs as opposed to construction and reconstruction (1). As a result, improved maintenance management procedures are the best means for better management and cost control of total highway operations at the local level. In this paper, procedures outlined for local road maintenance management and cost accounting using a microcomputer data base are discussed. The microcomputer program is based on existing Indiana county highway cost accounting guidelines and suggested reporting and management changes (2, 3). The maintenance management and accounting information system described can be expanded to cover total road surface management as counties and cities obtain the resources to manage road surfaces and apply suitable road performance criteria and condition measurement procedures. The microcomputer program can monitor cost of maintenance activities on both unpaved and paved roads as well as on agency-executed construction and reconstruction projects. Provision is also made for cost management of projects contracted out.

## INDIANA COUNTY HIGHWAY ACCOUNTING SYSTEM

The accounting system currently used by counties in Indiana is outlined in the guide manual published by the Highway

Extension and Research Project for Indiana Counties (HERPICC) (2). In 1961 the Indiana General Assembly enacted legislation that required each of the 92 county highway departments to install and maintain a system of cost records. The original legislation was amended by P.L. 103, Acts 1971 (IC 8-17-4.1). Cost records have since been kept and prepared by county, city, and municipal highway departments for the administration and maintenance of their road systems. By using this system, the cost of highway operations is the main basis for measuring the effectiveness of road programs and policy.

## BASIC ACCOUNTING REQUIREMENTS

Beginning in January 1973, 20 prescribed forms and records, including ledgers, have been recommended by the State Board of Accounts for hand keeping of accounts by county highway department. Any highway department can change a prescribed form with approval from the board and can also use other supplementary forms or records if desired. These additional forms, however, are not expected to replace prescribed forms or records.

Expenditures for county highway departments were classified into four expense account categories identified by a four-digit code. The first code digit is for the expense account category, and the second digit describes major budget classifications (Table 1). The third digit provides for minor budget classifications (Nos. 1–9) and the fourth describes expense items (Nos. 1–9) listed in the budget estimate for the particular county and year. Separate accounts are kept for the different county revenue funds including, "county highway fund," "cumulative bridge fund," "local road and street fund" or any other fund established for county road funding.

On December 31 of each year, annual operational reports are submitted to the State Board of Accounts. For some counties, the reports and budgets may be the only major annual highway management reporting effort. They are not suitable for maintenance management of the road network. Cities and towns usually prepare different annual reports.

## BUDGETARY COST ASSIGNMENT PROCEDURE

Further guidelines are provided in the manual for the assignment of costs under various budget categories. The assignment procedure enables the costs of labor, materials, supplies equipment charges, and contractual services to be charged to maintenance and repair as well as construction or reconstruction.

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TABLE 1 MAJOR BUDGET EXPENSE ACCOUNT CATEGORIES AND CLASSIFICATIONS

a. Major Budget Expense Account Categories	
Code	Item
1000	Administration
2000	Maintenance and Repair
3000	Constraction and Reconsruction
4000	General and Undistributed Expense
b. Major Budgetary Classifications	
X100 *	Personal Services
X200 *	Supplies
X300 *	Other Services and Charges
X400 *	Capital Outlays

\* NOTE: 'X' can be any of the expense category codes 1 to 4 given, above.

tion for either roads or bridges. The maintenance and repair accounts are generally costed to cover all roads and bridges in the county with no differentiation between individual roads or surface types.

It is optional for counties to keep separate summary reports for roads and bridges. Continuous monitoring of the cost of county highway operations provided the basis for road surface management. However, owing to lack of accounting personnel in many counties and the tediousness of manual accounting, detailed cost accounts have not always been kept in all counties. At best, maintenance programs have relied on estimates made by the supervisor, engineer, or the clerk. The extent to which counties have applied the complete cost assignment procedure has often demonstrated the differences in effectiveness of individual county highway maintenance programs. This research has suggested improvements in the current cost accounting system to enable maintenance activity costing as well as costing by road surface type.

As reported by Burke (4), maintenance management in Indiana counties follow a trend observed in many other counties and cities in other states whose aim is to provide better budgeting and cost information. With some modifications existing cost accounting systems provide the basis for improved maintenance management.

COUNTY ROAD MAINTENANCE MANAGEMENT PRACTICES

A few counties have begun to use commercial microcomputer packages for highway management cost accounting. In several other counties, mainframe computers have been installed in the courthouses for general county cost accounting and analysis. However, few highway departments have connections to the mainframe computers to summarize their road maintenance cost accounts. They usually use existing manual cost-accounting procedures by posting costs in appropriate ledgers to prepare required cost summaries.

Progress on refining current cost-accounting procedures into an improved maintenance management system varies greatly from one county to another. The 92 counties represent different levels of preparedness for increased sophistication in road maintenance cost accounting. In proposing a road surface management system, provision has been made to satisfy the different agency needs represented.

PURPOSE OF MAINTENANCE MANAGEMENT SYSTEMS

All maintenance management systems seek to provide better control of costs and, ultimately, the performance of the road systems involved. To achieve this, data base systems are designed to enable appropriate data compilation and storage for the assessment of costs as well as performance. Performance information enables needs to be determined for pavement management. As volumes of data increased, computers have been used to speed up the process of data handling and analysis. However, the need in most local highway agencies has been to improve highway cost accounting as an initial step toward improved maintenance management. With generally low annual revenues, the tendency is for an agency to do the best job, from local experience, for the money available. For many counties in Indiana the evaluation yardstick has been the satisfaction local residents expressed with the condition of their road network. Citizen complaints have often been the basis for taking action on roads needing repairs (3, 5). Figure 1 shows the levels of progress through which maintenance management systems could evolve for typical local agencies. It is expected that the rate of progress through those levels will differ for various counties or cities.

The basis for any maintenance management system would be to improve and adapt current cost-accounting procedures

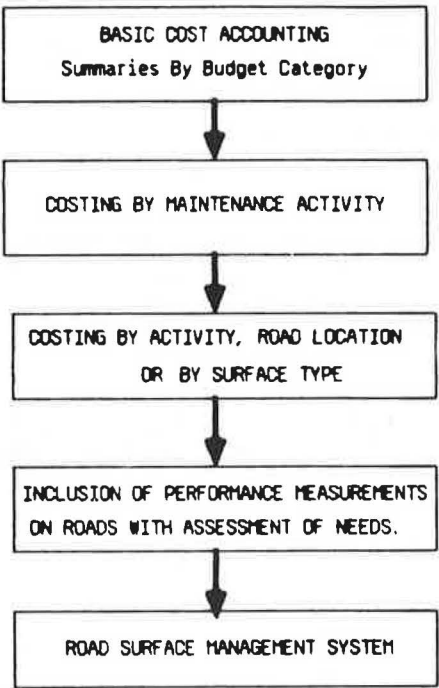


FIGURE 1 Levels of various local highway maintenance management.

to ensure that data reporting is in the form that will provide financial accounting for management purposes and information for effective planning and maintenance of the road system.

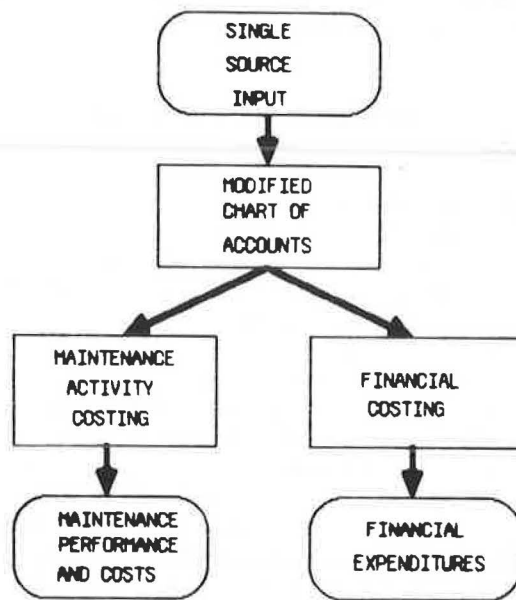


FIGURE 2 Integrated financial and maintenance management systems.

### NEED FOR ACTIVITY-BASED ROAD MAINTENANCE MANAGEMENT SYSTEM

A basic requirement of any public agency for implementing complete highway maintenance management systems is total commitment of all field personnel, and of management, to the collection of complete management information from daily work reports. An improved maintenance cost accounting and management system will require reliable daily work reports that, combined with accounting for other cost items, can be used in estimating maintenance costs. Implementation of such a system will require adequate training for all levels of field personnel, and supervisory and accounting staff. Figure 2 shows the flow chart for a typical integrated maintenance management and cost accounting system as suggested by Burke (4). The Daily Work Report form used in Indiana (Figure 3) provided useful cost information that was found to be limited in application.

In addition, the cost accounting system derived mainly gross estimates of the cost of resources used under major budgetary classifications such as maintenance and repair or construction and reconstruction. However, for effective maintenance management of the highway system, it was essential to identify differences in cost for various maintenance activities, different road surfaces, and location and functional classes. The analysis is useful for maintenance planning and also for undertaking maintenance activities at appropriate locations for maximum effectiveness at minimum cost. With proper cost estimation for the different road surface types and activities,

Form Prescribed By State Board of Accounts

County Highway Form No. 1 (Rev. 1972)

### COUNTY HIGHWAY DAILY WORK REPORT

Name of Employee: \_\_\_\_\_ Date: \_\_\_\_\_, 19\_\_

PROJECT OR LOCATION: (If work was on two or more construction projects describe each project separately by code "A", "B", etc.)					CONSTRUCTION AND RECONSTRUCTION				MAINTENANCE AND REPAIR			OTHER		
					Project A	Project B	Project C	Project D	Roads	Bridges		County Garage		
LABOR - TOTAL HOURS FOR DAY														
EQUIPMENT NUMBER	Speedometer		Total Miles	Number of Hours										
	Begin	End												

← IN

← OUT

**MATERIALS - SUPPLIES - REPAIRS:** (Describe and attach delivery or sales tickets, invoices, etc)

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FIGURE 3 County highway daily work report Form 1.

**FIGURE 4** Modified county highway daily work report Form 1A.

The existing county highway daily work report form was modified (Figure 4) to achieve the preceding objectives. The new form was patterned after the old one so that county highway department employees familiar with the basic format will find it easier to use the new form. Specific activity and location can be filled in together with employee time for each activity. The equipment used and the distance and time, as well as the road materials by predetermined codes and quantity, are also recorded. Each line of information in the main part of the form represents work performed in one location. However, if more than one piece of equipment or material are used by the same employee on the same road, the information is recorded on a new line. A total of 10 lines of data is possible with the possibility of using a second sheet if required. Provision is made for other materials and supplies such as fuel, spare parts, and so on, to be recorded on the bottom right of the form. Daily accomplishments, time employee arrives at work and time he or she leaves, as well as other remarks can be recorded.

To apply the suggested procedures and the modified daily work report form, special computer codes were specified for maintenance activities, typical materials, and cost items such as insurance, uniforms, and so on, of Indiana county highway

After initial meetings with the highway supervisor and the county clerk, a 3-hour training session was held for the field staff. Special sessions also were held with specialized groups of grader/operators, truck drivers, and mechanics, to point out specific requirements applicable to them. During the training session, the importance of every employee in road maintenance management was emphasized. It was pointed out that by using a management system, information or knowledge otherwise retained by individual employees is in part made available to subsequent employees in that position. This is important because each employee at the local level has the

TABLE 2 LIST OF HIGHWAY MAINTENANCE AND OTHER ACTIVITIES AND CODES

CODE	ACTIVITY	UNIT MEASURE	CODE	ACTIVITY	UNIT MEASURE
100	GRAVEL OR STONE SURFACES		180	VEGETATION	
101	Dragging	Road Miles	181	Machine Brushing	Man Hours
102	Grading	Road Miles	182	Manual Brushing	Man Hours
103	Graveling/Stoning	Road Miles	183	Mowing	Swath Miles
104	Spot Regravelling	Tons	184	Applying Weedeaters	Man Hours
105	Dust Control	Road Miles	190	BRIDGE MAINTENANCE	
110	SHOULDERS		200	ADMINISTRATIVE OVERHEAD	
111	Grading - Cut Berms	Road Miles	201	Supervision	Man Hours
112	Add Gravel or Stone	Shoulder Miles	202	General Admin	Man Hours
113	Cutting Hills	Shoulder Miles	203	Vacation/Holiday	Man Days
120	PATCHING		204	Sick Leave	Man Days
121	Truck Patching	Tons	205	Lot Maintenance	Man Hours
122	Full Depth Patching	Tons	210	GARAGE OVERHEAD (Paperwork, Errands, Cleaning)	
123	Crack Sealing	Gallons	211	Vehicle Repairs	Man Hours
124	Hand Patch	Gallons	212	Equipment Repairs	Man Hours
125	Chip Bleeding Roads	Tons	213	Vacation	Man Days
130	SURFACING		214	Sick Leave	Man Days
131	Seal Coat	Road Miles	215	Gasing/Maintaining Equip.	Man Hours
132	Plant Mix	Road Miles	216	Building Maintenance	Man Hours
140	DRAINAGE		217	Haul Material to Stock	Man Hours
141	Inspection/Clean/Paint	# Culverts	218	Road Inspection - Emergency Cleanup	Man Hours
142	Pipes/Tiles	Man Hours	220	MISCELLANEOUS	Man Hours
143	Ditching - Grader	7 Culverts	230	MAJOR IMPROVEMENT PROJECTS*	
144	Ditching - Gradall/Backhoe	Ditch Miles	231	New Route	Man Hours
145	Location of Cables	Man Hours	232	Relocation	Man Hours
150	SNOW & ICE CONTROL	Road Miles (Tons of Sand)	233	Reconstruction	Man Hours
160	TRAFFIC CONTROL/LIGHTING		234	Major Widening	Man Hours
161	Striping	Gallons	235	Minor Widening	Man Hours
162	Sign Manufacture and Repairs	Man Hours	236	Restoration & Rehabilitation	Man Hours
163	Sign Installation	No. of Signs	237	Resurfacing	Man Hours
164	Street Lighting	Man Hours	238	Bridge Replacement	Man Hours
170	ROAD/STREET CLEANING & SWEEPING	Miles	239	Bridge Rehabilitation	Man Hours
			240	Safety/Traffic Operations/TSM	Man Hours
			241	Environmental Projects	Man Hours

potential of rising through the ranks with time and experience to become a foreman or highway supervisor. The records are also invaluable for planning new maintenance activities, including rescheduling of equipment and application of materials at different road locations to better redistribute funds and minimize costs of individual activities.

Though the training session provided an initial favorable response to the new applications, it was necessary for the highway clerk to follow up on each employee. About 6 months was required to provide feedback and for necessary code changes and additions to be made. As expected, about six employees (20 percent) required special, continuous encouragement and correction before more accurate and complete daily reports could be obtained from them.

#### IMPROVING ACTIVITY ORGANIZATION AND REPORTING—DRAGGING AND GRADING

Dragging and grading activities presented the greatest challenge because they involve several road sections each day and require several lines of data. To minimize problems for drag

and grader operators, patterns of grading or dragging the road network were established by each operator from his daily routines. The predrawn patterns (A, B, C, D, etc.) were then deposited with the office clerk. The operator records the pattern for the day on the daily work report form and any omitted road sections with the time of operation. With this information, the clerk is then able to enter road sections from the patterns for costing. In White County, each drag operator is assigned an area within the county, and he usually drags or grades as often as he desires. However, with the system described previously, it is possible to specify dragging and grading frequencies on particular gravel road sections. Operators account for different frequencies by adding to or subtracting from the roads listed in a particular pattern. Figure 5 shows one such pattern for an operator indicating the area of responsibility and the road sections in the pattern. Table 4 shows suggested grading frequencies for varying traffic volumes on unpaved roads (3). Using the values, patterns of road network can be selected and varied to comply with established frequencies.

The data presented can be entered in the microcomputer data base application that is being developed by the Highway



TABLE 3 LIST OF HIGHWAY MATERIALS AND EXPENSE ITEMS AND CODES

Code	Material Type or Expense Item	Unit	Code	Material Type or Expense Item	Unit
1000	<u>Garage Supplies</u>		1705	<u>Fencing and Posts</u>	
1001	Regular Gasoline	Gallon	1706	Fence	L. Feet
1002	Engine Oil/Lubricant	Quarts	1707	Posts	Number
1003	Grease	Tubes	1800	<u>Asphalt and Tars</u>	
1004	Replacement Parts	Number	1801	Emulsions - AE90, AE-T, RS2	Gallon
1005	Diesel (Equipment)	Gallon	1802	Emulsions - AE150, AE200	Gallon
1006	L.P. Gas	Pound	1803	Cutbacks	Gallon
1007	Tires and Tubes	Number	1810	<u>Bituminous Mixtures</u>	Ton
1008	Welding Supplies	Number	1811	Cold Mix Patching Matl.	Ton
1009	Chainsaw Supplies	Number	1812	Plant Mix	Ton
1010	Grader/Drag Blades	Number	1850	<u>Cement and Ready Mix Concrete</u>	
1011	Unleaded Gasoline	Gallon	1851	Cement	Bag
1012	Diesel (Trucks)	Gallon	1852	Readymix Concrete	Cubic Yard
1013	Transmission Fluid	Quarts	1860	<u>Signs and Posts</u>	Number
1100	<u>Seed and Fertilizer</u>		1880	<u>Signals</u>	Number
1101	Grass Seed	Pound	1900	<u>Street Lighting</u>	Number
1102	Fertilizer	Pound	1901	Flares and Lighting	Number
1103	Liquid Fertilizer	Gallon	1920	<u>Pipes and Plumbing Supplies</u>	
1104	Mulch	Ton	1921	Plastic Tiles	Feet
1104	Sod	Square Yard	1950	<u>Roadway Paint and Painting Supplies</u>	
1200	<u>Building Materials</u>		1960	<u>Office Supplies</u>	Number
1201	Lumber	Number	1970	<u>Overhead Expenses</u>	Dollars
1202	Paint	Gallon	1971	Liability and Casualty Insurance	Dollars
1300	<u>Aggregate</u>		1972	Workmen's Compensation	Dollars
1301	Stone (#s 1,2,3,4,5,8)	Tons	1973	Group Insurance	Dollars
1302	Stone (#s 9,11,12)	Tons	1974	Official Bonds and Insurance	Dollars
1303	Stone (#s 53,73,10F, Cr. Runs)	Tons	1975	SS (OASI)	Dollars
1304	Rip Rap	Tons	1976	P.E.R.F.	Dollars
1305	'Chip Seal Aggregate'	Tons	1977	Uniforms	Dollars
1306	Screens	Tons	1978	Postal Services	Dollars
1400	<u>Herbicides/Chemicals</u>		1979	Telephone	Dollars
1500	<u>Chemicals for Ice and Dust Control and Soil Stabilization</u>		1980	Printing and Advertizing	Dollars
1501	Salt	Tons	1981	Utilities	Dollars
1502	Calcium Chloride	Gallon	1982	Radio	Dollars
1503	Ice Sand	Tons	1983	Land and Building Rental	Dollars
1600	<u>Bridge and Culvert Materials</u>		1984	Equipment Rental	Dollars
1700	<u>Guard Rails and Posts</u>		1985	Vehicle Rental	Dollars
1701	Guard Rails	L. Feet	1986	New Equipment	Dollars
1702	Posts	Number	1987	New Vehicles	Dollars
			1988	Road Equipment Repairs - Outside	Dollars
			1989	Other Equipment Repairs	Dollars
			1990	Building & Bdg. Equipment Repairs	Dollars
			1991	Dues & Subscriptions	Dollars
			1992	Drainage Assessment	Dollars

Extension and Research Project for Indiana Counties and Cities at Purdue University.

#### SPECIFICATIONS FOR THE MICROCOMPUTER DATA BASE APPLICATIONS

The system of maintenance management and cost accounting proposed in the preceding section was programmed by using the "R-Base 5000," relational, integrated database software

by Microrim. By using a system of menus, data can easily be entered with prompting by any county, city, or other local highway clerk. Tables 5-7 summarize the input and output tables currently specified on the program. Each input table (file) can be entered on a specially designed screen form with prompting to ensure accuracy and completion of data entry. The basic county or other local highway or street department information in Table 5 will only be modified periodically as the information changes. The data describe the general administration of the local highway or street department and

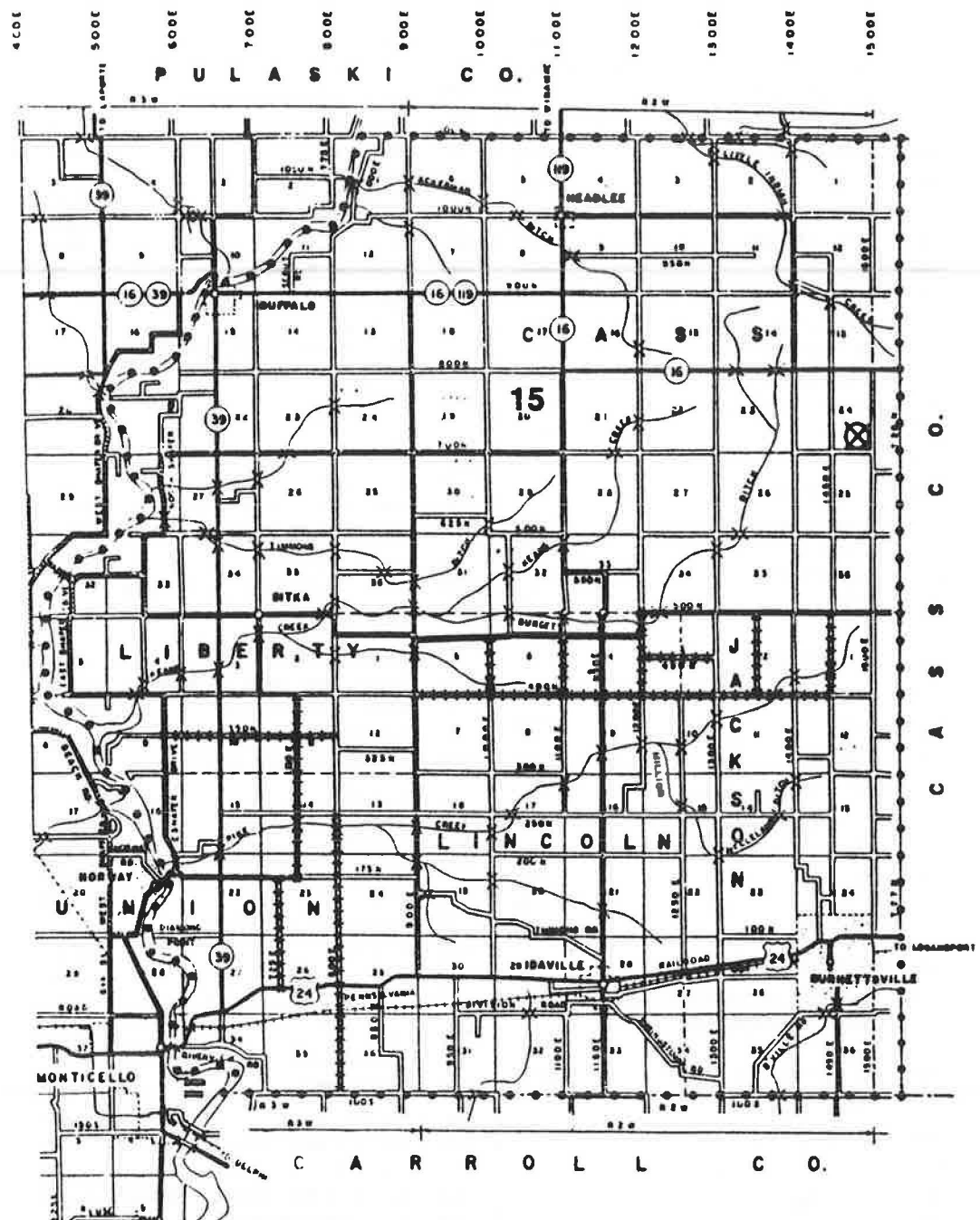


FIGURE 5 Map showing a day's road network pattern dragged by one operator in White County, Indiana.

TABLE 4 TRAFFIC VOLUME RANGES AND BLADING FREQUENCIES

Traffic Volume (vpd)	Grading Frequency Days Between (# Times/Yr.)		Annual Cost/Mi. (1982)	Remarks
< 50	40 - 60	(7 - 5)	\$150 - 108	Roads with steep grades Frequent Corrugation may require maximum freq.
50 - 100	21 - 40	(13 - 7)	\$280 - 150	Same as Above including locations with frequent driveways
100 - 200	7 - 20	(40 - 13)	\$860 - 280	Same as above some dust control may be required.
> 200	7 or less	(> 40)	> \$860	Same as above. Consider Stabilization or Paving

TABLE 5 LIST OF COMPUTER TABLES FOR BASIC ORGANIZATIONAL HIGHWAY INFORMATION IN THE DATA BASE

Computer Table	Variables	Computer Table	Variables
Accounts	Appropriation Number Description	Employee Category	Employee Number Work Category Regular Pay Overtime Pay
Activity	Activity Code Activity Description Production Units	Funds	Fund Number Fund Name
Calendar	Month First Day Last Day	Materials	Code Material Type Unit of Measurement Appropriation Number
Category of Work	Category Code Description Average Hourly Pay Average Regular Pay Average Overtime Pay Appropriation Number	Road Inventory	Section Number Current Road Name Section Beginning Section End Length Township Functional Class Surface Type R.O.W. width Surface Width Roadbed width Vertical Alignment Horizontal Alignment
Districts	District Number District Name	Traffic	Road Section Number Current Count Year Current ADT Previous Count Year Previous ADT
Equipment	Equipment Number Year of Manufacture Equipment Name/Description Purchase Year Purchase Price Estimated Life Trade-in Value Serial Number		
Employee Data	Employee Number Last Name First Name Middle Initial District Number Vacation Days Sick Leave Days		

are required to complete computations using information recorded as part of daily highway operations. The daily work report, equipment repair, and other expenses will be entered on the computer in smaller tables as shown in Table 6. The output computer tables in Table 7 provide storage for information that can be printed as specialized reports to be specified by county officials from the menus.

#### BASIS FOR COSTING MAINTENANCE ACTIVITIES

Each activity is costed in terms of the labor time and unit costs, equipment time or distance, and operating costs and the material quantities used and their corresponding unit costs. For full computer application, apart from activity and road



TABLE 6 LIST OF COMPUTER TABLES FOR DAILY HIGHWAY ACTIVITY INPUT

Computer Table	Variables	Computer Table	Variables
Activity Equipment	Equipment Number Activity Code Work Date Employee Number Road Section Number Operating Amount Miles or Hours	Equipment Materials	Equipment Number Work Date Employee Number Material Code Quantity Supplied
Activity Material	Material Code Activity Code Work Date Employee Number Road Section Number Quantity Used	Equipment Repairs	Equipment Number Work Date Labor Cost Parts Cost Outside Repair Cost
Activity Hours	Employee Number Work Date Road Section Number Length Activity Code Activity Hours	Equipment Use	Year Month Equipment Number Activity Code Miles/Hours Operated Units Used
Activity Production	Employee Number Work Date Activity Code Accomplishment	General Expenses	Invoice Number Purchase Date Material/Item Code Fund Number Appropriation Number Vendor's Name Quantity Quantity Unit Total Cost
Employee Time Card	Employee Number Work Date Work Category Code Time In Time Out Regular Hours Overtime Hours		

material and cost item codes, each employee is given a personal code and a work category code such as equipment operator, truck driver, supervisor, engineer, foreman, and so on. Each unit of equipment was also coded and identified by type, such as grader, truck, roller, or paver.

The costing procedure requires various inputs from all aspects of the cost-accounting system. Information from the daily work report form, as well as from equipment operating and daily expense records, is necessary in calculating the final cost of any activity. Overhead is calculated separately and added

TABLE 7 LIST OF SOME COMPUTER TABLES FOR OUTPUT INFORMATION

Computer Table	Variables	Computer Table	Variables
Equipment Costs	Year Month Equipment Number Miles/Hours operated Units Used Maintenance Labor Cost Parts Cost Fuel Cost Oil Cost Tire Cost Blades Cost Misc. Cost Depreciation Garage Overhead Cost	Garage	Year Month Labor Cost Supplies Cost Insurance Cost Utility Cost Building Cost Repair Cost
Equipment Operating Cost	Year Month Equipment Number Cumulative Usage Units Used Cumulative Cost Operating Cost	Material Costs	Year Month Material Code Quantity Total Cost Unit Cost
		Road Cost	Year Month Section Number Surface Type Activity Code Labor Hours Labor Cost Equipment Cost Material Cost

to the total maintenance cost. Equipment depreciation is also calculated and added as part of the equipment operating cost. However, typical equipment lives will be required in the calculation.

## SUMMARIZING THE COSTS

Initially, most counties require summaries of county highway maintenance costs by activity and by labor, equipment, and materials cost categories. Identifying the location of activities assists in computing costs by type of road surface, such as paved versus unpaved, as well as by pavement type as appropriate.

### Direct Activity Costs

Figure 6 shows the process for preparing the data summaries from the daily work report form, the vehicle equipment repair order form, and the daily expense table. The summary is produced for each activity by labor, equipment, and material costs, and by location. The road location information is further summarized by surface type though not indicated on Figure 6.

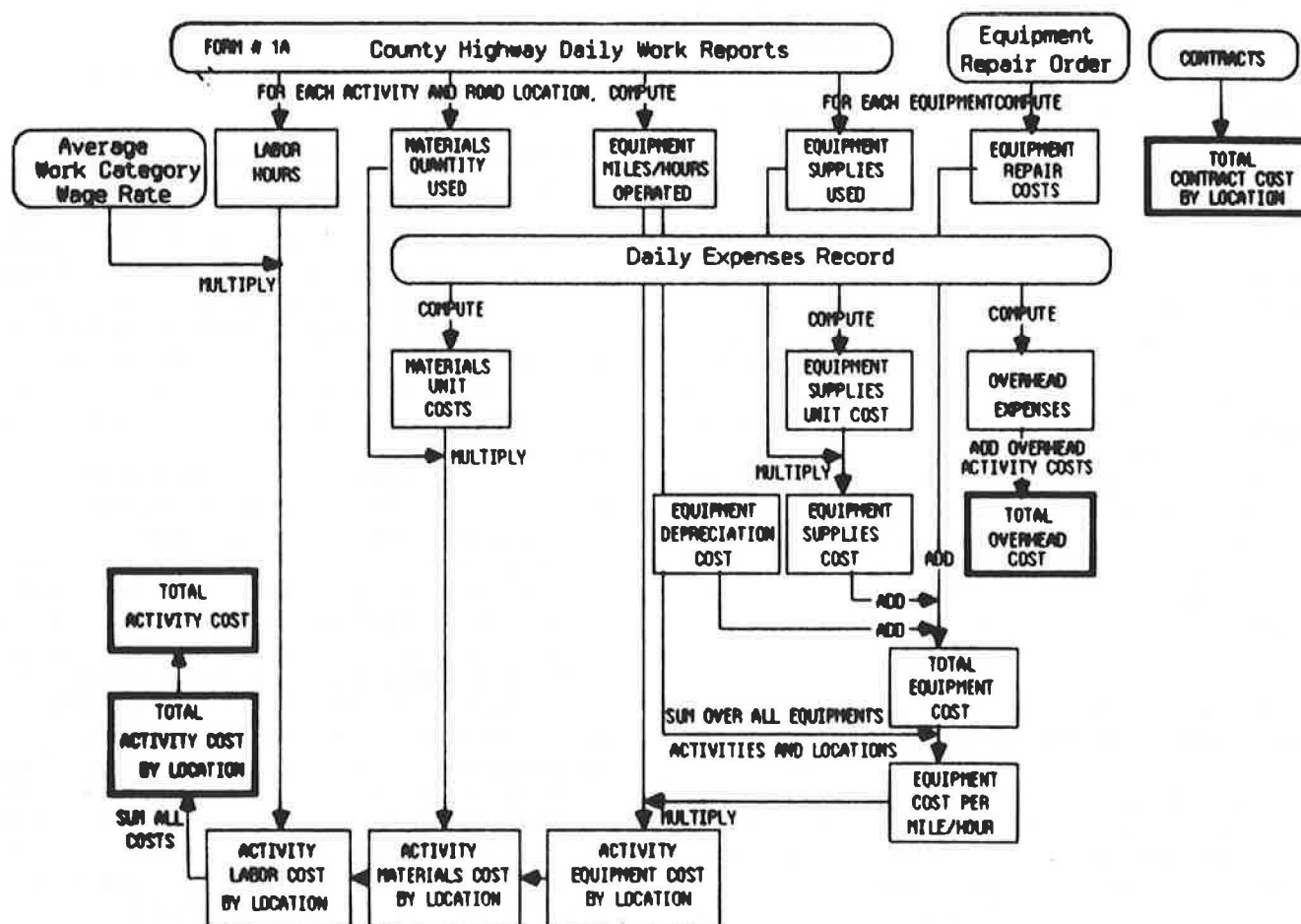
The cost summary procedure presented in Figure 6 use unit labor cost rates as well as unit equipment operation and material costs computed in the program. Labor costs are computed from the employee category table in Table 5, which is employee wage rates averaged out for each work category. Material unit costs are computed from the table of daily expenses in Table 6. Overhead costs are also computed partly from the daily expenses table and partly from the daily work reports and are added to the costs of labor, material, and equipment computed from daily work reports to obtain total costs for each activity.

### Equipment Operation and Depreciation Costs

Costs of garage mechanics' time and vehicle and equipment parts are combined from the equipment repair order table to calculate equipment repair costs. Cost of fuel and other supplies consumed are calculated and added to the equipment operating costs. Cost of equipment and vehicles repaired outside the county highway department are charged against the appropriate equipment from the equipment repair order file.

A straightline depreciation method is used to calculate total depreciation cost as shown in Equation 1.

$$D = PP + ST + TC + EC - TIN \quad (1)$$



where

- $PP$  = purchase price,
- $ST$  = sales tax (if applicable),
- $TC$  = transportation charges to point of receipt,
- $EC$  = erection costs at point of receipt, and
- $TIN$  = trade-in allowance on old equipment or salvage value.

The depreciation,  $D$ , is divided by the service life to obtain an annual depreciation charge on the equipment. Both  $TC$  and  $EC$  in Equation 1 are omitted in the current program because they are considered separately in calculating total costs. No depreciation is charged for equipment that has reached the end of its useful life. Life of equipment, however, will depend on its use within any county and may be estimated from the experience of each county or by using standard charts. Operating costs of vehicles and other equipment used for supervision and operational purposes will be charged to garage and mechanical overhead.

Equipment operating costs are calculated for each unit of equipment and averaged out for each equipment type for computing activity costs. Unit operating costs in the first year can be used initially in the second year but as more cost information is compiled, the more recent costs can be used.

#### Overhead Charges

Overhead charges usually encompass more than one activity at a time and are calculated separately. Overhead costs are divided into administrative and supervision overhead and garage and mechanical overhead. The administrative overhead cost is added to all activity costs, and garage and mechanical overhead is added to the cost of equipment operation.

#### Assessment of Daily Production and Accomplishment

Production rates for each activity are required for scheduling and budgeting purposes. Initially, estimates can be made from experience; however, provision has been made on the proposed Daily Work Report Forms for recording daily production or accomplishment. Alternatively, the county highway engineer or supervisor may choose to undertake periodic monitoring to estimate daily, weekly, monthly, or annual production rates of specific activities. As records are kept continuously, such production estimates in any year can be used to estimate the requirements for the following year. The difference between projected and actual accomplishment will enable the review of individual activities for frequencies, personnel, equipment, and road material use.

#### IMPLEMENTING THE ROAD SURFACE MANAGEMENT SYSTEM

Some of the basic inputs specified in Table 5 may not be readily available in every local highway or street department. For example, a description of the location of activities requires a complete road inventory with proper demarcation of maintenance sections. The grid road network system in most counties in Indiana enables road sections, usually 1 mile long, to be demarcated between road intersections as appropriate

landmarks in the absence of mile posts. This information will need to be prepared by each department to ease recording of road information.

#### INVENTORY OF ROADS AND DEMARCATION OF MAINTENANCE SECTIONS

Road sections defined must provide continuous information on age and construction and maintenance history. The best approach is for road sections to be designated as separate maintenance sections as soon as contracts are let for their improvement. A particular highway section planned for construction would thus form a maintenance section that would be considered as a unit in all operations. Maintenance undertaken after the construction will be monitored and assigned to the section. However, counties have not operated strictly on those lines in the past and, hence, such an approach was not used in this study. By using road intersections as landmarks defining the beginning and end of a section, special road sections were demarcated for White County roads. Road sections were defined with uniform characteristics of functional classification, surface type, traffic volume (estimated only) and, as much as possible, horizontal and vertical alignment (Table 5). As improvements are made, road section characteristics can be updated or road sections could be redefined as more information is obtained on the highway system characteristics.

#### FUNCTIONAL CLASSIFICATION AND TRAFFIC VOLUME COUNTS

The FHWA road functional classification system adopted by the Indiana Department of Highways (IDOH) was used for county road classification. Rural highway classes include Interstate, other principal arterial, minor arterial, major collector, minor collector, and local access roads. Roads maintained by counties principally fall into the last three classes. Interstate and arterial highways are maintained by the IDOH, but counties also have responsibility for some collector roads. A uniform functional classification system will enable comparison between counties and even comparison with the state system.

From a study of the distribution of functional highway classes in five counties (3), only major and minor collectors and local access roads were identified. The percentage of local access roads in the network averaged 73 percent and ranged from 64 to 74 percent. The various road classes exhibit different levels of service such as traffic volumes likely to reduce from major collector to local access roads. Local access roads may also be paved or unpaved, but it is expected that almost all collector roads will be paved in most counties. Additional functional breakdown of local roads, possibly by traffic volume and surface type, is necessary for maintenance and planning because more than 70 percent of road network is classified as local access. For unpaved roads, this will enable the application of different maintenance levels based on level of service provided by the road, instead of a blanket grading policy that could lead to avoidable higher costs of gravel road maintenance. Such subgrouping will be simplified if a comprehensive traffic volume count is undertaken on the road

network. Traffic volumes can also be used as a basis for determining annual road maintenance needs. Initially, counties can estimate traffic volume from past knowledge and confirm them later from traffic volume counts.

## SUMMARY AND CONCLUSIONS

The procedures listed in the previous section will enable basic improvements to be made in the current maintenance management of most county highway departments. For most counties, the ability to better monitor and control maintenance expenditure on all road surface types would be the major step required for improved maintenance management. Incorporating road performance characteristics will also assist most counties in further monitoring the effect of their maintenance policies on road performance and in determining their maintenance and rehabilitation needs. With the basic management information system developed, road performance characteristics may be programmed into the system to determine total road needs.

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## REFERENCES

1. *Highway Statistics 1985*. FHWA, U.S. Department of Transportation, 1985.
2. J. E. Hittle. *Guide Manual: Records and Reports for Indiana County Highway Departments*. Highway Extension and Research Project for Indiana Counties, Purdue University, West Lafayette, June 1981.
3. J. D. N. Riverson. *Unpaved Road Maintenance Management in Local Highway Systems*. Ph.D. dissertation, School of Civil Engineering, Purdue University, West Lafayette, Ind., (Unpublished) Dec. 1985.
4. C. A. Burke. Trends and Counter Trends in Maintenance Management Systems. In *Transportation Research Record 951*, TRB, National Research Council, Washington, D.C., 1984.
5. J. D. N. Riverson, K. C. Sinha, and C. F. Scholer. County Maintenance of Unpaved Roads. In *Transportation Research Record 985*, TRB, National Research Council, Washington, D.C., 1984, pp. 34-40.
6. M. L. Young. Maintenance Management Program. Mason County Department of Public Works, Indiana, March 1982.
7. Burke, Associates Inc. The New Management Information System. Public Works Department, City of Little Rock, Arkansas, June 1983.
8. Cost Records and Budgets—A Revision. *Association of County Engineers Action Guide Series*, Vol. 2, National Association of Counties Research Foundation, July 1972.

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