NCHRP Project 20-68A
Scan 09-01

Best Practices In Quality Control And Assurance In Design

Supported by the
National Cooperative Highway Research Program

July 2011

Acknowledgments

The work described in this document was conducted as part of NCHRP Project 20-68A, the U.S. Domestic Scan program. This program was requested by the American Association of State Highway and Transportation Officials (AASHTO), with funding provided through the National Cooperative Highway Research Program (NCHRP). The NCHRP is supported by annual voluntary contributions from the state departments of transportation. Additional support for selected scans is provided by the U.S. Federal Highway Administration and other agencies.

The purpose of each scan and of Project 20-68A as a whole is to accelerate beneficial innovation by facilitating information sharing and technology exchange among the states and other transportation agencies, and identifying actionable items of common interest. Experience has shown that personal contact with new ideas and their application is a particularly valuable means for such sharing and exchange. A scan entails peer-to-peer discussions between practitioners who have implemented new practices and others who are able to disseminate knowledge of these new practices and their possible benefits to a broad audience of other users. Each scan addresses a single technical topic selected by AASHTO and the NCHRP 20-68A Project Panel. Further information on the NCHRP 20-68A U.S. Domestic Scan program is available at http://144.171.11.40/cmsfeed/TRBNetProjectDisplay.asp?ProjectID=1570.

This report was prepared by the scan team for Scan 09-01, *Best Practices in Quality Control and Assurance in Design*, whose members are listed below. Scan planning and logistics are managed by Arora and Associates, P. C.; Harry Capers PE is the Principal Investigator.

Hossein Ghara, *PE, Louisiana DOT, AASHTO Co-Chair*

Kelley C. Rehm, *PE, Kelley Rehm Consulting, Principal Author*

Nancy Boyd, *Washington State DOT*

Tim Swanson, *Minnesota DOT*

Carmen Swanwick, *Utah DOT*

Robert J. Healy, *PE, Maryland DOT*

Richard W. Dunne, *PE, New Jersey DOT*

Robert S. Watral, *PE, Pennsylvania DOT*

Disclaimer

The information in this document was taken directly from the submission of the authors. The opinions and conclusions expressed or implied are those of the scan team and are not necessarily those of the Transportation Research Board, the National Research Council, or the program sponsors. This document has not been edited by the Transportation Research Board.

Scan 09-01

Best Practices In Quality Control And Assurance In Design

REQUESTED BY THE

American Association of State Highway and Transportation Officials

PREPARED BY

Hossein Ghara, P.E.,
Louisiana DOT, AASHTO Co-Chair

Kelley C. Rehm, P.E.,
Kelley Rehm Consulting, Principal Author

Nancy Boyd,
Washington State DOT

Tim Swanson,
Minnesota DOT

Carmen Swanwick,
Utah DOT

Robert J. Healy, P.E.,
Maryland DOT

Richard W. Dunne,
New Jersey DOT

Robert S. Watral, P.E.,
Pennsylvania DOT

SCAN MANAGEMENT

Arora and Associates, P.C.
Lawrenceville, NJ

July 2011

Table of Contents

List of Appendices

List of Figures

List of Tables

Abbreviations and Acronyms

AASHTO	**American Association of State Highway and Transportation Officials**
ACEC	**American Council of Engineering Companies**
AGC	**American General Contractors**
Caltrans	**California Department of Transportation**
DOT	**Department of Transportation**
FHWA	**Federal Highway Administration**
GDOT	**Georgia Department of Transportation**
GIS	**Geographic Information System**
IA	**Independent Quality Assurance (Caltrans)**
IDOT	**Illinois Department of Transportation**
ISO	**International Organization for Standardization**
KYTC	**Kentucky Transportation Cabinet**
Mn/DOT	**Minnesota Department of Transportation**
NCHRP	**National Cooperative Highway Research Program**
NTSB	**National Transportation Safety Board**
NYSDOT	**New York State Department of Transportation**
OBDP	**Oregon Bridge Delivery Partners**
ODOT	**Oregon Department of Transportation or Ohio Department of Transportation**
OTIA III	**Oregon Transportation Investment Act III State Bridge Delivery Program**
PE	**Professional Engineer**
PennDOT	**Pennsylvania Department of Transportation**
PM	**Project Manager**
PQAR	**Project Quality Assurance Report (NYSDOT)**
PS&E	**Plans, Specifications, and Estimates**
QC/QA	**Quality Control/Quality Assurance**

TRB	**Transportation Research Board**
VE	**Value Engineering**
VECP	**Value Engineering Change Proposals**
WSDOT	**Washington State Department of Transportation**

Executive Summary

Overview

On Wednesday, August 1, 2007, at approximately 6:00 p.m., the I-35W highway bridge over the Mississippi River in Minneapolis, Minnesota, experienced a catastrophic failure. As a result, 1,000 feet of the deck truss collapsed. The National Transportation Safety Board (NTSB) immediately began an investigation into the cause of the collapse. The investigation eventually determined that the collapse of the I-35W bridge initiated with the failure of the gusset plates at the U10 nodes on the truss..

The following safety issue, among others, was identified in the investigation:

> Insufficient bridge design firm quality control procedures for designing bridges, and insufficient Federal and State procedures for reviewing and approving bridge design plans and calculations. (NTSB, Nov. 2008).

This finding lead the NTSB to recommend to the Federal Highway Administration (FHWA) and the American Association of State Highway and Transportation Officials (AASHTO) that the two organizations work together to develop a more adequate program of quality control and assurance (QC/QA or QA/QC) in bridge design to be used by the states and other bridge owners. The NTSB recommended that this quality program include procedures to detect and correct bridge design errors before the design plans are made final. In response to this recommendation, AASHTO initiated a study to provide a synthesis of current state department of transportation (DOT) practices for QC/QA in the area of bridge design and plan review.

This domestic scan was initiated following the NTSB recommendation to build on the initial AASHTO studies. The scope of this scan was expanded to incorporate aspects of quality programs in highway design, bridge design, overall project delivery, and QC/QA for special contract projects, such as design-build. The scan team believes that it is important to look at overall project quality, rather than just focus on bridge design, since there are farther-reaching quality issues, such as higher numbers and greater costs of change orders. Finally, the scan team also investigated the QC/QA practices encompassing project programming and planning stages, environmental permitting, and highway and bridge design. The team also examined lessons-learned feedback loops through construction.

A preliminary analysis conducted through a desk scan refined the list of states based on the size of their programs, the region of the country, the nature of their organization (e.g., decentralized, centralized, and percent of work done by consultants) and innovative practices in QC/QA. The team chose the following states for visits because of innovative or standout QC/QA programs:

- New York
- Pennsylvania
- Kentucky
- Minnesota
- Georgia
- Oregon
- California

In addition, the team held separate meetings and teleconferences with the following states to discuss specific components of their QC/QA programs:

- Ohio
- Washington State
- Illinois

The scan team developed amplifying questions and sent them to the selected agencies before the visit to allow the host agencies to center their preparations on the specific areas of interest to this scan topic. The team's amplifying questions fell under the following headings:

- How do you define a successful QC/QA program?
- How do you measure the success of your program?
- How was your QC/QA process developed?
- What are the documentation and administration procedures for your QC/QA process in design?
- What reviews should be done across disciplines?
- What specific qualifications and education practices can you elaborate on?
- What should QC/QA programs do differently for specialized processes, such as design-build projects or value engineering processes?
- How are QC/QA processes involved in standards, drawings, submissions, and software?
- How does your QC/QA design program extend into the construction phase?

Biographical and contact information for the scan team members is provided in Appendix A and Appendix B, respectively. Key contact information for host agencies is provided in Appendix C.

Common Practices

The scan team discovered that many successful QC/QA programs have common practices in place. These common practices are discussed here.

Training and Well-Developed Communication Channels

Overall, the visited states agree that quality includes adequate tools, core competency of staff, and good standards. It is important to note the states believe that while documented quality processes are important, it is also important to have experienced, competent staff and good relationships across disciplines. Quality is also affected by political constraints and funding fluctuations. In the present economy, states are all working with less staff, increasing numbers of projects, and tighter schedules. Plan quality is often affected when the staff is less experienced and schedules leave less time for in-depth quality checks. These issues must be taken into consideration when adopting new quality processes or adapting existing ones.

A number of states with successful QC/QA programs have developed procedures and training classes specifically focused on QC/QA. One way these states are ensuring quality from their designers is by incorporating training rotations for new staff into their programs. New staff often works designing projects and then gains experience in the field building those projects before taking permanent assignments as designers. The experience earned in the field helps to ensure that future projects will be buildable and biddable.

States with well-developed QA programs also have regularly scheduled meetings with all disciplines involved in the projects, involving construction earlier in the process to ensure constructability. These set meetings not only help to develop relationships across disciplines, but also help to contribute to lessons learned feedback loops.

Lastly, good communication between consultants and department staff is important in states with successful QC/QA programs. Many of these states hold lessons-learned conferences with their consultants each year or partner with organizations such as the American General Contractors (AGC) or the American Council of Engineering Consultants (ACEC) to hold joint training or information-sharing sessions.

Drivers to Document QC/QA Processes

Documentation of quality processes and procedures and the use of checklists are also common among states with successful QC/QA programs. Several drivers contributing to the need to provide documentation of quality processes were mentioned.

- **Higher percentage of designs done by consultant**
  To maintain consistency, quality processes need to be documented and easily referenced by consultants.
- **High rates of retirement and staff turnover**
  Processes need to be well documented to counter the loss of institutional knowledge when long-tenured staff retires and when newer staff quickly rises to management positions.
- **Decentralized organizations**
  More guidance is needed to keep processes standardized and communication channels open when designs are completed in regional or district offices instead of in a central location.
- **Use of specialty contracting such as design-build**

More attention is given to QC/QA processes when design-build agreements are used, and this often leads states to look into similar quality processes for traditional design-bid-build projects

Common Review and Approval Practices

Successful states have a few review and approval practices in common in their QC/QA programs, including:

- Checklists outlining processes for designers, reviewers, and contract document compilation are used for each phase of project development.
- Consultants are rated or graded (although not all states use these ratings extensively for consultant selection).
- Decisions about the amount and type of review are made on a risk-based scale, taking into consideration the type and size of the project to determine the depth of the review.
- Although value engineering is done in all states, successful states evaluate the outcomes of these processes and use it as lessons learned feedback for future designs.
- Third-party consultant reviews are done for specialty projects or where DOTs do not have expertise or enough staff to meet deadlines.
- Plan signoffs or PE stampings are done at many different levels, including signoffs on original design, review, and even for design changes that are done in construction.
- States are moving to single-point data systems where multiple users and disciplines can look at and analyze documents to determine problem areas and make improvements in processes.

Summary of Initial Findings and Recommendations

The scan team noted that in successful states, it is important to have upper management support in the development, documentation, and use of a QC/QA program. Again, it is clear that adequate tools and documentation can lead to quality plans, but only with high-quality people and expertise behind the designs.

One of the biggest challenges each of the visited states faced was showing the benefit of time spent on QA processes. They asked, “How can we convey or market to decision makers that these quality programs are worth time and funding?” Overall, a successful quality program should be able to show that better quality in plans equals longer life and cost savings on projects. Many states recognize that a quality set of plans does not always equal a quality design, and that sustainability, constructability, and other considerations should be taken into account to really instill quality into a project.

Overall Successful Strategies

The following sections describe what the scan team determined to be successful strategies utilized by the visited states to ensure quality in their design plans. The scan team recognizes

that QC/QA programs that work well for one state may not work well for others, since there are large variations in organizational structure, political constraints, and funding availability throughout the states. For this reason, the team did not identify best practices, instead choosing to identify strategies that were successful in the given circumstances of each state.

Checklists, Manuals and Standards

All state DOTs, not just those with successful QC/QA programs, use checklists, process manuals, and standard details and drawings. However, successful states use these tools for communication, training, and regular re-evaluation of the processes. One state described the practice of "review training" for engineers who are performing QC reviews on plans. This training concentrates on teaching reviewers the best ways to identify errors or omissions, how to use manuals and checklists, and how to successfully convey comments back to the designer.

Some states have instituted separate divisions or bureaus specifically for QA. These divisions provide centralized points of contact on quality and provide a group of experienced individuals that can maintain and re-evaluate quality processes that are documented within manuals.

One other practice found in several successful states is the use of title blocks on plan sheets that clearly define the designer and the reviewers, as well as include sign-offs for when reviews are completed. This easily implemented, simple method ensures that designers and reviewers take responsibility for the quality of the plans.

Scoping and Environmental

Successful states include all parties involved in design and construction early on in the process. Several of the states the team visited include environmental, right-of-way, utilities, designers, any other relevant agencies, and even construction, in the scoping process. Continued involvement throughout the full design phase of all players involved is important and includes scheduled meetings at key points in the design, during construction, and for post-construction feedback.

Successful states also found that it was helpful to have state-funded positions located at regulatory agencies to help expedite scheduling and reduce external agency bottlenecks in the design process.

Another successful strategy found during the scan was the practice of including "green sheets" or environmental tables within actual plan sets. These sheets (which one state actually prints on green paper) or tables serve as a checklist for the contractor and resident engineer to ensure that all environmental commitments are met on each project.

Value Engineering Feedback

Value engineering (VE) is common and mandated for some projects in all states. However, many successful states are using feedback from their VE processes to analyze trends and make changes to their design processes. Some states have been able to involve contractors in their

processes, although legal issues make this a bit more complicated. Again, the VE process is not necessarily a best or unique practice; however, what is done with the information and feedback can help to ensure improved quality in future designs.

Consultant Selection and Communication

Successful states ensure the quality of their consultants' projects through thorough selection processes and good communication channels. Successful states often require submittal of consultant quality plans before they can be prequalified to perform work for the states, and many require project-specific quality plans to be submitted with proposals.

Construction Reviews and Feedback

Involving key players from construction early on in the design process is a successful strategy in many states. Early involvement is important to avoid comments on constructability at the end of product production when it is not practical to make changes. It is also important to look at feedback during the construction process and information provided during post-construction reviews. Several states survey construction administration staff and contractors to solicit feedback on design and plan quality. This information can show trends, such as the causes of the most change orders, and outline needed changes to standard drawings and manuals.

Quality in Existing Processes

Successful states look at improving quality in existing processes, not necessarily adding more processes. Examining existing processes and formalizing them through documentation can help identify unneeded steps and highlight areas where the process can be improved. After improvements are made, performance measures are developed. One state has looked at all of its checklists to determine the optimal amount of items that should be included, while another state has developed a series of steps for each discipline to go through to help them document all their processes. These actions help to add focus and efficiency to quality programs.

Future Research

The scan team found that in many cases it is hard to quantify the benefit of QC/QA procedures. In the future, it would be useful to identify the marginal benefit of more QC. For example, if another hour is spent reviewing a set of plans, how much quality does that add to the overall project? This also requires determination of how to measure that incremental increase in quality and identification of useful performance measures.

Planned Implementation Activities

The scan team recognizes the importance of implementing the findings of its review. Many important successful solutions and strategies were identified and would be of benefit to other state and local transportation agencies. Included in the team's proposed implementation plan are the following:

1. **Develop a webinar** – The team intends to present successful solutions to a large audience through webinar training sessions.
2. **Develop and make presentations to AASHTO and Transportation Research Board (TRB) committees** – These more in-depth presentations can be tailored to specific groups.
3. **Implement findings locally** – Ideas and successful solutions can be brought directly into the team members' states and host states.
4. **Identify future research** – The scan identified findings and issues that could be further investigated. Research proposals for these needs will be written and presented to supporting organizations, such as AASHTO or TRB committees.
5. **Draft a letter to the FHWA to inform it of scan findings** – The scan team will outline the scan findings in a letter to the FHWA's Bridge Technology Office to assist in the development of the Technical Advisory for QC/QA in Bridge Design that will be developed in response to recommendations by NTSB.
6. **Develop a Web site** – A Web site dedicated to QC/QA processes will make information more readily available.
7. **Identify places to submit journal articles or post links to the final report** – The team intends to submit articles to academic journals as well as to trade magazines and newsletters.

CHAPTER 1

Overview and Background

Study Objectives

Transportation agencies are constantly under pressure to do more with less when delivering projects. Influences such as the rising levels of congestion on U.S. roadways, shortfalls in funding, and loss of long-time employees to retirement without replacement are contributing to this trend.

The impact of these trends on the quality of projects has not gone unnoticed. The Wednesday, August 1, 2007, collapse of the I-35W highway bridge over the Mississippi River in Minneapolis, Minnesota, only brought more concern. The quality of design processes were questioned when the National Transportation Safety Board (NTSB) began an investigation that eventually lead to the discovery that the collapse of the I-35W bridge initiated with the failure of the gusset plates at the U10 nodes on the truss.

The following safety issue, among others, was identified in the investigation:

> Insufficient bridge design firm quality control procedures for designing bridges, and insufficient Federal and State procedures for reviewing and approving bridge design plans and calculations. (NTSB, Nov. 2008)

This finding lead the NTSB to recommend to the Federal Highway Administration (FHWA) and the American Association of State Highway and Transportation Officials (AASHTO) that the two organizations work together to develop a more adequate program of quality control and assurance (QC/QA or QA/QC) in bridge design to be used by the states and other bridge owners. The NTSB recommended that this quality program include procedures to detect and correct bridge design errors before the design plans are made final. In response to this recommendation, AASHTO initiated a study to provide a synthesis of current state department of transportation (DOT) practices for QC/QA in the area of bridge design and plan review.

This domestic scan was initiated following the NTSB recommendation to build on the initial AASHTO studies. The scope of this scan was expanded to incorporate aspects of quality programs in highway design, bridge design, overall project delivery, and QC/QA for special contract projects, such as design-build. The team believes that it is important to look at overall project quality, rather than just focus on bridge design, since there are farther-reaching quality issues, such as higher numbers and greater costs of change orders. Finally, the scan team also investigated the QC/QA practices encompassing project programming, planning stages, environmental permitting, and highway and bridge design. The team also examined lessons-learned feedback loops through construction.

Focus Areas

The scan team felt that while all states are delivering quality projects, some states are doing this more effectively and efficiently. It was determined that states that are showing more developed quality programs would have common successful solutions to share. These successful solutions fall into the following subject areas:

1. **Training and Communication Channels** – Communication between all parties involved in a project, as well as well-trained staff, make for better overall quality.
2. **Review and Approval Processes** – Review processes that delineate who performs the review, what types of review are performed, and how reviews are documented, contribute to overall quality of projects.
3. **Checklists, Manuals, and Standards** – The team was interested in states that had well-documented practices that were easy to follow and not cumbersome to overall production. Many examples of useful tools were presented during the scan.
4. **Scoping and Environmental Quality** – The quality process starts early in the scoping, and then continues during the environmental phases and through the final design. States visited showed innovative QC/QA processes within these early phases.
5. **Consultant Selection and Communication** – QC/QA for consultant designs were also discussed with host states to determine successful solutions for ensuring consistency and high quality from consultants.
6. **Construction Reviews and Feedback** – Although the scan team's focus was on quality in design processes, the team found that overall quality designs took into account feedback from construction processes and involved construction personnel early on in the design.
7. **Quality in Existing Processes** – Many states with successful quality programs look for ways to improve and enhance existing processes instead of adding additional steps to the design progression.

This report discusses each of these subject areas.

Study Organization and Approach

A detailed desk scan was prepared to help the team efficiently find and access agencies with successful solutions and processes in QC/QA. For the purpose of the desk scan, two separate surveys, one related to bridge design and the other related to highway design, were sent to all 50 states (see Appendix D for these survey questions). From the survey results, team members determined which state DOTs would be candidates for scanning visits and interviews.

The scan team decided to look for states that demonstrated well-documented QC/QA processes and exhibited innovative or standout processes for ensuring quality in their designs. The team also considered the DOT's organizational type (e.g., centralized or decentralized), the state's location (i.e., its region of the U.S.), and the size of the transportation funding programs. Team members wanted to make sure that all regions of the U.S. were represented, as well as states with both large and small overall funding programs.

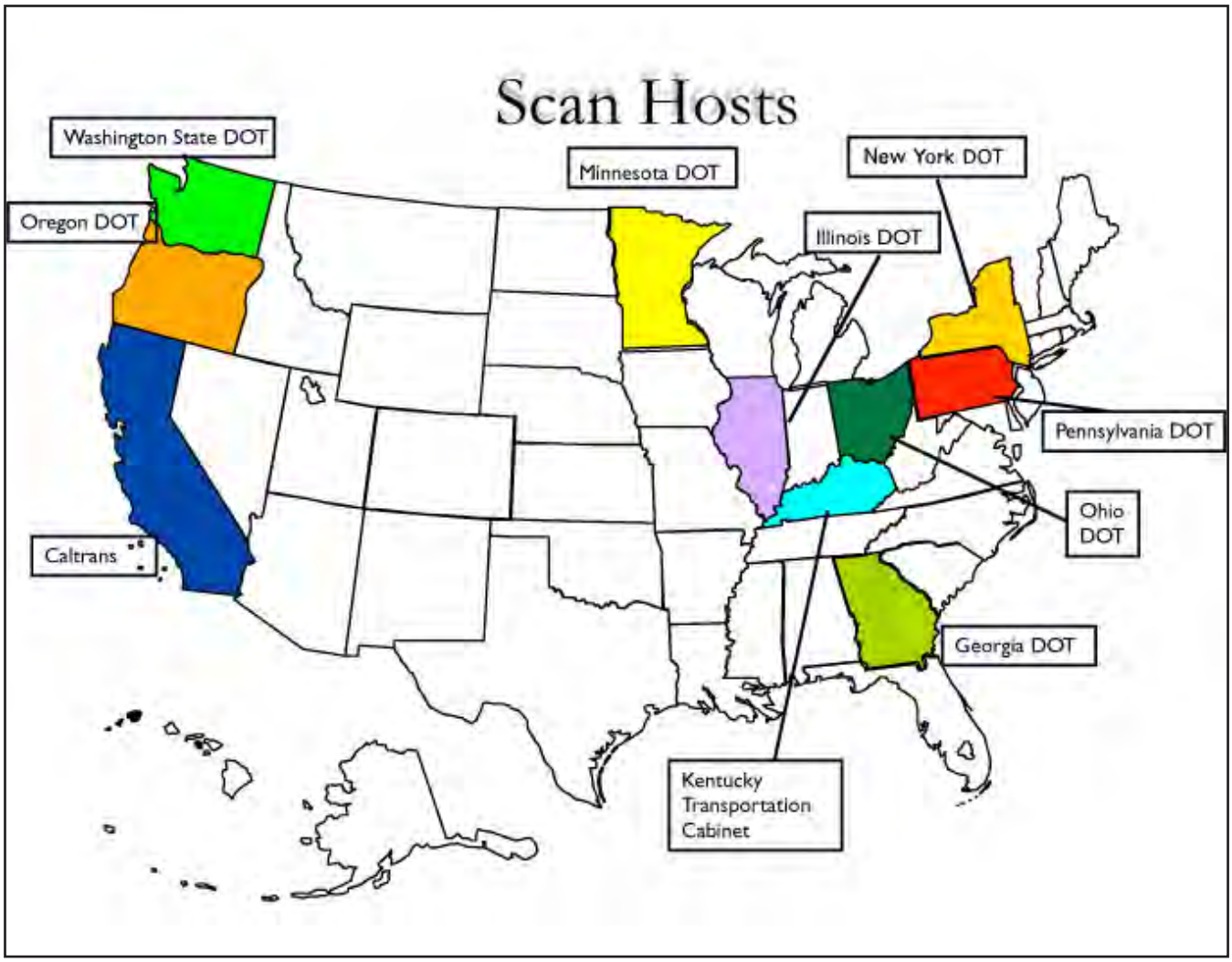


Figure 1.1 ***States included in the scan***

The following states were chosen for visits because they were found to have innovative and well-developed QC/QA processes:

Eastern U.S.	Western U.S.
Georgia New York Pennsylvania	California Oregon Washington State
Midwest U.S.	**Web Conferences**
Kentucky Minnesota	Illinois Ohio

The scan team developed amplifying questions for the selected states to consider and set the stage for the visit. The amplifying questions fell under the following headings:

- How do you define a successful QC/QA program?
- How do you measure the success of your program?
- How was your QC/QA process developed?
- What are the documentation and administration procedures for your QC/QA process in design?
- What reviews should be done across disciplines?
- What specific qualifications and education practices can you elaborate on?
- What should QC/QA programs do differently for specialized processes, such as design-build projects or value engineering (VE) processes?

Scan Team Composition

Scan team members (see Table 1.1) were selected to represent diverse knowledge and to represent all areas of the country.

Team Member	Organization
Hossein Ghara – AASHTO Chair	Louisiana DOTD
Nancy Boyd	Washington State DOT
Richard Dunne	New Jersey DOT
Robert Healy	Maryland DOT
Tim Swanson	Minnesota DOT
Carmen Swanwick	Utah DOT
Kelley Rehm – Principal Author	Kelley Rehm Consulting
Robert Watral	Pennsylvania DOT

Table 1.1 ***Scan team members***

Implementation

The main objective of the domestic scan program is to advance innovative actions and publicize successful solutions by sharing the information gained through scan team visits. The team evaluated the information gathered and developed an execution plan that can be used at the federal, state, and local levels. The plan, including implementation details, is included in Planned Implementation Activities

CHAPTER 2

Findings and Observations

The scan team was presented with a wealth of information and was impressed with the level of each host agency's efforts to ensure that the best information and practices were highlighted and shared. The scan team gathered, reviewed, and analyzed much information from each state visited.

While many successful solutions were common among the visited states, the differences in organizational makeup of each of the states preclude the team from calling these best practices. What may be best for one state and its organizational structure may not work successfully for all states. For this reason, innovative practices are described as successful solutions, since these practices are successful for their given states and may give other states ideas of how this innovative thinking might work for them. Key contact information for host agencies is provided in Appendix C.

The next several sections present the successful solutions that the scan team identified:

- Training and Communication Channels
- Review and Approval Processes
- Checklists, Manuals, and Standards
- Scoping and Environmental Quality
- Consultant Selection and Communication
- Construction Reviews and Feedback
- Quality in Existing Processes

The following sections of this report discuss each of these successful solutions and the next steps for each. Conclusions discusses the team's final thoughts and provides information about needed Future Research and planned Implementation Activities. The latter includes a plan the scan team has drafted to ensure that the findings of this scan are disseminated to all interested parties so that they can implement similar successful solutions in their own organizations.

Lastly, a series of appendices contain important reference information relevant to this scan:

- Appendix A – Scan Team Biographical Information
- Appendix B – Scan Team Contact Information
- Appendix C – Host Agency Contacts

- Appendix D – Amplifying Questions and Desk Scan Surveys
- Appendix E – State Forms and Documents

Quality Definitions

The first question the scan team addressed was, "How do we define quality?" This question can be answered in many different ways, depending on the point of view and the situation. The team agrees that quality programs include adequate tools, core competencies, and good standards; however, political and economical issues often hinder the quality process.

Another question the scan team pondered was, "How do I show the benefit of quality?" The issue of how best to convey or market to the decision makers that quality programs are worth time and funding was considered throughout all the host state visits. How can we positively state that these quality programs equate to longer life of the infrastructure?

The scan team noted that in successful states it is important to have the support of upper management in the development, documentation, and use of a QC/QA program. It is clear that adequate tools and documentation can lead to quality plans, but only with quality people and expertise behind the designs. Overall, a successful quality program should be able to show that better quality in plans equals longer life and cost savings on projects. Many states recognize that a quality set of plans does not always equal a quality design and that sustainability, constructability, and other considerations should be taken into account to instill quality into a project.

New York State DOT (NYSDOT), the first DOT visited on this scan, prompted the team with a few thoughts and questions on quality that summarized what the scan overall was looking to answer. Bob Dennison, the New York State highway engineer, asked, "Does a perfect set of plans equal quality? Can you produce a perfect set? Should you? How much time should we take to generate a set of plans?" All these questions become important when considering the current environment of reduced staff and funding and increased demand.

NYSDOT also challenged the team to determine an adequate measure of quality. Does quality equal the time taken to complete documents, meeting deadlines, or having final estimates match bid pricing? How do we know if the final document is a good design? How much is right and how much is personal preference? The team members posed these questions to each of the host states. Although this scan may not answer all these questions, the host states all gave significant insight to the team. The findings are presented here.

NYSDOT presented these simple, complete definitions of QA/QC:

- Quality Assurance – Actions to prevent defects or make improvements in the policies, procedures, and systematic actions established to ensure quality
- Quality Control – Actions to catch defects; the independent checking of work and use of control points (approvals) to ensure a high level of confidence that each product will meet expectations

The team also agreed that Oregon's QA/QC definitions were notable:

- Quality Assurance – All those planned and systematic actions necessary to provide adequate confidence that a structure, system, or component will perform satisfactorily in service
- Quality Control – Routine operational activities designed to consistently produce a predictable result

Each agency visited had slightly different opinions on the definitions of QC/QA, but all had carefully thought out quality programs.

Host States' Organization Structures

To understand why practices in host states were successful, it is first important to understand the organizational structures of each agency. The following gives background information on the host states to better put successful solutions into context. Each host state's organizational makeup for both bridge and highway design offices is described. The funding program size for each state's transportation programs and the percentage of work performed by consultants for both bridges and highways is also described. It is important to note that all of the visited states have regional or district offices doing some design work, so there are no purely centralized states; however, some visited states do have all bridge design work located in a central office.

Host States' Bridge Office and Highway Design Office Structure

California

Caltrans (California DOT) is geographically divided into 12 districts. For highway design, Caltrans administers design through five individual districts and two regional offices (North and Central Regions). The regional offices typically centralize the design operations in one of the districts (e.g., North Region has District 1, 2, and 3; design resides in District 3.) There are seven design offices statewide, and these offices review consultant engineering plans. A map on the Caltrans Web site[1] shows the counties represented by each of the state's 12 districts.

The Caltrans Bridge Design Offices are for the most part centralized. Bridge design within Caltrans is performed in a subdivision called Structures Design, which is one of eight subdivisions that form the Division of Engineering Services, located in Sacramento. Structures Design comprises approximately 370 staff and includes mostly design engineers and structural design technicians, who do detailing work. Of the six Structures Design offices, five do project direct work and one provides corporate support (i.e., guidance and technical support). Each office consists of between 60 to 80 staff and is made up of four or five branches. Each branch is made of about three-quarters structural design technicians and one-quarter registered engineers.

[1] Your Local Office, Caltrans web site, http://www.dot.ca.gov/localoffice.htm

The main Caltrans bridge design office is located in Sacramento, with two smaller regional design groups located in Los Angeles County and in the city of Oakland. Most of the consultant-designed bridge plans are reviewed in the main office in Sacramento.

California has over 50,000 lane miles of roadway, 12,940 structures on the state highway system (and almost as many on the local roads), as well as 26 tunnels and 9 large bay-crossing bridges. Unique to California, in addition to 58 counties and 18 metropolitan planning organizations, are 21 "self-help" counties. These counties have passed their own sales tax measures to support transportation and collectively contribute billions of dollars toward transportation in California ($3.9 billion in 2009, which was more than the SAFETEA-LU[2] estimated highway apportionment). Caltrans does project development oversight on all projects on the state highway system.

Georgia

The Office of Roadway Design, located at the Georgia DOT (GDOT) headquarters in Atlanta, traditionally designs the major arterials and freeway projects. District Design Offices design minor projects (e.g., intersection improvements, turn lanes, passing lanes, and some minor collector and arterial projects).

The Office of Bridge and Structural Design conducts all in-house structural design. All structural plans (in-house or consultant) are reviewed internally by the GDOT state bridge engineer and/or the assistant state bridge engineers. The Bridge Office is centrally located in Atlanta. GDOT has no district bridge offices. The central office reviews all consultant bridge plans.

Illinois

In Illinois, highway design offices are located in each of the nine district offices statewide. The district offices review all plans, and the central office is responsible for finalizing contract documents.

The Bureau of Bridges & Structures, located in the central office, is responsible for overseeing all bridge-related policies and approvals. Consultant bridge plans are reviewed at the central office within the Bureau of Bridges & Structures.

Kentucky

The state's Division of Highway Design is centrally organized in Frankfort. Liaisons from the Roadway Design Branch are assigned to various districts. Twelve districts comprise the Kentucky Transportation Cabinet (KYTC) across the state, and each district has a Roadway Design Section under the District's Project Development Branch. Both district and central office personnel review consultant plans.

---

[2] Safe Accountable Flexible Efficient Transportation Equity Act: A Legacy for Users, http://www.fhwa.dot.gov/safetealu/

The Bridge Office is centrally located, and this location performs all structure design work and structural consultant work review.

Minnesota

For highway design, Minnesota DOT (Mn/DOT) is decentralized, with district offices doing highway design and plan review. The central office compiles final contract documents and reviews them for completeness.

In Minnesota, bridge design remains a central function. The Bridge Office either prepares the plans or retains a consultant to prepare them. This office directs all bridge designs and reviews all consultant plans.

New York

Like Mn/DOT, NYSDOT is also decentralized. The department includes 11 regional offices, where most production takes place, along with a central office in Albany that provides design policy and production support for the regional offices. Each regional office includes both highway and bridge design functions. NYSDOT's main office incorporates the Office of Structures, which provides expertise and bridge design services, along with providing structural design standards and related policies. In addition, the main office includes the Design Services Bureau, which functions as an internal highway design consultant to the 11 regional offices. *New York's Project Development Manual*[3] identifies the regional and main offices' roles.

Personnel in the regional office where the project is located review the plans. The Design QA Bureau, Office of Design, and other functional units (i.e., technical experts) in the main office perform additional reviews.

The Office of Structures is centrally located in Albany and is responsible for developing structures-related policies and procedures for the DOT. The Office of Structures comprises four bureaus: Structure Design, Structure Design QA, Structure Evaluation Services, and Structural Engineering Services. There are regional Structures Units in each of the 11 regional offices, each with its own working group for bridge inspection, project development, and design. The Structure Design Bureau, private consultants, and some regional offices perform bridge design. The Structure Design QA Bureau performs most detailed reviews of consultant engineering bridge plans.

Ohio

The scan team chose Ohio solely to discuss its quality process in Bridge Design. The Ohio Bridge Design Office is decentralized. Some District bridge offices have strong technical abilities, while others do not have the same high level. Ohio has 12 district offices that are each responsible for the bridge inspection program and delivering design plans. Consultant

[3] NYSDOT *Project Development Manual*, https://www.nysdot.gov/portal/page/portal/divisions/engineering/design/dqab/pdm

bridge plans are reviewed at the central or district office, depending on their technical capabilities and available resources.

Oregon

For highway design, Oregon DOT (ODOT) has five regional offices, which also include offices for roadway design and reviews. ODOT headquarters is also available for additional consultation and review as needed. Regional engineering staff members are the primary reviewers of consultant engineering plans.

For bridge design, one central ODOT Technical Services Bridge Engineering Section contains the bridge design standards and specialty staff. Five regional field offices are located throughout the state where most of the bridge design work is performed. Consultant bridge plans receive a first-level review at the regional offices with QA, or second-level, reviews being done by standards and specialty staff at the central Bridge Engineering Section.

Pennsylvania

For highway design, Pennsylvania DOT (PennDOT) is a decentralized organization with 11 engineering districts and a central office. Each district has a Design Unit, and the central office has a Bureau of Design. District Design Units review consultant and in-house plans from a geometric perspective. Then, depending on the plans' complexity, by the central office's Bureau of Design. Depending on staffing and urgency, central office design engineers in the district office, at the consultant's office, or in the central office review consultant and in-house plans for right-of-way and construction from a plans presentation perspective. Minor projects not involving right-of-way are typically delegated to the districts.

Bridge design at PennDOT is decentralized, with 11 engineering districts and a central office. Within the central office Bridge Unit is the Bridge QA Division, which provides policy development and specialized technical assistance to the Engineering districts. The engineering districts review consultant-developed designs for noncomplex bridges. Both the engineering district and the central office review complex bridge designs (e.g., curved girder bridges or other major bridges).

Washington State

Roadway design is decentralized at Washington State DOT (WSDOT). Plans are developed and managed within regional offices around the state. There are nine regional/divisional offices; within each individual region, project offices manage and administer design work. In general, the region itself performs design/plan review, including consultant plans.

The Bridge and Structures Office is centralized. There are no district or regional bridge offices within the state. The central bridge office reviews consultant-prepared bridge plans.

Host State Program Size

The scan team visited states with a wide range of available funding (see Table 2.1). California had the largest program, while Oregon had the smallest.

State	FY 2006	FY 2007	FY 2008	FY 2009
California[a]	$3,240,610,039.52	$3,460,718,186.38	$3,604,882,214.24	$3,640,724,860.61
Georgia	$1,212,858,135.00	$1,272,797,717.00	$1,318,324,018.00	$1,331,431,858.00
Illinois	$1,137,198,214.63	$1,268,236,331.26	$1,339,035,993.85	$1,352,349,769.66
Kentucky	$604,109,176.81	$637,011,678.02	$659,583,180.66	$666,141,288.60
Minnesota	$538,915,049.36	$629,121,021.37	$673,231,542.37	$679,925,353.34
New York	$1,669,815,476.57	$1,683,966,455.19	$1,698,117,433.80	$1,712,268,412.42
Ohio	$1,227,434,172.00	$1,334,087,293.00	$1,397,438,434.00	$1,411,332,894.00
Oregon[b]	$422,864,223.78	$445,895,310.16	$461,694,906.18	$466,285,449.30
Pennsylvania	$1,632,727,877.94	$1,646,564,554.87	$1,660,401,231.80	$1,674,237,908.73
Washington	$593,326,168.32	$626,874,018.56	$654,936,761.03	$661,448,670.53

[a] California's totals do not include investment by the sales tax counties.

[b] Oregon's totals do not include Oregon Bridge Delivery Partners' $1.3 billion investment over 10 years.

Table 2.1 ***SAFETEA-LU estimated highway apportionments from 2005–2009***

Percentage of Designs Completed In-House or by Consultants

The processes each state use for QC/QA is greatly affected by the amount of design work that is done by consultants. The following table shows how much work is done by consultants in each of the host states according to number of projects. These numbers would be different if they were looked at from a total-cost-per-project point of view. Work performed by consultants is often for higher dollar, more complex projects.

State	Bridge design		Highway design	
	In-house design	Consultant design	In-house design	Consultant design
California	70	30	91	9
Georgia	40	60	50	50
Illinois	25	75	30	70
Kentucky	50	50	15	85
Minnesota	50	50	50	50
New York	50	50	90	10
Ohio	10	90	—	—
Oregon	50	50	—	—
Pennsylvania	40	60	20	80
Washington State	90	10	—	—

Table 2.2 ***Bridges and highways designed either in-house or by consultants***

CHAPTER 3

Successful Solutions

Introduction

What Is a Successful State?

For this domestic scan, successful states were not chosen because of a particular measure of quality plans. The team did not collect specific data on quality measures (e.g., number of change orders, letting dates met, or other measures that may be considered a measure of quality) for the desk scan. As mentioned in the Introduction, all states were surveyed on their QC/QA processes for both highway and bridge design (see Appendix D for the survey questions). These surveys were included in a desk scan report, and the team refined the list of states based on their program size, their region of the country, the nature of their organization (e.g., decentralized, centralized, and percent of work done by consultants), and noted innovative practices in QC/QA.

While this scan may not have specific measureable data showing that visited states' quality processes are "successful," the scan team believes that these states have innovative ideas; logical, well-defined processes; and well-written guidance documents that lead to successful quality programs.

Common Elements Among Host States

A number of states with successful QC/QA programs have developed procedures and training classes specifically focused on QC/QA. Another common element includes having regularly scheduled meetings with all disciplines involved in the projects, with earlier involvement from construction to ensure constructability. Lastly, good communication between consultants and department staff is important in successful states. Many states hold lessons learned conferences or meetings with their consultants each year.

Documentation of quality processes and procedures and use of checklists are common among successful states. Several drivers contributing to the need to provide documentation of quality processes were mentioned:

- **Higher percentage of designs done by consultant**
  To maintain consistency, quality processes need to be documented and easily referenced by consultants.
- **High rates of retirement and staff turnover**
  Processes need to be well documented to counter the loss of institutional knowledge when

long-tenured staff retires and when newer staff quickly rises to management positions.

- **Decentralized organizations**
  More guidance is needed when designs are completed in regional or district offices instead of in a central location to keep processes standardized and communication channels open.
- **Use of specialty contracting such as design-build**
  More attention is given to QC/QA processes when design-build agreements are used, and this often leads states to look into similar quality processes for traditional design-bid-build projects

Finally, successful states have a few review and approval practices in common in their QC/QA programs:

- Checklists outlining processes for designers, reviewers, and contract document compilation are used for each phase of project development.
- Consultants are rated or graded (although not all states use these ratings extensively for consultant selection).
- Decisions about the amount and type of review are made on a risk-based scale, taking into consideration the type and size of the project to determine the depth of the review.
- Although VE is done in all states, successful states evaluate the outcomes of these processes and use it as lessons learned feedback for future designs.
- Third-party consultant reviews are done for specialty projects or when DOTs do not have sufficient expertise or staff to meet deadlines.
- Plan signoffs or professional engineer (PE) stampings are done at many different levels, including signoffs on original design, review, and even for design changes that are done in construction.
- States are moving to single-point data systems where multiple users and disciplines can look at and analyze documents to determine problem areas and make improvements in processes.

The following sections give more information on these common elements, as well as on innovative, standout processes that visited states presented during the scan.

Training and Communication Channels

A number of states with successful QC/QA programs have developed procedures and training classes specifically focused on QC/QA. One way successful states are ensuring quality from their designers is to incorporate training rotations for new staff into their programs as well as training for all staff on ways to improve processes. Reporting on quality processes and awards for quality work helps to keep communication channels open throughout the agencies and helps to provide feedback on the QC/QA processes to all staff.

States with well-developed QA programs also have regularly scheduled meetings with all disciplines involved in the projects, with earlier involvement from construction to

ensure constructability. These set meetings not only help to develop relationships across disciplines, but also help to contribute to lessons learned feedback loops.

Lastly, good communication and relationships between consultants and department staff is important in successful states. Many states hold lessons learned conferences with their consultants each year or partner with organizations such as the AGC or the ACEC to hold joint training or networking meetings.

Training Rotations and Staff Training

The scan team recognizes that one of the first steps to quality in design is to have quality people trained well in core competencies. Several of the visited states had innovative training and mentoring programs for new staff as well as continuing education and training in quality processes for existing staff.

New York

The NYSDOT mentoring program is one example of this type of innovative training. The mentoring program is voluntary and open to all main office personnel. The goal of the program is to assist in the development of employee skills, techniques, and perspectives, and to help develop managers and leaders within the DOT. The program provides guidance in career planning, personal development, and help in achieving the department's corporate goals. Mentors and protégés are partnered on a one-to-one basis, matching mentors with certain skills/experiences with protégés who have a desire to attain those skills/experiences. The partners work together to set goals and identify activities that will assist the protégé in meeting his or her goals. The partners determine the duration of the mentoring relationship.

New York's Office of Design has a Workforce Development Program whose goal is ensuring that regional and main office design staff has the skills, knowledge, and proficiency necessary to develop and deliver quality, timely, and cost-effective capital projects. The program:

- Focuses on critical competencies that drive performance
- Provides a tool to streamline the process of matching competencies to employees based on job roles
- Includes a combination of technical, business, and leadership competencies
- Measures proficiency levels as fundamental, experienced, and expert
- Provides a basis to measure current knowledge and identify clear objectives for future development

In total, the program includes more than 100 competencies in 16 categories, ranging from technical topics like Estimating, Bridge Design and Work Zone Traffic Control to Business, Communication, and Coordination skills.

New York's regional offices also have a training rotation for new highway and bridge

design staff that places the designers in the construction field for at least one construction season. This program allows new design staff to learn valuable lessons, such as specific methods of construction, the need for clarity within plans, a better understanding of the specifications, and an understanding of realistic precision in the field and a better idea of the time needed to construct a project.

Kentucky

Kentucky is another host state that provides innovative ways to secure the best and brightest civil engineering students and train them in core competencies. The Kentucky Transportation Cabinet (KYTC) awards 10 to 20 new scholarships each year to qualifying students who are interested in attending the University of Kentucky or Western Kentucky University to obtain a bachelor of science degree in civil engineering. Students may also attend the University of Louisville J. B. Speed School of Engineering or attend pre-engineering courses at Kentucky State University or through the Kentucky Community and Technical College system and finish their bachelor of science degree in civil engineering at one of the accredited institutions.

The program provides students with a stipend that can be used for tuition or living expenses in exchange for the student agreeing to work for the KYTC upon graduation. The scholarship is on a one-to-one basis, so that if a student accepts the scholarship for one year, he or she agrees to work for the Cabinet for one year after graduation. The program also provides each student the opportunity for summer employment with the Cabinet, most often as construction inspectors. In this way, students often have extensive construction experience before they graduate.

This program began in 1948, and the KYTC has awarded nearly 1,700 scholarships, amounting to over $12 million in scholarships since its beginning. Each year 80 scholarship openings are filled with returning students and new students. Once students graduate, they are placed in training rotations that allow them to work three to four months in different divisions of interest (e.g., design, materials, construction, or planning) for one year. Once they choose a specialty, they are given a one-year intensive assignment before being permanently assigned.

Ohio

Ohio explained to the team an innovative process described as “review training” for engineers who are performing QC reviews on plans. This training concentrates on the best ways to identify errors or omissions and the use of manuals and checklists. It also teaches reviewers how to successfully convey comments back to the designer.

California

Training continues for more experienced staff and extends into the construction phases in California’s Resident Engineer Certificate program. This program leads to consistent

definitions of design error. Consistent handling of errors and omissions is intended to improve the performance of Caltrans construction staff, reinforce partnering, and help ensure consistent enforcement of Caltrans standards. The program recognizes certificate holders for having a certain level of knowledge and for the added effort they made to improve their skills so that they can provide even better service to Caltrans and its customers. As the resident engineers are responsible for administering the construction contract, these certified engineers are better prepared to identify when problems in the field are design errors or omissions. They are trained in ways of providing feedback information, working with designers to make sure that these errors are not repeated, and providing feedback to improve quality in future projects quality.

All of the above-mentioned states have programs that allow new staff to be well trained and mentored in the core competencies that are needed to produce quality highway and bridge designs.

Reporting and Feedback

Quality processes do not begin and end with review of designs and contract documents. Feedback and reporting are needed to ensure quality in future projects and instill effectiveness and efficiency into processes. Best practices and successful solutions within agencies should be recognized, reported, awarded, and incorporated into existing processes.

Georgia

Georgia has developed a process to identify best practices in design within its district offices and disseminate them to the entire state. The Office of Road Design scores individual in-house design groups across the state twice a year, identifying best practices by looking at these higher scoring groups or by identifying high performers based on recommendations from project managers (PMs). These best practices outline what these groups are doing differently, whether it is providing specific training, using checklists, or other program innovations. The Office of Road Design identifies high performers within district design offices, bridge design offices, and traffic operations offices and interviews them twice a year to determine if their practices are candidates for statewide implementation to improve quality.

California

Caltrans has developed a Contract Quality Management Program, because it also knows that feedback on processes is the key to knowing if a quality program is working. The Caltrans program defines not only QC and QA, but also independent QA (IA). As shown in Figure 3.1, this process leads to what Caltrans has termed “Best Bids” Quality Standards.

- QC – Design engineers are responsible for making sure that the design is correct.
- QA – PMs make sure that standards are followed and the QC process is being done.
- IA – The office engineer (program management) identifies quality trends and makes recommendations to improve the quality process overall.

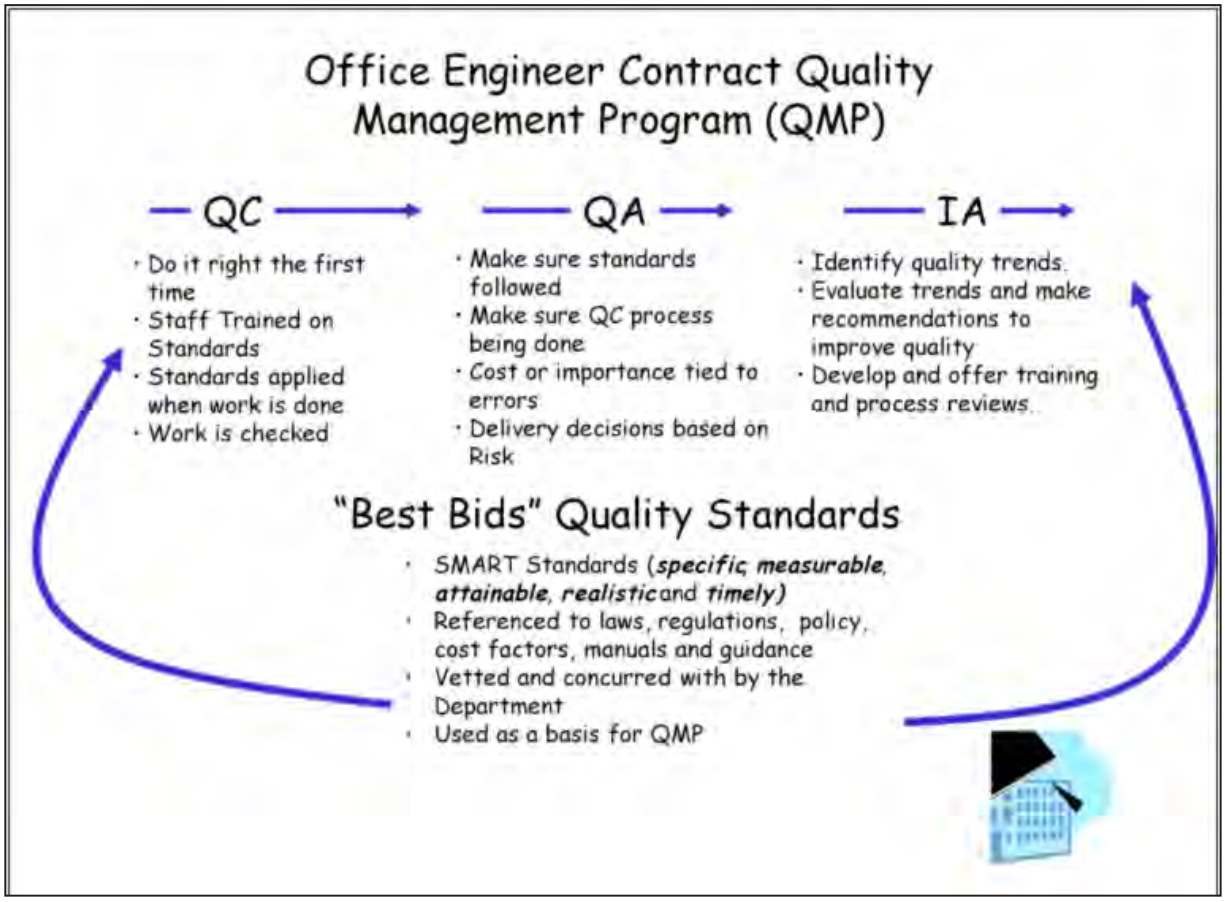


Figure 3.1 ***Caltrans contract quality management flowchart***

The IA evaluation is done on a sample number of projects each year and in certain instances is done for specific projects (see Table 3.1). The project evaluation process includes an annual feedback report to the districts and leads to the development of cooperative action plans in response to lessons learned.

Type	Description
Sampling Based *Required*	25% of eligible projects with a cross section of project types
Indicator Based	Based on performance measures, cost factors, and other historical data
Priority Based	Project specific beyond baseline delegation for AADD projects Determined on a case-by-case basis by request of appropriate senior authority

Table 3.1 ***Caltrans projects selected for IA evaluation***

New York

New York also recognizes the need for feedback and reporting to improve quality processes. Its Design QA Bureau tracks each design for several quality measures, such as:

- Timeliness
- Development of design standards and environmental analysis
- Completeness of design decision documents and final plan packages
- Changes between plans, specifications, and estimates (PS&E) submittal and advertisement (e.g., unit price changes)
- Amendments to design
- Low bid in comparison to the engineers' estimate
- Bidder and construction administration staff experience with the design product

The Office of Design meets semiannually with the regional design engineers, discusses the performance metrics, and identifies areas for improvement.

During the preliminary design process, NYSDOT uses the Design Report Review Checklist (see Appendix E) to evaluate the completeness of submissions for design approval and to ensure compliance with applicable federal and state environmental requirements. The checklist captures 14 key metrics that underpin the project development process.

At the end of the final design process, the PS&E packages are evaluated for process and technical quality. The Design QA Bureau issues a PS&E Quality Award certificate following the bid opening, recognizing those responsible for delivering designs meeting five key performance criteria. The performance data collected are also summarized at the statewide and regional levels and shared semiannually with the regional design engineers and the regional QC engineers.

At advertisement, project-specific industry feedback is solicited through the NYSDOT Contract Bid-Ability Survey (see Appendix E), which is included in the contract bid documents. The surveys provide the DOT with an industry perspective on the contract bid documents it produces. The data are collected and reviewed after bid openings, then summarized in a database, and the individual responses are shared with the regional offices. Comments are evaluated to identify regional and statewide improvement opportunities. Regional offices can query this database to see how they are doing on overall plan quality. These data have been collected for over two years; contractors have provided about 400 survey responses.

During construction, the engineer in charge prepares a Project QA Report (PQAR) for all projects that are greater than $2 million in contract value and are at least 80% complete. The Office of Construction collects and summarizes these individual reports annually and distributes the summaries to the main office and regional groups for use in identifying

improvement opportunities and implementing changes in procedures and practices. Additional information on the PQAR process is available on NYSDOT's Web site in Engineering Bulletin 10-007[4].

New York puts emphasis on feedback loops and actions taken in response to the feedback in its overall quality practices:

- Performance requirements are defined in:
  - *Project Development Manual* – project development process
  - *Highway Design Manual* – highway engineering standards and technical guidance
  - *Bridge Manual* – structural engineering standards and technical guidance
  - Other engineering issuances/guidance documents
- Performance measures include:
  - Design Report Review Checklist – preliminary design quality
  - Engineer's Estimate Accuracy – estimate quality
  - PS&E Quality Award – final design quality
- Customer feedback systems include:
  - Management/staff level partnering – FHWA/DOT
  - Executive level partnering – industry organizations/associations feedback
  - Bidability surveys – bidder, subcontractor, and materials supplier feedback
  - Project QA reviews – construction field staff feedback
- Corrective actions are taken:
  - Engineering products – Feedback is assessed and changes are made by those responsible for the products.
  - Engineering policies and procedures – Issues are quantified; changes to engineering policy are developed and vetted through internal and external stakeholders; and updated guidance is issued through the Engineering Information Issuance System to implement the change.

Regularly Scheduled Meetings Across Disciplines

Almost all states have scheduled milestone meetings to discuss issues with design projects, often at 30-60-90% complete reviews and for final reviews. However, some states with standout quality programs take the extra step to make sure all disciplines relevant to

[4] New York State Department of Transportation Engineering Bulletin EB 10-007, https://www.nysdot.gov/portal/pls/portal/mexis_app.pa_ei_eb_admin_app.show_pdf?id=10331

a project are involved in the early stages. For example, it is often beneficial to have construction engineering staff involved as early as the scoping phase and throughout the design. This helps prevent constructability issues from arising at a time when design changes cannot be easily made.

QA does not just occur at the end of the product production. It should take place throughout the design process with all relevant parties involved. This topic will be discussed more in both Scoping and Environmental Quality and Construction Reviews and Feedback.

One example of the benefits of early involvement of construction personnel can be seen in New York's Region 1 processes. NYSDOT's Schenectady office recognizes that involving construction engineers early on in the scoping phase and continuing that involvement throughout the design process can help avoid major construction problems and delays. An experienced construction supervisor becomes the liaison to the design team and deals with such issues as site accessibility, construction sequencing, material ordering, project waste management, environmental requirements, and public involvement. Construction is involved in constructability reviews, mid-design reviews, meetings dealing with utilities, and design VE sessions. The value added by this early and continuous involvement includes project buy-in by all involved, well-thought-out work zone and traffic control plans, constructible projects, avoidance of construction delays and claims, and fewer construction problems overall.

Relationships Between Consultants and the Departments

Keeping lines of communication open and maintaining relationships between consultants and DOTs is always important in producing quality plans. Of course, one way to do this is through regularly scheduled project-specific meetings and early involvement of all disciplines, as mentioned above. Some states, however, have come up with innovation solutions to maintaining good relationships between consultants and DOT staff.

Pennsylvania

PennDOT has several efforts with associations and consultant groups that help it build good relationships with consultants. One program developed by PennDOT's District 8 office includes a partnership with the American Society of Highway Engineers. The two groups have formed a Design Safety Review Committee to bring consultants and DOT staff together to resolve any issues on projects. The chief design engineer in the district chairs the committee, but maintenance, construction, and traffic engineers are at the table with the consultants as well; the FHWA is also involved where warranted. These weekly committee meetings are not a substitute for formal approval processes; however, they are a good place to work out any issues. No elected officials, contractors, or developers are allowed in the meetings.

The PennDOT staff believes that these meetings eliminate the "consultant wall" (i.e.,

throwing the plans over the wall with red ink and hoping that the consultants throw the final product back over the wall). As a result, the American Society of Highway Engineers keeps a list of the lessons learned and issues for discussion. These are discussed at an annual forum that includes design, maintenance, and construction engineers.

PennDOT has also partnered with the ACEC to develop QA performance measures. A task force made up of several DOT design engineers and consultant design engineers was formed in the fall of 2008. It created lists of expectations and provided metrics for each of the performance measures. The ACEC/PennDOT partnership's list of expectations from PennDOT included:

- Minimize review
- Minimize field changes
- Meet schedules
- Meet contract requirements
- Minimize design errors
- Manage budgets
- Establish a clearly defined scope

The partnership's list of expectations from consultants included:

- Provide well-defined scope and cost
- Do what they say they are going to do (expect QA/QC)
- Deliver on time
- Deliver within budget
- Limit rework/redo
- Limit addenda/work orders

Several areas were identified for performance measurement, including quality of design. Metrics for quality of design include:

- Work order data (number/cost attributed to design errors)
- Quality survey scores

For the quality survey scores, PennDOT developed a 15-question survey to evaluate consultant plans and specifications quality. A contractor representative and a department construction engineer complete this survey, which is separate from a consultant evaluation. PennDOT will begin measuring these performance measures in fiscal year 2011.

Other states visited also provide networking activities and learning tracks through annual forums for both DOT staff and consultants.

Kentucky

The KYTC works with the local ACEC branch as well as with the FHWA to hold an annual Partnering Conference. This conference provides a place for over 500 engineering professionals who are responsible for the highway design work done in Kentucky to network and attend learning workshops and tracks. The group is equally divided between members of the KYTC and the state's consulting engineers who support the Cabinet's efforts. The tracks include sessions and training for right-of way/utilities, planning, environmental, drainage, geometric design, and structure design; roundtable forums for questions and answers between consultants and KYTC engineers are also included.

Oregon

Oregon holds similar annual forums to bring consultant and ODOT engineers together. The annual Bridge Design Conference provides a forum where information can be exchanged between ODOT, local and other governmental agencies, and consultants on subjects of current interest to the bridge design community. This two-day event includes a variety of presentations from the bridge design community, zeroing in on hot bridge design topics and lessons learned that have broad audience appeal, such as accelerated bridge construction, design for aesthetics, staging and/or construction challenges, unique bridge strengthening methods, unique and interesting structure types, and changes to the *ODOT Bridge Design & Drafting Manual*.

Review and Approval Processes

Visited states have a few review and approval practices in common in their QC/QA programs:

- Checklists outlining processes for designers, reviewers, and contract document compilation are used for each phase of project development.
- Consultants are rated or graded (although not all states use these ratings extensively for consultant selection).
- Decisions about the amount and type of review are made on a risk-based scale, taking into consideration the type and size of the project to determine the depth of the review.
- Although VE is done in all states, successful states evaluate the outcomes of these processes and use it as lessons learned feedback for future designs.
- Third-party consultant reviews are done for specialty projects or when DOTs do not have sufficient expertise or staff to meet deadlines.
- Plan signoffs or PE stampings are done at many different levels, including signoffs on original design, review, and even for design changes that are done in construction.

- States are moving to single-point data systems where multiple users and disciplines can look at and analyze documents to determine problem areas and make improvements in processes.

This section takes a look at a few of the successful solutions that these states are using in the areas of VE feedback, third-party reviews for design, plan reviews and signoffs, and single-point data systems.

Value Engineering

VE is not a new process and is even required for states. However, VE processes can be valuable to quality processes when feedback is used to make design processes more effective and efficient. Several of the states that the scan team visited have innovative VE tracking and feedback processes.

Kentucky

The KYTC QA Branch is doing innovative things with VE process feedback. A new database of VE studies has been created within a geographic information systems (GIS) program. The VE studies, as well as the VE change proposals (VECPs) done during the construction process, are available within the GIS database. The database also includes other valuable feedback on projects, including post-construction review and constructability review data. This combined information forms a large lessons learned database that can be analyzed to find trends and areas for process improvement, which increases overall project quality in the future.

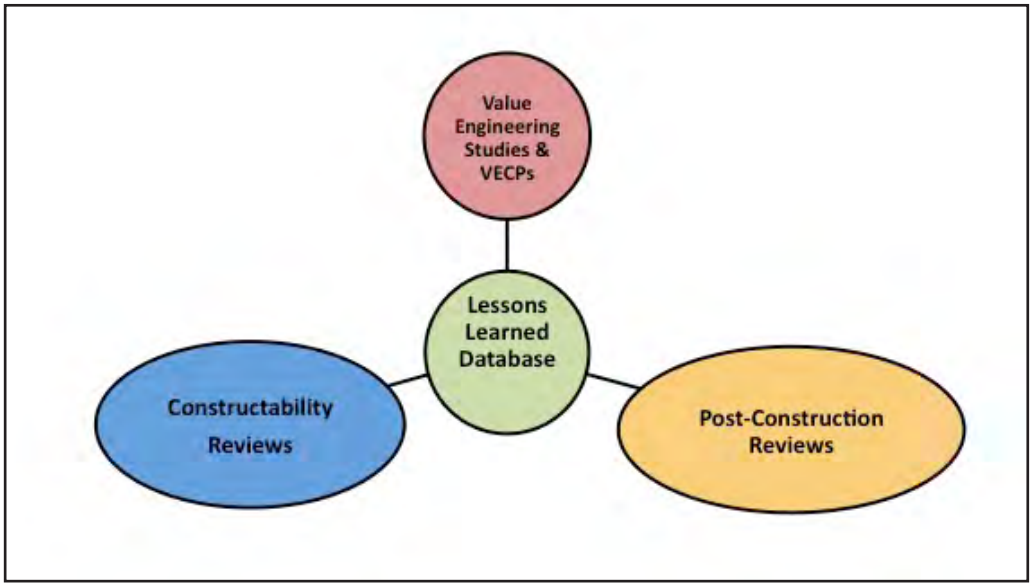


Figure 3.2 ***KYTC GIS lessons learned database model***

The QA branch reviews VE studies that were completed on the subject project to ensure that the proposed idea was not previously considered. It also acts as a liaison to Division of Highway Design personnel if they have any questions concerning the proposal. Finally, it tracks all VE proposals that are submitted through construction in a database that is accessible to KYTC employees.

KYTC tabulates all of the study's findings and recommendations in a VE data sheet it developed, which is passed along to PMs. The QA branch follows up with each PM to see which recommendations are valid and determine if they want to adopt and pursue any recommendations further. The QA branch also documents ideas that are not viable or do not warrant further investigation.

Also included in the KYTC's tracking systems are the VECPs that are proposed during the construction phase. With the tracking system, once the VE is identified as a trend, it becomes an accepted design method and work is done to have the method incorporated into the appropriate manuals and specifications. The GIS system imports all the VE and VECP data and maps the projects. The database can coordinate and track the proposals, including whether they were accepted or rejected, and show if there is a pattern to the type of VECPs submitted. The information is also used to determine what can be improved in design and construction processes to reduce these types of VECPs.

A VE study library[5], which is still in development and will be available to the public, will house all VE studies for reference on a KYTC Web site.

Third Party Reviews

Often, states find that they may need to hire consultants to do third-party reviews of design work. These reviews are done for specialty projects or when DOTs do not have sufficient expertise or staff to meet deadlines. Some states have moved to an even more aggressive use of third-party reviews to add an extra layer of QC.

Ohio

The scan team visited with the ODOT Bridge Design Division via Web conference to learn more about its extensive use of third-party reviewers. In the past, the Ohio Department of Highways had designed most of its bridges in house. Over time, ODOT started outsourcing more of the bridge design and just reviewed the plans. In 1985, a new bridge review program (often called the "fast track bridge program") was started and used until 1997. The program's goal was to improve bridge conditions statewide. This was done by designing new bridges to replace the existing short- to medium-span ones (primarily stream crossings). Using this program, ODOT replaced 350 bridges each

[5] The link to Kentucky's Value Engineering Study Library, will be available at this site: http://transportation.ky.gov/design/value/VALUE2010.htm

year, or around 4000 total bridges, on the general system.

ODOT decided to get help from the private sector with this task. An entire industry was created in Ohio to perform this work and included consultants, suppliers, and small-bridge contractors. Consultant support for this program included third-party reviewer consultant contracts, which were on a lump-sum-per-task basis. Third-party consultants participated in writing the scope of services, negotiating the design fee, reviewing the design plans, and grading the design consultant on how they performed.

Consultants were in essence an extension of the ODOT staff and consisted of three large consulting firms. These firms participated with the districts, since ODOT is a decentralized organization, in field reviews to write the scope of work, which was standardized. After a design consultant was selected, the design fees were submitted to the review consultants, who then negotiated the proposed fees. The ODOT Consultant Committee reviewed the fees and made the final determination. At first, many consultants resisted this arrangement, since the review firms had to negotiate with the design firms; however, relationships were eventually established.

There was no scope of service for the review consultant on what a review included. ODOT held regularly scheduled meetings with the review consultants. At the beginning of this process, ODOT's *Bridge Design Manual* had some deficiencies. Prior to this, ODOT had reviewed all the bridges so the manual did not identify all of the state preferences. ODOT updated the review process, consultants reviewed the plans and sent their comments to the design consultants and copied ODOT. Discussions between the review consultant and the design consultant happened frequently. If the firms came to an impasse, then ODOT would be consulted. Design consultants sealed the plans, but review consultants did not. All bridge plans were reviewed at three stages. After the final design documents were delivered, the design consultant was graded on his or her performance by the review consultant. Occasionally the design consultant, the review consultant, and ODOT met so that the review consultant could defend the grade.

Although the fast track bridge program ended more than a decade ago, ODOT continues to use third-party review. In the current program, ODOT generally no longer has the review consultant write the scope of services or negotiate design fees. ODOT does, however, use review consultants to review bridge plans. ODOT will generally have a bridge review consultant review the plans when ODOT staff is not available to do the review. Generally, the bridge review contracts are run out of central office and the assignments are made statewide. Occasionally for a big project, a district will put a bridge review consultant under contract. In the current program, contracts with bridge review consultants are typically on a cost-plus-fixed-fee basis with a not-to-exceed clause.

There are challenges to large-scale use of third-party reviewers. One is maintaining consistent review comments. To help with this, ODOT has invested in this process to

keep current practices in the *Bridge Design Manual* and develop more all-inclusive checklists.

Another challenge is the perception that the review consultant is trying to embarrass the design consultant. This issue has been addressed with meetings and with the understanding that minor issues like misspelled words and formatting issues should be grouped together in comments. This reduces both the number of comments and the perception of having many comments in a letter. In addition, the comments are first sent to the ODOT PM instead of directly to the design consultant. The PM then can question or remove any comment and then send comments on to the design consultant.

One other issue is the potential for the review consultant to have a conflict of interest. The review consultant cannot be on the design team or represent another agency with an interest in the project. This can be an issue with a large multi-office consultant. Proper preparation and documentation can solve these issues, and third-party review consultants can be a useful part of a DOT's quality process.

Plan Review and Signoffs

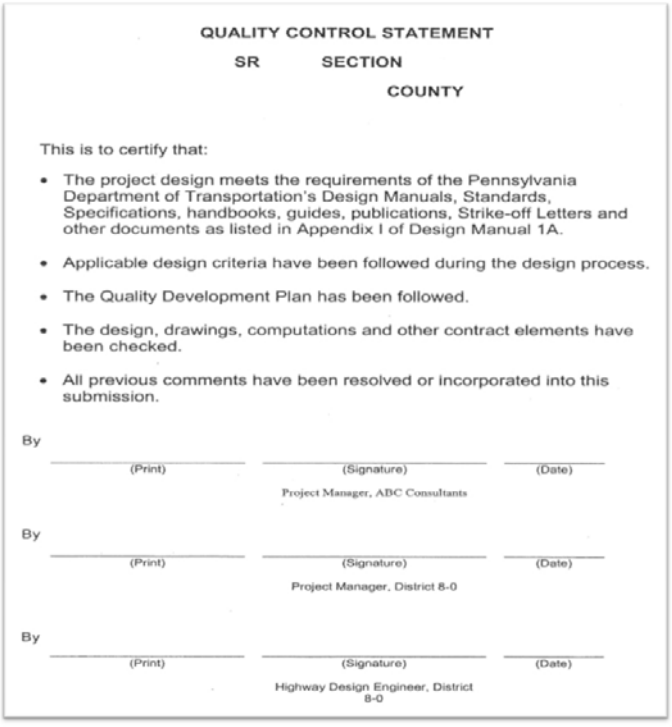
One other practice found in several successful states is the use of title blocks on plan sheets that clearly define the designer and the reviewers, as well as include signoffs for when reviews are completed. This is an easily implemented, simple task that ensures that designers and reviewers take responsibility for the quality of the plans. Plan signoffs or PE stampings are done at many different levels, including signoffs on the original design, for reviews, and even for design changes that are done in construction.

Pennsylvania

One example of consultant signoff can be seen in PennDOT's QC statement, which consultants must submit with each completed set of plans. This statement shows that each person who is ultimately responsible for the quality of the plans agrees that the plans are complete.

California

In California, Caltrans must independently check every highway structure. The Caltrans reviewer develops an independent set of design and analysis calculations as part of the design checker responsibility.



QUALITY CONTROL STATEMENT

SR SECTION

COUNTY

This is to certify that:

- The project design meets the requirements of the Pennsylvania Department of Transportation's Design Manuals, Standards, Specifications, handbooks, guides, publications, Strike-off Letters and other documents as listed in Appendix I of Design Manual 1A.
- Applicable design criteria have been followed during the design process.
- The Quality Development Plan has been followed.
- The design, drawings, computations and other contract elements have been checked.
- All previous comments have been resolved or incorporated into this submission.

By _____ (Print) _____ (Signature) _____ (Date)
Project Manager, ABC Consultants

By _____ (Print) _____ (Signature) _____ (Date)
Project Manager, District 8-0

By _____ (Print) _____ (Signature) _____ (Date)
Highway Design Engineer, District 8-0

Figure 3.3 *PennDOT QC statement*

Georgia

Another simple way to allow designers and reviewers to take ownership for the quality of the final plans is to use title blocks to clearly show the person responsible for each step on every plan sheet (see Figure 3.4). Georgia includes the initials of the designer and reviewer within the title blocks of its plans, as well as who is responsible for the final approval.

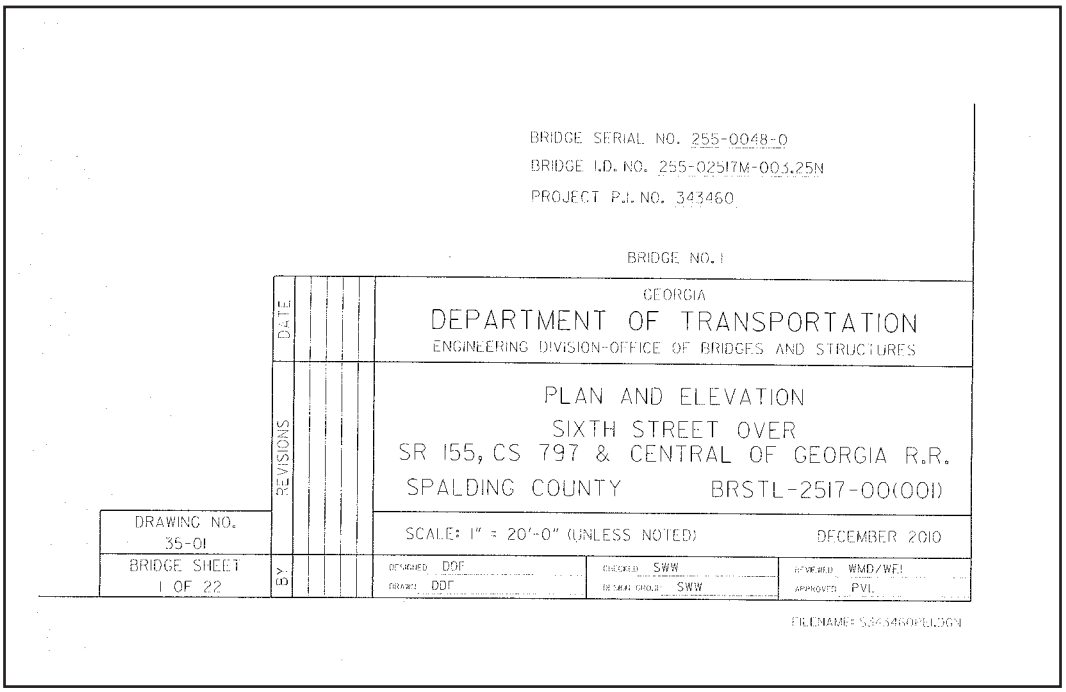


Figure 3.4 *Georgia plan title block*

During the review process, Georgia also requires a QA review stamp on each page of plans that are completed in-house (see Figure 3.5). This red stamp clearly shows the reviewers' signatures.

Figure 3.5 *Georgia in-house review stamp*

New York

In New York, designers must take full ownership of their work on plans by signing each sheet of the completed set. Every sheet that has any engineer-designed content on it must have a PE stamp on it. New York State education law requires that a note be placed on each plan sheet

stating that nothing on the sheet can be changed without review and re-stamping by a PE. This requirement promotes improved communication between design and construction staff and minimizes preferential changes during construction.

Single-Point Data Systems

The scan team found that many states are moving to single-point data systems where multiple users and disciplines can look at and analyze documents to determine problem areas and make improvements in processes. It seems that most states visited are using databases (e.g., Microsoft SharePoint[6] , ProjectWise[7], or other systems that were developed specifically for the state) that allow for document management and give the ability to analyze trends in design and construction processes. These data systems can be great contributors to the overall quality of projects.

Pennsylvania

Pennsylvania has a single-point data system called the Engineering Construction Management System. This system is a powerful tool that can be used from project advertising to consultant design to construction. Technical and price proposals are done through the system, along with all invoicing, construction advertising, and bidding processes. This system is accessible to all staff and is used across the board to track design submittals, review times, and environmental, bidding and construction processes. One important way that the Engineering Construction Management System is used in relation to quality is that it can easily track the amount of time PennDOT staff spent on plan review. This tracking was unique among the host sites, as many states did not have a good way to track this QC metric.

Kentucky

As has been already noted in this report, Kentucky sees the need to gather quality information into its innovative GIS database. KYTC uses Microsoft SharePoint and Microsoft InfoPath[8] forms to optimize the one-time data entry and utilization tools. It also uses a plan tracking submittal system, which ensures a quality bid package. This system provides a Web-based series of checklists for plan sheets and supplemental items, enabling users to track these items to ensure that they are included in the package, as well as to track the date of submittal, the contact person for the item, and even to record remarks for each item. Refer to Appendix E for an example of the plan submittal checklist.

---

[6] SharePoint is a registered trademark of Microsoft Corp., http://sharepoint.microsoft.com/en-us/Pages/default.aspx

[7] ProjectWise is a registered trademark of Bentley Systems Inc., http://www.bentley.com/en-US/Products/projectwise+project+team+collaboration/

[8] InfoPath is a registered trademark of Microsoft Corp., http://office.microsoft.com/en-us/infopath/

Checklists, Manuals, and Standards

Documentation of quality processes and procedures and use of checklists are common practices among the states the team visited. Several drivers contributing to the need to provide documentation of quality processes were mentioned:

- **Higher percentage of designs done by consultant**
  To maintain consistency, quality processes need to be documented and easily referenced by consultants.
- **High rates of retirement and staff turnover**
  Processes need to be well documented to counter the loss of institutional knowledge when long-tenured staff retires and when newer staff quickly rises to management positions.
- **Decentralized organizations**
  More guidance is needed when designs are completed in regional or district offices instead of in a central location to keep processes standardized and communication channels open.
- **Use of specialty contracting such as design-build**
  More attention is given to QC/QA processes when design-build agreements are used, and this often leads states to look into similar quality processes for traditional design-bid-build projects

All state DOTs use checklists, process manuals, and standard details and drawings, not just successful states. However, successful states use these tools for communication, training, and regular re-evaluation of the processes. Some states have instituted separate divisions or bureaus specifically for QA. These divisions provide centralized points of contact on quality and provide a group of experienced individuals that can maintain and re-evaluate quality processes that are documented within manuals. This section describes examples of these practices.

Documentation

When talking about documentation, the important thing to note is that more is not always better (i.e., the amount of checklists, manuals, and processes does not necessarily correlate with the level of quality). That being said, it is often true, as Caltrans believes, that "success is being organized," and documentation provides a level of organization and consistency in design that is important to quality efforts.

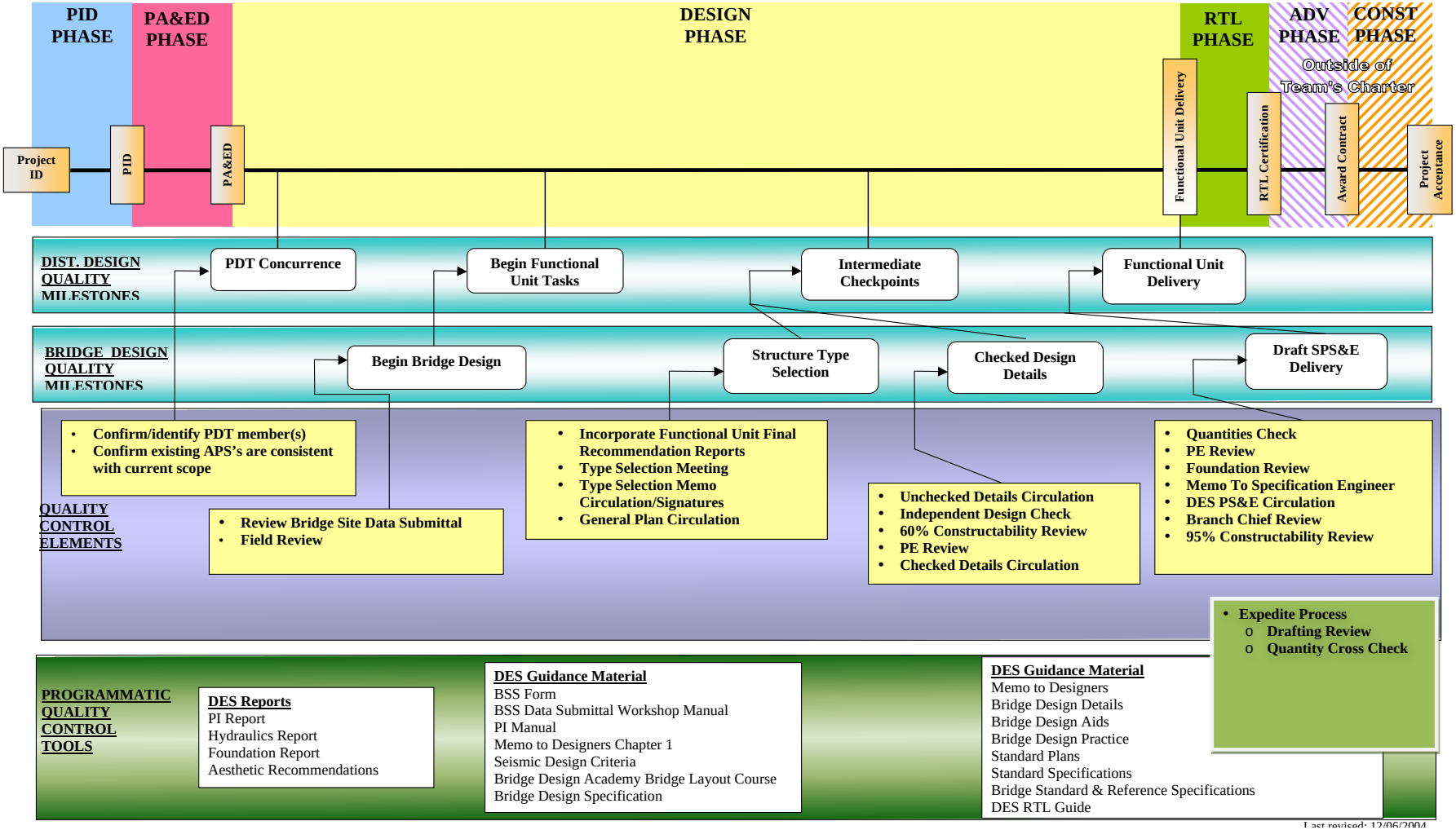
The states visited during the scan presented some examples of innovative or successful documentation and its uses. Pennsylvania has several well-established quality and design

[9] Pennsylvania Department of Transportation Bureau of Design *Design Manual*, Part 1X, ftp://ftp.dot.state.pa.us/public/bureaus/design/PUB10X/Pub10X_Cover.pdf

NORTH REGION QUALITY MANAGEMENT PLAN

DES Bridge Design North Project Specific Quality Control Plan

-DESIGN PHASE-



RTL = Ready to List (for advertising) PDT = Project Development Team DES = Division of Engineering Services BSS = Bridge Site Submittal

Figure 3.6 ***Quality flowchart for design phase***

manuals and checklists for its bridge design program. One standout document from PennDOT is Appendix D of the *Quality Management Manual for Project Development* (see Appendix E), which is part of PennDOT's *Design Manual*[9]. The manual's project development checklist is also provided in Appendix E.

WSDOT has been identified as having a very good, concise QC/QA document for its bridge design division (see Appendix E). The FHWA has identified this document as a good typical QC/QA program document and included it in a recently released guidance memo on QC/QA in bridge design.

The scan team believes that the quality manual flowcharts Caltrans presented during the team's visit are examples of innovative quality methods. These flowcharts outline QC/QA steps for the project initiation document and project approval/environmental and design phases. Figure 3.6 is the flowchart for the design phase. Flowcharts for all three phases are provided in Appendix E.

Separate Divisions for QA

Many of the states the scan team visited have instituted separate divisions or bureaus specifically for QA. These divisions provide centralized points of contact on quality and provide a group of experienced individuals that can maintain and re-evaluate the quality processes that are documented within manuals, specifications, and checklists.

Kentucky

Kentucky's QA Branch is located with the Division of Highway Design. As has been previously mentioned, this branch is responsible for VE processes and post-construction and constructability reviews. KYTC maintains all reviews within a GIS formatted database for easy analysis and feedback to improve future processes. Currently, the QA branch meets separately with each division to provide information from the post-construction reviews. These reviews show the areas where

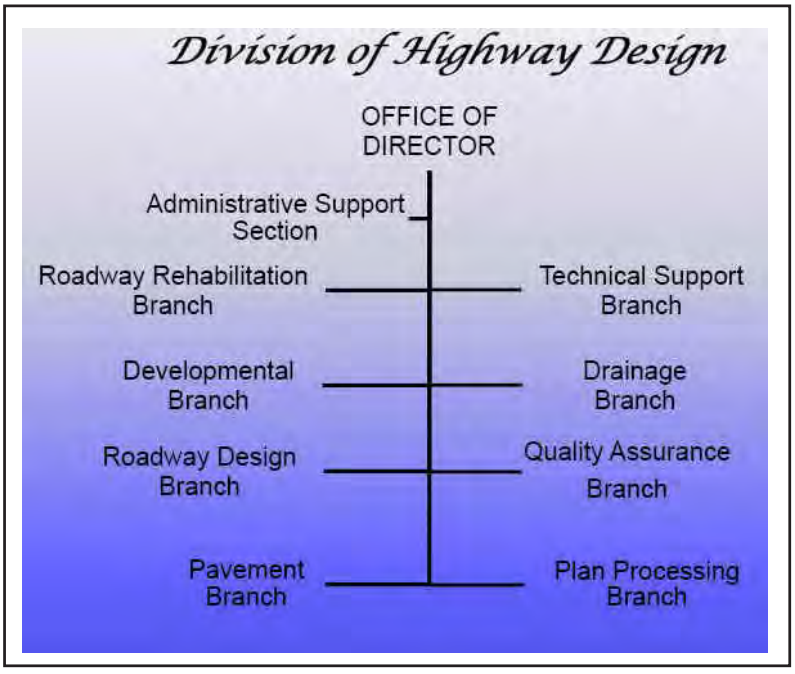


Figure 3.7 ***KYTC highway design organizational chart***

change orders in construction have been significant. For instance, structures change orders are presented to the Division of Bridge Design and range from alignment issues to guardrail quantity mistakes to omissions, among others. The QA Branch presents these types of change order issues to the Division of Bridge Design, along with possible solutions.

Pennsylvania

In Pennsylvania, QA is a centralized office within the Bureau of Design. The Bureau has a Highway QA Division, a Bridge QA Division, and an Environmental QA Division (see Figure 3.8 for the PennDOT design organizational chart). These offices within the central office set policies and standards; conduct special studies and investigations; oversee QA procedures; develop tools for district use; and participate on AASHTO, Transportation

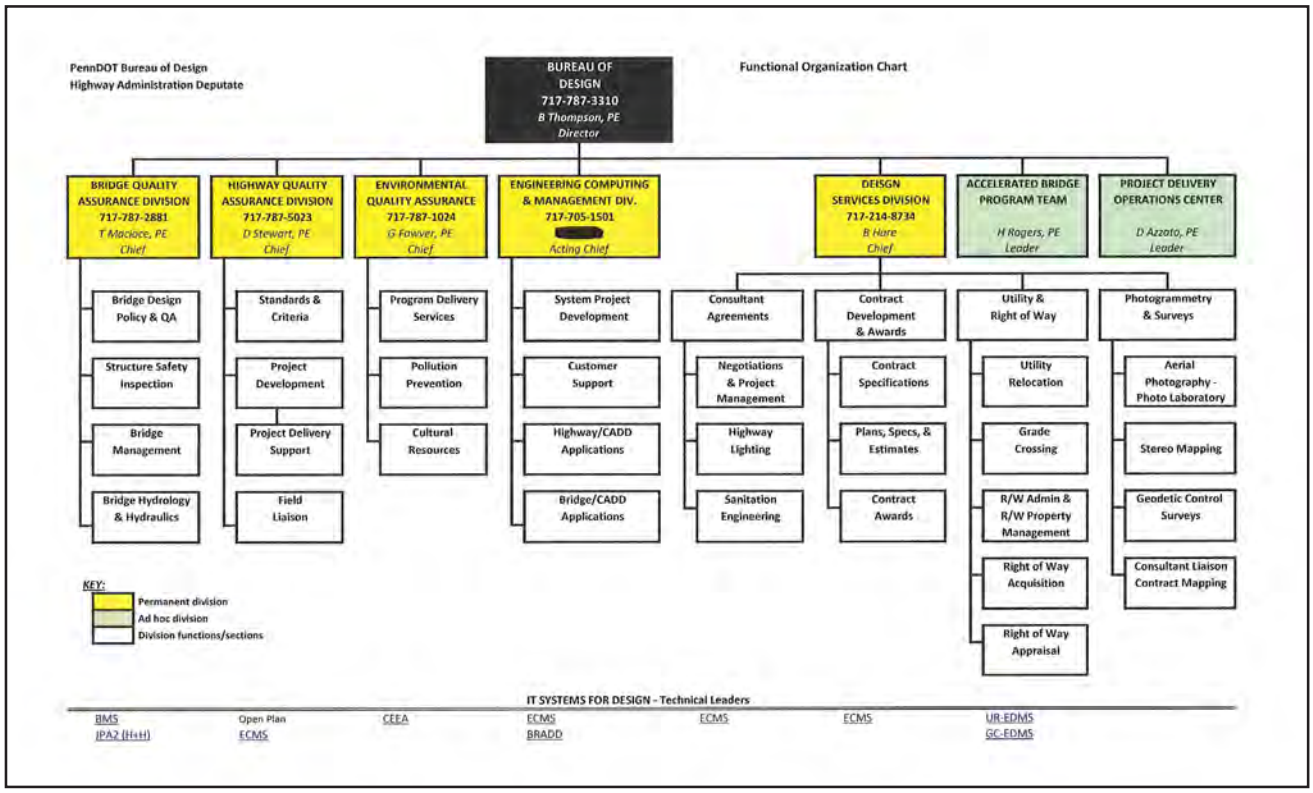


Figure 3.8 ***PennDOT design organizational chart***

Research Board (TRB), and National Cooperative Highway Research Program (NCHRP) committees. PennDOT is currently reorganizing its processes and merging all design and construction activities into a Project Delivery Bureau and all maintenance, safety, and traffic activities into an Operations Bureau.

New York

New York is another state that has centralized QA offices. The Design QA Bureau and the Structure QA Bureau are both located within NYSDOT's central office and are

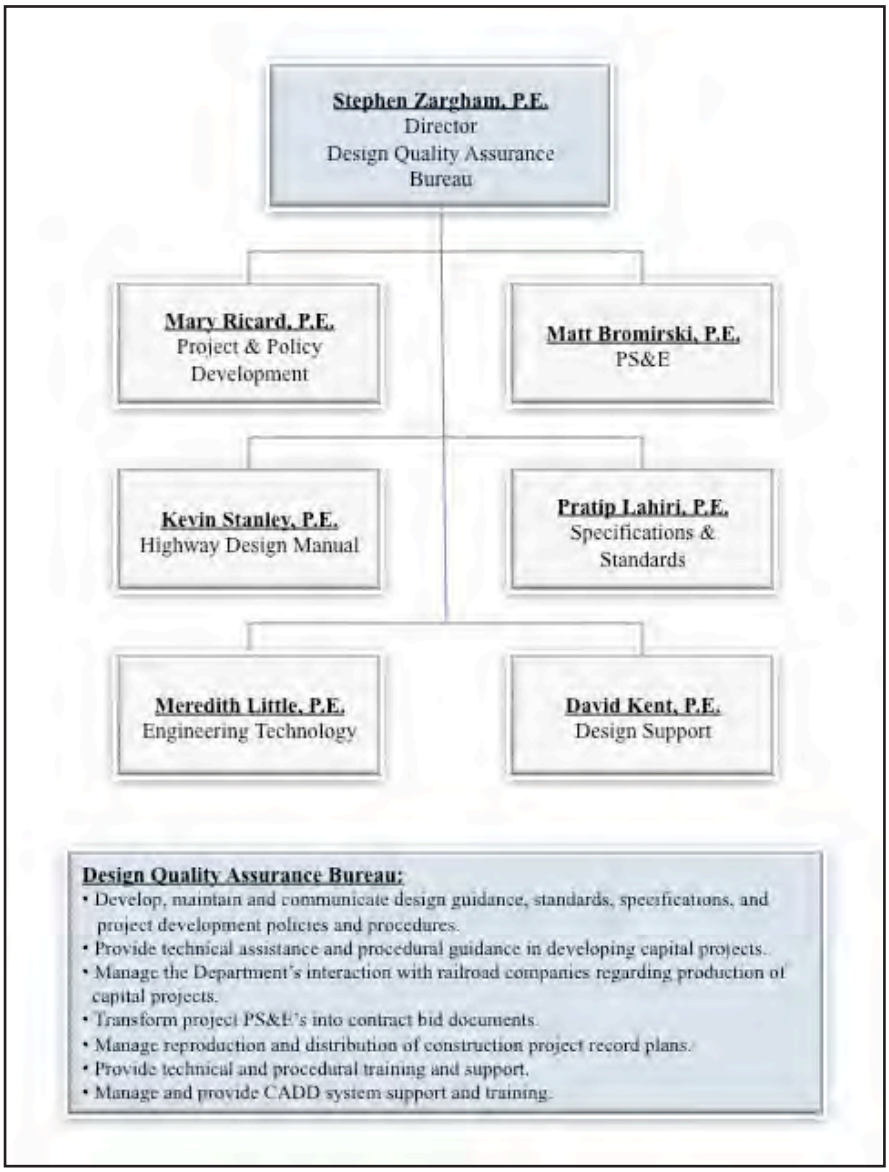


Figure 3.9 ***NYSDOT Design QA Bureau organizational chart***

Special Contracting

Use of specialty contracting such as design-build often leads to a heightened need to document QC/QA processes. This often leads states to look into similar quality processes for traditional design-bid-build projects. The following sections outline what a few states have done with their design-build and unique delivery quality processes and how these processes carried over into all types of projects, including traditional ones.

Design-Build: Minnesota

Minnesota is an example of a state that has a successful design-build quality process and has adapted that process to its design-bid-build projects. Minnesota has developed a design-bid-build quality template to help rate consultants' quality plans within their proposals (see Appendix E). This template was first established during Mn/DOT's ROC

52 design-build project. This project included a "lessons learned in the design phase" document that was posted on the agency's design-build Web site and sent out to the districts (see Appendix E). Mn/DOT then took these templates and determined how to translate them to design bid-build projects.

Mn/DOT hired consultants to help write the DOT's design-bid-build manual. PMs within the DOT were surveyed and, out of 18 PMs who responded, only six used checklists and none used QA/QC signoff forms. Concerns and issues were gathered from PMs during this survey, and a workshop was held to discuss these issues. A quality management plan was then drafted and a second workshop held. The main take-away from this workshop was that the QC/QA process needs to be flexible, it needs support from senior management, and development needs to be an ongoing process so that the document can be modified as necessary. A third workshop was held to develop useful templates, checklists, and forms. The final report includes a PM checklist, a form to document major design decisions, requirements for 30-60-90% complete reviews, and corresponding checklists for each phase check that requires reviewers' signatures.

Major elements of the quality management plan include:

- Functional group reviews
- Independent technical reviews
- Constructability reviews
- A review form for comments and responses
- Documented checking procedures
- A form for QC signoffs
- QA verification by the central office

The draft version of the Design-Bid-Build Quality Management Plan is provided in Appendix E.

Unique Delivery Methods: Oregon

Oregon is another state that has used unique delivery methods to build bridges and then used lessons learned in that process to develop quality processes for more traditional design. Its program, the Oregon Transportation Investment Act (OTIA) III State Bridge Delivery Program, is a 10-year program intending to repair and replace 365 bridges statewide. The Oregon legislature created a funding program of $1.3 billion over 10 years for this program. The OTIA III Program was built on the concept that a separate delivery mechanism from the rest of the ODOT work would be utilized; the Oregon Bridge Delivery Partners (OBDP) is a group of consultants that has provided this separate delivery. Only 25 members of ODOT agency staff from the Major Projects Branch are involved; however, there is a large consultant staff.

A quality plan for this project was needed to ensure consistency from all consultants involved. When the Major Projects Branch and OBDP looked at the available agency guidance, most of it had an in-house design focus, so new documents were needed. A new plan was developed that included a program execution plan, a project management plan, and a program procedures manual that included quality plan requirements for all consultants and checklists to ensure that these plans were being followed.

Two innovative quality processes introduced in Oregon through the OTIA III Program are quality audits and risk-based technical review processes. Design audits are held twice a year and include an administrative audit and a QC audit.

The OBDP technical review process is risk based. Checklists show each item as a high, medium, or low risk, and checklists are created for quality processes within each discipline. This process is structured to focus engineers' efforts on reviewing items that really matter, instead of concentrating on line weights and spelling, for example, and results in time savings overall.

Risk is defined as a risk to the agency through greater spending or time delays; however, it is not defined as a risk to the contractor or the prime consultant. The risk-based technical review approach does not eliminate errors or omissions; instead, it focuses the agency's time on those items that are the greatest potential risk for the agency. An example risk-based checklist for bridge repair plan review is included in Appendix E.

Design audits are also done in the OBDP processes. A quality management team within OBDP does these audits biannually for all consultants designing bridges in the program. The first audit is administrative based and looks at organizational and communication processes, reference documents, permitting processes, context-sensitive design, sustainability issues, right-of-way issues, and records control. The second audit covers QC issues and looks at engineering QC review procedures, the quality of final deliverables, designer certifications, and numbers of change orders in the construction processes. Quality alert reports with findings are issued for each audit.

Many lessons have been learned through the OTIA III Program, and the quality plans that were developed for this program are now being incorporated into overall ODOT quality programs.

Scoping and Environmental Quality

Successful states include all parties involved in design and construction early on in the process. Several states visited include environmental, right-of-way, utilities, designers, any other relevant agencies, and even construction, in the scoping process. Continued involvement throughout the full design phase from all players is important, and should include scheduled meetings at key points in the design, during construction, and for post-construction feedback.

Successful states found that it was helpful to have state-funded positions located at regulatory agencies to help expedite scheduling and reduce external agency bottlenecks in the design process. Still other states found that documentation of environmental commitments right within the design plans helps to ensure a better quality product. This section will describe some of these practices in more detail

Early Involvement of All Players

As mentioned before in this report, one of the most important parts of a successful quality program is the involvement of all parties involved in a project early in the process. Several of the states the scan team visited involved all parties early on in projects and kept communication lines open throughout project development.

NYSDOT's Region 1 presented the successful solution of involving construction as part of each project's scoping team and holding meetings with the entire project team from "cradle to grave." The region office first appoints an experienced construction supervisor to become liaison to the design team during the scoping phase of each project. The construction supervisor participates in the inter-disciplinary scoping meeting, during which the following topics are discussed:

- Computer-aided drafting and design expectations, the type of digital model, and survey limits
- Access to the construction site, easements, and right-of-way needs
- Construction staging areas
- Need for night work or an off-site detour
- Construction equipment impact on adjacent utilities
- Construction sequencing
- Lead times for ordering materials (e.g., steel)
- Project waste and disposal
- Environmental requirements
- Public Involvement Plan
- Setting early expectations about construction duration
- Scheduling of letting for the most efficient construction

The Region 1 office also began holding internal constructability reviews in the mid-1990s, which eventually evolved into what is now called a mid-design review meeting. Typically, these reviews are done anywhere from four to eight months before the PS&E and are done on every job, even for small operational jobs like guardrail replacement. These meetings include collaboration with design, construction, and traffic and discuss issues such as:

- Constructability reviews
- Work zone traffic control plan
- Staging construction
- Difficult construction techniques
- Unusual project features
- Unique special specifications
- Construction schedule
- Incentives/disincentives
- Time-related provisions

This office also holds design/utilities/construction meetings in the office, in the field, or sometimes in both locations. Design plans are shared among the three groups electronically. These meetings help to avoid lengthy relocation conflicts during the utilities phase.

NYSDOT occasionally holds contractor constructability reviews. These reviews may be advertised and open to any interested contractor (with all participants retaining their eligibility to bid the project) or limited to one or more solicited contractors who agree in writing not to bid the project. In either case, staff clearly communicates the intent and expected outcome of the review to all participants, and documents the process. During these meetings, the designer presents any major challenges on the project, and contractors provide input and solutions. Material suppliers often participate in these reviews.

Overall, these practices illustrate how NYSDOT has instituted successful processes by having early and continued involvement by all parties involved in a project through meetings and communications. These activities lead to project buy-in by all people involved, well-thought-out work-zone management plans, constructible projects, and avoidance of construction delays and claims.

Funded Positions at Regulatory Agencies

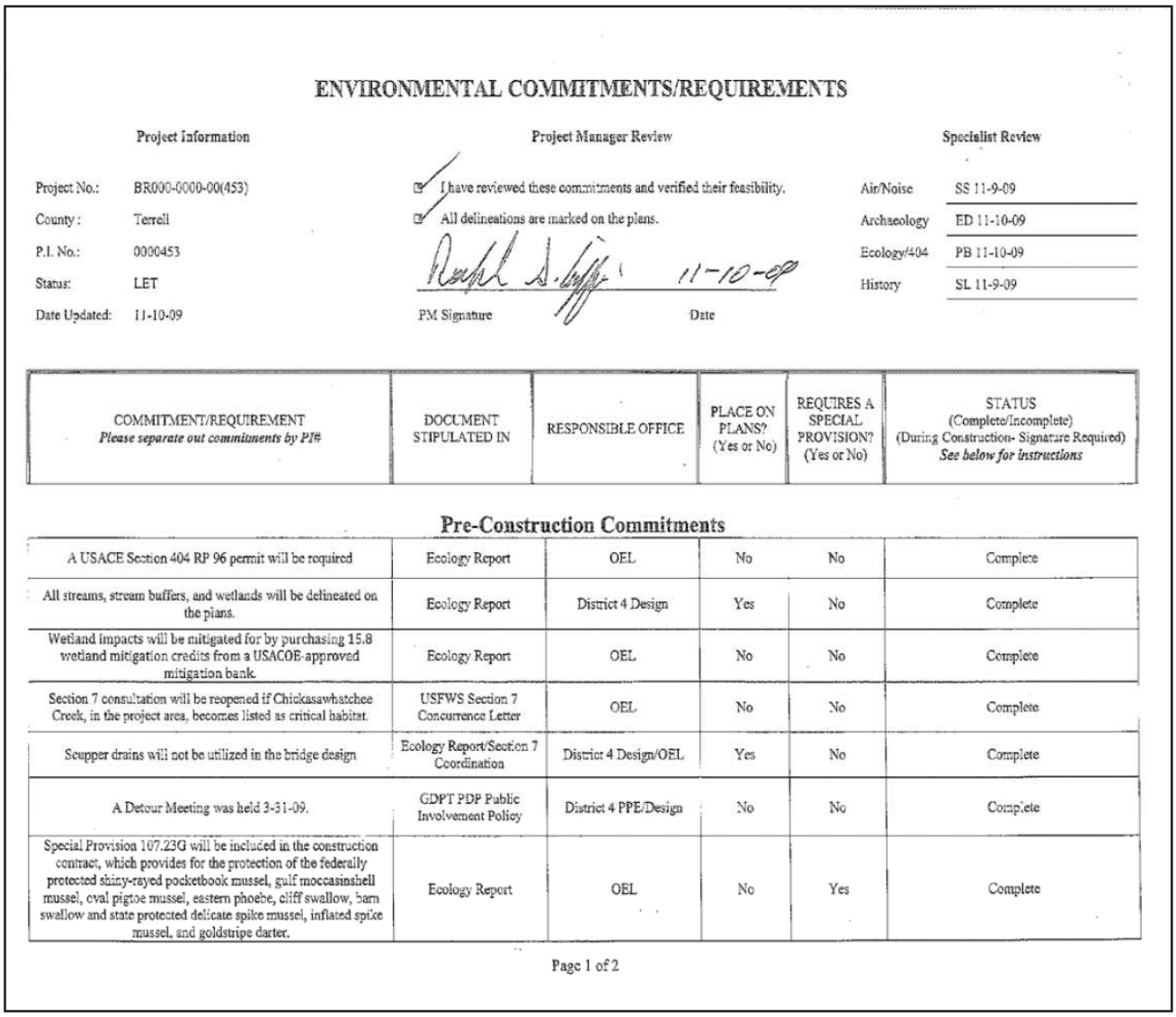
Some successful states also found that it was helpful to have state-funded positions located at regulatory agencies to help expedite scheduling and reduce external agency bottlenecks in the design process. PennDOT has funded 24 positions within regulatory agencies, including museum commissions, fish and boat commissions, game agencies, and the Army Corps of Engineers to help streamline the environmental processes and make sure that DOT projects get the needed attention within a timely manner.

Based on its experience with funding positions in other agencies, NYSDOT found that developing skills and interagency relationships at the staff level first, along with implementing streamlining efforts, were more effective than funding positions at other agencies. Similarly, NYSDOT has entered into an agreement with the New York State

Museum to provide cultural resource services to meet NYSDOT's obligations under the state and federal historic preservation acts.

Environmental Commitment Assurance

Another successful strategy found during the scan was the practice of including "green sheets" or environmental tables within actual plan sets. These sheets (which GDOT actually prints on green paper; see Figure 3.10) and tables act as checklists of sorts to ensure that all environmental commitments are met on each project.



ENVIRONMENTAL COMMITMENTS/REQUIREMENTS

Project Information		Project Manager Review		Specialist Review	
Project No.:	BR000-0000-00(453)	☑ I have reviewed these commitments and verified their feasibility.		Air/Noise	SS 11-9-09
County:	Terrell	☑ All delineations are marked on the plans.		Archaeology	ED 11-10-09
P.I. No.:	0000453	Rachel S. Cuff 11-10-09		Ecology/404	PB 11-10-09
Status:	LET			History	SL 11-9-09
Date Updated:	11-10-09	PM Signature	Date		

COMMITMENT/REQUIREMENT *Please separate out commitments by PI#*	DOCUMENT STIPULATED IN	RESPONSIBLE OFFICE	PLACE ON PLANS? (Yes or No)	REQUIRES A SPECIAL PROVISION? (Yes or No)	STATUS (Complete/Incomplete) (During Construction- Signature Required) *See below for instructions*
Pre-Construction Commitments					
A USACE Section 404 RP 96 permit will be required	Ecology Report	OEL	No	No	Complete
All streams, stream buffers, and wetlands will be delineated on the plans.	Ecology Report	District 4 Design	Yes	No	Complete
Wetland impacts will be mitigated for by purchasing 15.8 wetland mitigation credits from a USACOE-approved mitigation bank.	Ecology Report	OEL	No	No	Complete
Section 7 consultation will be reopened if Chickasawhatchee Creek, in the project area, becomes listed as critical habitat.	USFWS Section 7 Concurrence Letter	OEL	No	No	Complete
Scupper drains will not be utilized in the bridge design	Ecology Report/Section 7 Coordination	District 4 Design/OEL	Yes	No	Complete
A Detour Meeting was held 3-31-09.	GDPT PDP Public Involvement Policy	District 4 PPE/Design	No	No	Complete
Special Provision 107.23G will be included in the construction contract, which provides for the protection of the federally protected shiny-rayed pocketbook mussel, gulf moccasinshell mussel, oval pigtoe mussel, eastern phoebe, cliff swallow, barn swallow and state protected delicate spike mussel, inflated spike mussel, and goldstripe darter.	Ecology Report	OEL	No	Yes	Complete

Page 1 of 2

Figure 3.10 ***GDOT green sheet (actually printed on green paper) example***

As has been previously mentioned, Georgia's green sheets are a summary of all environmental project commitments and are required in all National Environmental Policy Act documents. The Environmental Resources Impact Table (see Figure 3.10 for an example) is used to communicate commitments in the construction plans; previously, commitments were standalone environmental documents in addition to the plans. Signatures are required on green sheets of parties responsible for carrying out the commitments. These commitments are also shown on the relevant plan sheet. The impact table is required on all level of environmental projects. Consultants are also required to submit green sheets.

Resource Name/Type	Location		Side	Construction Activity	Permitted Activity	Controlling Criteria	Special Provision?	Comments including any permit expiration dates
	Beginning STA	Ending STA						
Stream 1 buffer	114+00	115+00	Both	Culvert construction	Activities within 50 ft of culvert do not require variance from EPD	EPD memo dated 6/8/06		Roadway drainage exemption – activities beyond 50 ft will require variance
Wetland 2	119+15	121+26	Rt	Rip rap placement	0.5 ac permanent impact & 0.5 ac temporary impact	Section 404 of the CWA – NW14		Impacts permitted to ROW; permit expires June 30, 2011
Protected species	212+90	213+55	Both	Demolition of old bridge & construction of new bridge	Refer to Special Provision 107.23g	Endangered Species Act	107.23g	Contractor to direct questions to Engineer

Figure 3.11 ***GDOT environmental impact table example***

Consultant Selection and Communication

Successful states help ensure that they will get quality work from their consultants by using thorough selection processes and having good communication channels. Successful states often require consultants to submit quality plans before they can be prequalified to perform work for the states, and many require that project-specific quality plans be submitted with proposals.

Consultant QC/QA Plans

The scan team's preliminary research (i.e., survey results) showed that 41% of the 35 responding states require consultants to have QA/QC programs in place to prequalify to perform bridge design work but do not require the consultants to submit their plans. Thirty percent of responding states require consultants to have QA/QC plans in place to prequalify and require the consultants to submit their QA/QC plans. Twenty-three percent of responding states do not require consultants to have QA/QC plans to prequalify

for state bridge work; however, they do require presentation of QA/QC processes in the selection process. Only 2% of responding states neither prequalify consultants nor require information on QA/QC processes.

Although this information applies only to bridge design, it is easy to see that most states require their consultants to have some sort of QC/QA plans in place, and some even require that their consultants present project-specific QC/QA plans. This is important, since it was also reported that most states perform reviews rather than checks or give general acceptance rather than approval of consultant plans. This means that consultant plans are given broad reviews and, most often, calculations are not checked unless there are obvious warning signs or red flags. Most states believe that consultants assume full responsibility for the accuracy of their designs.

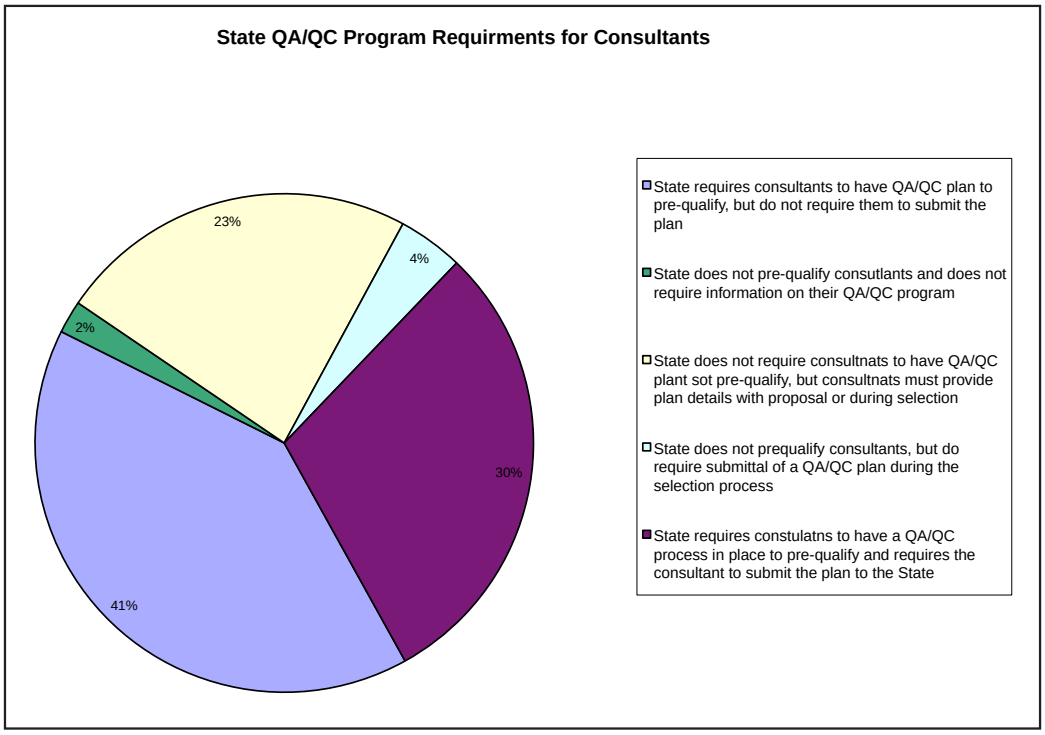


Figure 3.12 *QC/QA requirements of consultants doing bridge design*

PennDOT is one of the states the scan team visited that requires consultants that are prequalified to do DOT design work to have a QC/QA plan in place. For a consultant to do business with the DOT, it has to be registered as a business partner. To be a registered business partner with the DOT, consultants must submit an annual qualification package that includes a quality plan. PennDOT also requires that contractors submit a project-specific QA/QC plan procedure during technical proposal phase selection. Ten to 20% of the consultant selection evaluation will depend on the QC/QA plan.

In Minnesota, selection of design-build teams is heavily weighted on the team's QC/QA plan for a specific project. Mn/DOT has developed a consultant quality plan evaluation system (see Figure 3.13 for the criteria).

Evaluation Criteria	Qualitative Assessment Ratings				
	Excellent	Very Good	Good	Fair	Poor
PROJECT MANAGEMENT CATEGORY					
Quality Procedures					
Understanding the Department's role in the design quality process.	Very Good rating plus – Proposer has reflected a process to incorporate a web-based data system to link the Department into the design QC/QA process.	Good rating plus – Proposer has described a process to reflect how input from the Department's oversight will be incorporated into the final design.	Fair rating plus – Proposer clearly demonstrates a QC/QA plan that includes reporting of testing, reports, and audit procedures.	Poor rating plus – Proposer is committed to Department oversight role during design and has indicated review periods in the project schedule.	Proposer has described the Department role of oversight and understands the need for oversight during the design process.
Effectiveness of the design quality process, its organizational structure, and interrelationships with the Department.	Very Good rating plus – The Proposer has a process in-place to ensure that Department comments will be acted upon.	Good rating plus – The Proposer clearly demonstrates, within its design quality process, the Departments role.	Fair rating plus – The Proposer's organization has identified Key Personnel associated with Quality elements.	Poor rating plus – The Proposer's organization has identified the relationship between design and quality review staff.	Proposer has identified a design quality process for the Project.
Approach to internal resolution of design and construction disputes.	Very Good rating plus – Proposer had indicated the Department's role within its internal process.	Good rating plus – Proposer has identified an appeals process within its internal process to help resolve disputes.	Fair rating plus – Proposer's internal process has identified Key Personnel responsible for resolution disputes.	Poor rating plus – Proposer has described an internal process to resolve design and construction disputes.	Proposer acknowledges that design and construction disputes will be resolved.
Compliance with the Department's design standards.	Very Good rating plus – Proposer clearly states any differences in design standards that are anticipated on the Project.	Good rating plus – Proposer has described a process to secure design exceptions when needed.	Fair rating plus – Proposer has described which design standards will be used during its design.	Poor rating plus – Proposer has identified the existence of Department design standards.	Proposer acknowledges that design standards will be followed.
Process for independent design reviews before submittal to the Department.	Very Good rating plus – Proposer describes a process that reflects an independent review team that will be responsible for the detailed review of the Project.	Good rating plus – Proposer describes a process that reflects how Department comments will be incorporated into the final design prior to final construction.	Fair rating plus – Proposer's Project Schedule provides sufficient time to the Department to perform reviews.	Poor rating plus – Proposer's Project Schedule indicates an internal review process prior to plan submittal to the Department.	Proposer identifies plan submittal dates to the Department within the Project Schedule.
Approach to quality control (QC) reports and how they will be used to manage the Project.	Very Good rating plus – Proposer clearly identifies how the QC reports will be utilized during construction.	Good rating plus – The Proposer's QC database will be web based on the Project.	Fair rating plus – Proposer clearly identifies a QC database on the Project.	Poor rating plus – Proposer has a plan in place to maintain a log of all QC reports on the Project.	Proposer acknowledges that QC reports will be required on the Project.
Description of inspection, testing, and corrective action procedures and documentation.	Very Good rating plus – Proposer clearly shows the use of a web-based system to exchange documentation with the Department.	Good rating plus – Proposer clearly identified a system of checks and balances that will be utilized along with positions of responsibilities.	Fair rating plus – Proposer has identified a detailed computer based tracking program to be used on the Project.	Poor rating plus – Proposer has identified that inspection and testing during construction will be documented.	Proposer acknowledges that inspection and testing will be performed on the Project.
Proposed inspection program and training program to implement a continuous quality improvement program.	Very Good rating plus – The Proposer clearly identified the relationship between inspectors and project quality.	Good rating plus – The Proposer has identified Key Personnel of the Project team that will be responsible for training.	Fair rating plus – Proposer's training program is continuous and the program plan is indicated on the Project Schedule.	Poor rating plus – Proposer has identified a training program to update inspectors on the Project.	Proposer has identified a dedicated inspection program and inspectors on the Project.
The method of conformance with any applicable Federal oversight requirements.	Very Good rating plus – Proposer has researched and provided a matrix of requirements and procedures for providing reports that meet Federal requirements.	Good rating plus – Proposer has identified how Federal oversight requirements will interact with Department oversight.	Fair rating plus – Proposer indicates that results will be dual reported with the Department and Proposer both receiving real-time reports.	Poor rating plus – Proposer has clearly demonstrated any interaction between the Project team and Federal oversight.	Proposer has identified how conformance with Federal oversight requirements will be handled.
Plans for mobilizing the construction quality organization to be responsive to the planned Schedule.	Very Good rating plus – The Proposer demonstrates in detail the methodology to be used to involve construction personnel in the detailed design by performing constructionability reviews.	Good rating plus – The Proposer clearly demonstrates the interaction between design and construction personnel for the duration of the Project.	Fair rating plus – The Proposer's Project Schedule indicates construction personnel will be involved at the start of the Project.	Poor rating plus – Proposer's Project Schedule allocated construction personnel to be available during the design phases of the Project.	Proposer has identified construction periods within the Project Schedule.
Identification of personnel certified and qualified to perform inspection, testing, and training.	Very Good rating plus – Proposer has identified a plan to certify new inspectors to meet changing conditions or Project Schedule.	Good rating plus – Proposer has a plan in place to maintain certifications for all inspectors on the Project.	Fair rating plus – Proposer has identified the testing certifications that will be required on the Project.	Poor rating plus – Proposer has identified the certifications that each inspector currently holds.	Proposer states that inspectors will be certified.

Page 25

Figure 3.13 ***Mn/DOT consultant quality plan evaluation criteria***

Construction Reviews and Feedback

Involving key players from construction early on in the design process is a successful strategy in many states. Early involvement is very important to avoid comments on constructability at the end of product production when it is not practical to make changes. It is also very important to look at feedback during the construction process and information provided during post-construction reviews. This information can show trends, such as the causes of most change orders, and outline needed changes to standard drawings and manuals.

Construction Feedback and Post-Construction Reviews

Many states that have successful quality programs have realized the need to involve construction staff early on in each project to ensure that projects are "bid-able" and "buildable." Another very important contribution of construction staff is feedback on the bid-ability and construction phase processes.

New York

Two successful solutions providing bid-ability and build-ability feedback can be found in New York's bid-ability survey and its PQAR process. The survey (see Figure 3.14 for example responses) gives designers contractor feedback on their design and helps them answer the questions, "Can you bid it rationally?" and "Can you build it without significant contract changes?" for future lettings. The PQAR provides designers with feedback from construction administration staff about the build-ability of the contract documents and identifies both successful practices and those with room for improvement.

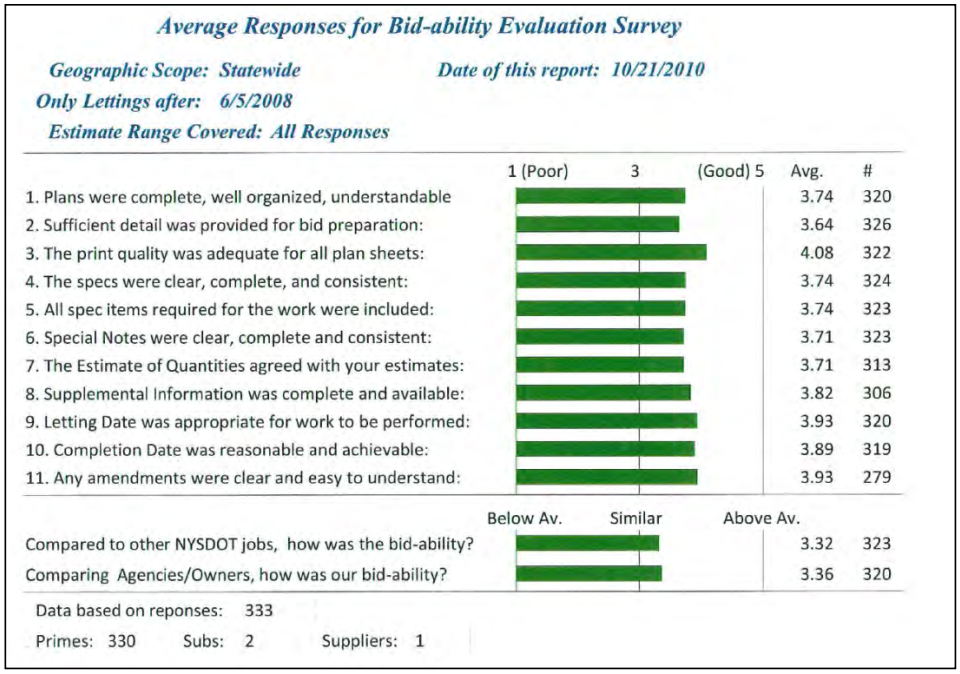


Figure 3.14 ***Average recent responses to NYSDOT's bid-ability evaluation surveys***

Kentucky

Kentucky is another state with an effective post-construction feedback system. The QA Branch performs post-construction reviews and then provides feedback to each division on where issues are and suggestions on how to address those issues. KYTC also issues a newsletter to Cabinet employees, outlining quality lessons learned (see Appendix E for an example of the newsletter).

Post-construction reviews started about 15 years ago, but were more "inquiries" for projects with high numbers of change orders. The reviews resulted in long reports that did not provide much useful information. Now, KYTC is performing post-construction reviews on projects with costs greater than $1 million. These projects are open to the public for a year, allowing time for assessment of the facility's quality and for the parties involved in the project to carefully review it. The QA Branch's goal is to review four projects from each district per fiscal year and to have more projects included that are below the $1 million dollar funding point.

The post-construction cycle for a fiscal year begins by soliciting district branch managers in July and August for their suggestions of projects to review. Meetings are scheduled from August until April in the districts, with attendees including district managers, consultants, contractors, and federal highway representatives. In preparation for the review meeting, all change orders are reviewed and discussed and solutions are suggested as to how the particular types of issues can be prevented in the future. Fact sheets are then created from this information. In the previous 15 years of post-construction reviews, reports were a different format and longer. The new fact sheets are only two to three pages long and are quick to read (see Figure 3.15).

The meetings are held in the district offices and contractors and consultants are invited to meet at the same time. Consultants often have not seen a project's change orders before this meeting. They appreciate receiving this

General Information

Project County:	**Pike**	Project Designer:	**Palmer Engineering**
Item Number:	**12-308.40**	Project Contractor's Name:	**Bizzack Construction, LLC**
PCN:	**030749**	Resident Engineer's Name:	**Paxton Weddington**
Route:	**US 119 - Pikeville-South Williamson Road**		
Project Type and Length:	**Lighting, Grade, Drain & Asphalt Surface, 2.994 miles**		
Project Description:	Bridge Replacement		
File Name:	P_12-308-40_Pike_3-10.pdf		

Change Order Total:	12
Original Project Cost:	$ 33,340,101.96
Change Order Total:	$ 4,898,680.18
Total Amount	$ 38,238,782.14
CO % Increase:	14.69%

Attendees:

Joe Tackett, KYTC D12	Kevin Damron, KYTC D12
Samuel Hale, KYTC D12	George Collins, KYTC D12
Paxton Weddington, KYTC D12	Shawn Ray, KYTC D12
Mary Westfall-Holbrook, KYTC D12	Ronald Slone, KYTC D12
John Michael Johnson, KYTC D12	
David Lindmeman, Palmer Engr.	
Brad Robson, Palmer Engr.	
Charles Allen, KYTC CO Design	
Boday Borres, KYTC CO Design	
Wheeler Nevels, KYTC CO Maintenance	
Vibert Forsythe, KYTC CO Construction	

Categories

Structures	Right-of-Way
Geotechnical	Utilities
Drainage	Pavement
Environmental	Operations
Erosion Control Plan (ECP)	Design
Traffic	Construction
Maintenance of Traffic (MOT)	Materials

Notes:

Category: Design **Sub-Topic:** Omission

Settlement platforms were needed on the project and was written in the geotechnical report but not in the Plans.

Solution:

Review plans for constructability.

Category: Geotechnical **Sub-Topic:** Top of Rock

Structure at Pier 1 (SB) had loose rock when excavated to the suggested elevation. Had to use mass concrete to remedy the situation.

Solution:

A thorough investigation for geotechinical data for areas where structures are involved. More borings are suggested possibly when substructure is designed and footer dimensions are known.

Figure 3.15 ***Example KYTC post-construction review fact sheet***

information and feedback and use it to make internal improvements.

In the past, the PDF forms were loaded into a database; however, the data was not available for analysis, nor was it user friendly. Now, KYTC has instituted a geodatabase (GIS) (as mentioned on page 45) that allows for easy entry of the fact sheet data; it also allows for analysis. Currently, KYTC is reformatting the older reports into the current template so that the historical data will be available in the GIS database. The fact sheet data contains original project cost information, change order totals, and the percent increase in cost from these change orders. Change orders are grouped into categories that show which division might be responsible for the issues and the type of problem. The fact sheet also includes a solutions section, where collective solutions are suggested to prevent the same type of issue from recurring in the future.

All of this information is available in an easy-to-use GIS format that is available to all KYTC employees. Examples of how the data is presented are provided in Figure 3.16, Figure 3.17, and Figure 3.18.

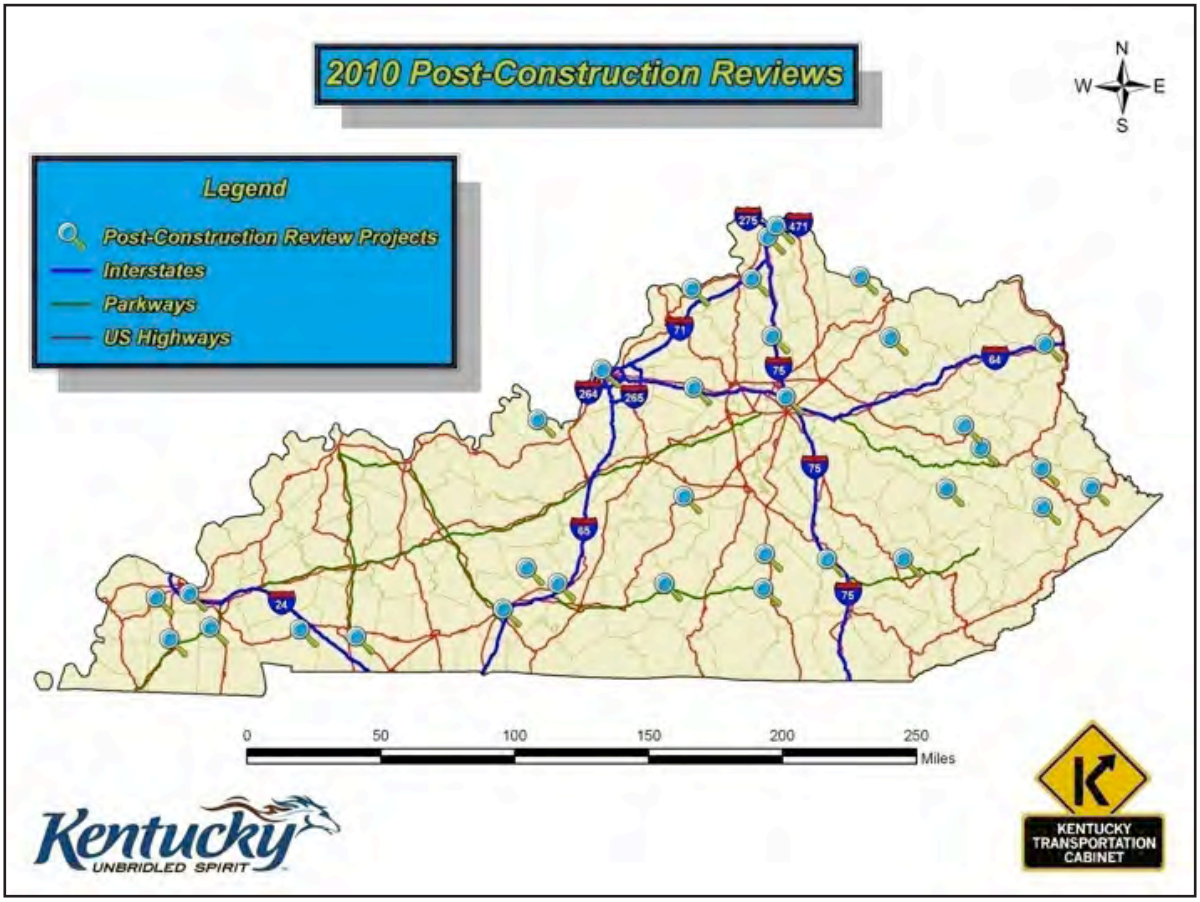


Figure 3.16 ***KYTC GIS database screen shot of post-construction reviews***

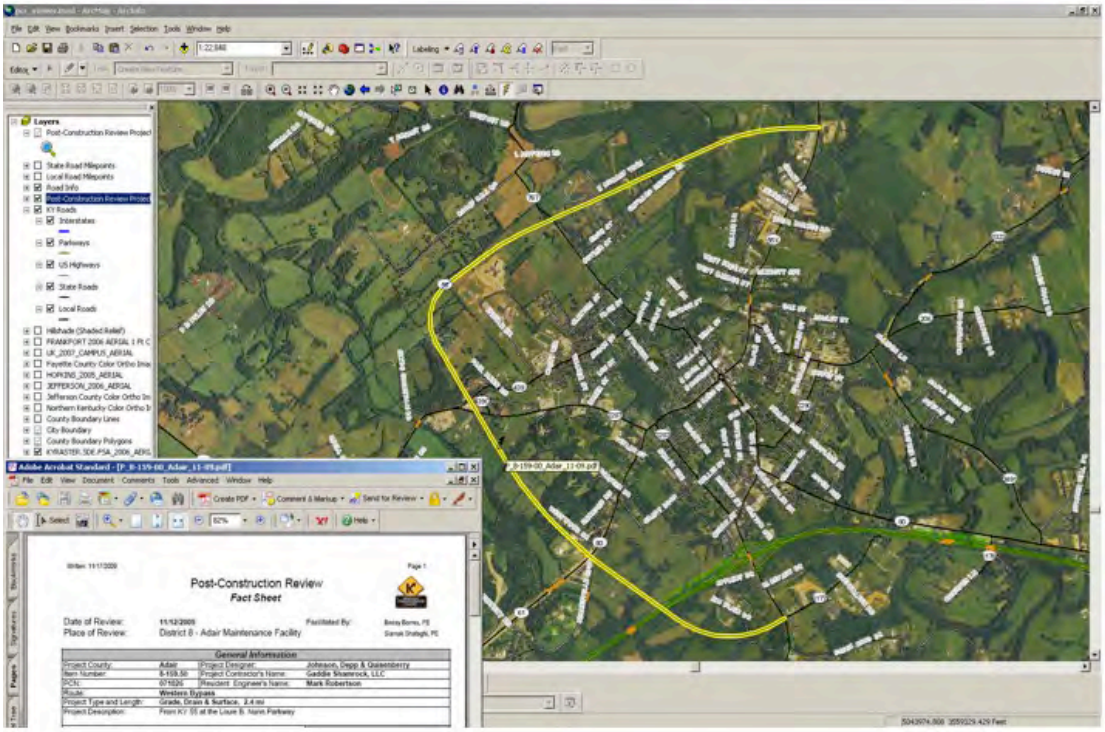


Figure 3.17 *KYTC GIS database screen shot of post-construction review*

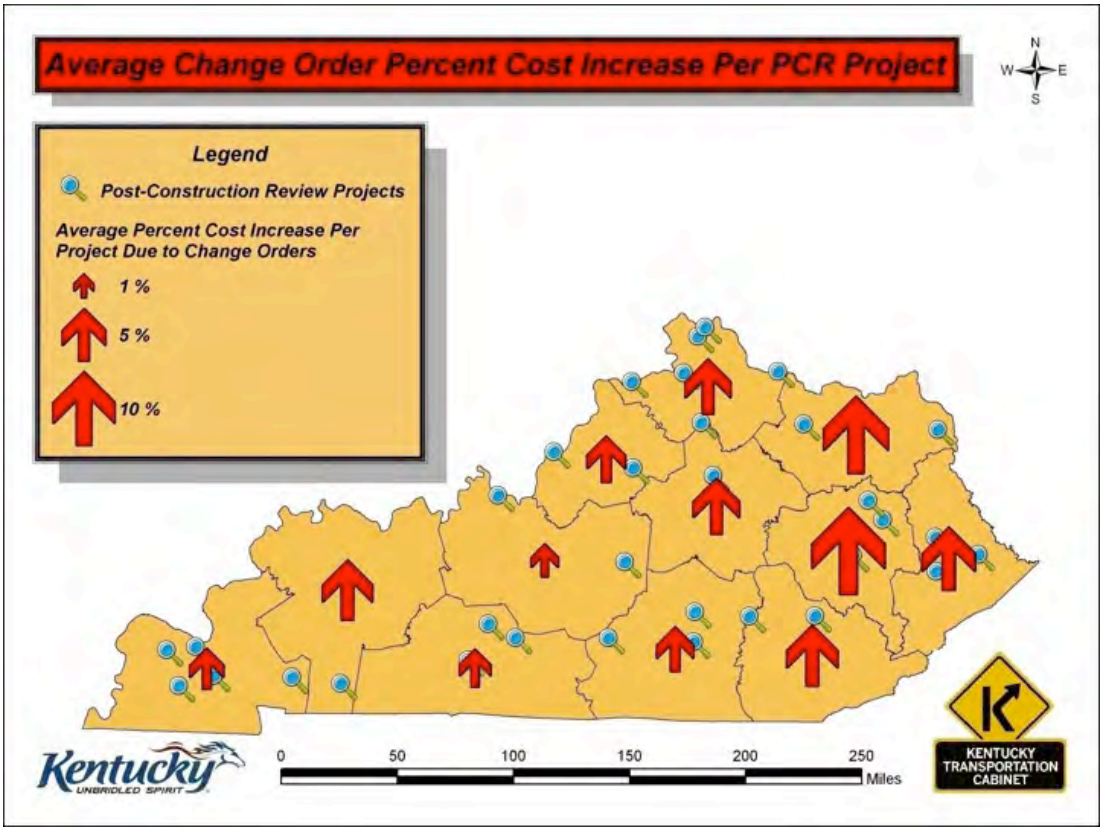


Figure 3.18 *Example analysis from KYTC GIS post-construction review database*

Quality in Existing Processes

Successful states look at improving quality in existing processes, not necessarily adding more processes. By examining existing processes and formalizing them through documentation, organizations can identify unnecessary steps and improve areas where the process is lacking. After improvements are made, then performance measures are developed. These actions help to add focus and efficiency to quality programs.

Effectiveness and Efficiency in Existing Processes

Successful states are looking at the processes they already use and seeing where quality can be added. Caltrans has looked at all of its checklists to determine the optimal amount of items that should be included, while ODOT has developed a series of steps for each discipline to go through to help them document all their processes.

Oregon

ODOT has developed a 12-step process to evaluate each division's processes and formalize them into QC/QA plans. The DOT's QA program focuses on the following:

- The quality management system
- Management's commitment
- Resource allocation
- Product and process management
- Measurement, analysis, and improvement

Oregon has developed a 12-step process based on these focus areas (see Table 3.2). Under the quality management system focus area, the first step is for each division to establish quality policies, objectives, and performance measures that are clearly linked to higher-level organizational strategic objectives. For example, the Bridge Division has performance measures related to the condition of bridges and ODOT has a higher-level objective concerning safety. Second, the division will define the scope of work. For instance, the Bridge Division may define part of its scope as "establish bridge design and drafting standards." The third step in the process is to identify current quality documents. The fourth step is then to assess quality document controls by asking such questions as:

- Are the documents being used?
- Who maintains them?
- Is there training on how to use them?
- How are they reviewed and edited?

The next area of concentration looks at management's commitment and responsibility. Step 5 focuses on customer service and defines internal and external customers. It also asks, "Do you have a functional customer feedback process in place?" The sixth and seventh steps are, respectively, to outline ways to manage risk and clarify the roles and responsibilities of staff involved, including staff in other divisions. The last step in this area is to assess training needs.

Step 9 falls under the resource allocation focus area and asks, "How can we best manage our resources and what tools and funding do staff need to best do their job?" Under the product and process management focus area, Step 10 asks, "Are the processes we are using efficient, are the correct quality controls in place, and do we have the right types of checklists or other documentation for each process?"

The last two steps are in the feedback and lessons learned subject area and look at how quality processes can be measured, analyzed, and improved. Step 11 asks the division to look at how it will monitor, assess, and report on its quality process, and Step 12 asks the division to consider how it will implement improvements.

The Quality Management System
1. Establish Objectives and Measures
2. Define Scope
3. Identify Current Quality Documents
4. Assess Quality Document Controls
Management's Commitment
5. Focus on Customer Service
6. Manage Risk
7. Clarify Roles and Responsibilities
8. Assess Training Needs
Resource Allocation
9. Optimize Resources
Product and Process Management
10. Analyze Process Approach
Measure, Analyze, and Improve
11. Monitor, Assess, Report on Processes
12. Implement Improvements

Table 3.2 ***Oregon's 12-step quality process assessment***

ODOT's Bridge Design Division has gone through this 12-step program and developed its own QC/QA plan (see Appendix E).

Illinois

The Illinois DOT (IDOT) has taken the extra step to have its plan review process meet the standards for ISO 9001:2000 certification[10]. The International Organization for Standardization (ISO) 9000 family of standards represents an international consensus on good quality management practices. It consists of standards and guidelines relating to quality management systems and related supporting standards. IDOT was one of the first state DOTs to achieve this certification, which requires a long, labor-intensive commitment.

The benefit of pursuing ISO certification is that it prompted IDOT to document and assess all of its processes for reviewing designs. This helps staff understand the procedures and available documents and helps in training new staff. However, the ISO process may be too detailed to use on every design and does not leave room for risk-based types of review. Some projects need a closer review than others; however, the ISO process has the same requirements for all projects.

Other benefits of the ISO certification process are the annual internal audits and biennial external audits to make sure that ISO parameters have been met. These audits prompt the DOT to maintain good document control, maintain good standardized forms, and clean up retained records. The audits help the DOT see where more improvement is needed and can be used as a good tool for strategic planning.

Another beneficial requirement of ISO certification is that objectives and measures are reported quarterly. These reports enable the DOT to track plan production for a month, quarter, and year and show when consultant plans have been rejected and why they are being rejected. The ISO reports reveal trends, and the DOT is able to adjust schedules to get better quality plans overall. Other ISO measures show where more manpower is needed and give proof of the need to hire. Still another ISO measurement tracks change orders in the field.

Overall, ISO is another tool that can be used to take lessons learned and feedback and translate them into better quality in future projects. However, the process of becoming certified is laborious, and the rigidity of the requirements to maintain certification requires significant staff time, so the option may not be viable for every state.

---

[9] International Organization for Standardization, ISO 9001:2000, http://www.iso.org/iso/catalogue_detail?csnumber=21823

CHAPTER 4

Conclusions

Team Conclusions

The scan team noted that in successful states, it is important to have the support of upper management in the development, documentation, and use of a QC/QA program. It is clear that adequate tools and documentation could lead to quality plans, but only with quality people and expertise developing the designs.

One of the biggest challenges each of the visited states faced was showing the benefit of time spent on QA processes. The team's hosts asked how they could convey or market to decision makers that these quality programs are worth time and funding. Overall, a successful quality program should be able to show that better quality in plans equals longer life and cost savings on projects. Many states recognize that a quality set of plans does not always equal a quality design, and that sustainability, constructability, and other considerations should be taken into account to really instill quality into a project.

Future Research

The scan team found that in many cases it is hard to quantify the benefit of QC/QA procedures. In the future, it would be useful to identify the marginal benefit of more QC. For example, if one additional hour is spent reviewing a set of plans, how much quality does that add to the overall project? How can that incremental increase in quality be measured? How can useful performance measures be identified?

Many states mentioned that they use a risk-based approach to their QA/QC reviews, meaning that they put their senior staff on projects that are more critical or made sure that a particular project got a longer timeframe for its review. However, none of this risk-based guidance was documented; it was simply a matter of the respective DOT staff members' experience. Follow-up research on developing parameters/criteria for such a risk-based approach to QA/QC reviews would be beneficial.

Implementation Activities

The scan team recognizes the importance of implementing the findings of this review. Many important successful solutions and strategies were identified and would benefit other state and local transportation agencies. Included in the team's proposed implementation plan are the following:

1. **Develop a webinar** – The team intends to present successful solutions to a large audience through webinar training sessions.
2. **Develop and make presentations to AASHTO and TRB committees** – These more in-depth presentations can be tailored to specific groups.
3. **Implement findings locally** – Ideas and successful solutions can be brought directly into the team members' states and host states.
4. **Identify future research** – The scan identified findings and issues that could be further investigated. Research proposals for these needs will be written and presented to supporting organizations, such as AASHTO or TRB committees.
5. **Draft a letter to the FHWA to inform it of scan findings** – The scan team will outline the scan findings in a letter to the FHWA's Bridge Technology Office to assist in the development of the Technical Advisory for QC/QA in Bridge Design that will be developed in response to recommendations by NTSB.
6. **Develop a Web site** – A Web site dedicated to QC/QA processes will make information more readily available.
7. **Identify places to submit journal articles or post links to the final report** – The team intends to submit articles to academic journals as well as to trade magazines and newsletters.

APPENDIX A: SCAN TEAM BIOGRAPHICAL INFORMATION

Appendix A:

Scan Team Biographical Information

HOSSEIN GHARA (AASHTO CHAIR) is the bridge engineer in Louisiana. In this capacity, he has oversight of all bridges designed, replaced, and rehabilitated in that state. He has been working as the State Bridge Engineer for the past 10 years and, prior to that, he was an assistant to this position for several years. He has been with the Louisiana DOTD for more than 34 years. Ghara is a member of the AASHTO Subcommittee on Bridges and Structures and serves its technical committees as the chair of the T-1, Bridge Security Committee and as a member of the T-10, Concrete Design Committee. He is a member of the panel working on the NCHRP projects 18-15 Light Weight Concrete and 12-85 Highway Bridge Fire-Hazard Assessment. He serves on a technical panel evaluating multi-hazard bridge design and the technical panel reviewing the design criteria for long span bridges; both are sponsored by the FHWA. He is also a member of the board of advisory for the master's program in bridge engineering at The State University of New York in Buffalo. He has a bachelor of science degree in civil engineering from The University of Louisiana, Lafayette. While employed with Louisiana DOTD, he earned his master's degree in business administration from Louisiana State University. Ghara is a licensed professional engineer in the State of Louisiana.

KELLEY C. REHM (Subject Matter Expert) is an engineering management consultant currently working as the program manager for bridges and structures as well as hydrology and hydraulics for AASHTO. Rehm, who has nearly 15 years' experience in bridge design, construction, and management, now works as a private consultant and previously as a design engineer with the Kentucky Transportation Cabinet. She has served as on several NCHRP panels and is currently under contract with the University of North Carolina at Charlotte as an investigator for the USDOT RITA project for remote sensing in bridge inspection and management. In her role as program manager with AASHTO, she acts as the AASHTO staff liaison for the Subcommittee on Bridges and Structures. She has worked with state highway departments and their directors of bridge design to develop structural specifications and instigate research and continued training in structural engineering. This involves working with volunteer members organizing meetings, developing documents, and monitoring publication schedules for structural design specifications and guidelines. She has also performed research, drafted testimony for legislative briefings (e.g., the House Subcommittee on Transportation and Infrastructure) and acted as contract manager for the project devoted to the Maintenance of the Load and Resistance Factor Bridge Design Specification. Recently, after the collapse of the I-35 Bridge in Minneapolis, Rehm was responsible for responding to the corresponding NTSB recommendations made to AASHTO. As a response to one of these recommendations, she authored the white paper, "Quality Control and Assurance Practices in State DOT Bridge Design Offices: A Synthesis." Rehm is a licensed professional engineer.

NANCY BOYD is the deputy state design engineer for the Washington State DOT. In this role, she oversees the preconstruction functions of 18 headquarters, including design policies and standards, hydraulics, real estate services, contracts and agreements, utilities, consultant services, VE, risk estimating, and computer-aided engineering. She has been with WSDOT nearly 20 years, holding positions in geometric design, safety research, plans review, planning, and geotechnical engineering. As a project engineer, she managed design efforts for the $1.4

billion Tacoma/Pierce County HOV program. Boyd is a graduate of Whitman College and is a licensed professional engineer and a registered engineering geologist in Washington State.

TIM SWANSON is the design support engineer in the Office of Technical Support for Mn/DOT. He provides technical engineering expertise, design support, and communications involved in the review and recommended approval of final detailed transportation construction plans prepared by district designers, consultants, state aid, municipalities, counties, and other functional areas outside and within Mn/DOT. He ensures that the over $500 million annual state construction program (280+ projects per year) and the $10 million annual set-aside program (40+ city and state aid projects per year) for locally initiated construction projects are complete for bid items, tabulations, details, specifications, accepted engineering standards, and DOT policies for the scheduled project lettings. Swanson graduated from the University of Minnesota and is a licensed professional engineer in Minnesota.

CARMEN SWANWICK, chief structural engineer for the Utah DOT, has over 15 year of experience in transportation, with an emphasis in bridge design, and design-build projects. Since receiving both her bachelor's and master's degrees in civil engineering from the University of Utah, Swanwick has played key roles in many large transportation projects across both the state and the nation, including the I-15 Reconstruction in Utah, the Big I in New Mexico, the Route 3 North Transportation Improvement Project in Massachusetts, and the TH 52 in Minnesota. Her project capabilities and leadership skills help her team meet the technical requirements of producing structural designs that are safe, economical, constructible, maintainable, aesthetic, and appropriate for their locations and surroundings.

ROBERT J. HEALY is the deputy director of the Office of Structures for the Maryland State Highway Administration (MDSHA) in Baltimore. In this role, he is responsible for management and oversight of the daily operations of that office, including the design, inspection, and maintenance of over 2,500 bridges and 5,000 small structures on the state highway system. He has also served as bridge project director for several recent mega-projects in Maryland, including the Woodrow Wilson Bridge and the Intercounty Connector. He has been with the MDSHA for 30 years, serving as a design engineer, a team leader, and in other management positions. He formerly was a principal and office manager for a major civil/structural consulting engineering firm in Alexandria, Virginia. Healy is currently on the executive committee of the AASHTO Subcommittee on Bridges and Structures, chairs its Movable Bridges Technical Committee, and serves on the Technical Committees for Construction and Bridge Preservation. He has served on several NCHRP panels and TRB committees. He is a member of the American Society of Civil Engineers and the Maryland Association of Engineers. Healy received a bachelor's degree from the University of Delaware and a master's degree from Virginia Tech, both in civil engineering. He is a licensed professional engineer in Maryland.

RICHARD DUNNE was the executive manager of structural engineering for the New Jersey DOT. In January 2011, Dunne began work in the Hamilton, New Jersey office of Michael Baker Jr. Inc., as the Director of Structural Engineering Services. His unit develops policy,

standards, manuals, and guidelines for the design, construction, maintenance, and inspection of all the bridges on the state highway system. His unit oversees and manages the federal bridge inspection program for some 6500 bridges in New Jersey. In addition, all geotechnical engineering services (e.g., foundation design, pile designs, hammer approvals, and rock-fall mitigation strategies) report to him. Dunne is New Jersey's representative on the AASHTO Subcommittee on Bridges and Structures and is a member of the Technical Committees on Movable Bridges, Bridge Preservation, Construction and Loads. He is a member of TRB Committees AFF10 on General Structures and AFH40 on Construction of Bridges and Structures. Dunne is a graduate of Lehigh University with a bachelor's degree in civil engineering and is a licensed professional engineer in New Jersey.

ROBERT S. WATRAL, as a bridge design QA engineer and a registered professional engineer, manages a QA program for bridge design in Pennsylvania DOT (PennDOT). He conducts QA reviews of bridge design activities performed by districts and consultants. He also develops, recommends for acceptance, and implements statewide bridge design criteria, standards, and construction specifications. Before joining PennDOT, Watral was a senior project engineer for Merck and worked for large engineering firms in the nuclear power plant industry, such as Bechtel and United Engineers, where he was involved with sophisticated QA/QC programs for monitoring design and construction activities. Watral is a graduate of Drexel University with a bachelor's degree in civil engineering.

APPENDIX B: SCAN TEAM CONTACT INFORMATION

Appendix B:

Scan Team Contact Information

Hossein Ghara, PE – AASHTO Chair
Bridge Design Administrator
Louisiana Department of Transportation and Development
PO Box 94245
Baton Rouge, LA 70804-9245
Phone: (225) 379-1302
Fax: (225) 379-1786
E-mail: hossein.ghara@la.gov

Kelley C. Rehm, PE – SME
Engineering Management Consultant
602 Idlewood Dr.
Mount Juliet, TN 37122
Phone: (859) 433-9623
E-mail: krehm6@hotmail.com

Nancy Boyd
Director Columbia River Crossing
700 Washington St., Suite 300
Vancouver, WA 98660
Phone: (360) 816-8865
E-mail: boydn@wsdot.wa.gov

Tim Swanson
Design Support Engineer
Office of Technical Support
Minnesota Department of Transportation
395 John Ireland Blvd.
St. Paul, MN 55155
Phone: (651) 366-4689
E-mail: tim.swanson@state.mn.us

Carmen Swanwick
Chief Structures Engineer
Utah Department of Transportation
4501 South 2700 W
PO Box 148470
Salt Lake City, UT 84119
Phone: (801) 965-4981
Fax: (801) 965-4187
E-mail: cswanwick@utah.gov

Robert J. Healy
Deputy Director, Office of Structures
Maryland Department of Transportation
State Highway Administration
707 N Calvert St., MS C-203
Baltimore, MD 21202-3601
Phone: (410) 545-8063
Fax: (410) 209-5002
E-mail: rhealy@sha.state.md.us

Richard W. Dunne
Director of Structural Engineering Services
Michael Baker Corp.
300 American Metro Blvd., Suite 154
Hamilton, NJ 08619
Phone: (609) 807-9670
E-mail: richard.dunne@mbakercorp.com

Robert S. Watral, PE
Sr. Bridge Engineer
Pennsylvania Department of Transportation
Bureau of Design
Bridge Quality Assurance Division
400 North St., 7th Floor
Harrisburg, PA 17120-0094
Phone: (717) 346-5974
E-mail: rwatral@state.pa.us

APPENDIX C: SCAN TEAM CONTACT INFORMATION

Appendix C:

Host Agency Contacts

California – Highway Design

Mark Robinson
Office of Cooperative Agreements
Division of Design
California Department of Transportation
1801 30th St., MS 9-2/7J
PO Box 168041
Sacramento, CA 95816-8041
Phone: 916-654-6682
E-mail: mark_robinson@dot.ca.gov

California – Bridge Design

Barton Newton
State Bridge Engineer
California Department of Transportation
1801 30th St., MS 9-2/7J
PO Box 168041
Sacramento, CA 95816-8041
Phone: (916) 227-8728
E-mail: barton_newton@dot.ca.gov

Georgia – Highway Design

Brent Story
Design Policy and Support Administrator
Georgia Department of Transportation
One Georgia Center, 24th Floor
600 West Peachtree St., NW
Atlanta, GA 30308-3607
Phone: (404) 631-1978
E-mail: bstory@dot.ga.gov

Georgia – Bridge Design

Paul Liles
State Bridge and Structural Design Engineer
Georgia Department of Transportation
One Georgia Center, 24th Floor
600 West Peachtree St., NW
Atlanta, GA 30308-3607
Phone: (404) 631-1985
E-mail: pliles@dot.ga.gov

Illinois – Highway Design

Scott E. Stitt, PE
Acting Engineer of Design and Environment
Illinois Department of Transportation
2300 S. Dirksen Pkwy.
Springfield, IL 62764-0002
Phone: (217) 782-7526
E-mail: scott.stitt@illinois.gov

Illinois – Bridge Design

Carl Puzey
Acting Chief of Bridges and Structures
Illinois Department of Transportation
Room 240
2300 S. Dirksen Pkwy.
Springfield, IL 62764-0002
Phone: (217) 782-2124
E-mail: carl.puzey@illinois.gov

Kentucky – Highway Design

Boday Borres
Quality Assurance Branch Manager
Kentucky Department of Transportation
200 Mero St.
Frankfort, KY 40622
Phone: (502) 564-3280
E-mail: boday.borres@ky.gov

Kentucky – Bridge Design

Mark Hite
Director, Division of Structural Design
Kentucky Department of Transportation
200 Mero St.
Frankfort, KY 40622
Phone: (502) 564-4560
E-mail: mark.hite@ky.gov

Minnesota – Highway Design

Jon Chiglo
Director, Office of Technical Support – State Design Engineer
Minnesota Department of Transportation
3485 Hadley Ave. North
Oakdale, MN 55128-3307
Phone: (651) 366-4826
E-mail: jon.chiglo@state.mn.us

Minnesota – Bridge Design

Kevin Western
Bridge Design Engineer
Minnesota Department of Transportation
3485 Hadley Ave. North
Oakdale, MN 55128-3307
Phone: (651) 366-4501
E-mail: kevin.western@state.mn.us

New York – Highway Design

Mary Ricard, PE
Section Leader – Project Development Section
New York Department of Transportation
50 Wolf Rd.
Albany, NY 12232-2633
Phone: (518) 485-2216
E-mail: mricard@dot.state.ny.us

New York – Bridge Design

Arthur P. Yannotti, PE
Director, Structures Design Bureau
New York Department of Transportation
50 Wolf Rd.
Albany, NY 12232-2633
Phone: (518) 457-6827
E-mail: ayannotti@dot.state.ny.us

Oregon – Highway Design

Beth Vargas Duncan, MPA, JD
Quality Assurance Program Manager
Oregon Department of Transportation
4040 Fairview Industrial Dr., SE
Salem, OR 97302-1142
Phone: (503) 986-3874
E-mail: elizabeth.vargasduncan@odot.state.or.us

Oregon – Bridge Design

Bruce V. Johnson, PE
State Bridge Engineer
Oregon Department of Transportation
4040 Fairview Industrial Dr., SE
Salem, OR 97302-1142
Phone: (503) 986-3864
E-mail: bruce.v.johnson@odot.state.or.us

Pennsylvania – Highway Design

Brian D. Hare
Chief, Design Services Division
Pennsylvania Department of Transportation
PO Box 2966
Harrisburg, PA 17105-2966
Phone: (717) 214.8734
E-mail: bhare@state.pa.us

Pennsylvania – Bridge Design

Thomas P. Macioce
State Bridge Engineer
Pennsylvania Department of Transportation
PO Box 2966
Harrisburg, PA 17105-2966
Phone: (717) 787-2881
E-mail: tmacioce@state.pa.us

Washington State – Highway Design

Pasco Bakotich III
State Design Engineer
Washington State Department of Transportation
PO Box 47340
Olympia, WA 98504-7300
Phone: (360) 705-7231
E-mail: bakotip@wsdot.wa.gov

Washington State – Bridge Design

Jugesh Kapur
State Bridge and Structures Engineer
Washington State Department of Transportation
PO Box 47340
Olympia, WA 98504-7300
Phone: (360) 705-7207
E-mail: kapurju@wsdot.wa.gov

Appendix D:

Amplifying Questions and Desk Scan Surveys

Amplifying Questions

A. How do you define a successful QC/QA program?

- What key attributes should a federal/state/company QA/QC program have?
- Define the limits of the engineering QA/QC boundaries (e.g., from planning, through the design stages to records retention and inspection/maintenance programs, into construction activities).
- What are the differences between the standard practices and what is done on a specialized, project-by-project basis?

B. How do you measure the success of your program?

- What performance measures should a QA/QC program use to determine effectiveness?
- Is there accountability in the process? What are the repercussions of bad quality plans?
- What are your errors and omissions policies?
- What are your consultant ratings/prequalification processes?
- What repercussions do engineers have for bad quality in-house (e.g., personnel reviews)?
- What are your lessons learned feedback loops within the agency for in-house and consultant design?

C. How was your QC/QA process developed?

- Did you use an ISO certification program or guidance from another quality group (e.g., the American Society for Quality)?
- How useful is the ISO certification program or other quality programs or certifications you may have?
- Did you use a consultant or third party to develop your processes?

D. What are the documentation and administration procedures for your QC/QA processes in design?

- How should QA/QC budgets be established? Does the DOT currently have a QA/QC budget? How much investment is made in the process (e.g., man-hours or funding)?
- Should AASHTO/FHWA provide guidelines, specifications, or even mandates for QA/QC functions?
- How would QA/QC differ for internal designs, consultant designs, design-build projects, or even consultant evaluation/selection?
- Does the DOT use multiple checklists to confirm that all pertinent design conditions were considered?

- How many opportunities are there for design review and at what stages of development?
- What exact documents are actually reviewed (e.g., plans, special provisions, and quantities/estimates)?
- Should red flag checklists be used?
- What level of documentation and recordkeeping on the QC/QA processes is required?
- What is the expected timeline for reviews and how is that built into the schedules for delivery of plans and documents?
- Should states implement QA/QC programs legally? Are there laws in place that require QC/QA programs?
- How are plans signed and sealed in your state? (Are PE stamps required? Chief engineer stamps/signature/approval? Does the state require PE stamps or just approval?)
- Is your state using project management teams that are separate from the engineering staff in bridges and roadways to ensure quality?
- How does the organizational structure of the agency affect the QA/QC procedures? Where does the QA/QC process reside in the agency?
- How do standardized details play into QA/QC processes?

E. What reviews should be done across disciplines?

- Are there consistent review procedures across all disciplines or does each unit (e.g., structures, highway, geotechnical, and traffic) have its own procedures?
- Do the review procedures include an opportunity for a field/site review? If so, at what stage of the project development?
- Are there specific reviews for environmental permitting or issues? Are these performed within the highway department or are they performed at a different agency?
- When is a constructability review performed and who is responsible for this review? Does an actual field inspection/construction management team review the plans at any stage?
- What special calculations are done to check final or as-built plans (e.g., initial load rating of new bridges, final capacity of piles in as-built plans, etc.)?
- How do you avoid communication issues between different divisions/specializations or between different phases of projects?

F. What specific qualifications and education practices can you elaborate on?

- Should architects/engineer consultants have QA/QC programs and internal audits to be eligible for DOT work?

- What level of detail is expected of FHWA reviews? How involved is the FHWA in your QC/QA process?
- What are the specific qualifications required for reviewers (e.g., training, continuing education, certification, and licensing?)
- Who specifically is performing reviews in your organization?
- Is specific training offered to QA/QC teams?
- Are there communications within the agency (e.g., newsletters) that contain, for example, helpful hints or educational articles?
- Does your agency participate in design forums, workshops, or conferences where QC/QA is discussed?

G. What should QC/QA programs do differently for specialized processes, such as design-build projects or value engineering processes?

- How are in-house DOT designs different from A/E designs and from design-build projects regarding QC?
- Do you apply different QC/QA processes for different types of projects or is the program "one size fits all" (i.e., are the processes risk based according to the complexity of the project)?
- Should both the design engineer and responsible reviewer seal/sign calculations and drawings for design-build or peer reviews?
- When should third-party reviews be considered: only for specialized projects or on a regular basis?
- Do departments ever use general engineering consultants (GEC) for overall management of major projects? Is design review included in the scope of work for the GEC?
- Is anything done differently for value engineering pre-award? How are reviews done for these projects?
- What QA/QC processes are in place for construction changes/value engineering post award?
- For other innovative contracting (e.g., public private partnerships and design-build-operate) types of projects, how can we ensure quality in these types of special projects?

H. How are QC/QA processes involved in standards, drawings, submissions, and software?

- Does your state have standard formats or templates or give example plans to consultants? Does this help in the QC/QA process?
- Does your state have electronic submission? How does this affect the QC/QA process?

- Are there computer-aided drafting and design standards for assembly of the documents?
- What is the overall procedure for final assembly of plans?
- Check of computer software output (e.g., earthwork quantities)?
- What QC/QA processes are in place for design software acceptance?

I. How does your QC/QA design program extend into the construction phase?

- Do you have mandatory pre-bid meetings?
- Do contractors ever do review of plans as a third-party review? (Not a contractor that will be bidding the job, but one contracted separately as a reviewer.)
- What is the QA/QC process for your contractor-designed aspects (e.g., temporary structures, traffic control plans, falsework, etc.)?
- What are your QA/QC processes for project specifications and other contract documents?

Desk Scan Survey on QC/QA Practices in Bridge Design

1. What is your procedure in reviewing consultant engineering bridge plans today? (Include manual excerpts, memos, etc., if available.)
2. Are consultants required to have a QA/QC program in place to pre-qualify? Do they provide QA/QC procedures to the department?
3. What is considered a red flag or major problem item when reviewing consultant engineering bridge plans? What follow-up actions or processes are used to address the red-flag item?
4. Do you review consultant engineering bridge plans concurrently with the FHWA Division Office or review the consultant plans with the expectation that the FHWA will be performing a similar type of review?
5. What separate or different processes are used for signature or special bridge projects?
6. Do you ever use third-party consultants for review of consultant bridge design work?
7. What are the qualifications of your department personnel who conduct the review of consultant engineering bridge plans?
8. How long do you retain records of bridge designs? What is included in the retained records (e.g., hand calculations, computer printouts, as-built design, etc.)? Who can access this information (i.e., are there security measures)?
9. What is the percentage of bridge design work that is done in-house versus the percentage that is done by consultant engineering firms?
10. Describe the structure of the bridge office in your department. For example, is the bridge office centrally organized? How many district bridge offices are located in the state? Are consultant engineering bridge plans reviewed at the central office or in district bridge office?

Desk Scan Survey on QC/QA Practices in Highway Design

1. What is your procedure in reviewing consultant design plans? Do you have a formal written procedure or manual? (Include manual excerpts, memos, etc., if applicable.)
2. What is your general procedure in reviewing in-house designs? Do you have a formal written procedure or manual?
3. Are consultants required to have a QA/QC program in place to prequalify?
4. What is considered a red flag or major problem item when reviewing plans? What follow-up actions or processes are used to address the red-flag items?
5. What separate or different processes are used for signature or special projects (e.g., design-build)?
6. What are the qualifications of your department personnel who conduct the review of plans?
7. What is the percentage of roadway design work that is done in house versus the percentage that is done by consultant engineering firms?
8. Describe the structure of your roadway design offices in your state. For example, is the roadway design office centrally organized? How many district design offices are located in the state? Are consultant engineering plans reviewed at the central office or in a district office?

Appendix E:

State Forms and Documents

- California
  - Quality Manual Flow Charts
  - Meeting Discussion Mural
- Georgia
  - Georgia's Quality Control and Assurance Plan
- Kentucky
  - Plan Submittal Tracking System Checklist
  - Quality Newsletter
- Minnesota
  - Lessons Learned on ROC52 Project
  - Independent Peer Reviews of Major Bridges
  - Design-Bid-Build Quality Plan Draft
- New York
  - Design Report Review Checklist
  - New York Manual Web References
  - Bid-ability Survey
- Oregon
  - Roadway and TCH Checklist Items for PS&E Risk Tables
  - Bridge Final Design Checklist
  - OBDP – Bridge Replacement Review Checklist
  - Sample Quality Plan – Bridge Division
  - 12-Step Process
- Pennsylvania
  - Example Project Development Checklist
  - Appendix D – Design Quality Manual
  - Design Feedback from Field Construction Form
- Washington State
  - Bridge Quality Process Documents


ONLY
ONLY