Guideline for Implementing Quality Control and Quality Assurance for Bridge Inspection

Requested by:

American Association of State Highway
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Standing Committee on Highways

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Definitions

Work Group: Organizational unit responsible for conducting or overseeing bridge inspection, such as a State district, county, township, or inspection consultant.

Corrective action: Corrective actions are steps that are taken to remove the causes of an existing nonconformity or undesirable situation.

Quality Control Officer (QCO): An individual responsible for conducting QC activities.

Quality Assurance Officer (QAO): An individual responsible for conducting QA activities.

Quality Report: A document that reports the outcome of a QC or QA review.

Inspection Requirements: A requirement is a need, expectation, or obligation. It can be explicitly stated, such as the NBIS requirements, or implied. A specified requirement is one that has been stated (in a document for example), whereas an implied requirement is a need, expectation, or obligation that is common practice or customary.

Procedures: A procedure is a way of carrying out a process, activity or function. A detailed procedure defines and controls the work that should be done, and explains how it should be done, who should do it, and under what circumstances. In addition, a procedure may explain what authority and what responsibility has been allocated, which inputs should be used, and what outputs should be generated.

Practices: The realized implementation or application of the procedures.

Expert Team: A group of individuals with advanced or special knowledge of requirements, procedures, and/or practices.

Quality Dimension: A characteristic that provides a measure of quality. For example, conformance of an inspection to established procedures is dimension of quality.

Control Inspection: An inspection conducted to provide a reference or standard for the assessment of quality for other inspections of the same bridge. Typically conducted by an expert team.

EXECUTIVE SUMMARY

The bridge inspection process is critical to ensuring the safety of highway bridges, identifying repair and maintenance needs, and determining the appropriate allocation of funds. As a result, the quality of the data produced during the inspection process is extremely important. Previous studies on the reliability of highway bridge inspection have indicated that there can be variability in the processes and results of visual inspections. Variations can arise from inconsistencies in the inspection procedures and practices, inspector characteristics (education, training, experience, etc.), understanding of inspection program requirements, and other factors. Reliability and consistency in load rating procedures are also needed to ensure bridge safety and support decision making.

Given the importance of the quality inspection results to successful bridge management, both in terms of resource allocation and safety, the need to improve the quality level of inspections and broaden the implementation of effective Quality Control (QC) and Quality Assurance (QA) procedures has been recognized. The goal of this document is to improve highway bridge safety by providing guidelines for implementing QC/QA procedures within existing bridge inspection programs. The document is intended to provide a resource that describes methodologies and practices for QC and QA, to improve the quality of the existing programs and allow owners to consider practices that best fit their programmatic needs.

The report documents both QC and QA practices that are presently implemented in the United States. A review of available literature, a series of discussions with bridge owners and experts, and investigation of current practices and procedures was conducted to develop the information included in the report. The fundamental tenants of quality systems are discussed, and quality dimensions for highway bridge inspection and load rating are described. The elements of a quality program, including documentation of inspector qualifications and roles and responsibilities within a quality program are discussed. Several models for different aspects of the QC process have been developed and described. These include characteristics of QC review processes, corrective actions, sampling approaches for QC and QC for load rating.

Several models that generalize procedures for implementing QA procedures have also been developed and described. These models describe different approaches to measuring quality for bridge inspection programs, and examples of implementation of the models is provided based on current practices in State Departments of Transportation (DOTs). Methods of measuring quality, approaches to sampling for QA, and metric methods are discussed. Sample forms from various State DOTs that can be utilized in the bridge inspection QC/QA process have been included.

The purpose of the report is to provide a resource for bridge owners that are developing, improving and/or implementing QC/QA practices. The report provides key information that can be practically applied and implemented to assure systematic QC and QA for the purpose of maintaining a high degree of accuracy and consistency in bridge inspection programs.

1 INTRODUCTION

The safety of highway bridges in the United States depends on the effective operation and maintenance of the almost 600,000 bridges in the National Bridge Inventory (NBI). A critical component of maintaining safety is the ability to evaluate the condition of in-service bridges, assess deterioration and implement maintenance and rehabilitation strategies to ensure bridges meet service and load bearing requirements. A system of periodic inspections and load-carrying assessments is implemented by State Departments of Transportation (DOTs) and Federal Agencies to meet this need. Quality programs are implemented within these systems to ensure the quality and consistency of data produced by the assessments. This guideline documents procedures and methodologies that can be utilized in a quality program to promote the quality and consistency of results. These procedures and methodologies support the overall goal of ensuring bridge safety and supporting effective maintenance and rehabilitation strategies.

The guideline discusses the background and purposes for developing quality programs within bridge inspection and load rating programs. The guideline describes typical procedures used for the implementation of quality control (QC) and quality assurance (QA). Essential characteristics of quality program documentation are also described, and several innovative QA procedures are summarized as they are currently implemented within State DOTs. The guideline is intended to provide a resource to bridge owners developing, implementing or improving quality programs within their individual bridge programs.

A review of available literature, a series of discussions with bridge owners and experts, and investigation of current practices and procedures was conducted to develop the information included in the report. Generally, information provided in the report documents existing practices or procedures that are presently implemented in select States. A number of State Departments of Transportation and the FHWA provided data and information to support the development of the guidelines.

1.1 Background

The National Bridge Inspection Standards (NBIS) were implemented in 1971 as a response to the tragic collapse of the Silver Bridge over the Ohio River at Point Pleasant, West Virginia on December 15, 1967[1]. The NBIS established requirements for 1) inspection procedure, 2) frequency of inspections, 3) qualifications of inspectors, 4) inspection reports and 5) inventory[2]. These standards have been revised and supplemented periodically since first being implemented, the most recent revisions being issued in 2004. The purpose of the NBIS is to set the national standards for the proper safety inspection and evaluation of all highway bridges in the United States. The existing inspection standards support a massive, continuous inspection effort across the country. This effort has been successful at ensuring the safety of highway bridges, determining programmatic requirements for funding and supporting the maintenance functions of State Departments of Transportation.

The bridge inspection process is critical to ensuring the safety of highway bridges, identifying repair and maintenance needs, and appropriate allocation of funding. The data produced from inspections are utilized to make critical decisions and effectively manage bridge inventories. As a result, the quality of that data is important for supporting effective and accurate decision-making. Methods for ensuring that quality are typically described as quality control (QC),

procedures intended to assure quality is maintained at a certain level, and quality assurance (QA), methods intended to assure the effectiveness of QC and verify or measure the overall quality of the program. These methods can vary widely, and many different formats and structures have been used to fill the need for ensuring the quality of bridge inspection results. Generally, these procedures are focused on assessing the quality of inspection procedures, practices and results to improve consistency and accuracy of the inspection outcomes.

An evaluation of the reliability of visual inspection published by the FHWA in 2001 indicated that the condition ratings normally assigned through the routine inspection process can vary significantly[3]. Ratings describing the condition of major bridge components (deck, superstructure and substructure) are assigned on a scale of 0 to 9, with 0 being a failed condition and 9 being excellent condition[4]. In the study, it was found that 68% of inspection results vary within +/- 1 from the average based on a statistical analysis. A tolerance of +/- 1 for condition ratings is generally accepted as characteristic of the inspection system utilized in the U.S., but the study found that a portion of inspection results would be outside that tolerance. Figure 1.1 shows the typical distribution of routine inspection results for a particular test bridge that was part of the study. The figure indicates a broad distribution of condition ratings were assigned by the inspector population (49 inspectors from 25 States), with each component having 4 or 5 different condition ratings. This distribution of condition ratings was found throughout the study, with an average of between 4 and 5 different condition ratings assigned to each primary component in the study. Other inspection variables, such as the time required for different teams to inspect the same bridge, were also studied. It was found that variability existed in the time required for executing inspections of the same bridge, indicating variation in inspection practice between

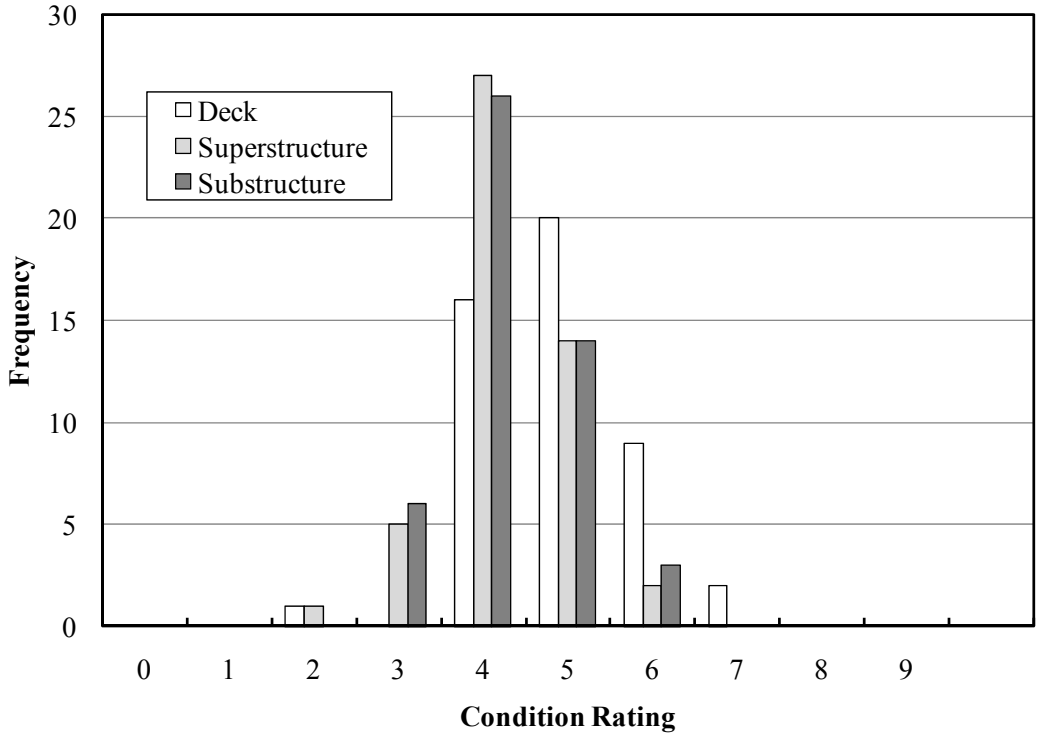

Figure 1.1. Condition rating dispersion for a highway bridge showing NBI ratings for the deck, superstructure and substructure.

inspection teams from different States. This evaluation was conducted using inspectors from across the U.S., and provides an overview for the variability that can occur in the inspection process.

Inconsistencies and inaccuracies in inspection results can have many sources, including variations between different inspectors, subjectivity of condition rating scales, inadequacies in training, procedures and practices, or simple errors. Because visual inspection is a subjective process, inspector characteristics can play an important role. Variance in inspection results between different inspectors can have several sources, including:

- Variations in training, education and experience
- Understanding of the inspection requirements and procedures
- Interpretation of the inspection practices when applied in the field
- Attitude and work ethic

Variations can also arise from inadequacies in the procedures and practices developed to implement the inspection program. These may include things like the quality of the inspection manual or inspection instructions/protocols, implementation and understanding of inspection program requirements, and available resources. Gaps may exist between inspection practices and the intended correct inspection procedures. Inconsistencies may arise from inadequate or insufficient training. Inconsistencies may also arise from simple errors, for example, miscoded items or errors in data entry.

The complex nature of bridge inspection is subject to inherent variations resulting from the fact that bridge designs, materials, age and exposure environment (climatic conditions) are highly diversified in the U.S.. As a result, it is not possible to develop an inspection system (requirements, procedures, practices and training) that adequately addresses all possible conditions without ambiguity. Therefore, there is always an element of subjectivity or interpretation in the inspection results that leads to variability that can be minimized but not fully eliminated.

Such inconsistencies in inspection results can have a negative impact on the ability to effectively evaluate the safety of bridges, and to accurately assess bridge repair and maintenance needs. The distribution of State and local funds may be affected by these results, and certain Federal funds are allocated based on sufficiency ratings that depends (in part) on inspection results. The effectiveness of repair and replacement programs can be influenced by the accuracy, consistency and thoroughness of condition ratings and related inspection findings[5]. Consequently achieving consistent, reliable and accurate inspection findings is critical to the long-term health of the bridge inventory. Reliability and consistency in load rating procedures are also needed to ensure bridge safety and support decision-making. Quality control and quality assurance procedures are intended to reduce the inconsistency and minimize the variations in the inspection and load rating programs. Historically, these procedures have had limited implementation nationally in the U.S., with a few notable exceptions[6]. Given the importance of the quality inspection results to successful bridge management, both in terms of resource allocation and safety, the need to improve the quality level of inspections and broaden the implementation of effective QC/QA procedures has been recognized.

To address the need for improving quality in the bridge inspection process, a scanning tour of selected European countries was conducted in 2007 to develop knowledge about quality processes outside the U.S.[7]. A 10 member team of was formed including representatives from the FHWA, State and County transportation agencies, and the academic and consulting communities. The scanning team conducted a series of meetings and site visits with government agencies and private sector organizations to investigate methods and procedures utilized in Europe to ensure the quality of bridge inspections. The scanning tour revealed that most nations visited employed a technical decision making process to determine the frequency and scope of bridge inspections. The scope of the inspection procedures observed during the scanning tour was typically more rigorous than is typical in the U.S., analogous to an in-depth inspection in the U.S., but these inspection were generally conducted less frequently. Innovative methods of ensuring quality were observed, including methods to measure the quality of inspection results and quantitative assessments of inspector quality.

In Finland, for example, a system of quantitative assessment of bridge inspection quality has been developed and implemented as part of the national bridge inspection policy[8]. The quality program has three components: control inspections on a sampling of the bridge inventory to assess the realized inspection quality under field conditions, bridge inspector examinations, and inspection qualification and training. The control inspections are conducted on a sampling of 1-2% of the 3000 bridge inspections conducted annually in Finland. The quality measurement consists of one standard and two control inspections. Following the standard bridge inspection, the agency responsible for conducting the inspection selects two "control" inspectors that perform an independent inspection under the supervision of Federal authorities (FINNRA, Finnish Road Administration). A system of measuring the quality of the inspection is based on the deviation of the standard inspection results from the average of the standard and control inspection results. The results of the control inspections and the original inspection are documented and differenced or inconsistencies identified. After the control inspection, the causes of deviations in inspection results are discussed as a training tool and corrective action to transfer knowledge of the inspection process.

To ensure that inspectors in Finland have the requisite knowledge and training to become certified inspectors, inspectors must attend a qualification program that includes practical training at bridge sites and inspection examinations. Inspector examinations include both a written component and a performance test that requires inspectors to perform inspections in the field that meet a standard level of quality. In addition, required annual training sessions are organized for certified inspectors. In the training sessions, lectures on inspection procedures, practices and possible problem areas are presented to the inspectors. The inspectors are also required to perform inspections on two common bridges. The results of these inspections are compared with a control inspection to identify inconsistencies and problem areas. These training sessions serve several purposes, including

- Creating a common understanding of inspection practices
- Calibrating inspection practices by having all inspectors evaluate the same bridges
- Facilitating knowledge transfer
- Providing for peer collaboration
- Obtaining direct feedback to and from inspectors
- Identifying problem areas

The results of quality evaluations are linked to corrective actions and control by using the inspector quality measurements obtained through the process in the evaluation of contract proposals for bridge inspection. Additionally, the system has a quality control requirement for agencies conducting inspections that requires reporting of deviations that occur and corrective actions to address the deviations.

The scanning tour also found the utilization of International Organization for Standardization (ISO) 9000 series of standards as a means of specifying quality requirements for contractors conducting inspections. The standards provide overall concepts and procedural requirements for effective quality programs. Additional quality practices that were found included that the host nation's typically had several well-defined scopes for their inspections. While detailed evaluations may be conducted only at long intervals, up to nine years, less comprehensive inspections were typically conducted in the interim to assess major faults or accidental damage. The competency of the inspection crew was considered as part the decision making process in determining the frequency and scope of inspections. The implication of this finding is that improved quality could be obtained from inspectors that met more rigorous or higher level qualification standards.

1.2 Goals, Objectives and Purpose

The goal of this document is to improve highway bridge safety by providing guidelines for implementing QC/QA procedures within existing bridge inspection programs. The document is intended to provide a resource that describes methodologies and practices for QC and QA, to improve the quality of the existing programs and allow owners to consider practices that best fit their programmatic needs.

The objectives of the document include the following:

1. Describe systems and methods for measuring and improving quality within the context of highway bridge inspection
2. Provide a resource for developing or improving QC/QA practices
3. Define and generalize model methodologies for inspection QC/QA

The purpose of the report is to provide a resource for bridge owners that are developing, improving and/or implementing QC/QA practices. The report provides key information that can be practically applied and implemented to assure systematic QC and QA for the purpose of maintaining a high degree of accuracy and consistency in bridge inspection programs.

1.3 Quality Tenants

The first challenge in developing an effective QC/QA program is to determine what is meant by the term "quality" and how it can be applied to bridge inspection and load rating. Most people have some conceptual sense of "quality" as being the common users' view of positive product or services attributes. Most common quality dimensions for consumer products include such attributes as performance, reliability, serviceability, and conformance to standards. As such, the customer perceives that product quality is demonstrated by the product demonstrating performance and reliability, having reasonable service requirements, and conforming to design standards. In summary, the totality of characteristics of an entity that bear on its ability to satisfy stated and implied needs. But there are problems in determining a common view about "quality." First, different users may have different views and weights for each dimension, and

these attributes may not directly relate to engineering dimensions unless properly mapped. Modern quality systems such as the ISO 9000 series define a unified clause that the general dimensions of quality include:

- Definition of needs for the product,
- Product design,
- Conformance to product design, and
- Product support.

These dimensions can be difficult to map to bridge inspection and load rating, since the product of inspection is complex, including bridge safety, definition of maintenance needs, or "successful" bridge management. Since the purpose of the inspection fundamentally is to ensure bridge safety, but operationally is to ensure safety, define maintenance requirements, and determine programmatic and funding needs, mapping these qualities to a model intended for the manufacturing of tangible products can be challenging.

There is also a well accepted modern definition of "quality" that utilizes a statistical concept for implementation, stating that "quality" is inversely proportional to variability. *The good quality of an entity means that its quality dimensions have little or no variation from target values*. Such a definition is more readily mapped to bridge inspection and load rating. It can be easily perceived that quality could be measured by examining the variability in inspection results of, for example, the NBIS condition ratings for bridge components. As such, consistent application of condition ratings could be a quality dimension. Other quality dimensions for inspection results could include items like scheduling of biennial inspections to meet the requirements established in the NBIS. Using this definition, one could easily imagine many facets of the bridge inspection or load rating that could be defined as quality dimensions and therefore be analyzed or measured to determine "quality" within bridge inspection programs.

Therefore, it may be practical to think of quality in the bridge inspection and load rating process to be represented or measured by determining the variability in quality dimensions as compared with established requirements, procedures and practices. Improvements in quality can therefore be achieved by reducing variation from target values, the target values typically consisting of properly implemented requirements and properly applied procedures. Quality can be measured by quantifying variations relative to established requirements, and the goals of assuring accuracy and consistency in the bridge inspection program can be demonstrated.

Procedures used to maintain quality are typically termed "quality control," (QC) which has the formal definition in the NBIS as follows: "*Procedures that are intended to maintain the quality of a bridge inspection and load rating at or above a specified level.*" Procedures that evaluate the effectiveness of QC and measure the quality in a program are "Quality Assurance," that has the formal definition in the NBIS of "*The use of sampling and other measures to assure the adequacy of quality control procedures in order to verify or measure the quality level of the entire bridge inspection and load rating program*."

The distinction between QC and QA can sometimes be difficult to determine, because similar actions may be undertaken for either purpose. For example, reviewing an inspection report to evaluate the quality of the report, that is, consistency with the established procedures and requirements, may be conducted for the purpose of correcting errors or inconsistencies. In that

case, the review is a QC function, with the goal of assuring that the inspection report is of adequate quality. However, the same review may be conducted for determining if the QC activities have been effective, and to measure the quality level that has resulted. In the latter case, the review is a QA function that is evaluating the QC function and measuring the quality of the inspection report. In practical terms, **Quality control** is conducted within a specific work group for the purpose of correcting or deterring errors, inconsistency or omission from specific bridge inspection or load rating outcomes. **Quality assurance** is conducted from outside the work group for the purpose of evaluating the quality level of the program overall, the effectiveness of QC in assuring that quality, and identifying deficiencies that can be corrected by changes to the program (changes to requirements, procedures, training, or guidelines, etc.).

1.3.1 Corrective actions

"Corrective Action" is a general term used to describe any steps taken to remove the causes of an existing nonconformity or undesirable situation. Corrective actions are usually defined in response to the results of a QC or QA review to address inconsistencies or errors, or to improve the overall quality of a program. Corrective actions may be specific, such as changing the description of a Commonly Recognized (CoRe) Structural Element to reduce variability in selection of the correct CoRe element[9]. Corrective actions may be communicative, such as preparing and distributing a report on the results of a QA review, or holding annual inspector meetings to exchange information on bridge inspection and quality. Corrective actions may be systematic, such as enhancing the minimum requirements for a Team Leader to raise the level of quality across the bridge inspection program.

Corrective actions are a critical component to effective quality management. Without corrective actions, QC and QA processes have little meaning and cannot lead to improvements in quality. Corrective actions address the source of variability to improve the quality of the outcome.

Corrective actions themselves may be an appropriate subject of QA review to ensure that corrective actions have been implemented. Although QA programs typically provide review and analysis for improving the quality of the bridge inspection program, a review of the effectiveness of the QA process itself can provide a means for ensuring adequate performance of the program and ensuring continual improvements are supported. In other words, *auditing or reviewing a QC/QA program to assess if corrective actions generated through the program have actually been implemented may be a suitable function or task within a comprehensive quality program*. This is a process that is often overlooked. Having an auditing component in a quality program to provide oversight of the process is a characteristic of a quality system that complies with the principles of ISO 9000.

1.3.2 Continual Improvements

Another characteristic of ISO 9000 quality systems is to have a mechanism for continual improvement. This implies that a comprehensive quality program will have a goal of improving the quality of the process, not just maintaining quality at a minimum level. In terms of bridge inspection, this suggests that a quality program would enable the continuous improvement of quality, that is, reducing the variability in inspection results as an ongoing process. This is a somewhat more ambitious goal than presently stated in the NBIS, but may be a consideration for developing a forward-looking comprehensive quality program.

1.3.3 ISO 9001 Requirements

The overall requirements of the ISO 9000 series are provided in Appendix A for the purpose of taking the users to compliance with the standard by providing general information on quality programs as applied in other industries. There are 11 fundamental requirements for ISO 9001 compliant quality programs that can be generally mapped to QC/QA processes for bridge inspection, several of which have already been mentioned. The essential characteristics of an ISO 9000 compliant quality program include such items as defining a quality system, defining management responsibility, maintaining a database for all documents, and maintaining the necessary resources to support quality systems (for example, is there budget available to implement necessary repairs, is there training available, etc.). The ISO 9000 requirements also include a process and documentation requirements for internal and external audits, and a process for continual improvement as a part of the quality system. Many of these requirements can be mapped to elements of bridge inspection QC/QA, though this process can at times be difficult. However, the requirements indicated in Appendix A provide some context for relating quality programs for highway bridge inspection programs to those utilized in other industries.

1.4 Characteristics of Effective QC/QA Programs

The report documents a number of different methods and approaches to QC/QA that are currently employed by State Departments of Transportation in the administration of their bridge inspection and load rating programs. Although the specific procedures and practices employed vary, there are certain common characteristics to these approaches that provide a foundation for effective QC/QA programs. Characteristics that are common to effective programs include:

1. <u>Independent Reviews</u>
   Reviews of reports and processes are independent and free from bias or conflict.
2. <u>Objective and quantitative measures of quality</u>
   Quality is assessed by a system of objective measures that are quantitative. For example, a schedule of thresholds for variations from target values is established to provide a measure of quality that can documented, analyzed and tracked over time.
3. <u>Quality program documentation</u>
   Quality documentation is established that allows for a complete understanding of the program by those affected by it, clearly defines roles and responsibilities, and ensures consistency in QC/QA processes over time. The documentation should assemble key data in a single location such that an overall review of the program can be conducted.
4. <u>Comprehensive coverage of the inspection and load rating program</u>
   QC/QA procedures address quality throughout the bridge inspection and load rating program, including all bridge owners conducting inspections and/or load ratings to fulfill NBIS requirements.
5. <u>Established procedures for corrective actions</u>
   Procedures for identifying, documenting and implementing corrective actions are established.
6. <u>Established schedule for evaluations</u>
   The frequency of reviews should be established and documented.
7. <u>Documented review procedures</u>
   Procedures for both QC and QA reviews are established and documented.

These characteristics of effective programs can be realized in different forms or methodologies, depending on specific programmatic characteristics and needs. Several approaches are described in Chapters 2 and 3 of this report. Variations on the approaches described that are consistent with these characteristics exist or will be developed in the future.

2 QUALITY CONTROL

2.1 Introduction

The definition of the QC, as provided in CFR part 650, are "Procedures that are intended to maintain the quality of bridge inspection and load rating at or above a specified level." Activities that are part of a QC program may include programmatic functions, such as organized maintenance of records and/or files, and review functions, such as review of inspection results and findings. Review elements of a QC program typically occur at specified sampling intervals, frequently 100% for inspection reports, or, for example, once a month for a field review, or on 10% of bridges, etc., while programmatic elements are systematic and maintained on an on-going basis. Therefore, a bridge inspection and load rating QC program typically consists of review functions, intended to ensure the quality level of specific inspection activities, and programmatic functions intended to ensure that the overall program meets NBIS requirements and maintains quality through meeting those requirements systematically. Specific items that could be considered as QC program elements include such items as:

- Systematic documentation of inspector qualifications
- Documented organization of bridge inspection program
- Required training and retraining programs for inspectors
- Maintenance of a high quality bridge inspection manual
- Maintenance of comprehensive bridge files in accordance with the AASHTO Bridge Evaluation Manual and State requirements

The requirements and procedures for programmatic elements of quality control typically originate from the central administrative offices. The activities themselves are QC processes that may be verified in a QC review within a work group, and/or verified during QA reviews. For example, documenting adequate inspector qualifications is a QC process that can be verified during a QC or QA review.

There are many activities or functions that could fit generally within the description of being a quality program element. Most of these are systematic and are fully described elsewhere, such as in the AASHTO Manual for Bridge Evaluation[10]. Several of these programmatic elements are described herein due to their close alignment with ensuring quality within the inspection program, or their relevance to inspection practice particularly. These include documentation of inspector qualifications, peer rotation for quality control, bridge file maintenance and QC roles and responsibilities. These elements are discussed in section 2.2, Quality Program Elements.

There are several different procedures for measuring the quality level within a work group through review activities. These review activities can be generally described within three procedures for implementing QC. This includes QC Office Review, focused on review of inspection reports to ensure quality, QC Field Review, which includes traveling to the bridge site

to verity data contained in the inspection report, and QC Field Performance Review, which is focused on the evaluating the performance of the inspection team during the process of inspection. These elements procedures are discussed more fully in Section 2.3, QC Review Procedures.

2.2 Quality Program Elements

This section describes quality program elements including documentation of inspector qualifications, rotation of inspection teams, bridge file maintenance and QC roles and responsibilities.

2.2.1 Documenting Inspector Qualifications

Inspector qualifications are a key element of ensuring quality control and maintaining compliance with the NBIS. The effective documentation of inspector qualifications, as well as the maintenance of required retraining, varies from State to State[11]. Several States utilize some form of a centralized reporting system to maintain a record of individuals that are qualified to perform bridge inspection in the State. Others rely on personnel records to contain adequate data to confirm the qualifications of inspectors. For other bridge owners, inspector qualifications may be documented and maintained as part of the bridge file or associated records.

A centralized certification of inspectors, where each inspector is provided with a certification number that is then entered on the inspection report, is a convenient means of providing documentation that the inspector is qualified. A database may be developed that includes the experience and training of individual inspector's to meet the requirement of the NBIS and State requirements. It may also provide data on training / retraining requirements and needs for individual inspectors. A centralized certification process can provide assistance to local agencies that employ consultant inspectors, as the State certification number is one means of efficiently verifying qualifications prior to the inspection process or the award of contracts. A centralized system for certifying inspectors can enhance quality in the program overall by controlling the authority to approve the qualifications of individual inspectors.

A sample form for documenting inspector qualification for centralized qualification systems is included in Appendix B, Exhibit B1. This sample form can be used for individual inspectors to apply to the centralized authority, such as the State Program Manager, to achieve approval of their education and experience as documented on the form. Exhibit B2 is a sample letter for verifying work experience that is utilized to confirm experience documented in the application.

Some States rely on personnel records or a personnel database having records of training and experience for Team Leaders. Such a process can be supplemented by the use of standardized forms such as the forms shown in Exhibit B3. The form can be used to document both the Federally required qualifications for team leaders and program managers and State- specific requirements that may exist. Exhibit B4 shows another sample that allows for entry of training experience and education data. Such a form can be maintained in the bridge file or adequately referenced from the bridge file such that inspector qualifications can be established at the time of the inspection and quickly verified in either a QC or QA review.

If a centralized database is used for tracking inspection qualifications, the inspector certification number and signature (or equivalent unique identifier) would normally be included as part of the

bridge inspection report. This confirms the participation of qualified personnel in the inspection and allows for subsequent review of the inspector qualifications during QC or QA reviews. If personnel records are relied on for establishing inspector qualifications, the inspection report should include the name and signature (or equivalent unique identifier) of the team leader. In this case, confirmation of the qualifications of the inspector should be documented sufficiently within the work group or agency to confirm the qualifications of the inspector at the time of inspection. This may require periodic review to ensure training and retraining requirements are maintained.

2.2.1.1 Performance Testing

Performance testing is a method of verifying that training and qualification requirements for a bridge inspector are successful in achieving the desired results. In a performance test, a bridge inspector is required to perform a bridge inspection on one or more typical highway bridges, within a timeframe that would be typical within the State given the size and complexity of the bridges being inspected. The results of the bridge inspection are then compared with control inspection results. The characteristics of the control inspections would typically be established by the Program Manager or Bridge Engineer to be in compliance with the State's procedures and guidelines for inspection. Control inspection results may be established by an expert team or by past inspection results for the bridge that are current and have undergone QC review to ensure consistency with established procedures. The results of the inspection by the subject inspector are then compared with the control results to measure variation and determine if the inspector has adequate and <u>operational</u> knowledge of the inspection procedures to successfully implement those procedures in the field. In other words, is the inspector's knowledge of proper inspection procedures and practices applied correctly under field conditions, resulting in inspection outcomes that are consistent with the control.

Performance testing can be utilized as a component of the certification of bridge inspection team leaders. Such performance testing establishes that training and experience requirements results in adequate performance of an inspector in the field. This confirms the effectiveness of training, and can highlight areas of training that may need to be improved to ensure consistent performance of inspectors. The results of performance testing can also assist in identifying individuals for which training and experience requirements have not been successful in reaching a full understanding of the inspection requirements, procedures, and practices. Performance testing would typically occur during the initial certification or qualification process. Once certified, performance testing may be conducted as a part of normal QC/QA review processes.

For example, a performance test might consist of an inspector being required to complete a number of bridge inspections over a defined time period, say over a two day testing interval. The inspector is required to complete condition ratings, element lists and condition states (if applicable) and complete NBI inventory information on the subject bridges. These results are then compared with a standard such as control inspections of the bridges, and the number of errors or inaccuracies documented. The threshold for an error might consist of a misidentification of a CoRe element, a condition rating greater than +/- 1 from a control rating, a serious error in the element condition states that indicate a lack of understanding in how to identify or quantify a condition state, or errors in recording inventory items. The thresholds and metrics for performance during the performance testing should be clearly documented prior to the testing to ensure the process is consistent, and that the inspector understands performance

expectations. A threshold number of errors per bridge could be used to evaluate the performance of the inspector[12].

2.2.2 Peer Rotation for Quality Control

The rotation of inspection teams can be used as a tool to enhance the quality of the inspection program. Under this scheme, inspection teams are rotated such that one team does not inspect a bridge on back-to-back inspection cycles. Such an approach has several advantages, including minimal cost, improvement in the safety of bridges, and enhancement in peer to peer information exchange.

Systematic rotation of bridge inspection teams can help ensure that teams are not inspecting the same bridges repeatedly, which can lead to complacency that may reduce the quality of the bridge inspection. Peer rotation can improve the overall safety of the bridge population by reducing the possibility of a deficient team conducts inadequate inspections of the same bridge in consecutive inspection cycles. This can help to assure that if there is an inspection team operating beneath expectations, that this team does not provide the only measure of bridge condition over consecutive inspection cycles. Another team, presumably operating at an adequate level, assesses the bridge and can identify deficiencies that may have been missed or inadequately reported.

Peer rotation may be a QC process, if the teams are rotated systematically as part of normal inspection practices and no assessment of variations or inconsistencies between inspections by different teams is made. When applied in this manner, the peer rotation does not provide a means for corrective action that addresses the cause of the inconsistency, it only corrects the inconsistency (assuming the current inspection has yielded the correct result). If the teams report inconsistencies in their inspections compared with the previous inspection, the peer rotation has a QC review element that allows for analysis of the cause of the inconsistency and corrective actions to be taken.

A peer rotation approach can have minimal cost to the owner agency because the same number of bridge inspections will occur as would have occurred if inspection teams were not rotated. If there are multiple inspection teams within the same office, there may be no additional cost for implementing a peer rotation. However, this has the disadvantage of limiting information exchange between the geographically separate offices. Geographically relocating inspection teams to perform inspections, for example, moving inspection teams between districts as part of a rotation cycle, can help to improve the consistency of inspection activities by exposing the inspection teams to the results of inspection from other teams operating in different work groups. This can support peer-to-peer exchange and indicate if the inspection teams are performing in a similar manner. This can also assist the owner agency in identifying inspection teams with substandard performance. The cost of such an approach is increased due to the requisite travel for the inspection teams to visit other districts to inspect bridges; the level of cost is dependent on the geographical and organization characteristics of a particular State.

Bridge safety overall can be improved by a peer exchange. If there is a deficiency in the performance of a particular team, presumably the impact on bridge safety will be reduced if the deficient team does not inspect the same bridge in back to back cycles. If the performance of teams is at an equal level, than different teams will bring a different perspective to the inspection,

because of differences in experience and training between teams. This provides an additional level of confidence in the inspection results for the owner agency and may improve the quality of the program overall.

A peer rotation scheme is frequently employed when consultant inspection teams are used. Utilizing multiple firms and rotating inspections between the firms provides a level of the quality control for the inspection process. For States with large consultant inspection pools administered from a central office, minimal effort is required to initiate such a QC process. Local owner agencies may not have easy access to a pool of consultant firms, and may need to be encouraged or even required to initiate a peer rotation scheme.

The peer rotation method can be enhanced if analysis of results is included in the QC procedure. This data analysis requires that inconsistencies between different teams' inspection results be documented and analyzed. Inconstancies between teams may stem from deterioration between inspection cycles, or may stem for inconsistent implementation of procedures, oversights and omissions, or other factors. Results of different teams' inspections may be analyzed to identify inconsistencies in inspection practices or inconsistencies in the process of data collection, that is, notes and photographs documented by the inspection teams. Such analysis can lead to corrective actions to address inconsistencies, such as improved training, identifying teams with deficient performance, or changes to the inspection procedures to provide for more uniform application (practices). Obviously, there is increased cost associated with consolidating and analyzing the results of peer rotation inspections.

2.2.3 Bridge File Maintenance

The maintenance of the Bridge File is a QC process typically verified by the QA review. This function is very important to ensure that the overall quality of the inspection program is maintained and reporting requirements are achieved. Procedures and requirements for maintaining the bridge file are documented in the AASHTO MBE, and as such do not bear repeating here[10]. The maintenance of comprehensive bridge files is a QC procedure that helps ensure the quality of the inspection results. Review of the bridge file for adequacy is a QA function typically, though may be a part of an oversight review for QC in decentralized systems or when consultant inspectors are utilized.

2.2.4 QC roles and responsibilities

Selecting suitable, qualified personnel to conduct a QC review is an important element in effective QC practices. States utilize a variety or personnel for the implementation of QC practices. These include peer team leaders, supervisors within an inspection unit or owner agency, or dedicated personnel identified with QC responsibilities. Individuals with QC responsibilities are referred to herein as Quality Control Officer (QCO). This term is applied in a general sense to indicate anyone assigned QC responsibilities as part or all of their job function.

Due to the diversified nature of bridge inspection organizations, especially at the local level, State-wide standard procedures for QC may not exist, as the QC role may be delegated to the owner agency. Minimum characteristics of individuals that perform a QC review (QCOs) typically include:

- Independence from the original inspection or load rating
- Full and operational knowledge of program requirements, procedures and practices

Independence from the original inspection report is important to reducing elements of bias that may exist from an inspector reviewing his/her own report. If the reviewer is not independent from the inspection team, the reviewer may be more reluctant to criticize other team members, create additional workload on the work group, and/or reveal ineffective inspection performance of a colleague. Additionally, if the reviewer is a part of the inspection team conducting the inspection, the transition from in-progress work to completed work can be ambiguous, and reviews may be conducted before it is appropriate. This can undermine the quality of the review.

It is also important that the individual conducting the QC review be qualified such that they have the requisite knowledge and experience to effectively review the results and conclusions of the inspection team. A QCO would ideally be familiar with the bridge inventory under inspection, such that local factors such as environment, special loading conditions, specific deterioration modes or common construction issues are familiar to the reviewer. Requiring a QCO to be qualified as a Team Leader or Program Manager under the NBIS requirements can provide an accessible framework for specifying QCO qualifications.

Typical methods used for ensuring independence of the QC review include peer review, in which a team leader from a separate team is charged with reviewing the inspection results. This peer may be from a separate team in the same work group, or from a separate work group. The second method is hierarchical, in which the QCO is in a supervisory role over the inspection team conducting the inspection. Under such a model, the supervisory reviewer should be fully qualified as described above, and be knowledgeable of the bridge inventory. A third approach could be to identify a specific individual to perform QC for several work groups, such as if a consultant was hired to perform QC functions for a specified population of work groups, say for all of the townships in a district, for example.

2.3 QC Review Procedures

The process of QC is typically conducted within the work group conducting the inspections, though the definition of a "work group" can vary significantly between different organizational structures utilized by individual States. A typical example would be to have quality control for an inspection program to be delegated to the district in which the inspections are conducted. When consulting firms are employed to conduct inspections, QC functions are frequently delegated to the consultants, with some QC oversight by the owner agency.

The purpose of QC is to ensure that the quality of the inspection process is maintained, and as such QC reviews typically focus on the quality of inspection process, as documented in the inspection report or may be observed through a review of activities. Evaluations of "quality" include evaluation of completeness of data, accuracy of data and data entry, adherence of practices to procedures, guidelines and training, qualifications of personnel, and consistency and accuracy of condition ratings and/or element condition states. The importance of recognizing problems and correctly identifying appropriate actions should be considered in determining the appropriate review procedures to be undertaken in a QC review.

Several review procedures for QC are utilized to ensure the quality of the bridge inspection process. These procedures can be generally described in four models. These include QC Office Review, QC Field Review of inspection data, QC Field Performance review of inspection teams,

and the Peer Rotation. The following sections will describe QC Office Review, QC Field Review, QC Field Performance Review more completely; Peer Rotation has been previously described in section 2.2.2. Typical QC programs would include procedures that were similar to one of more of these models, with the QC Office Review being the most widely implemented. QC Field Review is also frequently utilized. QC Field Performance Reviews and Peer Exchange are frequently components of program that include QC Office Review, QC Field Review, or elements of both.

2.3.1 Quality Control Office Review

A primary focus of QC review is ensuring the accuracy and completeness of the inspection report. This is typically accomplished through an office review of reports and/or a field review of inspection findings. The office review of reports consist of reviewing the inspection report to ensure it is complete and meets the State and FHWA reporting requirements. This review typically includes the following elements:

- Appropriate forms have been used
- Consistency of ratings for bridge components and/or elements
    - Consistency with previous inspection results (considering anticipated deterioration)
    - Appropriate recommended actions, critical findings and flags
    - Adequate supporting photographs, sketches and notes
- Proper identification of critical problems
- Maintenance recommendations consistent with inspection findings
- Accuracy of data entry in accordance with
    - FHWA coding guide
    - State specific inspection requirements
        - Bridge management systems (Pontis, etc)
        - State-specific Bridge inspection forms
- Scheduling of inspections for
    - Biennial inspections
    - Fracture critical inspections
    - Special inspection
    - Underwater inspections
- Scour
    - Scour evaluation
- Plan of Action, if requiredLoad rating
    - Load posting is consistent with load rating and inventory data
- Clearance and waterway profile updated as necessary
- Inventory items correctly entered
- Verification of inspector qualification

The QC review of the inspection report should review the report for the purposes of ensuring the accuracy of data input for the inventory items required as well as meeting the State inspection reporting requirements.

The accuracy of the ratings for NBIS rating are typically evaluated in an office review based on the photographic documentation included in the inspection report, supporting notes and comments, and previous inspection results. Component rating (items 58-62) should be compared with previous inspection results to ensure that the rating provided are consistent with expected deterioration behavior, and that significant changes to the ratings are adequately justified and consistent with supporting notes and photographs. Consistency with State procedures and guidelines should be included as part of this review. For element level inspections, the assigned condition states should be reviewed for consistency with supporting notes and photographs, and agreement with previous inspection finding considering anticipated deterioration. The appropriate selection of CoRe elements should also be assessed as possible provided the information available.

A tabulated check-list can be utilized to ensure that QC reviews are completed in a consistent and uniform manner. This check-list should be customized to meet the needs and format of individual States, but could be of similar form to that shown in Appendix C, Exhibit C1. This form includes documentation of the QCO (Reviewer), inspection team leader and members, and some general questions regarding the inspection activities. A tabular format for checking condition ratings and elements, and supporting notes, sketches and photographs is shown. Such a tabular format can be effective in ensuring that QC reviews are complete and uniform. In the check list, the QCO enters the previous rating for each component (last rating), the rating included in the inspection report being reviewed (new rating), and checks to ensure that adequate sketches, comments and photographs are included in the report. The generic form shown here is intended as a basic model that would be modified according to the data input model for a particular State, including CoRe elements if element-level inspections are being conducted. A sample form for review of element level inspection is illustrated in Appendix C, Exhibit C2. This form includes some inventory items that could be reviewed. It is not envisioned that these forms be adopted directly, but rather these are presented as examples to be adjusted to meet the needs of a particular bridge owner.

Critical findings, if any, identified in the report should be reviewed to ensure that supporting comments and photographs are included, and the data is properly entered and identified to ensure follow-up on critical findings according to State –wide procedures will be accomplished. Maintenance recommendations should also be reviewed to determine if they are consistent with available notes, sketches and photographs, and are consistent with common practices.

Most States require that evidence of inspector qualifications be included as part of the inspection report. This data may be included by an inspector's certification number, employee number, name or other reference that is traceable to a record of the inspector qualifications. The signature of the team leader on the report is normally required. The QC review should ensure that such data is provided in the report.

It should be recognized that such office QC of inspection findings does not provide a full measure of the accuracy of the inspection findings, but is a process for ensuring the quality of the report, i.e. that the report is complete and contains information that is consistent and appears adequate. However, since no assessment of the actual conditions at the bridge is available during such a review, there is an implicit assumption that all notable deterioration is included in

the report, and that inventory items are correctly indicated. If the inspector fails to document adequately deterioration or critical conditions at the bridge, there may be no way for the reviewer to be aware of the deterioration or condition. As such, the QC Office Review has some limitations in its ability to fully ensure the quality of the inspection results. The office review may be complimented with a field QC review that provides an opportunity to assess the accuracy of the condition ratings, notes and photographic documentation, and verify inventory data included in the report.

2.3.2 Field Quality Control Procedures

Field review procedures may also be a component of a QC program. Typical field procedures consist of two elements. First, a QC Field Review includes an independent verification of data included in the inspection report. The QC Field Review consists of evaluating the findings and documentation from the inspection report, and evaluates the quality and consistency of the data produced from the inspection. As such the review will evaluate the consistency and accuracy of component rating, inventory items, adequacy of photographic documentation and notes, recommended maintenance actions, critical findings, etc.. Field QC procedures may also include a QC Performance Review of inspection teams. The performance review evaluates the process of conducting the inspection, such as evaluating availability and use of resources (tools, access equipment, etc.), safety items, thoroughness of the inspection process, etc.. The QC Field Performance Review is described more fully in Section 2.3.3, "Quality Control Field Performance Review." These two separate functions may be combined to form a comprehensive QC review of the inspection process and inspection data, or may be conducted separately.

To perform a QC Field Review, the QCO visits a subject bridge with the new inspection report in-hand and reviews the entries in the inspection report to verify the accuracy and consistency with established procedures. The field review should be conducted within 1 to 2 months of the field inspection if practical to ensure conditions have not changed significantly. If done in coincidence with a QC Field Performance review, the visit would occur during a normal routine inspection. In this case, the QC Field Performance Review would be conducted during the inspection process, followed by the QC Field Review of the results of the inspection process.

The field review of inspection data typically includes the following components:

- Independent verification of condition ratings
- Proper identification of CoRe elements
    - Appropriate application of condition states
- Adequacy of photographs, notes and sketches
- Confirm critical problems have been identified
- Confirm appropriate recommended actions
- Confirm load posting (if applicable) and signage
- Confirm physical measurements
    - Vertical clearance measurement
    - Waterway measurements
    - Roadway width, etc.
- Evaluate maintenance recommendations
- Verification of inventory data

A standard form can be utilized to support the QC Field Review and document the results of the review. Use of such a form helps ensure that the reviews are conducted in a uniform manner, and that items are not overlooked. Such a form may be very similar to either Exhibit C1 or C2, depending on the type of inspection being conducted. If the field review includes evaluating the performance of the inspection team, the form may be supplemented with data as described below.

2.3.3 Quality Control Field Performance Review

A field review of inspection team performance is a QC procedure that can help assure that the process of the bridge inspection is being conducted in a uniform manner, and to verify the field performance of inspection teams. The goal of the QC Field Performance Review is to ensure that the process of inspection is conducted adequately to meet established procedures including NBIS and State requirements. The review may include safety related items to determine if State safety procedures are being followed in the field. The review may also include determining if the resources available or utilized by the team match requirements.

During a field performance review, the QCO witnesses regular inspections being conducted by teams operating within their jurisdiction. A typical field performance review would include the following elements:

- Timeliness
  - Is the inspection conducted at the appropriate time in terms of the biennial inspection cycle or other time-based schedules
  - Does the inspection team arrive on time
  - Does the inspection team utilize the appropriate amount of time to conduct the inspection to suggest the appropriate thoroughness of the inspection
- Thoroughness of inspection
  - Access to the structure utilized
  - Full review of all portions of the structure, etc.
- Safety practices
- Proper use of equipment
- On-site availability of resources to conduct the inspection
  - Adequate/appropriate equipment
  - Traffic control (if necessary)
- Confirm qualifications of on-site team
- Observe the overall performance of the inspection team
  - Attention to task
  - Previous inspection results available
  - Appropriate sketches and photographs
  - Note taking on-site, etc.

It is important that the field review of the inspection team be conducted in a constructive manner, such that inspection teams do not feel intimidated by the process of observation by the QCO. A positive environment of communication should be maintained with the inspection team being observed, such that the inspection team recognizes the role of QC as improving the overall

process, rather than a feeling of being "tested." A positive and constructive environment helps support improved communication that will enhance the quality of the process.

A sample form for a QC Field Review is included in Appendix C, Exhibit C3. The form illustrates a sample for evaluating the performance of an inspection team in the field, including general questions regarding field observation of team performance and tools used during the inspection. Exhibit C4 shows a sample form for evaluating safety items that may be reviewed as part of a field performance review. Again, these forms are exemplar in nature and are intended to provide a starting point for individual owners to develop to meet their needs.

2.4 Sampling Approaches for Quality Control Review

There is a variety of approaches to sampling for quality control. Many States implement first-line elements of quality control for 100% of bridge inspection reports. This QC review consist typically of the QC office review as described above. This may be limited to the quality control checks in error-checking software, but typically involves specifying review of the inspection reports by a supervisor or independent peer team leader to confirm adequacy of the inspection report. This review should include verification that all inventory items are correctly coded, that the report is complete with supporting photographs and notes, and the findings are adequately identified and justified with notes and photographs as required, as discussed in section 2.3. Performing QC checks on all inspection reports is good practice for ensuring the quality of data and avoiding coding errors, ensuring completeness of reports and maintaining a high quality level for the inspection reports.

This activity is sometimes delegated to the agency responsible for the inspections, such as a State district, local bridge owner or consultant. In such cases it may be appropriate for a smaller number of inspection reports, say 10% of the inspection reports, to be checked at a higher administrative level to ensure that QC procedures are being effectively implemented to achieve quality. It may also be appropriate to establish example QC procedure or expectations, to ensure that those responsible for conducting QC activities on a day to day basis have full understanding of the expectations for that activity.

Quality Control Field Reviews typically sample from the overall inspection inventory, for example, 10% of the bridges. The objective of the sampling is to evaluate each inspection team. The field review should include at least one field review for each inspection team submitting reports within the work group, to ensure that deficiencies that may be team-specific are identified and addressed. For inspection teams that are new to the inspection program, it may be appropriate to conduct a field review of the inspection results within the first few months of activity, to confirm the team is operating within the guidelines and procedures required. A secondary consideration for field QC reviews should be sampling a representative group of the bridge population for which the inspection teams are responsible.

Within the sampling for field reviews, including bridges with components with a low rating within the field sample population can assist in ensuring that deteriorated components are being adequately assessed. Bridges with components that are rated in poor or worse condition can be more difficult to assess consistently given the subjectivity of the rating scale. Requirements for notes, sketches and photographs of deterioration are greater, presenting a more complete opportunity for assessment of the performance of the inspection team. Maintenance

recommendations and critical findings are also more likely to be included as part of the inspection results. Additionally, review of bridge with severely deteriorated components can assist in ensuring safety by providing an additional review of bridge condition. As such, it may be appropriate to include bridge with low ratings as a component in identifying which bridges to sample for QC review.

2.5 Quality Control Organizational Structures

Quality control is typically implemented within a work group or organizational entity, to ensure the quality of work within that group. Depending on the organizational structure of the DOT, the QC organizational structure may be horizontal, in which the QC is the responsibility of a single organizational layer, or hierarchical, in which QC functions are delegated to several organizational levels to provide redundancy to ensure the effectiveness of the QC process.

A horizontal QC structure is characterized by QC activities being conducted within a single work group conducting the inspection, or within single organizational level. For example, if the QC function for bridge inspection is delegated to a local bridge owner (town, county or parish) in a decentralized system, without additional QC review procedures to confirm the delegated responsibilities are implemented. In these cases, QA processes are needed to address consistency between the separate work groups, to ensure that the defined QC procedures are implemented and that the QC practices are effective in maintaining quality. Such a horizontal system may have limited redundancy, and the frequency of QA reviews should consider the limitations that may exist if individual agencies are not effectively implementing QC within their inspection practices.

Another approach for QC structure is to apply a hierarchical model, in which sampling is done for the purposes of QC at a deescalating rate up a chain of command. Such a model is shown schematically in Figure 2.1. In this process, there is redundancy built into the QC process through the chain of command, and separate roles and responsibilities are clearly defined at each level. For example, in this structure, the bridge inspection supervisor is charged with performing two QC activities, a QC office review and a field review. The office review is conducted on 10% of the inspection reports generated the previous month. Every three months, 10% of posted bridges inspected during that 3 month quarter are reviewed to ensure current and accurate load ratings, and 25% of files for bridges with fracture critical members (FCM) are reviewed to ensure necessary data is present to support upcoming FCM inspections. This QC function is backed-up by a less frequent office review of 5 to 10 randomly selected bridges each quarter, and an annual review of the posted bridge list and fatigue and fracture inspection plan, conducted by the Bridge Engineer (BE). The BE also conducts a QC Field Review of four bridges inspected in the previous quarter. Finally, on an annual basis, a district engineer is charged with visiting inspection teams during unannounced site visits to observe inspection teams, and field – verify inspection results for two other bridges. This hierarchical structure provides redundancy in the QC process that confirms the effectiveness of each level of QC.

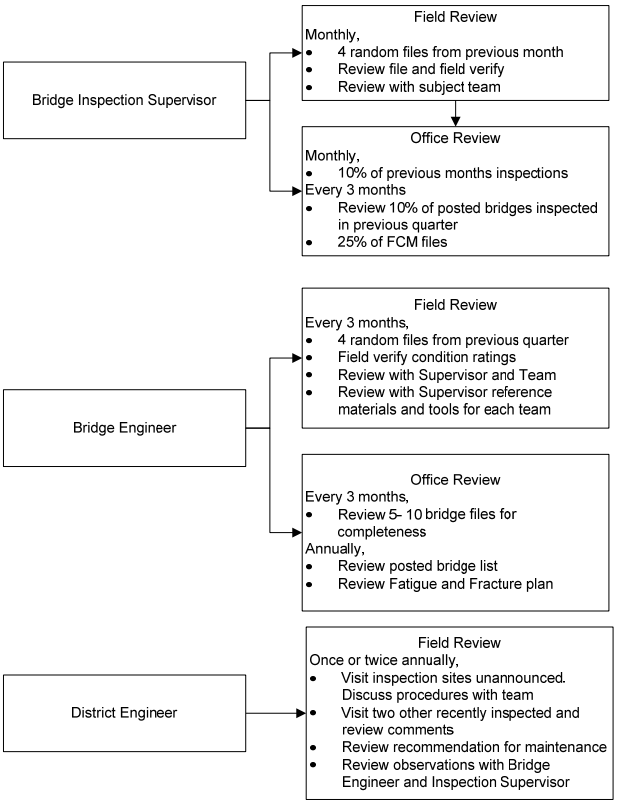

Figure 2.1. Schematic diagram of hierarchical QC structure.

An important element of both models is the review of QC results with inspection teams, supervisors and engineers to make certain that they are aware of any problems or inconsistencies determined through the QC review. This ensures that corrective actions can be taken in response to issues identified during the review. Without such interactions, mistakes are repeated and quality is not improved.

Such a hierarchical model can be applied to a variety of organizational structures and inspection programs. The fundamental characteristics of the hierarchical model are:

- Independence of reviews between organizational levels
- Reduction of frequency with increasing organizational level
- Documentation of review results and review with subject work group

An example of a hierarchical model for QC for a decentralized system, such as when localities or consultants are required to perform inspections and conduct QC, could include a QC field and/or office review applied at an intermediate organization layer, such as at a district office. In this case, and QC review is conducted for an appropriate sampling of inspection reports prior to submission of the report to the state. This ensures the quality of the data from the inspections is maintained at or above a specified level, and this is discriminated from Quality Assurance (QA) because it affects an identified work group (say, the district or region) and does not evaluate the effectiveness of QC practices across the inspection program. Rather, it is a QC procedure that maintains the quality of the bridge inspections within a defined jurisdiction (work group).

A schematic diagram of this type of approach is shown in Figure 2.2 for use when inspections are conducted by consultants under the direction of a State district. In this scheme, the consultant is responsible for QC of inspection reports and load rating bridges. The consultant QC plan may involve a supervisor reviewing 100% of the inspection reports submitted by each of their teams, and performing a field review of a sampling of the reports. Load ratings are also reviewed, at the specified level, and this may include a review of the underwater inspection reports and scour data. Corrective actions based on inconsistencies or errors in the inspection reports are corrected prior to submission to the responsible State unit, for example, the district. Any significant corrections should be confirmed with the inspection teams conducting the inspections. At the district level, a sampling of the submitted reports are reviewed to ensure consistency within the reports (QC office review), completeness of the bridge file, and check any load rating changes that have been submitted. A QC field review of a sampling of the bridges may be conducted to verify data in the inspection reports. Errors, inconsistencies or missing data is reconciled with the consultant submitting the reports, by returning the report to the consultant for correction or other corrective action as specified in the QC procedure. It is important that the consultant have within their QC plan a process to provide these corrective actions to the inspection teams conducting the inspections, to support continuous improvement of quality in the program. Once corrections are made, the report is finally submitted at the State level. At this level, a data check to confirm accuracy of the NBI data entries is made in preparation for submission of NBI data. An office or field review of selected reports and load ratings may be conducted as the final step in the QC process.

This process is discriminated from QA because the goal of the actions undertaken is to ensure the accuracy and quality of data within specific inspection reports. The review processes are undertaken within specific work groups, the consultant, the District and finally the State.

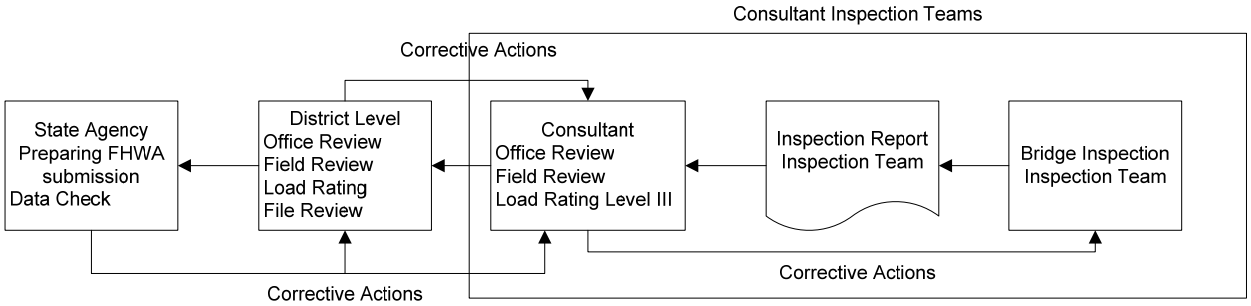

Figure 2.2. Flow chart for QC program involving consultant inspection teams.

2.6 Corrective Actions for Quality Control

The results of QC review of inspection reports may determine that inconsistencies or errors have occurred in the inspection process, or that new information has emerged that affects the inspection report. To ensure the validity and integrity of the bridge inspection report, all changes to the inspection report that occur after the original inspection is complete should be carefully controlled, documented, and the record maintained. Changes to the inspection report should be made by, or with the consent of, the team leader submitting the report. Changes made by the QCO should be limited. The QCO should not implement significant changes in the report without the knowledge and consent of the team leader. The team leader that conducted the

original inspection may have information not available to the QCO (or visa-versa), or may have a legitimate disagreement regarding the change. To address such cases, the QC procedure should include a documented process for implementing changes to the inspection reports based on the QC review, and for resolving differences between the inspection team leader and the QCO.

Specific procedures for controlling changes to the inspection report based on a QC review may vary from State to State based on the process for documenting inspection results and the overall organizational structure. For States utilizing electronic reporting processes, changes to the inspection report may be controlled through software tools that limit changes to an inspection report during the submission and acceptance procedure. For States using a paper reporting process, a procedure for controlling changes to the report can be developed to provide guidance on the process. The example given below illustrates the approach of one state to controlling changes to the inspection report. In this example, changes to the inspection report are categorized to provide guidance on when the team leader should be consulted in making a change.

Table 2.1 Example language for controlling changes to inspection reports.

Administrative changes	If an inspection report must be changed only for administrative reasons (such as a coding error in the control data), draw a single line through the incorrect entry and write the correct one above or below the lined-out entry. If the reason for the change is obvious, no further action is required. Otherwise, provide an explanatory note at the bottom of the page.
Changes in the Field	When a change is required to reflect new information (e.g. discovery of a defect not previously observed), line-out any ratings and/or comments as necessary and add the new ratings and/or comments next to the lined-out items. Provide an initialed and dated explanatory note at the bottom of the page.
Minor Quality Control Changes	When the QCE[1] needs to make a minor change, such as a 9 rating to an 8, or finds a discrepancy between a condition rating and the remarks or photos, (where the correction is obvious), the QCE should line-out the rating, remark or photo description, and write the correction next to the lined-out item. The QCE should date and initial the change.
Significant Quality Control Changes:	When the QCE disagrees with the conclusions of the Team Leader on one or more significant elements of the bridge, the QCE and the team leader need to confer and agree on the change (if any) that needs to be made. If a change is necessary, it can be made by either the TL or the QCE by lining out any ratings, photo description sketch components, remarks, etc. that have to be changed. New ratings, remarks, etc. should be made next to the lined-out items if possible. It may be necessary to supplement the report with additional pages of comments. All changes need to be initialed and dated. Changes made by the QCE should be co-initialed by the Team leader to show concurrence with the changes. If the TL does not agree with the QCE changes, the Regional Structures Engineer should be consulted to resolve the problem.

[1]QCE = Quality Control Engineer

To ensure continuous improvement through a QC program, it is important that the results of QC reviews be documented, and that the subject teams are notified when errors, omissions or inconsistencies occur. There are two components to documenting the QC review: first, documentation should be maintained that required QC reviews have been conducted. Second, results of the review, both positive and negative, should be provided to the inspection teams reviewed such that corrective actions can be taken to avoid errors and/or omissions in the future,

and to provide confirmation of procedures and activities when no errors or omissions have occurred.

Documentation that the QC reviews have been conducted may be in the form of a QC log book to track the performance of reviews over time. This log book should contain the name of the QCE conducting the review, the date of the review, and the bridge number. Other data that may be appropriate for the log book includes:

- Date of the original inspection
- Name or certification number of the Inspection team leader
- Results of the review, such as any problems noted during the review
- Information on the corrective actions taken, e.g. Notified team leader by email on 12/10/2008
- Type of review conducted, i.e. QC Office Review, QC Field Review, QC Field performance review

Corrective actions taken as a result of the QC review might be included in a periodic summary letter provided to the Team leader that identifies specific items from the review (s), discussions with the Team Leader or inspection team, or other written documentation that serves as a basis to ensure that quality improvements will occur as a result of the QC review and that inconsistencies are corrected.

Another method of corrective action is a periodic meeting (monthly, quarterly or bi-annually) within the work group to review the results of the QC review process. Such meetings serve not only to transmit data from the QC review, but also as a means of peer exchange that allows teams to share experiences, indentify deficiency or corrective action needed to improve the quality of the inspections, and allow teams to benefit from the experiences of other teams. These meetings also provide a vehicle for implementing changes or updates, or discussing new directives, requirements or advisories. The collaborative nature of the meetings helps ensure a common understanding of requirements that will improve consistency and helps promote team building.

2.7 Quality Control for Load Rating

Organizational structures for load rating vary widely between States. In some States, the responsibility for load rating of bridges lies in the design branch, in some States load rating is done within the centralized maintenance office, while in others the responsibility for load rating may be delegated to the bridge owner or consultant conducting biennual inspections. As a result, QC processes vary widely, and may range from review to ensure a subject bridge is properly posted according to its current load rating, to recalculating the load rating to ensure the quality of the load rating process utilized.

Systematic processes to ensure quality in load rating include clear documentation of the load rating processes being maintained in the bridge file (or available by reference) as described in the AASHTO MBE. In summary this documentation should include:

- Method of load rating
- Indication of the software used for analysis
- Supporting calculations

- Data input file
- A clear statement of all assumptions used in calculating the load rating
- Reference to guidelines or specification used in the load rating process
- Documentation of the engineer responsible for the load rating

Maintaining this documentation helps ensure the quality of the load rating process and enables the review and recalculation of the load rating during subsequent QC or QA reviews. The documentation also supports rapid recalculation of the load rating as a result of changes in the conditions at the bridge, such as a vehicular accident that damages the structure or an extreme weather event.

Review processes for load rating QC can generally be described as fitting a multi-level model that includes the following:

Level I	Review of load posting
Level II	Review of Documentation
Level III	Recalculation of the load rating

A level I review is conducted to verify that the load rating provided in the bridge file is consistent with the signage in the field, and the data entered in the bridge inventory. This ensures that any changes to the load rating are accurately reflected in signage at the bridge, and that the inspectors are noting the current load posting on the bridge. This is the most fundamental process for QC of load rating. This review should include an assessment to determine if the load rating is current, or if a new load rating is needed due to changes that may have occurred to the bridge. This should also include verification that the load rating engineer is appropriately qualified.

Level II QC review includes the review of assumptions and documentation of the load rating in the bridge file. This review should confirm that the load rating is up to date with the most recent bridge inspection, and has considered any changes in bridge condition. This includes ensuring that the load rating is updated to reflect maintenance or renovation activities at the bridge, changes in bridge condition revealed through inspections, or unexpected events such as vehicular accidents or extreme weather events. The assumptions utilized in the load rating may be reviewed for consistency with inspection results and available plans for the bridge. The Level II review should confirm that the bridge file includes the necessary data regarding the procedures used for conducting the load rating, as described in the AASHTO MBE.

A level III QC review of load rating includes a recalculation of the load rating by a supervisor or supervising authority. This recalculation can help reduce calculation errors and ensure that assumptions that support the load rating are consistent with the condition of the bridge, as determined through the biannual inspection process. A recalculation of the load rating should be conducted by a supervisor or QCE such that the recalculation is independent of the original load rating. This recalculation may be based on the assumptions used for the original load rating, such that the review confirms the accuracy of the calculations. Alternatively, independent assumptions for the load rating based on the current conditions at the bridge (as documented in the bridge inspection reports) can be developed, and the load rating recalculate based on independently developed assumptions. In such cases, it may be necessary to establish a

threshold for determining consistency in the load rating process. A typical measure for consistency might be a 10% difference in the load rating between the review load rating and the original load rating. Such a threshold for consistency might consider the condition of the bridge, the service level of the bridge and other factors, and should be developed by a bridge owner to best meet their needs and specific situations.

The three levels of QC review for load rating suggested would typically be cumulative, such that a Level II review would include the components of a Level I review, and a Level III review would include the elements in Levels I and II. When a hierarchical structure is used in the QC process, these reviews may be conducted at different levels of the hierarchy. For example, a Level I review may be conducted at the lowest level in the hierarchy, Level II at the next higher level and finally Level III at the highest level. This may have diminishing frequency at increasing organization levels.

Frequency of QC reviews for load rating vary widely in current practice. Level I and II reviews are typical QC practices that may be a part of the QC review of inspection reports, and as such have a sampling frequency that is the same as that utilized for inspection report review. This sampling frequency may be as high as 100% of inspection reports, or a sampling of the bridges inspected (for example, 10% of the bridge inspections). A level III review is more likely to be conducted on a sampling of bridges that may be random sampling (5% of bridges, for example) or event-based, i.e. conducted in response to changes in the load rating or major renovations at the bridge. The review of the load rating described may be a part of the QC program when applied within the organizational structure or work group, or may be part of QA process when applied across a bridge inventory.

3 QUALITY ASSURANCE

Quality assurance is defined in the NBIS as "The use of sampling or other measures to assure the adequacy of quality control procedures in order to verify or measure the quality level of the entire bridge inspection or load rating program." A key characteristic of QA so defined is that the evaluation of quality is focused on entire bridge inspection and load rating program. In contrast to QC procedures, which are typically executed within a work group or organizational element, the process of QA is intended to ensure that the QC procedures within the work groups are effective, that these procedures are adequate to achieve quality, and that the overall program is effective in maintaining quality. As such, QA is typically conducted from outside the work group, while QC is conducted within the work group itself.

In some cases, QC activities and QA activities may include the same functions, for example, a QC office review and QA office review may both include a review of ratings, inventory items and contents of the bridge file, but with different end goals. The QC review ensures that practices are adequate to ensure quality within the work group, and to correct deficiencies in specific inspection reports. The QA review ensures that these QC efforts are equally effective across different work groups, resulting in overall quality in the bridge inspection program. As a result, it can be difficult and confusing sometimes to determine if a particular function or activity is QC or QA. Generally, the objective of QA activities are not to correct deficiencies within a specific inspection report or load rating, but rather to monitor and adjust as necessary the

program requirements and procedures to ensure overall quality levels are maintained at the desired level.

It is important that a QA program have documented procedures and practices to ensure that QA is conducted in a uniform manner. This includes delineating the frequency of reviews, the procedures to be conducted as part of a QA review, methods of assessing quality, reporting requirements, and procedures for implementing corrective actions. It is important that the QA program be fair and objective, such that all work groups evaluated during the QA process undergo the same level of review. In conducting these reviews, it is equally important to establish procedures and practices that are constructive and have the overall goal of improving the inspection program. It is important that the subject of the QA review understand the process and appreciate the goals of the QA review, such that the process is perceived as a constructive and collaborative effort to improve the quality of bridge inspections. If the perception of the QA program is that the goal is to reprimand or punish inspectors, the program will be viewed in a negative way that could be detrimental to the overall goals. If the QA process is viewed as a constructive effort intended to improve the overall program, then it is more likely to be viewed positively by inspectors. A QA process can have many positive benefits for inspection teams, including identifying needs for improved guidelines, identifying where additional resources or training may be required, and supporting the efforts of the inspection program to support effective bridge management. If presented in a constructive manner, the implementation of a QA program can improve the morale of inspection teams and improve the overall quality of the program merely by its existence.

To ensure that the QA program is perceived as a constructive process by inspectors, it is important that the review procedures are well documented and understood by the inspection teams being evaluated. These procedures should be objective and fair, should provide quantitative results to the extent possible, and be administered uniformly and consistently during each review.

3.1 Elements of Quality Assurance Reviews

There are many different elements of a bridge inspection and load rating program that can be the subject of QA reviews, depending on the characteristics of a particular program. Common elements subjected to QA review and assessment include:

- Review of Inspection Reports
    - Appropriate forms have been used
    - Consistency of ratings for NBI items
    - Proper identification of CoRe elements
        - Appropriate application of condition states
    - Identification of critical problems
        - Appropriate recommended actions
    - Accuracy of data entry in accordance with FHWA coding and local requirements (Pontis, State-specific Bridge Management System, etc.)
    - Completeness of supporting notes and photographs
    - Appropriate use of recommended actions, critical findings and flags
        - Adequacy of follow-up actions on critical findings
    - Documentation of inspector qualifications
    - Maintenance recommendations consistent with inspection findings

    - Communication between inspection and maintenance groups
    - Clearance and waterway profiles
    - Scour evaluation
    - Inventory items
    - Current load rating
        - Load posting matches load rating and inventory data
- Field review of Inspection teams
    - Verification of NBI condition ratings
    - Proper identification of CoRe elements
        - Appropriate application of condition states
    - Identification of critical problems
        - Appropriate recommended actions
    - Adequacy and accuracy of photographs, notes and sketches
    - Verification of inventory data
    - Review of the Field performance of the inspection team
        - Timeliness
        - Thoroughness of inspection
        - Safety practices
        - Proper use of equipment
        - Availability of required resources
        - Confirm qualifications of on-site team
- Review of Bridge File elements
    - Scour evaluation
        - Scour plan of action, if needed
    - Load rating
    - Underwater inspections
    - Documentation of qualifications of inspection staff
    - Drawings and plans for the bridge
    - Inspection schedule
        - Underwater inspection schedule
        - Biennual inspections
        - Fracture Critical Members
        - Special inspections
        - Damage inspections
    - Review of critical findings
        - Reporting of critical finding
        - Schedules for addressing critical finding
        - Consistency with State-wide critical findings procedures

This listing provides examples of items that may be subject to review as part of a QA process, other items in addition to those listed may be required to meet the needs of bridge owners and may be found in existing QA programs. To provide an example, forms for conducted QA reviews have been included in Appendix D. This includes two forms from the State of Wisconsin. The first, Exhibit D1, is a sample form used for a review performed by the central office and FHWA representative of their inspection program. Exhibit D2 provides an example that a district might use to conduct a review of a locality. The third form, Exhibit D3, is from the

State of Minnesota. These forms show example methods of inquiry and quality dimensions that are evaluated during their respected QA programs, and are included here to provide examples of well-developed documentation for QA practice. The review and evaluation of the items identified in these forms and the listing above can be conducted through a variety of methodologies, as discussed below.

3.2 Methods of Quality Assurance

The application of QA procedures is widely varied from State to State due in part to the diversified organizational structures of States, and the level of sophistication for these QA practices cover a wide spectrum of possibilities. QA practices of States can be generalized into several models for conducting office and field reviews. These models address the overall procedures for QA review with the goal of validating the effectiveness of the QC procedures.

The models were developed to provide concise summaries of different approaches to conducting QA reviews of a bridge inspection program. Specific QA programs may have characteristics of more than one of these models, or more than one model may be applied within a program. The models are provided for guidance on different conceptual structures for a QA practice. Specific overviews of how such models can be implemented are provided.

There are certain characteristics of the models that are common and represent basic elements of effective QA procedures. This includes documentation of the QA process as discussed previously. This documentation describes, among other things, the qualification and characteristics of the review team, the procedure for selected the bridges to be part of the review, a description of the review process, and the documentation that will be generated as part of the review. The review function itself varies in characteristics according to the overall model for QA being implemented. There is a commonly a step in the process in which the results of the QA review are compiled and analyzed. Finally, there is a step in the process that provides feedback to the team being reviewed based on the QA review. This feedback identifies team-specific corrective actions that are used to improve the performance of the team or work group being reviewed. Corrective actions at the team level might include identifying additional training or resources required to improve the quality of inspections conducted by a particular team. Finally, the results of the QA review are compiled to determine corrective actions at a program level. Corrective actions at a program level might include changes to inspection requirements, changes to inspection procedures and guidelines, indentifying additional training needs, or providing different resources to the inspection teams across the State.

This section describes four general models for implementing a QA program. These models are intended to describe the organizational structure and goals of different approaches to QA currently utilized by State Departments of Transportation. Because the organizational structures of States vary considerably, the described models do not delineate specific positions, roles or procedures for QA, but rather describe an overall approach that can be adopted. Specific procedures can be developed within these conceptual models to meet the individual needs and resources of a State.

The first model described in the independent oversight model (IOM). The fundamental characteristic of this model is that there is an independent re-inspection of a sampling of bridges to identify inconsistencies between the re-inspection and the original inspection. The second

model presented in the Control Bridge Model (CBM). This model is characterized by the utilization of a small number of "control bridges" to evaluate inconsistencies in the results of many inspection teams performing inspections on the same bridges. The third model is the Collaborative Peer Review (CPR) model, which generally utilizes a collaborative, team-based approach to reviewing inspection practices and results to develop consistency in the inspection process. Finally, the Field Verification Model (FVM) is described, in which quality is evaluated by comparing a current inspection report with conditions in the field to verify the inspection results and identify inconsistencies. The following section describes the fundamental principles of each of these methods.

3.2.1 Independent Oversight Model

A commonly used model for QA review is the Independent Oversight Model (IOM), in which a third party is enlisted to re-inspect a number of bridges. Under this model, bridges that have been inspected by the subject work group undergo a complete re-inspection that is independent of the inspection being evaluated. This re-inspection generates a companion inspection result that can be compared to the subject inspection data for analysis of consistency and accuracy.

The re-inspection is typically conducted without knowledge of the subject inspection result to ensure the independence of the review. This reduces potential bias created by knowledge of the current inspection ratings and other data being evaluated by the review team. If the current inspection results are known to the review team, the review team may be reluctant to identify inconsistencies, or otherwise be influenced by the existing inspection results. The re-inspection is typically conducted without the subject inspection team being reviewed present during the re-inspection. This helps to maintain objectivity and ensure that the process is conducted without influence of personality, appearance, and/or personal interactions. The independence and objectivity of the re-inspection is important to ensuring the effectiveness and consistency of the QA process.

Specific methods of applying an IOM model to bridge inspection QA can vary according to the organizational structure of the State and resources available for conducting reviews. Key characteristics of a typical IOM model include:

- An independent re-inspection of bridges by a third party
- Review of bridge file including
    - Validating inspector qualifications
    - Review of load rating
    - Review of plans of action for scour critical bridges
    - Review of underwater inspections
- Report on difference between the re-inspection results and the original inspection results
- Close-out meeting with subject work group to review results and indentify inconsistencies found during the review
- Adjustments as required to requirements, procedures, training and inspection guidelines (corrective actions)
- Summary reports providing an overview of the QA results at a programmatic level

This model can applied through a variety of means for State and local authorities. A QA consultant may be used to perform the re-inspection; peer teams, supervisors or other qualified

personnel can also be used as independent re-inspectors to evaluate the performance of teams in the field. It is advantageous to utilize a limited number of independent reviewers to ensure consistency in the QA review. For example, if a large number of peer teams are used as independent reviewers, the variation in results across the population of review teams may be significant, reducing the ability to evaluate the overall consistency of the inspection results. The review team should also be free of conflicts, such as might be encountered if members of team review their own inspection findings, or finding from their own work group. The qualifications and organization of the review team should be described in the QA procedure.

An expert team may be utilized to conduct the review. This expert team is a bridge inspection team that is highly knowledgeable and experienced in the inspection practices and policies of the State. The expert team may include the bridge inspection Program Manager, or individuals selected by the Program Manager. Key members of the expert team may be fully qualified as team leaders and/or be highly knowledgeable of the correct implementation of the State's guidelines and procedures. Members of the expert team may have special knowledge developed by working closely with inspection program managers and/or working within a centralized unit responsible for defining the guidelines and inspection procedures. The review team may have other members that are not necessarily qualified as team leaders, but bring special knowledge to the process. This might include an FHWA representative, individuals from the design division, or other members that meet the specific needs of a particular State.

Efforts should be taken to ensure those selected as reviewers are conducting the review at the desired level of quality such that inconsistencies identified are meaningful. In the IOM model, the review team is assumed to provide a control inspection standard. The original inspection that is being reviewed is compared with this control inspection to determine inconsistencies. Therefore, it is imperative that the re-inspection provides reliable results that are consistent with all aspects of the guidelines and procedures used in the inspection process.

The IOM model is shown schematically in Figure 3.1, which shows generally the QA process. In this model, the documentation of the QA program includes a description of the review process, identifies the characteristics of the review team (i.e. QA contractor, expert review team, etc.). There is also documentation or policy on how many bridges are to be selected for evaluation, and what bridge characteristics should be utilized. There is a policy identifying what items are part of the QA review, for example, the elements of the bridge file that will be reviewed, what activities are to be conducted as part of the review, etc.. The inspection process of the subject work group is then evaluated through the independent re-inspection of selected bridges, a process that allows for evaluation of consistency between control inspection and the subject inspection team's finding. This may include condition ratings, inventory items and element level ratings if relevant. This may also include reviewing scour evaluations, load ratings, and other items.

The results of the QA review are typically summarized in a QA report generated and discussed directly with the subject work group at a closeout meeting, which provides an opportunity for corrective actions at the inspection team level. Because the evaluation of QA process is independent and quantified, it is possible to provide quantitative data on the consistency of the inspection process both at a local level and across the entire system. A summary report is

typically generated including the analysis of the results of the individual work group reviews, such that changes can be instituted at the program level.

Such a model is durable and can be applied to both centralized and decentralized organizations. For example, if localities are responsible for bridge inspections under a decentralized organizational structure, the expert team or QA consultant can be assigned to review a portion of the overall bridge owner population each year. Under a centralized organization, for example with districts reporting inspection results to the DOT, the QA review team may review each district conducting bridge inspections. Care should be taken to ensure that each work group responsible for conducting QC activities be reviewed as part of the QA process, such that the effectiveness of the QC system in achieving the desired level of quality is confirmed. A example of the IOM model is summarized in Chapter 5, section 5.1.

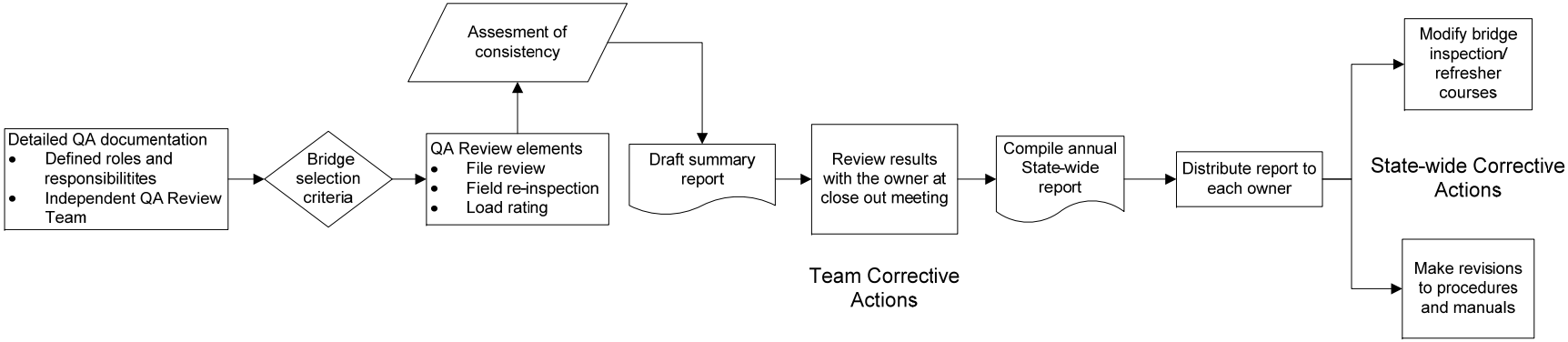

Figure 3.1 Example flow chart for IOM for QA of highway bridge inspections.

3.2.2 Control Bridge Model (CBM)

The Control Bridge Model (CBM) is characterized by the use of a small number of "control bridges" to evaluate inconsistencies in the inspection process. These control bridges are inspected by all of the inspection teams being evaluated as a part of QA review. Each inspection team conducts a routine inspection of the control bridges and generates a suitable and complete bridge inspection report. The results of the inspections from all of the teams are compared with a control inspection conducted by an expert team to identify inconsistencies or errors between the two inspection results.

The inspection results can then be analyzed for two purposes. First, the results can be used to evaluate the performance of individual teams in conducting inspections at the desired level of quality. This can indicate specific teams that are performing below expectations, and may need additional training or guidance to improve their inspection practices. Second, the results can be analyzed to determine inconsistencies that are programmatic in nature, and signal the need for improving certain characteristics of the inspection program. For example, if the inspection teams use a variety of different CoRe elements to describe the same element, this may indicate that the element descriptions are unclear, not well understood, or too many closely related elements are being used to allow for consistent utilization in the field. If there is a wide distribution of ratings for a particular bridge component, this may indicate that the descriptions associated each numerical rating are inadequate, or that additional training is required to ensure consistent application of the ratings.

Figure 3.2 shows a schematic diagram of the CBM model. In this model, a detailed QA plan is developed and an expert team selected to provide control inspections of the subject bridges. Bridges are selected to act as control bridges that are typical of the bridge inventory, or represent areas of focus for the inspection program. The expert team inspects the bridge to develop the control inspection. The subject teams then conduct independent inspections of the bridges, and may conduct other procedures identified for analysis. For example, load rating analysis or scour evaluation to determine if the bridges require a scour plan of action may be required. Results of the inspection and analyses by the subject teams are then compiled and analyzed to determine areas of inconsistency or common errors. Subsequently, a meeting of the inspection teams is held to discuss the results of the inspections and analysis of inspection results compared with the control. This review of the results allows the teams to compare their performance both with other inspection teams and with the control inspections. This provides both training of the inspectors and peer exchange. Corrective actions to address deficiencies both at the team level and at the program level are developed with input from the participating teams. Corrective actions such as changes to manuals or procedures are implemented at the program level, and presented to the inspectors at an inspector workshop the following year.

The advantage of this method is that it focuses on the individual inspection teams, ensuring that the QA process reaches each team. Additionally, the assessments are uniform across the population of inspectors participating, such that inconsistencies and frequent errors can be easily identified. This data can then be utilized to support corrective actions, such as changes to the inspection manual or specialized training.

A “control bridge” is simply a highway bridge of typical or common characteristics for the overall bridge inventory in a State. Each inspection team being evaluated observes the same bridges under the same conditions, and as such the bridge acts as an experimental “control.” In this manner, the approach to conducting the inspection, tools used, time required, and notes, photos and other supporting information should match across all of the inspector population, if the guidelines and procedures are being applied evenly. The advantage of such an approach is that inconsistencies in the inspection process can be clearly identified. Specific deterioration can be documented, for example, and the results from different inspection teams can be directly compared. This reduces the uncertainty in results compared with the evaluation of teams inspecting different bridges, where a one-to-one comparison between results from different inspection teams is not possible. The disadvantage of this approach is that only a small portion of the bridge inventory is evaluated during the review, such that the review is less broad than if a larger number of bridges were included.

A unique feature of the CBM as it has been implemented in Oklahoma is the inclusion of an experimental evaluation of load rating. This evaluation included a questionnaire distributed that included questions regarding procedures and assumptions for load rating based the AASHTO Manual for the Condition Evaluation of Bridges. A load rating for H-20 and HS-20 loading for the control bridges was part of the questionnaire, and subsequently compared with the results from the control team. This allows for the consistency of load rating engineers to be assessed in a uniform manner. The Oklahoma questionnaire is included in Appendix E.

One disadvantage of the CBM is that it evaluates primarily the bridge inspectors and inspection process, and does not include QA for other aspects of the typical bridge file. A separate activity to conduct office reviews within the work group conducting the inspection may be necessary to measure the effectiveness of the QC procedures within the work groups in terms of maintaining comprehensive bridge files, scheduling of inspections, and other items not addressed through the CBM process.

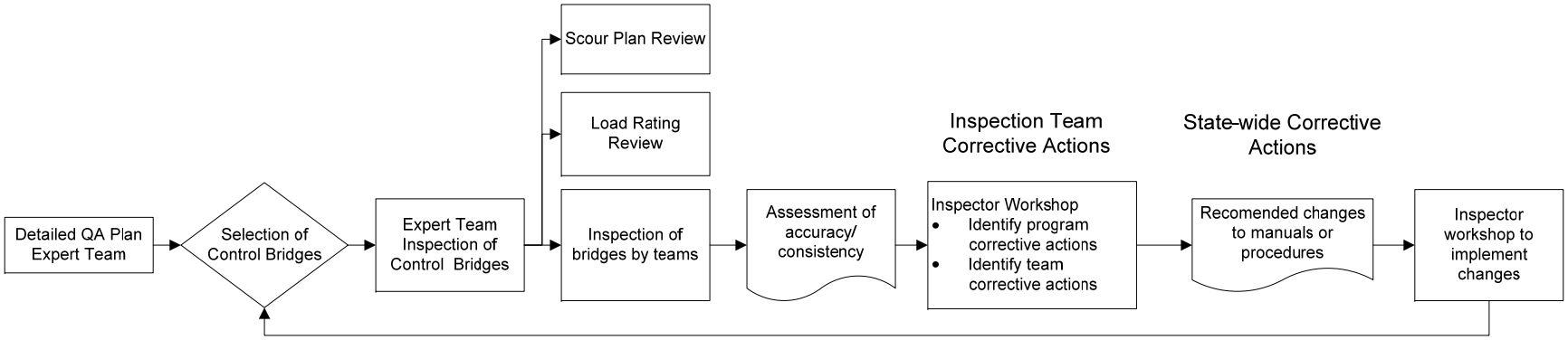

Figure 3.2 Example flow chart for CBM for QA of highway bridge inspections.

3.2.3 Collaborative Peer Review Model

The Collaborative Peer Review (CPR) model is characterized by a team-based approach to the review of inspection activities in the field. This process is similar to the IOM in that a re-inspection of bridges within a region or locality's jurisdiction is conducted. The process for CPR is shown schematically in Figure 3.3. In this model, the subject inspection team representative, such as the team leader (or the team), participates in a re-inspection of a sampling of bridges within their jurisdiction. A team of peers are assembled to participate in a team-oriented re-inspection. The peer team would normally be assembled from inspectors from another work group, representatives from the central office, and others that may be appropriate such as the FHWA bridge engineer, design group, or maintenance engineers.

Building from a blank inspection data sheet, the QA team including the subject inspector collaborates to develop appropriate component ratings and identify elements and condition states (if applicable). Discussion of appropriate ratings and element selection is ongoing during the QA inspection. After the team has developed its report, the original inspection report is reviewed and differences are discussed in detail among the team. A report is generated documenting the results of the review.

The consistency of inspection results are quantified by comparing the results of the collaboratively-developed inspection report with the original inspection results. This provides a means for identifying areas where improvements may be needed for the specific inspection teams, and the summarization of results from multiple reviews can be used to identify programmatic improvements.

The CPR process may include an office review that includes a review of the bridge file, scour plans of action, load rating compliance and inspection scheduling, etc.. The peer team may also review the resources available to the inspection teams, such as tools, access equipment, etc., confirm the qualifications of inspectors, load rating personnel and underwater inspectors, and other common components of an office and field reviews.

The collaborative nature of the inspection provides additional training for inspectors during the inspection and supports a positive environment for QA reviews. The ancillary members of the peer group also benefit from improved understanding of the inspection process and challenges faced in assessing the condition of the bridge. The inclusion of maintenance engineers or others responsible for the operation and repair of bridges can support improved communication between maintenance and inspection staff and assist in developing a more holistic approach to the inspection and repair of bridges. The inclusion of design staff in the CPR can also support the communication between work groups, and help design engineers to identify design characteristics that may have a negative impact on the durability of a bridge. Additionally, a better understanding of access challenges faced by inspectors can be developed in the design team, which may lead to improve bridge designs for inspectability.

A discussion of the effectiveness of the inspection process with local maintenance forces may be a part of a CPR model, and could be applied within any of the model structures presented here. Such an activity promotes the overall effectiveness of the bridge program, and is discussed further in section 3.3.

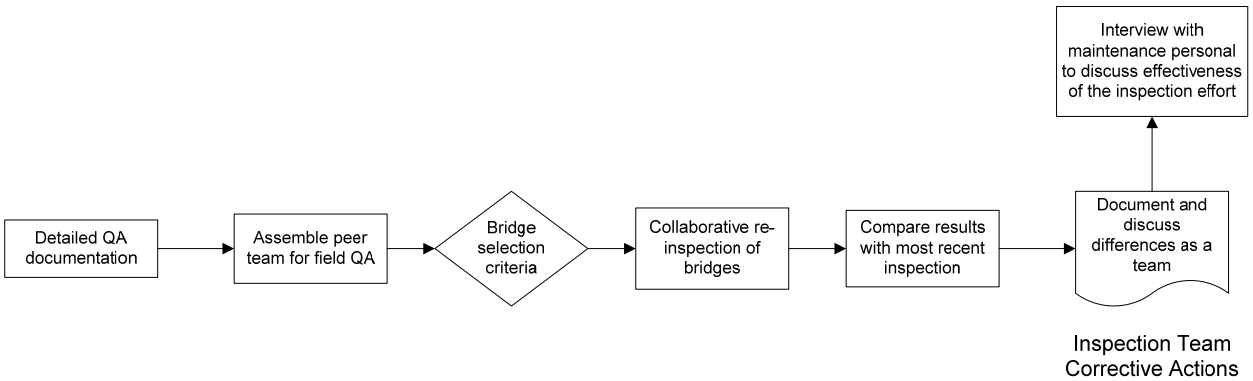

Figure 3.3 Example flow chart for CPR model for QA.

3.2.4 Field Verification Model

A fourth model used for the QA reviews is a field verification (FVM) of the inspection results. This approach is probably the least formal of the methods for QA. It consists of performing a field review of the bridge inspection results to verify the results. This is typically done by the QAO traveling to the bridge with the most recent inspection report in-hand, and reviewing the subject bridge in the field. The QAO reviews the bridge to assess the consistency of component ratings or element assignments with procedures and practices, to determine if appropriate notes and photographs are provided, and confirm that critical problems have been identified. Variations between the inspection report and the reviewers findings are documented. This review is typically conducted by an individual such as a supervisor or reviewing engineer with responsibility for oversight of one or more inspection teams, or a program manager for the State. Because the verification inspections are typically conducted with the most recent inspection report in-hand, the re-inspection is not necessarily independent or objective. This model is typically employed on a per-team basis, with the emphasis to visit each team during a specified interval, such as every year. Reporting on the results of such a field review may be through an individual report to the team to implement team-level corrective actions, and/or annual reports that summarize the finding of the field verification activities, develop recommended corrective actions, and highlight focus areas for quality improvement. Results of such a review can be qualitative in nature, resulting in some limitations in assessing the performance on a system-wide basis. Qualitative data is data that is not represented numerically, and typically would include such things as a list of specific recommendations or a list of inconsistencies found during the review that is specific to the work group evaluated. The inclusion of a quantitative approach to document the rate of inconsistencies could be included in such a model to lend a quantitative measure that can be used to document quality improvements over time.

3.2.5 Scalability and Cost

There are obviously variations on the basic models presented here, with specifics and personnel changing depending on the organizational structure of the individual Departments of Transportation. In particular, the IOM has fairly broad application in various forms to assess different levels of organizations, with the standard practice including oversight of bridge inspection practices by a higher organizational level. For example, a State conducting QA

reviews of local bridge owners or for inspections by consultants. Additionally, this basic model may be implemented in an ad-hoc fashion to address specific deficiencies recognized through QC and normal operations, such as a need for evaluation of load rating practices statewide.

The models presented are intended to be scalable to meet the needs of specific bridge owners. For example, the IOM model may be conducted on a State-wide level to assess each district within a State on an annual basis. However, the model could also be applied to a small population of work groups, for example, review of the consultant inspection team performance by a local jurisdiction such as a county or city. The model is also applied for the evaluation of portions of a bridge program on an annual basis, for example, to perform QA on a limited number of work groups each year with a goal of assessing all works groups over a multi-year time frame. Available resources for conducting the reviews is frequently a factor in the scope of the application of the models, as would be expected.

Given the influence of available resources, the cost of the various models may become an important factor in the selection of which model to apply. However, because the models are scalable, specific data on cost is difficult to characterize. The IOM model typically has a relatively high cost structure, because it requires re-inspection of bridges for which inspection costs have already been paid. However, the scope of the review can be adjusted to match available resources, with a commensurate reduction in benefit from a comprehensive review of all work groups. The model is frequently implemented using a consulting inspection firm to perform the QA procedures, so costs may be well defined.

The CBM requires inspections of a few bridges by all work groups, and as such has a costs associated with travel, time etc. for the teams participating in the process, and for the expert team providing the control inspection. These costs may be difficult to quantify when state forces form the bulk of the teams participating and overseeing the process. Similarly, the CPR model may be implemented largely using state forces, so costs may be difficult to fully quantify, but obviously a there is a large effort of time and resources to form the peer teams, travel to the subject work groups, and conduct the reviews. The CBM and CPR models can be generalized as having a medium cost structure, though the scope of the implementation obviously is a controlling factor.

The FVM models is generally the lowest in costs, involving possibly only a single person performing a verification review in the field. As such, reporting is limited, a re-inspection is not conducted, and documentation is generally limited to only deficient or inconsistent findings. As such, this model has a relatively low cost structure. However, consideration of the ability of this method to effectively achieve the characteristics of an effective QC/QA program may need to be considered in decision-making.

3.3 Communications Between Inspection, Repair and Maintenance Work Groups

The appropriate identification of critical findings from the inspection process is an important element of effective safety inspection of bridges. Once identified, follow-up on critical findings should be addressed in a timely manner, and procedures for ensuring this are required by the NBIS. Fundamentally this relies on effective communication between those responsible of the safety inspection of bridges and those responsible for the repair and maintenance of the structures on a day to day basis. Organizational structures within States vary considerably, and

these separate functions may or may not be within the same work group. Regardless, the QA process provides an opportunity for assessing this communication, and for evaluating and improving the procedures for ensuring follow-up on critical findings and maintenance recommendations generated from bridge inspections.

QA activities that could be applied to support this evaluation include:

- Interview local maintenance personnel
- Document and assess time intervals between inspection finding and follow-up actions
- Collaboration meetings between inspection and maintenance personnel

Interviews with local maintenance and repair personnel can provide feedback on the effectiveness of communication of inspection results to the maintenance personnel. Suitable items for inquiry might include:

- Is the data provided in the inspection report sufficient to support maintenance activities?
- Are critical finding reported and acted on in a timely manner?
- Is there adequate communication between the inspection work groups and the maintenance work groups?
- Are there improvements to the inspection reporting process that would assist you in more effective maintenance functions

Items such as these may also be addressed in collaboration meetings between the inspection teams and the maintenance personnel. Such meetings may be conducted as a normal business practice, or may be included as part of the QA review.

These practices supports a more holistic approach to inspection and maintenance of bridges, promoting collaboration across the organization in support of the overall goals of the program.

3.4 Load Ratings

The process of conducting QA on bridge load ratings can have the same elements as QC of load rating, though for somewhat different purposes. As part of a QA review, the load ratings may be evaluated according to the following schedule:

Level I	Review of load posting
Level II	Review of Documentation
Level III	Recalculation of the load rating

Like with a QC review, the Level I load rating review consists primarily of

- ensuring that the load posting at the bridge matches the load rating,
- The load rating in current
- The individual that conducted the load rating is qualified.

A level II review would include the components of the Level I review plus

- Is the load rating documentation complete, including assumptions and summary sheets?
- Do the assumptions match available plans and inspection results?
- Is the load rating analysis conducted according the appropriate procedures?

A level III review would generally consist of all of the elements of Levels I and II, but would also included a recalculation of the load rating. As with QC, this recalculation may be based on the assumptions documented in the bridge file, or may include developing new assumptions based on the inspection results and information available in the bridge file. In the latter case, a threshold for the accuracy of the load rating would need to be specified to determine the quality of the load rating, for example, a 10% difference in the load rating.

The QA for load rating according to the schedule shown can be implemented within any of the QA models presented. For Level III reviews under an IOM model, recalculation of the load ratings may be conducted for each of the bridges assessed as part of the program, or of a sampling of the bridges assessed. For a CPR model, a Level II can be conducted as part of the field review of the inspection team, other resources may need to be employed to conduct a Level III review.

Within a CBM, where inspection teams are focused on inspecting a small sample of bridges that they have not inspected as a normal part of their business, an alternative methodology is needed to assess the quality and consistency of the load rating process. One approach that has been utilized is to have the control bridges load rated by the work groups participating in the semi-annual meetings. This may be implemented through utilization of a questionnaire distributed to the work groups that requires the load rating of the test bridge, and questions asked regarding methodologies for load rating. An example questionnaire is included in Appendix E. This questionnaire contains questions regarding overall application of the AASHTO Manual for the Condition Evaluation of Bridges (the predecessor to the AASHTO MBE), and specific questions regarding applying procedures to the control bridges being evaluated. As part of the questionnaire, a load rating for the control bridge is calculated and compared with a control load rating for adequacy and consistency.

3.5 Metric Methods

Obtaining objective, quantitative data is an important component of effective QA. "Quantitative" data is any data represented numerically, while "qualitative" data is anything that is not represented numerically, and could include general observations or text descriptions of performance qualities (above average, inadequate, inconsistent, etc.). Quantitative data can be summarized more readily, analyzed statistically to represent trends, and readily used for comparison. Quantitative metrics can also provide more objective assessments of quality by reducing bias and subjectivity of entirely qualitative data. Examples of quantitative data from a QA review might include the number of deviations or inconsistencies in an inspection report when compared to a standard, the size of the deviation and a weighting factor that considers the criticality of the deviation, etc.. It may also include a numerical rating that compares activities that are assessed qualitatively with expectations established in a numerical rating system.

3.5.1 Quantitative Data

The use of quantitative data in the QA process allows for analysis of results of QA across the organization, provides a measure of one work group relative to the overall system, and can be a measurement for progress, i.e. continuous improvements in program. If the results of a QA review are not quantified, that is, represented as numerical scores, ranking or results, it is difficult or impossible to effectively analyze or compare the quality of the system or components of the system (work groups), or to evaluate and document improvements over time effectively.

Additionally, establishing quantitative methods of assessing inspection quality provides for systematic and objective assessments across a bridge inspection program.

Several approaches to establishing quantitative metrics for quality can be utilized for a QA review. These include measuring the consistency of inspection results overall, evaluating the error rate for specific observations, quality ratings for element – level inspections, and error rates on a per bridge basis. These methods focus on quantitative assessment of condition ratings and inventory items from inspection reports. Quantifying more process-oriented items, such as inspection photographs and notes, or critical findings, is discussed in section 3.5.2.

For NBIS-type inspections, one metric examines the consistency of assigned ratings and inventory items overall by dividing the number of inconsistent items, as determine by thresholds (+/- 1 condition rating), by the total number of items that could be inconsistent. This may include load rating accuracy and inventory items. This results in an overall figure representing the consistency between QA inspection results and the subject inspection result, and allows for the evaluation of quality improvements and assessment of the overall program.

Another related metric is to provide a quality rating or score that relates the component condition ratings to a control rating. In this metric, the component rating for a particular team is compared with the control rating provided. If the inspector rating matches the control, they receive a score of 100%. If the inspectors rating is +/- 1 from the control, they receive a score of 75%, and if the inspectors score is +/- 2, they receive a score of 25%. This allows for each inspector to have a quality score that captures the consistency of their inspection with the control inspection. It also allows for the consistency of a population of inspectors to be characterized for the purpose of obtaining summary data on a population. This provides more detail than identifying, for example, the number of inconsistencies based on some defined threshold value, such as +/- 1 from the control rating, because the degree of the inconsistency is assessed. As such, it is a quality measure of the variation from the target value, the control value in this case. It also supports the goal of continual improvements by measuring all variations from the control.

Element-level inspections allow for portions of a particular element to be distributed over several condition states. To assign a quantitative number to represent the consistency between control evaluation and the evaluation of a specific team, a weighted system that considers the number of possible condition states for an element and the portions assigned to each state could be used. In this approach, the inspector is granted 50% credit for assigning portions of the element to a condition state adjacent (diagonal) to the control, based on an element with 5 condition states. For example, if the control inspection rated the element as 100% in condition state 2, and the inspector rated this element as 100% in state 1, the inspector might receive a score of 50%. For elements with fewer condition states, the 50% modifier is normalized to the number of condition states possible for assignment. That is, if there were only 3 condition state possible, assignment to an adjacent condition state would received 3/5 * 50% or a score of 30% instead of 50%[13]. Utilizing this scheme, an overall percentage score is provided to represent the accuracy of the assignment of condition states that can be used to compare results with the larger population of inspectors, and help inspector identify areas where improvement is needed.

Another method of comparing element-level inspection data generally allows for variations in the assignment of portions of an element to a condition state, and credits the inspector for selecting the correct element and generally having the right apportionment within condition states. In this scheme, the overall inspection results, including assignment of elements, condition rating and inventory items are scored based on a number of errors per bridge, with a quality threshold established based on the number of errors per bridge.

3.5.2 Qualitative Data

Sometimes QA reviews are entirely qualitative in nature, with a report generated that provides an assessment of specific problems identified through the QA review. Such a report could use qualitative descriptions such as "substantially meets agencies requirements" or "results are generally consistent with the QA review." This would typically include statements identifying specific area of deficiencies, such as listing items that were incorrectly coded, specific ratings that were inconsistent with the standard, or practices observed that are not consistent with guidelines or procedurs. The report can be shared with the work group under evaluation as a means of corrective action and training. A summary report that synthesizes qualitative results across the program may be generated as a means of representing the overall quality level in the program and identifying areas where corrective actions are warranted.

However, using qualitative data, it may be difficult to measure the effect of the QA review, measure overall improvements to the program or establish an acceptable level of quality. Additionally, it can be more difficult to implement the QA process uniformly and consistently, since qualitative descriptions can be subjective and may depend heavily on the reviewer. In general, quantitative measures of quality are preferable to qualitative assessments. However, qualitative data can play an important role in documenting the results of a QA review by relating specified deficiencies and needs in plain language that informs the corrective actions to be taken in response to quality findings. Typically, a quality report may include both quantitative and qualitative elements.

Qualitative results can sometimes be converted to quantitative results by establishing a numerical system for expressing qualitative descriptions. The NBIS condition rating are an example of this, converting essentially qualitative descriptions such as Good, Fair or Poor into quantified levels on a numerical scale from 1 to 9. This enables the quantitative analysis of results and comparison across the inventory of bridges, for example. The establishment of a numerical rating system may also mitigate subjectivity by providing a framework for assessment that can be applied more uniformly and objectively.

This approach can be utilized to characterize essentially qualitative results from a QA review. This may be particularly useful for the assessment of process-related items for which specific thresholds may be difficult to establish. For example, if the assessment of the quality of notes in inspection reports was desired, a system of qualitative descriptions could be established ranging from comprehensive to inadequate, with intermediate levels to indicate partially completed notes that need improvement. Converting these levels to a numerical score, such as rating them on a 1-5 scale with associated descriptions for each level, establishes a framework that provides for more uniform and objective assessments. It also provides a means of comparison between different work groups to assess the quality of notes in the overall program.

3.5.3 Thresholds

To determine the consistency of reported inspection results with a standard, it is typically necessary to establish thresholds that define in-tolerance and out-of-tolerance conditions. Thresholds express the expectation of the accuracy of inspection results, and as such should reflect both the goals of the program and the criticality of the data. Thresholds for condition ratings are typically +/- 1 from a standard or expected rating. For standardized measurement quantities, such as minimum vertical clearance, and threshold such as +/- 0.2 ft. might be applied in comparing a review value with an inspection result. For other inventory items, such as identifying a member as fracture critical, exact coding is required and as such no tolerance would exist. For process-related items, such as the quality of inspection notes or photographs, a numerical framework for evaluating quality may need to be established based on the requirements and procedures within a particular State.

Documenting the tolerances for items reviewed in a QA procedure provides a standard for both reviewers and those being reviewed that enables an understanding of the expectations. It also provides for consistency in the process, and can identify items for which high accuracy is critical. Establishing such thresholds prior to the implementation of QA procedures is necessary to ensure the procedures are effective and consistent. In some cases, the items evaluated in the review may vary between periodic reviews, in which case a system of threshold can be established in each review cycle.

An some cases, measurements of quality can be further refined to measure discrete levels of consistency, as opposed to fixed thresholds. Such processes were discussed in section 3.5.1, "Quantitative Data."

3.6 Bridge Selection Criteria

An important question in the QA process is what bridges are to be selected for the a QA review. How many bridges should be selected to represent the existing bridge inventory? Or should the bridges be selected according to the inspection team, to ensure that each team is covered by a QA review? Hearn indicated that bridge selection criteria currently implemented includes[11]:

- Targeted at a random population of bridges
- Based on bridge condition or special features
- Targeted at specific inspection leaders or teams
- Based on targeted quality improvement

In general, the selection of bridges for IOM and CPR processes attempt to provide a cross section of bridge materials and designs that is representative generally with the population of bridges with the unit being reviewed. There is also consideration given to including a dispersion of inspection teams. A focus on bridges with low condition rating or bridges scheduled for rehabilitation is common. For the CBM, each team examines the same bridge or bridges, and these bridges are selected to representative of the existing inventory over several QA cycles. Given that the inspector is an important source of variability in the process, consideration in bridge selection to capture every team would seem to be an important element of bridge sampling.

Frequently, the goal of sampling bridges is stated to provide a *statistical* sampling of the inventory. However, given the high number of variables involved in the process, meeting a formal statistical requirement, as may be done when sampling materials for a particular quality such as tensile strength, for example, is not practical. Rather, the sampling of bridges is better termed a *representative* sample that provides a foundation for statistical analysis. By that definition, the larger the number of bridges included in the process, the lower the uncertainty of the results. Under this definition, the sampling of bridge should be rationally determined given the variability in the bridge population, such as to capture a representative sampling of the overall inventory.

This sampling should consider that much of the variability in the inspection process results from variations in inspector characteristics, including training, experience, and practices, not necessarily bridge characteristics. As such, the sampling of a representative population of inspectors may be as effective in ensuring programmatic quality as a representative sampling of bridges.

It can be recognized that sampling a representative population of bridges assesses the adequacy of procedures in addressing different design and deterioration characteristics. A sampling of representative inspectors assesses the implementation of those procedures according to variations in inspector characteristics. Each of these could be viewed as a quality dimension that is suitable for evaluation as part of the quality program. As such, it may be desirable to develop a rational methodology that considered the need to evaluate both quality dimensions within a comprehensive QA program, to meet the goals of maintaining accuracy and consistency in inspection results.

An alternative sampling methodology is to identify a specific target process for QA review. For example, a State may determine that a focused QA review is needed for a specific activity such as load rating. In this case, the sampling of bridges to be evaluated is matched to the process that is the focus of the review, and the overall goals of the review as determined by the bridge owner. The advantage of such an approach is that a more thorough and in-depth evaluation can be made of a particular process using generally the same resources as a more comprehensive review of the program overall. The disadvantage is that elements of the program are not regularly reviewed.

3.7 Inspector Feedback

As discussed earlier, a QA program should provide a constructive platform for continuous improvement to the bridge inspection program. The QA process should not be viewed as a means of penalize deficient work groups, but rather a means to improve the quality of the inspection process overall. As such, a comprehensive QA program should provide a mechanism to collect feedback from the teams and work groups that experience the QA process. Feedback on their experience and perception of the program should be sought. This provides a platform to identify misconceptions regarding the program, measure the quality of the program itself, and provides a vehicle for continuous improvement to the QA procedures and practices. Standardized customer feedback forms may be used as a tool to collect data on the experiences of the work groups. If there is an annual inspection meeting, a survey questionnaire can be completed at the completion of the meeting. Surveys may also be implemented as a stand-alone function during the course of normal business.

Topics that are suitable for the survey include such items as:

- A measure of satisfaction with the program
- Customer perception and understanding of the program
    - Customer perception of the value of the program
- Customer identification of deficiencies in the program
- Adequacy of resources to complete the QA process

These survey items can be assessed to motivate changes in the QA process as a means of continuous quality improvement. The completion of the customer feedback forms or other assessment tools should be compulsory, because those least satisfied with the program are also the least likely to complete a voluntary form. It may be suitable to identify who is responsible for the completing the assessments within the program documentation. The process for analyzing the assessments and implementing changes based on results of the survey tools may also be suitable for inclusion in the QA documentation.

3.8 Corrective Actions in QA

Corrective actions is a general term describing activities conducted to improve the quality of bridge inspection, typically in response to the outcome of a quality review. The term encompasses a wide range of activities, from specific reports on the performance of an inspection team to changes to manuals, procedures or policies, changes in the training regime, collaboration meetings, disqualifications of inspectors, and others. Corrective actions are perhaps the most important component of the quality process, because it is through corrective actions that improvements in quality are achieved. As discussed earlier, documentation of the process for corrective actions is an important element of a quality program, as is a process for ensuring that corrective actions are implemented.

This section describes some typical methods of implementing corrective actions within a quality program. These include work-group and system-wide quality reports, which develop knowledge of quality levels, and act as a vehicle for more specific corrective actions (i.e. recommendations or directives for specific improvements). It also describes inspector meetings that can be held to transfer and develop knowledge on the quality characteristics of a program, act as training activities and collaborative peer exchange, and development and implementation of specific corrective actions. Changes to inspector training and improvement to manuals procedures and guidelines in also described. Inspector disqualification is also discussed, a specific corrective action to address poor quality.

3.8.1 Workgroup QA Reports

The workgroup QA report provides data on the quality of specific work groups following a QA review. This report should provide a measure of the quality of the work group relative to a standard, identify deficiencies, and identify corrective actions to be implemented within the work group. The report is typically provided to the work group following the QA review. A meeting with representatives from the work group to discuss the finding of the review included in the report can provide improved communication of finding, address concerns or questions, and provide a means for discussion and resolution of disagreements, errors or perceived errors in the report. Such a meeting also provides a training opportunity.

3.8.2 System – Level QA reports

System-level QA reports described the level of quality of the overall bridge inspection system. Such a report would typically summarize and analyze the results of the workgroup reports to provide an overall picture of the quality of the inspection and load rating program, or summarize the results of individual QA reviews of work groups. System-level QA reports may include specific sections that are intended to allow for individual work groups to compare their quality level to the quality level overall.

System-level QA reports may be developed on an annual basis following the completion of yearly QA activities. This may be appropriate even if the entire system is not sampled annually. For example, if the bridge inspection system is decentralized such that every work group conducting inspections is not reviewed each year, the annual system-level report would report the results for that portion of the population evaluated that year.

3.8.3 Inspector Meetings

Periodic meeting of the inspectors to address quality issues arising through the QA process are an excellent means for providing technology transfer and improving the quality of the inspection program. Annual, biannual or quarterly inspector meetings are a common component of many State's QA programs. The benefits of inspector meetings include the following:

- Creating a common understanding of inspection practices
- Calibrating inspection practices
- Facilitating knowledge transfer
- Providing for peer collaboration
- Obtaining direct feedback to and from inspectors
- Identifying problem areas
- Improving morale of inspectors
- Implementation of corrective actions

Such inspector meetings are increasingly wide spread as an effective means of improving the quality of inspection programs. In some cases, meeting may be conducting including inspectors from different States in a region to provide technology exchange, promote best practices and identify common problems that may be suitable for cooperative actions.

3.8.4 Training

The results of QA review may determine that training methods presently used to qualify inspectors have inadequacies. This may be due to changes that have occurred since the training was originally developed, such as the need to focus on particular components or deterioration modes that were not originally envisioned. The inspector's ability to identify problems and effectively characterize the criticality of the problem may need to be improved. This may be due to new information that has developed, such as a need to focus on a particular bridge detail previously thought to have less importance to the safety of bridges. Certain elements of the training may not be adequate to result in effective implementation of the training in the realized inspection practices. Additionally, there is a tendency for the effectiveness of training to diminish over time such that the consistency of inspection practices increasingly varies from the intended procedures. Corrective actions identified through the QA review process may be suitable for implementation through changes to the training required to become qualified as an inspector, or to refresher training required to maintain that qualification. Such training may take several forms, such as annual inspector meetings in which training needs are addressed, or more

formalized training and retraining procedures and modules. Regardless of the form, modifications and improvements to the training provided to inspectors is a key component for implementing corrective actions identified through the QA review process.

3.8.5 Inspector disqualification

Because of the importance of the inspection results in ensuring the safety of bridges and providing a foundation for effective bridge management, efforts should be undertaken to ensure that the performance of inspectors meets the standards and goals of the program. Minimum requirements for being qualified to conduct bridge inspections are codified in the NBIS. These requirements generally describe a system of education, training and experience thought necessary to provide requisite knowledge to perform adequate bridge inspections. One function of QC/QA is to determine if meeting these minimum requirements, and additional requirements that may be specific to a State, results in the desired outcome, i.e. consistent and reliable inspections. It is possible that a particular inspector, meeting all the requirements for training and experience, does not perform at an adequate level. Performance testing of inspectors, as described in section 2.2.1.1, may be a part of an inspector qualification scheme that is a quality control function. Even so, it may be desirable to have a system for disqualification of inspectors as part of the QA program to provide an avenue for assessment of performance in the field during typical bridge inspections. Alternatively, adequate inspector performance during QA reviews may be stipulated as a qualification requirement to avoid negative connotation associated with a "disqualification" process.

Typical reasons for disqualification include:

- Failure to meet minimum standards for qualification
- Failure to address corrective actions from previous reviews
- Consistently sub-standard performance
- Dishonest or unethical behavior that negatively affects inspection results

An effective certification or qualification scheme may be utilized to ensure that deficient inspectors are not included in the population of inspectors meeting the qualification for bridge inspection.

A process for requalification of inspectors may be appropriate to provide a comprehensive program that allows for improvements in quality by inspectors. Such a requalification scheme would typically be founded on the minimum requirements to become certified initially. However, a requalification scheme should include some consideration of the fact that the initial minimum requirements were ineffective in ensuring adequate performance from an inspector that has already been disqualified.

4 DOCUMENTATION

Documentation is one of the most important elements of an effective quality program. The primary goal of quality program documentation is to ensure consistency in the implementation of quality functions. Documentation also promotes understanding of the quality program, provides a means for improving the quality program, supports oversight and auditing activities, and reports on the results of QC and QA practices.

Quality documents describe the processes and procedures to be implemented to maintain quality. Quality documents should include sufficient information to allow for a full understanding of the overall structure of the program, what activities and functions are intended, and roles and responsibilities of individuals involved in the program . Documentation should enable procedures to be conducted in a uniform manner. Quality documents should describe the expected outcomes and activities that are intended to redress deficiencies identified through the program (corrective actions).

The documentation should provide sufficient data such that those who will undergo the review can develop a full understanding of activities that will take place, the purpose and goals of the activities, and the corrective actions that will be taken in response to the review. The documentation should also enable the outside review or audit of the QC/QA program providing sufficient information to determine the method of assessing quality, the procedures undertaken, the roles and responsibilities of individuals involved in the program and the method(s) of corrective actions.

Documentation in a quality program consists of two primary elements: Quality documents, which describe the quality program policies, processes and procedures, and quality reports, which document the results of the quality program implementation. Quality documents are done before the fact, quality reports are completed after the fact. Quality reports would typically be identified in the quality documents, i.e. what types of reports are to be generated to record the results of the quality functions, and the appropriate distribution of the reports.

Quality documents may be in the form of a directive, included in the inspection manual or in written policies describing the organization of the bridge inspection program. Since QC may be delegated to local bridge owners or consultants, documentation of the QC program that includes identifying the individuals responsible for perform QC review functions, as well as what review procedures are expected, is very important. General characteristics of quality documents include being a controlled document, being widely available to those participating in the bridge inspection program, and providing a comprehensive overview of the program such that the characteristics of the quality program can be easily understood through the documentation.

Quality documents would typically include the why, who, what, how, when and where of the quality program. The documents would describe *why* the activities are conducted, *who* is responsible for conducting quality activities, *what* those activities are, *how* to conduct them, *when* to conduct them, and *where* they will be conducted.

4.1.1 Quality manual

Realizing the QC and QA are two parts of an overall quality program, it may be suitable to develop a unified quality manual that describes the overall system for quality in bridge inspections and load rating. A quality manual documents an organization's quality management system (QMS). Such a manual would typically include:

- Definition of the scope of the QMS.
- Describe how the QMS processes interact.
- Defines roles and responsibilities within the quality program
- Document the quality procedures or refer to them.

- Document the expected outcomes of the quality process

Such a manual can provide a convenient means of managing and controlling quality processes by providing a single reference describing the overall program. A quality manual can help indentify gaps in the quality program by providing a centralized overview of the entire program, including both QC functions and QA functions. Such a manual can also help ensure consistency across the program, the key goal of quality documentation. A quality manual can also provide for effective internal and external auditing.

4.1.2 Elements of Quality Documents

Regardless of how the documentation of the quality program within a State is realized, there are typical characteristics of the documentation that would normally be included to provide comprehensive documentation that meets the goal of ensuring consistency in the program. The quality documentation would typically include the following elements: Why, who, what, where, when and how. These elements of QA/QC documentation are described further below. To provide an example of how these elements are implemented in a practical quality document, Appendix F provides an example quality program document from the State of Pennsylvania included in their bridge inspection manual. Notations in the margin have been added to indicate specific examples of the elements described below.

Why: The goals and objectives of the QC/QA program should be described in quality documents. The role of QA and QC in ensuring bridge safety, reducing variation in bridge inspection results and providing programmatic support should be described. This allows for those charged with implementing the QA/QC procedures, and those that are the subject of the procedures (inspectors, work groups, etc.) to develop a full understanding of the purpose and <u>importance</u> of the program.

Who: A critical element of the quality program is to effectively document the roles and responsibilities of the individual members of the quality process. Documenting the roles and responsibility of the quality team members is critical to ensuring that individuals are aware of their responsibilities and the responsibilities of their colleagues and understand their role within the larger quality program. The functions and activities within the larger quality program should be properly addressed such that the requirements for the role of individuals have legacy when individuals leave the agency or are promoted/transferred.

The documentation should identify who has QCO and QAO responsibilities. This may include describing the qualification or general characteristics necessary to fulfill these roles, such as independence from the inspection process being reviewed, or a general description of knowledge necessary or expected from those filling particular roles. This may include identifying specific positions or individuals within the overall DOT structure. If quality functions are delegated, describe the work groups to whom the responsibility is assigned. The terms QCO and QAO are used here in a general sense to describe the individuals with QC/QA responsibilities, this may be one person in the work group, such as a supervisor or peer team leader. It may be a specific work group, such as a consultant or locality, or several people within an inspection program, such as assigning a QC function to the Assistant District Bridge Engineer in each district.

Documentation should define the individuals responsible for conducting QC/QA procedures. This could include the individuals responsible for ensuring that the reviews are conducted, who will actually conduct the reviews, and who will ensure the results of the review are distributed properly and implemented. The qualifications of the individuals responsible for conducting the reviews should be delineated sufficiently to ensure that the desired level of knowledge and experience is achieved. Such documentation should identify specific positions within the organizational structure, rather than simply identifying organizational units. For example, specifying "The Assistant Bridge Engineer shall ….." would be preferable to "The bridge design division shall….," since the latter can be ambiguous and does not suggest the level of qualification of the individual conducting or overseeing the QA procedure. If an outside consultant is utilized to conduct the QC or QA reviews, it may be specified in the documentation.

If QA or QC procedures will be conducted by a team of reviewers, then the characteristics of the team should be described in the documentation. For example, a QA review team may consist of a QA engineer from a central office, a team leader from another district, the team leader being reviewed, and the FHWA Division Bridge Engineer. Documenting the team characteristics in the quality documentation helps ensure the characteristics of the review teams are consistent and maintained between review cycles. This helps support consistency in the program, ensures reviews are conducted in a uniform manner, and that the QA process is fair and objective. This also supports a full understanding of the QA process based on the documentation, such that those that are subject to a review know what to expect, and the process can be reviewed.

The work groups that are the subject of the QC/QA review should also be described. Depending on the organizational structure of the specific State, this may include districts, counties, townships, consultants, etc.. Sufficient description should be provided to fully describe the subject work groups, such that the extent of the quality program can be determined, and those that are subject to reviews can identify their own role in the quality program.

What: Obviously, quality documentation should describe what activities and procedures will be conducted as part of the quality program. This includes describing the types of reviews to be conducted, such as office reviews of inspection reports, and may include documenting systematic elements that are maintained on an on-going basis within the program, such as inspector qualification and documentation procedures. The review functions that are to be executed by the QCO and the QAO should be described. Review functions might include a review of the inspection report, a field review of inspection results, a field performance review, a peer exchange, a combination of methods, or other approaches not mentioned here. Several methodologies for performing reviews for both QC and QA are documented in these guidelines, other procedures may be appropriate for a particular bridge owner or agency.

Effectively documenting what will occur during the quality process will help ensure that the subject of the process will have a full understanding of what will take place. It will also assist those implementing the QA process do so in a uniform and consistent manner. It provides an overview of the process that can be evaluated and reviewed as part of development and improvements to the program or during a program audit or review.

The documentation should specify how the process results and associated corrective actions will be documented and information distributed through quality reports. Sufficient data should be included to ensure that the results of quality reviews, either QC or QA, will be adequately documented in quality reports and disseminated or transmitted to relevant groups or organizational elements. Again, consistency in the QC/QA process is the end goal, and documenting what reporting is expected and to whom the report should be disseminated supports that goal. This also ensures that relevant participants in the process are aware any findings and corrective actions that are needed.

How: Quality documents should include specific descriptions of quality procedures to be implemented to achieve the goals of the quality program. These procedures provide specific descriptions of how certain reviews are to be conducted. For example, the quality program may implement an QC Office review as part of the QC process. The procedure for how to perform that review should be documented to ensure that the purpose and goals of the review are established, and that the reviews are done in consistent manner. Forms to be completed during the quality process can provide a means of ensuring that procedures are completed in a consistent manner, and items are not overlooked. Detailed forms or procedures may be a part of the quality manual that describes the program overall, or may be referenced from such a manual.

Alternatively, the specific procedures for conducting quality functions may be delegated to the work group conducting the inspection or load rating. For example, QC may be delegated to a local bridge owner or consultant. In such cases, it may be useful to provide some overall goals, minimum characteristics or expectations such that the delegated procedures meet the needs of the quality program in terms of thoroughness, rigor and consistency. This also ensures that those charged with developing the procedures have an understanding of what is expected.

When: The sampling frequency for the quality functions should be documented. Frequency of the quality function may be a measure of time, such as performing a procedure annually, or may be a quantity, such as a 10% of inspection reports, or a combination, 10% of reports annually. However stipulated, the documentation of frequency for the QC functions identified in the quality program help ensure that the functions are performed at the expected rate, that the dimension of the program is described, and the thoroughness of the program can be assessed. If the frequency of quality functions is delegated to the work group conducting the inspection, it should be so stated in the quality documents.

A QA procedure may include specific agendas or time schedules for the conduct of the QA review. This helps develop a full understanding of the process by the work groups being reviewed and helps ensure the reviews are conducted in a uniform manner. This may include a specific schedule for the QA review, for example, a daily schedule that provides and overview of when reviewers will arrive, what activities are anticipated during the review, and follow-up meetings to be held.

Where: The location of the QA reviews may be described in the quality documentation. This might include basic information specific to the State's organizational structure, such as "…the QA team will travel to the District office to conduct a review." This may also include general descriptions such as "at the bridge site," or "at the consultant's office." The "where" may also

be implied, such as stipulating "prior to submittal to the State," implies a "where" that is relevant to the submitter.

The elements indicated provide some guidance for what characteristics quality documents might possess. Given the diversified nature of State programs, the quality documents addressed herein may have many different forms or exist in many different kinds of documents, but these basic elements would normally be identified in effective and complete quality documentation.

5 QA PROGRAM EXAMPLES

This section provides summaries describing the implementation of the models described above. The IOM model described is based on the quality program in the State of Pennsylvania. The CBM described as implemented in the State of Oklahoma. A CPR model implemented in Oregon is also described.

5.1 Independent Oversight Model (IOM) - Pennsylvania

The Pennsylvania model is characterized by widespread, systematic and independent re-inspection of a large number of bridges. The population of bridges that are re-inspected include 30 bridges in each of 11 Districts and 15 bridges for the Pennsylvania Turnpike, for a total of 345 bridges per year. In this QA process, the focus is on a population of selected bridges as determined by a process described in the policy documents. The bridges are generally selected to representative of the District's local bridge inventory, and have had recent bridge inspections completed. The quality assurance review of these bridges is very comprehensive, and includes the following primary items:

- Office File Review: Review of bridge file content
- Field Inspection: Independent, complete NBIS re-inspection of bridges, including independent condition/appraisal ratings
- Load Rating analysis and Posting Recommendations: A load rating analysis is performed on the subject bridges and compared with existing load ratings in the bridge inspection file to identify inconsistencies, posting needs or difference, etc.
- Preparation of Summary Reports
- Field View and Close-out meeting
- Cycle Summary Report

The procedure also specifies specific limits for the expected consistency between the QA review inspection and the existing bridge inspection records. The original inspection item ratings are considered out-of-tolerance if they vary more than +/-1 from the ratings compile by the QA team. Capacity ratings are considered out-of-tolerance if they differ more than 15%, and for posted bridges the tolerance limit is 2 tons. Additional items for review, such as inventory items, also have specified tolerances for consistency.

The quality assurance system is applied using a consulting firm to re-inspect the bridges selected. There are two separate reports generated as a result of the QA review. A draft summary report is prepared for each district summarizing the results of the QA review. The results of the QA review are discussed at a close-out meeting including the QA consultant, the subject District engineer and inspection staff, or local bridge owners and their inspection consultants. A field

review of several of the bridges is conducted with members of the Bridge Quality Assurance Division (BQAD) prior to the close-out meeting to review the findings of the QA review. Following the close-out meeting, the summary report is finalized and submitted to the BQAD for review, and finally distributed back to the districts.

In addition, three cycle summary reports are prepared after the QA process has been completed for all of the Districts and Turnpike Authority bridges. A separate report is prepared for Department bridges, one statewide report for local bridge and one statewide report for the Turnpike Authority. The cycle summary report includes an overview of State-wide and individual District's results for the QA cycle, documenting State-wide bridge inspection trends.

Corrective actions include revisions to procedures and manuals and changes to bridge inspection training. The QA process has resulted in significant increases in the consistency in the inspection program for both local and State-owned bridges. The estimated cost of the QA program of bridge reinspection is $1 million / year [14].

5.2 Control Bridge Model (CBM) - Oklahoma

The Oklahoma model takes an entirely different approach, which is related to the control inspection concept utilized in Finland[15]. In this model, rather than having a selection of bridges chosen for re-inspection, a small number of "control bridges" are selected for inspection by all of the bridge inspectors being evaluated. In odd-number years, and each participating bridge inspection team is required to inspect those specific bridges prior to a bridge inspector's workshop. The bridges are inspected by a benchmark team from the Central Office to establish target values (control values) for component ratings and element descriptions and condition states. The data that the teams submit is evaluated for consistency and the results are presented to the participating inspectors at a workshop. During the workshop, small break-out groups of inspectors are utilized to develop recommendations on elements or areas that are found to be inconsistent. These recommendations are then presented to the entire workshop at the end of the day. ODOT management and the FHWA then try to implement the recommendations.

During even-numbered years, the annual inspector's workshop is utilized to review the implementation of recommendation's from the previous year's QA review process. The workshop format allows for interchange between inspectors regarding the appropriateness and effectiveness of the recommended changes. If the inspection teams agree to these changes, then the changes are implemented for the next cycle of inspections.

As part of the Control Bridge concept implementation, a scoring scheme has been devised to evaluate the consistencies between inspector's ratings and the ratings of the Benchmark team. The scheme is applied to Pontis data collected, and is intended to provide a means of evaluating the assignment of condition states. Because of the nature of the element-level inspection data, it is more complex to effectively evaluate the consistency of results. The scoring scheme compares the benchmark team rating with inspection results, and weights the assignment of quantities in various condition states and the number of possible states to determine one single score for the evaluation. This scoring methodology was described in section 3.5.1.

For component level inspection, the process of evaluating the consistency of results is less complex because portions of the component cannot be assigned to different states. The typical

estimate of condition ratings of +/- 1 is generally applied to evaluate the consistency of ratings. One advantage of the CBM is that quantifiable results are produced that can be easily compared for assessment and to identify particular shortcomings or inconsistencies on a uniform basis for all inspectors. Other models are implemented on a variety of bridges such that such 1 to 1 comparisons are more difficult. An example of data from Oklahoma is shown in Figure 5.1 which shows the results for the Item 58, bridge deck. The distribution of rating extends over 5 ratings for this component. The rating from the benchmark team is shown in red in this case. As can be seen from the figure, the inspectors generally rated this component higher than the benchmark team on average. A quality score was assigned to these ratings based the average consistency with the benchmark team. For the data shown in the figure, the average inspector score was 65.

Load ratings have also been part of the QA process. Load rating calculations for the subject bridges are completed prior to the annual meeting by engineers responsible for load rating of on-system and off-system bridges. These load rating are evaluated for consistency and compared with the benchmark team ratings. A written questionnaire has also been utilized to determine the source of inconsistencies stemming from basic knowledge of appropriate load rating practices and procedures. This written questionnaire is submitted prior to the annual meeting such that sources of inconsistency or error can be discussed at the annual meeting. This questionnaire consists of two sections. The first includes general questions as appropriate material properties, LFR rating equations, impact factors, etc. from the Manual for the Condition Evaluation of Bridges. The second section of the questionnaire includes specific questions

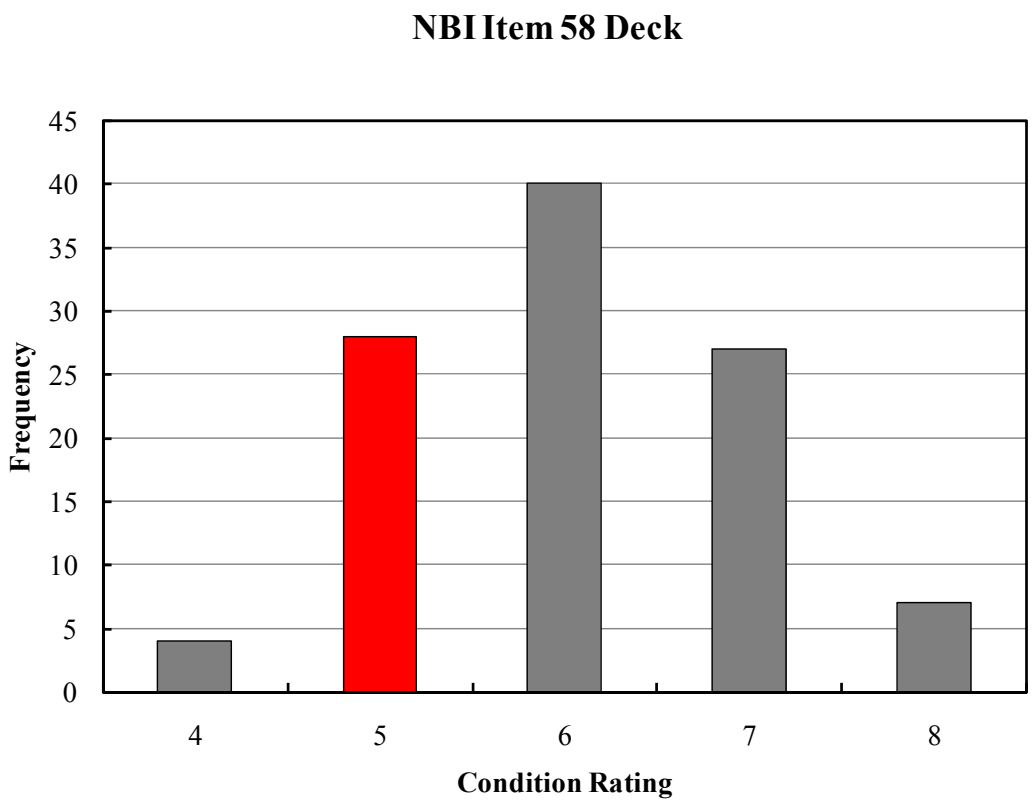

Figure 5.1. Deck component rating distribution for a control bridge in Oklahoma.

regarding the subject test bridges, including, for example, what is the appropriate compressive strength to be used for the bridge deck. Bridge plans are provided to support this portion of the questionnaire, and it is expected that the engineer will use the bridge plans provided and the Manual for the Condition Evaluation of the Bridges to answer these questions. A sample of this questionnaire is included in Appendix E

There is a master list of bridge inspectors maintained that documents qualifications of inspectors, and ensures that the inspectors have been participating as required in the annual quality assurance reviews and the associated training (annual bridge inspectors meeting). Corrective actions include adjustments to the bridge inspection manual, adjustments to the use of CoRe elements (for Pontis) and focused retraining implemented through the annual meetings[13, 15]. Discussions with personnel associated with the application of the CBM model in Oklahoma indicate that this process has had a significant, positive effect on their bridge inspection program overall. The process has led to numerous improvements in inspection manuals and indentified areas where additional resources or training are needed. The number of elements utilized for element level inspections has been reduced to provide more consistent identification, specific terms causing confusion have been defined, and inspection manual improved. Additional equipment has been procured in response to inspector needs identified through the process. Additionally, the engagement of bridge inspectors in the process has improved moral and led to an overall enhancement of the bridge inspection program in the State[13].

5.3 Collaborative Peer Review (CPR) Model - Oregon

A third generalized model for bridge QA is a peer review model that utilizes existing inspection resources from other jurisdictions to provide field review of bridge inspection findings. The model can be applied for the reinspection of the bridges in additional to regularly scheduled inspections, or can be applied within the context of the regularly schedule inspection as a business practice.

For the CPR model, the QA review is focused on a population of bridges within the subject entities responsibilities, sampling at least 5% of the population for a region. The QA review team typically consists of 3-4 individuals including a representative from the central office, a representative from another region or district, the bridge owner for locally-owned bridges, and an individual responsible for the original bridge inspection (for a consultant, in may be the consultants program manager, for State-owned bridges it is the Team leader in that region). The QA team conducts an inspection of the bridge utilizing a blank data form, identifying the elements in the bridge, the appropriate condition states for the elements, and NBIS data. The inspection data is formed through a group collaboration, with real time discussions of the appropriate elements, condition states and ratings. Ancillary reports that may be required to support condition ratings are made available from the bridge file.

Following the collaborative development of the inspection data, the results are compared with the most recent inspection finding and assessed for consistency and accuracy. The assessment consists of comparing the appropriate assignment of elements, reasonable consistency with element condition states, and +/- 1 NBIS condition ratings. Differences between the QA report and the previous inspection results are openly discussed within the QA team to identify sources of inconsistency. The results are documented in a report submitted to the inspecting agency.

Corrective actions are expected based on the results of the QA review. QA review data is assessed quantitatively based on the number of errors per bridge. The threshold for determining if adequate consistency exists between the QA review inspection and the original inspection data is 4 errors per bridge. It was reported that the average number of errors per bridge has reduced from an average near 4 errors/bridge to an average of ~2 errors per bridge, indicating the effectiveness of the approach[12].

The office review component of this model determines if inspections are performed by the prescribed due date, and if critical deficiencies are being addressed in a timely manner. Further QA activities include a yearly bridge inspector conference, which focuses on changes to procedures and policies such as modifications to the bridge inspection manual that may result from the QA process[12].

6 CONCLUSION

This document has presented an overview and description of various methodologies and procedures for implementing QC/QA for bridge inspection and load ratings. Definitions and quality tenants have been provided to develop a better understanding of the purpose of quality programs, what is meant by "quality" in regards to routine bridge inspections and load ratings, and what characteristics are common for effective bridge inspection QC/QA programs. The document is intended to provide a resource for bridge owners developing or improving their QC/QA programs. As such, the document provides a series of example methodologies and models that can be practically implemented to maintain and assure a high degree of accuracy in the bridge inspection and load rating practices.

It is envisioned that the information provided will be utilized by bridge owners as a foundation for developing QC and QA programs that meets the needs of their particular programs. These procedures can be utilized to assure the systematic QC and QA procedures are used to maintain a high degree of accuracy and consistency in bridge inspection programs.

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Appendix A: Fundamental requirements for ISO 9001 compliant quality programs.

1. Define Quality System	ISO 9001 requires a documented quality policy for the quality system, including procedures, instructions, rating systems, and performance measures.
2. Define Management Responsibility	Corresponding responsibilities for management and authorities for all personnel must be specified, not just an "agency." Available resources must be defined
3. Contract Review Material and Construction Process Tracing	ISO 9001 requires that construction contracts be reviewed to determine whether the original requirements are adequately defined. ISO 9001 also requires that all materials and processes used be identified and traceable during each inspection implementation.
4. Database for all documents.	The general documentation requirements of ISO 9001 stated: "(Clause 4.2) management must define the documentation including the relevant records needed to establish, implement and maintain the quality management system and to support an effective and efficient operation of the organization's process."
5. Design Control and Peer Review	ISO 9001 requires that procedures to control and verify the design and design changes be established. It also requires peer reviews for specified control procedures.
6. Test Equipment, Inspection Testing Procedures	ISO 9001 requires that equipment used to demonstrate conformance be calibrated and checked before use and rechecked at prescribed intervals. The inspection and testing are performed according to specified procedures. Inspection intervals must be properly defined.
7. Control of Inspection Results	ISO 9001 requires that inspection results must be thoroughly reviewed and causes of nonconforming features be traceable and corrected if feasible.
8. Internal and External Audits of the Quality Control Procedures	ISO 9001 requires that audits be planned and performed. The results of audits are communicated to management, and any deficiencies found are corrected.
9. Training	ISO 9001 requires that training needs be identified and that training be provided for implementation personnel. Records of training are maintained.
10. Analysis of inspection Results	ISO 9001 states that, where appropriate, adequate statistical techniques and tools are identified and used to verify the analysis of inspection results and in auditing procedures.
11. Continual Improvement	In ISO 9000:2000, a built-in mechanism of continual improvement of the quality management system becomes a requirement. Continual improvement is a giant step beyond "maintenance." It covers the entire spectrum of design, performance measure, production (inspection and service) procedures, documentation, analysis, QC/QA programs and resource allocation, etc. Quality improvement produces enhanced product reliability, longer product life, better user satisfaction and even cost reduction.

Appendix B, Exhibit B1: Wisconsin Qualifications Record

QUALIFICATIONS RECORD
Structure Inspection Program
Wisconsin Department of Transportation
DT2001 2003 s.84.17 Wis. Stats.

Applicant Name	Area Code - Telephone Number - Home	
Address	Area Code – Telephone Number - Work	
City	State	ZIP Code
E-Mail Address	Employer	

Refer to the Wisconsin DOT Structure Inspection Manual for required qualifications. Forward two completed copies of this form to the Statewide Structure Inspection Program Manager via the District Program Manager or directly at 4802 Sheboygan Ave., Room 601, PO Box 7916, Madison, WI 53707-7916. One copy will be returned to you with an assigned number if deemed qualified.

PART I - REGISTRATION/TRAINING - Complete All Information

Wisconsin Registered Professional Engineer - Yes Reg. No.: - Emphasis: Structural
NICET Level III or IV - Yes Reg. No.: If Yes, Attach Copy of Certificate
NHI Based 80-Hour Training Course - Yes Date: If Yes, Attach Copy of Certificate

Pertinent Inspection Related Training Courses Completed

Additional Specialized Certifications

APPROVAL: FOR WISDOT PROGRAM MANAGER USE ONLY! DO NOT WRITE BELOW THIS LINE.

☐ Visual Acuity Certificate Attached
☐ NHI Based 80-Hour Training Course Certificate Attached
☐ Experience Reviewed/Verified
☐ Reference Letter Attached

Qualified As ☐ Program Manager
☐ Team Leader

Reviewed By , Program Manager	Date
☐ Central Office ☐ District	☐ County

Assigned Number	Assigned By
Assigned Date	Date Copy Returned to Applicant

Page 1 of 3

PART II - EXPERIENCE - Attach Additional Sheets If Needed

Persons other than a P.E. or NICET Level III/IV are required to complete Part II in its entirety. A minimum of 5 years of responsible bridge inspection experience for Team Leaders and 10 years for Program Managers must be shown. P.E.'s and NICET individuals are also requested to complete Part II for informational purposes only. List all relevant experience.

Bridge Safety Inspection Field Experience

Please state your experience in various types of bridges (i.e., steel girders, concrete girders, trusses, slabs, prestressed girders, culverts, movable bridges, other complex structures, etc.).

Date From	Date To	Describe Bridge Type(s) and Inspection Type(s)	Name & Telephone No. for References	Approx. %*

* **Percent of year devoted to bridge safety inspection field work.**

I, the undersigned, affirm that all statements and data in Parts I and II are true and correct. I understand that any misrepresentation may constitute fraud, and may be punishable to the full extent of the law. Furthermore, I understand that it is my responsibility to stay current on bridge inspection issues, and that I will notify the WisDOT Statewide Program Manager of any name or mailing address changes in writing within 30 days.

(Applicant Signature) (Date)

Signature of Individual Providing Letter Reference: See attachment A for Format

(Signature) (Date)

Exhibit B2: Wisconsin Sample Reference Letter

ATTACHMENT A
SAMPLE REFERENCE LETTER

(Current Date)

Mr. / Ms. _____
Bridge Inspection Program Manager
(Address)

RE: (Name of Applicant) Qualifications

Dear Bridge Inspection Program Manager:

This letter is submitted as verification of the experience of Mr./Ms. (Name of Applicant) in the field of bridge inspection and allied areas. I have personal knowledge that Mr./Ms. _____ has ____ years of experience in bridge inspection and allied areas as outlined below:

i. (Please describe applicant's experience including percentage of time and the type of structures on which the applicant worked. In addition to bridge inspection field experience, please indicate experience in bridge inspection office experience, bridge design, bridge construction, bridge maintenance/repair, other structure inspection experience, etc. Furthermore, two copies of the applicant's Qualifications Record, Structure Inspection Program form should be attached to this letter with the author of this letter signing the second page.

ii. (Please explain your affiliation to the person and the WisDOT Bridge Inspection Program).

If you have any questions or concerns, please feel free to contact me at (xxx)-xxx-xxxx.

Sincerely,

_____
(Signature of Reference Letter Author)

_____
(Title and Bridge Inspection Program Affiliation)
(i.e., District Program Manager, County Manager, Consultant, etc.)

cc: (Name of Applicant)
Attachment: Qualifications Record (DT2001) (2 copies)

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Exhibit B3: Sample Record of Qualifications

Desired Minimum Bridge Inspection Experience Level
The predominate amount, or more than fifty percent, should come from NBIS bridge safety inspection experience. Other experience in bridge design, bridge maintenance, or bridge construction may be used to provide the additional required experience.

Evaluation of Experience Criteria:
When the State or Federal Program Manager evaluates an individual's actual experience for compliance with the experience requirements for a Team Leader, the following minimum criteria are to be considered:

1. The relevance of the individual's actual experience, i.e., has the other experience enabled the individual to develop the skills needed to properly lead a bridge safety inspection.
2. Exposure to the problems or deficiencies common in the types of bridges being inspected by the individual.
3. Complexity of the structures being inspected in comparison to the knowledge and skills of the individual gained through their prior experience.
4. The individual's understanding of the specific data collection needs and requirements.
5. Demonstrated ability, through some type of a formal certification program, to lead bridge safety inspections.
6. The level of oversight and supervision of the individual.

Team Leaders Name			**Date**	
Agency Name				
Education:	**Institution**		**Years**	
	Major		**Degree**	
	Comments:			
Professional Registration:	**State**		**Registration #**	
	Branch/Agency			
	Comments:			
Bridge Inspection Training:	**Course**		**Sponsor**	
	Hours		**Dates**	
	Comments:			

Special Technical Course:	**Course**		**Sponsor**	
	Hours		**Dates**	
	Comments:			
Bridge Inspection Experience	**Agency/Firm**		**Years**	
	Bridge Duties		**% NBIS bridge safety inspection experience**	
	Comments:			

Other/Comments:_____

_____

_____

To the best of my knowledge the above information is true and accurate.

Team Leader's Signature:_____ **Date:**_____

Exhibit B4: Washington State Bridge Inspector Expierence and Training Record

Washington State Department of Transportation

Bridge Inspector Experience and Training Record

Team Leader Name	Date

Agency Name

Education

Institution	Major	Years	Degree

Professional Registration

State	Branch/Agency	Registration Number

Bridge Inspection Training

Course	Hours	Sponsor	Dates

Special Technical Course

Course	Hours	Sponsor	Dates

Bridge Inspection Experience

Agency/Firm	Bridge Duties	Years

To the best of my knowledge, the above information is true and accurate.

Team Leader's Signature _____ Date _____

Having reviewed the above information, I conclude that this individual meets the minimum qualifications for a bridge inspection team leader as specified in the current National Bridge Inspection Standards.

Team Leader's Supervisor's Signature _____ Date _____

Supervisor's Name (Print) Title

DOT Form 234-100 EF
6/98

Appendix C, Exhibit C1: Sample Office Review Form

Reviewer			
Team Leader			
Team Members			
Bridge Number		**Inspection Date**	

The QC office review is designed to ensure the appropriate forms have been used, consistency of ratings, accuracy of data, consistency between reports, and completeness.

	Yes	No
Have the appropriate forms been used?		
Is the data accurate according to FHWA coding Guide and State requirements?		
Was the clearance and waterway profile updated as necessary?		
Are all inventory items correctly entered?		
Are channel profiles taken near substructures if visual inspection is not possible?		
Is the extent of scour documented by sketches?		
Are under water sketches done if necessary?		
If there are stream channel alignment problems are there stream alignment sketches?		
Is the water depth measured and documented to determine if diving is required?		
Is the load rating current?		
Is the bridge scour critical?		
Is there a scour plan of actions?		

Is Condition Adequately Documented by:			Sketches		Photos		Explanation	
Item 58. Deck	Previous	Current	Yes	No	Yes	No	Yes	No
Wearing Surface								
Deck Condition								
Stay In Place Forms								
Curbs								
Median								
Side Walks								
Parapets								
Railing								
Drainage System								
Lighting Standards								
Utilities								
Deck Joints								
Overall Condition								

Is Condition Adequately Documented by:			Sketches		Photos		Explanation	
Item 59. Superstructure	**Previous**	**Current**	**Yes**	**No**	**Yes**	**No**	**Yes**	**No**
Stringers								
Floorbeams								
Floor System Bracing								
Girders or Beams								
Trusses								
Pin and Hangers								
Conn Plt's Gussets and Angles								
Cover Plates								
Bearing Devices								
Diaphrams/Cross Frames								
Rivets and Bolts								
Welds								
Member Alignment								
Paint/Coating								
Overall Condition								

Is Condition Adequately Documented by:			Sketches		Photos		Explanation	
Item 60. Substructure	Previous	Current	Yes	No	Yes	No	Yes	No
Abutments								
a. Pedestals								
b. Bridge Seats								
c. Backwalls								
d. Breastwalls								
e. Wingwalls								
f. Slope Paving/Rip-Rap								
g. Pointing								
h. Footing								
i. Piles								
j. Scour								
k. Settlement								
Piers or Bents								
a. Pedestals								
b. Caps								
c. Columns								
d. Stems/Webs/Pierwalls								
e. Pointing								
f. Footing								
g. Piles								
h. Scour								
i. Settlement								
j.								
k.								
Pile Bents								
a. Pile Caps								
b. Piles								
c. Diagonal Bracing								
d. Horizontal Bracing								
e. Fasteners								
Overall Condition								

Exhibit C2: Sample QC review form for element level inspections. (Based on Oregon DOT Quality Assurance form)

QC Office Review

Bridge Name _____ Br. No. _____ Hwy No. _____ MP _____ Date _____

Agency / Consulant _____ Insp Area _____ Bridge Owner _____ Reviewer _____

	Previous	Current		Previous	Current
AC Depth			Deck Condition (58)		
Wearing Surface Type (108)			Superstructure Condition (59)		
Sturcture Status (41)			Substructure Condition (60)		
Bridge Posting (70)			Channel & Channel Condition (61)		
Safety Features (36)			Culvert Condition (62)		
Main Span Type (43)			Load Rating Needing Review?		
Appr Span Type (44)			Bridge Restrictions Appropriate?		
Scour Code (113)			Bridge Roadway Width (51):		
Lanes On/Under (28)			Appr Roadway Width (32):		
Waterway Adequacy (71)			Appr Roadway Alignment (72):		
Suggested Level Of Acess:			Vertical Clear over Deck (53):		
Suggested Inspection Frequency:			Detour Length (19):		

Element	Q'ty	1	2	3	4	5	1	2	3	4	5	Element	Q'ty	1	2	3	4	5	1	2	3	4	5

Remarks	Maintenance Recommendations

Exhibit C3: Sample Field Performance Review

Inspection start time:_____

Inspection completed time:_____

Performance Question	Yes	No
Are inspections completed in a thorough manner?		
Is the proper equipment utilized when needed?		
Is there and adequate number of inspectors present?		
Was proper determination and use of direction of orientation used?		
Was a field check of previous postings done?		
Was the previous inspection report used during inspection?		
Was 100% hands on inspection of non-redundant members performed?		
Were rating scales used properly?		
Was information input properly into report forms?		
Were appropriate sketches and tables used when preparing documentation?		
Were plans verified or updated?		
Does the team have the proper qualifications?		

Equipment Checklist

The following items were readily available to the bridge inspection team								
	Yes	No		Yes	No		Yes	No
Measuring Tape			Chipping Hammer			Chest Waders or Hip Boots		
100 ft. Measuring Tape			Shovel Spade			Ladder		
Calipers			Scrapper			Sounding Equipment		
Carpenters Level			Wire Brush			Timber Increment Borer		
Plumb Bob			Camera			Underclearence Rod		
Flashlight			Probing Rod			Inspection Mirror		
Binoculars			Boat/Canoe			Brush Hook/Machete		
Life Jackets			Magnifying Glass			Screwdriver		
First Aid Kit			Wrenches/Pliers			Thermometer		

Exhibit C4: Sample Personal Safety Evaluation Form

Bridge Access and Fall Protection

Safety Question	Yes	No
If bucket truck or aerial lift device is used have the operators been trained in its operation?		
Is the bridge being rigged? And if so…		
Is the team trained to perform this rigging and knowledgeable in all applicable OSHA regulations?		
Are proper safety procedures being followed?		
Does the team feel that additional safety equipment is needed?		
Does the team feel that additional training is needed?		
Does the reviewer feel that additional equipment/training is needed?		
Are the inspection crew members trained in fall protection?		

General Comments:_____

_____

_____

_____

Personal Protective Equipment Checklist

	Yes	No		Yes	No
Hard Hat			Harness		
Boots			Gloves		
Respirator			Ear protection		
Lanyard			Confined space air monitor		
High visibility apparel			First aid kit		
Protective eyewear			Dust mask		

Equipment

Safety Question	Yes	No
Is the appropriate personal protective equipment (PPE) being used?		
Is the required PPE available in the vehicle?		
Does the team have a list of emergency phone numbers?		

Work Zone Protection

Safety Question	Yes	No
Are cones and signs being utilized on approaches?		
Is maintenance and protection of traffic being used?		
Is the set up in conformance with MUTCD?		

GeneralComments:_____

_____

_____

_____

Appendix D, Exhibit D1: Wisconsin Level 1 Review Record

LEVEL 1 – REVIEW RECORD

Structure Inspection Quality Assurance Program

Review Performed by FHWA/WisDOT Central Office

Wisconsin Department of Transportation

DT2002 2003 s.84.17 Wis. Stats.

Date	Agency Under Review

QUALIFICATIONS

The AASHTO *Manual for Condition Evaluation of Bridges* states "Qualified personnel should be used in conducting bridge inspections". This section is to determine if personnel meet federal and state qualification requirements. Please refer to Section 2.3 of the Wisconsin DOT Structure Inspection Manual for the required qualifications in Wisconsin. If a consultant is hired to manage the program and/or inspect bridges, it is recommended that they are present during the quality assurance review. **IMPORTANT: Attach an updated copy of the originally approved Qualifications Record (DT2001) and current Inspector Visual Acuity Record (DT2005) for each individual listed below.**

Inspection Program Manager - Person in charge of inspection program

Name	WisDOT Qualification Approval Date
Registered Professional Engineer ☐ Yes ☐ No	
Experience	
Training	
Time Allocation (%) Bridge/Culvert Inspection	Other Bridge Related Activities / Non-Bridge Activities
Date of Last Visual Acuity Screening Form Submittal	

Inspection Team Leaders - People that sign the inspection reports

Name	WisDOT Qualification Approval Date
Registered Professional Engineer ☐ Yes ☐ No	
Experience	
Training	
Time Allocation (%) Bridge/Culvert Inspection	Other Bridge Related Activities / Non-Bridge Activities
Date of Last Visual Acuity Screening Form Submittal	

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Inspection Team Leaders - People that sign the inspection reports

Name	WisDOT Qualification Approval Date
Registered Professional Engineer ☐ Yes ☐ No	
Experience	
Training	
Time Allocation (%) Bridge/Culvert Inspection Other Bridge Related Activites Non-Bridge Activities	
Date of Last Visual Acuity Screening Form Submittal	

Inspection Team Leaders - People that sign the inspection reports

Name	WisDOT Qualification Approval Date
Registered Professional Engineer ☐ Yes ☐ No	
Experience	
Training	
Time Allocation (%) Bridge/Culvert Inspection Other Bridge Related Activites Non-Bridge Activities	
Date of Last Visual Acuity Screening Form Submittal	

Inspection Team Members - People that assist Team Leaders with inspections. Does not sign inspection reports.

Name	Date of WisDOT Qualification Form Approval
Registered Professional Engineer ☐ Yes ☐ No	
Experience	
Training	
Time Allocation (%) Bridge/Culvert Inspection Other Bridge Related Activites Non-Bridge Activities	
Date of Last Visual Acuity Screening Form Submittal	

RECORD KEEPING

The AASHTO *Manual for Condition Evaluation of Bridges* states, "Bridge owners should maintain a complete, accurate and current record of each bridge under their jurisdiction. Complete information, in good usable form, is vital to the effective management of bridges. Furthermore, such information provides a record which may be important in legal action."

Bridge File - The bridge file describes all bridges under the jurisdiction of the Program Manager. This file should contain all cumulative information about each individual bridge.

Location of Bridge File

File Accessible to Users

Bridges Sorted in the File by

☐ Bridge Number ☐ Road ☐ Township ☐ Other

Separate Lists of Bridges Requiring the Following Inspection Types

☐ Fracture Critical ☐ Diving ☐ Other Special Inspections

Length of Time Information is Kept in the File

Bridge File Documents

Yes	No	Document
☐	☐	Bridge Plans
☐	☐	Correspondence
☐	☐	Original Structure Survey Report
☐	☐	Original As-Built Plans
☐	☐	Load Rating Analysis Computations
☐	☐	Rehabilitation Plans
☐	☐	Initial / Inventory Update Inspection Reports
☐	☐	Routine Inspection Reports
☐	☐	Inspector Qualification Records
☐	☐	Inspector Visual Acuity Records
☐	☐	Inventory and Appraisal Field Review Report
		Special Inspections
☐	☐	Damage Inspection Reports
☐	☐	In-Depth Inspections Reports
☐	☐	Fracture Critical Reports
☐	☐	Underwater Probing Reports
☐	☐	Underwater Profiles Reports
☐	☐	Underwater Diving Reports
☐	☐	Load Posted Reports
☐	☐	Interim Inspection Reports
☐	☐	Movable Bridge Electrical Inspection Reports
☐	☐	Movable Bridge Engine Generator Inspection Reports
☐	☐	Movable Bridge Hydraulic Inspection Reports
☐	☐	Movable Bridge Mechanical Inspection Reports
☐	☐	Ferry Inspection Reports
☐	☐	Miscellaneous Support System Inspection Reports*
☐	☐	Border Bridge Inspection Reports
☐	☐	Other

* Highway sign bridges, high mast light poles, retaining walls, etc.

LEVEL 2 FILE REVIEW
Discuss Level 2 Reviews since last Level 1 Review.

INSPECTION
The AASHTO Manual for Condition Evaluation of bridges states, "Bridge Inspections are conducted to determine the physical and functional condition of the bridge". "Successful bridge inspection is dependent on proper planning and techniques, adequate equipment, and the experience and reliability of the personnel performing the inspection".

Planning and Scheduling

Number of Bridges the Program is Responsible to Inspect

Number of Inspections Performed in the Past Calendar Year

Number of Inspections Performed in a Day

Length of Time for an Average Inspection
Beam/Girder Slab Truss Box Culvert Other

Previous Inspection Reports Available at the Bridge for Review
☐ Yes ☐ No

Bridge Plans Taken to the Bridge for use During Inspection
☐ Yes ☐ No

Bridge Plans Available in Office, if needed
☐ Yes ☐ No

Initial Inspections - New and Rehabilitated Structures

Baseline Assessment Performed and Problems Identified
☐ Yes ☐ No

Inventory and Appraisal Field Review Report Verified
☐ Yes ☐ No

Bridge Inspection Report Form Updated to Reflect Modifications
☐ Yes ☐ No

Comments

Routine Inspections

List Frequency for Routine Inspections

All Inspections Performed in One Year
☐ Yes ☐ No

Inspections Performed Each Year
☐ Yes ☐ No

List Type of Vehicle Used for Bridge Inspection

Dedicated to Inspection Full-time or Part-time

List equipment carried on vehicle for inspection and taken to the site

Y/N/A	Equipment	Y/N/A	Equipment	Y/N/A	Equipment
	Extension Ladder		First Aid Kit		Feeler Gauge
	100-Foot Tape		Steel Wire Brush		Probing Rod
	6-Foot Rule		Brass Wire Brush		Vertical Clearance Rod
	Geologist Hammer		Calipers		Radio / Cell Phone
	Inspection Mirror		Shovel		2-inch Scraper
	Flashlight		Inspection Forms		Optical Crack Gauge
	Thermometer		Extra Paper		Magnifying Glass
	Plumb Bob/Protractor		Screwdriver		Hard Hat
	Camera		Pliers		Safety Shoes
	2-Foot/4-Foot Level		Wrenches		Reflective Vest
	Binoculars		Incremental Borer		Dust Mask
	Brush Hook		Sounding Chains		Respirator
	Laptop Computer		Hip Boots / Waders		Flashing Light
	Boat		Paint Stick / Marker		Harness/Lanyard
	Life Jackets		Scraper		Safety Glasses

Y/N/A - Yes, No, Available

INSPECTION - continued

SPECIAL INSPECTIONS

Damage Inspections

☐ Bridge load posted | ☐ Bridge closed

Load Posted / Closed Bridges

Number of Bridges

Describe How Load Posting and/or Closure was Determined

Computations for a Load Analysis is on File for All Bridge Load Posted and Closed
☐ Yes ☐ No

Comments

List Frequency of Inspection for Signs on Load Posted and Closed Bridges

In-Depth Inspections

Number of Redundant Bridges with Unique Features that May Require an In-Depth Inspection

_____ Pin & Hanger
_____ Pin Thru Web
_____ 3 Girder Trap Box
_____ Truss & Girder Bridges with Floor Beams & Stringers
_____ Fatigue Prone Details – Category D, E, E'
_____ ADT ∞ 50k
_____ Other Details

Fracture Critical Inspections

Number of Fracture Critical Bridges the Program is Responsible to Inspect

List Inspection Frequency

List Procedures and Criteria Used for a Fracture Critical Inspection

Underwater Inspections

List Number of Bridges that are over Water

List Number of Bridges that have Been Screened for Scour Susceptibility

List Number of Bridges that are Scour Critical

List Number of Bridges Requiring

_____ Visual/Probe Inspection _____ Frequency
_____ Diving Inspection _____ Frequency
_____ Underwater Profile Survey _____ Frequency

Scour Critical Bridges

Number of Bridges

Describe how Scour Critical Nature was Determined

Written Monitoring Action Plan for Each Bridge is Developed and on File
☐ Yes ☐ No

Monitoring System Installed on Scour Critical Bridges
☐ Yes ☐ No

INSPECTION - continued

SPECIAL INSPECTIONS

Interim Inspections

Who Determines What Bridges Require an Interim Inspection?

List Criteria Used

List of Bridges that Currently Require Interim Inspections

Number for Structural Condition

Number for Hydraulic Condition/Scour Critical

Other

Movable Structure Inspections

Number of Movable Bridges the Program is Responsible for Inspecting

List Inspection Frequency

Testing Equipment

List nondestructive testing equipment that may be used for special inspections and who determines the test requirements.

Type of NDT	Test Performed Y/N	Equipment Used	Bridge Component Tested	Who Determines Test Requirement
Audible				
Infrared Thermography				
Ground Penetrating Radar				
Acoustic Emission				
R-Meter				
Schmidt Hammer				
Impact Echo				
Windsor Probe				
Half-Cell				
Chloride Ion				
Material Sampling				
Ultrasonic				
Liquid Penetrant				
Magnetic Particle				
Monitoring Systems				
Unknown Foundation Investigation				

Access Equipment

List the Type of Access Equipment Available for Inspection

- ☐ Underbridge Access Unit
- ☐ Aerial Lift
- ☐ Ladder
- ☐ Scaffolding
- ☐ Boat
- ☐ Other

SAFETY

The AASHTO Manual for Condition Evaluation of bridges states, "Safety of both inspection members and the public is paramount." Inspection should always be performed as a team of two or more persons, never alone.

Personal Safety

Inspections Regularly Performed by a Team of Two or more Inspectors

☐ Yes ☐ No

Indicate Safety Equipment Available To You For Inspection.

☐ Hard Hat	☐ Ear Protection
☐ Safety Vests	☐ Confined Space Air Monitor
☐ Safety Glasses	☐ First Aid Kit
☐ Safety Shoes	☐ Dusk Mask
☐ Safety Harness	☐ Respirator

Public Safety

Work zone protection should be in accordance with "Manual of Uniform Traffic Control Devices." Describe how traffic control is set up for bridge inspection.

FOLLOW-UP ACTIONS

Each inspection report shall be reviewed by the maintaining authority for completeness and recommendations. The inspector's recommendations should be considered for implementation within the limits established for public safety, cost effectiveness, and fiscal restraints.

Inspectors Recommend Maintenance Actions on Inspection Form ☐ Yes ☐ No	Recommendations are Categorized or Prioritized ☐ Yes ☐ No
Special Maintenance Form Used ☐ Yes ☐ No	Recommendations Made by Inspector are Reviewed by Maintaining Authority ☐ Yes ☐ No
Inspectors Inform Maintenance Personnel About Routine Maintenance Needs ☐ Yes ☐ No	Repair Costs and Quantity Estimates are Made ☐ Yes ☐ No

Completed Repairs are Entered on a Paper or Electronic File

☐ Yes ☐ No

List Inspector's Contacts for Emergency Closures or Repairs

List Who has Authority to Close a Bridge Under an Emergency

List Who has Authority to Open a Bridge

Describe how Damage Repairs are Documented

List Who is Responsible to Develop Repair Plans and What Equipment is Available for Repairs and/or Maintenance

Describe how Bridge Repairs and/or Maintenance are Accomplished

Describe how Maintaining Authority is Informed when Maintenance Repairs are Completed

Bridge Replacement/Rehabilitation/Preservation

Taking Advantage of all Funds Available ☐ Yes ☐ No	Costs Entered onto the Bridge File ☐ Yes ☐ No

Describe Who You Contact for Bridge Projects

Describe How Bridge Projects are Prioritized

Describe Problems Encountered in Attempting to Program a Bridge

INSPECTED AGENCY COMMENTS
We have asked a detailed list of questions. Please take this opportunity to ask questions or make comments about the inspection program.

GENERAL
Does bridge inspection team feel it has enough time / equipment / training / experience to do their job properly?

FIELD REVIEW
The field review is intended to look at a minimum of three bridges (typically with problems); bridges that are in the replacement program; bridges with special features; bridges of local interest or questions; and load posted bridges.

List bridges along with reasons for selection.

SUMMARY OF LEVEL 1 REVIEW COMMENTS
Reviewer's Comments

Reviewer's Confidence Level

Good				**Poor**
☐ 5	☐ 4	☐ 3	☐ 2	☐ 1

(Reviewed Agency's Program Manager Signature) (Date)

(Statewide Program Manager or Delegate) (Date)

Exhibit D2: Wisconsin Level 2 Review Record

LEVEL 2 - REVIEW RECORD

Structure Inspection Quality Assurance Program

Review Performed by Region/County for Locals

Wisconsin Department of Transportation

DT2003 1/2007 s.84.17 Wis. Stats.

Date	Agency Under Review
Regional Program Reviewer or County Manager Reviewer	

QUALIFICATIONS

Please refer to Section 2.3 of the Wisconsin DOT Structure Inspection Manual for personnel qualification requirements.

Inspection Program Manager - Person in charge of inspection program

Name	WisDOT Inspector Certification Number
Registered Professional Engineer ☐ Yes ☐ No	Program Manager ☐ Yes ☐ No

Time Allocation (%)

Bridge/Culvert Inspection | Other Bridge Related Activities | Non-Bridge Activities

Inspection Team Leader(s) - People who conduct inspections and sign inspection reports

Name	WisDOT Inspector(s) Certification Number
Registered Professional Engineer ☐ Yes ☐ No	

Time Allocation (%)

Bridge/Culvert Inspection | Other Bridge Related Activities | Non-Bridge Activities

RECORD KEEPING

Bridge File

Location of Bridge File

File Accessible to Users

☐ Yes ☐ No – Comments:

Bridges Sorted in the File by

☐ Bridge Number ☐ Road ☐ Township ☐ Other:

Separate Lists of Bridges Requiring the Following Inspection Types

☐ Fracture Critical ☐ Diving ☐ Other Special Inspections:

Length of Time Information is Kept in the File

Bridge Inspection Reports

Bridge Inspection Reports Are Reviewed for Accuracy and Completeness

☐ Yes ☐ No – Reviewer:

INSPECTION

Planning and Scheduling

Number of Bridges the Program is Responsible to Inspect	Number of Inspections Performed in Past Calendar Year
Bridge Plans Available in Office If Needed ☐ Yes ☐ No – Comments:	

Page 1 of 3

INSPECTION - continued

Initial Inspections – New Structures

Baseline Assessment Performed and Problems Identified	Load Rating Performed and Calculations on File
☐ Yes ☐ No - Comments:	☐ Yes ☐ No

Inventory Update Inspections - Rehabilitated Structure

Bridge Inspection Report Form Updated to Reflect Modifications to Structure	New Load Rating Performed
☐ Yes ☐ No - Comments:	☐ Yes ☐ No
SI&A Information Updated	Fracture Critical Members Located and Recorded
☐ Yes ☐ No - Comments:	☐ Yes ☐ No

Routine Inspections

List Frequency for Routine Inspections

All Inspections Performed in One Year or Split Between Years
☐ Yes ☐ No - Comments:

Damage Inspections

Damage Inspections Performed
☐ Yes ☐ No - Comments:

Load Posted / Closed Bridges

Number of Load Posted Bridges	Number of Closed Bridges

Comments

In-Depth Inspections

Number of Redundant Bridges with Unique Features that May Require an In-Depth Inspection
_____ Pin & Hanger _____ Pin Through Web _____ Truss & Girder Bridges with Floor Beams & Stringers
_____ Moveable _____ Other: _____

Comments

Fracture Critical Inspections

Number of Fracture Critical Bridges the Program is Responsible to Inspect

List Inspection Frequency

Underwater Inspections

Number of Bridges that are over Water	Number of Bridges that are Scour Critical	Action Plans Implemented
		☐ Yes ☐ No
Number of Bridges that Require Underwater Inspection by Visual/ Probe - Frequency:	Number of Bridges that Require Underwater Inspection by Diving - Frequency:	

Interim Inspections

Who Determines what Bridges Require an Interim Inspection?
- Comments:

Number of Bridges that Currently Require Interim Inspections	Number of Load Posted
Number of Scour Critical	Other

Moveable Structure Inspections

Number of Movable Bridges the Program is Responsible for Inspecting
- Frequency:

Who conducts Structural, Mechanical, Electrical and Hydraulic Inspection?

SAFETY

Personal Safety

Inspections Regularly Performed by a Team of Two or More Inspectors
☐ Yes ☐ No - Comments:

Is Adequate Safety Equipment Available to you for use in Inspection Work?
☐ Yes ☐ No - Comments:

Public Safety

Work zone protection should be in accordance with the "Manual of Uniform Traffic Control Devices." Describe how traffic control is set up for bridge inspection.

FOLLOW-UP ACTIONS

Inspectors Recommend Maintenance Actions on Inspection Form
☐ Yes ☐ No

Recommendations Made by Inspector are Reviewed by Maintaining Authority
☐ Yes ☐ No - Reviewer:

What procedure is used to follow-up and track maintenance actions?

Are completed repairs noted in bridge file?
☐ Yes ☐ No

FIELD REVIEW

The field review is intended to look at a minimum of two bridges (typically bridges with problems); bridges that are in the replacement program; bridges with special features; bridges of local interest or questions; or load posted bridges.

List bridges along with reasons for selection

BRIDGE REPLACEMENT

Taking Advantage of all Bridge Replacement Funds Available
☐ Yes ☐ No

Describe how bridge replacements are prioritized.

SUMMARY OF LEVEL 2 REVIEW COMMENTS

Reviewer's Comments

Reviewer's Confidence Level

Good				Poor
☐ 5	☐ 4	☐ 3	☐ 2	☐ 1

(Regional Program Reviewer or County Manager Reviewer Signature) (Date)

(Reviewed Agency's Inspection Program Manager Signature) (Date)

Exhibit D3: Minnesota Quality Assurance Review

MINNESOTA DEPARTMENT OF TRANSPORTATION - BRIDGE OFFICE
National Bridge Inspection Standards (NBIS)
Quality Assurance Review of Bridge Owners

This questionnaire should be completed by the Agency's Inspection Program Administrator, and must be returned to the Mn/DOT Bridge Inspection Unit.

AGENCY	
ADDRESS	

1. Bridge Inspection Program Administrator

Each agency must designate an individual to oversee the inspection, inventory, and load capacity ratings of their bridges. This individual must be registered in Minnesota as a Professional Engineer and successfully complete the 2-week bridge inspection class.-To maintain certification, attendance is required at a minimum of two one-day refresher seminars every four years. ***Verify*** *the name and contact information for the Inspection Program Administrator below.*

ADMINISTRATOR'S NAME			
PHONE #		**EMAIL**	
PE REGISTRATION #		**MOST RECENT INSPECTION SEMINAR (YEAR)**	

2. Bridge Inspection Team Leader(s)

A bridge inspection team leader must be present during each bridge inspection. *Certification requires successful completion the 2-week bridge inspection class, 5 years of inspection experience (or engineering registration), and passing a field proficiency test. To maintain certification, attendance is required at a minimum of two one-day refresher seminars every four years.* ***Verify*** *the name and information for each Bridge Inspection Team Leader below. Note: Program Administrators who perform inspections must also be certified as Inspection Team Leaders.*

TEAM LEADER'S NAME:	1-WEEK CLASS (YEAR)	2-WEEK CLASS (YEAR)	LAST INSPECTION SEMINAR (YEAR):

3. Assistant Bridge Inspector(s)

An assistant bridge inspector cannot perform inspections unless accompanied by a certified Bridge Inspection Team Leader. *Anyone who successfully completes the 1-week bridge inspection course is listed as an Assistant Bridge Inspector.* ***Verify*** *the name and information for each Assistant Bridge Inspector below.*

ASSISTANT INSPECTOR'S NAME:	1-WEEK CLASS (YEAR)	2-WEEK CLASS (YEAR)	LAST INSPECTION SEMINAR (YEAR):

4. Frequency of Bridge Inspections

All bridges located on (or crossing over) public roads are required to be inspected and included on the Mn/DOT Bridge inventory. Bridges are generally inspected on a 2-year (24-month) cycle - bridges in poor condition (NBI ratings of "4" or less) must be inspected on a 1-year (12-month) cycle. Note: fracture critical bridges that carry vehicular or railroad traffic must be inspected on a 1-year (12-month) cycle. ***Review the attached Inspection Frequency Report. To request changes to inspection frequencies, submit the report (with any corrections) and the 2-Year Bridge Inspection Interval Request Form (available on the Bridge Office Website) to the Mn/DOT Bridge Office.***

TOTAL NUMBER OF BRIDGES	
BRIDGES CURRENTLY ON 12 MONTH INSPECTION CYCLE	
BRIDGES CURRENTLY ON 24 MONTH INSPECTION CYCLE	
BRIDGES ELIGIBLE TO MOVE TO 24 MONTH INSPECTION CYCLE	

Interim bridge inspections (at intervals less than 12 months) should be scheduled if the Inspection Program Administrator has reason to suspect that condition of a critical element may deteriorate substantially before the next regularly scheduled inspection. ***Verify the number of bridges with interim inspections below.***

NUMBER OF BRIDGES INSPECTED ON A LESS THAN 12 MONTH SCHEDULE	

5. Scheduling of Bridge Inspections

An annual bridge inspection involves, at a minimum, visual examination of all the structural elements of the bridge to determine if there has been any change from the previous inspection. If an excessive number of bridges are inspected in one day, this may indicate that inadequate time was allocated for a thorough inspection.

MAXIMUM NUMBER OF STRUCTURES INSPECTED IN ONE DAY	
HOW MANY OF THESE ARE USUALLY CULVERTS?	
COMMENTS:	

If bridge inspections are conducted in the winter, the inspector should return during more favorable weather conditions to complete the inspection. Follow-up inspections should be noted in the comments section of the inspection report

BRIDGES INSPECTED DURING DECEMBER, JANUARY, OR FEBRUARY	
FOLLOW-UP INSPECTIONS OR NOTES TO VERIFY COMPLETE INSPECTION?	
COMMENTS:	

While bridge inspections may be performed by one person, it is recommended that bridge inspections be performed by a team of two (or more). ***For each inspector, place an "X" in appropriate box (place an "X" in both boxes if inspections are sometimes performed alone).***

INSPECTOR'S NAME:	INSPECTS ALONE?	INSPECTS AS A TEAM?

6. Bridge Inspection Equipment

Indicate whether or not the following inspection is readily available to the bridge inspection team (Y/N)

MEASURING TAPE		**CHIPPING HAMMER**		**PROBING ROD**	
100 FT MEASURING TAPE		**SHOVEL/SPADE**		**BOAT/CANOE**	
CALIPERS		**SCRAPER**		**CHEST WADERS (OR HIP BOOTS)**	
CARPENTER'S LEVEL		**WIRE BRUSH**		**LADDER**	
PLUMB BOB		**BINOCULARS**		**SOUNDING EQUIPMENT**	
FLASHLIGHT		**CAMERA (FILM)**		**TIMBER INCREMENT BORER**	
BINOCULARS		**CAMERA (DIGITAL)**		**UNDERCLEARANCE ROD**	

7. Reviewing of Bridge Inspection Reports

Each agency is required to keep signed copies of bridge inspection reports - each report should be signed by the Inspection Team Leader (who was present for the inspection) and the reviewer (typically the Bridge Inspection Program Administrator). ***Enter the name(s) of who signs inspection reports, who reviews inspection reports.***

WHO SIGNS INSPECTION REPORTS AS THE REVIEWER?	

8. Reviewing of Structure Inventory Reports

It is important that information on the Structure Inventory Report be periodically reviewed for accuracy (preferably during each inspection). Items such as wearing course depth or required bridge signage often change over time. ***Inventory updates may be mailed in (or called in) the Mn/DOT Bridge Management Engineer.***

ARE STRUCTURE INVENTORY REPORTS BROUGHT ALONG DURING BRIDGE INSPECTIONS (Y/N)?	
WHO REVIEWS STRUCTURE INVENTORY REPORTS FOR ACCURACY?	

9. Critical Findings

A "Critical Deficiency" is a condition observed during a bridge inspection that, if not promptly corrected, could result in collapse or partial collapse of the bridge. This includes structural conditions or scour conditions that are found to be critical ***during the inspection*** *or that are* ***likely to become critical before the next scheduled inspection.*** *Technical Memorandum No. 05-02-B-02 (July 2005) outlines the policy for responding and reporting critical findings.*

The attached Critical Bridge Report lists all bridges with a rating of Condition "2" for the Critical Finding Smart Flag (PONTIS element #964) - this rating indicates that a critical finding is present. ***Review the attached Critical Bridge Report for accuracy…***

IF ANY BRIDGES ARE LISTED AS HAVING "CRITICAL FINDINGS", HAVE THESE FINDINGS BEEN REPORTED TO THE BRIDGE OFFICE AND HAVE ACTIONS BEEN TAKEN TO RESOLVE THESE FINDINGS?	
ARE ANY BRIDGES INCORRECTLY LISTED AS HAVING "CRITICAL FINDINGS"?	
COMMENTS:	

The attached Critical Bridge Report lists also lists bridges with an NBI condition rating of "2" or less for Items #58 (Deck), #59 (Superstructure), #60 (Substructure), #61 (Channel), # 62 (Culvert), or #113 (Scour) - these ratings may indicate a that a critical finding is present, or may be the result of improper coding.. ***Review the attached Critical Bridge Report for accuracy…***

IF ANY BRIDGES ARE LISTED AS HAVING AN NBI CONDITION RATING OF 2 OR LESS, WOULD ANY OF THESE CONSTITUTE A CRITICAL FINDING?	
ARE ANY BRIDGES WITH AN NBI CONDITION RATING OF 2 OR LESS STILL OPEN TO TRAFFIC?	
ARE ANY BRIDGES INCORRECTLY CODED AS HAVING AN NBI CONDITION RATING OF 2 OR LESS?	
COMMENTS:	

10. In-Depth Inspections

Review the attached lists of bridges in your county requiring "in depth" inspections - this includes Fracture Critical bridges, bridges with pinned assemblies, and bridges requiring underwater inspections. Indicate if any bridges should be added or deleted from these lists.

A copy of the "in-depth" inspection report (fracture critical, pinned assembly, or underwater) should be retained in the bridge file. It is the responsibility of the county to review the inspection report, and to respond appropriately to any "Critical Findings" or other high priority maintenance recommendations.

10.1. Fracture Critical Bridges

Fracture Critical bridges have at least one tension member whose failure would be expected to result in collapse of the bridge (trusses, two-girder structures, and welded steel pier caps are examples of Fracture Critical bridges). Note: only non-redundant bridges carrying vehicular traffic are considered to be Fracture Critical (railroad and pedestrian bridges are excluded). ***While "In-depth" inspections are usually performed by the Mn/DOT Bridge Office, the Program Administrator and bridge inspectors should be aware of which bridge members are Fracture Critical, and ensure that they are examined during each annual inspection - this should be noted under the Fracture Critical Smart Flag (Element #964)***

RE ANY BRIDGES INCORRECTLY LISTED AS BEING FRACTURE CRITICAL?	
RE ANY FRACTURE CRITICAL BRIDGES OMITTED FROM THE LIST?	
OMMENTS:	

10.2. Bridges with Pin & Hanger (or Single Pin) Hinge Assemblies

Bridges with pin & hanger (or single pin) hinge assemblies require ultrasonic inspection on a 5-year cycle (in addition to routine bridge inspections). The Mn/DOT Bridge Office Inspection Unit is available to conduct these inspections (traffic control is the responsibility of the county). ***Review the attached list of bridges with pinned assemblies requiring special ultrasonic inspection.***

RE ANY BRIDGES INCORRECTLY LISTED AS HAVING PINNED ASSEMBLIES?	
RE ANY BRIDGES WITH PINNED ASSEMBLIES OMITTED FROM THE LIST?	
OMMENTS:	

10.3. Bridges Requiring Underwater Inspections

If the underwater elements of a bridge cannot be routinely inspected by wading and probing, a special underwater inspection is required on a five-year cycle. These inspections are performed by divers under a statewide consultant contract. ***The underwater inspection contract for County/Local bridges is administered by the Mn/DOT State aid Office - they should be contacted if any bridges need to be added or deleted from this list.*** *Note: the inspection notes should indicate if the underwater elements of the bridge can be adequately inspected (by wading and probing) during a routine inspection - an interim inspection during low water (or summer months) may be required.*

RE ANY BRIDGES INCORRECTLY LISTED AS REQUIRING UNDERWATER ISPECTION (BY DIVERS)?	
HOULD ANY BRIDGES BE ADDED TO THE UNDERWATER INSPECTION ONTRACT?	
AVE THE RECOMMENDATIONS NOTED IN THE UNDERWATER REPORTS BEEN CKNOWLEDGED AND RESOLVED?	
OMMENTS:	

11. Bridge Load Capacity Ratings

Example bridge rating calculations are explained in the AASHTO Manual for Condition Evaluation of Bridges (available at www.aashto.org). If you have questions about bridge load ratings, please contact the Mn/DOT Bridge Load Ratings Engineer. ***The attached Load Posting and Rating Report lists all bridge within your jurisdiction that have load postings, speed restrictions, or are closed to traffic, review the report for accuracy.***

ARE ANY BRIDGES INCORRECTLY LISTED OR OMITTED FROM THE LOAD POSTING REPORT (Y/N)?	
COMMENTS:	
WHO PERFORMS BRIDGE LOAD RATINGS?	
WHO REVIEWS BRIDGE LOAD RATINGS?	

12. New Load Capacity Ratings

The date of the last load rating is displayed on the bridge's Structure Inventory Report. A new load rating is required when the dead load on the structure is increased (such as when a new deck wearing surface is installed). A new load rating may also be required if a bridge has been damaged or has deteriorated significantly since the last load rating. It may be appropriate to use engineering judgment to supplement calculations when assessing the load capacity of damaged or deteriorated bridge members. If a new load rating is performed, a copy must be submitted to the Mn/DOT Bridge Management Unit (load rating forms are posted on the Mn/DOT Bridge Office web site) - load rating calculations and documentation should be retained by the bridge owner. ***The Load Posting and Rating Report lists any bridge with a structural evaluation of "3" or less (serious condition) - if these bridges are not currently load posted or closed, a new load rating analysis may be warranted.***

ARE YOU AWARE OF ANY BRIDGES THAT REQUIRE NEW LOAD RATINGS (Y/N)? (LIST THE BRIDGES BELOW)	

13. Load Posting Signage

Bridges that cannot support legal loads must be posted with a weight restriction (the recent Timber Hauler's Bill has increased the number of bridges that must be posted). Load posting signs should be placed at each end of the bridge (advance warning signs are also recommended). Missing (or severely damaged) signs should be replaced promptly ***Review the Load Posting and Rating Report and verify that the actual bridge posting signs are correct.***

ARE ALL THE BRIDGES LISTED AS REQUIRING A LOAD POSTING PROPERLY SIGNED (Y/N)?	
COMMENTS:	

14. Bridge Scour Evaluation and Coding

Scour is historically the most common cause of bridge failure. As of a result of a scour evaluation, a bridge may determined to be at low risk for scour failure, limited risk for scour failure, or scour critical. The Mn/DOT Bridge Scour code is displayed on the Bridge Inspection Report (as well as on the Structure Inventory Report). If the Mn/DOT scour code is listed as D, R or U - the bridge has been determined to be "scour critical". However, the inspector should be aware that scour problems can develop even on bridges listed as "low risk".

The scour evaluation manual can be downloaded from the Mn/DOT web site (it is listed under "Documents, Downloads, Forms, and Links") - this manual also outlines scour action plans and scour monitoring. For new bridges, scour screening and evaluation tasks are typically done be the bridge designer. Contact the Mn/DOT Bridge Hydraulics Engineer if you have any questions regarding bridge scour analysis or scour coding.

14.1. Bridge Scour Screening

The FHWA requires that all bridges over water with a length of 20 feet or greater be evaluated for scour. Minnesota counties were required to assess all bridges for potential collapse due to scour by 1993. This process consisted of an initial scour screening, and if necessary, a more thorough scour analysis Contact the Mn/DOT Bridge Hydraulics Engineer for questions regarding scour evaluation or coding. ***The attached Scour Report lists all bridges within your jurisdiction with a scour code of F, G, or J. The scour screening & analysis process must be completed for these bridges - the scour code should be changed to H, I, L, M, N, O, P, R, or U, and the results should be reported to the Mn/DOT Bridge Management Unit.***

F - NO EVALUATION – FOUNDATION KNOWN *Bridge Structure. Scour calculation, evaluation, and/or screening have not been made (all substructure foundations are known). Note: most bridges rated "F" are typically new.*	
G - NO EVALUATION – FOUNDATION UNKNOWN *Scour calculation, evaluation and/or screening have not been made (substructure foundations are unknown). Note: Bridges with unknown foundations may require further evaluation, which may involve foundation investigations or be subjective based on engineering judgment, derived from observations of stream flow or performance during past high water events.*	
J - SCREENED – SCOUR SUSCEPTIBLE *Bridge has been screened and has been determined to be scour susceptible. Note: Bridges that have been screened as scour susceptible require further evaluation to develop a scour protection plan, or to plan for monitoring the bridge during a specified flood depth, or stage.*	

14.2. Channel Cross-Sections

The AASHTO Manual for Condition Evaluation of Bridges states that an assessment of scour vulnerability of substructures should be included in the bridge file. In addition, channel profiles and cross- sections from current and past inspections should be plotted to observe scour or stream instability. Refer to Section 2.4 of the manual and to Mn/DOT Scour Screening Guidelines for more information. ***Enter scour categories for which bridges are cross-sectioned, or "none".***

FOR WHICH SCOUR CATEGORIES ARE CHANNELS CROSS-SECTIONED?	
IF SO, AT WHAT FREQUENCY?	

14.3. Bridges Requiring Scour Action Plans

If the Mn/DOT scour code is listed as G, K, O, P, R, or U, the bridge must have a Scour Action Plan on file to outline procedures for monitoring or closure during high water events. **Review the attached Scour Action Plan Worksheet - verify that all bridges listed have a Scour Action Plan. If the worksheet lists "No" (under the action plan filed column), a copy of the Scour Action Plan must be submitted to the Mn/DOT Bridge Management Unit. Note: the bridge owner should file Scour Action Plans in a readily accessible location.**

G - NO EVALUATION – FOUNDATION UNKNOWN *Scour calculation, evaluation and/or screening have not been made (substructure foundations are unknown). Note: Bridges with unknown foundations may require further evaluation, which may involve foundation investigations or be subjective based on engineering judgment, derived from observations of stream flow or performance during past high water events.*	
K- SCREENED, LIMITED RISK *Bridge screened, determined to be of limited risk to public, monitor in lieu of evaluation and close if necessary.*	
O - STABLE – ACTION REQUIRED *Bridges that have been screened as stable, but field review indicates that action is required. It is required that a Scour Action Plan be developed and filed in the bridge file.*	
P - STABLE DUE TO PROTECTION *Bridges that have been identified as Stable due to protection require no further action. Annual or underwater inspections should note the condition of scour protection systems.*	
R - CRITICAL – LOCAL MONITOR *Bridges that have been determined to be Scour Critical need to be monitored during certain flood events or before reopening the bridge after a flood event. A Scour Action Plan must be developed for each bridge rated R to define at what flood stage to begin monitoring the bridge and the action required when a critical scour elevation occurs. A copy of the action plan is required to be placed in the bridge file.*	
U - CRITICAL – PROTECTION REQUIRED *Bridges that are rated Critical Protection Required have been determined that such frequent monitoring is required or may be too risky, and that installation of a protection system is a priority repair to this bridge. Until protection is installed, the bridge must be monitored during certain flood events or before reopening the bridge after a flood event. A Scour Action Plan must be developed and for each bridge rated U to define at what flood stage to begin monitoring the bridge and the action required when a critical scour elevation occurs. A copy of the action plan is required to be placed in the bridge file.*	

Enter the number of bridges with monitoring plans on file, protection systems inplace, and those requiring immediate action.

NUMBER OF BRIDGES RATED "R" THAT HAVE MONITORING PLANS IN BRIDGE FILES	
NUMBER OF BRIDGES RATED "U" THAT NEED SCOUR PROTECTION INSTALLED	

FOR BRIDGES THAT REQUIRE MONITORING, HOW DO YOU TYPICALLY DETERMINE IF SCOUR IS BEGINNING TO THREATEN YOUR BRIDGE, OR WHEN IT IS SAFE TO REOPEN?

15. Bridge Files

The AASHTO Manual for Condition Evaluation of Bridges states in chapter 2 that "Bridge Owners should maintain a complete accurate and current record of each bridge under their jurisdiction". Complete information in good usable form is vital to the effective management of bridges. It should provide a full history of the structure including damage and all strengthening and repairs to the bridge. The bridge record should provide data on the capacity of the structure, including computations substantiating reduced load limits if applicable."

As a minimum each bridge file should include a chronological record of Inventory and Appraisal sheets and inspections performed on the bridge, including special underwater and fracture critical inspection reports, bridge load rating and posting records, photographs, and relevant correspondence. Other suggested items for the file are listed in Section 2.2 of the AASHTO Manual for Condition Evaluation of Bridges.

Do you have a copy of the "AASHTO Manual for Condition Evaluation of Bridges"?	
Do you have a signed inspection on file for each bridge?	
Are Inspection Reports from past years filed?	
Are Structure Inventory Reports filed?	
Is bridge-related correspondence filed?	
Are bridge maintenance and repair records filed?	
Are recent photographs (roadway and elevation views) available for each bridge?	
How is bridge repair work prioritized and scheduled?	

Appendix E: Load Rating Questionare

Enclosure (2)

QC/QA Bridge Rating

The following questions apply to load rating engineers who currently load rate on-system bridges for ODOT or load rate off-system bridges for the counties. The questions can be answered using the following resources:

Manual for Condition Evaluation of Bridges, 1994 Edition
Manual for Condition Evaluation of Bridges, 2003 Edition

In addition to these resources, feel free to use any additional resources/software that you deem necessary to answer the questions. For the second set of questions relating to a specific bridge, use the bridge plans provided and the above resources. Assume a construction date of 1962 and 1959 design specifications. Select the answer that best fits your solution.

If software is available, please load rate the bridge and report the H-20 and HS-20 LFR ratings in tons in the spaces provided. If no software is available, please indicate this by entering N/A in the spaces provided.

Once the questions and load ratings have been completed, send a hard copy of your results to the following address:

Oklahoma Department of Transportation
Attn. Tony Sutton, Room 2B5
200 NE 21st Street
Oklahoma City, OK 73105

The solutions will be discussed at the May 2007 QC/QA meeting.

QC/QA Bridge Rating Questions - General

Name_____

Organization_____

Use the Manual for Condition Evaluation of Bridges (1994 or 2003) to answer the following questions. Choose the answer that best fits your solution.

1. What is the general expression for the LFR rating equation?

   A) $RF = (C - A_1D)/A_2(1+I)L$
   B) $RF = (C - D)/(1+I)L$
   C) $RF = (C - 1.3D)/1.3(1+I)L$
   D) $RF = (C - 1.3D)/2.17(1+I)L$

2. What is the steel yield stress (Fy) assumed to be for a bridge that is built in 1927?

   A) 18 KSI
   B) 36 KSI
   C) 30 KSI
   D) 33 KSI

3. What is the compressive strength of concrete (fc') assumed to be for a bridge built in 1962 if the strength of the concrete is unknown?

   A) 1.0 KSI
   B) 0.8 KSI
   C) 3.0 KSI
   D) 2.5 KSI

3. What is the yield stress (Fy) assumed to be for steel rebar in a bridge built in 1950?

   A) 60 KSI
   B) 40 KSI
   C) 36 KSI
   D) 33 KSI

5. What is the maximum amount of steel that can be assumed for a simply supported, reinforced concrete slab span bridge with no plans to be used to calculate ultimate moment capacity?

   A) 100% of ρ_{bal}
   B) 75% of ρ_{bal}
   C) 50% of ρ_{bal}
   D) 25% of ρ_{bal}

6. What are the appropriate values for A_1 and A_2 found in the LFR operating rating equation?

A) 1.0 and 1.0
B) 1.3 and 2.17
C) 1.0 and 2.17
D) 1.3 and 1.3

7. For a 3 X 12 timber plank deck with 3 X 12 runners, what is the effective plank width?

A) 11.50"
B) 12.00"
C) 16.75"
D) 18.00"

8. Using standard AASHTO provisions, what is the moment distribution factor for an interior steel beam if the center to center beam spacing is 7' 6"?

A) 1.25
B) 0.94
C) 1.36
D) 1.00

9. What are the appropriate values for A_1 and A_2 found in the LFR inventory rating equation?

A) 1.0 and 1.0
B) 1.3 and 2.17
C) 1.0 and 2.17
D) 1.3 and 1.3

10. Deflection caused by vehicular loading is most likely to affect which members most on a truss bridge?

A) U_1 U_2
B) L_1 U_1
C) L_2 L_3
D) L_1 L_2

Name_____
Organization_____

11. What is the standard AASHTO impact loading factor for a 53' beam?

A) 1.60
B) 1.45
C) 1.31
D) 1.28

Use the Manual for Condition Evaluation of Bridges (1994 or 2003) and the provided bridge plans to answer the following questions. Choose the answer that best fits your solution.

1. What is the yield (Fy) strength that would be appropriate for the structural steel in this bridge?

A) 26 KSI
B) 30 KSI
C) 33 KSI
D) 36 KSI

2. What is the compressive strength (fc') for the deck that would be most appropriate?

A) 1.0 KSI
B) 2.5 KSI
C) 3.0 KSI
D) 4.0 KSI

3. What is the web stiffener spacing near support 1?

A) 5.0'
B) 5.5'
C) 6.0'
D) N/A

4. What is the web stiffener spacing near support 2?

A) 5.0'
B) 5.5'
C) 6.0'
D) N/A

5. What are the dimensions of the web stiffeners?

A) 4" x 1/2"
B) 5" x 3/8"
C) 6" x 1/2"

D) 7” x 3/8”

6. What are the dimensions of the bearing stiffeners at support 1?

A) 4” x 1/2”
B) 5” x 3/8”
C) 6” x 1/2”
D) 7” x 3/8”

7. What is the dead load due to one curb (K/FT)?

A) .18
B) .25
C) .36
D) .50

8. What is the moment distribution factor for the interior girder?

A) 1.048
B) 1.182
C) 1.333
D) 1.409

10. What are the dimensions of the bearing stiffeners at support 2?

A) 5” x 3/8”
B) 6” x 1/2”
C) 7” x 3/8”
D) 8” x 1 1/2”

Using available software, list the H-20 and HS-20 ratings (in tons) below for the bridge shown in the plans. If there is no software is available, disregard this exercise.

	H-20	HS-20
Inventory	_____	_____
Operating	_____	_____

Appendix F. Pennsylvania's Quality Program

Publication 238, Part IP, Chapter 6 - Quality Measures for Safety Inspection

Why

6.1 QUALITY MEASURES

The bridge inspection process is the foundation of the entire bridge management operation and the bridge management system. Information obtained during the inspection will be used for determining needed maintenance and repairs, for prioritizing rehabilitations and replacements, for allocating resources, and for evaluating and improving design for new bridges. The accuracy and consistency of the inspection and documentation is vital because not only does it impact programming and funding appropriations but also it affects public safety. Therefore, the Department addresses this need with extensive formalized quality control and quality assurance procedures.

6.2 QUALITY CONTROL

What

Quality Control (QC) is the enforcement, by a supervisor, of procedures that are intended to maintain the quality of a product or service at or above a specified level. Quality Control of the inspection of highway bridges is a daily operational function performed in each organization performing the safety inspections, including consultants, owners, and District Bridge Units. A set of effective QC procedures will provide for uniformity of inspection and recording methods and will ensure quality reports. To ensure statewide uniformity and consistency the Department shall provide basic inspection training and mandatory biannual refresher courses (See IP 07, Training and Certification Program).

Each bridge safety inspection organization (e.g. Department District Bridge Units, engineering consultant firms, or bridge owner's staff) is to have internal quality control procedures in place to assure that the public safety is maintained on the bridge and that the inspections are performed in accordance with NBIS and Department standards. An effective quality control program for safety inspection should address the following areas:

- Organization and Staffing.
- Review ofField Inspections.
- Office File Review.
- Bridge Maintenance/Rehabilitation/Replacement Needs.
  Annual Meeting with Bridge Inspection Staff.

A record ofQC efforts (e.g. a QC Logbook) should be maintained by the inspection organization.

6.2.1 Inspection Organization and Staffing

What

An effective QC program begins with assuring that an adequate, qualified and properly equipped staff is in place to address the primary functions of a bridge inspection program:

- Engineer-in Charge
- Field Inspections and Final Report
- Bridge Analysis, Rating and Posting Evaluations
  Maintenance and Improvement Needs
- Internal Review Engineer

The Engineer-in-Charge is to maintain a roster and organization chart of the staff addressing these primary functions. The Engineer-in-Charge is to ensure that the staff meets NBIS and Department requirements for certification, training, and experience. The staffing complement must be sufficient and properly equipped to ensure that inspections are performed in a timely manner and in compliance with NBIS and Department requirements.

The District Bridge Engineer is to ensure that engineering consultants, bridge owners and Districts have the proper staff for the bridges assigned to them, see IP 2.1.

6.2.2 QC Review of Field Inspections

Review of the field inspections by the Engineer-In Charge and Review Engineer can be a most effective quality control measure. It can build a strong communication link between the inspectors and the reviewers. A sample plan for the Districts is suggested below. This can be modified for other organizations:

Who
When
Where
How

Bridge Inspection Supervisor

- Once a month (select different inspection team each month) do follow-up review as follows:
  - Pull four files at random from the previous month's inspections. Review files for the purpose of QC.
  - Visit bridge sites and cross check most recent comments in the inspection reports, and other items as warranted.
  - Upon return, enter sites visited in a QC logbook - with appropriate comments.
  - Review comments with respective teams within 2 weeks.

Bridge Engineer

Who
When
Where
How

- Once every three months, select four bridges that were inspected during the previous quarter, and visit sites.
  - Using BMS Coding Manual, rate the bridge for condition and appraisal ratings. Review field observations with the Bridge Inspection Supervisor and Team Leaders. Enter comments and site locations in a QC log book.
  - Review with the Bridge Inspection Supervisor reference materials and inspection tools with each team for adequacy.

Who
When
Where
How

District Engineer and/or ADE Design

- Once or twice (preferred) per year request current inspection sites for that week.
  - Visit inspection sites unannounced and observe inspection team. Discuss inspection procedures with team and question team on condition of bridges.
  - Visit two other recently inspected bridges and visually compare condition with inspector's comments in inspection report.
  - Review recommendations for maintenance and improvements.
  - Enter bridge sites visited and any observations/comments in a QC log book.
  - Review observations/comments with the District's Bridge Engineer and Bridge Inspection Supervisor.

6.2.3 QC Review of Office File

The bridge files in the office should be reviewed to ensure that the information needed for bridge inspection is readily available. All documentation of inventory and inspection information should be kept in an orderly and retrievable manner. A sample plan for the Districts is suggested below. This can be modified for other organizations:

Who
What
How

Bridge Inspection Supervisor

- Review the files for approximately 10% of the bridges inspected the previous month for completeness and accuracy.
- Every three months, review posted bridge lists and review the files or 10% of these bridges, which were inspected within the previous three-month quarter to see that the file documentation is sufficient and agrees with the posting, and the rating is current with latest inspection findings.
- Review 25% of FCM bridge files to ensure information needed for a fatigue and fracture inspection is available one month before the upcoming inspection.

Bridge Engineer

- Review five to ten bridge files for completeness at random, once every three months.
- Annually review the list of posted bridges to determine repair or replacement options for bridges on list
- Annually review Fatigue and Fracture Inspection Plan for District's FCM Bridges to develop rehabilitation/replacement strategies.

6.2.4 QC of Bridge Maintenance/Rehabilitation/Replacement Needs

The determination of bridge needs (maintenance, *rehabilitation,* and *replacement)* by the inspection organization should be reviewed annually. A sample plan for the Districts is suggested below. This can be modified for other organizations:

Assistant District Engineer-Design:

- Review with the District Bridge Engineer the procedures to be used in the event of a bridge emergency for reporting and coordinating repairs.
- Review with the District Bridge Engineer the procedures for selection of candidates for bridge maintenance program and rehabilitation/replacement programs. Review accomplishments and identify concerns.
- Review how large differences in bridge inspection condition/appraisal ratings or posting recommendations from the previous inspection are handled by the bridge inspection supervisor.
- Document and follow-up problems identified.

6.2.5 Annual Meeting With Bridge Inspection Staff

An annual meeting of field inspection staff with the Engineer-in-Charge, review engineer, and ratings engineer is recommended to ensure that the entire team is aware of the latest developments in safety inspection. Additional meetings should be considered if significant issues or concerns arise. The following suggestion is made for the Districts and may be modified by other organizations.

Bridge Engineer

- Once a year review all Q/C comments and observations with entire Bridge Inspection staff including local inspection coordinator.
  This review may be scheduled following a session of the Refresher Course for Bridge Safety Inspectors that one or more of the inspectors have attended to apprise remaining staff of the latest developments and the Department's current emphasis.
  This review should be separate from the Statewide QA program's District Close-out meeting.

6.2.6 Samples of Good Inspection Practices

Inspection teams take copies inspection files to the field and inspect each bridge. Team completes all condition and appraisal ratings, and reviews other items for correctness if directed by the supervisor on Forms D450 and D491 or BMS printout.

Bridge inspection teams should be rotated so that a team does not inspect the same bridge on consecutive routine bridge inspections. Consecutive inspections by the same team could lead to complacency because of too much familiarity with the structure.

The Bridge Inspector's Supervisor reviews each report for completeness and uniformity. He computes load ratings for any bridge which has changed due to section loss or recent repair, etc. or whose ratings were never computed.

6.3 PENNSYLVANIA STATEWIDE BRIDGE INSPECTION QUALITY ASSURANCE PROGRAM

What

Quality assurance (QA) is the verification or measurement of the level of quality of a sample product or service. The Statewide Bridge Safety Inspection QA Program is performed by the Bridge Quality Assurance Division (BQAD) in conjunction with its Bridge Safety Inspection QA Consultant.

Why

The purpose of Statewide Bridge Safety Inspection QA Program is to measure the accuracy and consistency of Pennsylvania's bridge safety inspections. The findings from this program are used to enhance or emphasize training needs in the state's bridge inspection training courses and to address any statewide bridge inspection anomalies.

Pennsylvania was the first state to implement such a program.

The Department's Statewide Bridge Safety Inspection Quality Assurance Program consists of independently re-inspecting 30 NBIS bridges in each of 11 Districts and 15 bridges for Pennsylvania Turnpike each year. The 30 District bridges include 15 Department-owned and 15 locally owned structures. The bridges are selected by random using a representative statistical distribution of each District's bridge types. Typically, bridges selected do not require special equipment to inspect, have reasonable ADT's and are of a reasonable size to minimize the cost of reinspect ion and the overall cost of the Statewide Bridge Safety Inspection QA Program.

What

On each bridge, the ratings of 15 inspection items from the QA blind inspection are compared to the ratings from the original inspection. The original inspection item ratings are considered to be out-of-tolerance if they vary more than 1± from the ratings compiled by the QA team. Bridge capacity ratings are redone for all bridges having sufficient documentation to do so. Bridge capacity ratings are considered to be out-of-tolerance if they vary by more than 15% from the capacity ratings done by the QA team. For posted bridges, the bridge is considered to be out-oftolerance ifthe posting evaluation varies by more than 2 tons from the QA team's posting evaluation.

Results of the QA inspections in the form of a draft District Summary Report are reviewed with the inspectors in each District during the District Close-Out Meeting. The Close-Out Meeting is an important part of the QA process because it encourages communication between the QA reviewers and the individual inspectors. Findings from the QA inspections, rating analyses and posting evaluations, and other bridge inspection related issues are discussed. The results of these meetings are used to emphasize training requirements, improve inspection techniques, and initiate needed changes to inspection and coding manuals and Department rating programs.

The results of the QA Close-Out Meeting are incorporated into the report and the Final Report is distributed to the District. The final results of the QA review contained in the District Summary Report are a collaboration of the inspectors, consultants, BQAD and the QA consultant.

When all District Summary Reports are finalized and distributed to the respective Districts, the annual Statewide Cycle Summary Report is compiled and a copy is distributed to each District.

The Statewide Cycle Summary Report is a compilation of all the Districts' QA results. This compilation gives an indication of statewide trends in bridge inspection. Any consistent problems are identified and corrected through the following means:

- Revisions to Procedures and Manuals
- Bridge Inspection Basic and Refresher Training Courses
  Other Bridge Inspection Related Courses

6.3.1 Procedures for the Statewide Bridge Inspection QA Program

The procedures for the quality assurance review on an annual basis for each of the Districts' and the Turnpike's bridges consists of six tasks for the QA consultant as outlined below:

How

• Task I - Office File Review - The office evaluation shall include the following:

General Bridge File Content - complete a bridge file checklist for each bridge that indicates critical contents of bridge inspection records, including but not limited to rating computations, posting evaluation and documentation, drawings, inspection reports, etc. (See chapter IP 8 for Bridge Inspection File contents).

Inventory and Inspection documentation (D450 Forms) comparison with the data in the BMS. Load rating analysis comparison with data entered in the BMS.

Compliance with posting policy (agreement with the Inventory and Operating Ratings in the BMS).

Verify that Form D450M of the Inspection Forms has been completed, especially with regard to critical deficient, narrative comments, and identification of maintenance needs. (Item H08).

Verify and highlight, as part of the QA effort, that a need for bridge cleaning as directed by IE 3.8.1.2 is being identified when necessary and note if cleaning has been performed.

Contact BQAD to obtain copies of shop Drawings referenced but not available at the District Office.

Determine if field measurements are needed to complete the load rating analysis.

Publication 238, Part IP, Chapter 6 - Quality Measures for Safety Inspection

- **Task II - Field Inspection -** Field inspection shall include a complete NBIS inspection of all selected bridges.

How

Verify and identify the structure.
Provide maintenance and protection of traffic.
Photograph the structure, preferably using a High Resolution Digital Camera.
Verify BMS inventory data.
Verify safety features and po stings signs.
Perform independent condition/appraisal ratings.
List and prioritize maintenance/repair needs. Conduct Maintenance needs assessment.
Take needed field measurements for bridge load rating analysis.
Prepare or amend field sketches for scour conditions.
Video tape the structure inspected, including; display sheet listing QA cycle, District, and BMS I.D, approach roadways, bridge elevation, channel upstream and downstream, and especially the items out oftolerance for viewing at the close-out meeting.

- **Task III - Load Rating Analysis and Posting Recommendations.**

How

Load rating analyses will be performed for those bridges with sufficient information to do so in the bridge inspection file. Typically, a load rating analyses is done for two-thirds of the bridges inspected. Some field measurements may be needed during Task II to supplement the office file data.
The load rating analysis shall be done using the Load Factor Method of analysis.
The QA load rating analysis shall be performed independently of the current load rating analysis in the bridge inspection file. The QA office file review and field inspection teams must have obtained sufficient data to perform the load rating analysis.
The analysis shall include Inventory and Operating Ratings for H20, HS20, ML80, and TK527 vehicles.
All calculations, both longhand and by computer, and any sketches are to be documented neatly and included in the QA load rating analysis.
Any computer input files and supporting calculations are to be included in the QA load rating analysis.
Compare these load rating analyses with those in the bridge inspection file and highlight any out-oftolerance differences. List any inaccuracies, omissions or errors.
Comment on existing or required load posting.
Be prepared to discuss differences in results or methods at the close-out meeting with each District, and Turnpike.

- **Task IV - Preparation and submission of District and Turnpike's Draft Summary Reports.**

This task includes a draft of the Summary Report, the individual bridge inspection reports, and the bridge load rating analyses for each District and the Turnpike.
The Summary Report contains a discussion about the bridge inspection, the load rating analysis, and the maintenance needs assessment for each of the bridges reviewed. Recommendations and conclusions regarding the District's effort are also included in this Report.
To prepare for Task V, one draft copy of the Summary Report and a set of the bridge load rating analyses are sent to the District for their review.

- **Task V - Field View and Close-Out Meeting for Each District and the Turnpike.**

A Close-Out Meeting is scheduled with each District to discuss the findings of the QA review. A field view of several of the bridges selected for the review is performed by the QA consultant and the BQAD personnel prior to the scheduled meeting.
Recommended attendees of the Close Out Meetings include: ADE-Design, District Bridge Engineer, District Inspection Staff including local bridge inspection coordinator, local bridge owners and their inspection consultants.
Using results from the field view and the Close-Out Meeting discussion, the Summary Report, bridge inspection reports and bridge load rating analyses are finalized and submitted to the BQAD for review. The reports and ratings are finally distributed to the District.

Task VI - Cycle Summary Report

After Tasks I through V have been completed for all the Districts and the Turnpike, 3 Cycle Summary Reports, (one statewide report for Department bridges, one statewide report for Local bridges, and one for the Turnpike bridges) are prepared and submitted to the BQAD for review and distribution to the Districts.

6.3.2 Selection of Bridges for Statewide Bridge Safety Inspection Quality Assurance Review

What

The Department shall perform an annual Bridge Safety Inspection Quality Assurance review statewide to assure the quality of Pennsylvania's Bridge Safety Inspection Program by independently re-inspecting 30 NBIS bridges in each of I I Districts, and 15 bridges for Pennsylvania Turnpike each year. (The 30 District bridges will include 15 state-owned and 15 locally owned structures.) Each District will be required to submit the fifteen locally owned bridges to be reviewed. BQAD will select the fifteen state-owned bridges for each District and the fifteen Turnpike bridges.

The bridges selected shall be chosen by a random selection process using a representative statistical distribution of each District's bridge types.

6.3.2.1 LOCALLY -OWNED BRIDGE SELECTION GUIDELINES

How

The locally owned bridge selection guidelines are as follows:

- Bridges selected should be from normal NBIS inspections that were performed preferably within the 6 months prior to the submittal date established by the Department. If necessary, this 6-month period may be extended to 9 months in order to obtain a sampling of a District's local bridge inventory in accordance with items 2 through 8 listed below.
- Bridges selected should be generally representative of a District's local bridge inventory.
  No more than 5 selections for each consultant, unless that consultant is performing inspections in more than one county.
- Consultants not previously included in the QA process are preferred.
- A void selecting bridges over railroads where there could be possible problems with access or obtaining permission.
- If needed, selections can be made to place emphasis on a specific bridge type, inspection team, or geographic area.
- Bridges must have final inspection reports that have been received and accepted by the District.
- Reasonable effort shall be made to avoid selecting structures that were reviewed in previous QA cycles. Please contact BQAD to obtain a list of previously inspected bridges in your District.

After determining what local bridges that are to be reviewed for the current cycle, complete and submit a copy of the *Bridge Safety Inspection QA Program, Selection of Local Bridges Form* (See Appendix IP 06-A). Location maps, preferably Type 10 County Maps with the selected bridge marked, are to be provided for each bridge site.

A request for reduction in the number of local bridges to be reviewed must be justified. Possible justifications may include: a small pool of inspections that have recently been performed, a large number of the same types of bridges being inspected, the same consultant having performed all inspections or the past performance of the consultant. If a submission of fewer than the required 15 bridges is selected, a letter of justification must be sent to BQAD two weeks prior to the District's submittal date.

The due dates for the Districts to submit their fifteen locally owned bridges to BQAD will be distributed by a Strike-Off-Letter from BQAD well in advance of the deadline for submission.

6.3.2.2 STATE-OWNED BRIDGE SELECTION GUIDELINES

The state-owned bridge selection guidelines follow the same guidelines used for selecting locally owned bridges.

6.3.2.3 PENNSYL VANIA TURNPIKE COMMISSION BRIDGE SELECTIONS

Fifteen Pennsylvania Turnpike Commission (PTC) bridges will be selected by BQAD from the Western, Central, Eastern, or Northeastern portions of the state.

The Statewide Cycle Summary Report includes:

- A compilation of both Statewide results and individual Districts' results for the past QA Cycle Out-of
  - Tolerances for Condition and Appraisal Items
  - Out-of Tolerances for Observed Scour Ratings
  - Out-of Tolerances for Bridge Capacity Ratings
  - Omissions of Maintenance Needs recordation
- Findings
  - Condition and Appraisal Items that are consistently out-of tolerance are noted and discussed
  - Discrepancies between the D-450's and the BMS D-491 Screens are noted
  - Out-of Tolerances for Observed Scour Ratings are discussed; especially noted, are the sub-items that makeup this Item that are consistently coded incorrectly.
- Conclusion and Recommendations

A similar Cycle Summary Report is separately prepared for and distributed to the PTC.