Condition Assessment and Improvement Needs of Locally Maintained Arterial and Collector Highways in Wisconsin

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A study has been conducted of the existing condition and the need for improvement of locally maintained arterial and collector highways in Wisconsin. The analysis required the collection of significant additional roadway condition data. Emphasis was placed on gathering information on pavement surface condition, drainage, and alignment and other geometrics. A 955-mi sample was surveyed initially. Existing conditions were analyzed and needs were projected for the 21,540-mi locally maintained arterial and collector system. The second phase of the study involved data collection and analysis for an additional 8,500 mi during 1986. Results of the condition assessment showed that on the average pavement conditions are similar to those of state trunk highways. However, the arterials and collectors that are maintained locally have poorer geometrics compared with those of state trunk highways. More than 3,500 mi have poor pavement conditions, 2,500 mi have poor alignment or drainage, and 2,900 mi have shoulders less than 2 ft wide. Existing federal aid funding for repairs is inadequate to meet projected future needs. Approximately $60 million annually of additional state and local funds will be necessary to address the projected needs of these vital Wisconsin highways.

The primary purpose of this work was to study the current and prospective improvement needs for arterial and collector streets and roads under local jurisdiction in Wisconsin. The goal was to identify the improvements required to have the whole of the state and local arterial and collector highway system provide an acceptable level of total highway service. Study results were also to be used to examine the adequacy of resources currently devoted to the rural secondary and urban systems. Recommendations were to be completed in time to incorporate them, as necessary, into the 1987–1989 Department of Transportation (DOT) budget proposal.

Arterial and collector highways maintained by local governments in Wisconsin have been a significant link in the state's highway network. Funding to improve these highways traditionally has been a combination of federal-aid secondary programs, federal-aid urban programs, and local funds. Current state aids from the transportation fund have also been used for funding improvements. The Surface Transportation Act of 1982 held these two federal-aid programs to previous levels of funding even though revenues collected for the trust fund increased significantly. This fact, coupled with the erosion by inflation of the purchasing power of highway revenues, has exaggerated the revenue gap. Subsequent policy discussions have raised further concern over future funding and perhaps even the existence of these categories of federal support.

In Wisconsin, the local government's ability to provide adequate funding for this highway network has been severely strained. At the same time, pavements have continued to deteriorate and traffic volumes to increase on these highways. Local governments have expressed serious concern over their future abilities to address improvement needs.

In response to these concerns, the Wisconsin DOT initiated a needs study to determine the condition of locally maintained arterials and collectors, and to assess the need for improvements. The study was to establish alternatives and funding levels to be considered in developing the 1987–1989 Wisconsin transportation budget.

There was virtually no data on the pavement condition of roadways off the state trunk highway system. Therefore, the first step in the study was to determine the condition of arterials and collectors maintained by local governments. Future needs for improving these highways were to be projected based on this condition information. The study was begun in fall 1984, and was to be completed with recommendations by fall 1986.

ORGANIZATION

A steering committee of 43 members, representing the Wisconsin DOT and local governments, directed the needs study. The committee members were primarily professionals and technical staff rather than elected officials.

The steering committee was organized into three subcommittees; the Wisconsin DOT provided staff support. Specific responsibilities of the subcommittees were as follows:

1. *Standards and Guidelines* Subcommittee. Identify data requirements; establish alternative threshold and improvement levels; and analyze and assemble alternative needs study results.
2. *Road Inventory* Subcommittee. Determine and select a valid sample; develop inventory methodology and procedures.
3. *Program and Financial Management* Subcommittee. Develop alternative management and financial programs.

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First the steering committee reviewed and affirmed the overall purpose of the study. It was agreed that the study should document existing arterial and collector roadway conditions, then develop improvement needs in terms of miles and costs to maintain this system in the future. Although the committee agreed that the condition study should be objective and would be unlikely to provoke controversy, the committee recognized that reaching a consensus on the level and distribution of future needs might not be possible. Therefore, as a minimum, the steering committee decided to develop a range of alternatives for consideration by the Wisconsin DOT, local associations, and the Wisconsin legislature.

STUDY METHODOLOGY

Scope

The steering committee first determined the basic scope of the study and approach. In Wisconsin, local governments of counties, cities, villages, and towns are responsible for maintaining 95,646 mi of roadway. Table 1 presents the distribution of this mileage. There are 21,540 mi functionally classified as arterials and collectors. This includes 10,669 mi currently on a federal aid system. Although the committee expressed considerable interest in condition assessment and improvement needs estimates for local roads, the scope of the study was restricted to include only arterials and collectors. This includes the federal aid system and most of the county trunk highway system. The rationale for this critical decision was that more than two-thirds of these miles are eligible for federal aid, and that concern over the future of the federal-aid program was a major emphasis in initiating this study. Furthermore, state responsibility for improving the arterial and collector system is potentially much greater than state responsibility for improving local roads. Therefore, it was determined to include only arterials and collectors; the methodology developed may prove useful for a future study related to local roads.

This study used the state functional classification system assigned to a section of road for distributing state transportation aids. The functional classification categories are the same as those used by FHWA, but the definitions have been modified slightly to reflect Wisconsin's specific characteristics.

The study does not include an assessment of bridge condition and needs. All bridges have already been inspected, inventoried, and rated. A program for rehabilitation and replacement is funded with federal, state, and local money. The committee believed that bridge needs are being addressed and should not be included in this study.

Concept

In Wisconsin, transportation aid funds from the Wisconsin DOT are distributed directly to local governments. Although these funds may be used for maintenance, construction, or other purposes, including highway improvement work, it is generally accepted that they be used for basic maintenance and low-level improvements. This transportation aid represents between 20 and 30 percent of the total local expenditures for roadway maintenance and improvement. Currently, there are no additional separate seate funds targeted for highway improvements. Although the distribution of existing transportation aids is obviously a subject of continuing interest and discussion, the steering committee decided it would not address that issue. The focus of the study was to identify improvement needs on the arterials and collectors and to formulate alternatives for additional funding for these improvements.

The report of the steering committee was to be available by fall 1986. Considering the size of the study and the work required, a careful work plan was required. Results of this study would identify improvement needs on a portion of locally maintained highways. These needs obviously had to be balanced with other statewide transportation needs. To assist in final analysis, it was determined that this study should use methodology similar to existing state highway planning procedures. This policy, which would allow comparison with the needs of the state trunk highway system, was considered essential in the decision-making process.

The steering committee also decided that to the extent possible existing data collection and analysis procedures would be used. Development of new methodology, though perhaps advantageous, was limited because of the restricted time schedule for this study. Therefore, the study methodology paralleled procedures for the development of the state highway plan and improvement programming.

TABLE 1 FUNCTIONAL CLASSIFICATION AND JURISDICTION OF LOCALLY MAINTAINED HIGHWAY

	Functional Classification[a]					
		Collectors				
Jurisdiction	Arterials (mi)	Major[b] (mi)	Minor (mi)	Subtotal (mi)	Local (mi)	Total (mi)
County	1,089	10,218	4,536	15,843	4,388	20,231
City	1,235	847	166	2,248	8,677	10,875
Village	116	148	80	344	3,008	3,334
Town	81	974	2,050	3,105	58,156	61,206
Total	2,521	12,187	6,832	21,540	74,106	95,646

[a]January 1, 1985, system data.
[b]Includes urban collectors.

Existing Data

Significant data on the local road system existed in Wisconsin DOT files. Data on mileage, location, jurisdiction, surface type, and function classification are currently on file. This information is collected and updated by district staff annually. Such basic geometric information as lane width, roadway width, right-of-way width, and actual or estimated traffic count is also included in the file.

Accident data on individual highway segments were not available from a centralized source. Data on roadway condition, drainage, and alignment also were not available.

Condition Assessment

The Standards and Guidelines Subcommittee reviewed the existing data and recommended the collection of additional data. The subcommittee considered the lack of existing pavement condition information a serious constraint. Improvements to highways under local jurisdiction are normally made only when surface condition has deteriorated significantly. Obviously, spot safety improvements are made and in urbanized or urban areas capacity improvements are also made. However, even in these cases priorities are assigned to roadway segments that also have poor surface condition. Therefore, it was determined that the needs study must collect additional pavement condition information. Table 2 presents a complete listing of data items used in the study, including not just items already available but also items that needed to be gathered in the field or generated in an office.

Because an emphasis on pavement surface condition was essential, the Standards and Guidelines Subcommittee evaluated various condition measurements. The Wisconsin DOT has recently developed one such procedure for surface condition evaluation called the pavement distress index (PDI). The PDI is based on a detailed survey of surface conditions. It measures the visible sign of pavement deterioration as determined by 10 distinct characteristics (cracking, rutting, flushing, distortion, etc.). These indications of deterioration, weighted and combined into a summary index of pavement structural adequacy, form the PDI. The PDI, which ranges from 0 (best) to 100 (worst), was developed under the guidance of experienced maintenance engineers to reflect existing judgment on severity of different surface distress conditions related to future highway life and rehabilitation needs. Data on the state trunk highway system have recently been completed. Because future maintenance and improvement needs will also be using this index on the state trunk highway system, the subcommittee selected the PDI as the measure of surface condition for this study.

The Wisconsin DOT has traditionally used the present serviceability index (PSI) in programming state roadway improvements. The PSI is a mechanical measure of surface roughness determined by an electromechanical meter mounted in an automobile. PSI is measured on a scale of 0 (worst) to 5 (best). Because of its traditional use and for objectivity, it was considered desirable to also collect PSI information in this local study. However, PSI data were collected on only approximately 20 percent of the sample because of minimum segment length and 50-mph travel speed requirements.

An alternative to the use of PSI was explored because of its need for equipment of limited availability and for an additional crew to survey the sampled segments. The pavement serviceability rating (PSR) as defined in the Highway Performance Monitoring System (HPMS) field manual *(1)* was selected. This item is a subjective measure of pavement condition recognizing not only ridability but also pavement distress. Values range from 0 (worst) to 5 (best). Because PSR is data collected by field personnel, it could be collected along with the PDI data. Because PSR data are less costly to collect than PSI data, correlation between PSR and PSI would be desirable for enhancing the use of PSR in future data collection efforts.

The importance of adequate drainage in long-term pavement performance is well recognized. Therefore, the subcommittee believed that some assessment of drainage condition was also essential in evaluating roadway conditions. The HPMS field manual describes an accepted procedure for assessing drainage

TABLE 2 DATA ITEMS FOR NEEDS STUDY

Data Available from Current Files	Office-Generated Data	Data Gathered by Field Inventory
County	Cross section	Pavement distress index
Section ID	Urban/urbanized code	PSR
Road name	Jurisdiction	PSI (rural only)
Termini	Surface type	Lane width (rural only)
Rural/urban code	Access control	Approach width (urban only)
Functional class	Shoulder type	Horizontal alignment (rural)
Federal aid system	Curb and gutter	Vertical alignment (rural)
Facility type	Divided roadway	Percent passing sight distance (rural)
Length	Average highway speed	
AADT	Capacity	Speed limit
Through lanes	Parking (urban only)	Drainage adequacy
Shoulder width, right (rural only)	Future AADT	Urban location (urban only)
	AADT volume group	
	Expansion factor	
	Pavement age	

adequacy; the HPMS rating scale was adopted because it could allow correlation with independent data.

Evaluation of safety was considered an important aspect in evaluating current conditions and future needs. However, adequate safety data on individual segments were not available. Records were scattered among various local agencies, and there appeared to be no practical way to collect accident data for each segment. After other indicators of safety were discussed, the subcommittee decided to use roadway geometrics. Because some assessment of horizontal and vertical alignments was necessary, and for the same reason stated for drainage, a rating scale for alignment similar to that in the HPMS manual was adopted by the subcommittee.

Sample Survey

A review of the data collection needs and the size of the system indicated it was necessary to collect data on a sample rather than on the entire system. The entire system contains 21,540 mi, and the inventory file breaks this into 29,936 individual segments.

A computer-aided random sampling process patterned after the HPMS procedure was used to select the sample. First the entire 21,540-mi system was stratified into several important categories. Obviously, the functional classification of arterials and collectors was important. The jurisdiction (maintenance authority) was also important. In Wisconsin, there are four types of jurisdictions—counties, towns, cities, and villages—that have various maintenance and improvement responsibilities. Because of their similarity, cities and villages were combined into one stratum. Conditions and needs were likely to vary by area type—rural, urban, and urbanized. Therefore, data collection should recognize rural (less than 5,000 population), urban (5,000 to 50,000 population), and urbanized (more than 50,000 population) areas. Samples were also chosen within certain traffic volume ranges; those categories having been selected to ensure that the sample adequately represented the entire system. A random sample of segments to be inventoried was selected for each unique combination of factors. The size of each sample differed in each case depending on the variability of traffic volumes within a particular stratum so that the sample data could legitimately be expanded to represent the entire mileage having that particular combination of factors.

Considering the possible stratifications of the data and various confidence and precision levels, sample size requirements for several options were developed. The committee determined that the minimum usable study would be to determine conditions and needs that would allow portrayal of highway needs on a statewide basis by jurisdiction and functional classification with a further statewide breakdown between rural, urban, and urbanized areas. It was believed that a confidence level of 90 percent and a precision of ±10 percent provided a reasonable compromise between sample size and usefulness of the data. The committee also believed the assessment of statewide needs would not provide sufficient detail required by local communities and decision makers to justify an additional improvement program. An expanded study is considered necessary to be able to adequately describe the needs and demonstrate the impact of this program. This option would allow determination of needs at the county level, but would not distinguish between individual towns and cities within the county. This expanded option would provide sampling of about one-third of the system and was considered a reasonable balance between cost and results.

A review of the data requirements in conjunction with staff availability indicated that a two-phase data collection effort was necessary. The statewide sample of approximately 1,000 mi could be collected during the summer of 1985. This effort would allow initial analysis in the fall of 1985 and early 1986 pending satisfactory results. It would permit sizing up the program on a statewide basis, but would not enable any needs-based funding distribution. It would also provide an opportunity to review a smaller set of data and make revisions before collection of 8,500 mi of data. The expanded sample of approximately 8,500 mi could then be collected in the summer of 1986. This would meet the project deadlines.

Data Collection

The initial 955-mi statewide sample data were collected in the summer of 1985. Originally all of the field work was to have been done by two Wisconsin DOT central office crews, but some districts volunteered to do part of the work within their district. All the field work, however, was coordinated by the central office. It was determined that two-man crews were required to efficiently and safely conduct the field inventory condition ratings. Because of the importance of pavement condition data to the study, the committee asked that experienced engineering and technical personnel be used to do the pavement rating work. Therefore, crews composed of an experienced engineer as crew chief and an engineering technician as an assistant were hired.

Central office and district crews were trained during a 3-day workshop on data collection. To provide uniformity in the statewide collection of condition data, central office engineers prepared a manual. Training included a step-by-step review of condition and pavement distress rating procedures in the manual, followed by field demonstrations. Preselected sections had previously been rated by Wisconsin DOT staff engineers.

Data collection efforts proceeded smoothly over a 3-month period. Total cost of the data collection for the 955-mi sample, including salaries, fringe benefits, travel, meals, motels, training, and computer charges, was around $80,000. Approximately 2,000 hr of effort were required. Crews were able to collect the required data on 24 segments of roadway in a 10-hr day. Because of the dispersion of the sample, an average of 8.62 mi of travel was necessary per sample segment.

Collection of data on approximately 8,500 mi of roadway was to be completed during the summer of 1986. Two-person crews from each of the eight district offices were to complete the inventory. All crew received training similar to the 1985 sessions. Total cost of the data collection effort for the expanded sample was projected to be $231,000. Ten crews of two persons each were expected to complete the inventory over a 3-month period. Sampling rates were expected to improve as a result of more experienced crews and the proximity of the 1986 sample segments. Travel to collect the required data was estimated to be reduced by about 15 percent.

Needs Assessment

The heart of the arterial and collector roads needs study was an assessment of the type and extent of physical improvement needs that would be required on locally maintained arterial and collector highways in Wisconsin to the year 2000. A computerized modeling procedure was developed to produce estimates of highway needs for three study periods: (a) 1986 or backlog, (b) emerging to 1990, and (c) emerging between 1990 and 2000. This modeling procedure was closely patterned after the procedure used in the development of the *State Highway Plan—2000 (2)* to assess required improvements on state trunk highways.

The study's highway deficiency analysis process compared various geometric and performance characteristics of segments of the locally maintained arterial and collector highway system against alternative sets of threshold condition levels to determine ranges of existing and future system deficiencies and the ranges of improvement programs needed to alleviate the identified deficiencies. Figure 1 shows the analysis process.

Deficiency Analysis Logic

The fundamental assumption of the arterial and collector highway needs analysis was that combinations of several key roadway conditions, when identified in a ranked order of consideration, indicate the level of physical improvement needed for any

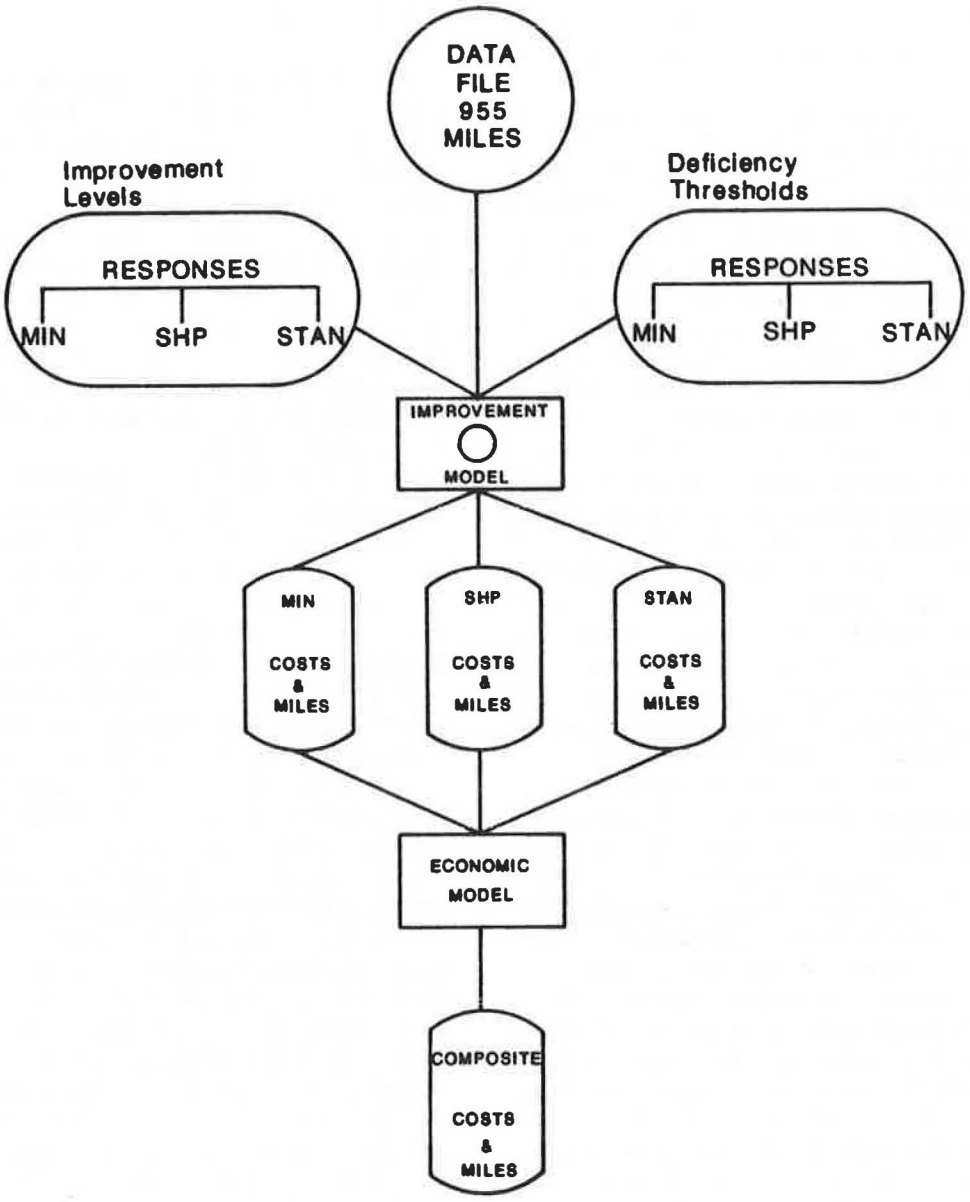

FIGURE 1 Deficiency analysis process.

given highway segment. If one or more of these key roadway conditions was at a less-than-satisfactory threshold level, then the highway segment in question was assigned to an improvement category. The threshold levels varied by definition for each alternative highway management strategy, but in every case those applied were consistent with accepted highway engineering principles. The specific design levels for each improvement category were correlated with the alternatives used to define each threshold condition level.

Highways are improved to alleviate deficiencies in capacity, pavement, or geometry. The deficiency analysis evaluated both existing and future conditions on individual segments of the arterial and collector highway system by examining these types of deficiencies. The source of the highway data analyzed in the study was the Wisconsin DOT's local road inventory file maintained by the Bureau of Environmental and Data Analysis, supplemented by additional data from the 955-mi inventory sample collected during the summer of 1985. The deficiency indicators used in the analysis are as follows:

Capacity
- 200th-hr volume-to-capacity ratio
- Number of lanes

Pavement
- Pavement serviceability rating (PSR)
- Pavement distress index (PDI)
- Bituminous road mix surface
- Gravel road surface

Geometrics
- Percent passing
- Lane width
- Shoulder width
- Shoulder paving
- Horizontal alignment
- Vertical alignment
- Drainage

The deficiency analysis logic differentiated between rural and urban segments by cross section type. Highway segments with rural cross sections have shoulders and ditches, whereas urban cross sections have curbs and gutters.

For any highway improvement need to be identified, the pavement deficiency indicators (PSR and PDI) had to be worse than the prescribed threshold conditions. Additional primary deficiency indicators of 200th-hr volume-to-capacity ratio and geometrics (alignment and drainage) were used to identify specific physical improvements. Unsatisfactory conditions in the other items listed were considered secondary indicators of need, which, when combined with an unsatisfactory primary measure, suggested the type of improvement required to adequately address those deficiencies.

To assess future needs, traffic volumes consistent with statewide forecasts for each target year (1990 and 2000) were developed for each highway segment. In addition, pavement conditions were deteriorated over the planning period by decaying the PSR and PDI values according to surface age and pavement type, based on the earlier state highway plan analysis of historic trends in pavement life on Wisconsin highways.

This process led to the identification of emerging traffic- and pavement-related deficiencies for 1990 and 2000. The process also updated pavement, geometric, and operating characteristics to reflect the improvements called for in each target year analysis.

Alternative Threshold and Improvement Levels

Each set of threshold and improvement levels represented an alternative or response that could be made to accommodate future travel demand (i.e., a planned quality of service for the locally maintained arterial and collector highway system). The following definitions are given to assist in understanding this concept.

Threshold—A level of roadway condition where a worse condition is considered to be unsatisfactory or deficient for that item.

Improvement level—The level of roadway condition associated with a new street or highway once an improvement project has been completed.

Improvement type—Improvement types considered in the analysis were as follows:

Resurfacing. Resurfacing or recycling of an existing pavement to provide a better all-weather surface and a better riding surface, and to extend the pavement life.
Recondition 1. Resurfacing plus widening of pavement or shoulder paving.
Recondition 2. Resurfacing or Recondition 1 plus shoulder widening with the improvement of an isolated grade, curve, or intersection, sometimes requiring right-of-way.
Reconstruction. Total reconstruction to improve maintainability, geometrics and traffic service, usually on existing alignment, and generally requiring additional right-of-way.
Capacity. Capacity expansion projects. Reconstruct existing two-lane facility to an expressway or freeway or add lanes.
Urban Recondition. Resurfacing plus drainage improvements.

Response—A compatible set of threshold and improvement levels that are used to estimate highway needs. Existing highway conditions are compared to the threshold levels to determine when a highway is deficient, whereas improvement levels specify the type of treatment required to correct the identified deficiencies.

Three alternatives or responses were considered:

Response STAN. Used existing county trunk highway standards in setting threshold and improvement levels for those factors for which standards were available. This was intended to be the highest level.

Response SHP. Used thresholds and improvement levels from the adopted state highway plan, which was being implemented for the state trunk highway system.

Response MIN. Used thresholds and improvement levels from the most austere alternative analyzed in the recent state highway planning process.

All improvement cost figures were calculated in terms of constant 1986 dollars. These costs were determined by applying a cost-per-mile rate based on state highway plan data and on a survey of local highway officials as to recent actual construction experience. These figures are illustrated in greater detail in Table 3.

Economic Analysis

Improving highway segments benefits highway users primarily by saving travel time, avoiding vehicle operating costs, and lowering accident rates. The benefits associated with the alternative threshold and improvement levels differ because they affect the condition and characteristics of a highway segment both before and after improvement. By comparing highway user benefits to highway improvement costs, the alternative producing the greatest increment of benefits over cost can be identified.

For each alternative (Responses MIN, SHP, and STAN), all rural highway segments projected to need reconditioning, reconstruction, or other capacity expansion were subjected to an analysis of the present value of the benefits and costs associated with such improvements. Benefits were analyzed using the Highway Investment Analysis Package (HIAP), a cost-benefit analysis model developed by the FHWA. Resurfacing was considered as the base option, and the analysis considered the incremental benefits and costs of improvements beyond resurfacing.

HIAP was used to estimate user benefits at the segment level. The actual cost-benefit analysis was performed for groupings of highway segments because the cost information available is best interpreted as an estimate of average cost. The segments were grouped based on the pattern of improvement levels called for by each of the study response alternatives. For each group, the response alternative that maximized the net present value of the improvements was identified. This response alternative was selected if its net present value was at least 5 percent greater than the Response SHP results for that group. Otherwise, the Response SHP was chosen. The combination of these selections formed a new alternative called the composite alternative.

Combining these elements into the composite alternative is more cost-effective than using any single response. The composite alternative has an additional $8.2 million in net present value (NPV). This increment represents a 170 percent increase over the NPV of Response SHP.

Because only limited traffic accident data were available for individual urban segments, the economic analysis has only been performed on rural highway segments. The annual NPV totaled $13.0 million for improvements to rural segments selected for the composite alternative. Response SHP was selected for all urban highways in generating the composite alternative. Because no benefits were assigned to improvements to urban segments, total benefits are understated.

RESULTS

Condition

Condition results are summarized in Table 4 by jurisdiction and functional classification. These data are based on the initial

TABLE 3 ANNUAL NEEDS TO 1990 LOCAL ARTERIAL AND COLLECTOR ROADS

Response Level	Length (mi)	Cost[a] ($)	Current Federal-Aid Programs ($)	Additional Local and State Funding Needed ($)
Minimum standards				
Arterials	19.7	5.8		
Major collectors[b]	180.3	16.7		
Minor collectors	140.4	20.2		
Total	340.4	42.7	24.5	18.2
SHP standards				
Arterials	70.7	16.7		
Major collectors[b]	186.2	23.3		
Minor collectors	210.6	35.2		
Total	467.5	75.2	24.5	50.7
Local standards				
Arterials	167.0	46.5		
Major collectors[b]	372.3	91.9		
Minor collectors	252.7	60.6		
Total	792.0	199.0	24.5	174.5
Composite				
Arterials	48.0	13.4		
Major collectors[b]	301.6	52.4		
Minor collectors	196.8	22.1		
Total	546.4	87.9	24.5	63.4

[a]Costs in millions of (1986) dollars.
[b]Includes urban collectors.

TABLE 4 CONDITION RESULTS 1985 WEIGHTED AVERAGES

	Pavement		Geometrics		V/C	Rural Cross Section Only		
	PSR	PDI	Alignment	Drainage	Ratio	Percent Passing	Lane Width (ft)	Shoulder Width (ft)
Range of values	0–5	100–0	8–2	4–1		0–100		
Jurisdiction								
County	3.43	40	4.0	1.6	0.06	49.6	10.7	3.2
Township	2.93	50	4.7	2.2	0.02	36.2	9.9	1.8
City or village	3.59	42	2.7	1.4	0.21	65.4	11.0	2.5
Total system	3.38	42	4.1	1.7	0.07	47.9	10.6	3.0
Functional classification								
Arterials	3.65	41	3.1	1.4	0.23	54.6	11.0	4.4
Major collectors[a]	3.41	41	4.1	1.7	0.06	50.2	10.7	3.1
Minor collectors	3.21	43	4.3	1.7	0.03	42.6	10.4	2.6
Total system	3.38	42	4.1	1.7	0.07	47.9	10.6	3.0
State truck highways	NA	NA[b]	NA	NA	0.34	64.6	11.3	6.3

NOTE: NA = not available.
[a]Includes urban collectors.
[b]PCC = 39; BIT = 46.

955-mi sample collected in 1985. For comparison, state trunk highway average values are also given.

The condition of arterials was better than that of major collectors, which were better than minor collectors. The pavement condition, as expressed by the PDI, of the arterials and collectors was similar to that of the state trunk highway. Pavements on the town road system were in worse condition than those on the county and city systems. The alignment and drainage ratings showed the overall system to be in fair condition, with a significant number falling into the poor category. In the rural areas, the volume-to-capacity ratio did not indicate significant levels of need. The average rate of passing on the rural cross-sections was 47.9 percent, which compares to 64.6 percent on the state trunk highway system.

The lane width and shoulder width are additional categories where roads under study fell significantly below standards. Shoulder width in particular averaged 3 ft compared to an average of 6 ft on the state trunk highway system.

It is also useful to review the condition data for severe deficiencies. Table 4 lists the results of this analysis. A total of 3,507 mi had poor pavement surface conditions, defined as having a PSR less than 3.0 and a PDI greater than 70, which are the thresholds for the minimum alternative. There were 2,518 mi with either poor alignment or poor drainage. Narrow lanes (less than 10 ft) existed on 1,007 mi and narrow shoulders (less than 2 ft) were common on 2,989 mi. Passing opportunities were restricted to less than 30 percent on 5,772 mi.

Improvement Needs

The study's deficiency analysis produced estimates of the total number of miles and costs of highway improvements for each analysis year. The 1986 needs represented an existing backlog of need. The 1990 results represented needs that will be emerging by 1990. The 2000 results represented needs that will be emerging between 1990 and 2000.

Because the study is not intended to be a segment-specific project program but a system plan, the analysis results for the detailed physical improvement types have been combined into three general categories of highway facility improvements.

1. Surface improvements are primarily minimal or low-cost improvements, particularly surface renewal, which only serve to keep a highway segment operational. These include the specific improvement types of Resurface and Recondition 1.
2. Geometric improvements enhance primarily the safety and geometric characteristics of a highway segment. Although this type of improvement also normally increases the highway's capacity, the increased capacity is only incidental. These include the specific improvement types of Recondition 2, urban recondition and rural reconstruction.
3. Capacity improvements enhance payment condition, safety, and geometrics, but their primary purpose is to increase the traffic-carrying capacity of the facility.

In summary, more than 4,600 mi (22 percent) of roads needed immediate improvement and more than 12,000 mi (59 percent) of the system will need some improvement by the year 2000. A total cost of $1.76 billion will be needed for these improvements.

Roadway improvement needs are most often related in terms of annual improvement programs. It is therefore necessary to take backlog needs and combine them with projected future needs to develop an annual improvement program.

Obviously, annual programs will be quite sensitive to the manner in which the backlog is handled. The backlog for state trunk highways is handled by projecting their elimination by the year 2010. For consistency, the same procedure was used in developing annual needs for the arterial and collector roads. Therefore, the backlog was divided by 23 to provide an equal annual program in 1986 dollars. In addition to that, annual improvements that emerge for the years between 1986 and 2000 must also be added. Because there is a greater degree of certainty in projecting future needs for the near term, it was decided to project annual needs for the next 4 years (through 1990). This then becomes the sum of the backlog divided by 23 years added to the additional annual projects that indicate the

TABLE 5 CURRENT SEVERE DEFICIENCIES BY JURISDICTION

Deficiency	County (mi)	Town (mi)	City or Village (mi)	Total (mi)
Poor surface condition (PSR < 3.0; PDI > 70)	2,420	747	340	3,507
Poor alignment of drainage	1,536	807	175	2,518
Narrow lanes (<10 ft rural)	352	652	3	1,007
Narrow shoulder (<2 ft)	1,873	866	250	2,989
Restricted passing (<30% passing)	4,211	1,460	101	5,772

need for improvement during the years between 1986 and 1990. Table 5 lists these needs for the various alternatives. With the assumption of a continuing federal program at the current level, there is a range of additional state and local funding required between $18 and $175 million.

CONCLUSIONS

The use of analysis techniques developed for state trunk highway planning purposes has served well in developing condition assessment and needs estimates for improvement of locally maintained arterials and collectors. It was not necessary to develop new technology or analysis procedures. The use of a parallel analysis and planning process allows easy comparison of needs between the two systems and facilitates decision making.

Significant additional condition data were needed on roadways under the jurisdiction of local agencies, including pavement, alignment, and drainage condition data.

There was a significant need for improvements on arterials and collectors maintained by local agencies in Wisconsin. More than 22 percent needed immediate improvement and 59 percent will need improvement by the year 2000.

The existing funding provided by the federal-aid secondary and federal-aid urban programs is inadequate to address these needs. An additional $63 million annually of federal, state, and local funds are needed.

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