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Final Report

LOCAL ROADWAY NEEDS ASSESSMENT

Dye Management Group, Inc.

July 2002

COLORADO DEPARTMENT OF TRANSPORTATION
RESEARCH BRANCH

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16. Abstract
This study represents the fourth time the Colorado Department of Transportation (CDOT) has examined local roadway needs in fourteen years. An ongoing process for monitoring and updating the statewide assessment of local roadway needs was never established, and the issues identified during the three previous needs assessments have not been resolved. This report presents a workable needs assessment methodology with recommendations for resolving local assessment issues. The methodology uses existing reporting processes, can be updated cost-effectively, provides for quality assurance, and is designed to fit with the statewide plan.

Implementation:
The product will be a comprehensive needs baseline assessment. While the initial implementation of the needs assessment methodology will require a significant commitment of resources, it can be updated using known engineering and planning relationships. The needs information would be usable for five to eight years with updates using the basic data already collected through existing reports.

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By Dye Management Group, Inc.

Report No. 2002-6

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Sponsored by the
Colorado Department of Transportation
In Cooperation with the
U.S. Department of Transportation
Federal Highway Administration

July 19, 2002

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Colorado Department of Transportation

Local Roadway Needs Assessment

Executive Summary

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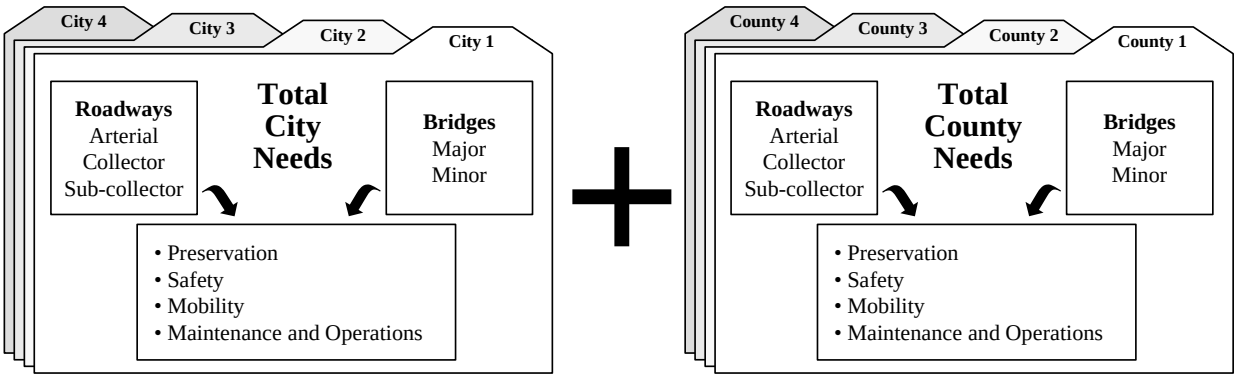
This executive summary presents the recommendations and implementation strategies from a study of local roadway needs assessment methodologies. Study oversight was provided by a steering committee of city, county, and regional officials, as well as the Colorado Municipal League (CML), Colorado Counties, Inc (CCI), and the Colorado Department of Transportation (CDOT).

CDOT has examined local roadway needs on three prior occasions: once in 1988, again in 1990, and finally in 1997. However, CDOT and local authorities did not establish an ongoing process for monitoring and periodically updating the statewide assessment of local roadway needs. The problems, issues, and concerns noted during the previous attempts have not been resolved. Today, almost 14 years after the first needs assessment, the department is facing the same issues. This study seeks to resolve those issues and build a workable needs assessment methodology that can be updated in conjunction with the statewide transportation plan.

Exhibit E-1 illustrates how the recommended methodology groups statewide local roadway needs:

Exhibit E-1: Classifying Local Roadway Needs



Aggregate Statewide City Needs **Aggregate Statewide County Needs**

A. Principles Guiding the Methodology

- The methodology is designed to fit with the statewide plan.

  The terminology used to describe local needs is the same used in CDOT's statewide planning process; for example, needs are categorized as system quality, safety, and mobility. The methodology is also designed so that it can be updated periodically along with the statewide plan.

- The information reported through the methodology can be updated cost-effectively.

  While the initial implementation of the needs assessment methodology will require a significant commitment of resources, it will produce a baseline needs assessment that can be updated using known engineering and planning relationships. Thus, we believe that the needs information would be usable for five to eight years with updates using the basic data already collected through existing reports.

- The methodology uses and enhances existing data collection and reporting processes in lieu of creating new systems to collect information.

The methodology incorporates the existing Mileage Reports and revenue and expenditure reports completed by cities and counties, as well as strengthens the reporting process to ensure accurate data.

- The methodology provides for quality assurance.

  Training and quality assurance review will build in quality and strengthen consistency in data collection, reporting, and measurement. Such validation should address the credibility problems that have faced prior local needs assessments.

- Where counties and cities have sophisticated data collection and reporting procedures, that data will be used.

  Those communities with pavement management systems will use the data generated by their system to generate or supplement data collected through Mileage Reports. Communities that collect minor bridge data can submit it to supplement the data that will be sampled on minor bridges.

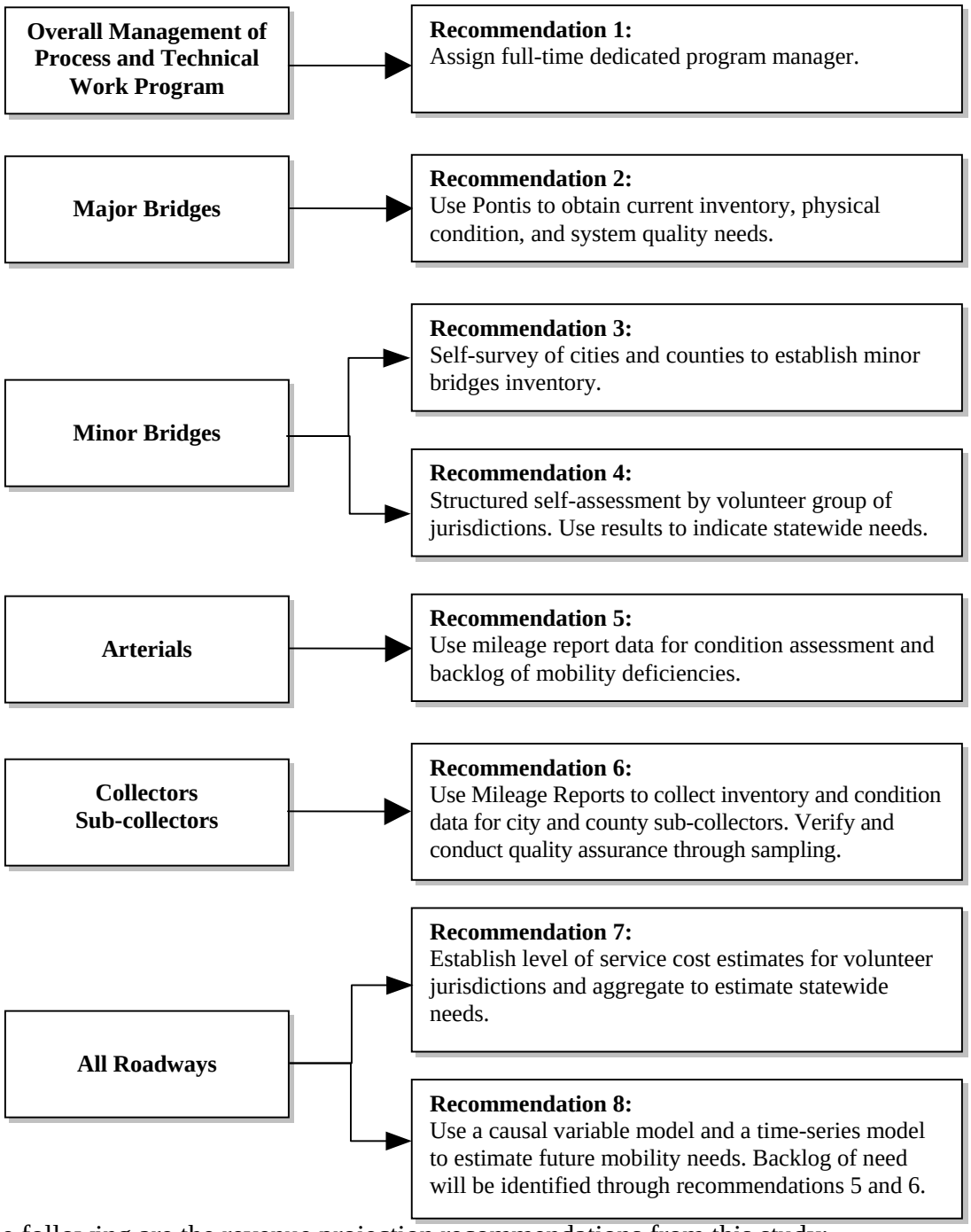
- The methodology is not an end in itself, but will help build capacity and strengthen condition analysis and reporting at the local level.

  In addition to the aforementioned benefit of strengthening weak reporting mechanisms, the methodology should increase the knowledge that both state and local officials have of local roadways.

B. Recommended Methodology for Assessing Needs and Projecting Revenue

The following exhibit illustrates the recommended needs assessment methodology:

Exhibit E-2: Recommended Strategy for Assessing Local Roadway Needs



The following are the revenue projection recommendations from this study:

Recommendation 9: Use CDOT OFMB's projections for HUTF and Vehicle Registration revenue.

Recommendation 10: Test the variance of other revenues against the variance of total state revenues and, if the appropriate statistical measures permit, use a time-series model to forecast other state revenues.

Recommendation 11: Historical data for assessed values, mill rates, and other tax rates, covering the same period as the historical revenue data, should be assembled from municipal and state records, then used to adjust the historical revenue data for changes in those values and rates.

Recommendation 12: Use information collected through the revenue and expenditure reports, adjusted as recommended above, to project local revenues.

Recommendation 13: Use causal variable models for property, sales, and specific ownership taxes.

Recommendation 14: Build separate models for each of property, sales, and specific ownership taxes with shared definitions for population, GDP, and household income.

Recommendation 15: Use a time-series model to forecast other local receipts.

Recommendation16: Use existing OFMB projections for federal revenues.

Recommendation 17: Use a causal variable model in which private contributions are a function of state and local expenditures on transportation infrastructure.

C. Resources Required

The following exhibit illustrates the resources required to establish the recommended methodology.

Exhibit E-3: Costs of Recommended Methodology – Summary of Estimated Resource Requirements (person hours)

Major Work Element Recommendations	Statewide Needs Assessment Resource	Local Jurisdictions	CDOT Staff
1. Overall Management of Process and Technical Work – Methodology Implementation	Overall project management administration and coordination: 1 FTE 2000 hours (over 14-18 months)	Participation in technical and policy oversight committees.	Participation in technical and policy oversight committees.
2. Major Bridges – Preservation (System Quality) backlog, annual, and scenario modeling based on funding level	24	Participation in technical committee meetings.	96
3. Minor Bridges – Preservation (System Quality) backlog and annual needs	456	Participation in technical committee meetings and 8-40 hours per jurisdiction.	
4. Arterials, Collectors, Sub-collectors • Inventory and condition assessment data collection. • Needs assessment backlog of preservation. • System quality needs and mobility needs. Needs assessment annual preservation (system quality) needs.	668	Participation in technical committee meetings.	Participation in technical committee meetings. 72
5. Level of Service cost estimate aggregated from a sample of jurisdictions.	140	Participation by volunteer jurisdictions.	
6. Recommended Methodology for Mobility Needs Assessment • Develop and use a causal variable model and a time-series model to estimate mobility needs for all system elements.	320	Participation in technical committee meetings.	
Total Resource Estimate	**3,608**	**8-40 hours per jurisdiction**	**168**

Colorado Department of Transportation

Local Roadway Needs Assessment

Table of Contents

I. Introduction

■

This report presents the results of a study of local roadway needs assessment methodologies and recommends a methodology for Colorado.

A. Study Objectives

The primary objective of the study is to establish a methodology for measuring and reporting local roadway needs that:

- Is actively supported by local governments in Colorado.
- Addresses the diversity of urban, rural, and regional conditions.
- Is methodologically strong – so that it provides "uncontested" information to policy makers.
- Balances the need for data with an understanding of what realistically can be implemented and maintained by local governments.
- Can be implemented to establish an agreed quantification of local roadway needs.
- Provides local needs information for the statewide plan and regional transportation plan update cycles.
- Provides fact-based information for policy makers regarding local needs, revenues, and finance gaps.

B. Success Factors

The following are success factors identified by Dye Management Group, Inc., in consultation with the project steering committee.

- **The approach and level of local involvement should ensure broad "buy-in."**

  The success of the needs assessment depends as much on the acceptance of the methodology as on the methodology itself.

  In order to ensure city and county involvement in data collection and reporting, the purpose of the recommended methodology needs to be clear and beneficial to all. The methodology also needs to be credible and unbiased. Local officials may decide not to participate if they feel the methodology is biased against them.

  At the policy level, it is important that decision-makers actively support the study process as the mechanism to provide an objective assessment of local needs. This will require agreement on what a "need" is and support for the overall analytical framework. Technical level buy-in is also necessary because acceptable levels of service, standards and hence needs will differ between areas of the state.

- **The approach should be implementable.**

  The approach to data collection and reporting must recognize resource limitations. A resource-conscious approach is required that includes sampling across jurisdictions and systems. The recommended methodology also needs to be sensitive to the variety of technical resources, including both equipment and expertise.

- **The approach should provide meaningful information to policy makers.**

  As needs are always large, it is important to structure the methodology to communicate outcomes from varying levels of investment. Such an approach allows decision-makers to actively take part in addressing needs.

- **The approach should ensure consistency of measurement across jurisdictions and should be integrated with existing planning and needs assessment processes.**

While leveraging local officials to collect and share data is a wise, resource-conscious approach, steps must be taken to ensure that inconsistent measurement techniques do not contaminate the methodology. The methodology should account for and build upon existing approaches that are used by cities and counties. The needs assessment must reflect urban, rural, and geographic differences in needs.

C. Approach

The approach for this study included:

- **Clarification and definitions of the questions to be answered by the study.** Dye Management Group, Inc. met with the project steering committee several times in order to refine the study objectives and the information the study was required to produce.

- **Literature review and benchmarking analysis.** Dye Management Group, Inc. completed a literature review and benchmarking analysis, contrasting the practices other states have used to compile and use statewide local roadway needs.

- **Collecting and analyzing data.** Data analysis was completed, based on information provided by CDOT, on local revenues and expenditures on local roadways and local roadway miles.

Study oversight was provided by a steering committee of city, county, and regional officials, as well as the Colorado Municipal League (CML) and the Colorado Department of Transportation (CDOT). The following officials were involved in the study oversight:

- Don Bachman, Fort Collins

- Chuck Brown, El Paso County Commissioner

- John Coil, Denver Regional Council of Governments (DRCOG)

- Jan Gerstenberger, Colorado Municipal League (CML)
- Jay Harrington, Pagosa Springs
- Dave Miller, CDOT Region 3
- Bill Moore, Pueblo Area Council of Governments
- Vince Rogalski, Gunnison Valley TPR
- Drew Scheltinga, Weld County Public Works/Colorado Counties, Inc. (CCI)
- Daryl Shrum, Winter Park NW TPR
- Gary Steffens, Grand County
- Quentin Vance, Washington County Commissioner
- Marilyn Beem, CDOT-DTD Statewide & Regional Planning
- Dutch Eikenberg, Kiowa County Commissioner
- Rich Griffin, CDOT-DTD Research Branch
- Vern Rominger, Rio Grande County Commissioner
- Herman Stockinger, CDOT-DTD Metropolitan Planning
- George Ventura, CDOT-DTD Regional Planning
- Vicki McLane, North Front Range MPO
- Lyn Brownfield, Kit Carson County Administrator

The committee provided input and validated the study at key points, including study inception and presentation of recommendations.

D. Report Structure

The body of this report is organized into the following sections:

II. Recommended Needs Assessment Methodology. This section presents the recommended methodology for conducting a periodic assessment of aggregate statewide city and county roadway needs in Colorado.

III. Revenue Projection Methodology. This section presents recommendations for developing a methodology to forecast aggregate statewide county revenues and aggregate statewide city revenues for use on local roadways.

Appendix A: Literature Review. This section presents the results of a literature review and benchmarking analysis.

Appendix B: Previous CDOT Local Roadway Needs Assessments. This section provides an overview of the previous local roadway needs assessments and some of the strengths and weaknesses of the approaches.

Appendix C: Resource Estimates for Alternative Recommendations.

II. Recommended Needs Assessment Methodology

■

This section presents the recommended methodology for conducting a periodic assessment of aggregate statewide city and county roadway needs in Colorado. The methodology is designed to establish a robust baseline quantification of statewide needs. It addresses the primary requirements of the Local Roadway Needs Assessment Methodology Steering Committee for developing information that provides an accurate planning-level quantification of the current backlog of needs, recurring needs, and future needs arising from economic development and population growth. The methodology also enables some scenario modeling whereby it will be possible to depict the impact on future needs of different funding levels.

This section is organized as follows:

- **Overview.** This section provides an overview of the makeup and costs of the recommended needs assessment methodology.
- **Issues with Designing a Needs Assessment Methodology.** This section reviews important issues that were considered while designing the recommended methodology.
- **Recommended Needs Assessment Methodology.** This section describes the recommended and alternative options for assessing city and county roadway needs.
- **Resource Estimates.** This section estimates the resources, measured in person hours, required to implement the methodology. An indication of implementation roles and responsibilities is also provided.

A. Overview

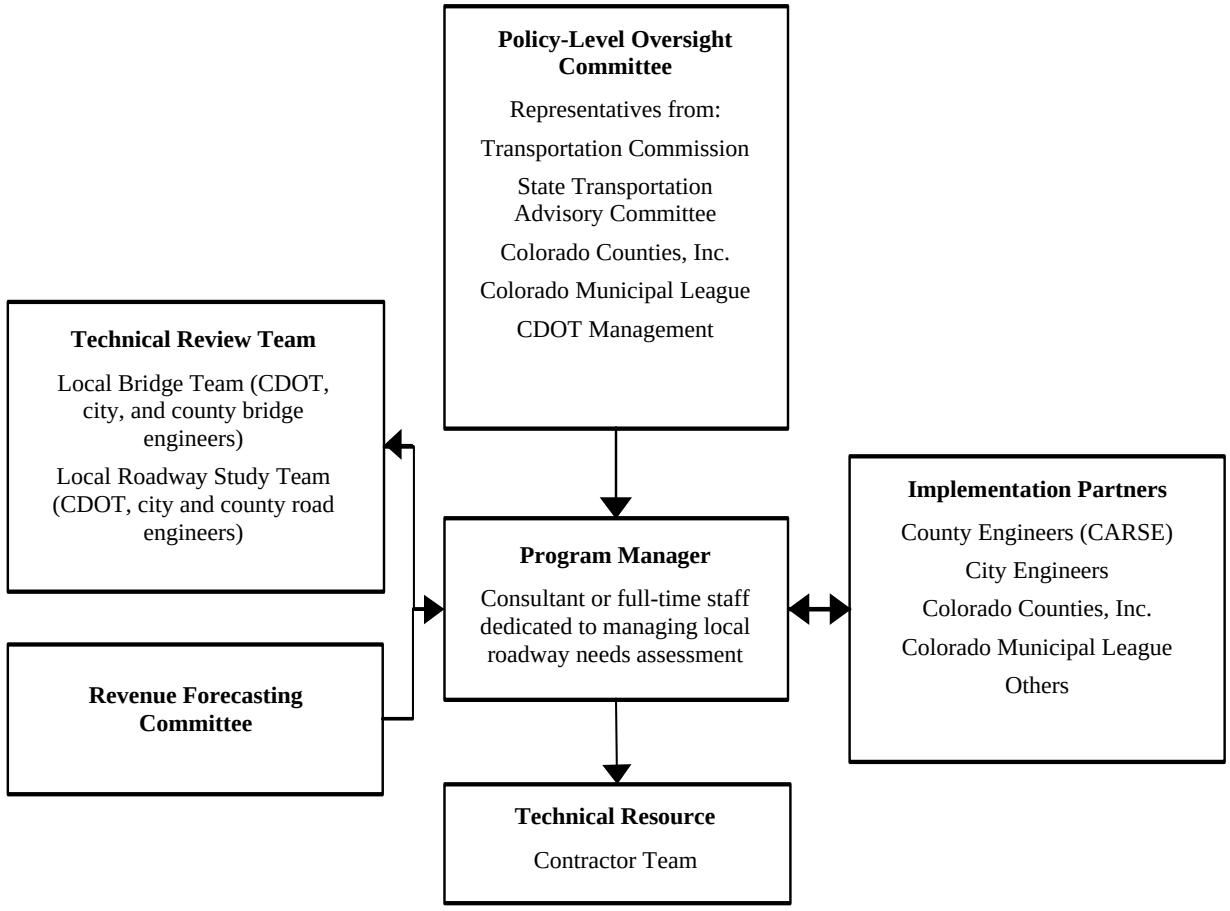
This section provides an overview of the:

- Process recommended for implementing the methodology.
- Recommended data collection and analysis methodology.
- Resource estimates for implementing the methodology.

1. Recommended Process

A process that provides policy and technical oversight is recommended. The elements of this process are depicted in Exhibit II-1 on the following page.

Exhibit II-1: Organization Structure of Needs Assessment Process



a. Policy-level oversight committee

This committee will provide oversight and policy-level direction for the study. This will ensure that the information addresses the policy perspective. Policy-level support will also help ensure jurisdictional support for the process and mobilization of the resources required. The policy committee would resolve any issues escalated by the technical review team.

b. Technical review team

This team will include engineering and other professional staff from local jurisdictions, CDOT regions, and headquarters. The technical review team will establish agreement on technical issues such as how to classify minor bridges, condition targets, and others. They will also help ensure effective liaison and participation by counties and cities.

c. Revenue forecasting committee

A revenue forecasting committee, appointed by the policy-level oversight committee overseeing the needs assessment program, will help to identify future revenue to address roadway needs. The revenue forecasting committee is discussed in more detail in Section III.

d. Program manager

A full-time dedicated program manager is required to manage the needs assessment, communicating frequently with city and county engineers. The program manager would receive technical assistance from the bridge and roadway study teams as well as the revenue forecasting committee.

e. Implementation approach

The methodology requires partnership with the professional and senior administrative staff of local jurisdictions.

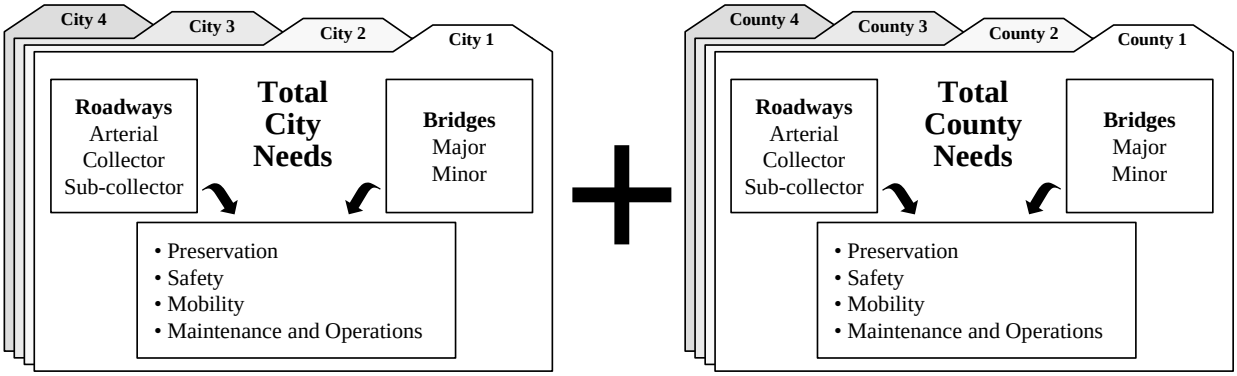
2. Recommended Data Collection and Analysis Methodology

The methodology establishes statewide need for counties and cities in the following categories:

- Preservation (classified as part of "system quality" by CDOT in the statewide plan).
- Mobility (roadway capacity expansion).
- Safety.
- Maintenance and operations (classified as part of "system quality" by CDOT in the statewide plan).

The methodology addresses all roads and bridges over which Colorado counties and cities have jurisdiction. The functional classes of roadways included are arterials, collectors, and sub-collectors. The classes of bridges are major and minor bridges. Exhibit II-2 illustrates the makeup of local roadway needs addressed by the methodology.

Exhibit II-2: Aggregate Local Roadway Needs



Aggregate Statewide City Needs **Aggregate Statewide County Needs**

a. Recommended data collection and analysis approach

The methodology to measure aggregate city and county needs will produce information on the asset inventory, inventory condition, backlog of needs, recurring needs, and future needs. The methodology will allow some scenario modeling whereby future needs would be shown under different funding scenarios. This could be used, for example, to show the impacts of deferred preservation treatments on need.

Exhibit II-3 shows the different components of needs information generated using the recommended needs assessment methodology.

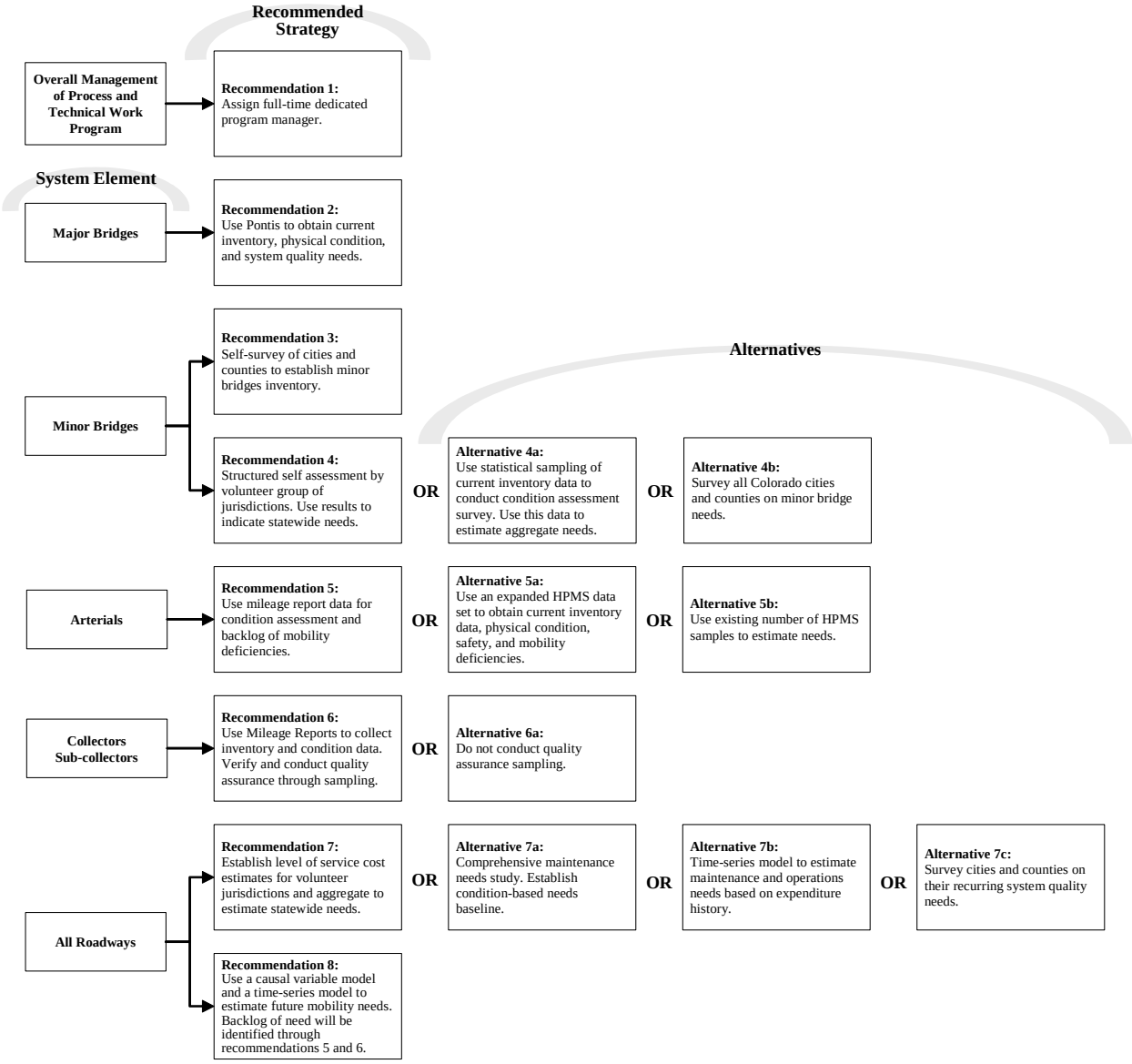
Exhibit II-3: Information Generated by Recommended Methodology

	Statewide Aggregate for Cities	Statewide Aggregate for Counties
Baseline Current Inventory Data	• Total lane miles of roadway by functional class. • Total major and minor bridges by type, total square footage of bridge deck by type.	• Total lane miles of roadway by functional class. • Total major and minor bridges by type, total square footage of bridge deck by type.
Baseline Physical Condition of Infrastructure	• Condition of pavement on city roadways (measurement to be determined e.g., pavement serviceability index (PSI)). • Sufficiency rating of major city bridges, number of functionally obsolete and structurally deficient bridges. • Condition assessment for minor city bridges.	• Condition of pavement on county roadways (measurement to be determined e.g., pavement serviceability index (PSI)). • Sufficiency rating of major county bridges, number of functionally obsolete and structurally deficient bridges. • Condition assessment for minor county bridges.
Backlog of Need • **System Quality – Preservation** • **Safety** • **Mobility**	• Cost to improve city roadways and bridges to targets established for: – preservation. – safety. – mobility.	• Cost to improve county roadways and bridges to targets established for: – preservation. – safety. – mobility.
Annual System Quality Needs • **Operations and Maintenance** • **Preservation**	• Annual cost to operate and maintain city roadways and bridges at target levels. • Annual cost to preserve city roadways and bridges at target levels.	• Annual cost to operate and maintain county roadways and bridges at target levels. • Annual cost to preserve county roadways and bridges at target levels.
Future Mobility Needs	• Cost to expand and build new city roadways and bridges to accommodate growth and maintain target performance levels.	• Cost to expand and build new county roadways and bridges to accommodate growth and maintain target performance levels.

b. Components of methodology

Exhibit II-4 shows the individual components of the recommended methodology, as well as alternatives that were considered in the process.

Exhibit II-4: Recommended Strategy and Alternatives for Assessing Local Roadway Needs



c. Timing and dependencies

The methodology can be completed over a 14 to 18 month timeline. However, a number of process dependencies need to be considered in developing a schedule. The process needs to:

- Fit with the annual mileage reporting.

- Coordinate with the annual revenue and expenditure reporting.
- Coordinate with the cycle of updates for Colorado's statewide transportation plan.
- Account for seasonality. Fieldwork cannot be undertaken when there is snow on the ground. Estimate resources for implementing the methodology.

3. Summary of Resource Estimates for Implementing the Methodology

Implementation of the recommended methodology involves a significant commitment of resources; however, it is important to recognize that the product will be a comprehensive needs baseline assessment. This can be used for a number of years. We believe that once this methodology is implemented, the existing ongoing data collection and reporting processes can be used to update the needs assessment for between five to eight years. Therefore, if the cost is annualized over this period of time it is significantly reduced.

Exhibit II-5 shows the estimated cost of implementing the major elements of the recommended methodology.

Exhibit II-5: Costs of Recommended Methodology – Summary of Estimated Resource Requirements (person hours)

Major Work Element Recommendations	Statewide Needs Assessment Resource	Local Jurisdictions	CDOT Staff
1. Overall Management of Process and Technical Work – Methodology Implementation	Overall project management administration and coordination: 1 FTE 2000 hours (over 14-18 months)	Participation in technical and policy oversight committees.	Participation in technical and policy oversight committees.
2. Major Bridges – Preservation (System Quality) backlog, annual, and scenario modeling based on funding level	24	Participation in technical committee meetings.	96

Major Work Element Recommendations	Statewide Needs Assessment Resource	Local Jurisdictions	CDOT Staff
3. Minor Bridges – Preservation (System Quality) backlog and annual needs	456	Participation in technical committee meetings and 8-40 hours per jurisdiction.	
4. Arterials, Collectors, Sub-collectors • Inventory and condition assessment data collection. • Needs assessment backlog of preservation. System quality needs and mobility needs. • Needs assessment annual preservation (system quality) needs.	668	Participation in technical committee meetings.	Participation in technical committee meetings. 72
5. Level of Service cost estimate aggregated from a sample of jurisdictions.	140	Participation by volunteer jurisdictions.	
6. Recommended Methodology for Mobility Needs Assessment • Develop and use a causal variable model and a time-series model to estimate mobility needs for all system elements.	320	Participation in technical committee meetings.	
Total Resource Estimate	**3,608**	**8-40 hours per jurisdiction**	**168**

4. Financing Implementation

Implementation is best funded as a partnership between the affected jurisdictions. One approach that would provide an equitable basis would be that each jurisdictional level contributes their relative amount of Highway Users Tax Fund revenue.

There are three options for resourcing implementation:

- Retain a contractor to manage and implement the methodology.
- Hire a project manager for the purpose of implementing the methodology.
- Reassign staff to implement the methodology.

The benefits and risks are summarized in Exhibit II-6.

Exhibit II-6: Alternatives for Resourcing Implementation

Approach	Benefits	Risks/Costs
Use a Contractor.	• Specialized expertise. • Does not impact other business functions. • More likely to be completed on schedule.	• Requires full funding of project at $400,000.
Hire a Project Manager and use state and local work groups as in-house staff.	• Reduces direct cost.	• Requires specialized expertise, which is hard to find. • In-house staff needs to be made available.
Reassign staff and use government labor.	• Reduces direct cost.	• Requires specialized expertise. • Needs to be a dedicated resource. • Needs to be independent of jurisdictional interest.

B. Principles Guiding the Needs Assessment Methodology

The following are the principles that guided the development of the recommended needs assessment methodology.

- The methodology is designed to fit with the statewide plan.

  The terminology used to describe local needs is the same used in CDOT's statewide planning process; for example, needs are categorized as system quality, safety, and mobility. The methodology is also designed so that it can be updated periodically along with the statewide plan.

- The information reported through the methodology can be updated cost-effectively.

While the initial implementation of the needs assessment methodology will require a significant commitment of resources, it will produce a baseline needs assessment that can be updated using known engineering and planning relationships. Thus, we believe that the needs information would be usable for five to eight years with updates using the basic data already collected through existing reports.

- The methodology uses and enhances existing data collection and reporting processes in lieu of creating new systems to collect information.

  The methodology incorporates the existing Mileage Reports and revenue and expenditure reports completed by cities and counties as well as strengthens the reporting process to ensure accurate data.

- The methodology provides for quality assurance.

  Training and quality assurance review will build in quality and strengthen consistency in data collection, reporting, and measurement. Such validation should address the credibility problems that have faced prior local needs assessments.

- Where counties and cities have sophisticated data collection and reporting procedures, that data will be used.

  Those communities with pavement management systems will use the data generated by their system to generate or supplement data collected through Mileage Reports. Communities that collect minor bridge data can submit it to supplement the data that will be sampled on minor bridges.

- The methodology is not an end in itself, but will help build capacity and strengthen condition analysis and reporting at the local level.

In addition to the aforementioned benefit of strengthening weak reporting mechanisms, the methodology should increase the knowledge that both state and local officials have of local roadways.

C. Recommended Needs Assessment Methodology

Exhibit II-7 summarizes the methods recommended to estimate needs, as well as some alternatives that were considered.

Exhibit II-7: Recommended Methods to Estimate Needs

Information	Bridges		Roadways	
	Major	Minor	Arterial	Collector / Sub-collector
Current Inventory Data	Pontis	Survey	Enhanced Mileage Report	Mileage Report
Physical Condition of Infrastructure	Pontis	Representative jurisdiction self assessment aggregated to statewide total	Enhanced Mileage Report	Mileage Report
Backlog of Need • **System Quality – Preservation** • **Safety** • **Mobility**	Pontis	Representative jurisdiction self assessment aggregated to statewide total	Enhanced Mileage Report	Mileage Report
Recurring System Quality Needs • **Preservation**	Pontis	Representative jurisdiction self assessment aggregated to statewide total	Enhanced Mileage Report	Mileage Report
Recurring System Quality Needs • **Operations and Maintenance**	Pontis	Representative jurisdiction self assessment aggregated to statewide total	Estimation of level of services cost for "volunteer jurisdictions" applied to statewide inventory	Estimation of level of services cost for "volunteer jurisdictions" applied to statewide inventory
Future Mobility Needs	*	*	Causal Variable Model/ Time-series Model	Causal Variable Model/ Time-series Model

* Expansion of bridge widths is included in roadway mobility needs.

The following sections describe the recommended needs assessment methods and alternatives. Implementation steps, estimated benefits, prospective roles and responsibilities, and estimated duration are outlined for each recommend element of the needs assessment.

1. Overall Management of Process and Technical Work

The recommended methodology will require a dedicated program management resource to oversee a large, complex process and technical work program.

Recommendation 1: Implement the methodology using a dedicated program manager through a process overseen by city, county, and state policy makers.	
Description	The recommended process involves retaining a dedicated program manager to manage the process and program of technical work. In addition, a policy committee that involves city, county, and state-level policy makers should oversee the methodology implementation. This should be supported by a technical review team that will ensure buy-in and participation from the local jurisdictions and their professional staff.
Implementation Steps	1. Secure funding for implementation. 2. Hire program manager and technical resources. 3. Establish policy and technical oversight structure. 4. Develop data collection work plan integrated across recommendation areas, coordinated with existing data collection and plan update processes. 5. Perform ongoing program management. 6. Manage process.
Benefits	• Provides dedicated program management resource which is essential for the success of a project of this type. • Policy maker oversight ensures executive support and ownership for results. • Technical review team will ensure credible results and facilitate local jurisdiction participation and data collection.
Roles and Responsibilities	• Contract program manager hired by technical review team. • Program manager coordinates, staffs, and facilitates the process. • Program manager coordinates and manages data collection and technical work elements. • Policy committee three to four meetings. • Technical review team 12 meetings and likely subcommittee assignments.
Duration	14 to 18 months

2. Major Bridges

Bridges are separated into major (over 20 feet) and minor (20 feet and under) bridges. FHWA requires that CDOT maintain a complete and current database of state and local major bridges. CDOT uses a sophisticated bridge management system to maintain

its database. This system, called Pontis, both stores an inventory and provides a recommended strategy for maximizing the system benefits from expenditures on bridges. CDOT currently collects data on the bridges, populates, maintains, and runs the Pontis system.

Recommendation 2: Use Pontis to obtain current inventory, physical condition, backlog of need, and recurring system quality needs on city and county major bridges.	
Description	This recommendation involves using the existing data collection and analysis procedures to determine major bridge needs. Cities and counties currently hire consultants every two years to collect inventory and condition data on major bridges.[1] This information is transferred to CDOT, where it is entered into Pontis. From the inventory and condition data, the backlog of needs and recurring system quality needs for major bridges can be calculated.
Implementation Steps	1. Use the existing data collection procedures for determining the total inventory and current physical condition of city and county major bridges. 2. Establish a bridge study subcommittee of the technical review team to review Pontis condition targets to determine appropriateness of applying those targets to local major bridges.[2] 3. Subcommittee to revise or endorse Pontis condition targets. 4. CDOT to run Pontis with agreed condition targets. 5. Document needs. 6. If applicable, use Pontis functionality to conduct scenario modeling.
Benefits	• Inventory and condition data is up-to-date and complete. • No additional data collection costs. • If CDOT applies the decision rules regarding condition targets within Pontis, need can be calculated using the system.
Roles and Responsibilities	• Use data collection process that is already in place. • CDOT is responsible for maintaining and updating the Pontis database. • Program manager staffs technical review team to direct CDOT analysis using Pontis. • Program manager documents and presents needs information.
Duration	Two months to establish bridge study team. Two months to measure major bridge needs.

[1] Costs are shared 80 percent/20 percent between FHWA and the local government.
[2] Currently, CDOT is reprogramming Pontis to reflect its own policy decision rules; in transitioning from a different system, CDOT has been using the default decision rules included in Pontis when it was purchased.

3. Minor Bridges[3]

To quantify minor bridge needs is more complex because cities and counties are not required to maintain data on their minor bridges. While some jurisdictions collect the same data on minor bridges that they are required to collect for major bridges, such practice is not the norm. For the purposes of statewide needs assessment there is currently no inventory of minor bridges, nor is there any condition information from which to estimate needs. Therefore the recommended methodology is designed to establish an inventory and then sample this inventory as the empirical basis from which needs can be estimated.

In 1995, Colorado Counties, Inc. (CCI) undertook a study of minor bridges. In the study, CCI found fewer minor bridges and much less minor bridge need in the counties than they expected. One explanation is that many minor structures, such as culverts, do not need as much maintenance as bridges. Secondly, projects on minor bridges are more likely to be affordable for smaller jurisdictions, so such projects are more often programmed.

Minor bridge needs are important to measure nonetheless. Neglected minor bridge needs can result in half-load postings (which have economic consequences), collapses (which have public life, agency trust and prestige, and liability consequences), or other failures.

a. Inventory

The methodology requires establishing a baseline inventory of all minor bridges by type. This can then be used for estimating statewide needs from needs information for a subset of Colorado jurisdictions. The inventory survey would

[3] The term minor bridges refers to all minor structures, including culverts and concrete boxes under 20 feet, in addition to the bridges under 20 feet.

be used to identify any jurisdictions that have condition information for their minor bridges that can be used to estimate needs.

Recommendation 3: Self-survey of cities and counties to establish minor bridges inventory.	
Description	This recommendation is for cities and counties to conduct a self-survey to establish the total number of minor bridges by type and general location. This will be accomplished by developing a survey approach that will result in the consistent classification of minor bridges. The approach will require preparing guidance for local jurisdictions and coordination assistance.
Implementation Steps	1. Establish local bridge technical review team as working sub-committee of the Technical Review Team. 2. Conduct team meetings and staff the team to prepare preliminary classification of minor bridges and listing of data items for survey. 3. Staff bridge technical review team to develop survey instrument and detailed instructions for cities and counties to count and classify minor bridges by type. 4. Program management resource will coordinate and communicate with counties and cities to explain purpose and process for data collection. 5. Technical resource to administer survey, answer questions, and follow up to ensure response. 6. Input inventory data. 7. Evaluate benefits of institutionalizing periodic minor bridge reporting, using Mileage Report reporting by exception. For example, adding or deleting minor bridges from the inventory.
Benefits	• Establishes local minor bridge inventory. • Builds capacity at the local level, especially for those jurisdictions that do not currently inventory their minor bridges.
Resources and Responsibilities	• Technical resource will staff process and provide technical guidance. • Local bridge technical review team will make technical decisions, approve survey instrument, and data collection process. • Cities and counties will be responsible for actual counting and classifying minor bridges. • City and county organizations will assist with communication to members. • Technical resource will input data and establish database. • Technical resource will tabulate results.
Duration	6 months.

b. Condition assessment and needs quantification

(1) Recommended approach

This approach draws on the potential to use data that is already available from some cities and counties. It also requires interested jurisdictions to estimate their needs. While not as robust as Alternative 4a, Colorado jurisdictions believe that it offers a viable low cost strategy for estimating minor bridge needs.

(2) Alternative 4a

The methodology is designed to establish a cost-effective way to assess minor bridge condition for the purpose of planning level needs assessment. The approach will not involve the same level of detailed engineering inspection that is conducted for major bridges. However, the methodology will require local jurisdictions to use their professional engineering staff, assuming they have them, to conduct a condition assessment. The methodology provides technical support for sampled jurisdictions that do not have professional engineering staff to collect their sample data.

To manage costs, the scaled-down minor bridge condition assessment would consist of two parts. The first part would provide the structure's age, last known treatment, current condition, and recommended time and type of next treatment. The second part would estimate operations and maintenance costs for the bridge. The general approach is to establish a sampling strategy from the inventory data. The sample approach would be to select a stratified sample of jurisdictions and for these jurisdictions to evaluate the condition of their minor bridges.

Recommendation 4: Establish a working group of volunteer counties to conduct a condition assessment and needs assessment self-survey, and use this data to illustrate the backlog of need and recurring system quality needs for minor bridges.	
Description	This methodology for determining minor bridge needs reflects input from local jurisdictions regarding a less costly approach to minor bridge needs estimation than that provided by Alternative 4a. This methodology involves identifying a working group of jurisdictions that either have current data or that will collect data on the condition of their minor bridges. The approach taken will be to structure the working group to establish an agreed categorization and measurement of condition. The approach will depend upon the donation of time by the participating jurisdictions.
Implementation Steps	1. Identify the participating jurisdictions. The inventory approach established through Recommendation 3 will be used to identify any jurisdictions that already have minor bridge condition data. These jurisdictions will be invited to participate. In addition, the Technical Review Team will identify jurisdictions that wish to participate. 2. Develop approach and prepare guidance for participating cities and counties to perform a condition assessment on minor structures. 3. Jurisdictions perform self-assessment. 4. Use results from participating jurisdictions to develop the estimated range for statewide needs.
Benefits	• Least cost strategy draws on any existing data and energy of interested jurisdictions.
Resources and Responsibilities	• Technical resource will provide limited staff support to local jurisdictions. • Local bridge technical review team will make technical decisions. • Participating cities and counties responsible for actual condition assessment.
Duration	4 months.

Alternative 4a: Use statistical sampling of current inventory data to conduct condition assessment survey. Use this data to estimate backlog of need and recurring system quality needs.	
Description	From the count of minor bridges compiled according to Recommendation 3, condition information will be collected on a stratified random sample. In a stratified random design, a random sample is picked within each category of bridge. Minor bridges would be separated into categories, or strata by jurisdiction, which most likely would match the classifications the bridge study team established in Implementation Step 1 of Recommendation 3. Stratified random design maintains objectivity while ensuring that all classifications are represented. Grouping data by classification may also speed the data gathering process. While the inventory data is needed to develop the statistical sample, at this stage the assumption is that jurisdictions will be identified and then from these a sample selected. This is essential to administer the data collection.
Implementation Steps	1. Use the inventory data collected through Recommendation 3 to establish a sampling and data collection strategy. 2. Develop approach and prepare survey form and guidance for cities and counties to perform a condition assessment on minor structures. 3. Randomly select a stratified city sample and a stratified county sample of minor bridges. 4. Obtain Technical Review Team consensus on condition measures, sample strategy, and implementation approach. 5. Provide training to jurisdictions in sample on administering the survey. 6. Administer and coordinate self-survey or consistent extraction of data from databases in those sampled jurisdictions that collect and maintain this information. 7. Provide technical engineering resource to any sampled jurisdictions that do not have suitably qualified staff to administer self-survey. 8. Jurisdictions perform condition assessment according to survey and instructions. 9. Add survey data on sampled bridges to minor bridge database.
Benefits	• Sampling strategy and self-survey help to manage costs. • Sampling strategy will allow statewide aggregation by city and county.
Resources and Responsibilities	• Technical resource will staff process and provide technical guidance • Local bridge technical review team will make technical decisions, approve survey instrument, and data collection process. • Cities and counties responsible for actual condition assessment. • Technical resource will assist jurisdictions with limited technical capacity to collect data. • Technical resource will input data and establish database.
Duration	4 months.
Reason Not Recommended	Although this alternative provides a robust methodology, the data collection effort required is large.

Alternative 4b: Include condition assessment on minor bridge count and classification survey.	
Description	A variant of the recommended approach, this alternative would require that cities and counties collect condition information on all minor bridges at the same time as they count and classify minor bridges.
Implementation Steps	1. Develop survey questions and detailed instructions for cities and counties to perform a condition assessment on minor structures. 2. Add questions and instructions to count and classification survey. 3. Follow implementation steps in Recommendation 3.
Benefits	• No sampling methodology needs to be designed.
Resources and Responsibilities	• Same as for Recommendation 3. However, all cities and counties responsible for assessing condition on all minor bridges.
Duration	6 months.
Reason Not Recommended	• This alternative would be burdensome for local jurisdictions, especially those cities and counties that currently do not collect any minor bridge data. It is judged unrealistic to think that jurisdictions would have or be prepared to devote the time required for this effectively 100 percent sample approach. • There would be significant risk that data would be poor and incomplete. There would likely be biases in the data. It would also cost more and take much more time to compile and analyze the data.

Under Alternative 4a, the sample data will be used to provide the basis for aggregation to establish the statewide baseline of minor bridge conditions. This would then be used to identify the gap between these conditions and the target conditions set by the technical review team.

The inventory data that will have information on the type of bridges will be used to estimate the types of treatment required. Unit cost data will be established using actual bid tab data and analysis conducted to determine any regional variations. Then a weighted unit cost will be established. It will be weighted using the inventory data.

4. Arterials

The most inventory and condition data is maintained on higher functional classes of roadways. Therefore, local arterials have more data than any other local roadways. One example of existing rich local arterial data are the sample segments in the

Highway Performance Monitoring System (HPMS). HPMS is a database and analytical process (AP) that includes detailed inventory and physical condition information collected annually on randomly selected sections of Colorado arterials. Information stored in HPMS includes (a) surface condition, (b) capacity requirements, and (c) geometric/safety requirements.

Previous CDOT local roadway needs assessments used the existing number of HPMS samples that CDOT collects on city and county arterials. However, the sample size was only 70 percent of the federally recommended size for generalizing to the total population at the time.

The recommendation involves using the existing mileage reporting procedure. This would be amended to obtain additional information from which to determine the backlog of mobility deficiencies on a consistent basis.

Recommendation 5: Use Mileage Reports for condition assessment data from which to determine baseline condition, backlog of mobility need, and recurring system quality needs for city and county arterials. Validate data with a random sample.	
Description	All Colorado cities and counties annually file a "Mileage Report" with CDOT in order to be eligible for HUTF funding. CDOT sends cities and counties the inventory data that the city or county submitted in the previous years; individual cities and counties are required to make any changes that have occurred within the past year. In addition, the Mileage Reports require cities and counties to update their reporting of the physical condition of the road. This data can be used to estimate backlog and recurring system quality needs for arterials. (Mobility needs would need to be estimated as collector and sub-collector mobility needs are estimated. See Recommendation 7.)
Implementation Steps	1. Coordinate with annual update of Mileage Report to include additional data required. 2. Revise mileage-reporting guidance, refine data items collected, and prepare new self-survey guidance package. 3. Communicate with local jurisdictions and administer self-survey. 4. Assemble inventory and condition data from Mileage Reports. 5. Facilitate Technical Review Team to set condition level targets by jurisdiction type. 6. Estimate local arterial need by comparing data collected from Mileage Reports to targets. 7. Validate data from Mileage Reports by comparing reported data to existing HPMS sample data for similar sections. 8. If validation shows that reporting is inaccurate, develop an action plan for improving the reporting process and data accuracy.
Benefits	• Builds upon current reporting process. • Local jurisdiction collection information on their own roads. • Does not require sampling.
Resources and Responsibilities	• Technical resource to establish method and strategy for dovetailing with Mileage Report process. • Technical Review Team to agree on target condition levels • Counties and cities to complete self-survey. • Technical resource to conduct quality assurance review of sample data.
Duration	6 months.

Alternative 5a involves expanding the HPMS arterial sample size to enable aggregation to the statewide level for cities and counties. This has the benefits of using the existing samples and also enabling the methodology to use the HPMS analytical process to perform scenario modeling. The disadvantage is that depending on the sample size required, this could involve 1800 person-hours of work.

Alternative 5a: Use an expanded HPMS dataset to obtain current inventory data, physical condition, backlog of need, recurring system quality needs, safety needs, and future mobility needs on city and county arterials.	
Description	Under this option, the HPMS sample would be expanded to the federally recommended size. Once the sample meets federal sample size requirements, it can be used more credibly to predict needs.
Implementation Steps	1. Establish sample size. 2. Train survey crew and collect additional HPMS samples. 3. Input and process data 4. Staff technical review team to set condition level targets in HPMS analytical package (AP). 5. Technical resource to use the HPMS AP to estimate needs.
Benefits	• The analytical tool to estimate needs is already developed, tested, and credible. • Builds on existing data collection and reporting procedures. Much of the data is already collected. • Enables scenario modeling.
Resources and Responsibilities	• Technical resource in conjunction with CDOT establishes sample size and sampling strategy. • Technical resource manages data collection • Technical Review team sets condition level targets • Technical resources run HPMS AP.
Duration	6 months.
Reasons Not Recommended	• With the information available it is not clear how much additional data is required. • While the data would provide a robust estimate of arterial needs, the potential data collection costs are considered too high. They could be as high at 1800 person-hours.

Alternative 5b: Use existing number of HPMS samples to estimate needs for local arterials.	
Description	Under this alternative, needs would be estimated from the existing number of HPMS samples.
Implementation Steps	1. Staff technical review team to set condition level targets in HPMS analytical package (AP). 2. Technical resource to use the HPMS AP to estimate needs.
Benefits	• Less costly than expanding the HPMS sample.
Resources and Responsibilities	• Technical Review team sets condition level targets • Technical resources run HPMS AP.
Duration	2 months.
Reason Not Recommended	Although this approach has been used in the past, the sample size is inadequate for generating statewide needs estimates. This issue undermined the confidence in this approach in the past.

5. Collectors and Sub-collectors

Collector and sub-collector needs, like minor bridge needs, are more difficult to estimate because less data is available. HPMS does not include many collector samples and does not include any samples from the sub-collector level. Also, HPMS is not designed to address the characteristics of sub-collectors. For these reasons, HPMS is not an appropriate method for estimating needs on collectors and sub-collectors. The recommended approach uses the existing Mileage Reports.

Recommendation 6: Use Mileage Reports to collect the inventory, physical condition data, backlog of need and recurring system quality needs for city and county collectors and sub-collectors.	
Description	Current inventory and physical condition data on sub-collectors can be compiled using Mileage Report data. That data can provide information about the backlog of needs and recurring system quality needs.
Implementation Steps	1. Assemble inventory and condition data from Mileage Reports. 2. Staff Technical Review Team to establish agreed condition targets (standards) by functional class for cities and counties. 3. Estimate local collector and sub-collector need by comparing data collected from Mileage Reports to condition targets. 4. If validation shows that reporting is inaccurate, develop an action plan for improving the reporting process and data accuracy. 5. Assemble unit cost information from local jurisdictions and develop unit costs to be used by treatment type. These will be weighted using the inventory data by region. 6. Apply unit costs and develop needs estimates.
Benefits	• Builds upon existing Mileage Report data collection and reporting process. • Minimizes initial local jurisdiction costs. • Addresses a data gap and can also improve the reporting process, which will increase the accuracy of data for this needs assessment.
Resources and Responsibilities	• Technical Review Team to establish target condition levels. • Technical resource to analyze and report data.
Duration	4 months.

6. Maintenance and Operations Methodology (System Quality)

The recommended approach and the three alternatives that were considered for estimating maintenance and operations needs are outlined. These needs fall under CDOT's system quality classification. The prior element of the methodology will identify pavement preservation needs that are included under system quality by CDOT.

The most important issue for the methodology is whether to establish a performance or service-level based approach to maintenance and operations needs or whether to define these needs based on what is spent on maintenance and operations. A service-level approach measures true maintenance needs. The expenditure-based approach severely understates needs and is really a function of what has been spent on maintenance and operations in the past. The main consideration in making the recommendation is financial.

Recommendation 7: Establish level of service cost estimates and unit costs for maintenance activities in selected jurisdictions and apply to local roads inventory.	
Description	This recommended approach involves jurisdictions in which the county or city engineer wishes to "volunteer" their time as a working group to establish unit cost estimates for accomplishing an acceptable maintenance level of service for selected maintenance activities. The approach will involve some level of staff support to ensure consistency and define the key maintenance activities to be addressed. The intent of the approach would be to apply the costs to the inventory of local roads established though the prior elements of the methodology. While this approach will involve considerable assumptions to generalize statewide, the methodology is considered preferable to alternatives 7b and 7c by Colorado local jurisdictions. Although not as robust as alternative 7a, it does not involve the level of resources that would be required for that alternative.
Implementation Steps	1. Work with the Technical Advisory Team to solicit jurisdictions to participate in the working group. 2. Staff working group to facilitate their consistent approach to estimating costs. 3. Identify principal maintenance activities and associated acceptable service levels. 4. Participating jurisdictions will estimate where they stand against these service levels, the cost of addressing their backlog of needs, and the estimated annual cost of accomplishing the service level. 5. Apply unit costs to the statewide level.
Benefits	• The primary benefits of this approach is that it is cost-effective and probably "good enough" for the purposes of the needs assessment.
Resources and Responsibilities	• Working group active participation
Duration	6 months.

Alternative 7a: Perform a comprehensive maintenance needs study.	
Description	Under this alternative, a technical resource would be used to establish a service-level based approach to measuring maintenance and operations needs. This would involve a sample of counties and cities conducting a self-survey. It would further require a quality assurance review of a subset of this data. The methodology would be similar to CDOT's maintenance service-level approach which is in turn derived from the methodology that Dye Management Group, Inc. developed for Washington State.
Implementation Steps	1. Establish a sampling strategy using mileage report inventory data. 2. Staff Technical Review Team to establish maintenance features to include and agree on condition measures. 3. Prepare guidance for sample of jurisdictions to perform self-survey. 4. Communicate to and train sample of cities and counties to conduct self-survey. 5. Technical resource to provide quality assurance review. 6. Process and analyze data. 7. Aggregate to statewide level and report.
Benefits	• The primary benefits of a comprehensive needs study are objectivity and accountability. • The methodology would provide a true needs-based assessment for local maintenance. Maintenance is the area which customer surveys repeatedly reveal to be of high importance to citizens. • Better understanding of adequacy of investment, public perceptions, level of service provided, etc.
Resources and Responsibilities	• Technical review team to agree on measures and standards. • Technical resources to design, administer, and provide quality assurance for data collection. • Sample jurisdictions to collect data. • Technical resource to analyze and report needs.
Duration	8 months.
Reason Not Recommended	• Methodology, although robust, requires level of effort beyond that which is likely to be available for the needs study.

Alternative 7b: Use a time-series model to estimate recurring system quality needs based on expenditure history.	
Description	This approach establishes maintenance needs as a function of maintenance expenditures. While being cost-effective to implement it is not truly needs-based. Colorado cities and counties submit revenue and expenditure reports annually that detail their expenses in the following recurring system quality categories: • Maintenance of condition (pavement maintenance) • Snow/ice removal • Parking/sidewalk maintenance • Weed control These numbers can be projected using a time-series analysis. In a time-series model, the future values of recurring system quality needs would be predicted using a mathematical model that incorporates previous values of the recurring system quality needs reported in the revenue and expenditure reports.
Implementation Steps	1. Develop the model. 2. Specify any assumptions. 3. Run and test the model.
Benefits	• Uses existing data and information. • Not resource intensive.
Resources and Responsibilities	• Technical resource to specify and test model. • Technical resource to report results. • Technical Review team to establish assumptions.
Duration	3 months.
Considerations	The maintenance categories in the expenditure report are limited. This approach also does not take into account that jurisdictions may currently underfund operations and maintenance. The approach also does not account for increasing system quality expenses in order to reduce construction expenses. (For example, employing a comprehensive pavement preservation strategy to reduce reconstruction expenses.)
Reason Not Selected	• Data not needs-based.

Alternative 7c: Survey cities and counties on their recurring system quality needs.	
Description	In this alternative, all cities and counties would be surveyed to provide their assessment of their operations and maintenance needs. This would require a detailed form along with precise instructions, in order to ensure that the data collected is accurate and consistent.
Implementation Steps	1. Develop survey instrument and detailed instructions for city and counties to estimate recurring system quality needs on their collectors and sub-collectors. 2. Administer survey. 3. Local jurisdictions to compile survey. 4. Enter data and compile needs.
Benefits	• Little effort involved.
Resources and Responsibilities	• Technical resource to develop survey instrument, administer survey, and compile results.
Duration	5 months.
Considerations	This option would result in considerable variation between jurisdictions and provide information that would be difficult to defend as accurate. There would likely be a high level of inconsistency between jurisdictions. Collecting all 330 surveys would be difficult.
Reason Not Selected	Results would be subjective and not readily credible.

7. Mobility needs

The recommended approach to establishing future mobility needs is to develop a causal variable model that predicts the increase in roads and lane miles as a function of population and economic growth.

Recommendation 8: Develop and use a causal variable model and a time-series model to estimate future mobility needs.	
Description	In a causal variable model, long-term roadway expansion forecasts would be generated by a model in which future roadway expansion is a function of future values of other variables, such as population and economic growth. In the past, CDOT employed a correlation model using population to predict future roadway growth for urban areas. For small urban and rural areas CDOT used simpler time-series model, predicting future growth with a trend line. Data on roadway mileage was collected from Mileage Reports; data on population growth came from the State Demographer. This is a pragmatic approach that should be analyzed and compared to actual figures periodically in order to validate the models.
Implementation Steps	1. Develop the model. 2. Specify any assumptions. 3. Run and test the model. 4. Compare to HPMS (AP) results. 5. Reconcile the two methods.
Benefits	• Once the models are calibrated and tested, they can be used without additional cost. • Relies on existing data, rather than new data collection.
Resources and Responsibilities	• Technical resource to specify, test, and run models.
Duration	3 months.

D. Resource Estimates

This section estimates the resources, measured in person hours, required to implement the methodology. An indication of implementation roles and responsibilities is also provided. The resource estimates are provided for each component of the needs assessment methodology.

1. Overall Management of Process and Technical Work

Major Work Element Recommendations	Statewide Needs Assessment Resource	Local Jurisdictions	CDOT Staff
1. Project administration-coordination, communications, and staffing of policy and technical committees over 14 to 18 months.	0.25 FTE 500 hours	Participation in technical and policy oversight committees.	Participation in technical and policy oversight committees.
2. Management, administration, and coordination of technical work elements.	0.25 FTE 500 hours		
3. Organization, presentation, and communication of results.	0.25 FTE 500 hours		
4. Documentation and institutionalization of methodologies and process.	0.25 FTE 500 hours		
Total Resource Estimate	**1 FTE 2,000 hours**		

2. Major Bridges Needs Assessment Recommended Methodology – Data Collection and Needs Quantification

System Element	Work Breakdown	Statewide Needs Assessment Resource	Local Jurisdictions	CDOT
Major Bridges	1. Coordinate with and use existing data collection procedures used for Pontis.	Included in overall project management and coordination.		16
	2. Review condition targets, needs definitions, and unit costs set within Pontis.	Included in overall project management and coordination.	Participation in Technical Committee meeting.	32
	3. Use analysis year data to run Pontis and develop needs estimates under different revenue scenarios.	Included in overall project management and coordination.		40
	4. Document backlog, annual and future needs.	24		8
Total Resource Estimate		**24**		**96**

3. Minor Bridges – Recommended Needs Assessment Methodology – Data Collection and Needs Quantification

System Element	Work Breakdown	Statewide Needs Assessment Resource	Local Jurisdictions
Minor Bridges Inventory	1. Establish technical detail and prepare self-survey guidance package.	60	Participation in Technical Committee meeting.
	2. Communicate with local jurisdictions to administer self-survey.	80	Attendance at training sessions.
	3. Conduct self-survey.		8 – 40 hours per jurisdiction.
	4. Administer survey, tabulate results, and ensure completeness.	120	
	Total	**260**	
Minor Bridges Condition Assessment	1. Identify participating parties.	16	Participation in Technical Committee meeting.
	2. Establish working group of interested counties. Develop condition assessment approach.	60	Volunteer counties to develop illustrative needs information.
	3. Conduct self-assessment of conditions, needs, unit costs.		24 – 80 hours per participating jurisdiction.
	Total	**76**	
Minor Bridge Needs Assessment	1. Use condition assessment and provide illustrative aggregate condition profile.	40	
	2. Use inventory data to estimate preservation (system quality) needs.	80	Participation in Technical Committee meeting.
	Total	**120**	
Total Resource Estimate		**456**	

4. Arterial, Collector, and Sub-collector Needs Assessment Methodology – Data Collection and Needs Quantification

System Element	Work Breakdown	Statewide Needs Assessment Resource	Local Jurisdictions	CDOT
Arterials, Collectors, Sub-collectors **- Inventory and condition assessment data collection**	1. Coordinate with mileage reporting process for timing.	16		
	2. To the extent necessary, revise mileage reporting guidance, refine data items collected, and prepare new self-survey guidance package.	40	Participation in Technical Committee meeting.	
	3. Communicate with local jurisdictions and administer self-survey.	80	Already being collected.	
	4. Conduct quality assurance and validation of mileage report data using HPMS data from Arterials.	40		
	5. Ensure completeness of data submitted and analyze.	200		Enter and process data. This work is already being performed annually.
	Total	**376**		

System Element	Work Breakdown	Statewide Needs Assessment Resource	Local Jurisdictions	CDOT
Arterials, Collectors, Sub-collectors **- Needs assessment backlog of preservation (system quality needs)**	1. Use mileage report data to establish aggregate condition profile for cities and counties.	60		
	2. Establish agreed condition targets (standards) by functional class for cities and counties.	32	Participation in Technical Committee meeting.	
	3. Define improvements required to address estimated aggregate deficiencies.	40	Participation in Technical Committee meeting.	
	4. Develop unit cost information to be used by treatment type using bid price data. (Weight price by lane miles by region.)	40	Participation in Technical Committee meeting.	
	5. Apply unit costs to define needs backlog using condition data to estimate preservation (system quality) needs.	40		
	Total	**212**		
- Needs assessment annual preservation (system quality) needs	1. Establish agreed approach to defining treatment cycles by pavement type, jurisdiction, and functional class.	16	Participation in Technical Committee meeting.	Participation in Technical Committee meeting.
	2. Develop unit costs to be used by treatment type using bid price data. (Weight price by lane miles by region.)	40		
	3. Apply treatment cycles and unit costs to inventory data to determine need.	60		
	Total	**116**		
Total Resource Estimate		**668**		

5. Recommended Methodology for Maintenance and Operations (System Quality) Methodology, Establish Level of Service Cost Estimates for a Sample of Jurisdictions and Aggregate

System Element	Work Breakdown	Statewide Needs Assessment Resource	Local Jurisdictions	CDOT
Roadways and Bridges	1. Establish volunteer jurisdiction work group and facilitate to identify principal activities and level of service targets.	60	Participation by volunteer jurisdictions in work session	
	2. Jurisdictions perform self assessment.		Participation by volunteer jurisdictions 120 hours each	
	3. Apply cost estimates to statewide inventory data.	40	4 hours per jurisdiction	
	4. Report as needs.	40	Participation in Technical Committee meeting.	
Total Resource Estimate		**140**		

6. Recommended Methodology for Mobility Needs Assessment

- Develop and use a causal variable model and a time-series model to estimate mobility needs for all system elements.

System Element	Work Breakdown	Statewide Needs Assessment Resource	Local Jurisdictions	CDOT
Roadways and Bridges	1. Develop the model.	40	Participation in Technical Committee meeting.	
	2. Specify any assumptions.	60		
	3. Assemble and enter data.	120		
	4. Run and test the model.	60		
	5. Review and refine results.	40		
Total Resource Estimate		**320**		

III. Revenue Projection Methodology

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In 1999, Colorado cities and counties spent more than $950 million to address their local street and bridge needs. $644 million of that money came from city and county sources, such as property tax, sales tax, and general fund contributions. $255 million came from state sources, primarily the Highway Users Trust Fund (HUTF). The remaining $51 million came from federal and private funds. It is important to forecast these revenues over the same period as roadway needs are projected, in order to analyze the ability of cities and counties to meet their future needs. The difference between projected needs and projected revenues illustrates the funding gap that must be addressed in the statewide transportation policy discussion.

This section presents recommendations for developing a methodology to forecast aggregate statewide county revenues and aggregate statewide city revenues for use on local roadways. The methodology, which will provide projected city and county revenues for each forecasted year, consists of three distinct approaches:

- Using existing long-range revenue projections for city and county portions of HUTF and federal funds. CDOT has institutionalized these annual projections in its Office of Financial Management and Budget (OFMB).
- Using causal variable analysis, in which the future values of sales tax, property tax, specific ownership tax, traffic fines, and private contributions are assumed to be functions of the future values of other variables, such as population and economic growth.
- Using time-series analysis, in which future revenues are assumed to be a function of the secular trends and cycles observed in the historical values of those revenues.

This section is organized as follows:

- **Issues with Projecting Local Colorado Revenues.** This section reviews some assumptions and details about projecting revenues for Colorado cities and counties.

- **Data Sources.** This section describes the source of data to be used for projecting local revenues.

- **Current Sources of Transportation Revenue for Local Revenues.** This section lists the current sources of revenue for city and county use on local roads and streets and illustrates the differences between city and county revenues.

- **Revenue Models.** This section presents and discusses two approaches to revenue projection and how they can be used to develop a comprehensive methodology for projecting local roadway revenue.

- **Recommended Forecasting Methods by Revenue.** This section identifies resources available for obtaining revenue projections and presents some recommendations for using them.

- **Implementation Steps.** This section provides steps to take in order to implement the recommended methodology.

A. Issues with Projecting Local Colorado Revenues

The following are some issues and concerns regarding projecting revenues for local roadways.

1. Public Policy Prerogatives

Current state and local laws establish guidelines for cities' and counties' abilities to raise revenue. Elected officials will make taxation and appropriation decisions within these guidelines, as they allocate resources against the public priorities of the day. These are public policy decisions that could be affected by the assessment of road and bridge needs and they should not be embedded in the forecasts as silent assumptions that they will remain unchanged over the forecast period.

Forecasts must recognize that elected officials will decide, first, what the tax base will be (i.e., what will be taxed and what will be exempt from tax) and, second, what tax rates will be applied to the tax base. For example, property taxes are the product of the definitions of taxable property, their assessed values, and the applicable mill rates.

Some local revenues are dedicated to roadway improvements; others are not. For instance, a portion of a city's sales and property taxes may be set aside for local roads and streets. General fund contributions, however, are discretionary. Local policy actions determine annually how much of the local general fund will be devoted to different local services, including transportation.

Long-range forecasts cannot simply assume that the current set of taxation and appropriation decisions will remain in effect and the forecasting approach must accommodate these decisions as assumptions so that changes in the decisions do not render the revenue projection methodology obsolete.

2. Public Policy Constraints

The Taxpayer's Bill of Rights (TABOR), passed in 1992, may impact revenue projections. TABOR limits the growth of city and county revenues to the sum of inflation plus local growth[4] of the previous calendar year. Excess revenues must be returned to taxpayers. While some local communities have passed referenda overturning local applicability of TABOR, TABOR does apply to most local revenues. Revenue projections should be adjusted downward if they exceed TABOR projections.

3. Modeling Considerations

Some revenues may be more amenable to one forecasting approach than another and, as a result, only one of the proposed approaches to forecasting may be successful. For

example, the HUTF revenues are dependent upon external factors: the state's population increase (or decrease), the health of the economy, and the price of gas. HUTF can be predicted using established projections of the other variables. On the other hand, some other revenues may not be predicted so easily using external factors and may be better forecasted using the trends and patterns found in the historical values of those revenues.

It is important to forecast with precision all the revenues that could cause significant variation in total revenues over the forecast period. The largest revenue sources can be expected to cause significant variations. According to the Government Finance Officers Association (GFOA) "Best Practices in Public Budgeting," analysis of major revenues is critical because even minor fluctuations in these revenues create major ripples though the budget. The top five revenue sources used on county roadways represent 85 percent of the total revenues used for county roadways; the top five revenue sources used on city roadways represent 69 percent of total revenues used on city roadways. However, those smaller revenue sources that vary radically over time, (thus account for a significant portion of the variation in the forecast of total revenues) must also be precisely forecasted.

4. Data Considerations

A wealth of revenue data is already collected from cities and towns through the annual revenue and expenditure reports. The revenue projection methodology should not require more information gathering from local governments. In addition, existing revenue projections for aggregate city and county portions of state and federal revenues should be used in lieu of developing new revenue projections if approaches used for those forecasts are compatible with the approaches recommended here.

[4] Local growth is defined as property that has been added to the tax roles. (Demolished property is subtracted from local growth.)

B. Data Sources

All Colorado cities and counties are required by CDOT to complete standard forms that identify the sources of funds used for local roadway improvements. These forms, formally known as FHWA-536, but more commonly referred to as "revenue and expenditure reports," are forwarded by CDOT to FHWA. FHWA uses the data from the revenue and expenditure reports to estimate local highway needs nationally.

CDOT's OFMB retains custody of the revenue and expenditure data. OFMB also projects city and county portions of some state and federal revenues.

C. Current Sources of Transportation Revenue for Local Roadways

The following table shows some of the major types of revenue listed in the revenue and expenditure reports that municipalities and counties use to address local roadway needs.

Revenue	Explanation
Local Funds	
Property Tax	Those portions of real property taxes that are appropriated to the construction and maintenance of roads and streets or for highway debt service plus special assessments, including road district levies, that are specifically levied for those purposes.
General Fund	Appropriations from local general funds used for roads and streets.
Traffic Fines	Those portions of traffic enforcement fines that are appropriated to local roads and streets.
Sales Tax	Those portions of local government sales taxes that are appropriated for roads and streets.
Specific Ownership Tax	An ad valorem tax on the value of motor vehicles, farm vehicles and certain types of construction equipment. Revenue is collected by the state and distributed to local governments on a proportional share basis of each taxing jurisdiction's mill levy to the sum of all the mill levies in the county.
State Funds	
Highway Users Tax Fund	All transfers of state highway-user taxes and fees, including motor-fuel taxes, motor-carrier taxes, and similar taxes and fees that were used for roads and streets.
Motor Vehicle Registration	Revenue from Motor Vehicle Registration Fund.

Revenue	Explanation
Federal Funds	
Forest Service	Funds received by local governments from the United States Forest Service that were used for roads and streets.
Mineral Leasing	The portion of the royalties paid on mineral leases that is passed to local governments.
Pay Lieu of Tax	Funds received by local governments in lieu of property taxes that would be due on federal lands within county boundaries if they were not exempt from such taxes.
FEMA	Funds received by local governments from the US Federal Emergency Management Agency that were used for roads and streets.
HUD	Funds received by local governments from the US Department of Housing and Urban Development that were used for roads and streets.
Other Funds	
Private Contributions	All amounts received by local governments from the private sector as cash or services for road and street programs. Private participation in the public road system should be reported in this item. Donations, such as cash or the transfer of real property, the construction of facilities, and the performance of support services (surveys or preliminary and construction engineering) are ways the private sector participates in financing public highway projects.

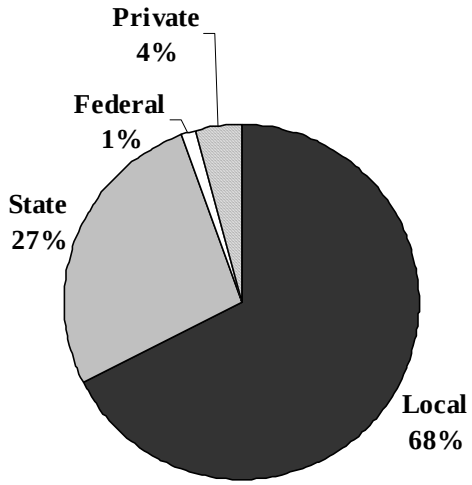
Sources: 1999 revenue and expenditure reports, Instructions for Form FHWA-536.

1. Revenues for Local Roadways

According to revenue and expenditure reports, local governments received $951 million in revenues for road and bridge projects as well as maintenance activities in 1999. Cities reported $613 million in such revenues, while counties reported $339 million.

Local sources comprise the bulk of funding for city and county transportation expenditures, followed by state and then private contributions. Federal money accounts for a small portion of funding for local roadways. Exhibit III-1 below illustrates the breakdown of local roadway funding by source:

Exhibit III-1: 1999 Local Transportation Funding by Source



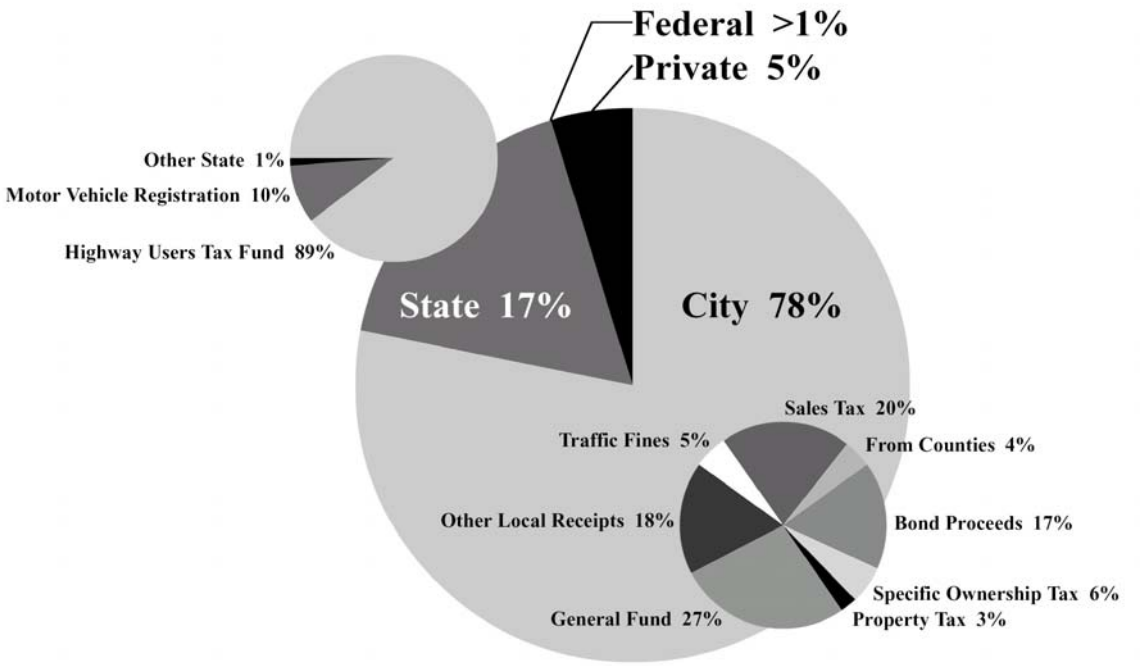
Source: 1999 revenue and expenditure reports

The proportions shown above represent an average distribution; cities and counties differ dramatically in their reliance on revenue sources for roadway needs. For example, counties are much more dependent on state funding than are cities. The following sections will illustrate the differences between city and county revenues.

2. Revenues for City Roadways

Local city funding (comprised primarily of general fund, sales tax, and other local receipts) accounts for more than three-quarters of city roadway improvement funds. State funding, mostly HUTF, comprises only 17 percent. Private contributions represent 5 percent of revenues, while federal funding accounts for less than 1 percent of city transportation funding. Exhibit III-2 shows the funding breakdown.

Exhibit III-2: 1999 City Transportation Funding by Source



Source: 1999 revenue and expenditure reports

General fund and sales tax were the top two funding sources, at 20 and 16 percent. HUTF revenue (the top revenue source for counties) ranks third for cities at 15 percent. Bond proceeds and specific ownership taxes complete the top five, representing 13 and 5 percent, respectively. Exhibit III-3 shows the top five revenue sources for cities, and the percentage of overall revenues that they represent.

Exhibit III-3: Top Five Funding Sources for Cities, 1999

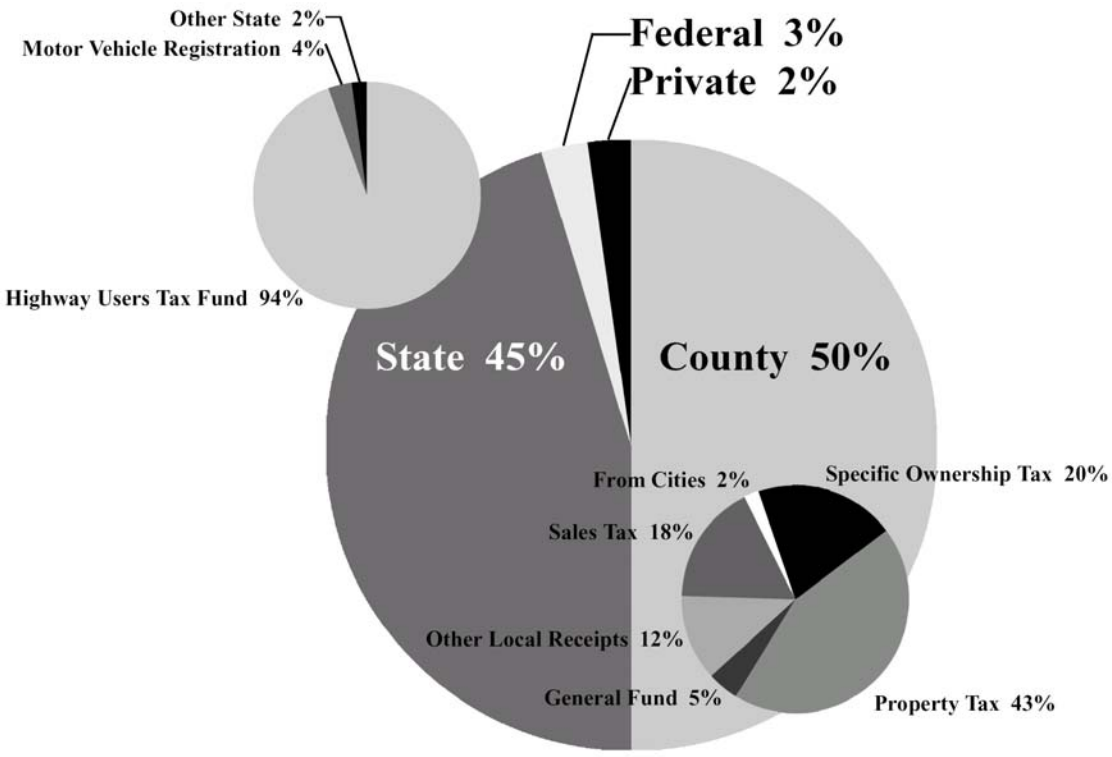
City Revenues	Amount	Percent of Total Revenue
General Fund	$ 125,854,232	20.54%
Sales Tax	96,093,193	15.68%
HUTF	92,015,817	15.02%
Bond Proceeds	80,296,399	13.10%
Specific Ownership Tax	28,735,148	4.69%
Total of top five sources:	**$ 422,994,789**	**69.03%**

Source: 1999 revenue and expenditure reports

3. Revenues for County Roadways

Local county funding (comprised mostly of property tax, specific ownership tax, and sales tax), accounts for half of county roadway improvement funds. However, state funding (almost entirely HUTF) is a close second at 45 percent. Federal and private contributions are a distant third and fourth, representing only 3 and 2 percent of revenues, respectively. Exhibit III-4 shows the funding breakdown.

Exhibit III-4: 1999 County Transportation Funding by Source



Source: 1999 revenue and expenditure reports

The single largest funding source for counties is the HUTF. The next four largest revenue sources for counties are all local funding – property tax, specific ownership tax, sales tax, and general fund. Exhibit III-5 shows the amounts and percentages of the top five revenue sources.

Exhibit III-5: Top Five Funding Sources for Counties, 1999

County Revenues	Amount	Percent of Total Revenue
HUTF	$143,891,191	42.48%
Property Tax	74,027,130	21.86%
Specific Ownership Tax	32,924,970	9.72%
Sales Tax	29,601,891	8.74%
General Fund	7,561,090	2.23%
Total of top five sources:	**$288,006,272**	**85.03%**

Source: 1999 Revenue and Expenditure Reports

D. Revenue Projection Models

The two widely used models to project economic variables, among which are transportation revenues, are causal variable models and time-series models. Whether to use one of the other depends on the type of revenue being projected, the forecast period and the availability of input data.

1. Causal Variable Models

In a causal variable model, a long-term forecast is generated by a model in which the future values of one variable are functions of future values of another variable (the technical terms for which are the "causal" variable, the "independent" variable, or the "exogenous" variable).

The general form of the causal variable model is:

$$y_t = f(X_{1t}, X_{2t}, \ldots X_{it})$$

Where:

y_t = the value of the dependent variable to be forecast in period t; and

X_{it} = the value of the each independent variable in period t.

The more exact the relationship between the dependent variable **y** and each dependent variable $\mathbf{X_i}$, the better the causal variables model will predict future values of **y**. The approach is to build a model that uses the least inexact relationship for which data is available.

The best relationship is found in the exact arithmetic relationships of *accounting entities*. The accounting entity for sales tax revenues is, for example: "number of sales" times "retail sales price" times "sales tax rate" equals "sales tax revenue." While accounting entities almost always exist for economic variables, predicted future values for their data are not usually available. In the sales tax revenue example, future values of "the number of sales" are unlikely to be available.

The next best approach is to use *behavioral relationships*, which are indirect and inexact but for which data and forecasts are readily available. In the example of sales tax, "number of goods sold" is some function of "household income," "retail prices," and "population." This alternative also allows the model to be simplified with *reduced forms*, in which one behavioral variable predicts the values of several variables in the accounting entities; for example, "household income" predicts "number of goods sold" and "assessed value of real property."

2. Time-Series Models

In a time-series model, the future values of a variable – a certain revenue category, in this case – are predicted from previous values of the same variable (the technical term for which is the "lagged endogenous variable").

The general form of the time-series model is:

$$\mathbf{y_t = f(y_{t-n}) = f(L*S*C*I)}$$

Where:

$\mathbf{y_t}$ = the value of the variable to be forecast in period t;

$\mathbf{y_{t-n}}$ = the value of the variable n periods ago;

L = a long term secular trend;

S = a seasonal component;

C = a long term cyclical component, usually an economic cycle; and

I = an irregular component.

Time-series models decompose past values of **y** into patterns of these four components – secular trend, seasonality, economic cycles, and a random process – then fit mathematical patterns to each of the decomposed components. These mathematical patterns are then recombined into a forecasting model.

There are many statistical tools that can be brought to bear on time-series forecasting, ranging from moving averages, an accumulating average ("trend lines"), simple function analysis, weighting and smoothing schemes, seasonal adjustment schemes, and onward to sophisticated methods. Economics or probability theory do not indicate, *a priori*, that any one these statistical methods will be superior to the others. The best method is, simply, the one that provides the best fit.

3. Choosing between Causal Variable and Time-Series Models

As a general rule, causal variable models are preferred over time-series models in long term forecasting. A causal variables model incorporates something of the reality of how transportation revenues are determined: the number of consumers and the

reaction of those consumers to the economic situation in which they expect to find themselves determines, for example, assessed real property values.

Time-series models ignore the real-world relationships between cause and effect; in this case, how changes in demographics and economic activity change the total values of the tax bases on which the relevant taxes were collected. For example, one significant tax base for cities and counties in Colorado is the retail value of goods sold that are subject to sales tax. Our knowledge of the economy suggests that future retail values of goods sold will be determined by future values of population, household income and retail prices. Time-series models ignore those relationships and, in this example, use only past retail values to predict the future retail values.

From this perspective, time-series models are a cheat, or an admission of failure. However, they are proven as the best method to forecast under the following circumstances:

- One of the causal variables is very difficult to predict but is known to follow a chronological pattern. Weather, for example, affects many transportation variables and is most simply modeled by the seasonal patterns of previous years' weather.
- The causal variables are complex or difficult to measure. Gasoline prices, like most commodity prices, are determined by the complex interplay among many political, economic, and physical variables. A causal model of gasoline prices would be very complex.
- There is a mismatch between the forecast period and the data period. This most often occurs when the forecast period is very short – days, weeks or months – but the available data for causal variables is only available in quarters or years. This is the case with several of the data required to forecast transportation revenues.

4. The Aggregation of Data

The choice of model is dependent on the availability of data. Forecasters often have some discretion about that availability; they may choose more detailed and disaggregated data, if it is available, or they may choose more summarized and aggregated data. The choice lies in the trade-offs between precision and complexity with disaggregated data on the one hand, or approximation and simplicity with aggregated data, on the other.

To keep forecasting simple and efficient, the usual approach to this choice is to aggregate data as much as possible until approximation, which is the loss of precision, becomes unacceptably high. Approximation has become unacceptably high when either:

- Data with different bases have been aggregated together. For example, private revenues and federal revenues are based on very different causal variables and, while they are both small, they can be expected to change independently of each other.
- The values of certain statistical tests, principally of the covariance of two sets of data, exceed standard limits. This may often occur when two relatively large revenues are aggregated or when two highly variable revenues are aggregated together.

As with the methodology designed for assessing roadway needs, the methodology for projecting revenues may employ a single or several different approaches. For example, the revenue projection methodology could be designed in three ways:

- Use a causal variables model or time-series model on each revenue individually.

  This approach would allow the forecasters to consider the historical patterns and any potential independent variables that impact each revenue stream, large or

small. While this may have the potential for a high degree of accuracy, it would likely be too cumbersome and time consuming to be useful on an ongoing basis.

- Group all revenues together and use a single time-series or causal variables model.

  Performing a single forecast on all revenues would be the simplest approach, but it would probably be less accurate. Some of the revenues do change irregularly from year to year and a time-series model would be inappropriate for them. However, it is unlikely that causal variables model could be made so complex that it would contain all of the independent variables needed to forecast all of the revenue streams.

- Group some revenues together, keep others separate, and build time-series or causal variables models as appropriate.

  This approach allows the forecaster to take advantage of the strengths of each approach.

E. Recommended Forecasting Methods by Revenue

This section identifies resources available for making revenue projections and presents some recommendations for using them.

1. State Revenues

OFMB projects state revenues in order to budget for state road improvement programs. OFMB projects the aggregate amounts that will be transferred to cities and counties from two of these state funds: HUTF and Vehicle Registration Revenues.

a. HUTF

OFMB projects HUTF revenues for cities and counties every year using multiple regression least-squares analysis to estimate a causal variable model. The causal variables in the model include the state's nonagricultural employment, migration into the state, the Consumer Price Index (CPI), and the price of gas.

HUTF comprises the bulk (92 percent) of the state's funding for local roads. However, HUTF represents only one quarter of the total revenues used for local transportation projects, 42 percent for county and 15 percent for city projects.

b. Vehicle Registration Revenues

OFMB also annually performs a least-squares analysis to estimate the relationships in a causal variable model of vehicle registrations, which is used to estimate that portion which will be transferred to cities and counties. The causal variables include nonagricultural employment, migration into Colorado, and the CPI.

Vehicle registration revenue comprises two percent of local revenues.

Recommendation 9: Use CDOT OFMB's projections for HUTF and Vehicle Registration revenue.

c. Other State Revenues

Together with HUTF, the two state revenue streams are 98 percent of the state's contribution to local roads; 44 percent of total county funds used for local roads and 17 percent of total city funds used for local roads. The remaining two percent of state revenues used for local roadways are proceeds from several small state

programs that appear to be independent of each other. If this is so, then the causal variables involved are likely to be many and obscure.

If state revenues can be shown to contribute very little to the overall variance[5] in state revenues from year to year then they can be safely modeled as an aggregate time-series, without reference to causal variables.

Recommendation 10: Test the variance of other revenues against the variance of total state revenues and, if the appropriate statistical measures[6] permit, use a time-series model to forecast other state revenues.

2. Local Revenues

Cities and counties prepare revenue forecasts as a part of the normal budgetary process. Cities and counties also include revenue forecasts in their capital planning processes. In addition, Transportation Planning Regions (TPRs) also may prepare forecasts specific to transportation-related revenue. However, these local-level forecasts cannot be easily aggregated across the state since cities, counties, and TPRs do not follow the same guidelines in preparing these estimates. Generally, they use different model specifications (i.e., the relationships between the causal variables and revenues), different definitions of data, different base years, different forecast periods, and different assumptions (e.g., prices and discount rates).

Fortunately, CDOT has detailed information on city and county transportation-related revenues that date back over a decade. This information is useful because all cities and

[5] The variance of a set of data around the mean of the data is "the sum of squares": $\sigma^2 = \frac{\sum_1^N X_i^2 - \mu^2}{N}$

[6] ANOVA (Analysis of Variance) and covariance tests.

counties are required to file the same data, and all jurisdictions face the same reporting instructions.[7]

Forecasting from the information already submitted to CDOT in the revenue and expenditure reports would be far easier than adjusting disparate local revenue forecasts to ensure consistency. Also, the needs assessment methodology recommended here does not require forecasts for individual cities and counties.

Revenue and expenditure reports record revenues, which are the products of "volume," "value," and "tax rate." Tax rates are, as discussed above, are the results of public policy decisions that should be specified separately in any forecasting model.

Recommendation 11: Historical data for assessed values, mill rates, and other tax rates, covering the same period as the historical revenue data, should be assembled from municipal and state records, then used to adjust the historical revenue data for changes in those values and rates.

Recommendation 12: Use information collected through the revenue and expenditure reports, adjusted as recommended above, to project local revenues.

a. Property Taxes, Sales Tax, and Specific Ownership Taxes

Property tax, sales tax, and specific ownership taxes are, for both counties and cities, significant portions of total revenues and must be forecasted precisely.

All three of the revenues share common behavioral relationships in that the number of properties and transactions, and the value of those properties and transactions, are functions of household income, state population, and gross state

[7] Recommended Implementation Step 2 addresses the concern that local jurisdictions differ in their interpretations of the revenue and expenditure report instructions.

domestic product (GDP). Beyond these shared independent variables, however, there will be significant differences among them. Property taxes and specific ownership taxes are a tax on stocks of assets, while sales taxes are levied on a flow of transactions. The specific ownership taxes are tied to the ages of motor vehicles, so vehicle age cohorts must be forecasted.

A causal variable model is the preferred approach for each of these sources and, since they share common behavioral relationships, they may be able to share a common specification of some of their independent variables. However, each of property taxes, specific ownership taxes, and sales taxes will have other independent variables unique to it, and each will require a separate model.

Recommendation 13: Use causal variable models for property, sales, and specific ownership taxes.

Recommendation 14: Build separate models for each of property, sales, and specific ownership taxes with shared definitions for population, GDP, and household income.

b. Traffic Fines

Traffic fines comprise about four percent of city revenues. The accounting entity is the “penalties” times the “number of violations,” the latter of which is directly related to “vehicle-miles driven.”

Vehicle-miles driven can be measured directly from odometer readings, if this data is required by Colorado upon vehicle registration or title transfer, or it can be estimated from traffic management data such that collected by vehicle count loops. In the absence of such data, vehicle-miles driven can be estimated from its behavioral relationships with population and economic activity.

Recommendation 7: Use a causal variable model for traffic fines.

c. Other Local Receipts

As other revenues are comprised of several small and mutually independent revenue sources, a time-series model may be appropriate. Other revenues are, for cities especially, a significant portion of total revenues so care should be taken that a time-series model yields a very good fit with the historical data.

Recommendation 15: Use a time-series model to forecast other local receipts.

3. Federal Revenues

Revenues from federal sources comprise less than five percent of total local roadway funds. OFMB already projects city and county portions of federal funds. Those projections should be used in the new methodology.

Recommendation16: Use existing OFMB projections for federal revenues.

4. Private Contributions

Private contributions do not currently represent a large portion of money used for local roadways – they comprise about two percent of total county revenues and about five percent of total city revenues – but they are likely to expand as more communities adopt impact fees and other methods to recoup infrastructure required by new development.

Private contributions are, more often than not, “deal-driven”: specific and individual opportunities arise to involve the private sector in street and road development. These opportunities usually arise either in the form of transportation infrastructure

expansions required in support of private real estate or industrial development, or in joint private/public land use developments. When they arise from such individual opportunities, private contributions tend to occur as large but infrequent payments.

The highly individual nature of private contributions makes time-series analysis infeasible since there are no clear historical patterns. It also makes the likely causal variables, such as economic activity and population, generally poor predictors of joint development agreements. Better predictors of the tendency of joint development opportunities to arise may be more leading indicators of activity in the construction industry generally and in highway and road construction generally. In effect, the revenues from private contributions may be best modeled as a function of the level of investment by the state and local governments in transportation infrastructure.

Recommendation 17: Use a causal variable model in which private contributions are a function of state and local expenditures on transportation infrastructure.

F. Implementation Steps

The following steps should be taken in order to implement the recommended methodology.

- Step 1: Form a revenue forecasting committee.

  While it appears bureaucratic to begin an initiative with the formation of a committee, establishing ownership of and accountability for the forecast is critical to the forecast's ongoing success. The development and maintenance of forecasting models is a complicated business and the entity that owns the forecast must be responsible for it through each of the implementation steps laid out below.

  The entity that owns the forecast must be a committee since no amount of statistical sophistry can replace the common sense of people who "know the business." As is often the case in the forecasting of government revenues, what constitutes "the

business" is a wide variety of taxation areas and thus requires several people to bring their detailed knowledge together. There must also be committee members who are familiar with the applications and limitations of the statistical techniques.

The revenue forecasting committee should be appointed by the policy-level oversight committee overseeing the needs assessment program. Policy-level support will help ensure jurisdictional support for the revenue projections and mobilization of the resources required.

- Step 2: Review the data and improve the reporting process.

  The revenue projection methodology depends heavily on getting accurate information from revenue and expenditure reports. However, anecdotal evidence suggests that local governments differ in their interpretations of the instructions for completing revenue and expenditure reports.

  Improving the directions for the form, initiating training seminars (perhaps through Colorado Municipal League and Colorado Counties, Inc.), and spot checking a small percentage of reports would increase the consistency in the information from the reports. This could be done with a combination of on-site reviewing of financial information and checking against information collected by regional organizations, such as Councils of Government or Transportation Planning Regions. Detailed instructions for completing the form should be written specifically for Colorado's jurisdictions to help ensure consistency in reporting.

- Step 3: Specify the models.

  Causal variable models and time-series models, as recommended above should be developed with reference to the best practices of other states, the Denver Regional Council of Governments, and other organizations within Colorado. While models cannot be directly imported from another state or region, CDOT can be guided by the

models successfully used by others towards similar causal variables or functional forms.

- Step 4: Specify the assumptions.

  Some of the models may require that broad economic parameters, such as price levels or the levels of net migration to the state, be entered as external assumptions.

  In particular, public policy prerogatives such as the rates of taxation and the portions of revenue appropriated to particular uses should be separately and explicitly modeled as assumptions. Collecting data in some of the accounting entities, such as tax rates, will assist in keeping past public policy decisions from being embedded in the parameters of the models.

- Step 5: Test the models.

  In general, models can be tested by two means: the models can be calibrated with one set of data and used to forecast another set of data in the same time period, or the models can be run to "back-forecast" a year of actual data.

  To test models with two sets of data, models populated with revenue and expenditure report data can used to predict archived local revenue data kept by OFMB. It may be unclear whether any differences are due to forecast error or a mismatch in the definitions of the data.

  The more reliable approach is to "back-forecast" the most recent year of actual data. For example, the models could be calibrated with data from 1990 to 1998 and used to predict the revenues for 1999. Those projections could then be compared to the actual figures for 1999.

- Step 6: Run the models under varied assumptions.

  The forecast committee should not rely upon a single run of each model, under a single set of assumptions, to make forecasts. Rather, the committee should be confronted with forecast results for different values of the assumptions. This variety of results will encourage the forecast committee, as well as the executives who are ultimately responsible for the forecasts, to ponder the sensitivity of the forecasts to changes in the assumptions and to carefully choose the forecast upon which they will rely.

- Step 7: Run the revenue projection annually.

  While the revenue projections are intended for the statewide plan process, after the revenue projection methodology is developed, the marginal cost to run projections is not high. However, the revenue projections can be used annually for the legislative resource allocation policy discussion.

  It is in the repeated and ongoing runs of the forecast model where the committee's knowledge of the business is critical. No statistical model can anticipate all of the impending events in the business of which committee members will be aware. The forecast committee should not hesitate to adjust the forecasts for events that they expect and know the models cannot anticipate.

- Step 8: Compare actual revenues to projected revenues every year.

  In order to improve revenue projections, the methodology should be checked as frequently as possible. A record should be kept of the variances between the actual and projected revenue. Any large deviations should be examined, and the methodology should be adapted as needed.

Appendix A: Literature Review

■

Dye Management Group, Inc. contacted transportation planning officials from the following states:

- Alabama
- Arkansas
- Delaware
- Florida
- Georgia
- Idaho
- Indiana
- Kansas
- Kentucky
- Michigan
- Minnesota
- Mississippi
- Nebraska
- North Dakota
- Oregon
- Tennessee
- Virginia
- Wisconsin

This review found that several states have developed methodologies to assess local needs on a recurrent basis. However, it was more common for states to assess needs by a one-time special study. The results of the literature review are provided below.

A. State of the Practice

The following are some observations about the state of local roadway needs assessment practices:

- Few states have in place a systematic process for estimating local roadway needs. However, several states have contracted with consultants to provide special studies analyzing local need or local funding requirements (Arizona, Florida, North Dakota, Ohio, Oregon, and Washington, for example).

- Five states retain responsibility for more than 65 percent of their state roads (West Virginia, Delaware, Virginia, North Carolina, and South Carolina). Under these systems, where nearly all roads are considered state roads, the issues of coordinating needs assessment among different jurisdictions are minimized.

- Some states with varying geography and demographics have recognized "needs" as a flexible term. Rather than comparing all state roads to one standard, they have encouraged local input in defining need. Urban or well-populated areas are likely to have a different conception of needs than rural or sparsely populated areas. For example, a well-maintained gravel road is sufficient for some areas; for others, gravel roads are unacceptable.

- Widespread use of automated pavement management systems has made estimating pavement needs and evaluating improvement strategies less labor intensive. Where the same pavement management system is used at the local and state level, data integration is much easier and faster.

- Bridge needs, more than any other need, are driven by federal standards (sufficiency ratings). Federal inspection requirements ensure that available data is reasonably current and consistent for bridges over 20 feet.

B. Summary of Findings

1. Different motives exist for assessing local roadway needs.

The intent of local roadway needs assessment studies affects the methodology design and the interest level in the study results. Assessments of local roadway needs have been used to:

- Provide a basis for the disbursement of federal and/or state highway funding.

- Inform policy makers and the public on the condition of local infrastructure.

- Prioritize projects, given that needs outstrip current or potential funding.
- Increase highway funding from the state legislature.
- Comply with a statutory mandate.

These different purposes can lead to a desire to emphasize different aspects of a particular method. The study's purpose will also influence participation and enthusiasm at the local level. Local officials will be more likely to participate if the study will affect funding than if it merely complies with a statutory mandate.

2. Building and maintaining a computerized inventory of roadway conditions facilitates ongoing needs assessment.

Assessing needs usually involves comparing current conditions to a desirable outcome. Without an accurate picture of current conditions, this exercise is unlikely to be productive. A number of states have developed a computerized inventory, or database, of lane miles, cross-section, and pavement conditions. Maintaining a database allows easier manipulation of data sets; the marginal costs of running different needs or funding scenarios are minimized.

3. Data collection and integration pose financial and logistical challenges.

While some departments of transportation (DOTs) retain responsibility to collect data on local roadway conditions, others involve cities, counties, MPOs, and other local planning agencies or districts. Under the former scenario, the DOT can incur tremendous expense in field work, but having one entity collect all data helps ensure consistency of measurement.

The later collection method may reduce DOT field inspection expenses, but it also reduces consistency of measurement. In addition, coordinating data submittals among disparate entities is likely to be a difficult process. Each entity may collect, present, or store data in a different manner. The process of integrating incongruent data can be time-consuming and expensive.

4. Sampling is a key component of two statewide local roadway needs assessment methodologies.

Minnesota and Mississippi use sampling techniques to extrapolate measured conditions to the whole state. Sample analysis can be more accurate than collecting data on all roads and streets because quality control on the data can be much better. However, the methodology must develop strict standards to ensure that a robust, representative sample is taken. The methodology also should inspire confidence rather than skepticism from local officials.

5. Pavement management systems facilitate needs identification and, often, data integration.

Many different pavement monitoring/management systems exist. Centerline, PAVER, IRIS, and other popular systems often develop advocates in those who have become accustomed to working in that particular environment. However, most pavement management systems perform the same fundamental tasks. The systems maintain an inventory of pavement characteristics, forecast conditions, and recommend the most cost-effective investments in the pavement infrastructure. When different levels of government use the same or similar pavement management systems, integrating data is easier. (Wisconsin DOT, for example, is piloting a system of collecting pavement condition from local jurisdictions. While some jurisdictions use the same pavement management system, others will submit data in different formats. The DOT hopes to

gradually increase the number of jurisdictions using its pavement management system in order to reduce data integration effort.)

6. Roadway needs are overwhelming across the country.

Most special studies have reported roadway needs that far outstrip available (and often even potential) funding. Funding shortfalls exceeded $10 billion over 20 years in several states.

7. It is difficult to estimate the costs associated with implementing and sustaining a methodology for recurring needs assessments.

Those states with recurrent needs methodologies did not have a good handle on costs. Tennessee, for example, noted that the needs analysis it performs on state roads is included in DOT overhead. A Tennessee Department of Transportation (TennDOT) official noted that the Department's needs analysis requires about seven people, several computers, and many hours of time (including field work) to collect and compile the data. Other states did not know the costs of collecting and analyzing the data.

C. Methodologies Used for Recurrent Studies

1. Mississippi Department of Transportation

As a part of Mississippi's 1996 Statewide Plan, Mississippi Department of Transportation (MDOT) conducted a statewide needs analysis for the local system. (The same task in subsequent plans is completed by a contractor.) In order to conduct the study:

- MDOT stratified Mississippi counties into three population/revenue groups to select samples for reporting financial information to the Federal Highway Administration (FHWA) on Local Road Finance.

- Two counties for each group were selected.

- Minimum tolerable standards, construction costs, and maintenance costs were collected and compiled for local roads of each type (county and city). The minimum standards were determined through discussions with county and city engineers.

- Input data was collected on the local systems for the HPMS.

- The needs produced for these counties were expanded to statewide needs by first producing the needs for each stratum of counties and then summing statewide.

2. Wisconsin Department of Transportation (WisDOT)

WisDOT is currently working with its local governments (counties, municipalities, and towns) to integrate needs information on local pavement conditions. The local governments are evaluating roadway sections and are supposed to submit information to the state by December. (The DOT expects that several jurisdictions will fail to provide information.)

This information gathering has been in development for several years, and the DOT expects that the quality of data will get better as the system matures. (Though they have requested electronic data, they're expecting much will arrive in printed form. The DOT and several communities use PACER, or PACERware, which was developed by the University of Wisconsin, as a pavement management system. It is expected that the use of PMS will grow over the years.)

The intent of this exercise is to update the information every two years.

3. Minnesota Department of Transportation

In Minnesota, a needs study methodology is used to apportion state aid money to the counties and to cities over 5,000. (The methodology only applies to those roads eligible for state aid: between 20 to 50 percent of municipal or county systems.) It was developed in partnership between the local agencies and the Minnesota Department of Transportation in the late 1950s and has been modernized and updated annually ever since.

The method is based on adopted construction standards, with some assumptions built in, and is intended to establish proportionate relationships among the counties, in comparison with each other, and among the cities, in comparison with each other. One half of the money available to the cities and counties each year is apportioned on the basis of the needs study.

Each year, all the cities and counties have an opportunity to update the needs study data for each segment of street or highway covered by the study. A District State Aid Engineer reviews the updates conducted by the cities and counties and makes further revision based on consistent application of the study methodology. Then the State Aid personnel make the final review and incorporate the results in the apportionment process.

The needs study is used to some degree to extrapolate total dollar needs at various levels, including from time to time, the statewide planning and political processes.

4. Michigan Department of Transportation

Michigan DOT, in conjunction with the County Road Association of Michigan, is currently piloting a data collection activity including joint county/state participation in collecting road attribute and condition information on a limited number of roads (those eligible for Federal Aid).

If implemented statewide, the effort will result in a consistent data set which one can use to evaluate the federal aid system conditions without respect to whom owns the roadway. It will allow state and local units of government to establish system performance levels, and enable those governments to manage those roadway assets as one would find by following asset management principles. (Michigan DOT has abandoned the traditional "needs" approach where existing conditions are compared to some engineering standard.) Additionally, it will allow local agencies to switch to the modified approach for the purposes of GASB compliance, for which there seems to be considerable interest at the local level.

5. Tennessee Department of Transportation

Tennessee Long-Range Planning for highways is a statewide, 25-year analysis and project prioritization process that incorporates both MPOs and rural and small urban areas (SUAs). Central to the long-range planning process is an automated deficiency analysis program. Using the Tennessee Roadway Information Management System (TRIMS) database (which stores a complete inventory of the road including schematics, type of surface, and even photographs), the deficiency analysis program evaluates the performance of each highway/road segment on a five-year cycle. The program not only shows current deficiencies, but also determines when a deficiency will occur within the planning years. The program recommends the type of improvement and provides cost data. The system projects traffic volume increases for a specific county, city, and highway, using historical growth data. The system will soon consider accident rates, though they generally correspond with the level of service needs. Also in the future will be a tool that analyzes curves and grades.

In consideration of guidance in TEA-21 and Tennessee's desire to invest in its highway system as efficiently as possible, the DOT involves the rural/small urban areas in the long-range planning process. At present, the DOT is acquainting local officials and planners with the program and its capabilities in determining present and

future needs. The next step is establishing city-county committees that will act as intermediaries with local officials and provide TDOT with community concerns and recommendations. This enables TDOT to factor land use, urban growth projections, and other information into the process in addition to understanding local concerns and priorities.

Another aspect of the deficiency analysis process is the conduct of field reviews whereby planners physically check and assess state highways in each of the 95 counties.

6. Idaho Transportation Department

The Idaho Transportation Department uses the Local Roads Inventory (LRI), a systematic data gathering program on county roads in Idaho. On a seven-year cycle, in a specially equipped van, a crew drives each of the county roads, measures its length, notes its characteristics (roadway width, shoulder type, pavement type, etc.), notes roadway features (intersections, bridges, culverts, cattle guards, etc.), and collects GPS coordinates.

This data is used for mapping county roads and for creating a database inventory of the roads' characteristics. This updated data is sent to each county for their information. Traditionally, the data has been given in paper form. This year for the first time, the data was made available on CDs for the counties.

Although the state does not use the data for needs assessment, they make it available to the counties for their own purposes. Many of the state's more technology-friendly county leaders are employing consultants or their own staff to do their own inventory, data gathering, and GPS mapping functions.

D. Methodologies Used For Special Studies

A few states have conducted special studies to estimate needs.

1. Oregon Department of Transportation

In 1993, Oregon DOT, in conjunction with the Association of Oregon Counties and the League of Oregon Cities, produced a report on the financial needs of the state's entire road transportation system. Needs were defined as conditions that fall below minimum tolerable conditions (MTC), as established by FHWA and AASHTO. Highway Performance Monitoring System (HPMS) was used to analyze a sample from each functional class in each jurisdiction within Oregon.

The study notes that road needs studies determined in isolation of the rest of the roadway system, or according to a fixed level of service, tend to result in higher estimates of need. Therefore, roadway needs were estimated taking into account the plans and needs of the entire transportation system. Road needs were prioritized using a return on investment analysis. The following four priorities were set:

- Preservation of Oregon's road system investment.
- Safety improvements.
- Capacity expansion.
- Facility upgrades.

The study outlined funding requirements for each level of prioritization. Needs were estimated at $26 billion for the highest priority projects over 20 years.

2. Arizona Department of Transportation

Arizona Association of County Engineers (AACE) conducted an initial needs assessment study in 1994. The study has been updated twice, in 1997 and in 2000. Needs are identified as:

- Programs and projects to upgrade and maintain existing county roads to a logical and agreed upon set of planning guidelines.
- New construction of arterials, collectors, and bridges if the projects are identified as necessary by a rigorous planning process such as a regional metropolitan transportation plan, small area study conducted with Arizona Department of Transportation (ADOT) assistance, or county long-range transportation plan.
- Maintenance of subdivision roads, primitive roads, and operating expenses for administering the county road program.

Subdivision street construction, improvements to primitive roads, projects currently being let or under construction, and projects outside road construction and maintenance are not considered in the needs assessment.

AACE received roadway inventories from each county in a standard format. When AACE encountered a roadway segment that did not conform to criteria from planning guidelines, they used a specialized computer application to estimate the cost of improvements.

3. Florida Department of Transportation

The Center for Urban Transportation Research at the University of South Florida (CUTR) conducted a Statewide Transportation Needs and Funding Study in 1995. The study recognizes that “needs” are flexible, and often indicate different levels of service

provided by the transportation system. In the report, CUTR identified four policy alternatives and their corresponding need:

- **Maintain funding.** Spending is limited to the current funding structure, which only increases as the tax base increases, or as gas taxes are automatically increased.
- **Maintain conditions.** No limit is set on spending. Improvements are made in order to maintain conditions at the current level of service.
- **Maintain conditions with maximum lane policy.** No limit is set on spending. Improvements are made in order to maintain conditions at the current level of service, but lanes are capped according the Florida Department of Transportation (FDOT) policy. Money that would have been spent on extra lanes is shifted from roadways to alternate modes of transportation.
- **Improve conditions.** Conditions are maintained at current levels of service and all current deficiencies in physical condition as well as deficiencies in the levels of service, are corrected over a 20-year period. There is no limit set on spending and no limit on lanes.

Needs under these scenarios range from $84 billion to $147 billion. The funding shortfall ranged from $0 to $58 billion.

A separate 1997 CUTR report estimated the statewide funding shortfall by reviewing the financial shortfalls reflected in the state's 25 MPO long-range transportation plans. Compiling the information required CUTR to develop methods to integrate inconsistent data. For example, the 25 plans had different horizon years and cost estimates based on different base years. The study showed a funding shortfall of approximately $22 billion.

4. North Dakota Department of Transportation

In North Dakota's first attempt at assessing local needs, a private consulting firm conducted a study of 53 counties and 13 urban areas. (The firm is currently updating the study to include a sample of towns under 5,000 people and township roads.)

In the North Dakota study, each jurisdiction was asked to define the condition of their roads. (The theory is that the locals know what their area needs. Need varies – some accept a good gravel road, others would consider it intolerable.) Locals were further asked to provide the current annual funding levels for maintenance and capital improvements, the current frequency of capital improvements, "reasonable" annual funding needs to maintain existing conditions, and "ideal" annual funding needs to improve existing conditions to a sustainable level.

The study showed that "reasonable" funding levels to maintain current conditions was twice current funding levels. The "ideal" funding level was more than triple current funding. The study also computed a 1.8 benefit/cost ratio for the "reasonable" funding level and a 1.85 benefit/cost ratio for the "ideal" funding level.

5. Ohio Department of Transportation

In 1995, the County Engineers Association of Ohio Needs Study Committee prepared a brochure titled "Ohio's County Highways 2003," which was used to pressure the Legislature for an increase in the county tax revenue.

The study established the following standards for determining need:

- All roads should be at least 20 feet wide and resurfaced at least once every 10 years.
- Bridges with a Bridge Sufficiency Rating below 50 should be replaced.

- Bridges with ratings between 50 and 80 should be rehabilitated.

- Signs, guardrails, and pavement markings should be brought to state standards.

Much of the data required for analysis is downloaded from the state's inventory of county roads. The information is updated as it changes, but it is just an inventory, it does not reflect current pavement conditions. Bridge data is also updated every year. The marginal cost of performing the analysis is not great because the state is collecting data anyway. However, exact cost information is not readily available.

Appendix B: Previous CDOT Local Roadway Needs Assessments

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Colorado Department of Transportation (CDOT) has examined local roadway needs on three prior occasions – once in 1988, again in 1990, and finally in 1997. While the approaches used before have strengths upon which a new methodology can be built, they also had significant shortcomings. Most importantly, CDOT and local authorities did not establish an ongoing process for monitoring and periodically updating the statewide assessment of local roadway needs assessment. The problems, issues, and concerns noted during the previous attempts have not been resolved. Today, almost 14 years after the first needs assessment, the department is facing the same issues.

This section provides an overview of the previous local roadway needs assessments and some of the strengths and weaknesses of the approaches. Suggestions are made to address each weakness.

A. Description of Previous Assessments

1. 1988 Assessment

In 1988, the state legislature's Highway Legislation Review Committee (now the Transportation Legislation Review Committee) requested that CDOT include local roadway needs in its update to the 2001 Surface Transportation Needs report. Due to the lack of a statewide planning process for local needs, CDOT relied on different methods to obtain the building blocks of its needs estimate. CDOT split needs into three categories: roadway deficiencies, bridge needs, and maintenance and operations needs.

- **Roadway deficiencies.** The federal Highway Performance Monitoring System (HPMS) was used to estimate needs for arterial and collector roadways surface condition, capacity requirements, and geometric/safety requirements. The existing number of roadway samples was used, though they were only 70 percent of the federally recommended sample size.

To estimate needs on the sub-collector system, only surface condition was evaluated. These estimates relied on generalized deterioration and costing formulas, in addition to the expertise of local representatives.

- **Bridge needs.** The CDOT bridge inventory was used to estimate the number of structurally deficient and functionally obsolete bridges. An annual deterioration rate was applied to project deficiencies over the forecast period.

- **Maintenance and operations needs.** Revenue and expenditure reports, submitted to CDOT annually by cities and counties, were used to estimate maintenance and operations needs.

Three alternative service levels were generated for each of three categories of need: high, medium, and low. Total projected needs were the high service level; medium represented progressively lower service standards and costs; and low represented still lower service standards and costs than medium. For example, for roadway capacity, high represented 80 percent lane miles improved, medium was 60 percent, and low was 40 percent. For Maintenance and Operations expenditures, the three levels represented three different inflation assumptions: 2.5 percent, 0 percent, and -5 percent.

2. 1990 Assessment

In 1990, the state legislature requested that CDOT update its local roadway needs assessment. CDOT considered four options for the update:

- The existing approach used in 1988.
- Municipal and county surveys.
- Methods used by other states.
- An expanded HPMS program.

The following is a description of CDOT's findings regarding the four options. As described below, CDOT chose to use a modified version of the 1988 approach.

a. The existing approach used in 1988

Described above, this method consisted of separating needs into three categories: roadway, bridge, and maintenance and operations. Data sources included the HPMS, generalized deterioration and costing formulas, local representative expertise, the state bridge inventory, and annual revenue and expenditure reports.

The method's primary drawback was that the existing HPMS samples were well below the level recommended by the FHWA. For example, existing state highway sections sample had a deficiency of 273 sections; arterials and collectors, 291 sections; and sub-collectors, 255 sections. The shortages in sample size would reduce the level of confidence in the estimate.

b. Municipality and county surveys

This approach would rely on designing a survey to obtain information on the needs of various municipalities and counties based on road and bridge deficiencies. Surveys would specify the threshold levels of what constitutes a need; counties and municipalities would make a judgment as to which elements of their system meets those criteria.

This approach is subjective because it relies mainly on the judgment of the staff involved in producing the numbers. For simple situations such as current conditions, reasonable predictions can be made about when and what type of treatments would be needed, using age, climate, and usage as a guide. For intricate situations where future demand is not obvious and where performance forecasting is fairly complex, the survey approach is less reliable.

c. Methods used by other states

CDOT surveyed a select number of states on how they assess roadway needs. CDOT concluded from the survey that:

- Other state experiences were parallel to those of Colorado.
- Estimates of the needs for a one- to five-year range were more reliable than long-term (ten or more years).
- There was no dominant method for estimating local needs.
- Most states dealt with the issue on an ad-hoc basis.
- 100 percent inventories of state roadway systems do not necessarily produce consistent and valid data and are costly to collect and maintain. (Most states supported statistical sampling methods application, provided that the methodology allows for input from locals regarding variations in criteria, standards, and unit costs.)

d. An expanded HPMS program

CDOT collects information on a sample basis for HPMS that is mandated by FHWA. This option would expand the sample size for HPMS and use it to estimate needs on local roadways.

As noted in the summary of the existing approach, CDOT's HPMS sample collected for the purposes of reporting to the federal government on the federal-aid eligible system is not large enough to use estimate needs on the higher functional class county and city facilities. The data for the missing observations would need to be collected in order to complete the HPMS file and render the process viable. Collecting this data would require increased CDOT effort, local data collection, or hiring an outside contractor. When completed, the sample would be much more reliable.

CDOT presented its review of methodologies to the state legislature for their review. It recommended that the 1988 approach be used to estimate needs. However, CDOT stipulated that a method for estimating new roadway needs was necessary. CDOT supported the use of the Denver Regional Council of Government's system, which uses a ratio of population to roadway miles for urban areas. For small urban and rural areas, CDOT recommended using a simple historical trend analysis of population and road mileage.

3. 1997 Assessment

CDOT completed its first statewide plan in 1995. Although the plan contained a summary of local roadway needs from the 1988 effort, participants in the planning process identified the summary as a serious deficiency that needed to be corrected prior to the 1997 plan update.

Working with a sub-committee of the Statewide Transportation Advisory Committee (STAC), and representatives from Colorado Counties, Inc. (CCI) and the Colorado Municipal League (CML), the Department developed a simple methodology for projecting local roadway needs at the transportation planning region (TPR) level. The methodology utilized a spreadsheet format and addressed needs in the following categories:

- Surface condition needs.
- Reconstruction needs.
- Bridge needs.
- Maintenance and operations.
- Projected new roadway miles (differentiated for local government versus private developer construction responsibility).

The spreadsheet methodology and supporting data (e.g., projected new roadway miles by TPR, and some preliminary unit cost data) were provided to each Regional Planning Commission (and their respective consultants) at the start of the regional planning process. As the regional plan update process was concluding, CDOT began aggregating the local roadway assessments from the TPRs and recognized anomalies in the information. For instance, categories of needs fluctuated widely between similar TPRs. In addition, when the TPRs local roadway needs were aggregated to a statewide level, participants in the process lacked confidence that the aggregated total sufficiently represented the overall needs, particularly when compared to individual county and municipal needs.

Unable to use the needs assessment generated from the 1997 methodology, local needs were again represented in the updated 2020 Statewide Transportation Plan relying on the 1988 assessment and updated anecdotal information from various county and municipal needs assessments. CDOT agreed to continue pursuing a better methodology for local roadway needs assessment prior to the next statewide plan update.

B. Strengths of the Previous Assessments

The previous assessments had three strengths:

- **Using different procedures for estimating different components of the needs**

  The flexibility of the approach allowed the usage of different procedures to estimate the needs for various components depending on their information availability and the ability to meet their then constraints. For example, the methodology used HPMS data for some roadway needs, bridge inventory data for bridge needs, and existing financial reporting to estimate maintenance and operations needs.

- **Taking advantage of existing full inventory data**

  For some circumstances, using a full inventory of measured conditions provides more accuracy than a sample. For example, the federal government requires current, accurate condition information for bridges to be maintained at the state level.[8] The information is complete and reliable for estimating system quality needs, although other methods are needed for assessing mobility and safety needs and to compensate for existing shortcomings.

- **Avoiding imposing a heavy workload on local authorities**

  In all three assessments, CDOT was sensitive to adding administrative burdens to the local government. The previous assessments relied heavily on existing information (HPMS, surface condition reports, bridge inventories). In 1997, CDOT requested input from local experts, which represents much less effort than requesting that local governments collect data and analyze it all over again.

C. Shortcomings of the Previous Methodologies

There were four major problems with previous local roadway needs assessment methodologies:

[8] However, the bridge database only accounts for "major bridges," or those greater than 20 feet in length.

- Need was not clearly defined.
- Needs were not well categorized.
- Sampling techniques lacked validation, especially for decision-makers.
- Collected data was inconsistent and unreliable.

1. Need Was Not Clearly Defined

The three assessments did not specify the criteria or the trigger thresholds that define a need.

a. Defining need

There are many different approaches to defining need. One approach is to compare existing conditions to established engineering and design standards. Differences between existing conditions and established standards, or deficiencies, are then identified and costs to bring conditions up to standards are calculated. This definition of need is usually referred to as "total needs." However, a community could tolerate some deficiencies, such as narrow roads, and postpone improving those roads until more critical conditions occur (e.g., surface conditions deterioration). The total needs method of estimating needs usually represents unrealistically large numbers.

Another approach is to define needs as the "minimum tolerable conditions" below which deficiencies become unacceptable. Such needs represent the bare minimum that must be spent in order to maintain safety and avoid litigation. This definition of need can be referred to as "basic needs." This approach does not guarantee the most efficient lifecycle cost, nor does it guarantee the protection of the value of the asset.

A third way to look at needs is plan driven. In this approach needs are defined as the improvement needed to accomplish objectives for the transportation system as defined in a transportation plan. Under this definition, conditions are assessed against network-wide condition/performance targets set during the planning process. A reasonable set of standards or targets needs to be developed and approved by local decision-makers, before the estimation process starts; once approved this set becomes the guide for local technical staff to gather information and analyze needs. Examples include:

- Level of service equal to or higher than Level D.
- An average network condition of 75 PCI or higher.
- Congestion travel as a percent of total travel not exceeding 15 percent.
- Backlog of expansion not exceeding 8-10 percent.

These types of targets can be varied with facility class, location or visibility of the facility. The procedure of estimation becomes driven by a set of acceptable standards not only from the technical and operational side, but also from the policy side.

2. Needs Were Not Well Categorized

One potential problem with the reported figures in the past attempt is in the way the needs were categorized. They were categorized simply as roadway, bridge, or maintenance and operations. Although this classification is administratively efficient, it does not lend itself to policy debates on how much impact, in what area, a certain spending would buy.

a. Alternative categorization methods

Another way of categorizing needs is to match them to different policy objectives. For example, CDOT's 2020 statewide plan takes an outcome-based approach, which separates needs into "investment categories" that identify performance measures and gauge progress toward goals set by the Transportation Commission. Local needs can be similarly categorized:

- **System Quality**

  System Quality projects preserve the taxpayers' investment in the roadway and avoid unnecessary expenditures over its lifecycle. For example, the current system needs to be maintained and kept operational in order to ensure usability. Summer maintenance is needed so that the small localized problems (such as potholes and pavement buckling) that pose a threat to safe driving are minimized, if not totally removed. Winter operations are needed for the treatment of snow and slippery conditions to ensure the motoring public can use the road safely in winter. When roads deteriorate, renewing the infrastructure by resurfacing or reconstructing the road is needed so that the taxpayer investment in the asset is preserved and unnecessary expenditures are avoided over the lifecycle of the assets.

- **Safety**

  Safety projects modify the existing system by adding new physical features or signs and zone paintings to enhance the safety of the motoring public. Examples include intersection improvements, truck climbing lanes, passing lanes, lighting, and signing of hidden intersections.

- **Mobility**

  Mobility projects expand the capacity and/or improve the operational efficiency of the existing infrastructure. On the physical infrastructure side, mobility projects include widening existing roads or building new ones in order to accommodate future growth and development, keep people and goods moving, and avoid gridlock in urban centers. On the management side, mobility projects include applying Travel Demand Management (TDM) methods and intelligent transportation systems (ITS) to ensure that the physical infrastructure is optimally used and its needs are minimal.

Breaking down needs by policy objective yields two advantages. Needs are separated into smaller components and are clearly designated towards specified objectives, hence benefits. Second, needs are broken down into categories more conducive to policy discussion on trade-offs among the various objectives.

3. Sampling Techniques Lacked Validation, Especially for Decision-makers

When sampling techniques are used, decision-makers can have difficulty accepting the validity of generalizing from a sample (relatively few observations) to the overall population. CDOT's HPMS sample is smaller than the federally recommended sample size, which pose an additional challenge to convincing decision-makers of its validity.

- **Building trust in sampling mechanisms**

  The viability and validity of sampling techniques should be proven in order to increase confidence in the methodology. One way to do this is to pick a random sample from full inventory data and estimate the needs based on the approved set of criteria. This need can then be compared with the actual summary obtained

from the full inventory data. The two results are compared and the level of confidence of the sampling technique is specified.

4. Collected Data Was Inconsistent and Unreliable

When earlier attempts to estimate local roadway needs involved gathering information from local sources (such as surface condition and lane mile costs), varying availability and precision levels existed. For example:

- Some communities had more reliable and complete data than others. Invariably this led to many subjective decisions regarding the estimation of needs for those communities with less reliable or complete data.
- Availability of key data used for roadway assessment (for example, traffic counts and condition information) varies greatly among different local jurisdictions.
- Variation in criteria, unit costs, and richness of solutions among different communities makes them difficult to compare.

a. Ensuring reliability of data

During the design of a statewide needs assessment methodology, attention should be focused on data reliability. For example,

- Sampling methodologies should ensure that a large enough sample is selected to meet pre-selected confidence levels.
- Surveys should be designed to remove subjectivity.
- Care should be taken so that there is no confusion about the data being collected.

- Units of measurement, scales, and dates should be agreed upon before data collection begins.

Appendix C: Resource Estimates for Alternative Recommendations

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Minor Bridges – Alternative 4a. Survey of Jurisdictions to Measure Needs Assessment Methodology – Conditions and Quantity Needs

System Element	Work Breakdown	Statewide Needs Assessment Resource	Local Jurisdictions
Minor Bridges Inventory	1. Establish technical detail and prepare self-survey guidance package.	60	Participation in Technical Committee meeting.
	2. Communicate and train local jurisdictions to administer self-survey through four training sessions.	120	Attendance at training sessions.
	3. Conduct self-survey.		8 – 40 hours per jurisdiction.
	4. Administer survey, tabulate results, and ensure completeness.	160	
	Total	**340**	
Minor Bridges Condition Assessment	1. Establish sampling strategy.	16	Participation in Technical Committee meeting.
	2. Develop condition assessment approach, prepare survey guidance.	60	
	3. Train jurisdictions with qualified engineering staff or derive from their existing databases. (four training sessions).	80	Attendance at training sessions.
	4. Conduct self-survey.		24 – 80 hours per jurisdiction
	5. Administer and coordinate self-survey and/or consistent extraction of data from local databases.	120	

System Element	Work Breakdown	Statewide Needs Assessment Resource	Local Jurisdictions
	6. Provide engineering support to undertake quality assurance through independent assessment of a sample of self-surveys.	120	
	Total	**396**	
Minor Bridge Needs Assessment	1. Use condition assessment and survey data to establish aggregate condition profile.	40	
	2. Define improvements required to address estimated aggregate deficiencies.	40	Participation in Technical Committee meeting.
	3. Develop unit cost information by region by treatment type using bid price data.	80	Participation in Technical Committee meeting.
	4. Apply unit costs to define needs backlog.	40	
	5. Use inventory data to estimate preservation (system quality) needs.	60	
	Total	**260**	
Total Resource Estimate		**996**	

Arterial Needs Assessment Methodology, Alternative 5a – Expanded HPMS Sample – Data Collection and Needs Quantification

System Element	Work Breakdown	Statewide Needs Assessment Resource	Local Jurisdictions	CDOT
Arterial Condition Data Collection and Needs Assessment: **- Backlog** **- Recurring needs** **- Mobility needs** **- Safety needs**	1. Validate sampling assumptions and finalize sample strategy.	80	Participation in Technical Committee meeting.	80
	2. Train data collection crew.	8		40
	3. Collect, process and input expanded sample.	1,600		
	4. Prepare data set and conduct HPMS (AP) analysis. • Run model under different revenue scenarios to show effects of increase in needs backlog due to underfunding.	80		80
Total Resource Estimate		**1,800**		**200**

Methodology for Maintenance and Operations (System Quality) Needs Assessment: Alternative 6a – Establishing Condition-Based Maintenance Needs Baseline

System Element	Work Breakdown	Statewide Needs Assessment Resource	Local Jurisdictions	CDOT
Bridges and Roads	1. Establish sampling strategy using road mileage data.	40	Participation in Technical Committee meeting.	
	2. Establish maintenance activities and features to be included in analysis, e.g., guard rail, pot hole patching, blading, etc.	80	Participation in Technical Committee meeting.	
	3. Prepare technical detail and prepare self-survey guidance package.	80		Coordinate with CDOT to establish as applicable consistency with CDOT maintenance level of service approach.
	4. Communicate and train sample of jurisdictions to administer self survey through 4 training sessions.	80		
	5. Conduct self-survey.	16	32 to 80 hours per jurisdiction sample	
	6. Conduct quality assurance in sample jurisdictions.	160		CDOT maintenance could further support quality assurance.
	7. Process data and establish maintenance condition baseline.	120		
	8. Establish agreed maintenance target service levels by maintenance activity, jurisdiction, and functional class. Establish maintenance unit costs.	80	Participation in Technical Committee meeting.	
	9. Compute and report maintenance needs backlog and annual maintenance needs.	60		
Total Resource Estimate		**716**		

Methodology for Maintenance and Operations (System Quality) Needs Assessment: Alternative 6b. – Time-series model to estimate annual maintenance and operations (system quality) needs based on expenditure history

System Element	Work Breakdown	Statewide Needs Assessment Resource	Local Jurisdictions	CDOT
Roadways and Bridges	1. Assemble local jurisdictions' annual revenue and expenditure reports.	24	Participation in Technical Committee meeting.	Provide revenue and expenditure reports.
	2. Develop the model and specify any assumptions.	60		
	3. Enter data and develop profile of expenditure by maintenance activity across all jurisdictions.	120		
	4. Run and test the model.	40		
	5. Project annual and future maintenance and operations expenditures. Report as annual and future needs.	40		
Total Resource Estimate		**284**		

Methodology for Maintenance and Operations (System Quality) Methodology Alternative 6c – Survey cities and counties on their recurring system quality needs based on expenditure history

System Element	Work Breakdown	Statewide Needs Assessment Resource	Local Jurisdictions	CDOT
Roadways and Bridges	1. Develop survey form and detailed instructions for city counties to estimate maintenance and operations expenditures.	80	Participation in Technical Committee meeting.	
	2. Administer surveys.	80		
	3. Complete surveys.		4 hours per jurisdiction	
	4. Enter data and compile needs from surveys.	120		
	5. Report as needs.	40	Participation in Technical Committee meeting.	
Total Resource Estimate		**320**		