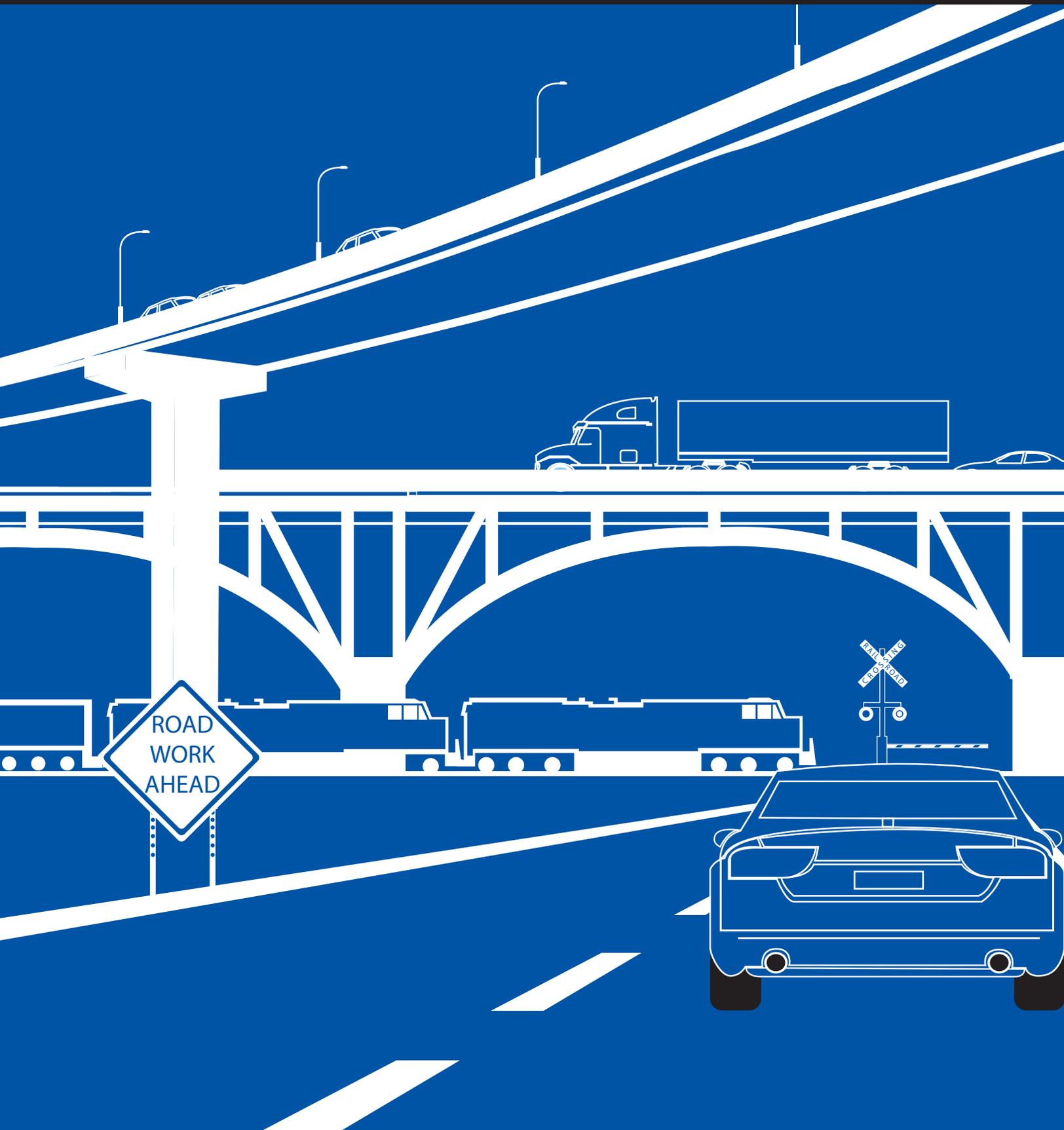




KYTC Maintenance Field Operations Guide Supplement

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Research Report
KTC-20-18/SPR18-563-1F

KYTC Maintenance Field Operations Guide Supplement

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16. Abstract The Kentucky Transportation Cabinet (KYTC) is tasked with managing an asset portfolio that includes over 27,500 miles of roadway and 9,000 bridges. Keeping these assets in sound condition demands significant effort from KYTC's Division of Maintenance, which includes activities ranging from mowing and litter pickup to cleaning out culverts and performing emergency roadway work. Despite the immense responsibilities shouldered by Maintenance personnel, until this project the Cabinet's 12 districts lacked a systematic method for capturing and recording maintenance activities. Through a series of workshops held in each KYTC's district with Section Engineer and Maintenance Supervisors, researchers at the Kentucky Transportation Center (KTC) facilitated efforts to inventory routine maintenance activities, document how frequently each activity is done, and capture the ways in which maintenance functions are adjusted in response to special projects (which generally receive priority over general maintenance functions). Key products of this research include a Statewide Maintenance Calendar, which defines — based on a combination of stakeholder feedback and statistical analysis — optimal time intervals for undertaking key maintenance activities, as well as district-specific maintenance calendars. Having recourse to these calendars will help district staff more efficiently plan, schedule, and coordinate maintenance functions.			
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Executive Summary

The Kentucky Transportation Cabinet (KYTC) oversees a sprawling network of roadway and bridge assets that carry millions of tons of freight and facilitates both intra- and interstate travel. Maintaining over 27,500 miles of roadway and 9,000 bridges requires significant effort from the Division of Maintenance. A robust maintenance program judiciously protects taxpayer-funded infrastructure by preserving the transportation network in a condition that facilitates safe and efficient travel for all residents. The maintenance program also supports current and prospective businesses by providing access to a reliable transportation system that fosters economic growth.

Maintenance issues vary across KYTC's 12 highway districts — and are continually evolving. When new roads are constructed and other changes are made to the built environment, for example, a district's maintenance functions will need to be revisited and revised. However, districts lack a systematic method for capturing and documenting the changing nature of their maintenance activities. Nor do districts have recourse to a procedure that ensures necessary maintenance is conducted efficiently and methodically. In recent years, a key factor in the growth of maintenance challenges has been the emergence of special projects that occur from time to time and which tend to be prioritized over general maintenance functions. Maintenance results are sub-optimal when special projects materialize, if general maintenance functions are undertaken using a disorganized approach, and when there is a lack of awareness of a county crew's core functions.

This goal of this project was to help each Cabinet district prepare a maintenance work plan for county crews that includes an inventory of reoccurring or routine maintenance activities, identifies how frequently they are done, captures how maintenance functions can undergo changes when special maintenance projects emerge, and which lays the groundwork for prioritizing maintenance requests. To this end, Kentucky Transportation Center (KTC) researchers conducted 24 workshops across the 12 highway districts (two in each district) to better understand maintenance priorities. One workshop was for Maintenance Supervisors while a second included Section Engineers.

Participants in both workshops were asked to list all the actions they perform or assign as a part of their job in maintenance for that district. Once these lists were developed, participants worked through a calendaring exercise to determine how frequently staff members would conduct and/or assign the maintenance activities under ideal conditions — where materials, staff and funding are available to conduct the needed maintenance activity in a consistent and ongoing basis. Actions were grouped into one of these frequencies: *Daily*, *Weekly*, *Bimonthly*, *Monthly*, *Quarterly*, *Biannually*, and *Annually*. In several districts two additional frequencies were identified: *As Needed* and *Never*. Participants also assigned a level of importance to each of the actions. They ranked actions on a scale from 1 to 9, with 1 being the most important action and 9 being the least important action.

Results varied across districts, however, the research team was able to piece together a *Statewide Maintenance Calendar* (Table E1). For some activities, a broad consensus emerged, which made it easy to locate them on the calendar. When consensus was lacking among districts regarding how often a specific activity should be performed, researchers undertook cluster analysis and assigned the activity to the median time interval. District-specific calendars were also developed, which

contain activities unique to each district (see pp. 80-92). With access to these calendars district staff can improve their scheduling and coordination of critical maintenance activities.

Table E1 Statewide Maintenance Calendar

Daily	Weekly	Bi-Weekly	Monthly	Quarterly	Every Six Months	Yearly	Seasonal	As Needed
Administrative Duties	Pothole Patching	Culverts and Pipes Cleaning	Inventory and Stockpile Material	Paver Machine or Grader Patching	Evaluations		Snow and Ice Removal	Accident Response
Respond to Citizens Concerns/ Complains	Ditching		Shouldering				Mowing	Emergency Flagging/Traffic Control
Litter Cleanup, Express Run	Litter Cleanup							Emergency Roadway Work
Flagging/Traffic Control for Others	Equipment Service							Repairing Cross Drains
								Dead-Animal Pickup
								Sign Maintenance / Replacement of Signs
								Repair to Landslides And Sinkholes

Chapter 1 Introduction

1.1 Study Overview

The Kentucky Transportation Cabinet's (KYTC) mission is *to provide a safe, efficient, environmentally sound and fiscally responsible transportation system that delivers economic opportunity and enhances the quality of life in Kentucky*. The agency manages over 27,500 miles of roadway, including over 9,000 bridges. Additional assets include 200,000 acres of right of way along with traffic signals, roadway lighting fixtures, traffic signs, guardrails, rest areas, weigh stations, and cross drains, among others.

Annually, Kentucky's transportation network carries over 800 million tons of freight valued at nearly \$580 billion,¹ while drivers travel over 48 billion miles on the state's roads.² A robust maintenance program safeguards taxpayer-funded infrastructure by preserving the transportation network in a condition that facilitates safe and efficient travel for all residents. The maintenance program also supports current and prospective businesses by providing access to a reliable transportation system which promotes economic growth.

The maintenance issues confronted by KYTC's 12 highway districts vary. When new roads are constructed and other changes are made to the built environment, for example, a district's maintenance functions will need to be revised. But districts lack a systematic method for capturing and documenting the changing nature of their maintenance activities. Nor is there a procedure to ensure that necessary maintenance is conducted efficiently and methodically. One reason for these issues has been the emergence of *special projects* that occur from time to time and which tend be prioritized over general maintenance functions. Maintenance results are sub-optimal when special projects materialize, if general maintenance functions are undertaken using a disorganized approach, and when there a lack of awareness of a county crew's core functions.

1.2 Research Objectives

This project sought to help each district develop a maintenance work plan for county crews. Work plans include an inventory of routine maintenance activities, their frequency, and describe how maintenance functions may be adjusted when special maintenance projects arise. This report inventories district maintenance and operations functions to establish baselines for level of effort and meeting performance targets. Additionally, it lays the groundwork for the Cabinet to develop a method for prioritizing maintenance and operational needs.

1.3 Structure of the Report

Chapter 2 explores literature related to maintenance scheduling, prioritization, and methodologies. Chapter 3 reviews the ambit of KYTC's Maintenance Division and some current information sources. Chapter 4 examines policies, guidance, and other published resources from selected state transportation agencies. Chapter 5 explains the twelve district workshops conducted with maintenance personnel and the results of those workshops. Finally, Chapter 6 summarizes the study results and presents some items for consideration.

1

http://transportation.ky.gov/Planning/Documents/Freight%20Planning/Freight%20Plan/2016%20KYTC%20Freight%20Plan/KentuckyFreightPlan_ExecSummary_FINAL_Sept2016.pdf

² <https://www.fhwa.dot.gov/policyinformation/statistics/abstracts/2015/state.cfm?loc=ky>

Chapter 2 Literature Review

This chapter provides a brief overview of literature related to maintenance scheduling, prioritization, and methodologies. Much of the literature on maintenance focuses on different approaches to preserving pavements, bridges, and other infrastructure. Some research has dealt with optimizing scheduling and funding to manage maintenance needs as efficiently as possible. Instead of reviewing all possible methods for conducting maintenance activities, we initially focus on the importance of maintenance before moving on to discuss work about programming and scheduling guidance. These portions of the literature are most salient for this project.

A state transportation agency's (STA) maintenance function generally encompasses maintenance and operations. Wu et al. (2012, p. 1412) noted that "Since the 1960s, highway agencies in the U.S. have gradually moved from a focus on expansion to one on preservation." *Maintenance* is the routine care of infrastructure. Before an STA rebuilds, rehabilitates, or conducts preservation projects, it routinely executes fundamental tasks to optimize the highway network's condition. Included among these tasks are patching potholes, repainting roadway lines and markings, cleaning debris from water runoff ditches, washing salt off steel bridges, mowing, and picking up litter. *Operations* refers to all tasks that keep highway traffic moving. Operational items include activities such as plowing and salting roadways; preserving signs, traffic signals, and roadway lighting in a state of good repair; removing dead animals in the roadway; and repairing damaged guardrails.

Maintenance is an important function of STAs. While other functions such as construction and rehabilitation are perhaps more visible, maintenance preserves current infrastructure in a state of good repair. The Federal Highway Administration (FHWA) differentiates between maintenance, routine maintenance, and preventive maintenance.³ *Maintenance* "describes work that is performed to maintain the condition of the transportation system or to respond to specific conditions or events that restore the highway system to a functional state of operation." *Routine maintenance* is work "performed in reaction to an event, season, or over all deterioration of the transportation asset." Finally, *preventive maintenance* is "a cost-effective means of extending the useful life of the Federal-aid highway."

An STA's maintenance function is critical for ensuring that the transportation network operates safely and effectively. As the transportation networks agencies are responsible for managing have grown, maintenance has become an integral part of keeping roads and bridges safe and in a state of good repair. With technological advancements redefining how transportation networks are maintained and managed, routine maintenance entails the regular upkeep of legacy networks as well as the effective deployment of new technologies. When agencies neglect upkeep of their assets, they deteriorate more quickly, often to the point where the only viable choices are rehabilitation or replacement, which are more expensive options. Infrastructure that is routinely cared for remains in better condition longer. Maintaining assets in good condition extends their service lives and provides other benefits such as improved safety, fewer constituent complaints, less demand for expensive replacement projects, and improved traffic flow with fewer construction work zones.

³ <https://www.fhwa.dot.gov/preservation/memos/160225.cfm>

Burningham and Stankevich (2005) cited several reasons why maintenance is important. Foremost among these is that delaying maintenance drives up future maintenance costs or leads to even greater expenses for rehabilitation or replacement. Additionally, they noted that drivers suffer increased economic burdens when they are forced to operate their vehicles on roads in poor condition. They divide maintenance into categories: routine, which are minor activities such as mowing and pothole repair; periodic, which demands more time and labor-intensive activities such as sealing; and urgent, which encompasses anything that requires immediate attention, such as landslides. Burningham and Stankevich also provided several strategies for ensuring maintenance is a priority. When agencies focus on a core network of roads with high traffic counts, these roads inevitably receive sufficient maintenance attention. Next, agencies should clearly define who is responsible for maintenance, involve all stakeholders and coordinate approaches, and have standards for road maintenance. Maintenance plans should also give consideration to assets besides roads (e.g., bridges, signs, sidewalks). Finally, agencies need to establish clear objectives and plans for conducting maintenance given their level of funding. Maintenance needs should be addressed as soon as practicable because each day of delay adds to the overall cost.

Chang et al.'s (2017) scenario⁴ analysis showed the impact of delayed maintenance manifests through “decreases of asset group condition over time; decreases of asset groups’ remaining life; increases in agency costs in future years to recover the desired level of service; increases in backlogged costs over time; and decreases in asset value over time” (p. 1). STAs often struggle with the allocation scarce maintenance dollars. A critical issue they face is determining the effects of maintenance strategies on asset performance and service life (Chang et al. 2017, p. 3), which can instruct how maintenance is prioritized and funding allotted.

If maintenance activities are delayed, costs increase (Hicks et al. 2000), potentially leading to more extensive rehabilitation or even replacement of assets. But undertaking maintenance too soon may result in unnecessary expenditures. As Zimmerman and Peshkin (2003, p. 3) contended, “preventive maintenance programs are cost-effective because they slow the rate of pavement deterioration, essentially delaying the need for major rehabilitation activities by several years.” Needs-based budgeting is often used when performance data and prediction models are insufficient (Wu et al. 2008). Analyzing budgetary trade-offs between infrastructure types, Gharaibeh et al. (2006) demonstrated, using a case study from central Illinois, that decision makers are risk-averse and drawn toward projects and activities that most significantly impact safety and are publicly visible (e.g., bridges and intersections).

Pavements are among agencies’ most important assets and require long-term planning for maintenance. Fwa et al. (2000, p. 367) described pavement management in the following way:

An ideal pavement management program for a road network is one that would maintain all pavement sections at a sufficiently high level of service and structural conditions, but require only a reasonably low budget and use of resources, and not create any significant adverse impacts on the environment, safe traffic operations, and social and community activities. Unfortunately, many of these are conflicting requirements.

⁴ Scenarios included do nothing, delayed maintenance, and budget-driven maintenance; for a summary of Chang et al.’s scenarios across asset groups see Table 32, p. 63.

Balancing these priorities and requirements can apply to maintenance activities generally, however we focus first on pavements. Several approaches to pavement maintenance and management are reviewed in the following paragraphs.

Pavement Management Systems (PMSs)^{5,6} are used often to identify areas for improvement and for prioritizing projects (Gurganus and Gharaibeh 2012, Wang et al. 2003). Agency goals are evaluated using a needs analysis (no budget constraints) and impact analysis (how funding will impact the network) (Haas et al. 1994, Smith 2002). Grivas et al. (1993, p. 25) pointed out that “Most PMSs include specific methodologies for characterizing pavement condition, identifying treatment options, predicting condition, and evaluating the economics.” PMSs have several benefits (Zimmerman and Peshkin 2004, p. 13):

- Enhanced planning ability at all levels, including strategic, network, and project;
- Decision making based on observed and predicted conditions rather than opinions; and
- Ability to generate alternative scenarios of pavement conditions based on different budget projections or management approaches.

Observing that a key feature of all PMSs is the development of maintenance priority rankings, Ramadhan et al. (1999) sought to understand how stakeholders rank the importance of maintenance activities. They surveyed various stakeholders (e.g., academics, highway and pavement maintenance department officials, engineers, qualified non-pavement individuals, and ordinary road), asking them to rank the importance of factors such as pavement condition, traffic, ride quality, safety, cost, classification, and overall importance of the road to the community. They found that the priority receiving the highest weight was pavement condition, followed by safety, community importance, classification, traffic, and cost.

STAs use a variety of methods to prioritize pavement preservation projects (Gurganus and Gharaibeh 2012). Gurganus and Gharaibeh (2012) developed a decision support tool that uses six parameters (p. 38) to rank pavement preservations projects:⁷

1. Visual distress
2. Average daily traffic
3. Current truck average daily traffic
4. Condition score
5. Ride quality
6. Section that receives most in-house maintenance

Applying their approach to a case study of a Texas Department of Transportation district indicated the results matched the actual prioritization decision 75 percent of the time. When projects match using the authors’ method, transportation officials will be able to validate their decisions. If results do not align with traditional methods, officials can potentially refine priority lists.

⁵ See Frangopol et al. (2007)

⁶ For more on pavement management practices in some STAs see: <https://www.fhwa.dot.gov/asset/pubs/hifl1035/hifl1035.pdf> and <https://www.fhwa.dot.gov/asset/pubs/hifl1036/hifl1036.pdf>.

⁷ For more on pavement scoring methods and performance measures see Papagiannakis et al. (2009).

Positive impacts of preventive maintenance programs for pavements include (Zimmerman and Pehskin, 2004, p. 14; Zimmerman and Peshking, 2003, p. 4):

- Delaying the onset of cracking
- Improving smoothness and surface friction
- Reducing moisture penetration
- Greater customer satisfaction
- Ability to make better-informed decisions
- More appropriate application of maintenance techniques
- Improved pavement conditions
- Increase in safety
- Reduction in overall costs

Combining preventive maintenance activities and pavement programs yield benefits as well (Zimmerman and Peshkin 2003). Zimmerman and Peshkin (2004, p. 20) listed several steps STAs can use to integrate maintenance activities and pavement programs.

- Examine current capabilities in key areas where integration is likely to take place, including pavement-condition data collection, performance modeling, and treatment selection.
- Based on the information presented here, identify the gaps between current practices and needs.
- Develop a plan for implementation. The plan should address changes that will fill the integration gaps and the questions of whether and how any interim changes will be addressed.

Gao et al. (2012) analyzed maintenance issues as a bi-objective problem (see also Wu and Flintsch 2009), focusing on pavement condition improvement and budget utilization. They found the most effective way to identify optimal solutions was through use of a parametric method. Similarly, Guignier and Madanant (1999) developed an approach to optimize maintenance and (capital) improvements, which are generally treated separately due to having different goals and budget allocations. However, efficiencies could be realized if tradeoffs between the two are calculated. Using a Markov decision model for joint optimization the authors found that savings can be realized through joint optimization and budget management.

Denysiuk et al. (2017) used a two-stage approach to address pavement maintenance in an effort to optimize scheduling, particularly for large networks. During the first stage, pavement sections within a network are collected and analyzed using a multi-objective approach; in the second stage, maintenance schedules for those sections are combined to develop an optimal maintenance plan. Validating this approach on a sample of Portuguese highways, the framework proved useful, indicating it could be used across other infrastructure asset types. Wu et al. (2008) leveraged a multi-objective approach to develop a decision-support model that considers maximization of service life and minimizing total cost, which helps support a needs-based budgeting approach to maintenance. Other researchers have also recognized that prioritizing pavement projects involves a number of potential goals and limitations, attesting to the benefits of using a multi-objective approach (Wu and Flintsch 2009, Fwa et al. 2000, Denysiuk et al. 2016, Wu et al. 2012).

Various analytical approaches such as multiple-criteria analysis, optimization techniques, performance measures and targets, benefit-cost analysis, decision trees, algorithms, and integer programming have also been used in attempts to prioritize pavement and other maintenance projects (Šelih et al. 2008, Frangopol and Liu 2007, Robelin and Madanant 2008, Medbury and Madanant 2014, Deshpande et al. 2009, Guerre and Evans 2009, Nuwirsii et al. 2006, Papagiannakis and Delwar 2001, Abo-Hashema and Sharaf 2009, Chan et al. 1994, Li et al. 1998, Wang et al. 2003). Cafiso et al.'s (2002) multi-criteria analysis identified five criteria that affect maintenance budget allocations: comfort, environment, safety, agency costs, and user costs. Chang et al. (2017) listed factors related to connecting maintenance and asset performance to consider (p. 3):

- Current asset condition;
- Timing of maintenance activities;
- Changes in asset condition created by the maintenance activity;
- Asset design features (e.g., materials, functionality, reliability);
- Performance measures;
- Communication needs (e.g., with funding entities);
- Expected levels of service;
- Mechanisms of deterioration over time;
- Expected asset service life; and
- Factors affecting the remaining asset service life (e.g., traffic volumes and loads, environmental conditions).

Hegazy (2006) examined different approaches to maintenance delivery, including conducting maintenance in-house, using contractors, and a combination of both. Scheduling models using variables for in-house maintenance consider the availability of labor, work location sequencing, and time and cost associated with travel from one site to another. Hegazy observed that (p.26):

An efficient delivery execution plan... is one that schedules the work at each site when its productivity is highest. As such, the execution order of various sites needs to be optimally decided, considering the time and cost of transporting resources from one site to the other.

Figure 1 (Hegazy 2006, Figure 2, p. 27) shows a breakdown of maintenance and repair projects with the best fit best in each category. Hegazy's approach allows for the use of outsourcing to develop cost-effective plans for maintenance and assists with deciding where and when the use of outsourcing can minimize costs.

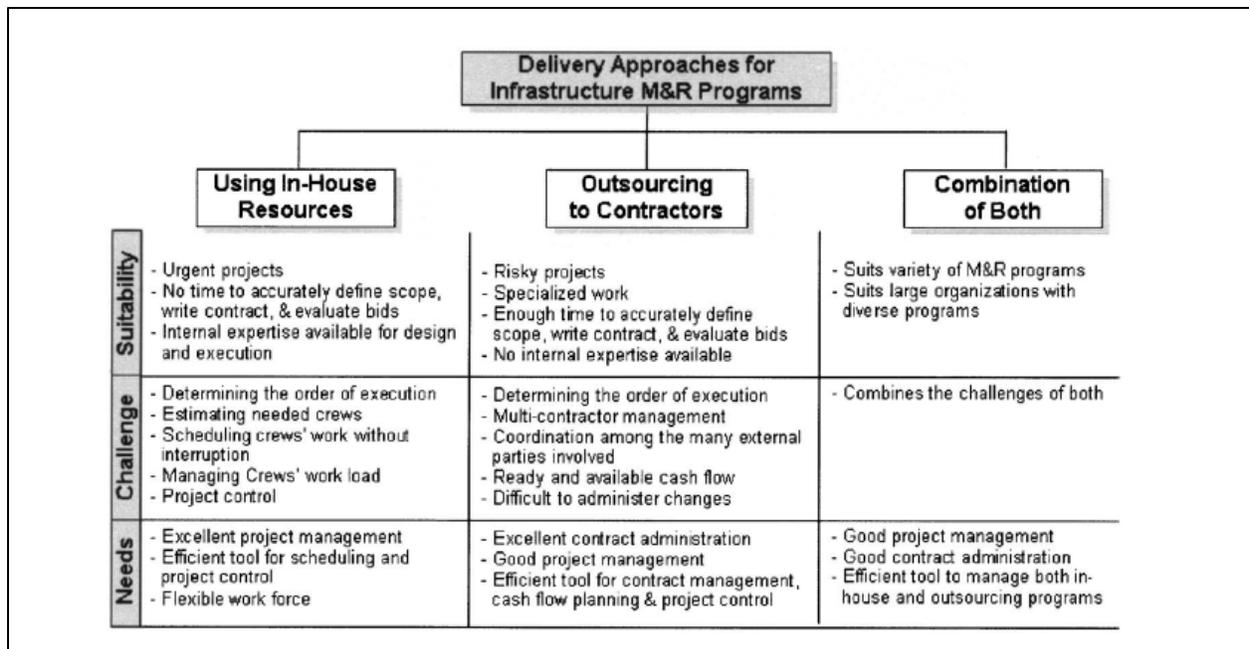


Figure 1 Delivery Approaches for Maintenance and Repair Programs

Moruzo et al. (2017) developed a method to rank Virginia’s transportation structures based on their importance to the highway network and the state’s economy. The scores are termed *importance factors* (IFs), but they are not related to the condition or age of the structure in question. Not developed to exclude other measures such as age or condition, IF scores provide additional information to policymakers to consider as part of an overall formula approach: “The new formula incorporates independent, normalized, dimensionless variables that address functionality, risk, importance, condition (health index), and cost-effectiveness” (p. 20). Such information could be used help prioritize maintenance budgets. A key conclusion from the report was that:

The IF score can be employed in conjunction with other tool scores that are based on physical condition data and cost-effectiveness to inform decision makers about which structures most justify priority funding and which structures are relatively less competitive for those funds (p. 28).

Similar to pavements, bridge management systems have also been developed (Thompson et al. 1998, Hawk and Small 1998, Miyamoto et al. 2000, Patidar et al. 2007). Pontis is likely the most recognizable example as it used by most STAs (Frangopol et al. 2001). Bridge management systems help STAs prioritize bridge maintenance needs and choose the most cost-effective option (Thompson et al. 1998, Hawk and Small 1998).

Key functions of bridge management include the establishment of optimal investment funding levels and performance goals for an inventory of bridges, as well as identification of the appropriate combinations of treatment scope and timing for each individual bridge over its life cycle. (Patidar et al. 2007, p. 1)

Patidar et al. (2007, Table 1, p. 20) developed a set of bridge management goals and corresponding performance measures that can be used to evaluate activities (Table 1).

Table 1 Bridge Management Goals and Performance Measures

Goal	Performance Measures
Preservation of Bridge Condition	a) Condition Ratings (NBI 58-60, 62) b) Health Index c) Sufficiency Rating
Traffic Safety Enhancement	a) Geometric Rating/ Functional Obsolescence b) Inventory Rating or Operating Rating
Protection from Extreme Events	a) Scour Vulnerability Rating b) Fatigue/Fracture Criticality Rating c) Earthquake Vulnerability Rating d) Other Disaster Vulnerability Rating (Collision, Overload, Human-Made)
Agency Cost Minimization	a) Initial Cost b) Life-Cycle Agency Cost
User Cost Minimization	a) Life-Cycle User Cost

Researchers in Ohio developed the Ohio Bridge Condition Index (OBCI), an assessment tool for bridges (Fereshtehnejad et al., 2017). Using state bridge databases, the index “evaluate[s] bridges at the element, component, bridge, and network levels and reflect[s] the impact on the condition of the system of existing defects as well as maintenance, repair, and replacement actions for the condition enhancement of individual elements” (p. 152). Implementation costs of maintenance, rehabilitation, and replacement are considered along with structural and service failure costs. Providing usable information about bridge conditions assists with devising budget allocations, effective maintenance and replacement schedules, and communications with stakeholders, including the public.

Noting that the “main objective of a bridge manager is to find the best maintenance plan for a group of bridges, or bridge components, over a prescribed time horizon” Neves et al. (2006a, p. 1005) developed a multi-objective analysis for bridge maintenance. The results showed that feasible solutions to managing bridge maintenance were possible when considering preventive maintenance and more extensive maintenance activities across a group of bridges. Liu and Frangopol (2004, 2005) also adopted a multi-objective approach that factored in bridge condition, safety, and cost. Morcoux (2007) used Pareto analysis to optimize bridge preservation decisions in a way that minimizes life-cycle costs while maximizing bridge conditions, while Neves et al. (2006b) considered different maintenance plans including preventive activities as part of their approach.

Chang et al. (2017) established a framework for quantifying the impact of delayed maintenance on performance. Maintenance is typically delayed because of a lack of funding, investment policies that shortchange maintenance, a short-term planning horizon, the inability to quantify the effects of delayed maintenance, and a lack of reports targeted at proper decision makers. Step one of their framework is to define the asset preservation policy, which includes identifying the maintenance needed, performance metrics, and how maintenance decisions are made. Step two is determining maintenance and budget needs. This step requires condition assessments, forecasting conditions, and identifying maintenance activities to meet objectives, which speaks to a focus on prioritizing maintenance activities and linking scheduling to performance metrics. Assessments vary across

transportation assets and agencies, with different points of emphasis such as determining when the level of service falls below a certain threshold or performance measures are not being met (see Table 2, p.12 for examples). Chang et al. listed expected service life and inspection frequencies for common assets (Table 1, p.11). Pavement inspections are recommended annually, bridges and signs every 1-2 years, pavement markings biannually, culverts greater than 10 feet every 1-2 years, and concrete boxes every four years. While inspections are not necessarily a scheduling tool, they can identify areas that require further maintenance attention, thus allowing prioritization and scheduling efforts to be more informed while potentially matching to performance measures. Chang et al.'s framework incorporated needs analysis as well, which helps identify maintenance activities needed to meet certain targets or goals. Conducting needs analysis can help agencies prioritize and schedule various activities to achieve desired results. Chang et al. envisioned using their process to integrate asset preservation into an overall asset management process (see Figure 2), which relies on defining policy, needs, and analyzing the impacts of different maintenance approaches.

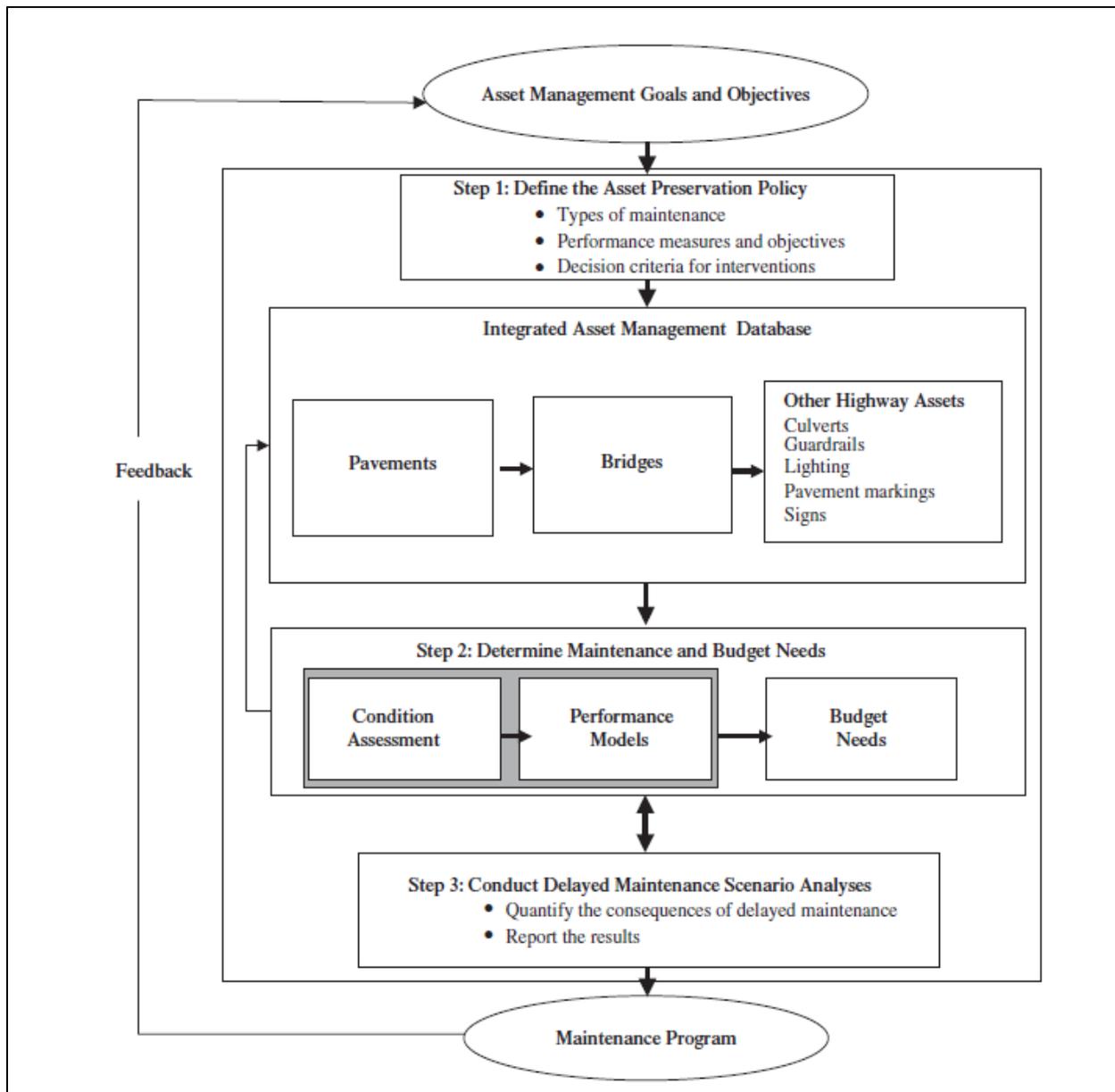


Figure 2 Asset Management Process⁸

Selecting performance measures for different asset classes can also produce valuable feedback on how maintenance activities are scheduled and prioritized. Chang et al. listed performance measures in their Appendix C that may be considered by when measuring the effectiveness, need, and frequency of various maintenance activities. Figure 3 presents a summary of strategic and network-level reports.

⁸ Source: Chang et al. (2017), Figure 4, p. 20

Performance Measure Report Category		Pavement	Bridge	Culvert	Guardrail	Lighting	Pavement Marking	Signs
Asset condition		✓	✓	✓	✓	✓	✓	✓
Remaining service life		✓	✓	✓			✓	
Agency costs		✓	✓	✓	✓	✓	✓	✓
Asset value		✓	✓	✓	✓		✓	✓
Sustainability ratio		✓	✓	✓	✓	✓	✓	✓
Sustainability and users' costs ¹	Safety (e.g., accident costs)	✓	✓					
	Mobility (e.g., travel time, operating costs)	✓	✓					
	Environmental (e.g., CO ₂ emissions)	✓	✓					

Figure 3 Performance Measures for Transportation Assets⁹

Deciding when maintenance is needed can hinge on pre-scheduled times and certain performance triggers that are tied to asset condition. Models designed to predict asset condition yield valuable data about potential future maintenance needs, which can also be evaluated against performance metrics.

Preserving transportation infrastructure in a good state of repair is an important function of STAs. Maintenance programs help realize this goal by keeping infrastructure safe and extending its service life. Literature on maintenance focuses on the various management programs and objectives used to optimize scheduling and funding under certain conditions. Existing literature and models do not, however, account for special projects that arise and the fact that citizen complaints may receive the highest priority. The next two chapters review KYTC districts' current approaches to managing maintenance activities and the methods used by other states to organize and schedule maintenance activities. Understanding strategies used by other states helps contextualize the Cabinet's current practices and potentially generate ideas for improving its approach to maintenance.

⁹ Source: Chang et al. (2017), Table 34, p. 64

Chapter 3 KYTC Maintenance Background and Current Approach

3.1 Background

KYTC's Maintenance function encompasses maintenance and operations as defined in Chapter 2. Maintenance and operations are the responsibility of the Department of Highways' Project Preservation units, which include the Division of Maintenance, the Division of Traffic Operations, and the district staffs dedicated to preservation. KYTC's Division of Maintenance contains five branches that cover corresponding maintenance and operations activities: Bridge Preservation, Operations and Pavement Management, Roadway Maintenance, and Roadside Maintenance and Permits. Bridge Preservation manages bridge inspections, bridge repairs, weight restrictions, bridge maintenance, the management program, and evaluates bridges on the Extended Weight Coal Haul Program.¹⁰ Operations and Pavement Management handles data collection that provides information on the condition of assets, system performance, and maintenance budget needs. This branch houses several additional programs, including the Maintenance Rating Program (MRP), Operations Management System (OMS), Sign Management System (SMS), Pavement Management, and Intelligent Transportation Systems (ITS).¹¹

Roadway Maintenance attends to road maintenance contracts through the Contracting Section and Field Maintenance Section. Some of these include the statewide resurfacing program, pavement rehabilitation, new guardrail program, coordination of emergency and disaster work, statewide coordination of slip and slide repairs, and statewide waterborne striping among others. Additionally, Roadway Maintenance works with district staff to review citizen concerns pertaining to state roadways.¹² Roadside Maintenance personnel focus on areas between the road and fence as well as winter weather response. The Roadside Maintenance Team oversees vegetation management programs, rest areas, and snow and ice activities, including salt, environmental waste management, and guardrail recycling. It also assists districts with setting up contracts for inmate crews to perform roadside management support along state rights of way.¹³ Finally, Permits reviews requests for road access and work on rights of way. Staff review and implement policies for utility installations; entrances and other correlated roadway modifications; altering or replacing existing drainage facilities; plantings on the right of way; replacing right-of-way fencing; locating facilities on rights of way; requests to conduct fairs, parades, festivals, banners, and welcome signs on rights of way; and new school site proposals on or near state roads.

The Division of Traffic Operations also provides maintenance and operations management and support throughout the state. Its three branches are Traffic Engineering, Systems Operations, and Traffic Design Services. The Traffic Engineering Branch provides statewide expertise and support for district requests regarding the proper application of traffic control devices and has primary responsibility for developing and implementing the Highway Safety Improvement Program. The System Operations Branch is responsible for the development of traffic signal timing and communications systems, while the Traffic Design Services Branch supports the development of traffic signal design plans.¹⁴

¹⁰ <http://transportation.ky.gov/Maintenance/Pages/Bridge-Maintenance.aspx>

¹¹ <http://transportation.ky.gov/Maintenance/Pages/Pavement-and-Operations.aspx>

¹² <http://transportation.ky.gov/Maintenance/Pages/Roadway-Maintenance.aspx>

¹³ <http://transportation.ky.gov/Maintenance/Pages/Roadside-Maintenance.aspx>

¹⁴ <http://transportation.ky.gov/Traffic-Operations/Pages/default.aspx>

KYTC’s maintenance budget for fiscal year 2017 was programmed for \$347.5 million; it increased slightly to \$349.1 million for fiscal year 2018.¹⁵ However, as Albright and Gibson (2017) noted, inflation has steadily eroded the maintenance budget’s purchasing power, which impacts KYTC’s ability to perform some activities and influences the frequency of others. This does not include funding sources that affect infrastructure conditions such as the federal bridge replacement and state resurfacing programs. Table 1 (Albright and Gibson, 2017, p.10) details some of the various maintenance activities covered by the maintenance budget.

Table 2 Description of Maintenance Categories

Snow and Ice – Training driver simulations, calibrating equipment, preparing equipment for winter, in-house labor and equipment during winter storms, salt and calcium chloride materials, and payment for contractor support.
Bridge maintenance – Equipment, labor and materials needed to complete minor repairs such as joint sealing, concrete patching, waterproofing, steel cleaning and patching, and cleaning debris on and around the structure (bridge inspection and larger maintenance projects are funded separately).
Mowing – State forces and equipment as well as contractor support for mowing and trimming.
Drainage – Cleaning and repairing pipes under the pavement and under access points, cleaning culverts, reestablishing roadside ditches, and pump station maintenance. Cut and grade high shoulders to allow water to properly drain from the roadway and to prevent water from creating false ditches immediately adjacent to the pavement structure, add and grade materials to low shoulders to eliminate pavement edge drop-offs.
Rockfall/Landslide – For minor rockfalls and landslides: the material, labor and equipment necessary to remove the debris, as well as protect and reestablish the slope (major slips and slides that require a geotechnical analysis will typically be funded separately).
Tree/Brush – Pruning or removing trees and shrubs along the right of way, treatment of stumps to prevent regrowth, and removal of trees that may originate off right-of-way but present a danger to the traveling public.
Litter/Debris/Sweeping – Contractor payments, inmate crew support, removal of animal carcasses and other debris on the pavement, and sweeping debris from the roadways and shoulders.
Weed Control – Spraying for noxious weeds listed in and as required by KRS 176.051, spraying herbicide around guardrail, training and calibration on proper use of the pesticide equipment, and other spraying as needed for vegetation control.
Guardrail Repair – Repairs made to longitudinal guardrail, crash cushions and end treatments by state forces or by contractors. Reimbursement is sought when the damage is the result of a known crash. However, those funds cannot be restored to the maintenance budget and are deposited to the general road fund instead.
Rest Areas – Custodial efforts and landscape management either by state forces or contractors and the inspection of work performed by contract (does not include utility expenses, larger repairs, and weigh station services).
Pavement Patching – Patching beyond potholes, such as strip patching and milling, for both the driving lanes and the shoulders.
Potholes – Pothole repairs on the driving lanes and shoulders.
Striping – Restriping work on the edge lines and lane lines.
Signs – Fabrication and installation of replacement sheeting and panel signs, either by state forces or contractors (does not include signs contained in construction contracts).

¹⁵ <http://transportation.ky.gov/Budget-and-Fiscal-Management/Documents/General%20Assembly%20House%20Bill%20304.pdf>

Signals and Lighting – Traffic signals and controllers, roadway lighting, overhead changeable message signs, navigation lighting, and aviation lighting.

3.2 Current Approach to Maintenance Activities

KYTC has three guidance publications to help plan the work of maintenance crews:

- *Field Operations Guide*,
- *Maintenance Guidance Manual*,
- and the Maintenance Rating Program.

Each document assists district managers with directing work needed in the coming year and deciding on the best method of execution.

Per the *Maintenance Guidance Manual*, the Department of Highways “maintain(s) all roads, streets, and bridges that are or have been accepted into the State Highway System by official order of the Secretary.” To fulfill that requirement, the Department staffs 124 county-level maintenance crews (three counties have more than one crew). A variety of specialized crews within in each district perform more specialized maintenance duties (e.g., traffic signal, signs, bridge, and roadside crews). County crews offer a broad spectrum of support for the 100-400 roadway miles they are assigned. These crews address maintenance that are not delegated to special crews or a contractor within their geographic area of responsibility. While those responsibilities vary throughout a year and may differ among districts based on factors such as topography and geography, there are several duties that are similar in both how they are conducted and how frequently they are needed. Most of those similar duties are outlined in the Cabinet’s *Field Operations Guide*, a policy manual dedicated to the consistent performance of those similar responsibilities.

When crews perform a maintenance activity, the date(s) of performance, roadway sections treated, labor power, and materials and equipment needed to accomplish the task are captured in the Cabinet’s Operations Management Software (OMS). OMS does not provide guidance but is the common reporting standard for maintenance work. The Cabinet is frequently asked to provide the amount of money spent on various activities or in a specific geographic area. The use of OMS lets Cabinet personnel respond to those requests quickly and confidently. Documenting this information also helps Highway Department determine how and where resources are being used. As the Cabinet implements asset management practices, having reliable data on where and at what cost regular maintenance is done, will help it provide the anticipated outcomes based on the budget provided.

The Maintenance Rating Program (MRP) catalogues maintenance work outcomes by documenting whether the Cabinet is meeting expectations for various maintenance categories. It provides a window into whether crews are doing enough work on various types of activities. But it does not offer guidance on when or how frequently to perform an activity. While the MRP is a statistically valid snapshot of the Cabinet’s maintenance activities, it only provides high-level direction on work programming.

3.2.1 Field Operations Guide Manual (FOG)

The FOG lists 81 activities and groups them into 13 major categories of work. Some of the 81 activities are similar but differ slightly based on whether state forces or a contractor performs the work. Several activities must be done to preserve roadway safety and are undertaken as soon as the Cabinet is made aware of the need, (e.g., snow and ice operations, repairing damaged guardrail or a break in the pavement). Other activities are important and can be scheduled around those critical activities based on seasonal priorities.

The FOG outlines many factors to consider when scheduling routine maintenance activities. The entry for each activity includes the following information:

- A written description,
- The typical crew size,
- Equipment needed,
- Procedures for how the work should be completed,
- How the activity will be entered in OMS,
- Recommended materials,
- Environmental considerations associated with the activity, and
- The typical funding source for the activity.

Beyond maintenance operations applied directly to roadways, the FOG also contains training activities and activities required to maintain environmental compliance on maintenance lots. Within each category, there is generally a miscellaneous activity code used for activities done so infrequently they do not require a pre-assigned activity code. While there is information on performing and documenting the activities, the only information on when or how often to perform them is a scheduling description, which accounts primarily for weather-related restrictions.

3.2.2 Maintenance Rating Program (MRP)

The Maintenance Rating Program (MRP) is a systematic measurement process that uses roadway condition surveys to support maintenance planning decisions. KYTC has used the MRP since 1997 to gauge, for 23 outputs of maintenance work, whether it is meeting its internal expectations and motorist expectations. Each year, the Cabinet gathers data for approximately 4,000 500-foot road segments. This number of segments offers a statistically valid snapshot of the condition of the state's roadways and therefore the quality of maintenance work done at the statewide and district levels. The final score for each 500-foot road segment evaluated is based on a cumulative assessment of the 23 outputs. The highest possible score for each segment is 100. Overall the Cabinet strives for a collective score of 80. Every three years there are sufficient new data to generate a statistically valid representation of county-level performance. To perform data collection, staff in each district are trained on how to collect the data; a field guidebook illustrates of how to calculate scores for each category. Approximately 10% of the segments are checked by Division of Maintenance staff to ensure consistent data quality and grading statewide. At the highest levels MRP data can provide guidance on tasks maintenance crews may need to focus additional effort on in the coming year. Likewise, it indicates areas where the maintenance forces may be striving for (and attaining) a higher level of service than is cost-effective.

Final performance scores are compared to customer expectations (based on customer surveys). KYTC uses results from the customer survey to calibrate the weights and performance goals in the MRP scoring process to align with the value taxpayers accord to various components. Conducted in 2010, the most recent survey indicated customers assign the highest priority to pavement surfaces, signs and markings, and roadside drainage. The highest perceived maintenance needs (which are given the highest weights) were signs, guardrails, and striping while the lowest were pavement surfaces, shoulders, and drainage.

3.2.3 Maintenance Guidance Manual

The *Maintenance Guidance Manual* contains policies related to the activities county crews perform. According to Section 205 of the manual, “Maintenance crews shall perform the following functions as directed (and in varying degrees) on all roads and rights of way on the state-maintained system in each assigned territory.” Section 205 describes 18 areas of responsibility and the activities to be done under the auspices of each. Section 207 directs maintenance employees to perform several formal and informal inspections. Informal inspections primarily consist of staff being attentive to conditions within their area of responsibility and reporting deficiencies to the Section Engineer so that corrective work can be scheduled. The Division of Maintenance performs the following formal inspections: cross drain and culverts, pavement inspections on Parkway and Other Non-Interstate Controlled Access Facilities, interstate conditions, and highway fill dams. Bridge inspections are undertaken primarily at the district level with annual reporting, quality assurance reviews, contract assistance and larger team inspections being initiated at the Division of Maintenance. Despite this guidance, many daily and weekly maintenance activities are dictated based on complaints, management-based priorities and the weather or other emergency response generators. Some attempts have been made at scheduling maintenance activities. Figure 4 shows an example of a weekly schedule provided to the research team by a former maintenance engineer.

WEEKLY CREW SCHEDULE

CREW #	Total Crew:					WEEK OF:					Scheduled By:													
	Job #1				Job #2				Job #3				Job #4				Job #5							
Day of Week	Planned vs. Actual	Act Code	Crew Size	Route Number	Accom	Act Code	Crew Size	Route Number	Accom	Act Code	Crew Size	Route Number	Accom	Act Code	Crew Size	Route Number	Accom	Act Code	Crew Size	Route Number	Accom	Remarks		
Monday	Planned																							
	Actual																							
Tuesday	Planned																							
	Actual																							
Wednesday	Planned																							
	Actual																							
Thursday	Planned																							
	Actual																							
Friday	Planned																							
	Actual																							
Alternate	Planned																							
	Actual																							
Alternate	Planned																							
	Actual																							
Alternate	Planned																							
	Actual																							

Figure 4 KYTC Weekly Maintenance Crew Schedule

Chapter 4 State Approaches to Routine Maintenance and Inspections

To deepen our understanding of how state transportation agencies around the U.S. execute, organize and implement their maintenance programs, we conducted a review of policies, guidance, and other published resources of select agencies. Although the maintenance programs of all state agencies were briefly examined, we limit our discussion in this chapter to five, which were selected based on the accessibility and completeness of their information and relevance to this project. Our focus stayed fixed on routine maintenance activities throughout, and that is what this chapter reports on. Routine maintenance encompasses activities such as patching potholes; rejuvenating striping and other pavement markings; sign installation and repair; inspecting and clearing pipes, culverts, and drainage outlets; and vegetation management; among others. Most agencies regard winter maintenance operations (e.g., snow and ice removal) as part of their routine maintenance program. As this is not a primary emphasis of this project, material regarding winter maintenance has been omitted. For each state, we discuss the divisions and personnel responsible for conducting maintenance, note key guidance documents, describe their procedures for scheduling maintenance activities, and present an overview of inspection programs that inform maintenance. While some agencies conduct some maintenance activities at regular intervals, others do not. The latter generally carry out maintenance activities in response to inspection results, or they are done on an as-needed basis. Most agencies, to some extent, tie their maintenance agenda to their inspection programs. Where available, scheduling intervals are included in the following narratives and tables.

4.1 Utah

At the Utah Department of Transportation (UDOT), all managers in the Maintenance Division, from the Director of Maintenance to Station Supervisors, are responsible for “[providing] the planned level of maintenance service in a manner that places continuing emphasis on the economic utilization of personnel equipment and materials.” The agency’s published guidance documents review its approach to maintenance. The most detailed information is found in the *Station Supervisor’s Maintenance Handbook* (hereafter SSMH) and the *Maintenance Management Quality Assurance Plus Inspection Manual*¹⁶.

The SSMH contains targeted guidance for Station Supervisors on the maintenance planning process, scheduling maintenance activities, and activity standards. UDOT has adopted a five-step, semi-cyclical process for planning and scheduling maintenance activities. The steps include: 1) planning, 2) identifying work needs; 3) scheduling activities; 4) following the accepted schedule; and 5) updating specific work needs. All annual work needs are planned for in the Annual Work Program, which is put together by Station Supervisors, Area Supervisors, and Maintenance Engineers. During the planning phase, a monthly activity schedule is created and stored in UDOT’s Operations Management System (OMS). Next, Station Supervisors identify work needs from a review of various sources, such as the approved annual work plan and budget, semi-annual inspections, complaints, field reviews, MMQA+ reports (see below), and OMS work requests. Scheduling maintenance activities is a three-step process. First, Station Supervisors enter the station work plan into the OMS. Information entered in the system includes the activity, required labor, equipment and materials needed, and anticipated outcome. Once Station Supervisors input station work plans into the OMS, Area Supervisors are responsible for coordinating station

¹⁶ See UDOT (2012) and UDOT (2017) for more detailed information.

schedules according to priorities and resources available within the area. After they obtain approval from Area Supervisors, Station Supervisors prepare and distribute work schedules. The fourth step in planning and scheduling maintenance is following the schedules. While a schedule should be hewed to as closely as possible, Station Supervisors have the discretion to rearrange schedules if exceptional circumstances warrant doing so. For example, accidents; hazardous weather; emergencies; unsafe roadway conditions or a change in the availability of staff, equipment, or material may compel schedule changes. Lastly, schedules are updated each week to reflect a station's current needs. Again, Station Supervisors are responsible for these updates and Area Supervisors are tasked with approving them. UDOT deems scheduling efforts a success if between 75 and 80 percent of scheduled work is completed as planned and on time. The SSMH also contains practical tips in its section on scheduling focused on improving workflows and optimizing the use of assets and resources (see UDOT 2012, pp. 8-10).

The second portion of the SSMH contains activity standards for all maintenance tasks crews may be required to perform. Section Supervisors are instructed to review activity standards carefully and adjust schedules and work assignments according to project context. For example, the number of planned crew members could be revised upward or downward in response to travel distance, special safety requirements, unique traffic control needs, or idiosyncratic job site requirements. All maintenance work should conform with the activity standards, although there may be some occasions where deviations are necessary (e.g., emergency conditions, experimenting with a new method or procedure at the request of UDOT executive staff, unusual traffic conditions). The SSMH warns against departing from activity standards unless it is absolutely necessary, because doing so results in inappropriate levels of service, budget overruns, and poor productivity. Activity standards fall into one of ten categories: 1) Snow and Ice Control, 2) Hard Surface, 3) Non-Hard Surface Maintenance, 4) Roadside Maintenance, 5) Vegetation Control, 6) Drainage and Slope Repair, 7) Major Structure Maintenance, 8) Traffic Services, 9) Support, and 10) Rest Area Maintenance. Standards are further subdivided into three activity types: *S Activities*, which require station approval; *D Activities*, which call for District Engineer approval, and *M Activities*, which are administrative and require District Engineer approval. The remainder of the SSMH consists of activity performance standards, or spec sheets (Figure 5 is a sample spec sheet). Each standard catalogues the following — a work description; a scheduling calendar, which indicates during which months an activity can take place; conditions for scheduling; average daily production; recommended procedure; personnel type and quantities; equipment and quantities; material and quantities; and a description of how activity quality is measured.

**UTAH DEPARTMENT OF TRANSPORTATION
MAINTENANCE DIVISION
ACTIVITY PERFORMANCE STANDARD**

Work Activity:	7D13 - Bituminous Surface and Shoulder Maintenance (Special)	Activity ID:	7D13												
MMQA Group:	2A1	Description:	Bituminous Surface and Shoulder Maintenance (Special)												
Work Description:															
Work where the quantity planned does not fit the guidelines of the other hard surface and shoulder activities. In most cases the accomplishment would be less than 7D07, 7D08, 7D09, 7S02, etc															
Calendar:															
Jul	Aug	Sep	Oct	Nov	Dec	Jan	Feb	Mar	Apr	May	Jun				
Conditions for Scheduling:															
Temperature requirements restrict effective surface replacement to the warmer months. Major emphasis should be exerted during the months April through September															
Average Daily Production:		300		Accomplishment Unit:		Square Yards									
Recommended Procedure:															
<ol style="list-style-type: none"> 1. Call Bluestakes if any excavation is required 48 hours before working 2. Notify local agencies and/or business. 3. Perform a project driver through to identify all aerial obstructions. 4. Mark with signs all overhead utilities crossing the road 50' on either side of crossing. 5. Use a spotter when working in the crossing zone. 6. Place safety devices and signs (See Standard Drawings). 7. Remove deteriorated surface 8. Brush or spray tack oil on vertical and horizontal surfaces to provide a bond between the existing surface and the bituminous premix material being placed 9. Dump or hand place bituminous premixed material in area 10. Level bituminous premixed material to original line and grade (x-section) with equipment or with hand tools 11. Roll area to proper compaction 12. Clean up material removed from deteriorated area 13. Re-establishment of striping shall be completed at the end of each day's operation 14. Remove safety devices and signs 															
Personnel				Equipment				Material							
		Qty.				Qty.				Code		UOM		Qty.	
People		5		0104 - Truck, Tandem Axle, SRE		1		Hot Plant Mix 9.5 (3/8")		74512160040		Metric Ton		19	
				0501 - Grader, Standard		1		58-22							
				0902 - Loader, FE up to 2 Yard		1		Liquid Asphalt SS or		74508151409		Gal		15	
				1001 - Asphalt Dist, Trailer, 600 Gal		1		CSS Concen							
				1803 - Roller, Self Prop, 3 to 6 Ton		1									
				3002 - Lease Truck, Pickup, 3/4 Ton		1									
				3011 - Lease Truck, 1 Ton, Dual Wheel		1									
				3502 - Platform Trailer, 5-15 ton		1									
				Traffic directional control devices may also be used if co											
Measure of Quality:															
1.															

Figure 5 Layout of UDOT SSMH Activity Performance Standards

First established in 1997 to establish statewide protocols for evaluating and reporting on the effectiveness of UDOT’s maintenance program, the Maintenance Management Quality Assurance Plus (MMQA+) acquired its current form in 2003 and underwent revisions in 2012. The principal goal of MMQA+ is to improve the agency’s efforts in reporting how well it is preserving the state’s infrastructure. Information collected as part of the program informs budget development and highlights areas in which more or fewer resources could be allocated. The program also helps UDOT set targets for future maintenance levels after accounting for available budgets and resources. While MMQA+ is instrumental for statewide maintenance programming, it is also critical at the station level for prioritizing and scheduling activities. Using MMQA+ reports, Station Supervisors evaluate what activities in their station should receive priority based on an examination of current conditions, performance targets, and funding.

The MMQA+ program measures and reports performance with respect to level of maintenance (LOM). Letter grades (i.e., A, B, C, D, F) are used to designate LOM. At the state level, each activity covered by MMQA+ is assigned a target LOM. While target LOMs vary among activities, they generally range from A to C. The *MMQA+ Inspection Manual* cautions that target LOMs are

not binding. Rather, the goal is to maintain a facility as close to the target LOM as possible while neither falling short nor exceeding the target. UDOT's strategic goals, the current LOM, available funding and resources (e.g., labor, equipment, materials), public feedback (e.g., customer survey results), and input from district engineers and department leaders all influence the LOM chosen for specific activities. Data collected during inspections enable UDOT to optimize resource allocation so that resources are shifted toward maintenance activities failing to meet their targets and away from those where target LOMs are being exceeded.

The *MMQA+ Inspection Manual* lays out standards for evaluating the following maintenance activities: 1) snow and ice control; 2) non-hard surface maintenance (shoulders, curbs, gutters); 3) roadside maintenance (litter, fences); 4) vegetation control (weeds, vegetation obstructions); 5) drainage and slope repair (grading and cleaning ditches, maintaining inlets and outlets, erosion repair); 6) traffic services (pavement striping retro-reflectivity, pavement messages, repair and replacement of signs and delineators, guardrails, sweeping); and 7) rest area maintenance. MMQA+ does not outline standards for maintaining or evaluating the performance of asphalt or concrete pavements, structures (e.g., bridges), or intelligent transportation systems, among others. MMQA+ evaluations occur at the station level. Station personnel divide routes into one or more segments and then use the published guidelines appraise the condition of each segment. During inspections, staff record the number of features requiring maintenance within an activity subgroup as well as the number of deficient features. Inspection data are loaded into MMQA+ software, which is part of the OMS software package, and used to aid in decision making about maintenance. Except for snow and ice control and rest area maintenance, measurements are taken twice per year.

The MMQA+ program has a quality assurance component as well, and each station is audited once per year. The Quality Assurance Coordinator is responsible for compiling a list of stations to audit during an inspection season and then using a statistical methodology they select route segments and MMQA+ measures to independently validate. Once the segments and measures have been chosen, a quality assurance team inspects the routes and compares their ratings to those of station personnel. Following the inspection, the quality assurance team meets with station personnel to go over its findings. If discrepancies exist between the inspection team's scores and the station personnel's score, they discuss why the variance exists and work to, in UDOT's words, "calibrate [their] eyeballs." While the measurements require subjective judgment, the agency's goal is to achieve statewide consistency in how maintenance activities are evaluated. In addition to reviewing the MMQA+ program, the inspection manual contains instructions for taking MMQA+ measurements. For each measurement, the manual includes a description of what is to be measured, notes on the desired condition, a description of what constitutes a deficient condition, and reporting guidelines. The reporting guidelines contain directions on measurement frequency, measurement area, reporting deficiencies and overall condition, and instructions for making supplemental comments. Representative illustrations accompany each section and provide examples of features in a desired condition and those in a deficient condition.

4.2 Arkansas

The Arkansas Department of Transportation (Arkansas DOT) defines maintenance activities as work that is intended to preserve the state's highway and structure system. While many activities are scheduled in advance, some are performed on an ad hoc basis (e.g., asphalt patching may not require pre-planning in some cases). The *Maintenance Supervisor's Manual* (Arkansas DOT,

undated) gives insights into Arkansas DOT's approach to maintenance and the strategies it uses to plan, schedule, and perform maintenance. Up front, it contains a list of functions for maintenance, including activity codes, a description of the work associated with each task, and work units. The agency divides its maintenance activities into the following categories: routine surface and shoulder maintenance; authorized surface and shoulder maintenance; routine roadside and drainage maintenance; authorized roadside and drainage maintenance; chemical weed and grass control; routine structure maintenance; routine traffic services; authorized traffic services; unusual or disaster maintenance; other services; and general maintenance.

Maintenance functions are grouped into four work categories: routine unlimited maintenance, routine limited maintenance, special authority maintenance, and betterment work. For routine unlimited maintenance, work needs vary throughout the state and across the year. It is generally not possible to accurately predict the amount of work that falls within this category; the category also includes the correction of unsafe conditions, where work must be done to keep the roadway system operational. Agency personnel plan work quantities for activities qualifying as routine limited maintenance. Because of the nature of these activities, it is atypical for the amount of routine limited maintenance performed to exceed what has been planned for. Special authority maintenance consists of large-scale maintenance activities, specialized tasks for which most crews lack the equipment or labor power needed to execute. When planning special authority maintenance activities, district maintenance engineers and district supervisors coordinate details about materials and loaning equipment. Lastly, betterment work includes activities geared toward improving roadway facilities so they reach a condition better than their originally constructed state. Activities in this category are far-ranging, from small improvement efforts to ambitious projects that require the use of special crews. Supervisors coordinate betterment projects, while district-level crews are usually responsible for their implementation. In some cases, area crews are brought in to assist. Betterment projects are paid for out of district maintenance funds or special project funds.

The Maintenance Division prepares annual work programs for each district. Work programs serve as the foundation for determining how much work will be carried out during the next year as well as the number of staff required for each crew and establishing a budget to complete needed work. Program content also depends on the allocation and types of responsibilities in each district, the assessed condition of roads and buildings, rest area usage, and number of mowable areas.

Maintenance personnel work across three levels — statewide, district, and county. Each level includes maintenance supervisors who are tasked with scheduling and executing a portion of the total maintenance work. Typically, activities fall within the purview of a single level, but there are some activities maintenance staff at all three levels participate in (e.g., maintaining traffic signs). Each year, job superintendents and area maintenance supervisors (commonly referred to as just *supervisors* in Arkansas DOT literature) receive a performance summary that includes the types and amounts of maintenance slated for their assigned area during the upcoming year. Work quantities are set annually at planning meetings held in districts each spring. As noted, there is an annual schedule developed for maintenance activities, which specifies when tasks are to be accomplished. Ideally, supervisors schedule maintenance activities one to two weeks in advance of their performance. And in some cases, planning occurs at the district level through a consultation between supervisors and district maintenance engineers. Supervisors prepare biweekly planning

worksheets to assist with scheduling and organizing activities; once completed, these worksheets are reviewed and approved by district maintenance engineers. Additionally, supervisors are responsible for continuously inspecting routes and facilities located within their jurisdiction; they are also required to conduct two night inspections per year.

The *Maintenance Supervisor's Manual* contains instructions on scheduling and outlines scheduling responsibilities for area maintenance supervisors and district maintenance engineers. The manual also provides comprehensive maintenance standards, which contain instructions for carrying out maintenance tasks. Each activity standard includes the following components: activity definition, guidance on identifying issues, concise directions for performing the maintenance, supplemental comments, a list of crew and equipment required to complete the activity, materials and tools needed, and information on daily production and productivity. Activity standards do not indicate how often each activity should be done or specify an inspection cycle for assessing infrastructure condition to determine whether any maintenance is necessary.

4.3 Montana

The Montana Department of Transportation (MDT) defines maintenance as those “tasks and subtasks performed by one crew at one location of the highway system at one time to keep the highway at a specific quality level” (MDT 2002, p. 9). MDT’s published maintenance manual describes maintenance activities and expectations for each. The manual is structured around discrete activity types. As such, it contains separate chapters on the agency’s eleven activity groupings: 1) Asphalt Pavement Program; 2) Concrete Pavement Program; 3) Roadway/ Roadside Maintenance; 4) Roadside Cleanup Program; 5) Maintenance of Facilities; 6) Guidance, Safety Devices, and Road Closures; 7) Winter Maintenance Program; 8) Structure Maintenance Program; 9) Materials Production Program; 10) Equipment Inspection, Operation, Preventive Maintenance, and Repair; and 11) Emergency Procedures.

Each chapter begins with a brief introductory section that describes in broad strokes the activities that fall within its respective grouping (and which receive more detailed treatments later on). The introductions proceed to discuss the types and purposes of the maintenance tasks, explicitly stating the ways in which those activities fulfill MDT’s programmatic goals. Depending on the activity class, the introduction may provide high-level guidance on planning work activities. Some chapters lack this information. For example, the chapters on asphalt pavement and concrete pavement preservation instead provide an overview of pavement deficiencies and their causes. Including this knowledge is useful for designing and implementing a long-term pavement maintenance program. Pavement chapters also integrate brief narratives on different types of deficiencies (e.g., rutting, raveling, cracking, potholes), specify their underlying causes, comment on methods to inspect and measure the severity of the deficiency (if available), and present corrective measures. Chapter introductions also discuss whether permits or approvals are generally needed to conduct specific tasks and direct supervisors and workers to the appropriate Montana state government agency to obtain the requisite permits. Permits are not generally necessary for maintenance activities, although they may be required for some (e.g., cleaning culverts, culvert replacement) which result in discharges to adjacent bodies of water covered by Section 404 of the Clean Water Act or state environmental regulations. Other issues addressed in some chapter introductions are safety and training — for those activities that may prove hazardous, — environmental best management practices, and necessary documentation. Like many other states,

Montana uses a Maintenance Management System (MMS) to record maintenance activities. It keeps track of labor, materials, equipment, and the activity cost according to route and location. Any documentation required for a maintenance activity is entered into the MMS according to the *Maintenance Management System Manual of Instructions*. Following chapter introductions, activity standards are laid out sequentially for each activity within the activity class.

Each activity standard begins with a description of the activity, focused principally on what the activity is designed to accomplish. For example, the activity description that accompanies Activity 5.1, *Cleaning Culverts, Culvert Opening, and Basin Inlets*, states that its goal is to remove obstructions from culvert ends as well as silt from inlets and catch basins. It then specifies other elements which are targeted (e.g., culvert catch basins). Following the activity description is a statement of purpose, which highlights the intended outcome of the activity. For example, removing dirt and excess vegetation from culverts helps improve water flow and drainage, which can have implications for maintaining ecologically suitable habitat. Purpose statements also mention, in some cases, how the roadway system benefits from performing an activity. Next, the standard defines the timing of maintenance. There is considerable variability in the specificity of timing statements. For many activities, the manual does not contain a set timetable for conducting inspections and performing regularly scheduled maintenance, or it directs personnel to execute an activity on an as-needed basis. Examples of activities without timetables for inspection and maintenance include surface patching of potholes (which should be repaired as quickly as possible once they appear), guardrail repair or replacement, and pavement striping and markings (both should be rejuvenated once their retro-reflectivity and visibility decline). Other activity standards lay out definite inspection and maintenance timelines. For example, chip sealing is to be done every five to seven years — contingent on pavement condition — or following the placement of a new overlay. Culverts, culvert openings, and basin inlets are inspected twice a year and following major storms to determine whether they require cleaning or structural repairs. A number of activity standards contain more ambiguous language regarding inspection, holding they should be done *routinely* or *regularly* or *periodically*, without specifying the timeframe associated with these descriptors.

Following guidelines on timing, activity standards list specialized equipment and materials needed to complete a maintenance task. Notes on special safety or training provisions follow and, if warranted, environmental best management practices. The final section in each activity standard is a condensed description of the procedure used to carry out the maintenance activity — notes on procedures cover everything from pre-planning and coordinating with other staff beforehand to instructions for onsite performance of the activity. In some cases, maintenance staff are directed to consult supplementary guidance, manuals, and handbooks (those issued by MDT as well as other state of Montana government agencies) for more comprehensive instructions. Table 2 summarizes key maintenance activities, including an explanation of the activities and timing requirements outlined in MDT's maintenance manual. The table is not exhaustive and omits activities that do not align with aspects of KYTC's core maintenance program being investigated by this study. Language reproduced in the table with respect to timing (words such as *promptly*, *routinely*, *periodically*) are taken verbatim from the manual. This information should give readers a better sense of which maintenance activities are placed on definite schedules and which are done regularly but lack explicit protocols.

Table 2 Key Montana DOT Maintenance Activities

Maintenance Category	Maintenance Activity	Activity Explanation	Timing, Scheduling, and Other Comments
<i>Asphalt Pavement Program</i>	Surface Patching — Hand	<ul style="list-style-type: none"> • Hand fill potholes 	<ul style="list-style-type: none"> • No set timetable or inspection schedule • Promptly repair potholes • Post warning signs near potholes if weather or other factors prevent immediate repair
	Crack Sealing/Joint Filing	<ul style="list-style-type: none"> • Route, clean, and seal/fill cracks 	<ul style="list-style-type: none"> • Examine overlays and new pavement surfaces for crack sealing every third year after a project has been completed • Use MDT’s Pavement Management System and visual analysis to determine if crack sealing is needed
	Chip Sealing	<ul style="list-style-type: none"> • Controlled application of liquid asphalt and aggregate cover to a highway surface 	<ul style="list-style-type: none"> • Every 5-7 years, based upon pavement condition, or after a new overlay
	Rejuvenating/Fog Seal	<ul style="list-style-type: none"> • Apply an emulsion or liquid asphalt to a roadway surface at a prescribed rate 	<ul style="list-style-type: none"> • Use following blade patches or chip seals • As a standalone treatment, use on an as-needed basis
<i>Concrete Pavement Program</i>	Temporary Patching of Portland Cement Concrete Pavement	<ul style="list-style-type: none"> • Patch broken or spalled areas 	<ul style="list-style-type: none"> • No set timetable or inspection schedule • Begin patching as soon as practicable after potholes form

	Permanent Patching of Portland Cement Concrete Pavement	<ul style="list-style-type: none"> • Use permanent patch materials (e.g., high, early-strength Portland Concrete Cement) to patch broken or spalled areas 	<ul style="list-style-type: none"> • Install permanent patches when: <ul style="list-style-type: none"> ○ Weather conditions support the proper curing of materials ○ Vehicle flow can be restored before peak times on busy routes ○ Traffic control can be established to allow for patching several areas in one control zone
	Crack and Joint Sealing	<ul style="list-style-type: none"> • Prepare and seal joints and cracks in concrete pavement • Prepare and seal the longitudinal joints between concrete pavement and asphalt 	<ul style="list-style-type: none"> • No set time table or inspection schedule • Repair cracks when they are at their widest due to the contraction of concrete and asphalt
<i>Roadway/Roadside Maintenance</i>	Cleaning Culverts, Culvert Openings, and Basin Inlets	<ul style="list-style-type: none"> • Remove obstructions from culvert ends and eliminate silt from inlets and catch basins 	<ul style="list-style-type: none"> • Inspect facilities twice each year and following major storms to establish whether cleaning or structural repairs are necessary

	Culvert Repair, Replacement, and Fish Betterment	<ul style="list-style-type: none"> • Repair and replace structurally deficient culverts • Repair and replace catch basins, drop inlets, manholes, culverts, erosion control features, fish baffles and weirs, retaining walls, and defects at pump stations 	<ul style="list-style-type: none"> • Inspect facilities twice each year • Repair facilities and structures when they no longer function as designed
	Cleaning, Shaping, and Repairing Ditches	<ul style="list-style-type: none"> • Clean and shape roadside ditches (includes hauling and disposal of excess material, restoring proper grade line and side slope configuration to preserve adequate drainage) 	<ul style="list-style-type: none"> • Periodically inspect ditches to evaluate their condition • Inspect ditches after major storms to determine if cleaning and shaping is necessary
	Slope Repair	<ul style="list-style-type: none"> • Repair slopes that have eroded or suffered flood damage 	<ul style="list-style-type: none"> • Conduct periodic inspections to resolve whether repairs are necessary • Repair slopes before they become safety hazards or undermine the structural integrity of the road • Perform work during water-work periods

	Unpaved Road Surface	<ul style="list-style-type: none"> • Blade unpaved surfaces and shoulders with a motor patrol 	<ul style="list-style-type: none"> • Routinely inspect gravel surfaces • Make repairs before drivability and integrity of the roadway surface are impacted • Execute repairs when surface moisture is present to ensure it is properly compacted
	Vegetation Management — Mechanical Mowing	<ul style="list-style-type: none"> • Mow roadside vegetation 	<ul style="list-style-type: none"> • No set timetable or inspection schedule • Mow when necessary, as part of a road management plan • Limit mowing to the growing season if possible • If possible, schedule mowing to support noxious weed control planning and forage removal/haying operations
	Chemical Vegetation Control — Chemical Spraying	<ul style="list-style-type: none"> • Use of chemical to limit the growth and spread of noxious weeds • Slow the growth of vegetation around structures (e.g., signs and guardrails), improve aesthetics, and enhance sight distance 	<ul style="list-style-type: none"> • Chemical applications are typically made in fall or spring according to manufacturer directions

	Vegetation Management — Brush and Tree Removal	<ul style="list-style-type: none"> Remove unwanted brush, trees, and vegetation from the right of way and adjacent to signposts, guardrails, or other structures 	<ul style="list-style-type: none"> Remove unwanted vegetation when it begins to reduce sight distance, sign visibility, or becomes a nuisance or fire hazard
	Maintenance of Landscaped Areas	<ul style="list-style-type: none"> Mowing, maintenance of water systems, fertilizing, weeding, and replacing turf in landscaped areas 	<ul style="list-style-type: none"> Mow when as needed to maintain aesthetics Prune trees and shrubs when they are dormant Frequently edge walks, curbs, and highly visible elements Winterize irrigation at the end of the growing season
	Inspection and Repair of Fences and Gates	<ul style="list-style-type: none"> Maintain or replace fence posts, top rails, and gates of MDT-owned fences 	<ul style="list-style-type: none"> Inspect fences twice per year and schedule repairs and maintenance accordingly
	Cattle Guard Repair	<ul style="list-style-type: none"> Repair and install cattle guards and related structures and fence connections 	<ul style="list-style-type: none"> Periodically inspect and clean cattle guards Immediately repair damage to cattle guards
<i>Roadside Cleanup Program</i>	Removal of Debris and Litter	<ul style="list-style-type: none"> Remove litter, debris, and trash from the right of way 	<ul style="list-style-type: none"> Conduct routine patrols periodically to remove roadway debris Frequency of cleanup is a product the amount of litter, debris, and hazardous items that have accumulated and whether unsightly, unsanitary conditions result

	Sweeping or Flushing	<ul style="list-style-type: none"> Remove gravel, dirt, and sand from intersections, bridges, travel ways, shoulders, and paved ditches by sweeping them or flushing them with water 	<ul style="list-style-type: none"> No set inspection schedule Remove dirt, sand, or other debris that pose a hazard as soon as practical Dirt, sand, or small debris collected in curbs, gutters, and drainage outlets should be removed as soon as practical to avoid sedimentation Sweep excess deicing materials from the roadway as soon as practical
<i>Maintenance of Facilities</i>	Maintenance of Rest Areas	<ul style="list-style-type: none"> Maintain and repair rest areas and truck parking areas 	<ul style="list-style-type: none"> Inspect rest areas at least once per week, but preferably daily Perform necessary repairs as soon as practical to keep facilities operational
<i>Guidance, Safety Devices, and Road Closures</i>	Traffic Signs	<ul style="list-style-type: none"> Encompasses: Repair, maintenance, and replacement of traffic signs, posts, and sign panels Cleaning, tightening bolts, straightening signage Maintaining single post, double posts, overhead sign faces, hazard markers, chevrons, and reference markers 	<ul style="list-style-type: none"> No set timetable or inspection schedule Promptly repair and replace signs critical to traffic safety Install a temporary sign if a quick and permanent fix is not possible

	Guardrail Repair and Replacement	<ul style="list-style-type: none"> • Maintenance of guardrails, including: • Repairing or replacing damaged or deteriorating panels • Replacing damaged posts • Straightening or aligning posts and panels • Replacing cables and posts • Removing and replacing concrete barriers • Performing routine inspections to ensure cables are properly tensioned, appropriate torque on bolts 	<ul style="list-style-type: none"> • No set timetable or inspection schedule • Repair damage to guardrails as quickly as possible
	Pavement Striping	<ul style="list-style-type: none"> • Place solid and skip pavement markings on pavement surfaces • Apply glass beads to lines after painting 	<ul style="list-style-type: none"> • No set inspection schedule • Renew pavement stripes after they have lost retro-reflectivity or line integrity • Complete 85 percent of restriping activities by July 1
	Pavement Markings	<ul style="list-style-type: none"> • Place markings, legends, and symbols on the pavement surface (e.g., crosswalks, 	<ul style="list-style-type: none"> • No set timetable or inspection schedule • Renew pavement stripes when visibility or retro-reflectivity diminishes

		stop bars, directional arrows, word messages)	
	Maintenance of Delineators, Reference Markers, and Snow Poles	<ul style="list-style-type: none"> • Replace bent, broken, or missing delineators, milepost markers, and snow poles 	<ul style="list-style-type: none"> • No set timetable or inspection schedule • Repair missing or damaged delineators as soon as practical • Clean delineators as needed to maintain retro-reflectivity • Conduct periodic inspections to identify damaged or missing mileposts and delineators • Install snow poles before the onset of the winter season
	Flashing Lights, Traffic Signals, and Luminaries	<ul style="list-style-type: none"> • Inspect, repair, and do preventive maintenance on flashing lights, traffic signals, and luminaries 	<ul style="list-style-type: none"> • Perform routine inspections to ensure all signals, lights, and flashers work properly • Inspect luminaries at night to identify malfunctions
	Impact Attenuators (Crash Barriers), Repair to Escape Ramps	<ul style="list-style-type: none"> • Repair or replace deteriorated and damaged attenuators 	<ul style="list-style-type: none"> • Perform routine inspections of impact attenuators and escape ramps to ensure their proper function • Correct deficiencies that impair the functional integrity of attenuators immediately

<p><i>Structure Maintenance Program</i></p>	<p>Maintenance and Repair of Structures</p>	<ul style="list-style-type: none"> • Repair damage or deterioration of bridge components • Remove debris and drift near piers • Clean drains, decks, joints, or bearings • Clean and paint timber bridge rails • Tighten or replace bolts and nuts • Repair or replace joint materials and joint headers • Repair or replace bridge rail, curb, or posts • Adjust bridge height following settlement • Repair and replace timber girders, caps, decks, and piles • Repair vehicle impact damage to beams and columns 	<ul style="list-style-type: none"> • Timing varies among activities — • Clean deck drains when temperatures are above 32 degrees • Clean bridge decks in the spring • Patch or repair concrete when weather permits • Remove debris and drift material around piers as soon as practical • Correct structural deficiencies as soon as practical
	<p>Inspection of Structures: Bridges and Culverts</p>	<ul style="list-style-type: none"> • Inspect bridges in accordance with National Bridge Inspection Standards • Inspect culverts, box culverts, and comparable drainage structures 	<ul style="list-style-type: none"> • Inspect all culverts and bridges occur every six months • Inspect bridges and culverts after they are impacted by a major event (e.g., earthquake, flood, high water runoff)

4.4 Alabama

The Alabama Department of Transportation (ALDOT) maintains approximately 12,000 roadway miles. The agency's Maintenance Bureau is responsible for overseeing and conducting maintenance activities. With respect to maintenance, there are four levels of management: top management, bureau of maintenance management, division of maintenance management, and district maintenance management. Each year, annual maintenance programs are developed that describe the type and amount of maintenance work to be performed during the upcoming fiscal year. Annual maintenance programs specify the labor, equipment, and materials necessary to accomplish the planned maintenance work, while annual maintenance budgets include allotments for routine maintenance (which includes emergency work), maintenance resurfacing, and minor maintenance betterments. Each division and district receives an individualized maintenance program that has been customized based on existing maintenance standards and current roadway inventory data. Once the annual maintenance program has been developed and approved, the Maintenance Bureau distributes the work program to personnel responsible for scheduling, supervising, performing, and controlling maintenance work. The Division Maintenance Engineer, District Engineer, and Superintendent are responsible for scheduling and performing authorized work. Superintendents in district offices are responsible for performing routine inspections to determine what maintenance activities are required; coordinate and schedule maintenance work with the District Engineer; and assign labor, equipment, and materials for maintenance work.

ALDOT has several publications related to the maintenance program, including a *Field Operations Manual* (ALDOT, undated), its *Level of Service Condition Assessment Data Collection Manual* (ALDOT 2015), and a compendium of maintenance performance guidelines (ALDOT 2014). The *Field Operations Manual* is a broad overview of the agency's maintenance program; reviews the delegation of responsibility amongst personnel; contains a detailed activity list that provides abridged narratives of work activities and identifies work measurement units; instructions for scheduling work crews; guidelines for evaluating work performance; and various templates of forms used by Maintenance Bureau personnel (e.g., maintenance activity summary worksheets, crew day cards). The manual also lists maintenance work control categories, which for each maintenance activity specifies the work control category it falls under, scheduling responsibilities, and the type of crew required.

ALDOT has four categories of maintenance tasks: routine unlimited activities, routine limited activities, special authority activities, and overhead activities. Routine unlimited activities encompass high-priority assignments that are completed on an as-needed basis to minimize roadway deficiencies. Activities falling under this designation include spot premix patching, snow and ice removal, and emergency maintenance. Routine limited activities are those for which quantities of work are prescribed and firmly adhered to. Examples include mowing — done a fixed number of times each year — and bridge inspections, which are undertaken every two years. Next, special authority activities are non-critical tasks which need not be completed within a given year. Some of the activities included under this heading are erosion control, shovel ditching, brush and tree cutting, and special maintenance activities (e.g., major bridge repair, minor maintenance improvements). Overhead activities consist of tasks that are unrelated to the maintenance of a specific roadway or structure, such as weighing operations, training, or materials handling. Personnel in Division and District offices have distinct responsibilities for scheduling maintenance tasks. Division-wide specialized activities that require division-wide crews (e.g., centerline

painting, major bridge repair, minor maintenance improvements) are scheduled by the Division Maintenance Engineer. It is the responsibility of the District Engineer to program some special authority work and specialized work, such as major premix patching and sign maintenance. Superintendents make decisions about scheduling day-to-day maintenance work; inspection activities must be performed regularly to identify locations where routine maintenance is necessary.

Table 3 Metrics Used by the Alabama DOT to Evaluate Maintenance Features

Asset Classification	Maintenance Feature	Maintenance Feature Condition Measure
Asphalt Pavement	Potholes ($\geq 6"x6"x1"$)	Number of potholes per lane mile
	Raveling	% of surface area distressed
	Shoving (Upheaval/Depression)	Square feet of deficiencies per lane mile
Concrete Pavement	Spalling ($\geq 6"x6"x1"$)	Number of spalls per lane mile
	Faulting ($\geq 1/4"$ high)	Number of faulted slaps per lane mile
	Joint Sealing ($\geq 1/4"$ wide)	Linear feet of joints requiring sealing per lane mile
	Pumping	Number of slabs deficient per lane mile
	Punchouts ($\geq 6"x6"$ surface area with full depth failure)	Number of punchouts per lane mile
	Shoulders	Potholes ($\geq 6"x6"x1"$)
Shoulders	Edge Raveling (Edge Failure)	Linear feet per shoulder mile
	Sweeping	Linear feet of paved shoulder needing sweeping
	Non-Paved — Drop Off ($\geq 2"$) (Low Shoulder)	Linear feet per shoulder mile
	Non-Paved — High Shoulder $> 1"$ (Built-Up Shoulder)	Linear feet per shoulder mile
	Drainage	Side Drains
Drainage	Cross Drains	% of pipes not functioning as intended or $> 10%$ blocked
	Unpaved Ditches	% of ditch length not functioning as intended (erosion or blockage)
	Paved Ditches	% of ditch length not functioning as intended or blocked
	Drop Inlets, Slotted Drains, and Catch Basins	% of inlets not functioning as intended or blocked
	Curb and Gutters	% of length not functioning as intended or misaligned

Roadside	Front Slope — Erosion Control	% of shoulder miles deficient — washouts > 12"
	Back Slope — Erosion Control	% of shoulder miles deficient — washouts > 18"
	Mowable Area	Average height of grass (in inches)
	Brush Control (blocking line of sight or signage or within the "clear zone")	% of shoulder miles with desirable brush
	Tree Removal	Number per shoulder mile
	ALDOT Fence	% of fence miles damaged (functionally deficient — requiring repair)
	Litter Control	Number of equal to or greater than fist-sized objects per shoulder mile
Traffic Services	Raised Pavement Markers	% of RPMs missing or damaged per center line mile
	Signals (e.g., bulbs malfunctioning, structurally deficient, facing wrong direction)	% of signals deficient
	Delineators	% of delineators deficient
	Object Markers	% of makers missing or damaged
	Signs — Warning and Regulatory (damaged, missing, illegible, retro-reflectivity)	% of signs deficient
	Pavement Striping (non-visible, missing, faded, chipped)	% of total length deficient
	Guardrail	% of guardrail length deficient
	Cable Rail	% of cable rail length deficient
	Impact Attenuators	% of impact attenuators needing repair
	Barrier Walls	% of barrier length deficient
	Highway Lighting (low or high mast)	% malfunctioning (LOS Condition only, no budgeting initially)
	Pavement Markings and Legends (non-visible, missing, faded, chipped)	% of symbols and legends deficient

ALDOT's *Level of Service Condition Assessment Data Collection Manual* states that data on the condition of infrastructure assets is used to “develop customer-oriented, performance-based work plans and budgets

and to assess results.” As such, these data inform the development of the agency’s Maintenance Management System. The manual contains procedures work crews should follow when collecting and processing road inventory data. Its first section focuses primarily on data collection guidelines, equipment required for field data collection, and safety protocols; it also includes an overview of maintenance condition assessment criteria. Where possible, agency personnel are instructed to gather inventory data and condition data from existing sources (e.g., office records, application databases, mainframe feature inventory). Information not found in these sources is collected in the field, ideally using three-person crews, which maximizes the efficiency of inspection work and enhances crew safety. Field data collection does not occur along every mile of roadway. Rather, each district randomly samples 0.1-mile road segments to assess their condition — the number of segments varies among districts and is determined by the total number of roadway miles in the district. For most districts, between 200 and 350 road segments must be appraised to obtain a statistically representative sample of roadway conditions. ALDOT recommends collecting data over the shortest possible time span to ensure an accurate representation of road conditions, as this informs planning and budgeting.

Following the introductory material, the manual provides a detailed review of data collection criteria for each maintenance feature. There are individual entries for each feature that requires inspection. Entries list the asset group and maintenance feature, specify what constitutes a deficient condition, notes measurement units, and describes the inspection procedures. Most entries also incorporate one or several images, which serve as a visual reference point to help field crews accurately evaluate roadway conditions and identify problem areas. Table 3 summarizes asset classifications, maintenance features, and the criteria used to determine asset condition. The manual does not discuss how inventory condition data are used to set maintenance priorities.

The final published maintenance resource is ALDOT’s catalogue of maintenance performance guidelines. Like other states, there are entries for each maintenance activity that include a description and purpose of the task; information on authorization and scheduling; and notes on the required crew size, equipment and material needs, how to perform the maintenance task, and average daily production. Many of the entries’ sections on authorization and scheduling lack precise timelines specifying when and how often maintenance tasks are to be carried out. Scheduling guidelines tend to be very broad. For instance, activities such as Other Roadway and Shoulder Maintenance (which includes tasks like sweeping, base repair, spot patching, and cleaning curbs and gutters) and Drainage Maintenance are to be scheduled throughout the year. Some activities include definite timelines. For example, Line Trimming should begin in the late spring. To familiarize readers with which activities occur at defined intervals or specific points during the year (and which are done on a more as-needed basis), Table 4 lists maintenance activities and the scheduling information provided in the agency’s maintenance performance guidelines.

Table 4 Alabama DOT Scheduling Guidelines for Maintenance Activities

Maintenance Activity	Scheduling Guidelines
Condition Assessments	<ul style="list-style-type: none"> <li data-bbox="699 1745 1328 1772">• Schedule at discretion of the Maintenance Bureau

Spot Premix Patching (Hand Operation)	<ul style="list-style-type: none"> • Schedule as soon as practical following discovery
Major Premix Patching (Machine Operation)	<ul style="list-style-type: none"> • Coordinate scheduling with division-wide resurfacing operations
Skin Patching	<ul style="list-style-type: none"> • No timeline specified
Strip Patching	<ul style="list-style-type: none"> • Coordinate scheduling with division-wide resurfacing operations
Crack Sealing Concrete Pavement	<ul style="list-style-type: none"> • Schedule after field inspections find existing crack sealers are no longer effective or random cracking has developed that could let water damage the base material
Crack Sealing — Asphalt Pavement	<ul style="list-style-type: none"> • Schedule after field inspections find existing crack sealers are no longer effective or random cracking has developed that could let water damage the base material
Pavement Planning	<ul style="list-style-type: none"> • Schedule as soon as practical once pavement defects or irregularities are found
Patching Unpaved Shoulders	<ul style="list-style-type: none"> • Schedule as needed
Blading Unpaved Shoulders	<ul style="list-style-type: none"> • Schedule work to take advantage of natural moisture (typically fall or spring)
Cleaning Concrete Joints	<ul style="list-style-type: none"> • Schedule once field inspections find existing joint sealers are no longer effective
Joint Sealing	<ul style="list-style-type: none"> • Division Maintenance Engineer authorizes and schedules work once field inspections indicate existing joint sealers are ineffective
Concrete Pavement Repair	<ul style="list-style-type: none"> • Schedule as needed throughout the year
Other Roadway and Shoulder Maintenance	<ul style="list-style-type: none"> • Schedule as needed throughout the year
Ditching	<ul style="list-style-type: none"> • Schedule, if possible, in early summer once ditches have dried so grasses can establish before winter
Cleaning Minor Drainage Structures	<ul style="list-style-type: none"> • Inspect all minor drainage structures at least once per year Cleaning is scheduled in the spring or fall and sometimes following heavy rainfall
Repairing Minor Drainage Structures	<ul style="list-style-type: none"> • Schedule as needed throughout the year (preferably during slack periods)
Other Drainage Maintenance	<ul style="list-style-type: none"> • Schedule as needed throughout the year

Impact Attenuator Maintenance	<ul style="list-style-type: none"> Schedule as needed throughout the year
Concrete Barrier Rail Maintenance	<ul style="list-style-type: none"> Schedule as needed throughout the year
Mowing (Interstate)	<ul style="list-style-type: none"> Schedule to begin in late spring before tall grasses reach maturity, but after clovers reach maturity
Mowing (Non-Interstate)	<ul style="list-style-type: none"> Schedule to begin in late spring before tall grasses reach maturity, but after clovers reach maturity
Boom Mowing	<ul style="list-style-type: none"> Schedule to begin in late spring before tall grasses reach maturity, but after clovers reach maturity
Line Trimming	<ul style="list-style-type: none"> Schedule to begin in late spring before tall grasses reach maturity, but after clovers reach maturity
Herbicide Treatments	<ul style="list-style-type: none"> Schedule as needed throughout the year
Herbicide Treatment Surveillance	<ul style="list-style-type: none"> Schedule at least 10 days after the initial herbicide treatment
Brush and Tree Cutting	<ul style="list-style-type: none"> Schedule when brush or tree growth may interfere with sight distance, traffic signs or signals, or impairs aesthetics
Erosion Control	<ul style="list-style-type: none"> Schedule as needed throughout the year
Litter Pickup (Full Width)	<ul style="list-style-type: none"> Schedule work before the start of the mowing season and after the mowing season Some areas require attention throughout the year
Litter Pickup (Spot)	<ul style="list-style-type: none"> Schedule work before the start of the mowing season and after the mowing season Some areas require attention throughout the year
Spot Herbicide Treatment	<ul style="list-style-type: none"> Schedule work in the spring when temperatures are warm enough for treatment to be effective Reschedule as needed throughout the year
Landscape Enhancement Projects	<ul style="list-style-type: none"> Schedule at discretion of the Maintenance Bureau

Wildflowers Projects	<ul style="list-style-type: none"> • Schedule at discretion of the Maintenance Bureau
Other Roadside Maintenance	<ul style="list-style-type: none"> • Schedule as needed throughout the year
Sign Installation, Replacement, or Removal	<ul style="list-style-type: none"> • Schedule as needed throughout the year to ensure all sign installations conform with the MUTCD
Sigh Maintenance	<ul style="list-style-type: none"> • Schedule as needed throughout the year
Centerline and Edge Painting	<ul style="list-style-type: none"> • Coordinate scheduling with resurfacing activities
Pavement Markings and Legends	<ul style="list-style-type: none"> • Schedule as needed throughout the year Emphasize crosswalks prior to the school year beginning
Guardrail Maintenance	<ul style="list-style-type: none"> • Schedule as needed throughout the year
Cable Rail Maintenance	<ul style="list-style-type: none"> • Schedule as needed throughout the year
Traffic Signal Maintenance	<ul style="list-style-type: none"> • Schedule as needed throughout the year
Raised Pavement Marker Maintenance	<ul style="list-style-type: none"> • Coordinate scheduling with resurfacing activities
Other Traffic Operations	<ul style="list-style-type: none"> • Schedule as needed throughout the year
Roadside Improvements	<ul style="list-style-type: none"> • Division Maintenance Engineer authorizes and schedules work throughout the year as needed
Drainage Improvements	<ul style="list-style-type: none"> • Division Maintenance Engineer authorizes and schedules work throughout the year as needed
Traffic Operations Improvements	<ul style="list-style-type: none"> • Division Maintenance Engineer authorizes and schedules work throughout the year as needed

4.5 Florida

The Florida Department of Transportation’s (FDOT) Office of Maintenance is responsible for maintaining the state’s infrastructure assets. Several published resources are available from the agency detailing various aspects of its maintenance program, including the *Maintenance Rating Program Handbook*, *Bridge Maintenance and Repair Handbook*, *Guide for Roadside Vegetation Management*, and several others related to FDOT procedures. At FDOT, maintenance engineers recommend levels of service for highway elements (the targeted condition for assets), while field supervisors adopt these suggestions to inform inspection and maintenance activities. Field supervisors are responsible, as well, for judging which roadway elements are to be maintained at a targeted level of service and which can be allowed to fall below that condition. To establish maintenance standards and inspections procedures that would be applied consistently throughout Florida, in 1985 the agency introduced its Maintenance Rating Program (MRP). Individual districts administer the MRP. Our focus here is on FDOT’s *Maintenance Rating Program*

Handbook (FDOT 2017; hereafter referred to as *handbook*), as it offers the most insights how the agency approaches rating asset conditions and maintenance.

In addition to discussing the broad contours of FDOT's maintenance program, the handbook outlines methods for conducting visual and mechanical evaluations of routine highway maintenance conditions. It does not apply to bridges, as they are covered by a separate program. Data collected from inspections are used to plan and prioritize routine maintenance activities and ensure maintenance programs are being designed and implemented consistently around Florida. During each reporting period (of which there are three per year), the Office of Maintenance uses a random sampling methodology to specify which facilities will be inspected. There are three reporting periods throughout the fiscal year. After the facilities are chosen, they are evaluated by an inspection team consisting of two people, one of whom is qualified as a team leader. Inspection teams examine 30 points per facility type or cost center, or a minimum of three points per mile for facility types that are less than 10 miles long. Each sample is 1/10 mile (528 feet). The handbook provides instructions on collecting data, lists the equipment and supplies needed to conduct facility inspections, and includes coding sheets that are used to record survey data in the field. Individual entries in the handbook offer detailed guidance on inspecting facilities (see below).

FDOT classifies facilities into four groups based on the type of maintenance applied to them: 1) rural limited access, 2) rural arterial, 3) urban limited access, and 4) urban arterial. Each facility is then partitioned into five elements — roadway, roadside, traffic services, drainage, and vegetation and aesthetics. Each element has several characteristics that are inspected. Taken together, the characteristics make up the maintenance element. For instance, the following attributes comprise the roadway element — unpaved shoulder, front slope, slope pavement, sidewalk, and fence. The handbook states that six characteristics are evaluated on all samples: 1) potholes, 2) depressions, 3) raised pavement markers, 4) striping, 5) tree trimming, and 6) litter removal. On rigid roadways, joints and cracking are evaluated for all facility types, while for flexible roadways all samples are inspected for edge raveling and shoving. Once inspection teams collect data they enter them into FDOT's data processing system, after which they are used to inform decision making about maintenance. The handbook and processes described therein are regularly reviewed by staff from around the state to determine whether revisions are necessary. The agency performs quality assurance reviews annually for each MRP team leader. A quality assurance team scrutinizes the quality of their work (to ensure their assessments are consistent) and adherence to the agency's safety protocols.

The second portion of the handbook is comprised of a catalogue of detailed entries that provide an overview of how different characteristics are to be evaluated and rated. Entries list the target condition for each characteristic as well as a description of the feature; a detailed, step-by-step inspection procedure; supplemental notes if necessary, a list of conditions which, if present, would cause the characteristic to not meet MRP standards; and ample photographic examples inspectors can use in the field to guide their assessments. Table 5 lists, for each roadway element and its associated characteristics, targeted maintenance conditions. Assets failing to meet these threshold conditions warrant maintenance attention. While the handbook does not list intervals for conducting routine maintenance activities, readers may be able to approximately infer their frequency based on the inspection schedule and targeted maintenance condition.

Table 5 Target Maintenance Condition for Florida DOT Infrastructure Characteristics

Element	Characteristic	Target Maintenance Condition
Roadway	Flexible Pothole	<ul style="list-style-type: none"> No defect with an area greater than 0.5 square feet and no individual measurement greater than 1.5" deep No exposure of the pervious base
	Flexible Edge Paving	<ul style="list-style-type: none"> 90% of total roadway edge free of raveling No continuous section of edge raveling greater than or equal to 4" is more than 25 feet long
	Flexible Shoving	<ul style="list-style-type: none"> Cumulative shoved area is not greater than 25 square feet
	Flexible Depression/Bump	<ul style="list-style-type: none"> No deviation greater than 0.5" for any area greater than 1 square foot No one measure should exceed 2"
	Flexible Paved Shoulder/Turnout	<ul style="list-style-type: none"> Paved shoulders are to be rated for potholes, edge raveling, depressions, and bumps Rate flexible turnouts for only potholes
	Rigid Pothole	<ul style="list-style-type: none"> No defect with an area greater than 0.5 square feet and no individual measurement greater than 1.5" deep No exposure of the pervious base
	Rigid Depression/Bump	<ul style="list-style-type: none"> No deviation greater than 0.5" for any area greater than 1 square foot No one measure should exceed 2"
	Rigid Joint/Cracking	<ul style="list-style-type: none"> 85% of the length of transverse longitudinal joint material functions as intended, or 90% of roadway slabs have no sealed cracks wider than 1/8"
	Rigid Paved Shoulder/Turnout	<ul style="list-style-type: none"> Rigid paved shoulders are to be rated for potholes, depressions, bumps, joints, and cracking Rigid turnouts are only rated for potholes and cracking
Roadside	Unpaved Shoulder	<ul style="list-style-type: none"> No deviations across the shoulder wider than 5" above or below the design template No shoulder build-ups greater than 2" anywhere across the design template for 25 continuous feet No shoulder drop-offs more than 3" deep within 1 foot of the pavement edge for 25 continuous feet Sand, soil, grasses, or debris are not to encroach 12" or more on the outside the paved shoulder for 25 continuous feet

		<ul style="list-style-type: none"> No washboard areas with a total differential greater than 5" from the low spot to high spot
	Front Slope	<ul style="list-style-type: none"> No depth or height deviations greater than 6"
	Slope Pavement	<ul style="list-style-type: none"> No individual areas of missing, settled, or misaligned areas greater than 10 square feet
	Sidewalk	<ul style="list-style-type: none"> 99.5% of sidewalk area does not have vertical misalignments greater than 0.25" or horizontal cracks greater than 0.5" No visible hazards
	Fence	<ul style="list-style-type: none"> No unrestrained free entry is allowed
Traffic Services	Raised Pavement Markers	<ul style="list-style-type: none"> 70% of required markers are functional (reflective) No locations where there is more than 100 continuous feet of centerline or lane line without a reflective marker
	Striping	<ul style="list-style-type: none"> 90% of the length and width of each lane line functions as intended
	Pavement Symbols	<ul style="list-style-type: none"> 90% of existing symbols function as intended
	Guardrail	<ul style="list-style-type: none"> Each single run functions as intended
	Signs Less Than or Equal to 30 Square Feet	<ul style="list-style-type: none"> 95% of signs function as intended
	Signs Greater Than 20 Square Feet	<ul style="list-style-type: none"> 85% of signs function as intended
	Object Markers and Delineators	<ul style="list-style-type: none"> 80% of markers function as intended
	Lighting	<ul style="list-style-type: none"> 90% of all luminaries of combined sign and highway lighting function as intended
Drainage	Side/Cross Drain	<ul style="list-style-type: none"> 60% of each pipe's cross section contains no obstructions and functions as intended
	Roadside/Median Ditch	<ul style="list-style-type: none"> Ditch bottom elevation cannot vary from the design elevation by more than 1/4 of the difference between the edge of pavement elevation and the ditch's design elevation
	Outfall Ditch	<ul style="list-style-type: none"> Ditch bottom elevation cannot vary from the design elevation more than 1/3 of the difference between the natural ground and design flow line
	Inlets	<ul style="list-style-type: none"> 85% of the opening is unobstructed

	Miscellaneous Drainage Structure	<ul style="list-style-type: none"> 90% of each structure functions as intended
	Roadway Sweeping	<ul style="list-style-type: none"> Material accumulation does not exceed 0.75" for more than 1 continuous foot in the traveled way, or Material accumulation does not exceed 1.5" for more than 1 continuous foot in any gutter
Vegetation and Aesthetics	Roadside Mowing	<ul style="list-style-type: none"> No more than 1% of mowing exceeds the specified height guidelines (including seed stalks and decorative flowers): <ul style="list-style-type: none"> Rural Limited Access — 5"-18" Rural Arterial — 5"-12" Urban Limited Access — 5"-12" Urban Arterial — 9" maximum
	Slope Mowing	<ul style="list-style-type: none"> No more than 2% of vegetation is higher than 24" (excluding seed stalks and decorative flowers) Evaluate using standards in <i>A Guide for Roadside Vegetation Maintenance</i>
	Landscaping	<ul style="list-style-type: none"> 90% of landscape vegetation is in a healthy, attractive condition
	Tree Trimming	<ul style="list-style-type: none"> No trees, tree limbs, or vegetation should encroach upon the travel way or clear zone lower than 14.5 feet, or below 8.5 feet for sidewalks, curbs, and gutter clear zones
	Curb/Sidewalk Edge	<ul style="list-style-type: none"> No vegetation or debris encroachment onto the curb or sidewalk for more than 6" for more than 10 continuous feet Soil height cannot deviate more than 4" above or 2" below the top of the curb or sidewalk for more than 10 continuous feet
	Litter Removal	<ul style="list-style-type: none"> Litter volume is not greater than 3 cubic feet per acre, excluding all travel way pavement No unauthorized graffiti or stickers within the state's right of way on state-owned property No litter hazards on the roadway, paved shoulder, or clear recovery zone
	Turf Condition	<ul style="list-style-type: none"> Turf in mowing area is 75% free of unwanted vegetation No unwanted vegetation growing out of Mechanically Stabilized Earth and Sound Wall greater than 6" in length No more than 7.5 square feet of unwanted vegetation in any 50 square foot area of paved shoulder, pavement joints, concrete traffic

		separators, curb/asphalt joints, and under guardrail <ul style="list-style-type: none"> • No vegetation damaging or displacing the asset structure
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4.6 Key Takeaways

- The organization and implementation of maintenance programs vary among state agencies with respect to scheduling and executing work.
- Many agencies have set target maintenance conditions, which specify a desired level of service and define what conditions should be present at a facility to achieve performance goals.
- Inspection programs are integral to setting maintenance priorities. Many STAs inspect a random sample of facilities two or three times per year to identify what maintenance is needed. MDT, for example, inspects some facilities, such as ditches and drainage outlets, following extreme weather events (e.g., flooding) that can impact their performance. Some maintenance activities are performed at regular intervals, but many are done on an as-needed basis pursuant to the findings of inspections or when a problem first arises.

Chapter 5 KYTC District Workshops

We conducted 24 workshops across the Cabinet’s 12 highway districts — two workshops in each district. In each district, both workshops were held on the same day. The morning workshop included Maintenance Supervisors while the afternoon session was for district Section Engineers. Our team assigned both groups the same task — list all of the activities they perform or assign as a part of their job in maintenance for that district.

After each person brainstormed answers individually, participants worked together in groups to ensure all activities were captured. Activities were recorded on half sheets of paper and attached to a sticky sheet placed at the front of the room. The session facilitator helped participants group similar activities together into clusters. Once the activities were grouped together and the duplicates removed, a calendaring exercise was begun on another sticky sheet.

The calendaring exercise was used to determine how frequently staff members conduct and/or assign maintenance activities under *ideal* conditions. Ideal conditions were defined as those where materials, staff, and funding are available to conduct the needed maintenance activity in a consistent and ongoing manner. Participants could select from the following categories for the calendaring frequency: Daily, Weekly, Bimonthly, Monthly, Quarterly, Biannually, and Annually. After all the actions were placed on the calendar, we held a second group discussion to arrive at a consensus on the frequency of each action. In several districts, the need for two additional categories emerged from the discussions: As Needed and Never.

During the final portion of each workshop participants assigned a level of importance to each action. Participants ranked them on a scale from 1 to 9, with 1 being the most important action and 9 being the least important action. Participants used electronic devices to anonymously rank the importance of each action for their district. As participants were ensured that their answers in the workshop would remain anonymous, the district calendars are labeled A-L. Groups of Section Engineers and Superintendents are identified for comparison purposes. Calendars are reproduced on pp. 50-73.

District A: Superintendents

Daily	Weekly	Bi-Weekly	Monthly	Quarterly	Every Six Months	Yearly	Seasonal/As Needed
Schedule training for tech re-class	Pothole	Moving equipment to other counties	Safety training	Stock piling rock and materials	Washing pipe		Snow and ice removal
Inventory management	Equipment service			Office supply ordering			Snow and ice preparation
Slope protection				Employee Evaluations			Spraying ROW
Slope mowing (if equip available)							Mowing support
Bridge maintenance							Planting flower beds in spring
Job assignments daily							Seeding
Email work location							Fertilize median
Time sheet supervision							Replace piping
Ditching							Repair guardrail
Dead animal pickup							Shoulder repair (breaks and slides)
Take complaints/ PR work							Setting out high water signs
Check for material we need for job							Bleeding water
Debris removal							
Brush removal							
Deal with call-outs from dispatch							
Maintain grounds and facilities							
Load material							

District A: Section Engineers

Daily	Weekly	Bi-Weekly	Monthly	Quarterly	Every Six Months	Yearly	Seasonal/As Needed
Respond to complaints	Building and ground maintenance	Ditching	Assist contractor	Inventory	Bridge deck patch		Snow and Ice
Dead animal/debris removal			Brush cutting				Bridge cleaning
Some admin work			Potholes				Roadside mowing/slope mowing (if manpower can be daily)
Assist mechanics			Repair/replace drainage				Channel repair
Training!							Shoulder, slip/slide repairs
							In road response (emergency)
							Move equipment
							Cribbing and back filling breaks

District B: Superintendents

Daily	Weekly	Bi-Weekly	Monthly	Quarterly	Every Six Months	Yearly
Environmental compliance	Slab replacement	Clean out homeless camps	Storm cleanup	Slope protections	Base failures	Snow/ice
Runs for stuff in road	Clean drains	Swept & vacuum	Mowing		Clean up slides	Make brine
Dead animals	Replace pipes		Mow ROW		Clean debris from bridges	SNIC
Truck wrecks	Put in pipes		Rail mowing		Graffiti	
Traffic control	Cross drain/ Private entrances.		Cut trees		Paint	
EME projects					Flooding	
Work on equipment/Equipment repairs						
Time admin reporting						
Check complaints						
Public complaints						
Crush rocks						
Ditches						
Fix shoulders						
Flagging						
Fix bridges						
Fix potholes						

District B: Section Engineers

Daily	Weekly	Bi-Weekly	Monthly	Quarterly	Every Six Months	Yearly
Citizen complaints	Potholes	Discuss needs list	Stockpile materials (inventory)	Water samples	Slope repair	Bridge maintenance
Traffic control	Ditching	Prioritize needs list	Site distance		Add shoulders	Slab repair
Emergency call outs	Replace/clean cross drains		Mowing R/W			Crack sealing
	Driveway pipe		Tree cutting			Joint sealing

District C: Supervisors

Daily	Weekly	Bi-Weekly	Monthly	Quarterly	Every Six Months	Yearly	As Needed/ Seasonal	Never
Good relations w/ other governments	Litter pickup		Do monthly inventory	Service equipment	Evaluations		Make work orders for equipment	Take water samples
Public relations			Put down pavement				Snow and Ice	School
Routine flagging			Ditching				Road signs to close roads	
Customer service							Emergency flagging	
Checking roads							Storm clean up	
OMS + payroll							Cross drain repair	
Job assignments							Dead animal pickup	
Babysit							Mowing	
Lock all equipment								
Personnel Issues								
Traffic control								
Pothole patch								
Repair signs								

District C: Section Engineers

Daily	Weekly	Bi-Weekly	Monthly	Quarterly	Every Six Months	Yearly	As Needed/ Seasonal	Never
Address complaints	Assign special projects	Tree removal	Material/ Inventory stockpile	Cross drain replacement			Mowing	
Equipment Repair	Haul materials		Service equipment	Base failure repairs			Snow and Ice	
Roadkill removal	Shouldering		Pipe replacement				911 call outs	
Office work			Entrance permits				Emergency repairs	
Work orders			Sign and inventory replacements				Emergency traffic control (flagging)	
Submit payroll			Cleaning bridge gutter				Pothole patching	
OMS inventory							Clean debris from drain	
Phone calls							Sign repair	
Traffic control/event coordination								

District D: Superintendents

Daily	Weekly	Bi-Weekly	Monthly	Quarterly	Every Six Months	Yearly	Seasonal/As Needed
Dangerous Tree inventory	Potholes	Weed eating for sight distance	Inspect rest areas	Inspect tree cutting		Spray bare ground, shoulders, guardrail, etc.	Mowing
Dead animal pick-ups and recaps	Ditching	Repair/ replace tiles	Keep stockpiles and inventory maintained	Service trucks/equipment		Grader patching	Snow and ice
Minor equipment repairs	Maintain lots			Clean creek channels		Brush control	Obnoxious weeds
Clean tiles	Litter pickup					Pavement marking inspections	Spray summer weeds
Sign maintenance	Mailbox and shoulder maintenance						Mowing zone maintenance
Communicate with public for complaints and requests							Inspect mowing
Flagging planned							Respond road failures
Transport equipment materials							Working wrecks
Tree cutting/trimming							Flagging emergency
							Slips & slides

District D: Section Engineers

Daily	Weekly	Bi-Weekly	Monthly	Quarterly	Every Six Months	Yearly	Seasonal/As Needed
Dead animal pickup	Litter pickup	Bridge and box		Water sampling	Repairs prior to scheduled paving projects	Required training	Permitted private entrance pipe construction (as needed)
Time sheets/payroll	Shouldering	Culvert cleaning		Lot maintenance		Traffic signal inspections	Pipe repairs or replacements (as needed)
Routine route checks	Ditching	Debris removal		Road sign maintenance			Guardrail repairs
Slope mowing		Cleaning pipes		Inventory			Hazardous tree removal
Pothole patching		R/W Clearing					Special projects, turn lanes/slide repairs
Answering public complaints							Hydro seeding
Equipment rental support							Snow and ice
Equipment maintenance							R/W mowing
Lot maintenance							R/W spraying (March-October)
							Grader patching (April-November)

District E: Superintendents

Daily	Weekly	Bi-Weekly	Monthly	Quarterly	Every Six Months	Yearly	As Needed/ Seasonal
Check on any sight distance problems	Change and maintain drainage pipes, cross drains, entrance drain pipes	Ditching	Sky trim tree cutting	Right of way mowing	Clean bridges	Rocking mailboxes	Clip high shoulders, so water will drain from roadway
Maintain road signs	Clean equipment	Repair base failures	Minor equipment repair and oil change	Inspect contractors	Fencing		Small paving operation (hot mix)
Interstate debris removal	New entrance tiles		Low shoulder	Hauling rock/stockpile			Spray roadside vegetation
Housekeeping	Trees on R/w		Shoulder work				SNIC
Debris pickup	Chipping brush		Slope repair				Salt brine
Answer dispatch calls	Potholes		Slope protection				Bush hog weeds and grass
Call ins							Straw blanket seed
Call and locate utilities 811							Remove dead animals on road
Slope mow							Water issues
							Sink hole
							TOC (social media)

District E: Section Engineers

Daily	Weekly	Bi-Weekly	Monthly	Quarterly	Every Six Months	Yearly	As Needed/ Seasonal
Inmate supervision	Service equipment	New entrance pipes	Trees: sky trim, sight dist., trim, removal)	Pipe cleanout	Clean bridges		Maint. Contractor inspection (equipment, sweeping, ceiling)
Ferry boat	Pothole patching	Facility maintenance (mow, spray, environmental compliance)	Sweeping: Wide shoulders, curb and gutter)		Embankments (cutting, filling)		Dead animal removal
Public complaints	Base failures	Culvert repair					Markings, thermo
811 Locates							Emergency response
Litter							Concrete work
Shoulder repair (cutting, filling,							Fence repair
Temp. traffic control							Guardrail repairs
Signs (new and repair)							Sinkhole repair
Ditching							Contract mowing inspection
Debris in roadway							Spraying (daily)
							SNIC

District F: Superintendents

Daily	Weekly	Bi-Weekly	Monthly	Quarterly	Every Six Months	Yearly	As Needed/ Seasonal
Paperwork	Pothole repair	Equipment Maintenance	Stockpile/ inventory materials		Cutting trees and bushes	R.S Program	Wrecks/Traffic control
Prioritize jobs	Litter pickup	Ditching				Grade shoulders	Base failure repair
Public relations							Dead animal pickup
Crew operations assignments							High water
Keep crew motivated and safe							Slide repair on ROW
Traffic control							Special projects
Slope mowing							Demolition for road construction
							Concrete work
							Sign maintenance
							Cable barrier repair
							Cross drain repair
							Slope protection (? Months, material issue)
							Seed and straw
							Mowing ROW (daily)
							Snow and Ice

							Spraying (2 weeks)
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District F: Section Engineers

Daily	Weekly	Bi-Weekly	Monthly	Quarterly	Every Six Months	Yearly	As Needed/ Seasonal
Address public request	Potholes	Facility and lot maintenance-organization	Pipes- extend or replace	Mowing	Strip patching (needs \$)	Repairs before construction	Sinkhole mitigation
	Interstate clean-up (debris)		Guardrail repair	Cut/fill shoulders	Bridge ends	Channel living (ditches, slopes, slides, bridge scour)	Roadkill pickup
	Ditching roadside		Cable barrier repair	Tree removal			Special projects
	Traffic control - scheduled		Vehicle maintenance	Inventory			Incident management
				Seeding			Concrete joint/slab repair (10 yr. cycle)
				Bridge maintenance			Gabion basket retaining wall
							Slope repair
							Snow and Ice
							Base failures (weather, ADT, \$)
							Spraying (weather dependent priority to ___)
							Stream mitigation (1yr)
							Drift removal scouring (1yr)

District G: Superintendents

Daily	Weekly	Bi-Weekly	Monthly	Quarterly	Every Six Months	Yearly	As Needed/ Seasonal
Working in construction with all contractors	Mowing office yard	Repair cross drain	Inventory	Water samples	Gravel shoulder maintenance	Cleaning bridge decks and under	Snow and ice
Slope mowing	Litter pickup	Repair entrance	Cleaning pipe dig out dirt from ends of pipe to improve drainage	Clean tiles with sewer rat	Mail boxing- use shoulder maintainer one driver one shovel man	Fix right of way fence	Snow and Ice- prepare equip. plow and salt
Work on equipment	Ditching		Pothole repair		Political signs		Mow and trim state ROW
	Call 811		Grade high places for side of road so water can drain				Plow driveways back after storms
			Cutting trees and brush				Dead animals/debris pickup
			Remove dangerous trees, cut brush to improve sight distance				Spread sand for 911
			Cut shoulder from roadway				Cut trees 911
			Attend training				Repair cable rail
			Sweeper truck				Flagging- emergency
							Fill in sinkholes
							Clean up car wrecks
							Install concrete panels

District G: Section Engineers

Daily	Weekly	Bi-Weekly	Monthly	Quarterly	Every Six Months	Yearly	As Needed/ Seasonal
Prepare paperwork	Slope mowing for sight improvements		Patching	Roadway improvements	RS/FD05 recommendations	Snow/Ice prep	Snow and ice removal
Prepare estimate of work			Ditching	Clean ditches to drain	Brush cutting		Mowing
Construction inspection duties			Inventory	Cut back shoulder			Remove political signs
				Collect water samples			Delineators on GR
							Remove dead animals
							Remove dead trees
							Install entrance pipes
							Road side cleanup
							Slide repair coordination
							Complaints
							Pipe repair/ replace
							Equipment repair/needs
							811

District H: Superintendents

Daily	Weekly	Bi-Weekly	Monthly	Quarterly	Every Six Months	Yearly
Pothole Repair	Litter Pick-up	Equipment Inspections	Sign Maintenance (Only Stop Signs after hours--not required, but needed)	Mowing ROW	Snow/Ice Removal	Larger Slip Repairs
Construction Office Step Child --Corrective work --Jobs that are not really part of maintenance	Dead Animal Pick-up	Pipe Replacement/Cleaning	Cleaning and Clearing Drains Cross Drains and Entrance	Litter Removal	Blacktop with Paver	Shouldering
Call Outs (Trees, Deer, Potholes, Accidents)	House Keeping	Culvert Replacement	Tree and Brush Removal			
Weather Log			Storm Damage Clean-up/Repair			
			Smaller Slip Repairs			
			Tree / Brush Trimming			
			Cut Trees for Sight			
			Ditching			

District H: Section Engineers

Daily	Weekly	Bi-Weekly	Monthly	Quarterly	Every Six Months	Yearly	As Needed/ Seasonal	Never
Fill out Paperwork and Forms		Tree and Brush Removal	Material Inventory	Slide Repairs	Snow and Ice Removal	Clean Clogged Culverts and Drains	Flooding Issues (Pumping or Clogged Drains-- Randomly Occurring)	Driveway Permits
Dead Animal Pick-up		Sign Repair/Report	Ditching	Paving	In Place Grader Patches	Replace Culvert Pipes	Perform Traffic Control for Others (Scheduled)	Fix Construction Issues (Rural vs. Urban Issue)
Traffic Control (Emergency)		Tree and Brush Trimming	Entrance Pipe Replacement and Cleaning	After "Hours" Flagging		Add Drop Boxes		Spray Vegetation (Rural vs. Urban Issue)
Guard Rail Strikes			Garbage Removal	Mowing				Removal of Political Signs out of the ROW
Potholes			Fix Shoulder Drop Offs	Slope Mowing				
Emergency Call Outs				Bridge Maintenance (Drain Cleaning)				
Downed Signs (Report/Check)				Culvert Cleanout Repair				
Deal with Personnel Issues				Rolling Roadblocks and Pothole Patching				
				Service Vehicle Equipment				
				Sweep Road Shoulders				

District I: Superintendents

Daily	Weekly	Bi-Weekly	Monthly	Quarterly	Every Six Months	Yearly	As Needed/ Seasonal
Remove and add material to OMS	Pothole patching	Hold safety meetings	Make equipment repairs	Grade roads	Do evaluations	Repair bridges and cleaning	Mowing
Ditching	Relay new policies to workers		Service equipment				Snow and Ice
Cut trees and brush for line of sight	Pick up dead animals		Shoulder and slide repair				Spray brush
Be a support to the crew	Repair signs		Tree cleanup				Blacktop work
Make out daily job assignments	Litter removal						Cleaning culverts
Check contractor							Bleed roads
Do paperwork							Clean roadway of spills
Approve and sign leave requests							Emergency flagging
Job assignments							Handle emergency situations
Address complaints from the public							Replace cross drains
Traffic control							Sink hole repair
Lane closures							

District I: Section Engineers

Daily	Weekly	Bi-Weekly	Monthly	Quarterly	Every Six Months	Yearly	As Needed/ Seasonal
Flagging/traffic control	Pothole repair		Inventory	Grading	ALBC Install		Stop sign replacement
Personnel issues	Mechanical work		Training	High shoulder removal	Bridge sweeping		Animal removal
Inmate supervision	Tracking MIA contracts		Pipe repair	Tree removal	Clean DBI's		Traffic control for crashes
Respond to complaints (10+ times a day)	Residential entrance permits (sign and distance)						Guardrail repair
	Train new hires/interviews						Slide repair
	Brush removal for sight distance						Snow and Ice
							Mowing
							Road closure signs
							Storm clean-up
							Paving
							Ditching (daily)

District J: Superintendents

Daily	Weekly	Bi-Weekly	Monthly	Quarterly	Every Six Months	Yearly	Seasonal/As Needed
911	Litter pick-up	Slides	Right of Way permits	Water samples	Evaluations	Clean Cuts	Snow and Ice removal
Talk to public	Service Equipment -without full training -greasing ruins uniforms -mechanic?			Quarter inspections	Spray weeds	Ditching	
Sign crew out	Drainage repairs						
Keep garage clean	Clean pipes						
Safety talks	Repair breaks						
Approve leave forms	Pothole patch						
Approve timesheets	Grader patch						
Pick up and dispose of dead animals	811						
Tree removal							

District J: Section Engineers

Daily	Weekly	Bi-Weekly	Monthly	Quarterly	Every Six Months	Yearly	Seasonal/As Needed
Dead animal removal	Garage Maintenance	Inventory			Contractor tree removal	Summer weed spray	Mowing
Checking out citizen complaints	Facility Housekeeping				Shoulder work	Ditching	Rock falls
Accident response	Equipment cleaning and maintenance					Snow and ice	Clear slides
Emergency calls						Anti-icing	Traffic control
						Grader patching	Flag for others
						Cleaning drains	Flood clean-up
							Look for problems
							Pothole patching
							Replace pipes
							Cutting brush
							Repairing roadway breaks

District K: Superintendents

Daily	Weekly	Bi-Weekly	Monthly	Quarterly	Every Six Months	Yearly	Never
Pothole patching	Express runs	Ditching	Cleaning pipes	Slight distance	Winter-SNIC	Environmental work	Traffic control for other crews
Trash of all kinds	Dead animals	Equipment upkeep	Install entrances	Brush removal and grinding	Plowing snow	Base failure repair	Political Signs
Emergency calls	Slope mowing		Pipe replacement	Tree removal	Snow Ice	Grading shoulders	Traffic control for other crews and accidents
Paperwork	Wrecks		Culvert replacement	Daylighting road signs	Gabion Basket's		Oil change on equipment
Complaints	Weed eating and mowing		Inventory		Slope repair		
			Equipment/barn maintenance				
			High water				
			Cleaning bridge decks				

District K: Section Engineers

Daily	Weekly	Bi-Weekly	Monthly	Quarterly	Every Six Months	Yearly	Never
Stuff in road	Equipment/vehicle maintenance	Sign repair/replacement	Inventory	Mowing	Slope mowing	Ditching	Emergency traffic
Animal/trash removal	Patching		Drain clean	Snow and ice	Tree/brush removal	Minor slide repair	Private entrance
Traffic control	Pothole/pavement repair		Cross-drain replacement/cleaning		Tree and brush trimming	Slide repair	
			Pipe replacement			Shouldering	
			Culvert replacement			Small construction work	

District L: Superintendents

Daily	Weekly	Bi-Weekly	Monthly	Quarterly	Every Six Months	Yearly
Ditching			Pipe replace		Slope mow	Evaluations
Private entrances			Private entrances (urban vs. rural) new construction		Tree trimming, tree removal	
Regen equipment wastes time					Shouldering	
Lack of equipment					Mowing	
Pothole patching					SNIC	
Paper work					Service equipment and trucks	
Administrative duties					Evaluations	
Complaints from public						
Social media						
Dead animal pickup						
Emergency call outs						
Storm cleanup						
Litter						

District L: Section Engineers

Daily	Weekly	Bi-Weekly	Monthly	Quarterly	Every Six Months	Yearly	Seasonal/As Needed
Potholes	Culvert maintenance	Ditching	Cable	Bridge structure maintenance		Slide repair	Mowing
Complaints	Pipe Replacement	Culvert repair/replace	Guard rail repair	TC for bridge work		Slip repair	Snow and Ice activities
Traffic control (flagging)	Equipment maintenance	Flush Pipe					Emergency assistance to counties/ cities
	Equipment Repair	Beaver dam removal					Accident assistance
	Debris/Animal Removal						Other duties as assigned
	Pavement repair						Sign repair
	Patching						Sign maintenance
	Base Failure Repair						Trees/storms
	Brush/tree maintenance						Storm damage evaluation/ repair
	Tree cutting						
	Shouldering						
	Driveway/ Entrance maintenance						

5.1 Calendaring Results

The workshops resulted in two calendars for each district — one produced by the Maintenance Supervisors and one by Section Engineers. Each maintenance activity described during the session was analyzed and tallied based on the category in which participants placed that activity. Some activities were calendared similarly across all districts. Other activities exhibited greater variability, with a broader range of recurrence intervals. A review of the 24 calendars demonstrates significant variation between districts in terms of when they perform maintenance activities.

For several maintenance activities, respondents provided a full spectrum of answers for how frequently they perform or should be performed. For instance, participants said that clearing culverts and pipes and shouldering need to be done daily, weekly, biweekly, monthly, quarterly, biannually, annually, or as needed. Even within individual districts staff differed in their opinions of how frequently culverts and pipes should be cleared. In District J, Maintenance Supervisors said this should be done weekly, whereas the section engineers felt it can be done once per year. In District H, the Maintenance Supervisors identified clearing culverts and pipes as a monthly job, whereas Section Engineers said it needs to be completed once per year. Across all the districts, Maintenance Supervisors, on average, viewed clearing pipes and culverts as something that needs to happen more frequently than Section Engineers did. For shouldering activities, 59 percent of participants calendared this activity needing to occur on a monthly basis or more frequently. Forty-one percent calendared shouldering being necessary on a quarterly, biannual, or annual basis.

Table 6 Comparison of Maintenance Supervisor and Section Engineer Activity Timelines

Group ID		Daily Activities	As-Needed Activities	Combined	Number of Activities Identified
A	Maintenance Supervisors	17 (55%)	6 (19%)	23 (74%)	31
A	Sections Engineers	5 (26%)	6 (32%)	11 (58%)	19
B	Maintenance Supervisors	16 (42%)	*	*	38
B	Sections Engineers	3 (15%)	*	*	20
C	Maintenance Supervisors	13 (45%)	6 (21%)	19 (66%)	29
C	Sections Engineers	9 (31%)	6 (21%)	15 (52%)	29
D	Maintenance Supervisors	9 (31%)	4 (14%)	13 (45%)	29
D	Sections Engineers	9 (29%)	7 (23%)	16 (52%)	31
E	Maintenance Supervisors	10 (24%)	5 (12%)	15 (37%)	41
E	Sections Engineers	10 (31%)	8 (25%)	18 (56%)	32
F	Maintenance Supervisors	7 (31%)	11 (35%)	18 (58%)	31
F	Sections Engineers	1 (3%)	10 (31%)	11 (34%)	32
G	Maintenance Supervisors	3 (8%)	8(22%)	11 (30%)	37
G	Sections Engineers	3 (11%)	11 (41%)	14 (52%)	27
H	Maintenance Supervisors	4 (17%)	.	.	24
H	Sections Engineers	8 (22%)	2 (7%)	10 (27%)	37
I	Maintenance Supervisors	12 (33%)	11 (31%)	21 (58%)	36
I	Sections Engineers	4 (13%)	9 (30%)	13 (43%)	30
J	Maintenance Supervisors	9 (35%)	0 (0%)	9 (35%)	26
J	Sections Engineers	4 (15%)	10 (37%)	14 (52%)	27
K	Maintenance Supervisors	5 (14%)	.	.	36
K	Sections Engineers	3 (13%)	.	.	25
L	Maintenance Supervisors	13 (57%)	.	.	23
L	Sections Engineers	3 (9%)	7 (21%)	10 (29%)	34

The potential disconnect in communication between Maintenance Supervisors and Section Engineers (across multiple districts) is apparent in the different timelines they have for specific activities and for activities taken collectively. For example, in District L Section Engineers stated that 9 percent of maintenance activities need to be completed on daily (Table 6). Conversely, the district's Maintenance Supervisors stated that 57 percent of maintenance activities should be completed once per day. All of the districts exhibit some level of disconnect between the Maintenance Supervisors and Section Engineers in terms of how often each activity should occur.

Activities classified *as needed* by the Section Engineers and the Superintendents better align as an overall percentage of the number of activities that need to occur as those situations present themselves. For example, Accident Response, Emergency Roadway Response, and Emergency Flagging cannot be scheduled and thus require an *as needed* response. Although consistent with the *Field Operations Guide* (FOG), having multiple maintenance activities classified *as required* or *as needed* makes scheduling other activities more challenging, particularly when those activities happen daily or weekly. The FOG notes that activities such as Repairing Cross Drains, Dead Animal Pick-up, Litter Cleanup, Express Run, and Sign Maintenance are scheduled *as required*. However, the calendaring activity demonstrates that Dead Animal Pickup, Litter Cleanup, and Express Run occur daily or weekly. Repairing Cross Drains is a weekly to monthly job requirement, and Sign Maintenance and/or Replacement of Signs is a daily activity. While maintenance activities are done *as required*, given the consistency with which they occur, a maintenance schedule should allot time for their completion on a regularly scheduled basis.

The calendars help reveal why KYTC maintenance crews find it challenging to complete projects that require long-term planning and coordination. In 21 out of the 24 workshops, participants stated that responding to public complaints is part of their daily maintenance routine. In prioritizing public complaints and emergency call-outs on a daily basis, it is very difficult to plan and schedule the other 30 plus activities that are a part of maintenance duties.

5.2 Administrative Duties

Both Maintenance Supervisors and Section Engineers identified multiple administrative activities that are required as a part of their daily job. Activities such as job assignments and prioritization, personnel issues, leave requests, interviewing and training new hires, and creating a needs list for the district are examples of activities maintenance supervisors must complete due to their knowledge and expertise. However, district supervisors identified several other administrative activities that could be completed by an employee with clerical and/or secretarial skills. Multiple workshop participants mentioned that the administrative burden has become more intense since the “timekeepers” were removed from the maintenance barns. Transferring some of the administrative duties to a staff member that is not required to be in the field should afford greater flexibility when choosing activities for the maintenance crews. Table 7 summarizes the administrative duties identifies in the maintenance workshops.

Table 7 Administrative Activities Identified in Workshops

Equipment Work Orders	Create/Discuss Needs list for District	Training new hires
OMS Inventory	Weather Log	Paperwork: time reporting, environmental compliance, and work estimates
Payroll	Water Samples	Interviews
Job Assignments/ Prioritization	Social Media	Equipment Rental
Personnel Issues	Local Inventory	Leave Requests
Contact 811		

5.3 Seasonal Activities

All districts identified seasonal maintenance activities such as snow and ice removal and mowing (contracted or in-house). A few districts highlighted additional district-specific seasonal activities, including seeding and spraying and brush removal. Clearly, weather conditions affect how impactful seasonal activities are on crew calendars. As such, the Supervisors and Section Engineers must be aware of the impact of additional activities when preparing daily, weekly and biweekly schedules for the crews.

5.4 District-Specific Activities

Each district identified maintenance activities that are either specific to their district or that are done in only a couple of the districts. These activities are summarized in Table 8. It is possible that the activities identified below are performed in additional districts. However, they were not specifically mentioned in those districts.

Table 8 District Specific Activities

Contractor Inspections	Private Driveway Entrance Permits	Route Inspection	Facility and Lot Maintenance
Inmate Supervision	Bridge Maintenance	Mechanized Sweeping	Transporting Equipment
Construction Work	Graffiti Removal	Seeding	
Concrete Repair	Spraying and Removing Brush		

5.5 Crew Concerns

Workshop participants identified several work tasks they do not believe should be assigned to maintenance workers: providing emergency traffic control for roadway accidents or incidents, performing traffic control for other crews and agencies, removing the political signs from the right of

way, issuing private driveway permits and construction of private entrances, and changing oil on equipment.

Participants also discussed the amount of required maintenance work in relation to available funding, crews, and equipment. Some district crews are so short staffed that prioritizing work via a schedule makes little difference since there are not enough people to meet the minimal number of staff required for many activities. Relatedly, participants stated that there are not enough qualified people to operate necessary equipment in districts, resulting in staff refusing to ride with operators they perceive as unsafe. Ultimately, employees do not want to learn equipment operations.

Most district personnel commented on the lack of available equipment and being forced to share equipment that is available. For example, a specific piece of machinery is used twice a year, for two months at a time. However, a single crew may keep the equipment in use for the entire two months when it is to be shared among more than 10 counties. Another example provided by participants involved Bobcats and their needed attachments. In this particular case, three Bobcats were available for use but only one set of attachments. Participants requested that inventories of all district equipment be completed, GIS-tagged, and managed to ensure that equipment is not hoarded or “lost.” Participants also requested that equipment management and funding allotments for district equipment be discussed with district personnel prior to purchase. Multiple cases were noted in which new equipment was purchased, but not what was needed in the district for completion the maintenance activities.

5.6 Ideal Calendars for Each District

We analyzed the 24 calendars to identify consensus about when activities should be completed, with common names assigned to similar activities such as pothole patching. Where there was no consensus over when an activity should be completed, we performed a cluster analysis and the median time was selected. These activities were then placed on the Statewide Maintenance Calendar. District-specific activities are also included on the individual calendars. However, as many of the district-specific activities mentioned are likely to be performed in the other districts as well, they should be considered when completing a work schedule for each district. These calendars are reproduced below (pp.79-91).

Statewide Maintenance Calendar

Daily	Weekly	Bi-Weekly	Monthly	Quarterly	Every Six Months	Yearly	Seasonal	As Needed
Administrative Duties	Pothole Patching	Culverts and Pipes Cleaning	Inventory and Stockpile Material	Paver Machine or Grader Patching	Evaluations		Snow and Ice Removal	Accident Response
Respond to Citizens Concerns/ Complains	Ditching		Shouldering				Mowing	Emergency Flagging/Traffic Control
Litter Cleanup, Express Run	Litter Cleanup							Emergency Roadway Work
Flagging/Traffic Control for Others	Equipment Service							Repairing Cross Drains
								Dead-Animal Pickup
								Sign Maintenance / Replacement of Signs
								Repair to Landslides And Sinkholes

District 1

Daily	Weekly	Bi-Weekly	Monthly	Quarterly	Every Six Months	Yearly	Seasonal	As Needed
Administrative Duties	Pothole Patching	Culverts and Pipes Cleaning	Inventory and Stockpile Material	Paver Machine or Grader Patching	Evaluations		Snow and Ice Removal	Accident Response
Respond to Citizens Concerns/ Complains	Ditching		Shouldering				Mowing	Emergency Flagging
Litter Cleanup, Express Run	Litter Cleanup							Emergency Roadway Work
Flagging/Traffic Control for Others	Equipment Service							Repairing Cross Drains
Route Inspection								Dead-Animal Pickup
								Sign Maintenance / Replacement of Signs
								Repair to Landslides And Sinkholes
								Storm Clean-up

District 2

Daily	Weekly	Bi-Weekly	Monthly	Quarterly	Every Six Months	Yearly	Seasonal	As Needed
Administrative Duties	Pothole Patching	Culverts and Pipes Cleaning	Inventory and Stockpile Material	Paver Machine or Grader Patching	Evaluations		Snow and Ice Removal	Accident Response
Respond to Citizens Concerns/ Complains	Ditching		Shouldering				Mowing	Emergency Flagging
Litter Cleanup, Express Run	Litter Cleanup						Spray Brush	Emergency Roadway Work
Flagging/Traffic Control for Others	Equipment Service							Repairing Cross Drains
Contractor Inspection								Dead-Animal Pickup
Inmate Supervision								Sign Maintenance / Replacement of Signs
								Repair to Landslides And Sinkholes
								Storm Clean-up

District 3

Daily	Weekly	Bi-Weekly	Monthly	Quarterly	Every Six Months	Yearly	Seasonal	As Needed
Administrative Duties	Pothole Patching	Culverts and Pipes Cleaning	Inventory and Stockpile Material	Paver Machine or Grader Patching	Evaluations		Snow and Ice Removal	Accident Response
Respond to Citizens Concerns/ Complains	Ditching		Shouldering				Mowing	Emergency Flagging
Litter Cleanup, Express Run	Litter Cleanup		Mechanized Sweeping				Spraying and Removing Brush	Emergency Roadway Work
Flagging/Traffic Control for Others	Equipment Service						Seeding	Repairing Cross Drains
	Facility and Lot Maintenance							Dead-Animal Pickup
								Sign Maintenance / Replacement of Signs
								Repair to Landslides And Sinkholes
								Contractor Inspection
								Concrete Repair

District 4

Daily	Weekly	Bi-Weekly	Monthly	Quarterly	Every Six Months	Yearly	Seasonal	As Needed
Administrative Duties	Pothole Patching	Culverts and Pipes Cleaning	Inventory and Stockpile Material	Paver Machine or Grader Patching	Evaluations	Construction Work	Snow and Ice Removal	Accident Response
Respond to Citizens Concerns/ Complains	Ditching	Facility and Lot Maintenance	Shouldering	Seeding			Mowing	Emergency Flagging
Litter Cleanup, Express Run	Litter Cleanup						Spraying and Brush Removal	Emergency Roadway Work
Flagging/Traffic Control for Others	Equipment Service							Repairing Cross Drains
								Dead-Animal Pickup
								Sign Maintenance / Replacement of Signs
								Repair to Landslides And Sinkholes
								Concrete Repair
								Storm Clean-up

District 5

Daily	Weekly	Bi-Weekly	Monthly	Quarterly	Every Six Months	Yearly	Seasonal	As Needed
Administrative Duties	Pothole Patching	Culverts and Pipes Cleaning	Inventory and Stockpile Material	Paver Machine or Grader Patching	Evaluations	Crack and Joint Sealing	Snow and Ice Removal	Accident Response
Respond to Citizens Concerns/ Complains	Ditching	Mechanical or Hand Sweeping	Shouldering		Graffiti Removal	Concrete Repair	Mowing	Emergency Flagging
Litter Cleanup, Express Run	Litter Cleanup		Storm Clean-up					Emergency Roadway Work
Flagging/Traffic Control for Others	Equipment Service							Repairing Cross Drains
Bridge Maintenance	Concrete Replacement							Dead-Animal Pickup
								Sign Maintenance / Replacement of Signs
								Repair to Landslides And Sinkholes

District 6

Daily	Weekly	Bi-Weekly	Monthly	Quarterly	Every Six Months	Yearly	Seasonal	As Needed
Administrative Duties	Pothole Patching	Culverts and Pipes Cleaning	Inventory and Stockpile Material	Paver Machine or Grader Patching	Evaluations		Snow and Ice Removal	Accident Response
Respond to Citizens Concerns/ Complains	Ditching		Shouldering	Mechanized Sweeping			Mowing	Emergency Flagging
Litter Cleanup, Express Run	Litter Cleanup		Storm Clean-up				Spraying and Brush Removal	Emergency Roadway Work
Flagging/Traffic Control for Others	Equipment Service							Repairing Cross Drains
Construction Work	Facility and Lot Maintenance							Dead-Animal Pickup
								Sign Maintenance / Replacement of Signs
								Repair to Landslides And Sinkholes
								Private Driveway Entrance Permits
								Storm Clean-up

District 7

Daily	Weekly	Bi-Weekly	Monthly	Quarterly	Every Six Months	Yearly	Seasonal	As Needed
Administrative Duties	Pothole Patching	Culverts and Pipes Cleaning	Inventory and Stockpile Material	Paver Machine or Grader Patching	Evaluations	Construction Work	Snow and Ice Removal	Accident Response
Respond to Citizens Concerns/ Complains	Ditching		Shouldering				Mowing	Emergency Flagging
Litter Cleanup, Express Run	Litter Cleanup		Facility and Lot Maintenance					Emergency Roadway Work
Flagging/Traffic Control for Others	Equipment Service		Driveway Entrances					Repairing Cross Drains
			Storm Clean-up					Dead-Animal Pickup
								Sign Maintenance / Replacement of Signs
								Repair to Landslides And Sinkholes

District 8

Daily	Weekly	Bi-Weekly	Monthly	Quarterly	Every Six Months	Yearly	Seasonal	As Needed
Administrative Duties	Pothole Patching	Culverts and Pipes Cleaning	Inventory and Stockpile Material	Paver Machine or Grader Patching	Evaluations		Snow and Ice Removal	Accident Response
Respond to Citizens Concerns/ Complains	Ditching		Shouldering				Mowing	Emergency Flagging
Litter Cleanup, Express Run	Litter Cleanup		Mechanical or Hand Sweeping					Emergency Roadway Work
Flagging/Traffic Control for Others	Equipment Service							Repairing Cross Drains
	Facility and Lot Maintenance							Dead-Animal Pickup
								Sign Maintenance / Replacement of Signs
								Repair to Landslides And Sinkholes
								Storm Clean-up

District 9

Daily	Weekly	Bi-Weekly	Monthly	Quarterly	Every Six Months	Yearly	Seasonal	As Needed
Administrative Duties	Pothole Patching	Culverts and Pipes Cleaning	Inventory and Stockpile Material	Paver Machine or Grader Patching	Evaluations		Snow and Ice Removal	Accident Response
Respond to Citizens Concerns/ Complains	Ditching		Shouldering				Mowing	Emergency Flagging
Litter Cleanup, Express Run	Litter Cleanup		Private Driveway Entrance					Emergency Roadway Work
Flagging/Traffic Control for Others	Equipment Service							Repairing Cross Drains
								Dead-Animal Pickup
								Sign Maintenance / Replacement of Signs
								Repair to Landslides And Sinkholes
								Storm Clean-up

District 10

Daily	Weekly	Bi-Weekly	Monthly	Quarterly	Every Six Months	Yearly	Seasonal	As Needed
Administrative Duties	Pothole Patching	Culverts and Pipes Cleaning	Inventory and Stockpile Material	Paver Machine or Grader Patching	Evaluations		Snow and Ice Removal	Accident Response
Respond to Citizens Concerns/ Complains	Ditching	Transport Equipm	Shouldering				Mowing	Emergency Flagging
Litter Cleanup, Express Run	Litter Cleanup						Spraying and Removing Brush	Emergency Roadway Work
Flagging/Traffic Control for Others	Equipment Service						Seeding	Repairing Cross Drains
	Facility and Lot Maintenance							Dead-Animal Pickup
								Sign Maintenance / Replacement of Signs
								Repair to Landslides And Sinkholes

District 11

Daily	Weekly	Bi-Weekly	Monthly	Quarterly	Every Six Months	Yearly	Seasonal	As Needed
Administrative Duties	Pothole Patching	Culverts and Pipes Cleaning	Inventory and Stockpile Material	Paver Machine or Grader Patching	Evaluations		Snow and Ice Removal	Accident Response
Respond to Citizens Concerns/ Complains	Ditching		Shouldering				Mowing	Emergency Flagging
Litter Cleanup, Express Run	Litter Cleanup						Seeding	Emergency Roadway Work
Flagging/Traffic Control for Others	Equipment Service						Spraying and Brush Removal	Repairing Cross Drains
Route Inspection	Transport Equipment							Dead-Animal Pickup
	Facility and Lot Maintenance							Sign Maintenance / Replacement of Signs
								Repair to Landslides And Sinkholes

District 12

Daily	Weekly	Bi-Weekly	Monthly	Quarterly	Every Six Months	Yearly	Seasonal	As Needed
Administrative Duties	Pothole Patching	Culverts and Pipes Cleaning	Inventory and Stockpile Material	Paver Machine or Grader Patching	Evaluations		Snow and Ice Removal	Accident Response
Respond to Citizens Concerns/ Complains	Ditching		Shouldering				Mowing	Emergency Flagging
Litter Cleanup, Express Run	Litter Cleanup						Spraying	Emergency Roadway Work
Flagging/Traffic Control for Others	Equipment Service							Repairing Cross Drains
	Facility and Lot Maintenance							Dead-Animal Pickup
								Sign Maintenance / Replacement of Signs
								Repair to Landslides And Sinkholes
								Route Inspection
								Storm Clean-up

5.7 Maintenance Activity Rankings

After the workshop participants completed the calendaring exercise, they were asked to provide a ranking of those activities. Using keypads, participants were asked to rank the activities on a scale of 1—9, where activities categorized as a score of “1” was considered “Most Important” and a score of “9” was considered least important. **Error! Reference source not found.** provides an example of a ranking activity for a district.

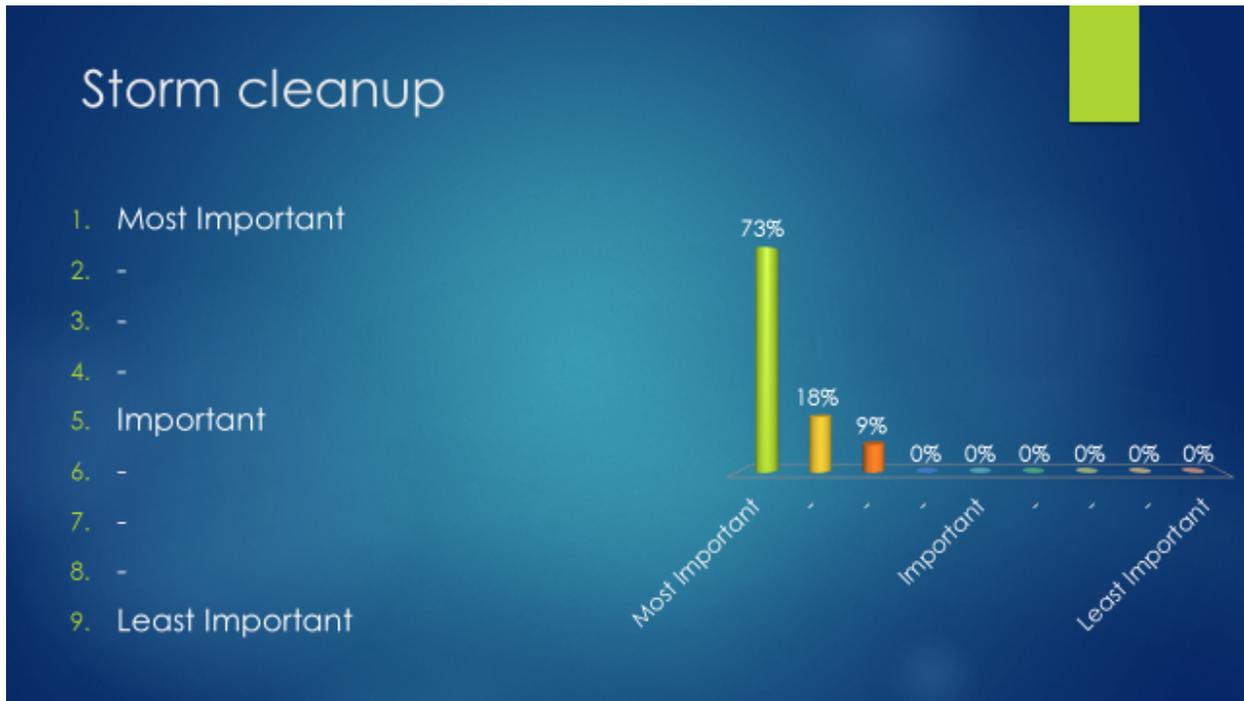


Figure 6 Activity Ranking Example

The rankings data from all 24 workshops was combined and analyzed to determine which activities workshop participants considered most important to least important. The total number of workshop participants was 235. Rankings for each individual workshop were created based upon the activities created during the calendaring exercise in that workshop, meaning that there were not 235 observations for every activity identified across the state. For some activities, such as administrative duties, districts ranked more than one administrative duty. For those districts that ranked more than one administrative duty, those duties were combined as the average of all tasks was used to compute the ranking for that district. However, it should be noted that participants considered some administrative duties more important than others. Table 9 provides the top 10 “Most Important” activities, the number of observations for that activity, and the average ranking score.

Table 9 Top 10 Participant Ranked Maintenance Activities

Maintenance Activity	Average Ranking	Number of Observations
Snow and Ice Removal	1.81	202
Emergency Response	2.25	136
Storm Clean-Up	2.57	88
Traffic Control	2.66	119
Pothole Patching	2.81	235
Repair to Landslides and Sinkholes	2.92	154
Ditching	3.28	235
Emergency Response (Flagging)	3.28	100
Clean, Repair, Replace Drains	3.49	146
Clean, Repair, Replace Pipes	3.64	141

A table with all 46 ranked activities is included in the Appendix B. The activities ranked as most important by the Supervisors and Section Engineers support the discussions held with the crews across the state; that providing a safe and secure transportation system for their communities is one of the best parts of their job. Seven of the ten most important maintenance activities directly concern responding to emergency safety situations that arise on Kentucky’s roadways. The other three activities are activities that help to ensure the proper flow of water to help keep our roadways open and safe.

Nine of the 10 most important activities identified via the rankings were also identified on the All District Calendar. Five of the activities (Emergency Response, Emergency Response (Flagging), Repairing Drains, Repair to Landslides and Sinkholes, and Traffic Control) were calendared under the “As Needed” category. Pothole Patching and Ditching were activities that participants stated should occur on a weekly basis and cleaning pipes and culverts was a bi-weekly activity. None of the activities that participants calendared as needing to occur on a daily basis were ranked in the top ten activities. However, litter clean-up, express run, was closest in terms of its importance ranking at 3.96. The two activities participants considered as least important were the removal of political signs (7.71) and litter clean-up (6.99).

Chapter 6 Conclusion

Maintenance challenges vary across the Cabinet's 12 districts. And these challenges will continue to evolve in response to changes in the built environment and the construction of new roads. The FOG flags many issues to consider when scheduling routine maintenance activities; the manual lists 81 distinct activities grouped into 13 major categories of work. Each category also generally contains a miscellaneous activity code used for activities done so infrequently they do not require a pre-assigned activity code. While the FOG includes information on performing and documenting activities, the only information on when or how often to perform them is a scheduling description, which accounts primarily for weather-related restrictions. Leading up to this project, districts lacked a systematic method to capture and document the evolving nature of their maintenance activities. Nor was there a procedure to ensure the efficient and methodical execution of necessary maintenance. The emergence of *special projects* has proven especially cumbersome for districts. Although occasional, the projects tend to receive priority over general maintenance functions. KYTC's maintenance results tend to be sub-optimal when special projects arise, a disorganized approach is taken to general maintenance functions, and there is a lack of awareness of a county crew's core functions.

This project addressed KYTC's maintenance challenges by inventorying how districts track maintenance and operation functions. Holding 24 workshops across the 12 districts provided insights into common issues and unique factors maintenance crews face around the state. The purpose of the calendaring exercise was to determine how frequently staff members should conduct and/or assign maintenance activities under *ideal* conditions. Under ideal conditions there are sufficient materials, staff, and funding available to conduct needed maintenance activities in a consistent and ongoing manner. Despite Kentucky's diverse geography, terrain, and distribution of rural and urban areas, the Statewide Maintenance Calendar we prepared identifies a basic set of activities and recommends frequencies for their performance. Adopting this calendar will better structure how maintenance crews allocate their time and ensure various maintenance activities are done on a regular schedule. The Cabinet will also see improved system performance and system outcomes because crews will be focused on performing core activities at regular intervals.

Additionally, district-specific calendars were developed that address some of the issues that are more a function of geography and crew priorities. These are more targeted approaches to district-specific issues that should be integrated into maintenance planning process. During our workshops, we noted differences in the perceptions and priorities of Maintenance Supervisors and Section Engineers. Reconciling these differences will foster better communication and yield a better-defined set of expectations for maintenance crews. To strengthen relationships between Maintenance Supervisors and Section Engineers, we recommend building clearer, more robust communication lines. They need to regularly discuss crew scheduling, priority tasks, and how to address requests as they are received. Discussions held weekly or bi-weekly will bolster crew efficiency and enhance system performance.

Feedback we received on the importance of each maintenance activity can supplement existing FOG manual guidance. Using available resources (e.g., MRP) to direct scheduled maintenance activities will help crews identify areas for improvement. KYTC can use MRP to measure the impact of improved scheduling and prioritization given that regularly scheduled maintenance

activities are more likely have a direct influence on maintenance features being measured than public requests that are received.

Another important task is structuring routine maintenance and prioritizing emergency work and planned work. Crews are concerned that they have to handle issues beyond the scope of their responsibilities, which distracts from planned maintenance tasks. Activities that interfere with regularly scheduled tasks are: providing emergency traffic control for roadway accidents or incidents, performing traffic control for other crews and agencies, removing the political signs from the right of way, issuing private driveway permits and constructing private entrances, and changing oil on equipment. Delegating these tasks to others, particularly those outside the Cabinet such as contractors, could free up time that could be devoted to calendared activities.

Having the necessary equipment available is another important piece for ensuring routine maintenance is completed. Workshop participants strongly recommended inventorying district equipment, tagging individual pieces with GPS receivers, and instituting stronger management procedures to maintain availability. Another common request was that equipment management and funding allotments for district equipment be discussed with district personnel before purchases occur. As such, we recommend that all districts inventory and tag equipment so its location and availability are visible to crews. Further, we suggest that crews be canvassed before buying equipment as this can help make certain purchases align with needs on the ground.

The Cabinet can use the findings presented in this report to create a prioritization method for managing maintenance and operational needs. Should 1) KYTC elect to develop an app that can be used to input maintenance requests, and if 2) Section Engineers or other maintenance staff retain discretion over slotting requests, the ranking results shown in Appendix B can be used as guidance for evaluating the importance of maintenance requests as they are received. Table 9, which lists the top ten activities, includes many that are not scheduled (e.g., snow and ice, emergency response, repair to landslides or sinkholes, emergency response (flagging), and storm clean-up). These important tasks must be addressed in quickly, however, they are not part of normal, scheduled workflows. The other activities (pothole patching; ditching; and cleaning, repairing, or replacing ditches and drains) can be regularly scheduled to ensure that Kentucky's highway infrastructure remains in good condition and is safe for the traveling public. Even if an app is not developed, our results can help personnel evaluate the importance of maintenance requests as they are submitted and assign them to the workflow in an appropriate manner. Adopting methods which can differentiate urgent problems from those that may impede safety or mobility — and which therefore could be addressed at a later date or as part of the regular workflow — is critical for establishing a sound maintenance program. Finally, staffing and funding shortages remain a concern. Dedicating additional funding or manpower to maintenance (if possible) would undoubtedly improve outcomes.

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Appendix A District Notes

District A – Superintendents

Superintendents claimed that the most positive parts of their jobs are patching a bridge, meeting new friends, getting paid, getting the whole crew paid, and keeping the roads safe. Dead animal pickup has been removed from job duties. The roadside crew plants flower beds, sprays right of way, hydroseeds, and fertilizes the median. Other concerns and suggestions include:

- There is no FOG activity code for moving equipment from one county to another, even though it takes 2 employees half a day or more to accomplish the task.
- The district A county crews do not regularly perform traffic control for other crews. They believe that the crews could accomplish more with more equipment, especially gradalls and excavators. The crews currently share an excavator between 3 counties, so it moves around a lot and takes 2 employees half a day for each move.
- Crews frequently are asked to cut a trench with a shovel in a high-grass shoulder, called “bleeding water”, which fills back in quickly.
- Slope mowing should be done much more often, but it would need more crews and equipment.
- Every time a new piece of equipment breaks down, because it is under warranty, it has to be sent out for repair. An equipment piece can be out of service for months at times without a loaner, so adding a requirement for a loaner to the contract would be helpful. The mechanics are not able to touch this equipment — it would void the warranty.

District A – Engineers

Engineers report that the best parts of their jobs are seeing things get better and dealing with the public. They brought up the following maintenance issues and suggestions:

- Anything that happens on the road that leads to a phone call will take a higher priority, particularly when it’s an object in the lanes, which is also known as “in road response”.
- The facilities include routine maintenance/cleaning and concrete work by the bridge crew, who also do channel repair. The crew also does cribbing and back filling.
- Moving equipment incites “territorial behavior” from the crew. A lot of coordination is needed because of the challenge in sharing equipment. The district would like to have someone for district-level equipment coordination. This idea started but never came to fruition. The N drive is currently being used to anticipate organizing and coordinating.
- There is a need to balance the inventory and distribution of special equipment. The district needs the right amount so that it’s there when needed but there is not a lot of expensive equipment sitting idle for much of the year. There is also not enough equipment or man-power to properly do all jobs at one time.
- The warranty on new equipment should include a loaner for items like the gradalls, which the crews cannot fix.
- Slope mowing could be done every week and the crew may never truly catch up, slopes will only get a better appearance. Engineers suggest contracting out slope mowing for liability reasons and for the new safety standard that requires 300 ft. of clearance while conducting and stopping traffic.
- There is one operator for the lowboy, so the ability to contract a lowboy when the operator is unavailable is needed.
- There is a need to pick up political signs during election season.

- The district needs a standard response for spills on the highway. Several questions come up such as:
 1. Are materials used to provide friction or absorption?
 2. Is KYTC responsible for cleanup, either of spill or of material used in response to the spill?
 3. What is the appropriate response in regard to the environmental concerns?
 4. When do districts call in the Natural Resources Environmental Response Team?

District B – Superintendents

The district’s maintenance tasks are seasonal, and they can perform them daily during the appropriate seasons; for example, patch potholes in the spring or dig a ditch in the summer when it is dry. Trees are cut when the leaves have fallen so that it is easier to see what is being cut. The superintendents believe tree cutting in the correct season helps with spotting hazards such as power lines and makes hauling tree limbs easier. This practice results in less complaints from the citizens.

Superintendents noted the following maintenance issues:

- The backlog of needs keeps growing.
- The biggest concern among superintendents is the lack of employees. To complete the work with an average crew size of 6, employees are frequently shared across crews. Most activities require 5 employees so to perform one task per day, the superintendents must be at the work site if employees are absent, interfering with a superintendent’s ability to plan ahead.
- Current training requirements can place a burden on employees and superintendents, making it difficult to schedule and complete work because most of the crew have been to a class.

District B – Engineers

- Foreman’s training is needed.
- Needs knowledge management.
- HT superintendents respond that the training is good, but they never have a full crew and need bodies. They do not respond to complaints quickly, and the course is more difficult in the urban areas. There is a 4-5-day delay when dealing with things, and it needs to happen more quickly.
- There is a lot of “hand holding”, so how to fix it? A weekly schedule is sent in, reviewed and sent back. There is also a need for foreman meetings.
- Superintendents provide no response or closure of public complaints. There needs to be communication between requests and fixes.
- Commitment and morale are low among superintendents. The A & B crews both hate it, and half of any crew is on emergency stand-by every other week. So, the question is who can help if there is emergency? The district may consider getting other counties and making it competitive.

District C – Superintendents

When questioned about their jobs, District C superintendents claim that the most positive aspects are being outside, keeping the public safe, setting and accomplishing goals, doing different tasks

every day, and seeing crews take initiative. The superintendents' years of service range from 10 to 46 years.

As for issues and challenges faced on the job, they report that the public in general does not respect yellow lights. Other issues are listed below.

- KYTC ends up cleaning up spills when the fire department does not respond as needed.
- For emergency situations such as crashes, law enforcement leaves when the accident is reported but before the KYTC crew is done.
- If dead animals don't get picked up within a certain length of time or the animal is far enough away from the roadway pavement, they will get treated with lime instead. The superintendents indicated that removal is important in the lanes but not important outside the lanes.
- Litter pick-up is done by inmate crews and could expand into counties where the inmate program is not in place. Moreover, the DOC has removed chainsaws from eligible activity.
- Superintendents suggested that mailboxes knocked over during snow and ice removal be reinstalled by the driver who knocked them over. For protection, any complaints of mailbox hits should require a photo. County crews received many complaints last year but were not aware of any existing public announcement about the policy on C routes.

During the session, it was mentioned that the sign crew performs the tasks of putting down pavement markings and repairing signs.

District C – Engineers

District C engineers report that the positive aspects of their jobs are doing different tasks every day, seeing a project from conception to completion, and making positive impacts. The level of experience ranges from 1 year to 20 years.

The following issues were brought up:

- Pertaining to permits, engineers in District C typically do not install entrance pipes. The entrance request is generally sent to the superintendent to review and approve.
- Inmates have helped with cleaning bridge gutters in several counties.
- Not all pothole repairs are defined as emergency repairs, except for those that can cause vehicle damage.
- There is not a consistent method of prioritizing maintenance tasks in place currently, stemming from the lack of a performance measure, or litmus test, on public safety.
- Assigning special projects in the district (e.g., construction) includes inspection and testing associated with a construction project, not with the actual construction.

District D – Superintendents

Several different spray activities are “in the same family”, and these activities are performed almost exclusively by the roadside crew. The traffic crew does pavement marking inspection and sign maintenance. Cleaning creek channels is done by removing debris around the bridge abutments and piers. The superintendents monitor for “dangerous tree inventory” wherever they go during the course of other duties.

The superintendents brought up several suggestions:

- “Sight distance for kids” is needed and can be achieved by bus-stop clearance of tree limbs, brush, and weeds.
- “Obnoxious weeds” need taking care of the noxious weeds program.
- “Setting signs”: this work involves setting up the signs for temporary traffic control during maintenance work.
- “Service trucks and equipment”: each piece of equipment is generally serviced quarterly, but the activity happens more often between all the pieces assigned to each county.
- To clean bridges on a regular schedule, they could use another vacuum truck.
- One comment was made: “At the state, we have done so much with so little for so long that now we can do anything with nothing.”

District D – Engineers

Mowing includes 3 cycles, and it is a daily activity during each cycle. The district has several counties that are still mowing. They plan to install a new residential entrance pipe when the property owner purchases the pipe. Not all districts do that. The engineers offered the following suggestions:

- They recommend “R/W Clearing”, which means daylighting pavement.
- The “special projects” are usually slides that include hydro-seeding, while turn lanes are a separate type.
- The “RS projects” make repairs prior to scheduled paving projects on the RS system. They believe that this effort can also be applied in advanced of the FD05 resurfacing projects and preventive maintenance projects.
- Slope mowing could/would/should happen daily if there were enough staff members and equipment.
- The road sign maintenance (sign crew) only puts out fires of downed signs. The crew rarely has time to proactively run a route and upgrade or replace signs as needed.
- Most areas would benefit from a ditching crew that runs all the time, even if ditching is summer seasonal.
- Spraying is a roadside crew activity.
- Pipe repair can be an emergency issue, but is normally done as part of the work in advance of a paving project.
- If they could schedule the daily, weekly, or even monthly items, then a lot of the emergency work may go away.

District E –Superintendents

The level of experience for District E superintendents ranges from 17 to 30 years.

The superintendents listed several maintenance issues that occur within the district:

- It typically takes 2-3 days to respond to an 811 call. Some local utilities are not 811 members, which makes contacting the caller difficult. Crews must call 811 unless they are working in the same hole as the utility. Superintendents must confirm 811 has been called before sending the crew out.
- Superintendents are responsible for confirming TOC in Frankfort is called if the crew has to close a lane. The TOC tends to call the superintendents after hours and they often call the wrong county.

- District E county crews are assigned to routine spraying. Local dispatch frequently calls them about frivolous items such as small branches on the road, but the superintendents nonetheless have to respond to the call.
- The superintendents suggest placing gravel around the base of mailboxes that are placed at the edge of major roadways, or “rocking mailboxes”. This will also be used for school-bus pull-offs.
- Superintendents believe that ditches cannot be cleaned during wet seasons.

District E –Engineers

Maintenance issues brought up by the district engineers include:

- There has been a request to revisit the minimum staffing requirements in the FOG manual. This information can be used against the district staff that assign work to the crews.
- Maintenance contract inspection includes sweeping, snow & ice, and contract equipment with operator. Sweeping varies a lot in frequency — sometimes weekly on the interstates during the warm part the year, or monthly during the cold season or on low volume roads. Wide shoulders in rural areas may be swept twice a year.
- The engineers propose that pipe cleanout be made more routine instead of on an as-needed basis. There could be emergency calls on a single pipe. They suggest cleaning all pipes on a route prior to an FD05 project or creating a contract to clean several pipes but not all on one route (more likely the more-troublesome locations.)

District F –Superintendents

Superintendents report the best parts of their jobs are being outside, helping out the drivers, having a lot of “Fridays”. They discussed three maintenance tasks:

1. RS Program: Several items are addressed in advance of a resurfacing project on the RS System. These include cleaning/reestablishing ditches, repairing/cleaning pipes, cutting trees, reestablishing shoulders, etc. This program is annual for routes that are approved for resurfacing work.
2. Special Projects: These include parking lots, constructing turn lanes, and other works of similar natures.
3. Concrete work: This consists of repair of curbs and drop-boxes. This is frequently done by bridge crews, but one county crew appears to have done some work.

Maintenance issues brought up by the superintendents include:

- Sinkholes are often paired with slide repairs by the participants. Superintendent duties were grouped accordingly and considered separately from crew duties.
- Cross drain repair – dig-out and blacktop needs – cannot be done in the winter due to the lack of hot mix. Nonetheless, some of these tasks could be performed daily if they had the manpower and/or equipment access.
- Stockpiling of materials is considered to be a rainy-day job.
- Resurfacing ideally should schedule work in advance including shoulders, base failures, ditches, pipes, etc. This does not happen very often like it used to, primarily due to poor communication about scheduling. Grade shoulders are reported to be resurfaced yearly.
- Superintendents feel that bucket trucks were formerly on a rotation for trimming hazardous trees and branches, but the trucks are no longer used on a rotation.

- Seeding is seasonal and primarily done by the agronomy crew, which may receive an assignment every 6 months. Mostly, seeding is done in conjunction with another task such as cutting shoulders or ditches or pipe replacement.
- Mowing occurs daily until the mow cycle is complete (3 cycles done between April and October.) Spraying is done with different chemicals for different purposes and is tied to mowing; it should be completed 2 weeks prior to a mow cycle. It takes about 2 weeks to complete a spray task in a county and is very weather dependent due to the effects of precipitation and wind.
- “Service work” means equipment and vehicle maintenance. For the counties without any ranked service work, cable barrier repairs are considered to be less important. Superintendents proposed that crews within a section specialize in performing tasks that need to be done regularly.

District F – Engineers

District engineers listed the following maintenance issues:

- Some counties that have subset crews are more focused on primary routes (such as the interstates.)
- Guardrail hits that are not in critical/frequently-hit locations tend to accumulate, without being repaired. A work order is issued to the contractor for repairs about once a month, although repair needs in the more frequently-hit areas are addressed more urgently.
- Concrete slab repair along each route should be addressed regularly about once every 10 years. Engineers believe that scheduling the work in a district with a small amount of concrete pavement is beyond the scope of CO. The engineers also indicated some funding issues due to earmarking of certain funds.

District G – Superintendents

Superintendents feel that the best parts of their jobs are helping the public, working with the crew, and being appreciated by the public. Their years of experience range from 19 to 24 years.

They offer the following suggestions for improvement:

- Each activity takes 2-4 flaggers; portable flagging stations would be helpful and would free up 2 employees. A flagger in the middle extremely important for safety reasons.
- One slope mower could be used per each county, and the county is supposedly working on getting more slope mowers. Counties where they cannot or do not spray as much, use the slope mower more often.
- Repairing equipment is a problem and getting new fleet vehicles is difficult. New pickup trucks are long overdue.
- Timekeeper duties in each barn help with the paperwork, because without them, the superintendents are trapped at the barn. However, if the crew is given timekeeper duties, members will say it means that they are working outside of their duties.

District G – Engineers

- Most engineers think that the best part of the job is the construction itself, but they need to get the right equipment, repair equipment, and determine needs for new equipment.
- RS/FD05 should be used in preparation for the review to schedule the following year’s projects (not the work before an approved project starts.)

- They suggest changing the FOG codes to match the federal reimbursement activity codes. Federal reimbursements and TC 10-1s do not use the alpha numeric codes used in OMS.
- The new activity codes for 811 coordination and the job safety briefings would be helpful.

District H – Superintendents

The following issues were brought up during discussion:

- County jailers are using state funds to clean up county roads and callouts are increasing. Repairs are scheduled with the district mechanic, so the machine could be down for days or weeks rather than just hours.
The district cannot tell the crews about the plans for the next day, because they may not show up to work. It is impossible to rely on a weekly plan due to frequent callouts and calls from D.O.
- Equipment is shared within the district, and there is not enough of it to go around. For example, if there is a piece of machinery that is used twice a year for 2 months, one county may keep it for that long. There are 11 counties sharing the equipment, but no sense of what or when equipment is available. District H has 3 bobcats and only 1 set of attachments. If there were 3 sets of attachments, then all the bobcats could be used.
- Once an equipment inventory is complete, superintendents would like a review of sharing practices and to figure out some common-sense solutions. They asked:
- Is there someone in the district that could manage the equipment and its location so that the items are not lost or hoarded?
- Thoughts on GIS property ID tags?

District H – Engineers

The following issues were discussed with the engineers:

- Master Agreements (MA) are in need of a hot button — there is no flexibility in using the MA items or non-MA items.
- District crews cannot always plan for challenges that arise on the job, especially if they are short of materials. Lowes is usually the only place where needed items can be picked up quickly. The biggest problem is that in some counties, Lowes is 45 minutes to 1 hour away. A solution for remote counties could be to allow small purchases at the local stores so that time is not wasted while driving to get materials.
- When equipment is in need of repair, there is no method of prioritizing and deciding whether to assign the task to the maintenance crew or the repair crew. Repairs need to be made quickly when possible on the time table of the maintenance crew. If the mechanics are too busy to take care of the repair quickly, then the maintenance crew needs to be able to take the repair to a private vendor. The result is that mechanics compete for work, like in project design.
- Equipment is not always interoperable, and there should be a survey to determine what each barn needs. There is not enough equipment, and some sections even hoard the equipment. Moreover, some equipment is reported to be automatically replaced. Some sections/district may not need that equipment, but they do not want to turn it down and cannot substitute for any other equipment they need. They suggest having a swap meet across the state.

- Engineers asked the following questions pertaining to equipment and maintenance crews: 1. Who is in charge? 2. How can the district fix this to help maintenance crew be more efficient and effective?
- Engineers question who has the responsibility for downed signs, is it the county crews and how should that be communicated? The division of duties between the county crews and the special crews needs to be identified.

District I –Superintendents

District I Superintendents claim the favorable parts of their jobs are making a difference, helping the public, seeing the bright smiling faces of the crew, and completing projects.

- One of their suggestions was to explore the concept of “bleed roads” or making a cut in a drain where water collects on the pavement surface.

District I –Engineers

The engineers brought up the following challenges and issues:

- Residential entrance permits should be reviewed for sight distance.
- District I does not install pipes for entrance permits.
- Clean DBIs should be used as an abbreviation for clean drop-box inlets.
- Kentucky should have a centralized call center for complaints which issues a work order instead of calls to every district office and county barn.
- Cleaning bridges should happen twice a year, but it is difficult to get the contractor in that often. The northern part of the district floods every spring, so they work during flooding season instead of as needed.
- One district staff member prioritizes maintenance tasks on a scale of 1 to 9; the scale is based on reducing complaints.
- The solution for slides and guardrail repair needs could be flatter slopes.
- Equipment repair should be the work of the equipment crew, not the maintenance crew.
- Inventory always ranks low because it is “never right” and “too petty”.

District J –Superintendents

- “811” directs toward utility location. They report that 811 coordination holds up work, especially with gas lines, and “911” directs toward emergency callouts.
- Pertaining to water samples, the superintendents came up with the following question for the Division of Environmental Analysis: why do we want the pond to discharge instead of routinely holding the water?
- It’s concerning that staff without training are performing some of the service requirements.
- The highly visible uniforms are “getting ruined” with grease, oil, and hydraulic fluid. On defining the roles on the equipment servicing, the superintendents state that some crews are greasing equipment while the mechanic to the barn is doing it in other crews. Moreover, they believe that there is a communication breakdown between Frankfort and crews.
- The decisions on how the equipment allotment is spent are inconsistent compared to orders being turned in.

- Crews can see how easily the change orders can be approved on construction projects but cannot get overtime, make purchases, or get equipment. The lack of being able to respond to these issues can cause delays in getting their work done.

District J –Engineers

- There is a need to differentiate between procedures in OMS and checking what is in the lot. They report that pothole patching is all year and as-needed. Cleaning drains is on a 3-year rotation or as-needed depending on the weather.
- Crews handle emergency cases on tree cutting as-needed if trees fall. They report that the contract removal lasts over a year. During the process, the contractor will spend a quarter in each section of the planned removal.
- Mowing is seasonal and is done 3 times during the season. Also, they report that ditching can be daily (or at least weekly) during summer.

District K – Superintendents

The superintendents reported the following maintenance issues:

- Equipment is not kept running long enough to get the work done and is insufficient for the job. 3 out of 5 trucks are down while cleaner air fluids of trucks do not burn hot enough. On top of that, the trucks’ transmission gets hot, and there are equipment burnouts which require 45 minutes to regenerate. The equipment overall is said to be not suitable for the district’s needs; for example, old slope mowers.
- In some districts, inmates can pick up dead animals, but other jailers will not let inmates do so. Since it is getting harder to get workers, and there is a need for inmates to pick up dead animals. The high water issue could be improved if ditching happened more quickly.
- Currently, there is a 10-week schedule in place for teams that includes rotating crews, helping morale, having an alternative. However, the superintendents believe that the county does not have enough qualified people to operate equipment. The crew will not ride with unsafe workers, and people do not want to learn to operate equipment.
- There is a need of a more uniform, consistent system of assigning work activities, at least in the district. Some crews are so shorthanded that prioritizing work just does not make any impact.
- Regarding emergency management, superintendents feel that X County does not know how to work with accidents, and the wrecker service does not do a good cleanup job.

District K – Engineers

The engineers brought up the following issues and suggestions:

- KYTC’s best interest to action lies within private entrance, subject to CDE/CAN.
- There are not enough personnel to handle emergency traffic, and leadership would like a response to this problem.
- They recommend focusing on work tasks such as fixing ponds, environmental concerns, and emergency management for more than 4 hours. This has been new development.
- They believe that towing must clean up the accidents.
- About 1/3 of the equipment does not work, and all the old equipment does not work. There are not enough mechanics to perform repairs and also not enough workers to

operate (many do not know how to operate the equipment.) Winter trucks breaking down is often tied to both user and equipment failure.

- Full crews are needed on emergency call-outs. One county faces base failures — they currently have only 6 crew members, while the resurfacing schedule specifies 13 to be a full crew.
- The engineers propose several reasons for the difficulties and offer solutions to hiring and keeping district crews fully staffed:
 1. Hiring is difficult due to no pension and lower pay than county and surrounding areas
 2. Urban counties face the biggest hiring challenges because of competition from many other job opportunities
 3. A different pay scale for urban areas where they cannot keep workers should be considered

District L – Superintendents

Superintendents claim that the favorite part of their jobs is making a difference in the home county. They brought up the following issues and suggestions:

- Potholes have become worse since the introduction of permeable pavements, especially when they are used on top of the older less-permeable pavements. The freeze/thaw process affects the water trapped between the 2 layers. The higher amount of recycled material in the pavement also has an effect.
- The micro-surfacing project is holding up well and the district should consider using this technique more often.
- Losing the timekeepers in the barns has created more of a burden on the superintendents. They spend more time on paper work, and having an HT assistant in the barn means that they are operating outside their job duties. Monthly inventory is considered an administrative duty, and if a mechanic is on site, then someone else has to stay at the facility for safety reasons.
- For after-hours callouts, since there are only 2 keys to the facility gate, one of the called-out people will get involved every time. The superintendents often handle the callout or work with the others included, depending on the job.
- Not having the right equipment means that projects will take longer. Many superintendents keep a running list of needs but do not get to address them because of emergencies and complaints.
- Environmental triggers affect productivity and should not occur during certain times. The regenerate requirement during operating hours means that a truck has to pull over for 30 minutes regardless of what is being done, and that has occurred once during a snow event. The virtual technician and auto shutoff can also impact productivity.
- Online training can take a crew all day when taking into account sharing computers and the variability of computer literacy. The superintendents may have to walk employees through the training if they are not familiar with how to use a computer.
- Ditching could be daily if they had the man power. The private entrances:
 - Are maintained while ditching unless there is a washout
 - Are seasonal for new constructions
 - Are more common in more urban areas

- Include installations handled that are handled differently between the 2 branches. One will install the property owner's pipes, but the other one will not.

District L – Engineers

The engineers report the following maintenance-related issues:

- Beaver dams clog ditches, pipes, and culverts.
- Cable barriers repair is being done in-house and takes a lot of time and money.
- The district is beginning to take on sign repair which includes STOP sign and other critical signs. Other sign types are turned over to the sign crew.
- Potholes are repaired daily and seasonally as well.
- The engineers asked the following question: is it possible to look at the work frequency in OMS?

Appendix B All Maintenance Activity Rankings

Activity	Average	Observations
Oversee Safety	1.69	23
Snow and Ice Removal	1.8	202
Flagging for Others	1.97	39
Emergency Response	2.25	136
Sight Distance Issues	2.56	30
Storm Clean-up	2.57	88
Traffic Control	2.66	119
Route Restoration Prior to a Project	2.7	10
Pothole Patch	2.81	235
Slide and Sinkhole Repair	2.92	154
Route Inspections	3.04	43
Emergency Response (Flagging)	3.28	100
Restore Ditches	3.28	235
Clear/Repair/Replace Drains	3.49	146
Pipe install/repair/replace/clean	3.64	141
Maintain and Repair Equipment	3.7	226
Mowing	3.76	209
Litter, Express Run	3.96	51
Pavement Draining--Bleeding Roads	4.07	14
Tree Removal	4.14	188
Slope Repair	4.21	115
Sign Maintenance	4.33	131
Restore Shoulders	4.34	194
Guardrail Maintenance	4.43	53
Roadway Repair	4.46	80
Administrative Tasks	4.5	191
Grading/Paving	4.52	114
Address Public Concerns	4.58	210
Roadside Vegetation Control (Spraying)	4.67	115
Pavement Markings	4.8	41
Bridge Maintenance	4.95	139
Inspection of Contractors	4.95	89
Maintain Facility	5.01	100
Training	5.05	53
Cleaning Drainage Channels	5.21	28
Review Entrance Permit Requests	5.41	17
Transport Materials	5.41	24
Special Projects	5.65	29

Inventory	5.83	160
Dead Animal Removal	5.89	226
Inmate Supervision	6	17
Install/ Repair Entrance Pipes	6.2	90
Sweeping	6.21	41
Maintain Right of Way Fence	6.65	40
Litter Pickup	6.99	118
Political Sign Removal	7.71	45