INDOT TUNNEL INSPECTION MANUAL

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INTRODUCTION

The Tunnel Inspection Manual contains the following chapters:

1. Program Overview
2. Types of Inspections
3. Reporting Systems
4. Emergency Notifications / Critical Findings
5. Quality Control and Quality Assurance

These chapters define the qualifications required to become a team leader and the procedures that the team leader must follow. The performance expectations and responsibilities are provided in this manual. This manual provides the regulatory guidance and outlines the requirements that must be performed in order to provide the documents in the format and timely manner necessary for INDOT to fulfill the requirements of the National Tunnel Inspection Standards. In addition, refer to TOMIE Manual for additional information.

1.0 PROGRAM OVERVIEW

1.01 Program Summary

It is important for the safety of the driving public that qualified personnel inspect Indiana's Tunnels. The Tunnel Inspection Team Leader and other tunnel personnel are required to render judgment on a regular basis pertaining to the safety and integrity of the structures inspected.

The individuals involved in the State Tunnel Inspection Program (TIP) have critical input on many issues, including the allocation of scarce and limited rehabilitation funds and the decision to close tunnels. It is important that the Tunnel Inspector is highly trained and proficient; he/she must understand the mechanics, behavior trends, and economics of a wide range of Tunnel types.

Indiana's State Tunnel Inspection Program (TIP) operates under the directives of the Federal Highway Administration (FHWA) and the Indiana Department of Transportation (INDOT). The mission of the program is as noted below:

1. Ensure public safety.
2. Provide for the efficient use of resources in maintaining the serviceability of Indiana's tunnels.
3. Comply with all federal and state laws, rules, and policies.
4. The State is given the responsibility to accurately inventory and inspect all highway tunnels on public roads. The State shall inspect the tunnels on its highways and assigned non-state tunnels.
5. If a tunnel is not assigned to be inspected by the state inspectors, then the failure of a county to perform these responsibilities may cause a loss of funding. The State shall have the authority to take the appropriate action to assure tunnel safety. These assurances will include that the tunnel has been inspected at the proper frequency, that if necessary the tunnel is posted, and that the posting in done in a timely manner. The State shall have the authority to close unsafe tunnels.

1.02 Inspection Program

The State Tunnel Inspection Program (TIP) is federally mandated and has been in effect since 2016. The program policies are based on the Specifications for the National Tunnel Inspection Standards (NTIS). Tunnel inspection reports and records are stored in the Tunnel Inventory Database.

The required tunnel data is forwarded to the FHWA on an annual basis.

NTIS define a tunnel as *"an enclosed roadway for motor vehicular traffic with vehicle access limited to portals, regardless of type of structure or method of construction. Tunnels do not include bridges or culverts inspected under the National Bridge Inspection Standards (23 CFR 650-Subpart C- National Bridge Inspection Standards). Tunnels are structures that require, based on owner's determination, special design considerations that may include lighting, ventilation, fire protection systems, and emergency egress capacity."* This definition is consistent with the definition used by the American Association of State Highway and Transportation Officials (AASHTO).

This manual will address all tunnels that meet this definition.

1.03 Organization

The Tunnel State Program Manager (TSPM) is charged with administrating the State Tunnel Inspection Program (TIP). The Assistant Tunnel State Program Manager (ATSPM), Tunnel Inspection Team Leaders (TITL), Assistant Tunnel Inspectors (ATI) report to the TSPM. The TSPM, ATSPM and TITL are all required to be fully qualified Tunnel Inspectors. Load Rating and other specialties will report to the TSPM.

The ASPM ensures all Tunnel inspection reports and data have been uploaded to the Tunnel Inventory Database.

The organization of the State Tunnel Inspection Program is shown in figure 1.1 and described in detail later in this section. The review and quality assurance/quality/control procedure is discussed in chapter 5.

1.04 Qualifications and Responsibilities

Below are listed the qualifications required for the various tunnel inspection positions and categories. In order to apply for these, one must: Submit an Inspection Qualifications Form. Qualifications have been determined for the following tunnel positions:

1) Tunnel State Program Manager (TSPM)
2) Assistant State Program Manager (ATSPM)
3) Tunnel Inspection Team Leader (TITL)
4) Assistant Tunnel Inspector (ATI)
5) Load Rating Engineer (LRE)
6) Specialty Contractors or Discipline Specific Inspectors (SC or DSI)

For more information, refer to Section 4.4 of the TOMIE manual.

All certified Tunnel Inspectors in the state of Indiana are required to have their respective Tunnel Inspection certification certificate uploaded in BIAS (Bridge Inspection Asset Software).

1.04(01) State Program Manager (TSPM)

The TSPM is responsible for setting all tunnel inspection policies and procedures, and for all tunnel inspections and related reporting in the state.

TSPM Minimum Qualifications

The TSPM must meet the following minimum qualifications:

1. Capable of overseeing the Tunnel Inspection Team Leaders (TITL) in Indiana, and other assigned Tunnel personnel.
2. Sound background in tunnel inspection and/ or Bridge inspection.
3. Specialized knowledge and skills in bridge or tunnel design, construction, soils, construction materials, and emergency repair techniques.
4. Successful completion of the Safety Inspection of In-Service Bridge (FHWA-NHI-130055) course or Safety Inspection of In-Service Bridge for Professional Engineers (FHWA-NHI-130056.
5. Successful completion of Tunnel Safety Inspection (FHWA-NHI-130110) course.
6. Registered Professional Engineer (PE) in the state of Indiana.
7. Has a minimum of 10 years of experience in either bridge and/ or tunnel inspection.
8. Complete a cumulative of 18 hours of FHWA-approved tunnel inspection refresher training over each 60 months period.
9. Be able to determine when a team leader must meet additional requirements for complex and or other tunnels.

TSPM Responsibilities

As a part of the responsibilities of this position, the TSPM shall:

1. Oversee the INDOT or consultant Tunnel Inspection Team Leaders (TITLs).
2. Manage the statewide tunnel inspection and inventory programs.
3. Ensure all tunnels in the state are inspected at a frequency and by a method consistent with the NTIS and state law.
4. Ensure that tunnel inspection data is uploaded to the Tunnel Inventory Database within mandated time frames.

5. Ensure load ratings are completed in accordance with all federal requirements.
6. Oversee quality assurance and quality control of all tunnel inspection programs.
7. Coordinate with federal, state, toll road, county, and local governmental agencies.
8. Formulate and monitor unique or special features requiring additional attention during inspection to assure the safety of such structures.
9. Conduct annual inspections of state border tunnels in company with respective states' personnel and district offices to determine required actions and lead the effort to accomplish Indiana's portion of any required actions.
10. Notify FHWA of all critical findings based on requirements within this manual.
11. Ensure proper signage is in place for tunnels that require load posting or other restrictions.
12. Ensure a system is in place that will notify INDOT or consultant TITL(s) of required inspections and their due dates.
13. Ensure a system is in place to upload all approved inspection data.
14. Formulate and administer programs and policies.
15. Develop, implement, and evaluate inspection and preservation policies, standards, procedures, and programs.
16. Analyze federal and state legislation, administrative rules, and national and industry standards for incorporation in programs and policies.
17. Recommend the revision of legislation and participate in new legislation development.
18. Lead prompt, decisive, and effective responses to emergencies such as floods, earthquakes, and major tunnel damage.
19. Train tunnel inspection personnel when needed.
20. Develop, monitor, and update training programs for state and consultant inspectors.
21. Arrange or conduct inspection training programs and refresher programs throughout the state.
22. Provide training on proper access, equipment operation, and safety procedures.
23. Review and approve Tunnel Inspection Team Leader and Assistant Tunnel Inspectors qualifications.
24. Maintain a list of all qualified Tunnel Inspection Team Leaders. The list will identify training required to keep the qualifications up to date.
25. Evaluate Tunnel Inspection Team Leaders and other tunnel personnel that require additional training as necessary.

26. Advice on technical issues concerning problems or deficiencies discovered during inspections.
27. Act as a Tunnel Inspection Team Leader, as needed.
28. Monitor inspections and develop a good, general knowledge of all tunnels in the state and their inspection records.
29. Manage state tunnel inspection personnel and consultants to meet the needs of the State Tunnel Inspection Program.
30. Manage state-owned tunnel access equipment to assist in the inspection of tunnels statewide.

1.04 (2) ATSPM Minimum Qualifications and Responsibilities

The ATSPM is responsible for assisting the TSPM and to help ensure that National Tunnel Inventory (NTI) Data is being collected in a timely manner and stored in the Tunnel Inspection Database properly, and reported to the FHWA as required.

ATSPM Minimum Qualifications

The ATSPM must meet the following minimum qualifications:

1. Same as the Tunnel State Program Manager (TSPM).
2. Capable of acting as TSPM, when called upon.

1.04 (3) INDOT and Consultant Tunnel Inspection Team Leader (TITL)

The TITL is responsible for the tunnel inspection and reporting for all assigned state-owned Tunnels, when assigned. In addition, TITL is responsible for ensuring the tunnel inspection work is filed properly and has ensured that ASPM has received such documentations. Consultant TITL may inspect any local or county tunnels when assigned by local or county government.

INDOT and Consultant Tunnel Inspection Team Leader (TITL) Minimum Qualifications

The INDOT TITL must meet the following qualifications:

1. Successful completion of the Safety Inspection of In-Service Bridge (FHWA-NHI- 130055) course or Safety Inspection of In-Service Bridge for Professional Engineers (FHWA-NHI-130056.
2. Successful completion of Tunnel Safety Inspection (FHWA-NHI-130110) course.

3. Complete a cumulative total of 18 hours of FHWA-approved tunnel inspection refresher training over each 60 month period.
4. Qualified as a tunnel Inspection Team Leader in the State of Indiana.
5. Capable of overseeing Assistant Tunnel Inspectors (ATI).
6. Demonstrate a strong background in such areas as bridge or tunnel structural engineering, structural behavior trends and bridge or tunnel rehabilitation techniques.
7. Demonstrate management abilities.
8. Demonstrate thorough familiarity with NTIS, this manual and applicable INDOT guidelines.
9. Must meet one of the following:
    a. Registered professional engineer and at least 6 months of tunnel or bridge inspection experience.
    b. 5 years of tunnel of bridge inspection experience.
    c. Appropriate combination of education and experience, which is stated in the INTIS, from the following:
        i. Have a BSCE and EIT certification, as well as two years of bridge or tunnel experience
        ii. Have an Associate Degree in Civil Engineering and at least four years of bridge or tunnel experience.
10. Good eyesight and the ability to walk and climb over uneven surfaces. In addition, be comfortable working at heights, near water, in confined spaces and close to live traffic.

INDOT and Consultant Tunnel Inspection Team Leader (TITL) Responsibilities

As a part of the responsibilities of this position, the INDOT TITL shall:

1. Coordinate inspections to ensure that all inspections are completed in compliance with this manual.
2. Oversee assistant Tunnel Inspectors.
3. Ensure that all tunnel inspection results are approved and sent to the TSPM or ATSPM within 60 days of the date of the inspection and within seven days for all closures and emergency inspections.

4. Notify the TSPM and ATSPM of all tunnel critical findings in accordance to this manual.

1.04 (4) INDOT and Consultant Assistant Tunnel Inspector (ATI)

The Assistant Tunnel Inspector (ATI) is the person responsible for assisting the Tunnel Inspection Team Leader (TITL). Preferably, the tunnel inspection team should consist of at least two persons: a TITL and an ATI or two TITL(s). When deemed appropriate by the TSPM or ATSPM, other tunnel specialty personnel may be required.

Assistant Tunnel Inspector (ATI) Minimum Requirements

The ATI must meet the following requirements to be considered qualified:

1. Be responsible in assisting in the field work and be on site during the inspection.
2. Demonstrate a strong background in such areas as structural, structural behavior trends, and Tunnel rehabilitation techniques.
3. Good eyesight, the ability to walk and climb over uneven surfaces, and the ability to work at heights, near water, in confined spaces, and close to live traffic.
4. Be a certified Bridge Inspector in Indiana. Successful completion of the Safety Inspection of In-Service Bridge (FHWA-NHI-130055) course or Safety Inspection of In-Service Bridge for Professional Engineers (FHWA-NHI-130056).
5. Recommended that ATI are registered and certified Tunnel Inspectors; however, this is not a mandatory requirement.

Assistant Tunnel Inspector Responsibilities

The Assistant Tunnel Inspector is responsible for the following:

1. Following all Tunnel Inspection Team Leader (TITL) instructions in a safe and appropriate manner.
2. Assisting the TITL in the field.
3. Documenting his/her participation and experience.

1.04(5) Load Rating Engineer (LRE)

Routine load ratings of state-owned tunnels are generally performed and maintained by INDOT's Tunnel Load Rating Engineer who will also be a fully qualified Bridge Load Rating Engineer (LRE). The load rating of local tunnels is generally done by the consultant Tunnel Inspection Team Leader (TITL) of record for the owner.

LRE Minimum Qualifications

The LRE must meet the qualifications listed below:

1. Have experience calculating load ratings and knowledge of load capacity rating computer programs.
2. Registered PE licensed in the state of Indiana, qualified to oversee, review and certify all load capacity ratings performed under his/her supervision.
3. It is preferred that the LRE successfully complete FHWA-NHI-130055, Safety Inspection of In-Service Bridges and Tunnel Safety Inspection FHWA-NHI-130110 Tunnel Safety Inspection.
4. It is preferred, but not required, that the LRE be a certified Tunnel Inspection Team Leader in Indiana.

LRE Responsibilities

The LRE must:

1. Provide engineering judgment to those performing the load ratings.
2. Be actively involved in reviewing the quality and accuracy of all load ratings.

1.04(6) Specialty Contractors or Discipline Specific Inspectors

Specialty contractors (SC) or Discipline Specific Inspectors (DSI) may be required to inspect Complex or specialized tunnel systems. This type of inspector may be necessary for In-Depth Inspections of tunnel systems where specialized tests for a system such as tunnel ventilation, emergency generators or other systems are required

It should be noted that Specialty contractors may require very specific certifications to perform their Inspection work: For more information, refer to Sections 4.4.3 and 4.4.4 of the TOMIE manual.

SC or DSI Minimum Qualifications

When complex civil/structural, mechanical, or electrical systems need to be inspected, the team leader should assign discipline specific specialists (DSI) with suitable training and experience to help conduct these inspections. Ideally, these specialist individuals should be registered professional engineers or at least engineers-in-training.

Specialty contractors (SC) are beneficial when the regular inspection staff lacks the specialized skills and experience necessary to inspect sophisticated equipment or complex systems such as power distribution systems, fire protection and detection systems, security systems, and SCADA (Supervisory Control and Data Acquisition) systems. It is advisable to use qualified specialty contractors when inspecting complex units that pose elevated risks to safety such as boiler units, electrical systems, or energized equipment like transformers. This may help to minimize health and safety risks to the inspection crew and prevent damage to very expensive equipment.

SC or DSI Responsibilities

The SC and DSI are responsible for the following:

1. Following all Tunnel Inspection Team Leader (TITL) instructions in a safe and appropriate manner.
2. Assisting the TITL in the field.
3. Documenting his/her participation and experience.
4. Adhere to your assigned SC or DSI specific duties in Sections 4.4.3 and 4.4.4 of the TOMIE manual.

1.05 Tunnel Inventory Database

As the "Lead Agency" in interactions with USDOT/FHWA, it is INDOT's responsibility to maintain an inventory of all tunnels within Indiana. All tunnel data shall be stored in the following location (link) which is referred henceforth as Tunnel Inventory Database:

RM-BRDGINS (\\STATE.IN.US\FILE1\SHARED\INDOT6\SHARED)(X) > Indiana Tunnel Inventory Data

All inspection data shall be approved by the Inspection Team Leader.

Additional inventory information, inspection reference materials, field notes/sketches, and quantity take-offs can be found in above aforementioned link.

These materials include the following:

Structure Inventory

1. Field inspection information including sketches and photographs showing typical and deteriorated conditions. This requirement includes a brief narrative to justify a change in condition rating. A plan of action is to be included, if required.
2. Critical Findings in accordance with this manual
3. Other Inspection Procedures. These items will include other required reports such as fracture critical. These reports will be in accordance of this manual.
4. Load Rating. A dated load rating along with identification of the analysis to determine capacity. Results must be included which clearly identify the loads and methodology used in the analysis. Identify controlling members. Include any updates that reflect changes in the condition of structural members. If calculations cannot be provided due to lack of information, provide documentation for justification of determined load rating.
5. Posting Documentation which is in accordance with this manual.

2.0 TYPES OF INSPECTIONS

2.01 Introduction

There are numerous types of inspections, each designed to obtain specific information. For example, an Initial Inspection is performed after a tunnel is constructed to document the as-built conditions, whereas Routine Inspections are used to monitor the condition of a tunnel at regular intervals. Damage Inspections are used to assess damage resulting from events such as deterioration, impacts, fires, or floods. These inspections help create a complete picture of a tunnel's condition and are described in detail in this chapter.

Visual inspection is the primary examination method for all inspections. Nondestructive testing (NDT) techniques may be required to identify internal flaws or hard-to-see external defects in critical members. NDT is detailed in this manual.

2.02 Inspection Types

The Federal Highway Administration (FHWA) and the state of Indiana dictate the type of inspection each tunnel requires, and the maximum interval between inspections. Figure 1.2 Tunnel Inspection Types and Maximum Intervals gives an overview of the types of inspections, the maximum interval between inspections, and the governmental unit responsible for the inspection policy. These are the following five (5) types of tunnel Inspections that will be discussed in this manual:

1) Initial Inspection
2) Routine Inspection
3) Damage Inspection
4) In-depth Inspection
5) Special Inspection

For more information, refer to Section 4.6 of the TOMIE manual.

2.03 Inspection Schedules

Once a Routine Inspection has been conducted (which means there was an Initial Inspection performed) on a Tunnel, the following Routine Inspections and other scheduled inspections should be completed in the same month unless the SPM approves changing the frequency. A scheduled inspection can be conducted early, but must never be conducted late.
Upon final approval of any inspection type, the *Scheduling* fields will be reviewed on the primary Inspection Report Information page. All report type schedules will be maintained.

The Due Date and Schedule Date is calculated based on the last approved inspection of that type and can only be edited after the inspection report has been uploaded to the Tunnel Inventory Database.

In the event that a Schedule needs modified following the upload and report approval, the ASPM and SPM will need to be notified to ensure changes are reflected in the Tunnel Inventory Database.

2.04 Inspection Plan of Action

Occasionally deterioration, or other issues are found on a tunnel that may require a reduced inspection frequency and/or more thorough inspection. In these cases an Inspection Plan of Action is to be written and attached to the report and be stored in the Tunnel Inventory Database. The Plan of Action should be detailed in describing the actions needed, the time frames they are needed, and who should be informed if additional issues are found, and how to document the findings.

2.05 Initial Inspections

2.05(01) Purpose

An Initial Inspection is the baseline inspection that should be completed on every new tunnel, after a major rehabilitation, or when the configuration or geometry of a tunnel changes (e.g., when a tunnel is widened). An Initial Inspection is a fully documented inspection using the Tunnel plans to determine basic data which will be stored in the Tunnel Inventory Database. Initial Inspections are also used when a tunnel is discovered that has not been previously inventoried. In this case, the tunnel plans may not be available. As part of the Initial Inspection, inspectors evaluate the tunnel and decide what other foreseeable inspections will be required throughout its life, which include Special, and In-depth Inspection.

As a part of the Initial Inspection, Inspectors must review the "Tunnel File" and research and look for all missing documents and have any that are found scanned and uploaded into the Tunnel Inventory Database.

2.05(02) Precision

The Initial Inspection should be a fully documented investigation. Inspectors must be able to identify any deficiencies and verify the geometric data. All observed deficiencies, cracks, construction errors, and alignment problems should be documented.

An Initial Inspection should include:

1. Verify and record all Structure Inventory and Appraisal (SI&A) data required by federal and state regulations.

2. Gather relevant information required to maintain an accurate Tunnel file, scan and uploaded in the Tunnel Inventory Database. Further investigation may be needed by searching ERMS or archived records.
3. Ensure that all tunnel systems are noted and evaluated in accordance to the SNTI which may include the following:
    - Emergency Generator System
    - Miscellaneous Mechanical systems
    - Electrical Distribution systems
    - Electrical and Lighting systems
    - Fire and life safety, emergency systems
    - Emergency communication systems
    - Tunnel security and operation systems
    - Tunnel ventilation systems
    - Other tunnel systems that need special consideration
4. Determine and evaluate the baseline structural condition, as well as systems.
5. Identify the location and condition of any fracture critical members or details.
6. Identify the location and condition of any details that may require a Special Inspection.
7. Verify that all clearances and geometric dimensions are probably noted in the Tunnel Inventory Database.
8. Identify any critical findings and notify the appropriate individuals and agencies identified in this manual.

All inspection results should be fully documented and filed in the Tunnel Inventory Database.

2.05(03) Repairs

Rehabilitation repairs are permanent repairs that are intended to improve the structural condition of a member and/or component. Access to the repair plans is needed to determine if and to what extent rehabilitation improves any specific rating number.

Tunnels used to maintain traffic during construction must be inspected in the month the Routine inspection is due. The Contractor is required to provide access for inspectors to conduct a Tunnel Inspections of any type.

2.05(04) Frequency

For state-owned or state-assigned tunnels, an Initial Inspection should be completed before the new construction or rehabilitation construction contract is finalized and the tunnel is open to traffic. These inspections are often performed in conjunction with the construction department's Pre-Final Inspection. Approved Initial Inspection data, including the SI&A data, must be entered in the Tunnel Inventory Database within 90 days of the completion of the construction.

For toll road, county, and local agency tunnels, Initial Inspections will be completed as soon as reasonable. Approved Initial Inspection data, including the SI&A data, must be entered in the Tunnel Inventory Database within 90 days of the opening of the tunnel.

A tunnel not previously documented in the Tunnel Inventory Database shall receive an Initial Inspection within 90 days of the discovery of the tunnel. The data must be entered the Tunnel Inventory Database. In addition, the report will be approved within 90 days of the discovery of the tunnel.

2.06 Routine Inspection

2.06(01) Purpose

Routine Inspections are regularly scheduled inspections consisting of observations and/or measurements needed to determine the physical and functional condition of the tunnel, and to identify any changes from previously recorded conditions. The Routine Inspection also ensures that the tunnel continues to satisfy present service requirements. Routine Inspections must occur within a 24 month interval except if required to be inspected more frequently.

2.06(02) Precision

Routine Inspections will follow a Plan of Action, documented in the Tunnel Inventory Database, if the tunnel may unique issues such as difficult access which requires access equipment or traffic control.

Routine Inspections are generally conducted from the portal to portal or from permanent work platforms and walkways, if present. A complete walk-around visual inspection of all components of the structure and adjacent roadway is required. A complete walk-around visual inspection of all tunnel systems is required, such as:

A Routine Inspection should include the following system inspections in accordance to SNTI, if present:

- Emergency Generator System

- Miscellaneous Mechanical systems
- Electrical Distribution systems
- Electrical and Lighting systems
- Fire and life safety, emergency systems
- Emergency communication systems
- Tunnel security and operation systems
- Tunnel ventilation systems
- Other tunnel systems that need special consideration

1. Complete an inspection and evaluation of all required data identified in accordance with this manual.
2. Verify SI&A data.
3. Gather other relevant information required to maintain an accurate Tunnel file, scan and upload to the Tunnel Inventory Database.
4. Note any existing problems or components.
5. Note the condition of fracture critical members or details.
6. Identify the location and condition of details that may require a Special Inspection.
7. Note signs of bats and cliff swallows at state-owned or state-assigned tunnels.
8. Take alignment photos from both ends of the tunnel. Closing, posting, and/or restriction signs should be visible and legible in the photos.
9. Take elevation photos, preferably of both ends of the tunnel, (as a minimum on one side of the tunnel).
10. Take photos of all tunnel elements with a condition state of 3 or 4.
11. If needed to complete the tunnel file, take one clear photo under each superstructure type, clearly showing details.
12. If needed to complete the tunnel file, take one clear photo of each substructure unit in the water.
13. If needed to complete the tunnel file, take one photo looking at the portal entrance (north or east portal entrance).
14. If needed to complete the tunnel file, take one photo looking at end portal entrance (south or west entrance).
15. If needed to complete the tunnel file, take one photo of any fracture critical member or details.

16. If needed to complete the tunnel file, take one photo of any detail that requires a Special Inspection.
17. Take photos of significant deterioration and collision damage.
18. Note if a new load rating is warranted.
19. Identify any Critical Findings and notify the appropriate individuals and agencies identified in this manual.

2.06(03) Inspection Frequency

Tunnels must receive a Routine Inspection every 24 months unless widespread deterioration dictates more frequent inspections. If only a portion of a tunnel needs more frequent inspections, a Special Inspection is required. For more information, refer to Table 4.3 of the TOMIE manual.

Tunnels with a condition state of 4 for any element or system shall have a reduced interval between Routine Inspections. A maximum inspection interval of 12 months will be used.

A reduced frequency may be warranted for any of the following tunnel structural components or systems if present:

- Emergency Generator System
- Miscellaneous Mechanical systems
- Electrical Distribution systems
- Electrical and Lighting systems
- Fire and life safety, emergency systems
- Emergency communication systems
- Tunnel security and operation systems
- Tunnel ventilation systems
- Other tunnel systems that need special consideration

For more information, refer to Chapters 4 and 5 of the TOMIE manual and the SNTI.

2.07 Special Inspections

2.07(01) Purpose

Special Inspections are scheduled to examine a portion of a tunnel in more detail or at a greater or lesser frequency than is standard for Routine Inspections. Special Inspections may provide follow-up after a Routine, Damage, or Initial Inspection. The Special Inspection mandates the

component being inspected is at arm's length, and Non-Destructive Evaluation (NDE) methods utilized when necessary to complement visual evaluations.

Details and tunnels that may require a Special Inspection include the following:

1. Fatigue category E and E' details (Most welded steel cover plates can be removed from this category. Historical evidence has shown by both Purdue research and detailed inspections since +- 1988, that cracks rarely develop, even from poor welds, and if they do, they grow very slowly. If a detail has a +- 30 year history of no cracks, an Inspector can request that the State Program Manager remove this from requiring a Special Inspection of these details).
2. Hangers of all types
3. Hinge or pin connections
4. Known defects, significant section loss/deterioration, or damage severe enough to warrant extra scrutiny
5. Unique or problematic details as determined by the SPM
6. An asbestos inspection is a special inspection may be required for any tunnels built before 1980.
7. A tunnel may require special inspection for the following systems:
    - Emergency Generator System
    - Miscellaneous Mechanical systems
    - Electrical Distribution systems
    - Electrical and Lighting systems
    - Fire and life safety, emergency systems
    - Emergency communication systems
    - Tunnel security and operation systems
    - Tunnel ventilation systems
    - Other tunnel systems that need special consideration

2.07(02) Precision

Special Inspections may include a Plan of Action, if required. The Plan of Action may include:

1. A time table for conducting each inspection.
2. The personnel requirements for each portion of each inspection.
3. A list detailing what is required to be inspected under each inspection.

4. The required access equipment needed for each inspection.
5. The required traffic control for each inspection.
6. Assistance from a specialist for potential problems for the following tunnel systems:
    a. Emergency Generator System
    b. Miscellaneous Mechanical systems
    c. Electrical Distribution systems
    d. Electrical and Lighting systems
    e. Fire and life safety, emergency systems
    f. Emergency communication systems
    g. Tunnel security and operation systems
    h. Tunnel ventilation systems
    i. Other tunnel systems that need special consideration

2.07(03) Special Inspection because of unique or problematic details

For tunnels that require a Special Inspection because of unique or problematic details, the inspector must make sufficient measurements and observations to quantify the deficiencies to allow for future monitoring. Inspectors should document:

1. The physical and functional conditions of the known or suspected deficiency.
2. Any developing problems such as deterioration, foundation settlement, scour or erosion of the slopes, scour at the supports, ice damage, or other problems that, if left unchecked, would degrade the load-carrying capacity of the tunnel.
3. Signage is in place and visible for load-posted or restricted tunnels.
4. The ability of the tunnel to satisfy its present service requirements.
5. The condition state of the specific element or potential tunnel systems like:
    a. Emergency Generator System
    b. Miscellaneous Mechanical systems
    c. Electrical Distribution systems
    d. Electrical and Lighting systems
    e. Fire and life safety, emergency systems
    f. Emergency communication systems
    g. Tunnel security and operation systems

h. Tunnel ventilation systems

i. Other tunnel systems that need special consideration

2.07(04) Recording Inspection Results

Inspection results must be recorded in the Tunnel Inventory Database. The date of the inspection and a list of the deficiencies investigated must be included. If any deficiency has become more severe, it may be necessary to notify the owner and re-evaluate the tunnel load rating. Critical findings shall be reported to the appropriate individuals and agencies identified in this manual.

Some Special Inspection tasks need not be performed with an Inspection Team Leader on site. Inspection Team Members can be sent out to perform specific inspection or measurement tasks under the direction of an Inspection Team Leader. Such tasks might include measuring a crack, photographing a weld, or measuring section loss on specific members. These tasks must be clearly documented in the Special Inspection Plan of Action. The Inspection Team Leader is still required to review and sign off on all inspection data entered into Tunnel Inventory Database.

For state-owned or state-assigned tunnels that require a Special Inspection, a lead Inspection Team Leader is assigned by the State Program Manager. The Plan of Action will be developed and modified by the lead Inspection Team Leader in consultation with the State Program Manager.

The lead Inspection Team Leader for state-owned or state-assigned tunnels may or may not be the Inspection Team Leader for any individual inspection performed as a part of the Special Inspection. The Inspection Team Leader for each individual inspection will approve the inspection results entered in the Tunnel Inventory Database for that inspection. The lead Inspection Team Leader must review all individual inspections performed as a part of the Special Inspection, as well as generate/approve a summary of the Special Inspection. This summary must be entered in the Tunnel Inventory Database.

Inspection teams for state-owned or state-assigned tunnels may consist of state personnel, consultants, or a combination. The lead Inspection Team Leader will ensure that each team is working within the scope of its professional ability.

For toll road, county, and local agency complex tunnels that require a Special Inspection, a lead Inspection Team Leader may be assigned by the Inspection Consultant but must be approved by the SPM.

The Plan of Action will be developed and modified by the lead Inspection Team Leader in consultation with the State Program Manager.

The lead Inspection Team Leader must review all individual inspections performed as a part of the Special Inspection, as well as generate/approve a summary of the Special Inspection. This summary must be entered into the Tunnel Inventory Database.

Depending on the extent of the damage or deterioration, a Special Inspection may include a recommendation for a load rating to assess the capacity of damaged or deteriorated members. Nondestructive tests and/or other material tests may be needed to assist in determining the safe load-carrying capacity.

Critical findings shall be reported to the appropriate individuals and agencies identified in this manual.

All inspection results should be fully documented in the Tunnel Inventory Database.

2.07(05) Frequency

Special Inspections for unique and problematic details are completed in addition to Routine Inspections. The maximum inspection interval for a Special Inspection is 60 months. A problematic detail that is performing well on a structure can have an inspection interval of 60 months. A structure with a problematic detail that has a rating of 4 or less shall be inspected on a 12 month interval.

A written request should be sent to the SPM requesting the Special Inspection be removed if the detail has been retrofitted or rehabilitated.

The inspection frequency of each component inspection of a Special Inspection for a complex tunnel may be identified in the Plan of Action. It may be most efficient to conduct all of the inspections at one time, using the same inspectors. However, it may not be practical to schedule inspections requiring different types of traffic control, access equipment, or NDT at the same time.

2.08 In-Depth Inspection

2.08(01) Purpose

In-Depth Inspections are a close-up, hands-on inspections conducted on one, several, or all tunnel elements or functional systems. These inspections are used to identify deficiencies that are not readily identifiable during initial, routine, or damage inspections. In-depth inspections may involve testing of tunnel systems, components, and/or materials. More extensive disassembly and cleaning of equipment parts may occur. This type of inspection may be used to support a structural analysis or a functional system evaluation where more information is needed. In-depth inspections are scheduled based on the needs of the tunnel facility, inspection findings, and established written procedures.

2.08(02) Precision

The scope of an In-Depth Inspection shall be defined in advance and shall be to inspect one, several, or all tunnel elements or functional systems. In-Depth inspections shall always be close-up and hands-on. An In-Depth Inspection is a scheduled inspection that will

allow the inspector the opportunity to make sure that all of the components of the structure are performing as intended.

2.08(03) Frequency

The maximum frequency of an in-depth inspection is 96 months.

2.09 Damage Inspections

2.09(01) Purpose

A Damage Inspection is an unscheduled inspection to assess structural damage resulting from environmental factors or human actions. Flood damage, fire damage and vehicle impact are examples of events that may call for a Damage Inspection.

2.09(02) Precision

The scope of a Damage Inspection should be sufficient to determine whether there is a need for emergency load restriction, or closure of part or all of the tunnel to traffic. Inspectors of state-owned or state-assigned tunnels should also assess the level of effort necessary to repair the damage. The amount of effort expended on this type of inspection may vary significantly and depends on the extent of the damage. If major damage has occurred, the inspector shall document the damage, including measuring section loss or misalignment, and any loss of foundation support.

Inspection data and pictures shall be entered into the Tunnel Inventory Database as soon as possible, and no more than seven days after the inspection. This inspection may be supplemented by a timely Special Inspection to more fully document the extent of damage and the urgency and scope of repairs. A more refined analysis, to establish or adjust interim load restrictions, may also be required as follow-up for a Damage Inspection. A structural engineer may need to be consulted for the inspection or analysis. If the inspection identifies a Critical finding, the inspector must follow the notification procedures outlined in this manual.

A damage inspection is required for all tunnels in which the event has left permanent physical evidence. The damage inspection data and pictures shall be entered into the tunnel Inventory Database as soon as possible and no more than seven days after the inspection.

The Inspector of state-owned or state-assigned tunnels should gather data on the vehicles and drivers involved and any police report after a crash. This information will be used to bill the appropriate insurance company for damages.

2.09(03) Frequency

A Damage Inspection is an unscheduled inspection that is performed to determine if significant damage has been done to the tunnel. Based on the findings of the damage inspection, the inspector will determine if the damage warrants placing the structure on a special detail inspection. Pictures of any damage will be uploaded into Tunnel Inventory Database with a complete description of the event. Generally, a law enforcement officer on the site of an accident involving a tunnel will notify the owner who will request a Damage Inspection be performed to determine if the tunnel should be closed. Damage Inspections may be needed after flooding or earthquakes.

2.10 Tunnels Closed To Traffic

If a tunnel is closed to all traffic, for construction when an inspection is due, the inspection team shall:

1. Document the tunnel is properly closed with photos.
2. Note that the inspection date was changed in the Tunnel Inventory Database.
3. Verify the estimated date of completion of the construction.
4. Schedule on the Tunnel Inventory Database, a new Initial Inspection and all other required inspections for the estimated completion date. All rescheduled inspections must be completed within 90 days of being opened to traffic. The Routine Inspections shall remain in the month that it had been prior to construction, once the Initial Post-construction Inspection is complete.
5. Leave other NTI data items unchanged, until the initial inspection is conducted.

If a tunnel is only partially closed to traffic during construction, then a tunnel inspection is required. On INDOT tunnels, the contractor is required to provide a time and access for inspectors to conduct all needed inspections.

If a tunnel has been closed permanently when inspection is due, the inspection team shall:

1. Document the tunnel is properly closed with photos. No other inspection work is required. If the tunnel is not properly closed, a critical finding must be immediately submitted.
2. A memorandum will be published stating that the tunnel is permanently closed. The memorandum will be electronically stored on the Tunnel Inventory Database.
3. Code the appropriate NTI Date Item(s) with the date the inspectors were at the tunnel.
4. Note that the inspection dates were changed in the Tunnel Inventory Database.
5. Leave other NTI data items unchanged.
6. Recommend the removal of the tunnel be scheduled as soon as possible.

Permanently closed tunnels are generally not eligible to use federal tunnel inspection funds to conduct inspection activities.

3.0 REPORTING SYSTEMS

3.01 Tunnel File

The Tunnel file is the collective term for all documents necessary to provide a comprehensive history of each Tunnel Asset. There are two official repositories for documents that comprise the Tunnel file: the Tunnel Inventory Database and the INDOT Electronic Records Management System (ERMS). At a minimum, the Tunnel file is to contain the following documents prior to being identified as complete. Each item is annotated with the required repository.

Tunnel Inspection Reports Tunnel Inventory Database. A minimum of 10 years of inspection history is required for all assets more than 10 years old.

Original Plans (Either Approved Design signed by PE or As-Built Record) – ERMS

All Tunnel Rehabilitation Plans (Either Approved Design signed by PE or As-Built Record) – ERMS:

1. Significant Correspondence – ERMS. Significant correspondence includes agreements regarding inspection responsibility, ownership, or other issues that have an impact on timely inspections.
2. Memoranda of Agreement (including Maintenance Agreements), where applicable – ERMS
3. Relinquishment Agreements, where applicable – ERMS
4. Load Rating Reports and Load Rating Calculations/Models- Tunnel Inventory Database Tunnel Inspection Report

The required report sections in a Tunnel inspection report include the following:

1. Report Cover and Location Map
2. Executive Summary. The executive summary is to include a general statement of condition of the Tunnel and a statement of areas of concern.
3. National Tunnel Inventory and Miscellaneous Asset Data.
4. Field Inspection Information. Field inspection information is to include sketches and photographs showing typical and deteriorated conditions. A brief narrative is required to justify a change in condition rating. All pictures inspection report are to be labeled.
5. Critical Findings. Critical finding documentation is to be in accordance with this Tunnel Inspection Manual.

6. Other Inspection Procedures. Other inspection procedures include other required reports such as fracture critical and under water. These reports are to be in accordance with Part 1of the Tunnel Inspection Manual.
7. Posting Documentation. Posting documentation is to be in accordance with this Tunnel Inspection Manual.
8. Pictures and Sketches. All pictures and sketches in the inspection report are to be labeled.
9. Load Rating.

3.02 Tunnel Number

The state uses an alpha-numeric numbering system to identify the Indiana Department of Transportation (INDOT) Tunnel identification number. Since Indiana has very few tunnels compared to bridges and culverts, the numbering system is based on:

1) State (IN)
2) Number 2 (second program)
3) The actual county name
4) An assigned six digit number

The following are examples of the current numbering system and location:

1) **IN2MARION000001** South Capitol Avenue under CSX RR and Other Items
2) **IN2MARION000002** Illinois Street under CSX RR and Other Items
3) **IN2MARION000003** Meridian Street under CSX RR and Other Items
4) **IN2MARION000004** Pennsylvania Street under CSX RR and Other Items
5) **IN2MARION000005** East Street under CSX RR and Heliport

4.0 EMERGENCY NOTIFICATION/CRITICAL FINDINGS

4.01 Introduction

The procedures in this chapter set forth a uniform method for timely notification of serious tunnel deficiencies that require an immediate response. They also document the baseline requirements for assuring that appropriate corrective or protective measures have been taken within a reasonable time frame and that established documentation protocol have been followed. Counties and other local government agencies may have additional guidelines for alternate route information, public relations, and information dissemination procedures that should be followed.

The procedures outlined in this chapter should be used to report conditions posing danger to persons or property or conditions that, if left unattended, would likely become such a danger.

This chapter outlines the responsibilities of the Inspection Team Leader, Inspection Consultants, District Inspection Engineers, and the State Program Manager in an emergency.

Any INDOT Approved Inspection Team Leader may close any tunnel if it appears to be unsafe.

4.02 Critical Findings

A critical finding is a structural or safety related deficiency that requires immediate follow-up inspection or action.

A structure-related deficiency can interrupt the load path, not allowing the loads to be transferred as designed. This can cause surrounding elements to become overstressed or unstable, potentially leading to partial or total collapse of the structure. Critical findings may also be non-structural deficiencies which jeopardize the safety of motorists or pedestrians.

The follow-up action may be a structural review to determine the strength or serviceability of an element or tunnel.

4.02(01) Procedures for Inspectors

Upon identifying a potential critical finding, immediately report the deficiency to the appropriate agency officials. For non-state- owned or non-state-assigned tunnels, the finding is to be first reported to the employee of responsible charge (ERC). The finding for state- owned or state assigned tunnels and the second reporting for non-state owned tunnels is to be the Tunnel State Program Manager (TSPM).

The immediate actions taken by the inspector will vary with the circumstance. The inspector may close all or part of the structure until further analysis can be performed to determine the structural integrity of the structure. Alternatively, the inspector may recommend that remedial work be performed within a short time frame. Even if no immediate action is taken, it is still required to report the potential critical finding immediately, even in situations where the structural review will ultimately resolve the structure as having adequate strength.

The Inspector shall notify the State Program Manager at the time he reports a Critical Finding as to whether the Critical Finding is “Urgent” or “Severe”. An “Urgent” Critical Finding must have an action completed and the Critical Finding closed-out with 3-days of it being found. A “Severe” Critical Finding must have an action completed and the Critical Finding closed-out within 30-days of the Critical Finding being found. This longer time may be used to conduct a load rating, have signage made, or other items that cannot be done immediately.

In addition to the initial reporting of the potential critical finding, which may be by verbal notification, email or by phone, a critical finding must be submitted to the Tunnel State Program

Manager (TSPM) within 24 hours. If notification is via phone or verbal, then inspector shall follow up with an email notification. Send to the TSPM or ATSPM, all of the pertinent data and picture, sketches, and other related files.

The Tunnel State Program Manager will record the critical finding for tracking and will notify the FHWA in a timely manner. If further action is required, the TSPM or ATSPM will request additional information or actions be done by the inspector. Once the immediate safety concerns are addressed, the inspector will notify the TSPM or ATSPM that the critical finding is closed and the SPM may close out said critical finding.

4.02(02) Documentation

Critical Findings must be documented in the Tunnel Inventory Database within 24 hours for all tunnels. The Critical Finding will become a permanent record in the Tunnel file.

An ACTION must be recorded in the Tunnel Inventory Database Critical Finding Report, along with photos attached, in order for the SPM to close-out a Critical Finding. This does not necessarily mean that the deficiency has been corrected. It just means that an action has been taken to address the immediate safety concerns.

All INDOT Approved Team Leaders are required to take and pass an on-line Fracture Critical Course, and to attach their completion form into their account file the Tunnel Inventory Database.

5.0 QUALITY CONTROL AND QUALITY ASSURANCE

5.01 Introduction

Quality Control and Quality Assurance are integrated into all aspects of tunnel inspection. They contain the essential requirements to demonstrate that care, skill and diligence is used in the preparation of tunnel inspection reports.
The Tunnel Inspection personnel will put in place those management tools needed to define, implement, and evaluate the effectiveness of each tunnel inspection, to provide feedback for performance enhancement and institute actions to prevent recurrence. Together these activities ensure that:

1. Quality Control is the checks necessary to maintain a uniform level of quality. For the purposes of this Chapter, the Assistant Tunnel State Program Manager (ATSPM) is the Quality Control Engineer (QCE) who performs these checks.

2. Quality Assurance is an independent evaluation of a service (i.e., an inspection) to establish that a pre-described level of quality has been met. For the purposes of this Chapter, the ATSPM is the

Quality Assurance Engineer (QAE) who performs this evaluation. The Quality Assurance Supervisor (QAS) is also the ATSPM.

The review for the Quality Control and Quality Assurance program shall include the ATSPM and the Tunnel State Program Manager.

5.02 Quality Control Engineer

The QCE's responsibilities include but are not limited to the review of the inspection reports and review of the inspection methods by the teams in the field.

The QCE and his/her assistant shall collectively review 100% of all inspection reports. The QCE will sign all inspection reports reviewed by him/her. This review will be performed on inspection reports prepared by INDOT staff and/or Consultants. The QCE is not responsible for the review of inspection reports prepared for other agencies.

The QCE may delegate inspection reports for review except he/she will be personally responsible for the review of the following inspection reports:

All inspections containing element(s) with condition state 4 defects.

The QCE's review of inspection reports will consist of the following:

1. Overall review of the inspection report to ensure that the correct form has been used, that the correct tunnel is identified and that all required information has been entered.
2. Review that all information has been correctly entered in accordance with the SNTI and this manual. This review will include but not be limited to a check that proper coding conventions, format, significant digits and correct units have been used.
3. Check that the overall quantity of condition states is consistent with the condition states of the individual element deficiencies.
4. Check that there is adequate documentation for elements that have deficiencies in condition states 2, 3 & 4.
5. Check that all sketches, charts and/or photographs have been properly cross referenced in the inspection report.
6. Check that there is consistency of information between the current inspection report and previous inspection reports and/or rating report, if applicable.
7. Check that proper documentation was incorporated into the inspection report for any changes that may have occurred from the previous inspection report.

8. Review of all items after data entry to check that they have been properly and correctly entered.
9. For every Initial Inspection, a check of the inventory data against the construction plans to ensure that the data is consistent.
10. For every Initial Inspection, a set of inventory photos has been taken and included in the report and saved in the Tunnel Inventory Database.

5.03 Quality Assurance Engineer

The review by the QAE will include checking that the inspection data complies with the Federal and INDOT requirements. As a minimum, the QAE shall review 100% of the following inspection reports:

1. All inspections containing element(s) with condition state of defects.

2. Also the QAE shall review a minimum of 10% of all reports for completeness.

The QAE is responsible for ensuring that the defined quality control procedures are enforced throughout the state. A review includes all aspects of functions to ensure adherence to Federal and State inspection criteria, laws, codes, standards, and regulatory requirements.

Also, the review may include the evaluation of inspection personnel's choice of inspection equipment, information retrieval methods, investigational processes, time and frequency of required inspectional services, etc.

Tunnel inspection consultants shall maintain a current list of all qualified tunnel inspection personnel with their most current personal data regarding titles, duties, education, certification and training. Copies of certificates should be maintained in the Tunnel Inventory Database.

5.04 Inspection Team Field Evaluation

The Inspection teams shall be field evaluated by the QAE and assisted by the QCE. The purpose of the Field Evaluation is to establish a uniform method of evaluation for the field performance of a tunnel inspection team.

This procedure shall be used as a basis for a tunnel inspection field evaluation. This evaluation shall document the arrival time, set-up time, preparations made for equipment, safety conformance, access methods, and the quality and thoroughness of each inspection team’s activities. It should also note

wither or not safety equipment was properly used, whether appropriate access methods were used, and an evaluation of whether the inspection served its desired purpose.

5.05 Quality Control and Quality Assurance

Every inspection shall be evaluated in the field at least twice a calendar year. Also, every Consultant Firm shall be evaluated in the field at least once a calendar year.

After each field evaluation, the Evaluation Team shall fill out an Inspection Team Field Evaluation Form and shall discuss the result of its findings with the inspection team, so any improvement, as needed, can be initiated more quickly.

If a team field evaluation by the QAE and the QCE results in an unsatisfactory review of the actual inspection performed by the TL, then the QAE shall notify (via email) the State Bridge Engineer, Tunnel Engineer, QCE and the TL of the result of the field evaluation. The Tunnel Inspection Team Leader (TITL) shall then address the comments for the unsatisfactory review and shall forward them to the Tunnel Engineer, QAE, and QCE. The QAE shall then randomly perform another field evaluation on an inspection done by the same TITL not less than two months from the date of the unsatisfactory field evaluation.

5.06 Inspection Report Evaluation

The inspection reports prepared by the inspection teams shall be field evaluated by a review team consisting of the QAE and the QCE. The evaluation is conducted to ensure a uniform quality of the individual tunnel inspection report. Also, the review is to monitor the inspection for completeness, thoroughness, consistency, accuracy and standardization. It is recommended that an evaluation be made soon after an inspection so that conditions will not have changed.

5.07 Inspection Report Evaluation Procedures

This procedure shall be used to form the basis of a tunnel inspection report evaluation. The report shall list the structure type, team, and comparisons of the previous and current (and, if available the Review Team Inspection Report) for the Structural Elements, Civil Elements, Mechanical Systems, Electrical Systems, Fire/Life Safety/Security Systems, Signs, Protective Systems. This procedure shall be undertaken in the field. Also the report shall address the documentation provided by the inspection team with a particular emphasis on sketches, photographs and detailed explanations. Conclusions shall be checked to verify that they are logically stated and correct and that they were independently checked by the Review Team. Finally an overall evaluation shall be given of the inspection report.

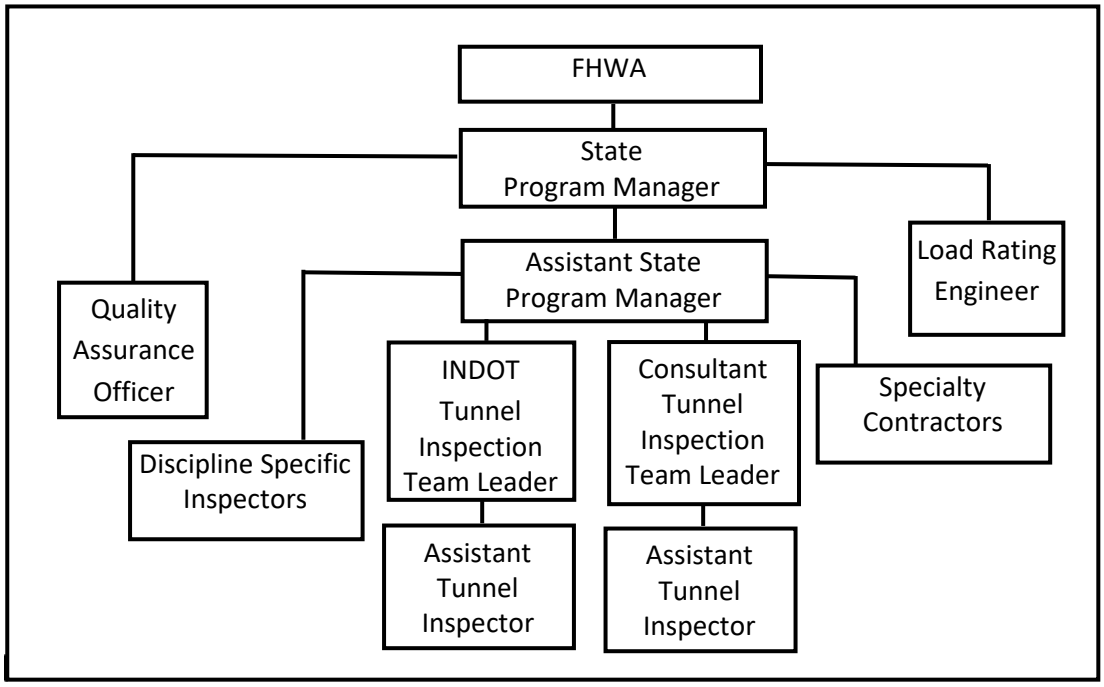
Inspection reports shall be randomly evaluated on a regular basis.

After each inspection report evaluation, the Evaluation Team shall fill out an Inspection Report Evaluation Form and shall discuss the result of its findings with the inspection team, so any improvement, as needed, can be initiated more quickly.

If an evaluation by the QAE and the QCE results in an unsatisfactory review of the report prepared by the TITL, then the QAE shall notify (via email) the State Tunnel Engineer, QCE and the TITL of the result of the report evaluation. The TITL shall then address and correct the changes that the QAE and the QCE observed in the prepared report and shall resubmit the report for review. The QAE shall then randomly perform another report evaluation on a report prepared by the same TITL not less than two months from the date of the unsatisfactory evaluation.

FIGURES

1.1: State Tunnel Inspection Program Organization



1.2: Tunnel Inspection Types and Maximum Intervals

Inspection Type	Maximum Inspection Interval	Agency
Initial	Prior to Opening to Traffic	FHWA Mandate
Routine	24 months	FHWA Mandate
Special	60 months	FHWA Mandate
In-Depth	96 months	INDOT Policy
Damage	As needed	FHWA Mandate

* Plan of action required