Implementing Findings From the Louisiana Maintenance Research Project

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The Louisiana Maintenance Research Project was undertaken in September 1965 and will be completed in June 1969. The project is directed toward establishing an operating, modern maintenance management system in the Louisiana Department of Highways. To present the experience of Louisiana in implementing the findings of this research, this paper has been divided into two major sections.

1. Project results to date—a discussion of the background associated with the project and a report of the results of the major phases with special emphasis on the management reporting process, maintenance planning and changes in organization.
2. Experience in implementation—a discussion of the performance laboratory where basic data were gathered and methods reviewed. A discussion of the use of these data, management actions required, training and the results of these efforts in areas other than the performance laboratory.

In addition to the two major sections, the Appendix includes tables and figures which illustrate specific findings, conclusions and procedures.

BACKGROUND

The rapidly increasing cost of maintenance has for several years been of concern to the maintenance engineers of the Louisiana Department of Highways. It was recognized that eventually budget requests to the legislature would have to be documented as to their relationship to actual needs. The maintenance and operations engineer felt that either the Department must install some management system on its own volition or a management system would be forced on it by the legislature. It was decided in 1965 to conduct management research in the maintenance section. The original intent of the research project was to have available a series of recommendations with regard to maintenance management to be brought out at such time as the State legislature began to look at the high cost of maintenance with a jaundiced eye.

In September 1965, the Department entered into a contract with Roy Jorgensen and Associates to conduct the management research. The project was jointly financed by the Department and the Bureau of Public Roads. The original contract was for 18 months.

During the early stages of the project, the main emphasis was placed on data collection and analysis in order to document existing practices of the Department and to define those areas where improvement could be made. The Department's cost records did not have any data showing the relationship of cost to work performed. Also, the AASHO function codes in many cases were so broadly defined that it was impossible to select any one work factor for work measurement.

A pilot reporting system was established in one District for a year. By adding a fourth digit to the AASHO function codes, they were more clearly related to specific types of work. A system code was added to correlate unit quantity to the four highway systems. A measure of work accomplishment was added in order to evaluate man-hour rates for specific work accomplishments. A reporting form was designed for processing by keypunch operators and a computer program was written to summarize the reported data.

Field trips were made to observe the crews at work. Specific types of work were observed in different parishes and districts. Many of the supervisors were interviewed

as to why they did work a certain way; as to who gave these working instructions; and as to how they planned their work.

Analysis of the data showed wide differences in performance from management unit to management unit. Figure 1 in the Appendix shows the cost of surface maintenance for bituminous surface-treated roads for each parish. The parishes are grouped according to district and three-year averages were used to level out year to year variations. These roads are all of essentially the same character, carry the same traffic, and should have generally the same maintenance requirements. (The variation indicates the potential for improvement.)

The data from the pilot reporting system and field observations pointed out the causes of the variations. These can be summarized in terms of:

1. Quality—Different supervisors were working toward different levels of service. Some were repairing defects which did not need repair, some were ignoring conditions which should have been fixed.
2. Quantities of Work—Some supervisors predominately used hot pre-mix materials for patching all defects; others used multiple layers of liquid asphalt and cover aggregate of varous sizes. Some patches were extended beyond the immediate area needing repair by as much as ten times for the sake of appearance.
3. Productivity—Many different arrangements of men, equipment and task assignments were noted. All of these had a direct effect on the unit costs of doing work.

From this analysis, it was concluded that the best method of obtaining improvement was to establish better management practices. The key elements involve determining the best way to do work (performance standards), the setting of objectives in terms of good performance and staffing accordingly (planning and budgeting), the developing of simple management procedures for superintendents, and providing information related to standards so they can correct poor performance.

A supplemental agreement was made with the consultant expanding the original research through June 1969. The expanded project has five major phases (the schedule for these phases is shown in Fig. 2 in the Appendix):

1. To develop and test a maintenance work reporting system which will be compatible with existing fiscal requirements and provide management information required for effective planning, execution and control of the Department's highway maintenance activities.
2. To conduct a performance laboratory for the research and testing of maintenance methods and procedures, the testing of performance standards and the testing of management procedures.
3. To form a Department standards panel for the purpose of observing and evaluating the performance laboratory operations and for developing standards of quality and productivity as guides for department-wide planning and control of maintenance operations.
4. To develop a comprehensive maintenance management system and a plan for the implementation of such a system.
5. To develop and test training procedures and training materials appropriate for maintenance personnel.

As each phase of the research is completed, an individual report is prepared. Also, as part of the research in each phase, the new management procedures are being field tested in order to check their validity under actual operating conditions. This means that while the final report for any particular phase has specific recommendations for managment improvement, many, if not all, of the recommendations will have already been implemented in some of the Department's districts through the testing procedure.

At the present time, Phase II, the new reporting system, has been in effect for a year. The performance laboratory and the standards panel have completed their primary job. Reports covering the reporting system and the performance laboratory have been written. Training courses built around the new work standards are being tested. The development of management procedures, a statewide work plan, and control procedures are being tested.

WORK REPORTING SYSTEM

Any work reporting system has to serve two needs: that of fiscal management; and that of management control by the operating personnel. In the past, the work reporting system of the Department was fiscally oriented. The accounting section is mostly interested in documenting where money was spent. The need of management is to know quantities of work, man-hour rates, unit costs of doing work, and how well actual work quantities correlate to the work plan; these items were not a part of the work reporting system. There were three basic types of reporting documents: the payroll, the equipment report and the material-used report. There was, in many cases, poor correlation in the activity reporting on these documents for the same gang in the same period.

A series of meetings was held among the accounting section, the maintenance section and the consultants to design a reporting system that would serve the needs of both the accounting section and maintenance. Consideration was given to several possible approaches to work reporting documents. It was finally decided to have a job-oriented type of reporting where all required information of man-hours, equipment hours, material and accomplishment would be on one document. This document was designed for data transmission by wire to the accounting 418 UNIVAC computer.

Basically, this new reporting system follows the AASHO Manual of Uniform Accounting Procedures. However, there were some major revisions in the various accounts:

- The highway investment code was eliminated and a system code was substituted consisting of the four basic roadway systems—Interstate, primary, secondary and farm-to-market; two general administrative systems of buildings and grounds and overhead and individual expenses; three off-system codes of rural roads, urban streets and others.
- The use of control sections in work reporting were eliminated except in the case of (a) a project, (b) special test sections, (c) operation of ferries and tunnels, or (d) special instructions such as reimbursable accidents.
- Structures were to be identified as to basic types: concrete, steel, elevated roadway, or ferries.

The function codes were redefined. It was found that 30 work functions covered 96 percent of all work reporting. In this group were several functions that were too broadly defined. Work functions such as patching surface, which covered 21 percent of maintenance cost, were broken into several specific functions to more clearly identify what type of work was being done and on what type of surface. Other work functions such as pumping stations and monument recovery, which accounted individually for less than 0. 1 percent of maintenance costs, were lumped into some general catch-all function numbers. Figure 3 (Appendix) illustrates the number of functions related to their size and importance.

The new reporting document, called the "Biweekly Activity Report" (BAR), was basically a summary of all work in a reporting period done under a specific parish superintendent or gang foreman that could be charged to any one combination of work function, parish, system and structure type. Figure 4 (Appendix) shows an example of a BAR completed for surface treatment patching on a secondary road.

Daily work reports are prepared by individual foremen. These are turned into the parish headquarters and summarized on the BAR by the parish clerk. A separate work report is required in any one day for any combination of work function, parish, road system or structure type.

The new work reporting procedures were pilot-tested for four weeks under the supervision of the research staff and district administrative people. A meeting was held with the parish foreman and supervisory personnel. During the first few days of the test, daily visits were made to the parish headquarters to see if any unusual problems developed.

The pilot-testing revealed no major flaws in the reporting procedure or format. Plans were then made for statewide testing with a representative parish and district-

wide crews in each district. Key administrative people and teleprinter operators were brought to Baton Rouge from each district. Instruction books were prepared with specific sections devoted to each of the new reporting documents and each new procedure. The Baton Rouge meeting was organized as a workshop. After a general presentation of the new procedures and a question and answer period, the large group was broken up into smaller groups actually using the new documents in trial reporting problems.

Each district then made a pilot test with the new reporting system in a representative parish and in district-wide crews for a biweekly period. The documents were to be processed in the district office and the data transmitted by teleprinter to the accounting section for computer processing. This provided a testing of the complete procedure of handling the work reports from the working crews to the accounting section.

For the last two weeks of the old fiscal year, a statewide test was planned in which all maintenance personnel performed duplicate reporting, using both the old reporting system and the new. At the end of the two week test, the old system was dropped and the new continued. This allowed the highway personnel to become familiar with the new reporting procedure and correct any major reporting errors before the data from the new system was fed into the official records.

The reporting system has now been in effect for a year and is generally well accepted by maintenance personnel. While most supervisors endorse the system, there are a few hard-core areas which are still resistant to the change—but this is to be expected in any major change. The information collected is proving satisfactory for both accounting purposes and management purposes.

The advantages of the reporting system are: (a) more accurate reporting by combining labor, equipment and material relating to a specific work function on one document; (b) a measure of work accomplishment is now included which allows a measurement of performance; (c) the documents are oriented for wire transmission, which relieves the keypunch section of some 50, 000 cards every two weeks; and (d) the job-order-oriented reporting documents have made work reporting more closely related to work scheduling.

PLANNING

Work planning is one of the elements that enables management to manage. By work planning, the highway maintenance administrator is able better to allocate the available resources of manpower, equipment and materials on a basis of needs. Unplanned work, although productive in character, tends to be wasteful of these resources. It results in a maximum number of crises, with most work being done on a "fire fighting" procedure. Also, while most of the work gets done, some needs are neglected, while others are overemphasized. Planning furnishes a guide to the field supervisors in their day-to-day work scheduling. Also, management reports enable middle and top management to compare the plan to actual work and know better how well the job of maintenance is being done.

The values that go into planning are called standards. A later section will detail the development of these standards. The significance of standards is that they are good objectives. The plan is then an objective as opposed to an estimate of what will happen if we sit back and do nothing to improve.

An annual maintenance work plan or program is prepared. This program is the process by which standards are applied to a road system. To prepare a work program, certain basic elements are required.

1. Work Load—The miles of road of different systems and types, the acres of right-of-way to be mowed, the length of bridges in the road system, or some other common denominator upon which to base planning.
2. Quantity of Work—The average amount of work per planning unit for each function. This can be in terms of cubic yards of surface treatment patching per mile of road, times mowed per year, or the miles of seal coat per mile of road.

3. Unit Cost—The cost per unit of work (cubic yard, acre, etc.) which is expected when good methods are used.
4. Production Rate—The number of man-hours required per unit, again based on correct work procedures.
5. Cost Distribution—The breakdown of the unit cost into labor cost, equipment cost, and materials or contractural services cost. This breakdown allows the program to be used in developing a plan along objects of expenditures, which is a valuable guide for budgeting.
6. Annual Distribution—The quarterly amount of work on each function so as to provide an essential guide to supervisors as to when they are expected to do each kind of work.

A planning work sheet was developed in which the elements of planning were tabulated. The sheet was designed for keypunch operation. Columns were established for each component. The actual program is prepared by the computer. Examples of the planning work sheet and the planning summary are given in the Appendix (Figs. 5 and 6).

There are 62 parish maintenance superintendents and each superintendent had a work plan for the area under his supervision. The planning summary is printed with a parish summary, a district summary and a State summary. This planning summary becomes not only a work plan for the fiscal year, but the basis of budget requests for operating funds.

The total of the man-hour column and the total of the cost columns become the man-hour requirements to do the planned work load for one year and the amount of money needed to do the job.

ORGANIZATION CHANGES

The basic geographical unit in Louisiana is the parish, with a superintendent in charge, and the district. The number of men in a parish vary from 20 to 50 with 2 to 6 gangs and the number assigned district-wide averages 240 men per district organized into about 15 to 20 gangs.

Some of the parishes operate from a central parish headquarters. However, in many of the parishes there are two or three outlying unit headquarters. These outlying units are a carryover of the days when the majority of the road mileage was gravel roads. Each small unit patrolled a small circle of gravel roads. With the road system mostly all weather roads and with modern trucks, the need of these outlying units has been eliminated. Now in most parishes the average travel distance from a centralized parish headquarters would be from 20 to 30 miles. Efficiency in work scheduling and overall operations more than offsets the small increase in travel caused by centralization of the parish work forces.

One of the problems encountered in Louisiana in implementing management techniques was the gang organization. The original basic organization unit was a highly specialized gang, such as a concrete gang, asphalt gang, mowing gang or bridge gang. The personnel and equipment staffing of a gang was based on its speciality. If one of these specialized gangs was able to work on its specialty day in and day out, this would not have been too bad a way to organize.

Parish Organization

Basically, the concrete and asphalt crews were 10-man crews with three or four dump trucks. The actual work load of these crews was quite varied. During a year's time, they would perform some 15 or 20 different functions of work. It was evident early in the study that the usual practice was that all men under a specific foreman went to do any job that he was assigned. This meant that whether the job was large or small and required anywhere from 2 to 10 men, all 10 men went along. In most cases, the required crew size for a specific job was under the 10-man assignment. This practice of having people in sets of ten resulted in a waste of about 20 to 25 percent of the available manpower.

It was evident that some type of a work scheduling procedure had to be established in the parishes. Also, it was apparent the men should be assigned to work on the basis

of job requirements, not prefixed gang size. If the superintendent was to schedule work and assign men on the basis of needs, it would be necessary to introduce a high degree of flexibility in the parish work organization. The rigid specialized gang organization did not have this degree of flexibility.

The men in the parishes had long been associated with individual foremen, and work patterns are difficult to change. It was decided that the combining of all parish crews into one large gang so that the men would tend to lose identity with individual foremen was necessary. This was tried in a couple of pilot parishes and proved successful. Also, there was a reduction in the number of biweekly activity work reports required, which made the supervisory personnel happy.

The one gang concept of parish forces was then tried in one parish in each of the seven highway districts. Eventually, six of the seven districts renumbered all of their parish into a one gang system. At the present, 43 of the 61 parish superintendents are operating under the one parish gang numbering system. One highway district has actively resisted this change. In the other two districts, one has a parish renumbered and likes it; the other is just slow to make up its mind.

The one gang concept has a large potential in savings from better manpower utilization over the specialized gang concept. Over a year, there are many different work functions performed. The manpower requirements by function vary from 2 to 9 men. The superintendents are scheduling work on a weekly basis. Being able to schedule men to specific work functions, based on the job requirements and any special qualifications the men may have rather than work assignment by gangs, gives the superintendent a high degree of flexibility in work scheduling and personnel assignments. In those parishes where the one gang system is used in conjunction with work scheduling, there has been a noticeable increase in work output. This increase is primarily due to the scheduling techniques, but it is the organizing of the work force as a labor pool that makes the use of scheduling more effective.

This change also tends to make the superintendents job conscious. The specific jobs are analyzed by the superintendent on the basis of standards, manpower requirement, equipment requirements and material requirements. A better utilization of the primary resources of manpower, equipment and material is the result.

District Organization

The Department also has functioning on a district-wide basis and statewide basis specialized work gangs. These gangs do road reconstructions, resealing, bridge repairs, electrical repair and traffic services. On the district level, due to fluctuations in work load and the seasonal character of much of their work, these crews perform routine maintenance on an intermittent basis. When they cannot work at their specialty, they move into routine maintenance. Since most of the routine work is already planned for and staffed in the parishes, the work of these crews is superfluous when used on routine maintenance and usually results in unnecessary duplication of work.

These crews are also used to work on projects off the State system. The Department annually works on many miles of parish roads and city streets. Some of the work is maintenance in nature, but most of it consists of betterment projects. The work has to have prior approval of the Baton Rouge headquarters. The volume of this work fluctuates considerably which makes it extremely difficult for it to be scheduled economically. Since these employees are monthly employees, weather conditions and seasonal variations make these projects more expensive than contract work of the same nature. At the present time, there is some disagreement in thought as to the need of these specialized district-wide crews. It could be that after some additional work analysis and testing is made, that much of the work done by these crews can be phased into the parishes.

MANAGEMENT REPORTS

Out of the data collected in the work reporting system, various management reports are prepared. These reports are designed to let managers at each level of organization receive timely information as to how they and their subordinates are doing. Their

actual performance is compared against the planned performance (performance standards) in a series of four reports (the need for all of these is still under examination):

1. Performance Analysis—a monthly summary of production rates and unit costs prepared for each superintendent, district, and the State as a whole.
2. Performance Report—a quarterly report for each manager which emphasizes amounts of work being done.
3. Productivity Analysis—an annual summary organized to help review performance on individual work functions. This report shows the number of organizations which achieve standard productivity and those who do not.
4. Quantity Analysis—another annual report for evaluation of the amounts of work being done. This, as is the productivity analysis, is primarily designed to verify and update standards and to initiate further research where needed.

A sample of each report is given in the Appendix. The first two are shown completed, the third only in blank form inasmuch as the year was incomplete at the time of writing. The fourth is still being reviewed for content.

The performance analysis report was originally planned to be a monthly report for the guidance of the parish superintendents. It listed by gangs, accomplishment, work effort, cost and comparison with standards. This report is now being printed summarizing work by superintendents. It is still a useful report for middle and top management and as a quarterly report does furnish the superintendents some help. However, it has been found to be beneficial for production rates to be computed by the parish clerks and superintendents from the biweekly activity reports and summarized monthly. These summaries are to be brought to a monthly meeting of the superintendents and made part of a group discussion. Those districts using this technique find a greater awareness of the value of productivity standards developing among the supervisory personnel.

It is realized that the continual reassessment of these reports will be needed and that probably future changes will be necessary.

MAINTENANCE POLICIES

In the same way as the planning process sets work objectives, overall management objectives are set through policies. In Louisiana, policies are being developed by an advisory committee composed of major section heads and district engineers.

The basic policies which have been recommended for approval are shown in Exhibit 1. These policies reflect the way the Department intends to handle the management of maintenance. These policies spell out the kinds of standards which will be developed, the use of standards in planning, and the process for continuous performance evaluation and improvement.

Exhibit 1.

BASIC MAINTENANCE OBJECTIVES AND POLICIES

OBJECTIVES

The objectives of the maintenance function are as follows:

1. To preserve the investments made in state highways, bridges and appurtenances.
2. To provide adequate levels of safety, comfort and convenience to the motorists.
3. To ensure economy in the expenditure of resources.

BASIC POLICIES

The three objectives set forth above shall be fulfilled through implementation of the five basic policies set forth below:

1. Standards of performance relative to work quality, work quantity and work methods applicable to maintenance activities shall be established.

Exhibit 1. (Continued)

Quality Standards . . . To define the level-of-service objectives for highway facilities.

Quantity Standards. . . To estimate the volumes, by type, of the maintenance work required to maintain highway facilities at adequate levels of service.

Methods Standards. . . To define the most effective methods developed for doing the work, and to establish productivity rates that can be expected through using these methods.

2. Annual maintenance programs shall be developed and adopted.

Annual maintenance programs shall be developed to define the types and amounts of maintenance required. Programs shall be based on established performance standards and shall reflect estimated requirements for manpower, equipment and materials for each maintenance activity in each District.

Maintenance programs shall be developed under the direction of the Maintenance Engineer, reviewed by the Chief Construction and Maintenance Engineer and by the Chief Engineer, and approved by the Director.

Approved maintenance programs shall be the basis for preparation of maintenance budgets and for the allocation of resources to individual Districts. 1/ Budgetary allotments shall define specific funds for:

+ Routine maintenance and operations
+ Special maintenance programs
+ State force construction and betterment
+ Administration and overhead.

3. A system of performance evaluation and control shall be adopted.

A system of work reporting shall be established to provide a record of work accomplishment in terms relatable to the work programs. Performance reports shall be made available to maintenance managers at all levels in forms best designed to serve their needs.

Performance reports shall be used to guide managers and supervisors in (1) the fulfillment of the planned maintenance program, (2) the evaluation and improvement of performance, and (3) the review and verification of performance standards.

4. A system of long-range planning shall be adopted.

A system of long-range maintenance planning shall be established to provide a basis for estimating long-term requirements for manpower, equipment, materials and money.

Projection of maintenance needs shall be over a period of years sufficient to permit fiscal coordination with long-range highway construction programming.

5. A series of operating policies shall be adopted.

It shall be the responsibility of the Chief Maintenance and Operations Engineer to develop and establish operating policies and procedures within the framework of the basic objectives and policies.

_____ DIRECTOR OF HIGHWAYS _____ DATE

1/ Effective for Fiscal 1969 - 1970 Budget.

EXPERIENCE IN IMPLEMENTING

The results obtained at the performance laboratory with emphasis on findings from methods studies and the development and utilization of management procedures at the operating level are discussed in the following sections. The implementation of these results in other areas of the State is also discussed.

PERFORMANCE LABORATORY

General Results

During 1967, a maintenance performance laboratory was conducted in Natchitoches Parish. The following were the results of the laboratory.

1. The best staffing, equipment assignments, and procedures for work performance were determined. Productivity standards were established based on these methods.
2. Quantity and quality standards were developed for the major maintenance functions for application on a statewide basis.
3. Management procedures necessary for operation of the maintenance management system were developed and implemented.
4. The potential for improved performance of maintenance operations through the use of standardized work methods and management procedures was demonstrated.

The laboratory was conducted as a joint effort between the Department and the consultant. The consultant provided a resident research associate at the Alexandria district as well as specialized assistance from the project manager and consultant staff. Department participation included the assistant maintenance engineer from the Alexandria district who acted as performance laboratory coordinator, a research analyst, and four technicians. Data on maintenance operations were collected, summarized and analyzed to fulfill the objectives of the study. Alternative methods and procedures were tested and performance standards compiled.

Quantity standards were defined in terms of the annual amount of work required per planning unit. Quantity standards were set in three ways. First, standards for certain functions applying to bituminous surfaces were established through an economic comparison of alternative ways of performing work. Next, some standards were set following inspection and observation of maintenance requirements at the Laboratory and analyses of data from the reporting system. Finally, certain quantity standards were established on the basis of a desired service frequency. A summary of the approved quantity standards is shown in Figure 10 (Appendix).

Quality standards were defined by the standards panel for the major routine maintenance functions. Similar standards developed by AASHO, Virginia, and Ontario were reviewed. The final quality standards were based on the collective judgment of experienced maintenance personnel on the standards panel. The approved quality standards were then incorporated in a set of standard work procedures for each function. An example of these work procedures is shown in Figure 11 (Appendix).

Several methods or accomplishment studies, similar to those used on the Iowa and Virginia research projects, were conducted in order to develop detailed data relating to specific maintenance operations. Observers employed wristwatches to obtain a complete record of working time and delays associated with each individual element of work throughout the day. An example of the type of data collected through accomplishment studies is shown in Figure 12 (Appendix).

Findings from the accomplishment studies coupled with field observations of work performance and analyses of data generated under the daily reporting system were used to determine optimum staffing patterns, equipment assignments, and procedures. Once an optimum method was selected, it was implemented as the standard practice in the parish. At the conclusion of the laboratory, a standard production rate—in terms of labor hours per unit work quantity—was derived for each major maintenance function. A standard unit cost when performing each function by the standard method was also derived. Crew staffing and equipment assignments were standardized based on average conditions encountered; the Parish Superintendent has leeway to alter basic staffing if a hauling distance or traffic control problem exists. An example of approved productivity standards is shown in Figure 13 (Appendix).

A standards panel, consisting of a maintenance representative from each of the nine districts in the State, as well as one from headquarters, was formed and met monthly for the duration of the laboratory. The panel reviewed and evaluated the basic approach taken in the laboratory and the conclusions reached. The panel was instrumental in establishing quality standards, setting quality standards, and defining the

standard methods and productivity values. Members of the panel established test parishes in their own districts to try out methods and evaluate the management procedures being developed.

The implementation of improved methods and procedures at the laboratory resulted in better utilization of manpower, materials and equipment which was indicated by improved productivity trends. An example of the improved productivity attained at Natchitoches during the laboratory is shown in Figure 14 (Appendix). When improved work methods and management procedures were installed at the laboratory, the parish forces performed betterment-type work. The betterment projects were work items not normally undertaken by maintenance forces that were designated specifically for the laboratory.

As standard methods and productivity values were finalized at the laboratory, they were introduced gradually to other parishes of the Alexandria district as well as statewide in the test parishes. After being developed, the performance standards were incorporated into a "Maintenance Superintendents Manual" which was distributed to all parishes. As mentioned previously, training materials and techniques are being developed which will instruct maintenance personnel in the proper application of the performance standards for the major maintenance categories.

Methods

A number of alternative methods for performing maintenance operations were evaluated at the laboratory. In general terms, the following items were evaluated: (a) crew size, (b) type and number of equipment units, and (c) work procedures.

The methods chosen for testing were selected as the result of a review of methods studies conducted in other states, analyses of data from the accomplishment studies, and conclusions reached following general work observations. The criterion used to accept or reject any particular method was an improvement either in workmanship or productivity. It was necessary, of course, to evaluate subjectively any changes in workmanship that occurred as a result of using different methods.

Crew size or staffing was the single most important factor affecting productivity of operations. The fixed-size gangs virtually dictated the use of a full-sized crew for almost all operations regardless of actual requirements. For example, it was not uncommon to see an asphalt gang of 10 to 12 men used to premix patch and the same gang at a later time used to repair cracks in the road. Aside from those operations where hauling distance for materials became involved it was found that, in general, the fewer men assigned to an operation the better the resultant productivity. For example, when patching with cold premixed material stored at the unit, the smaller crews achieved higher productivity than the larger crews. The relationship between the size of the crew and resultant productivity is shown in Figure 15 (Appendix). If two men were assigned to remove trash from litter barrels, the maintenance supervisor could expect an overall productivity about twice as high as that achieved by a single man. The same held true for blading and reshaping shoulders or gravel roads. A single motor grader functioned more effectively than two motor graders working as a team on the same job.

On those operations where varying haul distances for materials were involved, the absolute size of the crew was not as important as achieving the proper balance between men and equipment for the different distances. For example, in patching nonpaved shoulders it was found that, at times, both small and large crews might attain good productivity values. It was important to have enough trucks assigned to the operation so they could make their trips to and from the pick-up area without causing any major delays in the operation. The number of hauling trucks and men had to vary as the hauling distance was closer or further away from the work site. On the basis of average haul and dump times, Figure 16 (Appendix) was developed as a guide for the parish superintendents when scheduling this activity. So, for this type of activity, a nominal crew size and equipment complement was established and the parish superintendent made adjustments as the occasion demanded. If haul distances were extensive, then the addition of a truck or two to the basic crew would result in better productivity and

conversely when haul distances were shorter the trucks had to be eliminated in order to achieve high productivity.

Besides the crew size and amount of equipment taken to a job, the sequence of operations or work procedures were an important aspect of the job if high-quality work was to be expected. Adequate work procedures were developed for the major maintenance functions. Without continual follow-up action by managers, personnel were apt to slip back to their old habits when performing maintenance work. For example, tack coating prior to a premix patch is generally regarded as an essential step to effect a permanent repair. Yet field personnel who had not been in the custom of placing a tack coat found it difficult to adjust to the new requirement.

Another important aspect of methods was the organization of work so that a crew had a full day's job. This was really a part of the scheduling process. It was obvious that if the right number of men and equipment were sent to do a job and the job did not require a full day and if the crew did not have anything else in sight, then, even though they used correct procedures, they were going to dawdle around so that their overall daily productivity for that job would be lower than need be. The supervisor of field operations had to assure that the work was there to be done and that when a crew finished on one road they either had an assignment on another road or some other task to do. Otherwise, they were being used ineffectively and did not attain the desired end result of good productivity.

The best methods were the basis for productivity, unit cost, and cost distribution standards. The standards so selected were thus field tested and attainable by all parishes in the State providing they used the same methods and scheduled work in the same manner as was done at the laboratory.

MANAGEMENT PROCEDURES

Work Emphasis

A chronic problem with maintenance work in the State was that field personnel did more than that which was necessary. Maintenance, of course, falls into two basic categories. Either it is corrective or preventive in nature. Corrective maintenance such as repair of potholes or serious road depressions must be undertaken immediately to provide for safe travel by the public. The area of preventive maintenance is the one where judgment enters the picture. At what point is it necessary to go and correct a minor fault in the road? Must roads be maintained to an as-built condition?

It was found that roads were generally over-maintained although this was probably attributable to the over staffing existing at the field level. Because of the virtually limitless manpower available, the roads were literally being worked to death. All trivial depressions were leveled, all surface cracks, regardless of width, were poured. Nonpaved shoulders and gravel roads were bladed more often than necessary. No guides were available to field personnel as to when work was required.

For corrective maintenance, the decision of when to repair was relatively straightforward—a traffic hazard existed and had to be removed. But with items of a preventive nature, no criteria existed as to when work should be undertaken. It was also found that different supervisory personnel had a tendency to stress different types of activities so that, somewhat paradoxically, it was not uncommon to see some particular maintenance operation neglected. The development and enforcement of quality and quantity standards helped alleviate this situation at the performance laboratory.

Another adjunct of the excess labor force was an emphasis on performing minor daily activities. This was necessary because the men had to be kept busy and, even though it may have been more economical to perform major activities with large work forces instead of the minor activities, this was clearly impractical from an operating level viewpoint. For example, one foreman at the laboratory had been in the habit of using a bituminous mixer (pugmill) every day to keep his assigned road miles in shape. This was what had been done before and his experience dictated that this had to be done almost every day to keep the roads in good condition. But with the same number of men he used for the pugmill operation he could have purchased premix material from a

commerical plant and accomplished as much in one day as it was taking him five days to complete. Of course, with the pugmill his men were busy all week, however inefficiently, rather than just one day.

Particularly on bituminous surface activities, a shift will be made from minor daily activities to major work. The prime example is the seal coat program. The cost of surface treatment patching by parish forces is about $15 per cubic yard as opposed to a seal coat cost of $10 per cubic yard. But more emphasis had been placed in the State on the higher-cost surface treatment patching rather than planned seal coats. With the new standards, seal coats of bituminous roads will be programmed to occur on the average of every five years and surface treatment patching will only be used as a stop-gap measure to protect a road in-between seal coats. Thus, the money expended will be more fruitfully employed than it had been in the past.

Planning and Inspections

An annual maintenance program for each parish will be developed from the performance standards specified for routine maintenance functions. An example of the annual program for Natchitoches Parish during Fiscal Year 1969 prepared from approved standards is shown in Figure 17 (Appendix). The miscellaneous category is the contingent plan to take care of work on those functions for which there are no standards. The labor hours for construction and betterment projects represent, in reality, the excess manpower available at the parish when only the proper amount of routine work is done by the best-known methods. As a guide for field personnel, the annual program of the parish will be broken down by quarters according to the recommended seasonal distribution. An example of a quarterly breakdown of the annual program for bituminous surface maintenance is shown in Figure 18 (Appendix).

An annual road inspection was conducted at the laboratory to inventory existing maintenance requirements. This inspection was carried out by a representative from the district and the parish superintendent. Inspection forms are still in a developmental stage but the versions currently being evaluated are shown in Figure 19 (Appendix). The purpose of the inspection is twofold: first, to locate and identify, in general, the routine maintenance work that is required; second, to locate and identify, in detail, the special work to be done during the year such as seal coats, overlays and betterment projects.

Obviously, an annual inspection cannot uncover every maintenance requirement that will develop during the year, but it can pinpoint conditions that exist at the time of the inspection and that will have to be corrected. A road that has already started to ravel seriously will have to be patched, a ditch that is blocked will have to be cleaned. The need for annual inspections is an absolute; without it, the field supervisor will not be in a position to schedule work adequately.

The superintendent relied on annual inspection forms as his general guide for scheduling operations at the laboratory. When work on a road was completed, the superintendent crossed it off the inspection form with a red pencil. To supplement the annual inspection forms, the superintendent made personal inspections of roads prior to scheduling to determine if the maintenance requirements had changed drastically. This pre-scheduling inspection was conducted on an informal basis.

In addition to the annual inspection and pre-scheduling inspections, the superintendent inspected work while it was in progress as well as when it had been completed. The geographical extent of the parish and number of crews set up on any day made it physically impractical for him to check every job every day. He had to exercise judgment and spot-check the high-cost jobs or those that the men were unfamiliar with or those where one crew was not as competent as another. All three elements of work performance—quality, quantity, and productivity—are closely interwoven and, while making inspections the superintendent had to evaluate the adequacy of all three of them.

Scheduling

It was evident from the begining of the project that very little planned scheduling of work was being done at the parish level. Reports of road conditions made by supervisors

from the district level or others caused changes in parish operations at the last moment. These reports often caused the parish superintendent to change plans for the day's work with little regard for economics. At best, scheduling of work was sporadic. Job assignments, when made by the parish superintendent, were normally done on a daily basis although most of the time each gang foreman was responsible for scheduling the work for his gang.

Because of the variety of operations that might take place in any one parish, it was recognized that a formal scheduling technique was needed. A written schedule met only partial acceptance by field personnel mostly because of their low education level.

However, the district must assure that parishes develop short-range schedules which fully utilize the capacity of the parish. The type and amount of work scheduled must be in accord with the types and amounts specified in the annual program or uncovered through the annual inspection. Likewise, the labor and equipment scheduled must generally approximate that recommended in the standard methods. Otherwise, the district may find the parish doing work other than that which was necessary or using more labor or material than had been anticipated.

Several techniques for scheduling work were tested in the laboratory; the one finally selected and one that met the approval of most of the parish superintendents was merely a fiberboard, approximately 4 by 8 ft, posted with appropriate entries that hung in the parish superintendent's office where it could be viewed by all parish personnel. The scheduling board is shown in Figure 20 (Appendix). The scheduling board served in a dual capacity, acting not only as a means of formalizing the work schedule, but also as a means of making specific daily job assignments of personnel and equipment. The scheduling board was posted by the parish superintendent, as a minimum, once each week. No permanent record was kept of any weekly schedule; if it ever were necessary for management to know precisely what work was done on a particular day, they could determine this from the daily work reports used in the reporting process.

The scheduling board contained a columnar listing of personnel in the parish, two tables of maintenance activities and codes, and two maps of the parish showing each state maintained road color-coded by road system classification. To the left of the personnel listing were columns where any type of leave could be posted for all personnel. To the right of the personnel listing were two columns, one for normal schedule and one for the inclement weather schedule. Thumb tacks of various colors were used as markers to designate the functions that would be done, the number of specific names of men assigned to each, and the road locations where the work would take place.

The parish superintendent scheduled work on a weekly basis. So, once he set up a repair crew, he tried to keep the basic crew intact for at least a week if there was enough work to do so. The scheduling was done on the Friday preceding the work week. Prior to the superintendent's scheduling, the parish clerk placed markers in the leave columns beside the names of the men who were known to be on leave.

To illustrate how the scheduling board was used, assume a surface treatment patching crew was being set up. The superintendent would place a colored marker in the normal schedule column beside the names of the seven men (standard crew size for this function) he selected to be in the crew. He would then place a similar colored marker in the normal schedule maintenance "Function Table" under Function 411—surface treatment patching. Finally, a similar colored marker would be placed on the parish map on the specific road where work was to commence.

Other crews were scheduled in the same manner but with different colored markers. By using recommended crew sizes, there were usually two to three men left over who would then be assigned some miscellaneous task of low priority. If a member of one of the regular crews was unexpectedly absent on a given day, one of these men could be reassigened to the regular crew with relative ease. Only rarely did it become necessary to readjust the entire schedule because of absentees.

Using the same techniques, the superintendent would then devise an inclement weather schedule for the parish. The superintendent finally reached a point where it took him about an hour to schedule the work for the week. On a daily basis, the only thing that had to be done was to change road markers when a crew completed their work

on one road and to make any minor modifications necessary when men were absent or a true emergency had arisen such as an equipment breakdown.

In making job assignments, the superintendent relied on his intimate knowledge of personnel and equipment capabilities. Certain personnel were better at performing some tasks than others. Even when the same equipment and procedures are used, personnel are going to perform differently—not as differently as when they had used non-standard procedures but still a natural variation will exist. For example, older personnel will not perform as vigorously as their younger counterparts. Different items of equipment also will perform differently. There were no standard hitches on trucks, for example, so when the towed air compressor was assigned for an operation the superintendent had to make certain that only a truck with the appropriate hitch was designated to tow it. These, as well as other factors, had to be taken into consideration by the superintendent when making the schedule.

Although it happened infrequently, sometimes the superintendent was not able to inspect the roads prior to scheduling because of the press of administrative details or necessity for him to oversee personally an on-going operation, particularly some of the betterment projects where the men were unfamiliar with the operation. When this happened, the superintendent had to rely solely on the annual inspection forms for his schedule.

Using district and parish supervisory personnel, attempts were made to delineate the actual maintenance requirements in more detail. For example, areas to be patched were outlined on the road with spray paint. But this was more in line with training than scheduling and due to the time and expense involved did not justify the results for routine maintenance activities. When field personnel become well versed with the quality standards, they will be capable of making decisions of this nature by themselves.

Scheduling of maintenance work was generally accepted across the State. Even before the laboratory was completed, most parishes had adopted similiar devices and had begun to formalize work scheduling.

Work Control

Control over maintenance operations, or assuring that performance standards are met, must take place at both the parish and district levels. The criteria for evaluating the quality of work are, for the most part, subjective in nature; for this reason, the district bears a heavy responsibility for assuring uniformity among the parishes in work quality. The quality and quantity standards were designed to guide the undertaking of operations. At the laboratory, district personnel made frequent inspections of parish roads and checked the quality of work that was completed in addition to insuring that only needed work was done. If the standards were not adhered to by the parish, action could be taken by the district to bring the work in line.

Of course, the parish superintendent, foremen and workers did not relinquish their responsibilities for performing high-quality work. Workers had to be conscientious and apply proven techniques when they performed. The foremen had to direct their men so that a quality job was done. Also, the foremen had to make any individual decisions regarding road conditions and the need for work; for example, the specific areas that had to be patched and how far the patches had to extend.

To achieve field control over work quantity and productivity, the superintendent had to be provided with up-to-date information on operations almost instantaneously. This was provided at the laboratory through employment of a work control board (Fig. 21, Appendix). By posting the cumulative results of operations every two weeks, the superintendent had immediate knowledge of the existing situation in his parish with regard to work quantity and productivity for planned maintenance activities.

On the work control board, each planned work function and its numeric code was listed in left-hand columns. For each road system, the planned quarterly work quantity for each function was listed. As work was completed, it was posted in the actual column for the appropriate function and system. Data on the amounts of work done were taken

directly from the biweekly activity reports which were submitted to Baton Rouge for processing on the computer. Thus, the parish superintendent could tell at a glance what work, if any, was being neglected and on what road system. The planned work quantities posted were taken from the annual maintenance program and, as such, had to yield to legitimate requirements uncovered during road inspections. If the actual work quantity for a function was higher or lower than that planned because of road inspections, there was a valid reason for the difference and no control action was necessary. However, if it was different because no work had been scheduled or the crews were overworking the roads, then the superintendent had to take action to correct the situation. On entering a new quarter the planned work quantities for that quarter were added to those already on the Board thus providing a cumulative total of the amount of work planned to be done.

Also listed on the board were the planned man-hours necessary to accomplish the work and the standard labor productivity. As work was completed the actual man-hours used and actual productivity attained were posted. The productivity for each operation was computed by the parish clerk, who in fact, bore responsibility for making all entries on the board after he had completed the biweekly activity reports. With the productivity values on the board, the parish superintendent could tell immediately which operations were in line with the standard productivity; those that were not, required some type of action on his part. Thus, with the board, the parish superintendent had the information readily available that he needed to take action to bring work quantities and productivity in line with planned values.

To control operations from the district level, a similar work control board was kept at the district office (Fig. 22, Appendix). The same activities as those listed on the parish work control board were listed. But, in this case, the planned and actual work quantities were not broken down by road system, only the planned and actual total quantities for the district as a whole were listed. For each parish the actual productivity attained to date on each operation was listed. Thus, an immediate comparison of the productivity results at each parish could be made.

Total work quantities were posted on the board by district personnel; productivity values for each parish were posted by parish superintendents. By requiring parish superintendents to post their own productivity values, they were drawn more directly into the control process and displayed more interest in actually achieving standard productivity. The district work control board was posted once a month; a copy of the monthly entries was kept on a form at the district office. The board was reviewed at a monthly meeting held at the district office with parish superintendents. These meetings served as open forums for discussing mutual problems and differences in productivity. The meetings also were useful as informal training sessions for personnel in current methods and procedures. With information from the district board, district managers could take whatever steps they deemed necessary to bring results closer to those anticipated.

The use of control boards at parish and district levels did not obviate the need for computer output reports. But, rather than have field personnel wait for computer reports, the boards provided immediate information for the field. An implicit assumption in using the boards was that labor productivity was a sufficient indicator of efficiency for field use because the boards did not furnish any information on the cost of operations. The computer reports, however, do summarize operations and provide information on costs to district and upper-level management

PERSONNEL TRAINING PROBLEMS

A survey was made to identify the training needs of the personnel who supervise the maintenance and operation of highways, bridges, ferries, and tunnels in Louisiana including: (a) an analysis of the characteristics of the supervisor and potential supervisor forces; (b) an analysis of the work performed and the knowledge, skills, and abilities required to perform that work; (c) measures of the extent to which current and potential supervisors possess the required knowledge, skills, and abilities; and (d) identification of the capacities and the willingness of the current and potential supervisors to learn that which they need to know in order to effectively do their work.

Age

A total of 636 persons are currently employed to supervise the maintenance and operations of highways and bridges. Another 1,662 persons are employed in positions from which promotions to the supervisory level are made.

The supervisors and potential supervisors range in age from less than 25 to more than 65 years, indicating that special steps will have to be taken to insure that all personnel can participate effectively in any training provided.

The average age of the supervisor personnel is 51 years; the average age of the potential supervisor personnel is 49 years. These data indicate that: (a) little difference exists in the age characteristics of the two groups, and (b) both groups are represented principally by personnel who have had little or no formal training exposure for more than 30 years.

Education

Thirty-four percent of the supervisors have had less than eight years of education, whereas 32 percent have graduated from high school. Seven percent of the supervisors have attended college and 3 percent have graduated from college.

Sixty-three percent of the potential supervisors have had less than eight years of education, and 11 percent have graduated from high school.

These differences in educational attainments among persons in the same training population indicate that great care must be taken to insure understanding of the training materials by all personnel without reducing the motivation for training attributable to the better educated individuals. These data further indicate that any training program must consist of basic courses to be taken as prerequisites to technical courses for persons with limited educations.

Experience

The range in experience for both supervisors and potential supervisors is from a few moths to more than 20 years. Sixty-nine percent of the supervisors and 41 percent of the potential supervisors have had more than 10 years of experience. These experience data indicate that: (a) most employees have had considerable exposure to highway operations and can be expected to have strong feelings about how work should be done, and (b) the training approaches will have to recognize that some personnel have had little opportunity to acquire knowledge of maintenance technology while others have learned a great deal through work performance.

Work Force Makeup

The distribution of all personnel employed in the maintenance function of the Department is shown in Figure 23 (Appendix).

1. The total force consists of 4, 852 persons employed at the state, district, and parish levels.
2. The supervisor group consists of 636 persons—13 percent of the total force.
3. The potential supervisor group consists of 1, 662 persons—34 percent of the total force.
4. The non-supervisor group includes 2, 326 persons—48 percent of the total force.
5. The clerical group includes 228 persons—5 percent of the force.

The reaction of those Department personnel already introduced to the new methods and procedures has varied from total acceptance to total rejection. Generally, we found that newer employees with less experience or familiarity with the existing practices in the Department were the quickest to adapt to the new procedures. Older employees, who tended to worry more about job security, were more reluctant to accept the changes. However, as the benefits and advantages of the new practices became evident to these people, they began gradually to accept the changes. We felt that most of the Department employees would be able to adjust to the new system with proper training and follow-through by management.

As mentioned, one phase of the current project is devoted to the research and development of training techniques and procedures appropriate for maintenance personnel. New concepts will be investigated and tested. Examples of training materials also will be developed and tested.

Four basic techniques for training maintenance personnel are being tested:

1. Programmed Instructions—self-instructional material in a printed book form designed so that trainee can proceed at his own pace.
2. Audio-Visual Instructions—self-instructional material in which a regular slide projector and tape recorder will be used.
3. Workshop—a carefully led small group where emphasis is placed on group participation.
4. Conference or Seminar—conventional training utilizing an instructor to present the material.

The subject matter for the first series of training courses covers work on bituminous surfaced roads. This category of work was selected for development of training material because bituminous surface care involves a high percentage of the cash outlay for maintenance. Training materials for other categories of maintenance are also being developed.

The training materials will be evaluated in two stages:

•Short-term—an evaluation directed to the comparative communication ability of the various methods as determined from pre and post testing.

•Long-range—an evaluation from the reporting system which will show performance change and dollar savings.

The training will be administered by the line organization. Primary evaluation of effectiveness will be by district engineers. It is anticipated that all four basic techniques will be used on a permanent basis with the situation dictating which technique is required.

SUPERINTENDENTS MANUAL

The Superintendents Manual was designed as a "working manual" to help field personnel in performing work more effectively. The contents of the manual are based on research work conducted in the performance laboratory. The manual was developed to permit changes to be made readily as new sections are added from time to time as well as revisions made to existing sections.

Contents

A brief description of the contents of each section of the manual follows:

Section 1 Responsibilities

This section informs the superintendent of the basic objectives of the Maintenance Department and tells him of his responsibility as a supervisor. An overview of the entire maintenance management system in terms the superintendent can understand is also presented.

Section 2 Maintenance Standards

A general description of the performance standards, as approved by the standards panel and tested in the performance laboratory is presented.

Quality Standards—These standards provide a tool for supervisors in that they define conditions that are acceptable as well as conditions that are unacceptable. For example, the Quality Standard for mowing says that roadside grass should not be higher than twelve inches. Another example is found in depressions in bituminous surfaces. When these are less than one inch in ten feet they are acceptable, however, depressions greater than one inch in ten feet cause a rough riding surface that is uncomfortable and if they develop into potholes they are a hazard. These are unacceptable and should be corrected.

Quantity Standards—These standards provide the basis for the initiation and measurement of work thus providing a tool for planning and controlling work.

Methods and Procedures—These standards provide guides for staffing arrangements and equipment assignments as well as proper procedures to assist the superintendents in performing work uniformly on a statewide basis.

These standards also provide a production rate and unit cost to enable the superintendent to become aware of what it costs to do the work.

Section 3 Annual Program

This section shows how work is planned in accordance with the standards. The following is an example for premix patching.

Parish Mileage Responsibility

Primary system	-	100 miles
Secondary system	-	60 miles
Farm-to-market system	-	140 miles

Annual Quantity Standards

Primary system	-	2.0 tons per mile
Secondary system	-	4.0 tons per mile
Farm-to-market system	-	4.0 tons per mile

Annual Quantity

Primary	-	100 miles	×	2.0 tons per mile	=	200 tons
Secondary	-	60 miles	×	4.0 tons per mile	=	240 tons
Farm-to-market	-	140 miles	×	4.0 tons per mile	=	560 tons

Total pre-mix required for year. . . . . 1,000 tons

Man-Power Required

The productivity standards indicate a rate of 3.0 man-hours per ton to place pre-mix; therefore, 3.0 man-hours × 1,000 tons = 3,000 man-hours required.

Funding Required

Labor	-	1,000 tons	×	$6.60 per ton	=	$6,600
Equipment	-	1,000 tons	×	2.20 per ton	=	2,200
Materials	-	1,000 tons	×	8.20 per ton	=	8,200

Total $17,000

Section 4 Inspection

This section of the manual covers inspections in the following order:

- Annual inspection
- Pre-scheduling inspection
- On-the-job inspection
- Workmanship inspection

Section 5 Scheduling

This section of the manual stresses the importance of scheduling work. Five questions the superintendent must have answers to in order to schedule his work effectively are:

- What is to be done?
- Where is it to be done?
- How is it to be done?
- Who is to do it?
- When is it to be done?

Section 6 Performance Reports

This section lists and describes sources of information made available to the superintendents, including:

- Biweekly activity reports
- Annual maintenance program
- Performance analysis report
- Quarterly performance report

Section 7 Methods and Procedures

This section presents the performance standards for all major functions. The standards provide the following information:

- Function description
- Recommended crew size
- Recommended equipment complement
- Approximate accomplishment per day

This section also includes the annual work quantity standards and unit costs and productivity standards so as to give each superintendent a complete picture of the management system at his level.

Distribution and Implementation

The Superintendents Manual was distributed to each district for use by all parish superintendents. Training in the use of the manual was handled by district personnel. The intent of the manual is to provide information for employees who are superintendents now and also for those who will be promoted to superintendents.

IMPLEMENTATION OF RESULTS

Certain aspects of the maintenance mangement system have been implemented statewide. For example, the reporting system and scheduling process are being utilized throughout the State and are working satisfactorily. Other aspects of the system, such as the use of standard methods and formalized inspections, have been implemented in several parishes.

A formalized step-by-step implementation of the total maintenance management system will be conducted during Fiscal Year 1969 in the Lake Charles district. At present, implementation of the system or any part thereof in the remainder of the State is at the discretion of the district engineers.

Procedures are being developed for preparing the district annual maintenance budgets on the basis of performance standards. We anticipate that the Fiscal Year 1970 maintenance budgets for all districts in the State will be prepared in this manner.

Appendix

The following pages contain charts, forms, and tables referred to in the text of the paper.

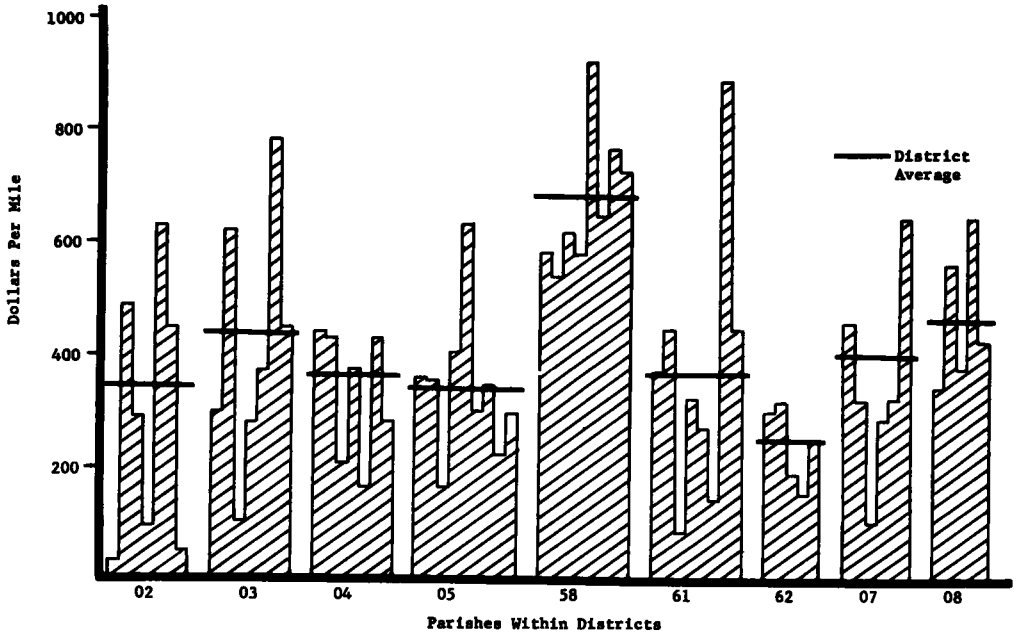

Figure 1. Average annual cost per mile for patching on selected control sections, fiscal years 1963-1965. Data from functional cost reports and system surface logs.

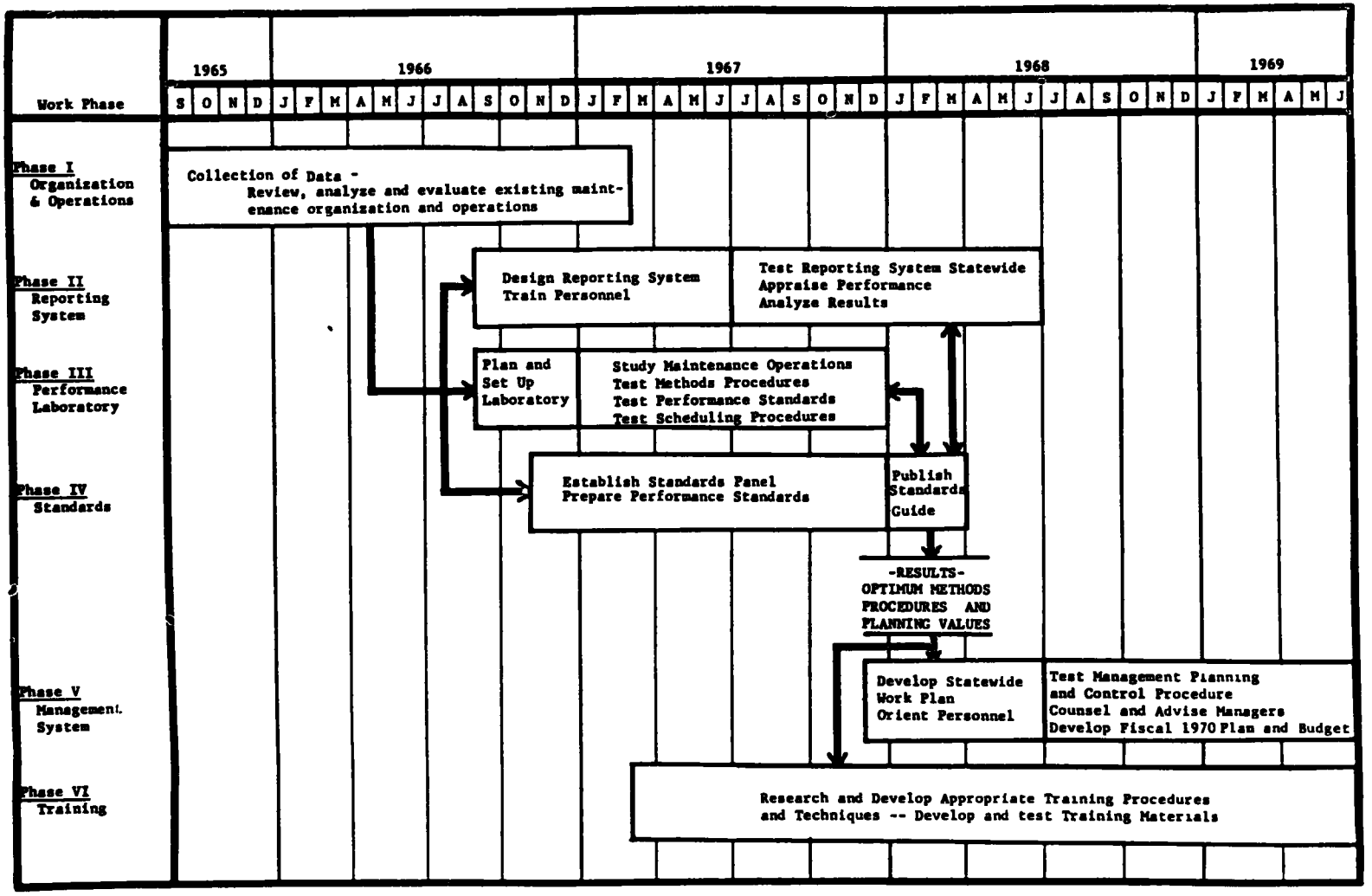

Figure 2. Maintenance research project schedule.

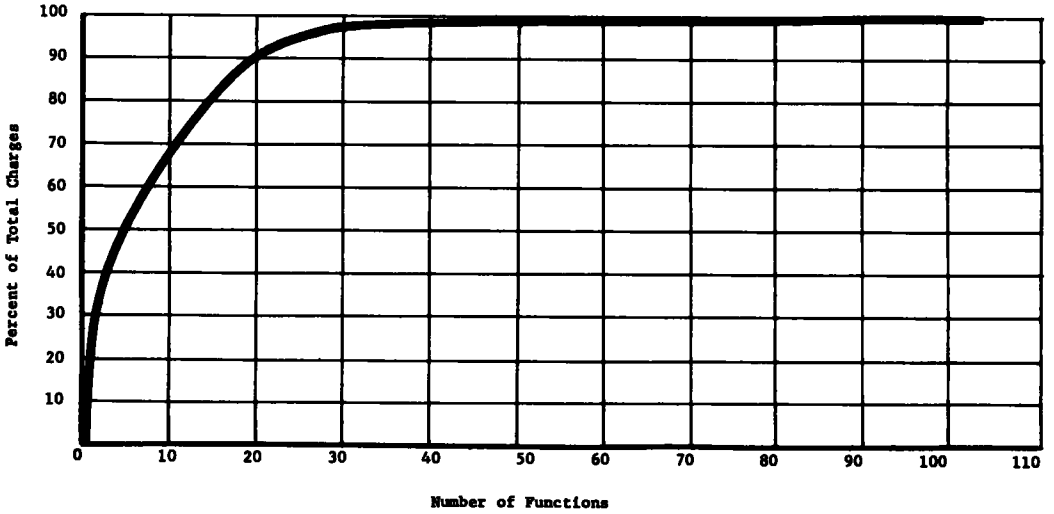

Figure 3. Distribution of charges to maintenance functions, fiscal 1965.

FORM NO 4129

61505

STATE OF LOUISIANA
DEPARTMENT OF HIGHWAYS
BIWEEKLY ACTIVITY REPORT

	Payroll District	Payroll Gang	Period Ending No	Period Ending Day	Period Ending Year
9	07	550	5	22	68

Description of Work

Work Force Identification Dist	Work Force Identification Gang	Parish	Function	System Code	Control Unit or Equip No	Struct Code	Proj No	Ident Code
07	550	10	411	4				

MATERIALS USED RECORD (61505)

Stock Pile Location	Description	Iss Dist	Stock No	Iss Par	1st W	1st T	1st F	1st S	1st S	1st M	1st T	2nd W	2nd T	2nd F	2nd S	2nd S	2nd M	2nd T	Quantity	Unit of Meas
Lake Charles	C-3 Aggregate	07	24-02-6820	10	20	24						22	19	23					108	55
Lake Charles	AC-8 Asphalt	07	24-03-1325	10	550	650						600	600	650					3050	20

Transmission Totals 3158

EMPLOYEE TIME & PER DIEM RECORD

Employee Name & Number		1st W	1st T	1st F	1st S	1st S	1st M	1st T	2nd W	2nd T	2nd F	2nd S	2nd S	2nd M	2nd T	Total Hours Regular	Total Hours Overtime	Total Amount Per Diem
Labor	PD																	
NO	HR	64	64						56	64	64					312		

Transmission Totals 312

EQUIPMENT USED RECORD

Daily Hours or Miles Charged

1st W	1st T	1st F	1st S	1st S	1st M	1st T	2nd W	2nd T	2nd F	2nd S	2nd S	2nd M	2nd T	Equipment No	Total Hours	Total Miles
8	8						8	8	8					140-650	40	
8	8						8	8	8					140-651	40	
8	8						8	8	8					140-780	40	
8	8						8	8	8					263-562	40	
8	8						8	8	8					250-221	40	

Transmission Totals 200

ACCOMPLISHMENT RECORD Description

Number of Units Accomplished

1st W	1st T	1st F	1st S	1st S	1st M	1st T	2nd W	2nd T	2nd F	2nd S	2nd S	2nd M	2nd T	Unit of Meas	Total Number of Units
20	24						22	19	23					55	108

Jack Smith
PARISH CLERK OR SUPERVISOR

Henry Miller
DISTRICT ADMINISTRATIVE ASSISTANT OR SUPERIOR

ACCOUNTING

Figure 4. BAR for surface treatment patching.

Fiscal Year 1968-69 (1–6) District No. (7–8) Parish No. (9–10) Parish Supt. Gang No. (11–13) Document Code 30 (78–79) (1)

BITUMINOUS SURFACE MAINTENANCE

Function	System	Funct. Code (15–17)	Sy. Code (20)	System Miles (21)	Planning Units (27)	Q./Plan.Unit (33)	M.H./Q. (39–44)	Unit Cost $/Q (46)	Cost Distr. - Percent: Labor (52)	Equip. (55)	Mat. (58)	Contr. Serv. (61)	Seasonal Distr.-Percent: 1st. Quar. (64)	2nd. Quar. (67)	3rd. Quar. (70)	4th. Quar. (73)
SURF. TR. PATCHING	Interstate	411	1			0.2	2.0	13.50	39	17	44		30	20	10	40
	Primary	411	2			4.0	2.0	13.50	39	17	44		30	20	10	40
C.Y. Aggr. per 2-lane mile of B.S.T.	Secondary	411	3			4.0	2.0	13.50	39	17	44		30	20	10	40
	Farm-to-Market	411	4			4.0	2.0	13.50	39	17	44		30	20	10	40
PREMIX PATCHING	Interstate	412	1			1.0	3.0	17.10	39	13	48		50	20	15	15
	Primary	412	2			2.0	3.0	17.10	39	13	48		50	20	15	15
Tons Premix per 2-lane mile of Bitum. Surf.	Secondary	412	3			4.0	3.0	17.10	39	13	48		50	20	15	15
	Farm-to-Market	412	4			4.0	3.0	17.10	39	13	48		50	20	15	15
PATCHING BASE	Interstate	413	1			2.0	2.0	8.70	45	38	17		35	5	30	30
	Primary	413	2			2.0	2.0	8.70	45	38	17		35	5	30	30
C.Y. Material per 2-lane mile of Bitum. Surf.	Secondary	413	3			5.0	2.0	8.70	45	38	17		35	5	30	30
	Farm-to-Market	413	4			5.0	2.0	8.70	45	38	17		35	5	30	30
CRACK REPAIR	Interstate	414	1			2.0	0.5	1.70	53	42	5		0	50	50	0
	Primary	414	2			5.0	0.5	1.70	53	42	5		0	50	50	0
Gallons Filler per 2-lane mile of Bit. Conc. Surf.	Secondary	414	3			5.0	0.5	1.70	53	42	5		0	50	50	0
	Farm-to-Market	414	4			5.0	0.5	1.70	53	42	5		0	50	50	0
SEAL COAT	Interstate	415	1				52.0	80.00	11	5	84		50	0	0	50
	Primary	415	2			0.2	52.0	80.00	11	5	84		50	0	0	50
Miles Sealed per 2-lane mile of B.S.T.	Secondary	415	3			0.2	52.0	80.00	11	5	84		50	0	0	50
	Farm-to-Market	415	4			0.2	52.0	80.00	11	5	84		50	0	0	50
PREMIX LEVELING	Interstate	416	1				1.3	11.20	21	10	69		50	0	0	50
	Primary	416	2			10.0	1.3	11.20	21	10	69		50	0	0	50
Tons Premix per 2-lane mile of B.S.T	Secondary	416	3			10.0	1.3	11.20	21	10	69		50	0	0	50
	Farm-to-Market	416	4			10.0	1.3	11.20	21	10	69		50	0	0	50
SPOT SURFACE REPLACEMENT	Interstate	417	1			1.0	2.8	16.40	34	20	46		50	20	15	15
	Primary	417	2			2.0	2.8	16.40	34	20	46		50	20	15	15
Tons Premix per 2-lane mile of Bitum Surf.	Secondary	417	3			2.0	2.8	16.40	34	20	46		50	20	15	15
	Farm-to-Market	417	4			2.0	2.8	16.40	34	20	46		50	20	15	15
	Interstate		1													
	Primary		2													
	Secondary		3													
	Farm-to-Market		4													

Figure 5. Maintenance planning worksheet.

Fiscal Year 1968 69 District No 07 Parish No Parish Supt Gang No 881

FUNCTION NAME	NO	ACCOMPLISHMENT UNIT	QUANTITY	LABOR HOURS	COST—DOLLARS LABOR	EQUIP	MATERIAL	CONTR	TOTAL	UNIT COST	RATE MH/O	SEASONAL DIST % 1 Q	2 Q	3 Q	4 Q
BITUMINOUS SURFACE															
SURFACE TREAT PATCH	411	CY AGGR	848	2138	2991	1303	3379		7668	13 50	2 8	30	20	10	40
PREMIX PATCHING	412	TONS MIX	753	8259	8823	1674	6180		12877	17 10	3 8	50	20	15	15
PATCHING BASE	413	CY MAT	893	1786	3497	2953	1320		7770	8 70	2 0	35	5	30	30
CRACK REPAIR	414	GAL FILL	498	248	496	354	42		842	1 70	5		50	50	
PREMIX LEVELING	416	TONS MIX	1420	1896	3388	1591	10973		15904	11 20	1 3	50			50
SPOT SURF REPLACE	417	TONS MIX	483	1352	2694	1583	3644		7921	16 40	2 8	50	20	15	15
CONCRETE SURFACE															
PATCHING SURFACE	421	CY CONC	650	3900	6523	3374	12593		22490	34 60	6 0	30	50	20	
PREMIX PATCHING	422	TONS MIX	84	252	561	187	688		1436	17 10	3 0	30	50	20	
PATCHING BASE	423	CY MAT	835	1670	3270	2760	1235		7265	8 70	2 0	30	50	20	
CRACK REPAIR	424	GAL FILL	835	418	782	596	72		1450	1 70	5		50	50	
JOINT REPAIR	425	100 LN FT	1040	1457	2925	770	153		3848	3 70	1 4		50	50	
GRAVL-SHELL SURFACE															
PATCHING SURFACE	431	CY AGGR	160	192	382	312	722		1416	8 85	1 2	5	45	30	20
RESHAPE SURFACE	432	ROAD MI	388	614	1244	1521			2765	7 20	1 6	15	25	35	25
RESTORING SURFACE	433	CY AGGR	648	384	749	499	2912		4160	6 50	6	5	45	30	20
SHOULDER & APPROACH															
PATCH NON-PAV SHLDR	441	CY MAT	499	599	1178	883	884		2945	5 90	1 2	5	75	10	10
RESHAP NON-PV SHLDR	442	SHLDR MI	550	825	1682	2058			3740	6 80	1 5	30	15	10	45
RESTOR NON-PV SHLDR	443	CY MAT	1007	705	1417	782	1527		3726	3 70	7	5	75	10	10
SURFACE TREAT PATCH	451	CY AGGR	275	963	1974	790	2172		4936	17 95	3 5	30	20	10	40
PREMIX PATCHING	452	TONS MIX	51	153	338	156	373		867	17 00	3 0	50	20	15	15
PATCHING BASE	453	CY MAT	48	96	188	159	71		418	8 71	2 0	35	5	30	30
ROADSIDE & DRAINAGE															
CLEAN-REP DRAIN STR	462		2796	2796	5595	836			6431	2 30	1 0	15	20	15	50
CLEAN-RESHAPE DITCH	463	DITCH MI	4	960	1918	1508			3424	856 00	240 0	20	40	20	20
MACHINING DITCHES	464	DITCH MI	69	552	1118	1366			2484	36 00	8 0	20	40	20	20
MOWING	470	ACRES	18632	18632	35773	23849			59622	3 20	1 0	50	20		30
LITTER CLEANING	473	LOADS	256	5120	10295	1404			11699	45 70	20 0	10	30	40	20
TOTAL PLANNED MAINT				48915	95871	53268	48935		198074			35	27	14	24

Figure 6. Maintenance planning summary.

Fiscal Year 1967 68
Period From 07 01 67 To 03 31 68

District No 07 Parish Supt Gang No 081 Gang No SUPT. SUMMARY

FUNCTION NAME	NO	ACCOMPLISHMENT UNIT	QUANTITY	LABOR HOURS	TOTAL COST	UNIT COST STANDARD	UNIT COST ACTUAL	RATE—MH/Q STANDARD	RATE—MH/Q ACTUAL
BITUMINOUS SURFACE									
SURFACE TREAT PATCH	411	CY AGGR	1076	5452	24475	1682	2275	35	51
PREMIX PATCHING	412	TONS MIX	4923	5329	18898	5439	384	168	11
PATCHING BASE	413	CY MAT	194	1004	3356	1681	1730	39	52
CRACK REPAIR	414	GAL FILL	800	140	492	130	62	5	2
OTHER BIT SURFACE	419			993	2687				
CONCRETE SURFACE									
PATCHING SURFACE	421	CY CONC	104	1455	5614	4633	5398	100	140
PREMIX PATCHING	422	TONS MIX	5	112	340	5440	6800	169	224
PATCHING BASE	423	CY MAT	70	1266	3984	1681	5691	39	181
CRACK REPAIR	424	GAL FILL	800	254	784		98		3
OTHER CONC SURFACE	429			684	1856				
GRAVL-SHELL SURFACE									
PATCHING SURFACE	431	CY AGGR	148	208	898	735	607	13	16
RESHAPE SURFACE	432	ROAD MI	1156	1897	8401	815	727	17	16
SHOULDER + APPROACH									
PATCH NON-PAV SHLDR	441	CY MAT	3190	5985	22488	458	705	14	19
RESHAP NON-PV SHLDR	442	SHLDR MI	122	234	999	1251	819	27	19
SURFACE TREAT PATCH	451	CY AGGR	15	70	314		2093		47
PREMIX PATCHING	452	TONS MIX	17	110	468		2753		65
PATCHING BASE	453	CY MAT	10	24	100		1000		24
OTHER SHLDR + APPR	459			56	180				
ROADSIDE + DRAINAGE									
EROSION CONTROL	461			56	162				
CLEAN-REP DRAIN STR	462			297	1104				
CLEAN-RESHAPE DITCH	463	DITCH MI	12	2159	6932	22560	57767	800	1799
MACHINING DITCHES	464	DITCH MI	11	24	113		1027		22
MOWING	470	ACRES	7680	15430	48971	358	638	10	20
CUTTING BRUSH	471			3392	6820				
LANDSCAPE MAINT	472			216	557				
LITTER CLEANING	473	LOADS	285	7359	15231	6115	5344	317	258
SERV LITTER BARRELS	474	BARRELS	569	510	1139		200		9
OTHER ROADSIDE + DR	479			1301	2749				
STRUCTURE MAINT									
OTHER STRUCT MAINT	499			128	436				
TRAFFIC SERVICE									
SNOW + ICE CONTROL	511			1819	4224				
PUBLIC FACILITIES	542			126	269				
BARRICADES+DETOURS	553			38	84				
OTHER TRAFFIC SERV	559			277	704				
RIVER CROSSING OPER									
OPER OF FERRIES	561			11578	43704				
RIVER CROSSING OPER									
OPER MOVABLE SPANS	563			11882	31760				
DISASTER MAINT									
ACCIDENT DAMAGE	602			7	17				
STATE FORCE CONSTR									
BASE + SURFACE	623			128	351				
SHOULDER IMPROVEMNT	624			8	38				
ROADSIDE DEVELOPMNT	625			6	27				
MAINT OVERHEAD									
FIELD MAINT OH	681			2896	7798				
MATERIAL HANDLING	653			323	605				
STANDBY TIME	655			2412	4464				
ANNUAL LEAVE	656			3474	6373				
SICK LEAVE	657			3672	6755				
COMPENSATORY LEAVE	658			704	1276				
OTHER LEAVE	659			6928	13581				
CLEARING ACCOUNTS									
REPAIRING EQUIPMENT	732			8	18				
SERVICING EQUIPMENT	733			1052	1922				
ADMINISTRATION									
GROUNDS MAINT	884			542	1156				
BUILDING MAINT	885			15	28				
GANG TOTALS				103600	305298				

Figure 7. Performance analysis.

Period From 07 01 67 To 09 30 67

District No 08 Parish NATCHITOCHES Parish Supt Gang No 085

FUNCTION NAME	NO	ACCOMPLISHMENT UNIT	QUANTITY PLAN	QUANTITY ACTUAL	%	LABOR HOURS PLAN	LABOR HOURS ACTUAL	%	TOTAL COST PLAN	TOTAL COST ACTUAL	%	UNIT COST PLAN	UNIT COST ACTUAL	%	RATE—MH Q PLAN	RATE—MH Q ACTUAL	%
BITUMINOUS SURFACE																	
SURFACE TREAT PATCH	411	CY AGGR	1212	124	10	2424	1607	66	16968	5792	34	1400	4671	334	20	130	648
PREMIX PATCHING	412	TONS MIX	1084	525	48	3252	1847	57	21680	9283	43	2000	1770	88	30	35	117
PATCHING BASE	413	CY MAT	509	434	85	1019	688	68	3565	2159	61	700	497	71	20	16	79
CRACK REPAIR	414	GAL FILL										180			5		
SEAL COAT	415	SQ YD		54068			344			4792			9				
CONCRETE SURFACE																	
PATCHING SURFACE	421	CY CONC	89			443			2655			3000			50		
PREMIX PATCHING	422	TONS MIX	50			150			1000			2000			30		
PATCHING BASE	423	CY MAT	90			180	7	4	630	20	3	700			20		
CRACK REPAIR	424	GAL FILL										180			5		
JOINT REPAIR	425	100 LN FT										270			9		
GRAVL-SHELL SURFACE																	
PATCHING SURFACE	431	CY AGGR	18	79	439	12	117	975	105	564	537	600	713	119	7	15	212
RESHAPE SURFACE	432	ROAD MI	219	72	33	350	220	63	1313	974	74	600	1353	226	16	31	191
SHOULDER + APPROACH																	
PATCH NON-PAV SHLDR	441	CY MAT	175	373	213	175	667	381	628	2246	358	358	602	168	10	18	179
RESHAP NON-PV SHLDR	442	SHLDR MI	473	97	21	710	444	63	3607	1946	54	762	2007	263	15	46	305
PATCHING BASE	453	CY MAT					6			13							
ROADSIDE + DRAINAGE																	
CLEAN-REP DRAIN STR	462						482			1059					2000		
CLEAN-RESHAPE DITCH	463	DITCH MI	2			360	120	33	1080	297	27	60000			10	13	126
MOWING	470	ACRES	7294	2996	41	7294	3783	52	25529	12698	50	350	424	121	200	215	107
LITTER CLEANING	473	LOADS	53	15	28	1066	322	30	2399	715	30	4500	4764	106			
SERV LITTER BARRELS	474	BARRELS		403			219			569			141			5	
TRAFFIC SERVICE																	
SIGN MAINTENANCE	533						240			464							
DISASTER MAINT																	
ACCIDENT DAMAGE	602						132			375							
MAINT OVERHEAD																	
OTHER GENERAL FUNCT	699						2838			6369							
TOTAL PLANNED MAINT						17435	14083	81	81159	50334	62						
STATE FORCE CONSTR							4286			29891							
LEAVE							4496			8933							
ADMIN AND OVERHEAD							2904			6669							
TOTAL STATE HIGHWAY							25769			95826							
OFF SYSTEM WORK							84			417							
TOTAL							25853			96243							

Figure 8. Maintenance performance report.

Fiscal Year 1967-68
Period From 06-28-67 To 07-25-67

District No 08 Function SURFACE TREAT PATCH Function No 411 Accomplishment CY AGGR

PARISH SUPERINTENDENT LOCATION	GANG NO	QUANTITY	LABOR HOURS	TOTAL COST	PERCENT OF COST LABOR	EQUIP	MAT	CONTR	UNIT COST	RATE MH/Q
ALEXANDRIA	210	9	54	220	44	22	34		2443	60
ALEXANDRIA	211	78	736	2994	48	26	26		3839	94
ACTUAL		87	790	3214	48	26	26		3694	91
PLAN		816	1632	11424	29	15	56		1400	20
HESMER	120	100	800	2893	53	20	27		2893	80
HESMER	220	12	104	403	54	19	27		3356	87
HESMER	221	27	312	915	65	13	22		3388	116
ACTUAL		139	1216	4211	56	18	26		3029	87
PLAN		783	1566	10962	29	15	56		1400	20
MANY	130	98	440	2010	45	22	33		2051	45
MANY	230	136	408	2107	38	19	43		1550	30
ACTUAL		234	848	4118	41	21	38		1760	36
PLAN		870	1740	12180	29	15	56		1400	20
LEESVILLE	140	137	464	2413	37	21	42		1761	34
LEESVILLE	240	78	416	1840	45	21	34		2358	53
LEESVILLE	241	126	464	2328	36	21	43		1847	37
ACTUAL		341	1344	6580	39	21	40		1930	39
PLAN		839	1677	11739	29	15	56		1400	20
NATCHITOCHES	550	412	1215	7062	33	19	48		1714	29
ACTUAL		412	1215	7062	33	19	48		1714	29
PLAN		1212	2424	16968	29	15	56		1400	20
WINNFIELD	260	137	520	2537	39	23	38		1852	38
WINNFIELD	261	28	160	690	45	23	32		2463	57
ACTUAL		165	680	3227	41	23	36		1956	41
PLAN		1029	2058	14406	29	15	56		1400	20
DRY PRONG	170	24	80	385	39	18	43		1605	33
DRY PRONG	270	274	548	3816	28	18	54		1393	20
DRY PRONG	271	30	160	630	45	22	33		2101	53
ACTUAL		328	788	4832	31	19	50		1473	24
PLAN		660	1320	9240	29	15	56		1400	20
DISTRICT ACTUAL		1706	6881	33242	40	20	40		1949	40
DISTRICT PLAN		6209	12417	86919	29	15	56		1400	20

Figure 9. Productivity analysis.

FUNCTION		FUNC. CODE	WORK QUANTITY MEASUREMENT	PLANNING UNIT	ANNUAL QUANTITY PER PLANNING UNIT				SEASONAL DISTR. - %			
					INTERSTATE	PRIMARY	SECONDARY	FM-TO-MKT.	July - Sept.	Oct - Dec.	Jan - Mar.	Apr - June
Bituminous Surface Maint	Surface Treatment Patching	411	C Y. Aggregate	Per 2-lane Mile of Bit. Surface Treated Road	0 2	4.0	4 0	4.0	30	20	10	40
	Premix Patching	412	Tons Premix	Per 2-lane Mile of Bit Surface Road	1 0	2.0	4 0	4.0	50	20	15	15
	Patching Base	413	C Y. Material	Per 2-lane Mile of Bit Surface Road	2 0	2 0	5 0	5.0	35	5	30	30
	Crack Repair	414	Gallons Filler	Per 2-lane Mile of Bitum Conc. Road	2 0	5.0	5 0	5 0	0	50	50	0
	Seal Coat	415	Miles Sealed	Per 2-lane Mile of Bit Surface Treated Road		0 2	0 2	0 2	50	0	0	50
	Premix Leveling	416	Tons Premix	Per 2-lane Mile of Bit Surface Treated Road		10 0	10 0	10 0	50	0	0	50
	Spot Surface Replacement	417	Tons Premix	Per 2-lane Mile of Bit. Surface Road	1 0	2.0	2 0	2 0	50	20	15	15
Concrete Surface Maint	Patching Surface	421	C. Y. Concrete	Per 2-lane Mile of Conc. Surface Road	5.0	5.0	5 0	5.0	30	50	20	0
	Premix Patching	422	Tons Premix	Per 2-lane Mile of Conc Surface Road	0.5	1.0	1 0	1.0	30	50	20	0
	Patching Base	423	C. Y. Material	Per 2-lane Mile of Conc Surface Road	5.0	10.0	10.0	10 0	30	50	20	0
	Crack Repair	424	Gallons Filler	Per 2- lane Mile of Conc Surface Road	5 0	10 0	10 0	10.0	0	50	50	0
	Joint Repair	425	100 Lin Ft Joint	Per 2-lane Mile of Conc Surface Road	8 0	8.0	8 0	8 0	0	50	50	0
Gravel or Shell Surf. Maint.	Patching Surface	431	C Y. Aggregate	Per 2-lane Mile of Gravel or Shell Surface Road		5.0	5 0	5 0	5	45	30	20
	Reshaping Surface	432	Miles	Per 2-lane Mile of Gravel or Shell Surface Road		12 0	12.0	12.0	15	25	35	25
	Restoring Surface	433	C. Y. Aggregate	Per 2-lane Mile of Gravel or Shell Surface Road		20 0	20 0	20 0	5	45	30	20

Figure 10. Performance standards for annual maintenance work quantities; perliminary values only effective date May 1968.

LOUISIANA DEPT OF HIGHWAYS —— MAINTENANCE STANDARD

INDEX NO M-1
FUNCTION NO 411
EFFECTIVE DATE 3/1/68

SURFACE TREATMENT PATCHING

DESCRIPTION

Patching bituminous roadway surface with one or more applications of hot asphalt and aggregate.

PURPOSE

To seal small areas and prevent surface deterioration from cracking or raveling.

PROCEDURES

1. Broom area to be patched.
2. Adjust width of spray bar and shoot asphalt in a rectangular area at least six inches beyond deteriorated area. Small area patches will be shot with hand hose.
3. Spread aggregate uniformly over the asphalt, using the choke board where necessary.
4. Roll the patch, overlapping each pass, until the entire patch has been rolled
5. If more than one application is used, only the last application need be squared up.

Figure 11. Work procedure—premix patching.

DISTRIBUTION OF 680 MAN-HOURS NAWT FOR MEN ASSIGNED TO PREMIX PATCHING WITH HOT MIX (412)

Items	Total Minutes	Percent of NAWT	Performance (Average Per Hour)
At Worksite			
A Cyclic work items			
1. Remove old pavement	787	1.9	
2. Tack hole	461	1 1	
3. Spread hot mix	7,588	18.6	217 square yards 6.5 tons
4. Roll patch	510	.1.3	
5 Move ahead to new work area	1,343	3.3	
B. Supporting work items	3,684	9.0	
C. Delays - wait on cyclic work items	4,848	11.9	
D. Delays - other	2,306	5.6	
Total Worksite	21,527	52.7	0.6 tons
Other			
E. Travel to, from, or between worksites	14,895	36.5	
F. Supporting work items	2,139	5.3	
G. Delays	466	1.1	
H. Non-supporting work items	1,750	4.4	
Total Other	19,250	47.3	
Grand Total	40,777	100.0	0.3 tons
Productive time (A/B/E/F)	31,407	77.0	

Figure 12. Accomplishment study data summary.

	FUNCTION	FUNC. CODE	WORK QUANTITY MEASUREMENT (Q)	AVERAGE RATE MAN HOURS/Q	AVERAGE UNIT COST $/Q	COST DISTRIBUTION - PERCENT			
						LABOR	EQUIP.	MATERIAL	CONTR. SERV.
Bituminous Surface Maint.	Surface Treatment Patching	411	C Y Aggregate	2.0	$ 13 50	39	17	44	
	Premix Patching	412	Tons Premix	3 0	17 10	39	13	48	
	Patching Base	413	C Y Material	2.0	8.70	45	38	17	
	Crack Repair	414	Gallons Filler	0 5	1.70	53	42	5	
	Seal Coat	415	Miles Sealed	52 0	800 00	11	5	84	
	Premix Leveling	416	Tons Premix	1.3	11 20	21	10	69	
	Spot Surface Replacement	417	Tons Premix	2.8	16.40	34	20	46	
Concrete Surface Maint	Patching Surface	421	C Y. Concrete	6 0	34 60	29	15	56	
	Premix Patching	422	Tons Premix	3 0	17.10	39	13	48	
	Patching Base	423	C Y Material	2 0	8.70	45	38	17	
	Crack Repair	424	Gallons Filler	0 5	1 70	53	42	5	
	Joint Repair	425	100 Lin. Ft Joint	1 4	3.70	76	20	4	
Gravel or Shell Surf. Maint.	Patching Surface	431	C Y. Aggregate	1.2	8.85	27	22	51	
	Reshaping Surface	432	Miles	1 6	7.20	45	55	--	
	Restoring Surface	433	C Y Aggregate	0 6	6 50	18	12	70	

Figure 13. Performance standards for maintenance unit costs and productivity; preliminary values only effective date May 1968.

Activity	Amount Done In 1967	1966-1967 Rate Differential	Man-Hour Savings 1/	1966-1967 Unit Cost Differential	Dollar Savings 2/
Surface Treatment Patching	3,356 Cu. Yds.	-0.3	- 1,007	-$ 3.10	-$10,404
Premix Patching	1,921 Tons	2.1	3,951	3 16	6,089
Concrete Patching	370 Cu. Yds.	16.5	6,105	41.22	15,251
Premix Patching - Concrete	5 Tons	6.0	30	18.91	95
Patching Non-Paved Surface	401 Cu. Yds.	0.6	241	2.98	1,195
Reshaping Non-Paved Surface	815 Miles	0.3	245	0.36	293
Patching Non-Paved Shoulders	4,196 Cu. Yds	0.3	1,259	1.10	4,616
Reshaping Non-Paved Shoulders	618 Miles	-0.2	- 124	- 2.25	- 1,391
Mowing	12,075 Acres	0.3	3,623	0.81	9,781
Litter Cleaning	224 Loads	-1.1	- 246		- 455
Total	--	--	14,077	--	$25,070

1/ Man-Hour Savings -- Amount Done in 1967 (1966 Rate Minus 1967 Rate)

2/ Dollar Savings -- Amount Done in 1967 (1966 Unit Cost Minus 1967 Unit Cost)

Figure 14. Benefits from method improvements.

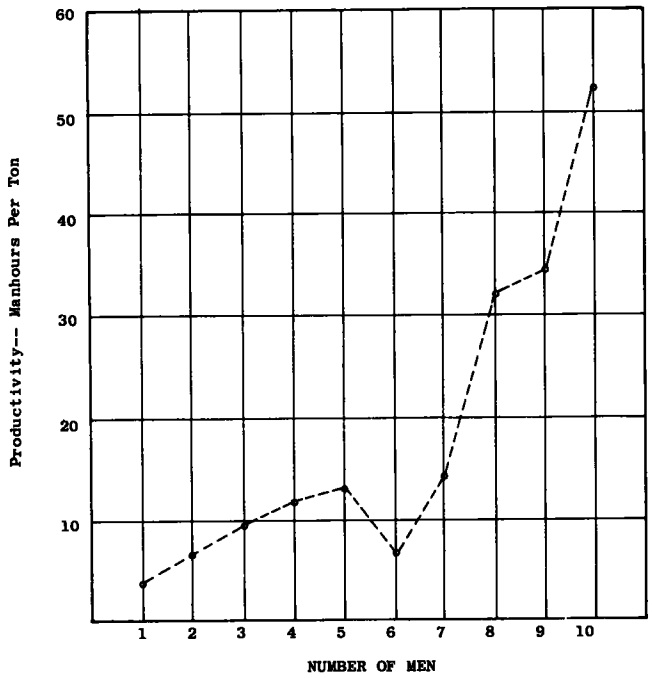

Figure 15. Productivity for cold-mix patching related to crew size.

Haul Distance	Number Of Trucks	Quantity (Cubic Yards)	Accomplishment (Man-Hours Per Cubic Yard)
0 - 5 Miles	1	45	0.4
6 - 10	2	56	0.5
11 - 15	2	34	0.8
11 - 15	3	51	0.6
16 and up	3	42	0.8

Figure 16. Number of haul trucks for various distances.

Activity	Quantity	Labor Hours	Total Cost
Bituminous Surface			
Surface Treatment Patching	1,114 Cu. Yds.	2,228	$ 15,039
Premix Patching	1,223 Tons	3,669	20,913
Patching Base	1,477 Cu. Yds.	2,954	12,850
Crack Repair	398 Gallons	199	676
Seal Coat	55 Miles	2,860	44,000
Premix Leveling	2,785 Tons	3,621	31,192
Spot Surface Replacement	716 Tons	2,005	11,742
Concrete Surface			
Patching Surface	102 Cu. Yds.	612	3,529
Premix Patching	20 Tons	60	342
Patching Base	203 Cu Yds.	406	1,766
Crack Repair	203 Gallons	101	345
Joint Repair	162 100 Lin.Ft.	227	599
Non-Paved Surface			
Patching Surface	135 Cu. Yds.	162	1,195
Reshaping Surface	322 Miles	515	2,318
Restoring Surface Shoulders	536 Cu. Yds.	322	3,484
Patching Non-Paved Shoulders	600 Cu. Yds.	720	$ 3,540
Reshaping Non-Paved Shoulders	773 Miles	1,160	5,256
Restoring Non-Paved Shoulders	1,132 Cu. Yds.	792	4,188
Paved Shoulder Maintenance	--	245	2,102
Roadside and Drainage			
Clean and Repair Drainage Structures	3,271 Man-Hours	3,271	7,523
Clean and Reshape Ditches	4 Miles	960	3,424
Machining Ditches	81 Miles	648	2,916
Mowing	14,243 Acres	14,243	45,578
Litter Cleaning Roadside	263 Loads	5,260	12,019
Servicing Litter Barrels	2,080 Barrels	1,248	3,016
Total	--	48,488	$239,552
Total less Seal Coat and Premix Leveling 1/		42,007	
Allowance for Leave (17%)		17,136	
Miscellaneous (18%)		18,144	
Betterments and Construction		23,513	
Total Available		100,800	

1/ Special maintenance items to be done by districtwide forces.

Figure 17. Annual program for Natchitoches Parish, fiscal 1969.

	Quarter							
	1st		2nd.		3rd.		4th	
Activity	Quantity	Labor Hours	Quantity	Labor Hours	Quantity	Labor Hours	Quantity	Labor Hours
Surface Treatment Patching	334 C Y.	668	223 C.Y	446	111 C Y	222	446 C Y	892
Premix Patching	612 Tons	1,835	245 Tons	734	183 Tons	550	183 Tons	550
Patching Base	517 C Y.	1,034	74 C.Y.	148	443 C.Y.	886	443 C Y	886
Crack Repair	--	--	199 Gal.	100	199 Gal.	99	--	--
Seal Coat	27 Mi.	1,430	--	--	--	--	28 Mi.	1,430
Premix Leveling	1,393 Tons	1,810	--	--	--	--	1,392 Tons	1,811
Spot Surface Replacement	358 Tons	1,002	143 Tons	401	107 Tons	301	108 Tons	301

Figure 18. Quantity breakdown of quarterly plan for bituminous surface maintenance Natchitoches Parish, fiscal 1969.

ROAD INSPECTION AND MAINTENANCE INVENTORY

Date _____ Sheet _____ of _____

Parish _____ Start Point _____ at _____ miles

Route Number _____ Heading N S E W

Control Section _____ End Point _____ at _____ miles

Mileage											
Miles From Start	1	2	3	4	5	6	7	8	9	10	Notes
Function/Surf Type											
411 - Surf Treat Patch											
412 - Premix Patching											
413 - Patching Base											
414 - Crack Repair											
417 - Surface Replace											
421 - Patching Surface											
422 - Premix Patching											
423 - Patching Base											
424 - Crack Repair											
425 - Joint Repair											
431 - Patching Surface											
441 - Patch NP Shoulder											
Edge Rutting											
442 Reshape Shoulder											
Cut & Haul											
461 - Erosion Control											
462 - Drainage Struct											
463 - Clean Ditches											
464 - Machining Ditches											
471 - Brush Cutting											
Other Work & Remarks											
Major Work											
Seal Coat											
Levelling											
Overlay											
Restore Shoulders											

CONDITION	Surface	Shoulders	Roadside	Traffic Serv	Overall
RATING	E G F P	E G F P	E G F P	E G F P	E G F P

Inspected by _____ and _____

Control Section _____

Figure 19. Work inspection form.

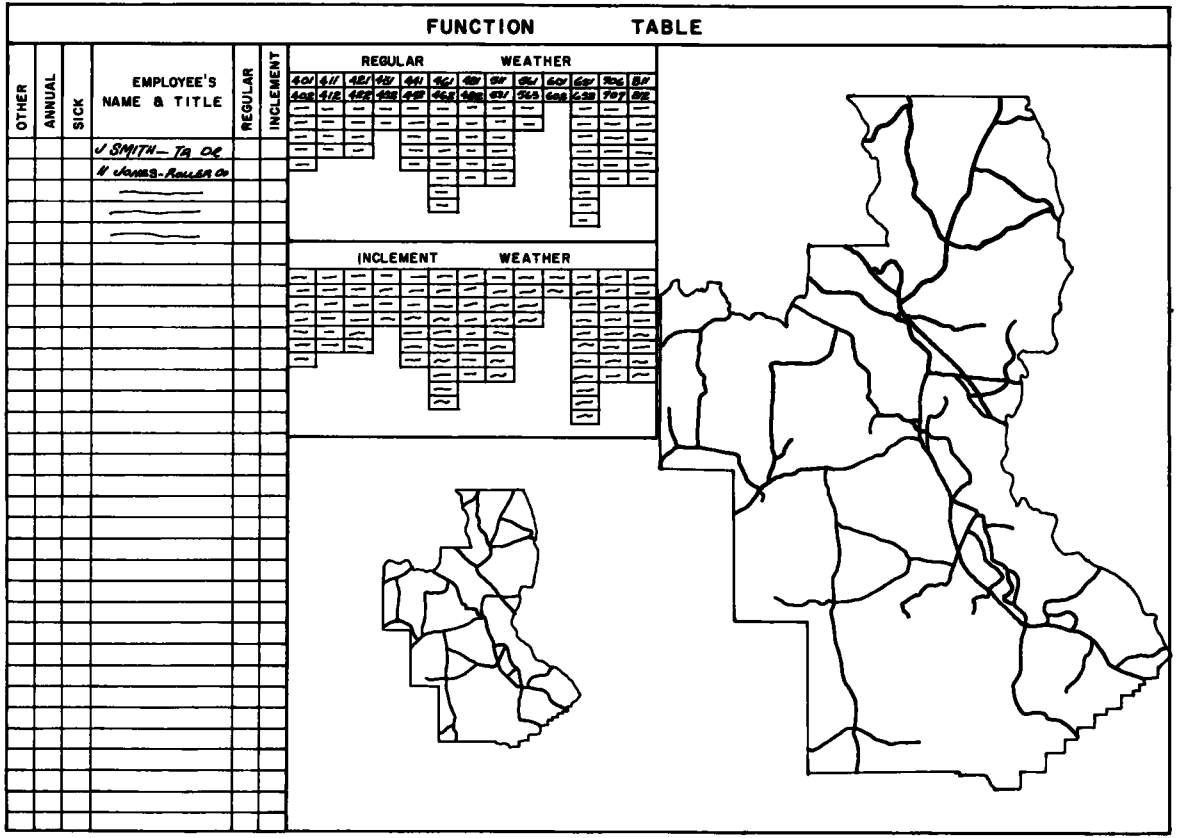

Figure 20. Work scheduling board.

Quantity Summary		Fiscal Year 1968		Actual Accomplishment Posted Thru 10/ 3/67						Quarter 1 (2) 3 4	
Function No.	Description	"A" System		"B" System		"C" System		Man-Hours		Productivity	
		Planned	Actual	Planned	Actual	Planned	Actual	Planned	Actual	Planned	Actual
411	Surface Treatment Patching C.Y.	525	110	750	0	745	472	4,040	1,789	2.0	3.1
412	Premix Patching (Bit) Tons										
413	Patching Base (Bit.) C.Y.										
414	Crack Repair (Bit.) Gal										
421	Patching Surface C.Y.										
422	Premix Patching (Conc.) Tons										
423	Patching Base (Conc.) C.Y.										
424	Crack Repair (Conc.) Gal.										
425	Joint Repair (Conc.) 100' of Joint										
431	Patching Surface (Gravel) C Y.										
432	Reshape Surface (Gravel) Road Miles										
441	Patch Non-Paved Sh. C.Y.										
442	Reshape Non-Paved Sh Sh.Mi.										
463	Clean & Reshape Ditches Ditch Mi.										
470	Mowing Acres										
473	Litter Cleaning Roadside Loads										

Figure 21. Parish work control board.

Quarter 1 (2) 3 4						District 08			Period Ending 10/31/67					
							PRODUCTIVITY							
Function No.	Description	Q. Planned	Q. Actual	M/H Planned	M/H Actual	Planned Accomplishment	Avoyelles	Grant	Rapides	Natchitoches	Sabine	Vernon	Winn	District Average
411	Surface Treatment Patching C.Y.	9,800	8,000	19,600	28,000	2.0	3.3	5.0	4.8	3.1	3.4	3.5	6.0	3.5
412	Premix Patching Tons													
413	Patching Base C.Y.													
414	Crack Repair Gal.													
421	Patching Surface C.Y.													
422	Premix Patching Tons													
423	Patching Base C.Y.													
424	Crack Repair Gal.													
425	Joint Repair 100' of Joint													
431	Patching Surface C.Y.													
432	Reshape Surface Rd. Mi.													
441	Patching Non-Paved Shoulders C.Y.													
442	Reshape Non-Paved Shoulders Sh. Mi.													
463	Clean & Reshape Ditches Ditch Mi.													
470	Mowing Acres													
473	Litter Cleaning Roadside Loads													

Figure 22. District work control board.

Employment Category	Persons in Force	Percent of Force
SUPERVISOR GROUP		
Headquarters Administration	28	
Statewide Gang Foremen	15	
District Administrators	76	
Resident Maintenance Engineers	4	
Maintenance Superintendents II	21	
Districtwide Gang Foremen	186	
Maintenance Superintendents I	59	
Parish Gang Foremen	210	
Bridge, Ferry and Tunnel Foremen	37	
Subtotal	636	13
POTENTIAL SUPERVISOR GROUP		
Equipment Operators III	240	
Equipment Operators II	119	
Equipment Operators I	1,228	
Equipment Inspectors and Mechanics	52	
Bridge, Ferry and Tunnel Operators	23	
Subtotal	1,662	34
NON-SUPERVISOR GROUP		
Equipment Operators II	531	
Equipment Operators I	98	
Carpenters	8	
Painters	61	
Electricians	13	
Equipment Maintainers	176	
Aides and Inspectors	2	
Laborers, Bridgemen and Trades Helpers	128	
Bridge, Ferry and Tunnel Operators	309	
Subtotal	2,326	48
CLERICAL GROUP		
Clerks	228	5
TOTAL	4,852	100

Figure 23. Distribution of maintenance personnel force.