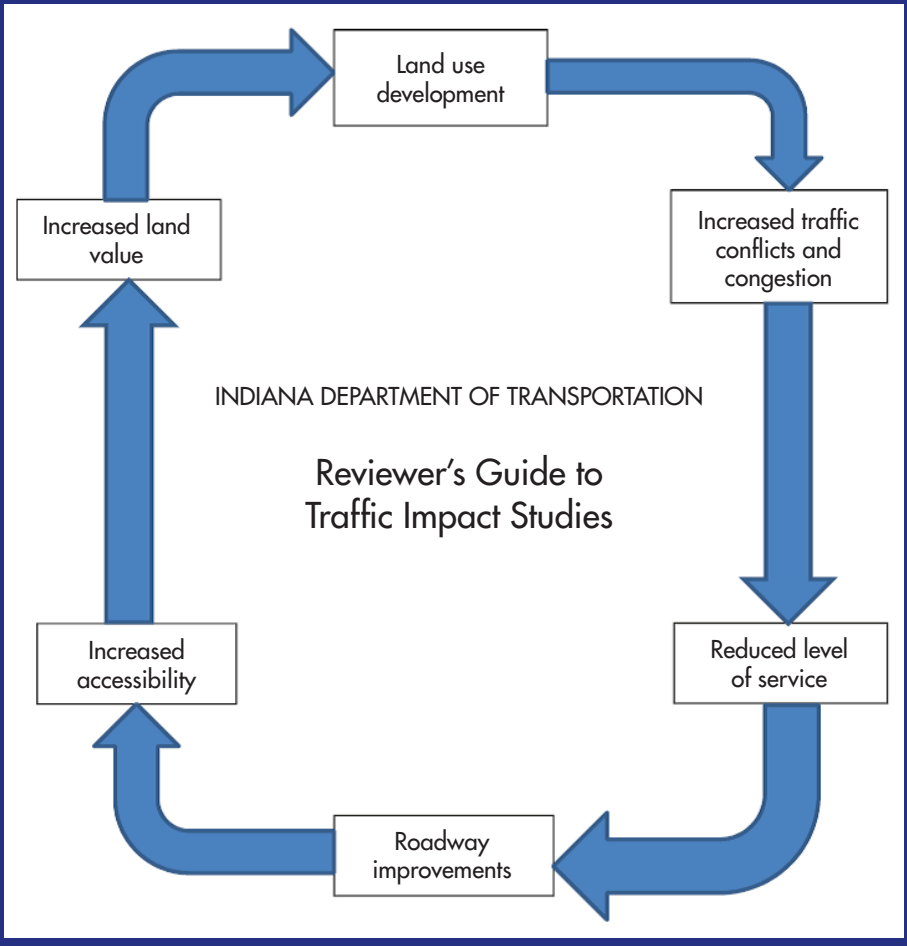
JOINT TRANSPORTATION RESEARCH PROGRAM

INDIANA DEPARTMENT OF TRANSPORTATION
AND PURDUE UNIVERSITY

Updated Methods for Traffic Impact Analysis, Including Evaluation of Innovative Intersection Designs

Volume III—Reviewer's Guide



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SPR-3605 • Report Number: FHWA/IN/JTRP-2013/32 • DOI: 10.5703/1288284315338

INDIANA DEPARTMENT
OF
TRANSPORTATION

REVIEWER'S GUIDE TO TRAFFIC IMPACT STUDIES

Approved: _____
Deputy Commissioner of Operations

Date: _____

Approved: _____
Deputy Commissioner of Engineering and Asset Management

Date: _____

RECOMMENDED CITATION

Bollinger, G. T., and J. D. Fricker. *Updated Methods for Traffic Impact Analysis, Including Evaluation of Innovative Intersection Designs: Volume III—Reviewer's Guide*. Publication FHWA/IN/JTRP-2013/32. Joint Transportation Research Program, Indiana Department of Transportation and Purdue University, West Lafayette, Indiana, 2013. doi: 10.5703/1288284315338.

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The Joint Transportation Research Program serves as a vehicle for INDOT collaboration with higher education institutions and industry in Indiana to facilitate innovation that results in continuous improvement in the planning, design, construction, operation, management and economic efficiency of the Indiana transportation infrastructure. https://engineering.purdue.edu/JTRP/index_html

Published reports of the Joint Transportation Research Program are available at: http://docs.lib.purdue.edu/jtrp/

NOTICE

TECHNICAL REPORT STANDARD TITLE PAGE

1. Report No.	2. Government Accession No.	3. Recipient's Catalog No.
FHWA/IN/JTRP-2013/32		

4. Title and Subtitle	5. Report Date
Updated Methods for Traffic Impact Analysis, Including Evaluation of Innovative Intersection Designs: Volume III—Reviewer's Guide	December 2013
	6. Performing Organization Code
7. Author(s)	8. Performing Organization Report No.
Gerald T. Bollinger, Jon D. Fricker	FHWA/IN/JTRP-2013/32
9. Performing Organization Name and Address Joint Transportation Research Program Purdue University 550 Stadium Mall Drive West Lafayette, IN 47907-2051	10. Work Unit No.
	11. Contract or Grant No. SPR-3605
12. Sponsoring Agency Name and Address Indiana Department of Transportation State Office Building 100 North Senate Avenue Indianapolis, IN 46204	13. Type of Report and Period Covered Final Report
	14. Sponsoring Agency Code

15. Supplementary Notes
Prepared in cooperation with the Indiana Department of Transportation and Federal Highway Administration.

16. Abstract

The INDOT Reviewer's Guide to Traffic Impact Analysis (TIA) is a product of SPR-3605 Updated Methods for Traffic Impact Analysis. It is intended to provide guidance to individuals who are charged with the responsibility to evaluate the Traffic Impact Analysis (TIA) reports submitted to INDOT (or other public agencies). This guide replaces the 1992 Reviewer's Guide for Traffic Impact Studies. The 1992 Guide was essentially an extended version of the 1992 Applicant's Guide to Traffic Impact Studies. This time, the Reviewer's Guide is written with the knowledge that the Applicant's Guide is available to both applicants and reviewers. The 2013 Reviewer's Guide focuses on added information that may help the reviewer assess the TIA report contents.

17. Key Words	18. Distribution Statement
traffic impact analysis, traffic impact studies	No restrictions. This document is available to the public through the National Technical Information Service, Springfield, VA 22161.

19. Security Classif. (of this report)	20. Security Classif. (of this page)	21. No. of Pages	22. Price
Unclassified	Unclassified	24	

Form DOT F 1700.7 (8-69)

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1. INTRODUCTION

1.1 The INDOT Reviewer's Guide to Traffic Impact Analysis

This Reviewer's Guide is intended to provide guidance to individuals who are charged with the responsibility to evaluate the Traffic Impact Analysis (TIA) reports submitted to INDOT (or other public agencies). This guide replaces the 1992 *Reviewer's Guide for Traffic Impact Studies* (*1*). The 1992 Guide was essentially an extended version of the 1992 *Applicant's Guide to Traffic Impact Studies* (*2*). This time, the Reviewer's Guide is written with the knowledge that the Applicant's Guide is available to both applicants and reviewers. This Reviewer's Guide will focus on added information that may help the reviewer assess the TIA report contents.

The Applicant's and Reviewer's Guides are based on a research report, *Updated Methods for Traffic Impact Analysis* (*3*). There are other references that provide good guidance on the requirements and standard practice related to. Foremost among them are:

- *Transportation Impact Analyses for Site Development: An ITE Recommended Practice* (2nd ed.). Institute of Transportation Engineers, 2010.
- *Access management guide.* AECOM Transportation for Indiana Department of Transportation, 2009.
- *Indiana Design Manual.* Indiana Department of Transportation, 2011.

This Applicant's Guide does not attempt to replicate what these resources contain, but a reviewer should have access to them.

1.2 Purpose of the Applicant's and Reviewer's Guides

The 1992 guides established a standardized procedure for requesting, preparing and/or reviewing a traffic impact study for a proposed development that would affect state highways. Use of the 1992 Guides allowed INDOT to be made aware of the transportation aspects of a site's development before permits were requested for access to state routes. This has led to better site designs and driveway locations. It can also allow INDOT (or other public agencies) to coordinate their policies. Furthermore, with a standardized TIA framework, the time from concept to opening will decrease.

The Applicant's Guide allows enough flexibility to the study preparer to use innovative methods based on sound engineering judgment and the conditions at a specific site. However, this should be done with the prior consent of the study reviewer(s).

1.3 The Research Project

This Reviewer's Guide is a product of SPR-3605 "Updated Methods for Traffic Impact Analysis." The study was conducted by the Joint Transportation Research Program (JTRP) in the School of Civil Engineering at Purdue University in conjunction with the Indiana Department of Transportation (INDOT) and the Federal Highway Administration (FHWA). The purpose of this study was to review the Applicant's and Reviewer's Guides that were published in 1992 and make changes that would bring them in line with the methods and conditions that have emerged since then.

Scott Burress, Shuo Li (Project Administrator), Dwane Myers, James Poturalski, Steve Smith, and Bill Smith of INDOT, and Karen Stippich of FHWA, served as members of the Study Advisory Committee (SAC). Transportation and planning professionals who accepted our invitations to attend SAC meetings and who provided valuable perspectives were: John Ayers (Hendricks County and Indiana Association of County Highway Engineers and Supervisors), Jodi Dickey (City of Fishers), Larry Lee (City of Lebanon and Indiana Street Commissioners Association), Mike McBride (City of Carmel and Indiana Association of City Engineers), and Hardik Shah (American Structurepoint, Inc. and Indiana Section of the Institute of Transportation Engineers).

This report is dedicated to Stephen C. Smith of INDOT's Division of Planning & Asset Management, Technical Planning Section, who passed away on 30 May 2013, as this report was being completed. Steve was the motivator for the 1991 Traffic Impact Analysis Project HPR-2039, which put Indiana among the leaders in TIA. Among his many responsibilities and accomplishments, he maintained a keen interest in TIA and led the development of INDOT's Access Management Study, Documents, and Draft Policies.

2. PREPARER AND REVIEWER QUALIFICATIONS

2.1 Preparer Qualifications

In order for a professional engineer to stamp and certify plans for a public project in Indiana, he/she must be licensed in Indiana (*4*). Traffic impact studies should be prepared by a transportation professional with training and experience in traffic engineering and transportation planning. It must be prepared by or under the supervision of a professional engineer licensed in Indiana with experience in traffic engineering operations. The study should contain a statement of certification as follows:

> I certify that this Traffic Impact Analysis report has been prepared by me or under my immediate supervision and that I have experience and training in the field of traffic and transportation engineering.
>
> (signed)
>
> John O. Smith, P.E.
>
> Indiana Registration 12345
>
> Consulting Firm, Inc.

2.2 Reviewer Qualification

The traffic impact study shall be reviewed by one or more of the professional staff members of the Indiana

Department of Transportation or of any other participating agency (City, County, etc.) who collectively have training and experience in traffic impact study methodology, land use planning and traffic engineering, including traffic safety and operations.

2.3 Ethics and Objectivity

A Traffic Impact Analysis often requires the analyst to make assumptions and judgments regarding a variety of values, e.g., trip generation rates, internal capture rates, and pass-by trip percentages. These and other judgments should be justified clearly in the report. Although study preparers and study reviewers might have different objectives and perspectives, they should adhere to established engineering ethics (similar to the Canon of Engineering Ethics) and conduct all analyses and reviews objectively and professionally.

3. STUDY PROCEDURE

The Applicant's Guide lists the conditions under which INDOT gets involved in the traffic impact analysis procedure. The possible steps in a traffic impact study procedure are shown in flow diagram form in Figure 3.1. The steps are described in the Applicant's Guide.

4. PRELIMINARY NOTIFICATION

A preliminary notification to INDOT will be required of all developments seeking access to a state

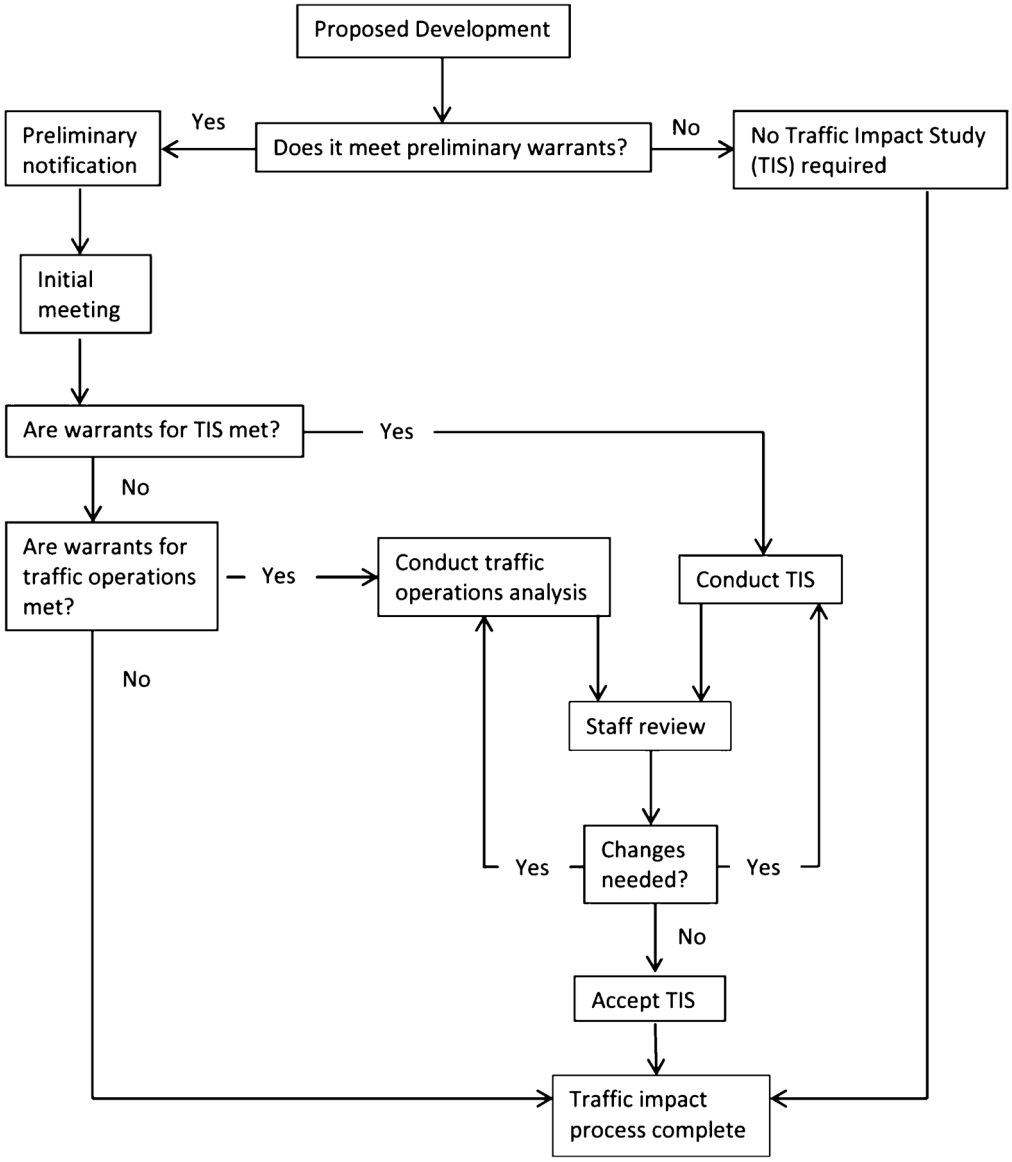

Figure 3.1 Flowchart showing the traffic impact study procedure.

highway that meet the preliminary threshold values for traffic impact analysis.

4.1 Preliminary Warrants or Thresholds

The Preliminary Warrants in Figure 3.1 are designed to avoid unnecessary Traffic Impact Analyses, e.g., when a proposed project is unlikely to have any significant impact on traffic operations on adjacent streets. Sometimes, however, it is not easy to estimate trips to be generated without some degree of a Traffic Impact Study. To address this circumstance, which is not that uncommon, ITE's Recommended Practice *Transportation Impact Analyses for Site Development* (*5*) offers guidance in the form of Table 4.1.

Table 4.1 is Table 2-2 in ITE's Recommended Practice (*5*). If the expected number of trips cannot be established directly, Table 4.1 can be used to set approximate upper bounds on land use intensities that are equivalent to threshold values of 100 and 500 peak hour trips. "The 500-trip threshold is suggested as a definition of a moderate size development" (*5*). The preliminary warrants are based on certain predictor variables associated with the proposed development at full "build-out," such as number of residential units, gross floor area, etc. Developments having land use intensity greater than the threshold values qualify for the preliminary notification action.

The reviewer should also be aware of "special generators" that have usually high trip generation rates, such as parking garages, banks (both drive-in and walk-in), fast food restaurants, and service stations with convenience stores. These land uses will require a preliminary notification, unless a waiver (for roads not under INDOT jurisdiction) is obtained from the local public transportation agency (city, county, etc.) concerned. The reviewer(s) will decide whether or not a waiver is justified, based on experience and engineering judgment.

Also, if the thresholds in Table 4.1 do not reflect "local conditions and priorities" (*5*), reviewers can apply a lower (or higher) threshold if it can be justified and applied on a consistent basis. For example, "many jurisdictions in more densely populated areas tend to use lower thresholds for initiating a transportation impact analysis. These thresholds fall in the range of 30 to 100 peak-hour trips" (*5*).

For mixed-use developments, for developments that cannot be grouped under one of the land use categories given in Table 4.1, or for those discussed in the previous paragraph, the estimated trip generation rates should be determined using the latest available edition of ITE *Trip Generation* (*6*). If the development under consideration will produce more than 100 vehicle trips during the adjacent street's peak period, then the preliminary warrants are satisfied. For developments that generate a significant percentage of truck traffic, the truck trips should be converted to equivalent vehicle trips. The *Highway Capacity Manual* (*7*) provides instructions on how to estimate passenger car equivalents for trucks.

4.2 Preliminary Notification Contents

The contents of the preliminary notification are listed in the Applicant's Guide. The preliminary notification is intended to provide a foundation on which to base discussion during the initial meeting. INDOT and/or the local transportation agency may be contacted for any existing traffic data that are available to help prepare such a description.

The preliminary notification should be submitted along with the petition for an access permit. If the

TABLE 4.1
Land use intensity thresholds based upon weekday trip generation characteristics

Land use	≤100 peak hour trips	≤500 peak hour trips
Residential		
Single-Family Home	95 units	565 units
Apartment	150 units	880 units
Condominium/Townhouse	190 units	1,320 units
Mobile Home Park	170 units	N/A
Single-Family Home	95 units	565 units
Apartment	150 units	880 units
Condominium/Townhouse	190 units	1,320 units
Mobile Home Park	170 units	N/A
Shopping Center (GLA)	6,000 sq. ft.	70,000 sq. ft.
Fast-Food Restaurant with Drive-In (GFA)	3,000 sq. ft.	N/A
Gas Station with Convenience Store (Fueling Positions)	7 fueling positions	N/A
Bank with Drive-In (GFA)	3,900 sq. ft.	N/A
General Office (GFA)	67,000 sq. ft.	376,000 sq. ft.
Medical/Dentist Office (GFA)	31,000 sq. ft.	N/A
Research and Development Facility (GFA)	73,000 sq. ft.	518,000 sq. ft.
Light Industrial/Warehousing (GFA)	180,000 sq. ft.	460,000 sq. ft.
Manufacturing Plant (GFA)	149,000 sq. ft.	661,000 sq. ft.
Park-and-ride Lot with Bus Service	170 parking spaces	655 parking spaces

GFA = gross floor area.

development under consideration *does not exceed* the preliminary warrants, the applicant should nevertheless consult as early as possible with INDOT (or LPA) regarding the *location* of the requested access. Driveway placement should anticipate any future development in the vicinity that may necessitate a frontage road, a new intersection, etc. No further action is required and the TIA procedure stops here.

5. INITIAL OR SCOPING MEETING

If the values for a proposed development exceed the preliminary warrants (Table 4.1), an "initial meeting" or "scoping meeting" between the developer's representative and INDOT personnel should be scheduled. Depending on the nature of the development, the type of information to be discussed at the meeting, and the way in which an INDOT jurisdiction (normally, the District) has organized its functions, it may be sufficient to have the INDOT District Permit Manager attend the initial meeting. In some cases, the Permit Manager may also invite:

- Representatives of affected LPAs
- District Traffic Engineer
- District Technical Services Director
- District Construction Director
- INDOT Central Office Counterparts of the District Personnel

For brevity, the developer's representative will hereinafter be called the Traffic Impact Study "preparer" and the INDOT personnel will be referred to as the "reviewers."

If any local jurisdiction may be affected by the development, a representative of that LPA should be invited to the Initial Meeting. This is not only good practice when a project seeks access to a state highway, it also creates a cooperative relationship with LPAs that may, in the future, be considering projects with direct access to local roads that may affect nearby state roads.

The discussions in the initial meeting between the preparer and the reviewers will be based on the information contained in the preliminary notification. The initial meeting will serve the following purposes:

1. To decide whether a detailed traffic impact study or traffic operations analysis is required for the proposed development.
2. If further studies are required, the meeting will help the study preparer to understand the reviewer's expectations.
3. To discuss critical issues like extent of the study, study area, horizon years, time periods to be analyzed, data sources and availability, etc.
4. To ensure that all relevant issues are adequately addressed in the traffic impact study, and that no extraneous elements are included in the study.

If a traffic impact analysis is warranted (see Chapter 6), some of the issues that need to be addressed in this meeting are discussed below.

5.1 Study Area

Any Traffic Impact Study should include at least all site access points and major intersections adjacent to the site. For added guidance, Table 2-3 in ITE's Recommended Practice *Transportation Impact Analyses for Site Development* (*5*) is reproduced in Table 5.1 in the Applicant's Guide. Beyond this area, the reviewers and the preparer should collectively determine any additional area that may directly or indirectly be impacted by the proposed development.

5.2 Horizon Year

The horizon year of a Traffic Impact Study should refer to the anticipated completion date of the proposed development, assuming full build-out and occupancy.

5.3 Time Periods to Be Analyzed

The critical time period for any development will be directly associated with the peaking characteristics of both the development and the adjacent roadway system. Special consideration should be given to developments like shopping centers, which might peak after the adjacent street peak or on a Saturday. The following time periods should be considered during the initial meeting:

- AM and PM street peak (weekday)
- AM and PM site peak (weekday)
- Noon peak (weekday)

5.4 Future Off-Site Developments

Most studies will have to take into account future off-site developments to ascertain the "base condition" in the horizon year. Both the reviewer and the study preparer should agree on off-site development assumptions for the horizon year. In case of a failure to reach an agreement, the reviewer will designate the quantity, type and location and types of developments to be assumed in the study.

5.5 Discussion Checklist

A discussion checklist has been provided in Appendix A of the Applicant's Guide to aid both the parties in recording information and comments. However, the discussions should not be restricted to the issues addressed in the checklist. An Initial Meeting Checklist in pdf template format that is shown in Appendix B of the Applicant's Guide. After Preliminary Notification (see Figure 3.1), the District completes its part of the template and sends it to the Applicant, who adds as much information as possible before the scoping meeting, and returns it to the District. In this way, the participants in the Initial meeting can devote their time in the meeting to less routine items. After agreement has been reached between Applicant and Reviewer, the

updated pdf template serves as a record of the Initial Meeting.

Larger developments in densely developed areas will need more in-depth discussion, while smaller sites might not need discussion on many of the issues in the checklist. Table 5.2 in the Applicant's Guide lists data that should be used in preparing a TIS.

5.6 Record of Initial Meeting

Immediately after the initial meeting, the TIA study preparer should submit a document that confirms the following:

- study scope
- data sources
- any unusual methods or subjective assumptions that may be applied
- report content (see Chapter 16 and Appendix C of this Guide)
- other pertinent issues discussed in the initial meeting

The meeting record should request concurrence by the reviewing agency staff representative.

5.7 Staff Concurrence

The reviewing agency should review the contents of the meeting record. If the reviewers agree, the reviewing agency should communicate staff concurrence to the applicant/preparer. This can be done in electronic or written form, including use of a template such as that provided in Appendix B.

6. WARRANTS FOR A COMPLETE TIA

A formal transportation impact analysis (TIA) will be requested for any development that meets any of the warrants described below. Each warrant is described in the Applicant's Guide.

- Warrant 1. Land Use Intensity
- Warrant 2. Level-Of-Service Warrant
- Warrant 3. Roadway Modifications
- Warrant 4. Special Cases

Whether or not a development meets a particular warrant should be decided at the initial meeting.

7. TRAFFIC OPERATIONS ANALYSIS

Typically a traffic operations analysis is conducted whenever a proposed development compromises the existing design standards and therefore might cause safety and operational problems in the immediate vicinity of the site. The analysis should be done for the entire traffic impact study area (see Table 5.1 in the Applicant's Guide) and not just the driveway or access point under consideration. A traffic operations analysis might include:

1. Study of proposed driveway locations, resulting sight distances, queuing provisions, etc.
2. Safety analysis
3. Traffic signal warrants and progression analysis
4. Delay analysis
5. Gap studies

Each of these activities usually involves significant data acquisition and engineering analysis, so they should be undertaken only when necessary for a complete Traffic Impact Study.

7.1 Warrants for Traffic Operations Analysis

A traffic operations analysis will be required if one or more of the following conditions is/are satisfied:

1. Development generates enough turning movements into or out of the development to require an auxiliary lane, such as an acceleration/deceleration lane, passing blister, or separate turn lane.
2. Request for new or modified driveways near intersections or interchanges.
3. Requests or probable need for a new (or modified) traffic signal to control driveways or streets serving a proposed or existing development (s).
4. Opportunity to evaluate alternative intersection geometries.
5. Existing sight distance limitation or high accident location near the site.
6. Requests for median openings.

8. NON-SITE TRAFFIC ESTIMATE

To estimate the traffic impacts of a proposed development, it is essential to analyze the traffic conditions on the horizon year roadway network for two cases: (a) with the proposed development and (b) without the proposed development. The incremental impacts are attributed to the site-generated traffic. To do this, we must establish the "base condition." The base condition will correspond to the traffic that would exist in the study area in the horizon year without the proposed development. This traffic is commonly referred to as non-site traffic. Non-site traffic may be of two kinds:

- Through traffic, which has neither an origin nor a destination in the study area.
- Traffic that has either an origin or a destination or both in the study area. This traffic is generated by *other* developments in the study area.

Non-site traffic estimation may be done by one of three methods:

1. Build-Up
2. Using the Transportation Plan for the (Sub)area
3. Trends or Growth Rate

See Chapter 4 of the ITE *Recommended Practice* (*5*) for details.

9. TRIP GENERATION

Trip generation involves estimating the number of trips that will be produced from or attracted to the

proposed development. This is one of the most important steps in traffic impact analysis.

9.1 Acceptable Data Sources

9.1.1 ITE Trip Generation Data

The most popular and widely used sources of trip generation data come from the Institute of Transportation Engineers (ITE). In its current format, the ITE *Trip Generation Manual* (*6*) consists of three volumes. Volume 1 is a 154-page "User's Guide and Handbook," which provides guidance on the proper use of the data in Volumes 2 and 3. The User's Guide was Volume 1 of the 3-volume *Trip Generation Informational Report* (8th ed.) (*8*). The Handbook—formerly a separate publication (*9*) but now part of Volume 1 (*6*)—provides information on issues of importance that arise when estimating trip generation. These issues include pass-by and diverted-link trips, multi-use developments, and other factors that may influence the actual amount of new traffic (*10*). The data in Volumes 2 and 3 are displayed on 2000-plus pages for hundreds of land use types. Despite this extensive resource, trip generation can be a challenging undertaking, even for common land uses such as shopping centers. Examples of challenges are mentioned in the Applicant's Guide.

9.1.2 Primary Sources of Trip Generation Data

Primary data are collected by the analyst for a specific purpose. Data obtained from other sources, such as ITE, are called *secondary* data. Normally, secondary data have the advantage of being based on a larger sample size than can be acquired with reasonable time and expense for a specific project. The drawback of secondary data is that they may have been collected at locations that do not replicate the particular site that is the subject of a TIA. For example, secondary data in the *Trip Generation Manual* (*6*) for a proposed Fast-Food Restaurant with Drive-Through Window are based on 132 studies. It is probably not worth the time and expense to collect trip generation data at enough local Fast-Food Restaurants with Drive-Through Window to replace the secondary data, unless the trip rates do not seem to fit the case at hand. If some local data are available, however, they can be combined with secondary data to improve the data. See Section 4.2 of the Technical Report (*11*).

9.1.3 Other Sources of Trip Generation Data

Data from prior studies made on a similar kind of land use under similar conditions may be used, if properly documented. If existing data are not available or are not a good representation of specialized characteristics that the site under consideration might have, a data collection effort has to be conducted at sites that exhibit similar characteristics as the study site. Forms that guide the collection of trip generation data can be found in Appendix C of the User's Guide in the ITE *Trip Generation Manual* (*6*).

9.2 Mixed-Use Developments

In case of mixed-use developments, certain deductions might have to be made to the trip generation rate derived by adding the trip generation rates of the individual land uses to accommodate the possibility of internal trips. Mixed-use developments are discussed in Chapter 12 of the Applicant's and Reviewer's Guides.

9.3 Pass-by Trips

The methodology for handling pass-by trips is discussed in detail in Chapter 11 of the Applicant's and Reviewer's Guides.

10. TRIP DISTRIBUTION AND TRAFFIC ASSIGNMENT

10.1 Trip Distribution

Trip generation estimates the number of trip ends associated with a proposed development. Because each trip has two ends, it is necessary to determine where the other end of each trip is, at least in terms of the direction from which a trip arrived, or to which a departing trip will go. This step is called *trip distribution*. The outcome is an origin-destination pattern of trips to/from the site, which permits an assessment of which streets are being used by those trips.

The *trip distribution* step in Traffic Impact Analysis is not precise. There are at least four methods that could be used, each with its advantages and limitations. See the Applicant's Guide for details.

1. Subarea analysis
2. Gravity model
3. Estimates of pass-by trip percentages
4. Using traffic microsimulation software to adjust an origin-destination matrix

No single method is clearly superior to the others, but TIA report preparers often have adopted or developed methods in which they have confidence. A brief description of the method used should be included in the report.

10.2 Traffic Assignment

Traffic assignment loads the distributed site trips onto specific paths in the road network. The result of traffic assignment is the total project-generated traffic by direction and by turning movements on the horizon-year roadway network in the study area. Assignment should be made after taking into account logical routing, available roadway capacities, and projected and perceived minimum travel times.

- User-equilibrium static traffic assignment has been done by travel demand software for many years.
- Dynamic traffic assignment software is now available that can account or the variability of traffic between and within hours, if there are data to support such a loading.
- Some traffic microsimulation software allows the user to input an origin-destination matrix, whereupon the software loads the network while taking into account signal timing at intersections.

11. PASS-BY TRIPS

11.1 Definitions

In trip generation, each vehicle trip that arrives at a development can be classified as *primary*, *diverted*, *or pass-by*. (Figure 11.1 below is Figure 5.1 in ITE 2004 (*9*) and ITE 2012 (*6*).) Traffic that does not enter or exit the site is considered *background traffic.*

A *pass-by trip* is a trip that would have been on the roadway passing the new development's site, whether the development was in existence or not. Details are given in the Applicant's Guide.

Primary and diverted trips attracted to the new development's site add to the number of vehicles on the roadway; the pass-by vehicles do not. However, all three trip types—even the pass-by trips—involve vehicles turning into and out of the development's site, adding traffic conflicts at the access points. If the vehicles shown in Figure 11.2 would have been on the streets shown in any case, but the drivers chooses to patronize the new shopping center or new gas station, no new traffic has been added to the streets. However, the number of traffic conflicts has been increased.

11.2 Pass-by Trip Data Collection

The three types of trips are easy to define, but they are not easy to document. A license plate survey method is described in Chapter 3 of the 1992 INDOT Manual (*12*). Section 5.6 of the ITE Trip Generation Handbook (*6,9*) sets out an interview-based survey.

11.3 Estimating Pass-by Trip Percentage at a New Development

Section 5.4 of the ITE *Trip Generation Manual* (*6*) contains a database with pass-by percentages for several types of retail developments. The Applicant's Guide contains an evaluation of several equations to estimate pass-by percentages.

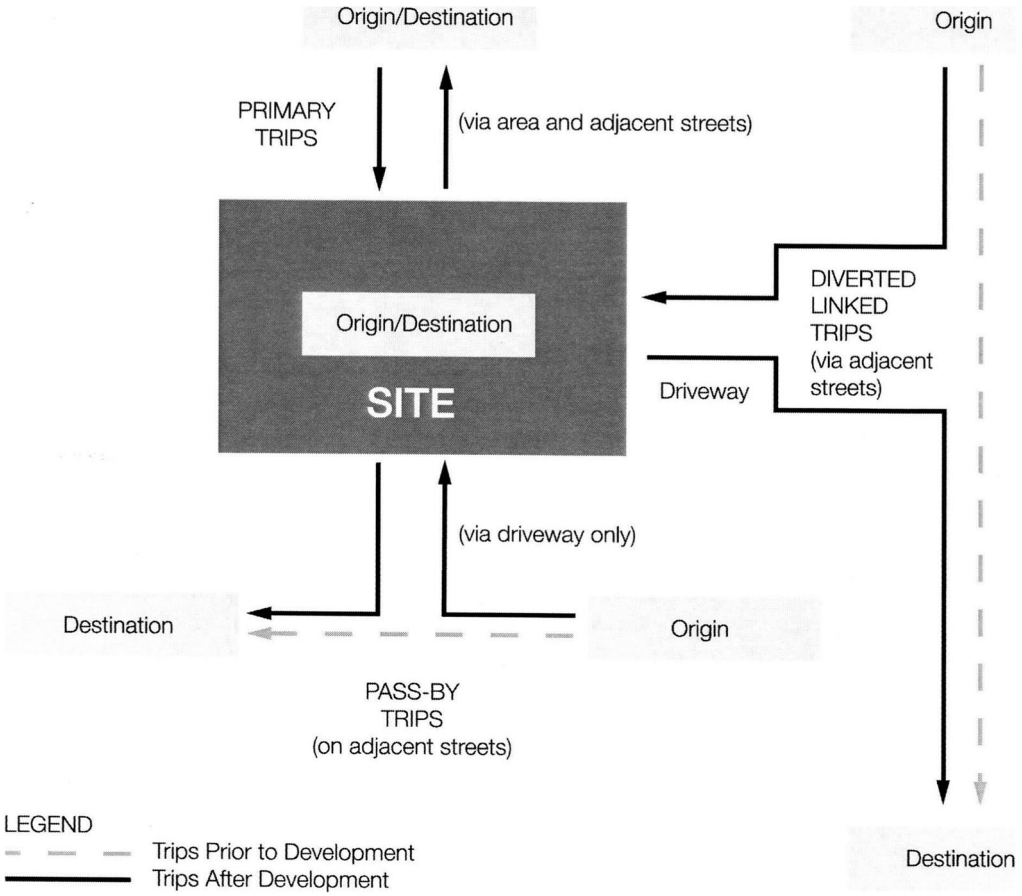

Figure 11.1 Types of trips.

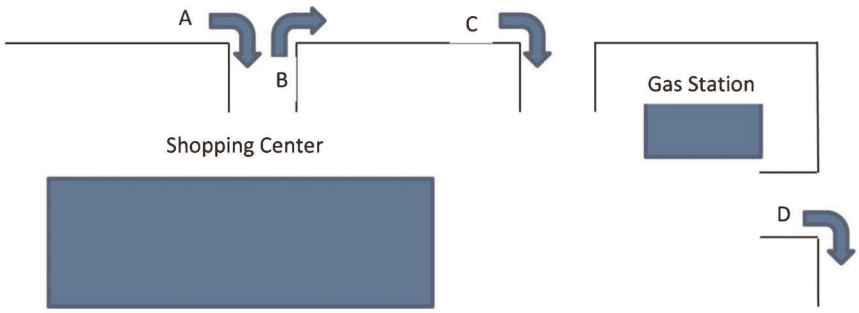

Figure 11.2 Pass-by trip and traffic conflict points.

11.4 The Pass-by Trip Assignment Process

Section 5.2 of the ITE *Trip Generation Handbook* (*9,6*) demonstrates the steps involved in estimating the number of trips added to the traffic volume on a street adjacent to proposed shopping center, along with the associated turning movements into and out of the site. An annotated overview of the steps is given in the Applicant's Guide.

12. MIXED-USE DEVELOPMENTS AND INTERNAL TRIPS

12.1 Internal Capture Rate

Chapter 7 of the ITE *Trip Generation Handbook* (*6,9*) describes the difficulty in estimating the traffic impacts of mixed use developments. They are difficult to define and data for the *internal capture rate* are scarce. The internal capture rate is the percent of trips made to one location at a site that began at another location at that same site. A trip was made, but it did not have any effect on the external streets.

Tables 7.1 and 7.2 in the ITE *Trip Generation Handbook* combine locations at a site into office, retail, and residential categories. The internal capture rates vary from 0% to 53% for various categories and times of day. The challenge for any large mixed use site is to develop a relationship between driveway counts and visits made to locations at the site.

12.2 Lessons Learned from a Data Collection Effort

Chapter 9 in the research report for this project covers Internal trips in Mixed Use Developments. Volumes 2 and 3 of the ITE *Trip Generation Manual* (*6*) do not contain equations or data to use to predict the trip generation for many of the individual store types within a shopping center. These store types may be absent from the ITE *Trip Generation Manual* because they do not commonly locate in stand-alone buildings. Even if the ITE *Trip Generation Manual* has data for store types in a shopping center, those data are for stand-alone stores. Using those data can lead to an overestimation of trips to the shopping center, because some of the trips will be made between stores at the site.

If it is decided that a data collection effort should be made to support the analysis of a proposed mixed use shopping center, the main objective is to determine what percent of trips to stores did not start from outside the shopping center's site. It can be difficult to visually track internal trips from origin to destination within the site. Store type and location within a shopping center may impact the site's total trip generation and number of internal trips. It would be helpful to conduct trip generation counts at shopping centers once fully developed and compare the counts to what the predicted total trip generation prior to construction was (or would have been) for the shopping center.

13. INNOVATIVE INTERSECTION DESIGNS

Chapter 6 of the research report for this project (*11*) describes some non-traditional designs that might be considered as ways to improve operations at intersections affected by new development nearby:

- Median U-Turn (MUT) Intersections
- Restricted-Crossing U-Turn (RCUT) Intersections
- Displaced Left Turn (DLT) Intersections
- Quadrant Roadway (QR) Intersections
- Roundabouts

Diagrams and photos of the innovative intersection designs are also provided in the Applicant's Guide. Chapter 7 of the research report for this project (*11*) presents the results of some microsimulation studies of innovative intersection operations.

INDOT has a written procedure to follow in determining whether a non-traditional intersection has merit. It is the INDOT *Intersection Decision Guide*, published in January 2014. The link to that document is http://www.in.gov/indot/files/ROP_IntersectionDecisionGuide.pdf.

14. ANALYSIS

14.1 Factors to Consider in a Traffic Impact Analysis

Chapter 7 of the ITE Recommended Practice (*5*) lists the analytical techniques that are an integral part of a Traffic Impact Study:

- Capacity analysis at each major street and site access intersection location (signalized and unsignalized) within the study area.

- Capacity analyses for roadway segments or transportation links that are likely to be sensitive to site traffic, such as weaving sections, ramps, major internal site roadways and on- and off-site storage for vehicle queuing.

Other factors that should be considered for analysis include (*5*):

- Safety
- Circulation patterns
- Traffic control needs
- Transit needs or impacts
- Transportation demand management
- Neighborhood impacts
- On-site parking adequacy and off-site parking facilities
- Pedestrian and bicycle movements
- Service and delivery vehicle access
- ADA provisions (See Indiana Building Code, Chapter 11, and INDOT Operations Memorandum 14-10, *Accessible Pedestrian Signal (APS) Studies and Installation Considerations*, dated January 9, 2014.).

The analyses to be conducted as part of the Traffic Impact Study should be decided at the Initial Meeting. They provide the basis for the Traffic Impact Study's findings, recommendations and conclusions. The Traffic Impact Analysis should not be ended until one of three conclusions has been reached:

1. The proposed development can be accommodated in the horizon year transportation infrastructure with no additional improvements.
2. The proposed development can be accommodated in the horizon year transportation infrastructure consistent with agency policy and operating conditions subject to specified recommended improvements/modifications.
3. The area will operate below the accepted level of service even without the development. No further significant deterioration will result if the proposed development is accommodated with the recommended changes.

14.2 Analytical Methods

The ITE Recommended Practice (*5*) presents further explanation for some of the analyses listed above and describes the state-of-the-practice methods commonly used. Brief excerpts and updates are provided below.

14.2.1 Capacity Analysis

Level of service—intersection capacity analysis. The *Highway Capacity Manual* (*7*), which was published after the ITE Recommended Practice, is the source document used almost exclusively. The level of service (LOS) is a qualitative assessment of the quantitative effect of factors such as speed, volume of traffic, geometric features, traffic interruptions, delays and freedom to maneuver. Many jurisdictions currently apply LOS "C" or LOS "D" thresholds for defining automobile site traffic mitigation. Exhibit 18-4 in the 2010 HCM (replicated here as Table 14.1) lists the LOS thresholds for the automobile mode at a signalized intersection.

TABLE 14.1
LOS Criteria for Automobile Mode

	LOS by volume-to-capacity ratio	
Control delay (s/veh)	**≤1.0**	**>1.0**
≤10	A	F
>10–20	B	F
>20–35	C	F
>35–55	D	F
>55–80	E	F
>80	F	F

At many signalized intersections, nonautomobile modes should also be considered. Exhibit 18-5 in the 2010 HCM (replicated here as Table 14.2) lists the LOS thresholds for the pedestrian and bicycle modes at a signalized intersection.

Level of service—roadway segment analysis. Again, the *Highway Capacity Manual* (*7*) is the most commonly used reference, but arterial analysis computer packages are also available to evaluate complex situations. The LOS criteria in the 2010 HCM (shown in Table 14.3) depend on the facility type.

14.2.2 Safety Analysis

Sometimes when conducting a TIA, there are locations within the study area that experience high crash rates or an usual number of specific crash types. For these locations, a safety analysis may be warranted and should be included in the TIA. The ITE Recommended Practice (*5*) suggests that an intersection with a collision rate of more than one per million entering vehicles may be worthy of additional analysis, subject to consultation with the appropriate agency. The need for a safety analysis should be discussed with the governing jurisdictions at the scoping meeting.

In Indiana, crash data are collected by law enforcement agencies and compiled into an Automated Report and Information Exchange System (ARIES) database by an independent contractor. INDOT's policy is to require the applicant to acquire the crash data needed for the analysis directly from the appropriate source(s). In this way, the TIS preparer can decide what data (and how much) are needed for the TIS.

Also published after the *ITE Recommended Practice* was the *Highway Safety Manual* (*13*). The HSM can

TABLE 14.2
LOS Criteria for Pedestrian and Bicycle Modes

LOS	LOS score
A	≤2.00
B	>2.00–2.75
C	>2.75–3.50
D	>3.50–4.25
E	>4.25–5.00
F	>5.00

TABLE 14.3
Level of service criteria

Facility type	HCM chapter(s)	Auto criteria	Non-auto criteria
Multilane highways	14	Free-flow speed and density (pc/mi/la)	LOS score for bicycles
2-lane highways	15	Average travel speed and percent time spent following	LOS score for bicycles
Urban Streets	16–17	Average travel speed as percent of base free-flow speed	LOS scores for pedestrians, bicycles, transit

help quantify and predict the safety performance of roadway elements, but its use requires an investment in time to learn its procedures.

The safety analysis should include identification and recommendations about locations with frequent crashes, restricted sight distances, and pedestrian/bicycle safety.

14.2.3 Site Access Points

All site access points should conform to current INDOT standards and specifications (*10*).

14.2.4 Traffic Control Needs

Warrant analyses for traffic control devices such as traffic signals, stop and yield signs should be carried out in accordance with the *Indiana Manual on Uniform Traffic Control Devices* (*14*).

14.2.5 Median Openings

In some cases, a new development causes questions to arise regarding a median. Two common examples are:

A. Should an existing median opening be closed to prevent unsafe left turns into a new development? See Figure 4.5 in (*3*).
B. Should a new median opening be created to permit left turns into a new development? See Figure 4.5 in (*3*).

Section 4.6 of the Research report for this project looks at the legal and operational issues that affect the answers to Questions A and B above. INDOT has the legal authority to either introduce or close a median opening ((*15*), p. 26), as long as INDOT is using the authority granted it by IC 9-21-4-2 to "maintain traffic control devices … and specifications upon all state highways" to (under IC 8-23-4-8) "promote public convenience and safety."

If a median opening is requested, a detailed analysis should be carried out to find out whether a median opening would hamper the operating condition of the roadway. Due consideration should be given to the following:

- warrants for a left turn signal at the opening
- approach speed of the opposing vehicles
- gaps in opposing traffic
- storage space at the median opening
- queuing and delay to the vehicles
- distance from nearest intersection
- spacing between median openings
- special geometric situations, including sight distance and perceived approach speeds.

With the growing use of traffic microsimulation software, several proposed geometric and traffic control device solutions can be evaluated against each other and against reasonable standards for delay and level of service.

14.2.6 Neighborhood Impacts

Neighborhood transportation impacts are primarily caused by site-generated traffic using neighborhood streets as short cuts. This can hamper pedestrian safety, air quality, community cohesion and, consequently, property values. Most neighborhoods are sensitive to this and hence an analysis should be conducted to estimate the neighborhood impacts of the proposed development and mitigating measures suggested.

15. CONCLUSIONS AND RECOMMENDATIONS

If the traffic impact analysis reveals that the projected traffic volumes on the horizon year roadway network will operate in a safe and efficient manner at an acceptable level of service, then no improvements are required. However, if deficiencies are detected, mitigating measures have to be recommended. These measures may include:

1. Installation of traffic signals
2. Installation of traffic control signs
3. Addition of through lanes
4. Addition of acceleration, deceleration, and turn lanes (specify length)
5. Restricted turn movements
6. Adjusting cycle lengths
7. Introducing additional signal phases

If reasonable mitigating measures cannot be found to make the traffic operate in an efficient way, a more detailed evaluation of project size, land use types, and development phasing may be required. If viable transportation improvements cannot be recommended, then steps have to be taken to reduce the trip generation rate of the proposed development during the problem period. Some of the possible approaches that may be adopted are:

- increased transit usage
- carpool/vanpool programs

- congestion pricing
- reduced parking or increased parking fees
- staggered work schedules

Any transportation demand management recommendations should take into account:

1. Timing of the short and long-range transportation system improvements that are already scheduled or anticipated.
2. Anticipated timing of adjacent developments.
3. Phasing of the subject development.
4. ROW needs and availability.
5. Local priorities of transportation improvement funding.
6. Cost-effectiveness of the proposed improvements.

15.1 Recommended Plan of Action

Implementation recommendations should be presented as a "plan of action." This action plan should recommend improvements, state why they are needed, and when they are to be implemented.

Although the emphasis of Traffic Impact Analysis is on peak periods, such an analysis should not lead to treatments that are detrimental to off-peak operations. The plan of action should be reviewed with all hours of the day taken into account.

16. THE REPORT

The traffic impact study report should document the purpose, procedures, data sources, assumptions, findings, conclusions and recommendations of the study. It should be concise and complete. The report should be organized in a logical sequence and methodically take the reader through the entire process of traffic impact analysis. A Sample Report Outline is provided in Appendix C of this Guide. A uniform framework will facilitate both the preparation and the review of the report. Any major departures from this standard format should be agreed upon at the initial meeting and mentioned in the subsequent memorandum of understanding (see Chapter 5).

It should be kept in mind that the report might be of interest to the decision makers and other non-technical people. Hence, clarity should not be sacrificed. Two ways to accomplish this are (a) an effective Executive Summary and (b) effective use of exhibits.

16.1 Executive Summary

An executive summary should be placed near the beginning of the traffic impact study report (Section I.B in Appendix C Sample Report Outline). It should be one-page or two-page document to facilitate examination by the reviewing agency. It should contain the salient features of the study and should summarize the study purpose, and its conclusions and recommendations. Letters and memorandum reports under 10 pages do not need an executive summary.

16.2 Suggested Exhibits

Visual displays (figures and maps) and tabular displays (tables) can improve the communication of information to reviewers, public officials, and citizens. Table 16.1 is Table 10-2 in the ITE Recommended Practice (*5*). The "Examples" cited in the rightmost column of Table 16.2 refer to exhibits in the ITE Recommended Practice (*5*). The exhibits listed in Table 16.1 that are actually used in a TIS report will depend on the nature of the particular Traffic Impact Analysis.

16.3 Public Record

Traffic impact study reports become public record upon acceptance by INDOT.

TABLE 16.1
Suggested Figures and Tables for a Transportation Impact Study Report

Item	Title	Description	Example in (*5*)
Figure A	Site location	Area map showing site location	Figure 6-1
Figure B	Study Area	Map showing area of influence	Figure 6-2
Figure C	Existing transportation system	Existing roadway system serving site. Show all major streets, minor streets adjacent to site and site boundaries. Show also transit, bicycle and major pedestrian routes, if applicable, along with right-of-way widths and signal locations. In some cases, may be combined with Figure A.	Figure 3-4
Figure D	Existing and anticipated area development	Map at same scale as Figure H showing existing and anticipated land uses/ developments in study area	Figure 4-3
Figure E	Current daily traffic volumes	Recent or existing daily volumes on roads in study area. May be combined with Figure C or F. Include existing moving lanes if not shown in Figure C.	Figure 3-2
Figure F	Existing peak-hour turning volumes	Current peak hour turning volumes at each location critical to site volumes access or serving major traffic volumes through study area. May be combined with Figure E. Also existing moving lanes if not shown in Figure C.	Figure 3-3
Figure G	Anticipated transportation system	Area transportation system map showing programmed and applicable planned roadway, transit, bikeway and pedestrian-way improvements affecting site access or traffic flow through the study area. May be combined with Figure C.	Figure 4-5
Table A or Figure H	Directional distribution of traffic	Map or table showing (by percentages) the portion of site traffic approaching and departing the area on each roadway. May differ by land use within multi-use development.	Figure 6-5
Table 8	Estimated site traffic generation	Estimated peak hour (and daily, if required) trips to be generated by each major component of the proposed development. Must be shown separately for inbound and outbound directions.	Table 5-4
Figure I	Site traffic	Map of anticipated study area roadway network showing peak hour turning volumes generated by site development.	Figure 6-7
Table C	Estimated trip generation for non-site development	Trips generated by off-site development within study area. Similar to Table B. A map similar to Figure I can also present this information.	Table 4-1
Figure J	Estimated non-site traffic	Map similar to Figure H, showing peak hour turning volumes generated by off-site development within study area plus through horizon year traffic.	Figure 4-2
Figure K	Estimated total future traffic	Map similar to Figure H, showing sum of traffic from Figures I and J.	Figure 7-1
Figure L or Table D	Projected levels of service	Levels of service computed for critical intersections in study area. Include existing, horizon year non-site and total horizon year (with site development) conditions.	Figure 7-2 or Table 7-1
Figure M or Table E	Recommended improvements	Map showing recommended off-site transportation improvements, site access points, and on-site circulation and parking features, as appropriate. May require more than one figure. Table will describe improvements by location and type. If phasing of improvements is to be stipulated, this should also be shown on these or on a separate figure or table.	Figures 8-1, 8-2, 8-3, and 8-4
Figure N or Table F	Study checklist	Checklist showing the required/optional elements of a transportation impact analysis report, whether or not they have been incorporated and their locations in the report.	Figure 10-1

17. STAFF REVIEW

The purpose of staff review is to ensure that the traffic impact study (TIS) has been properly prepared, and that the recommendations made by the preparer are realistic and can be implemented. Staff reviews are not intended to deter new developments. They are to ensure that traffic-related problems are anticipated and that effective mitigation measures are identified. If questions arise, contact between the preparer and the reviewer during the preparation of the TIS is encouraged and should be documented in the final report.

17.1 Formal Review

Traffic impact studies should be reviewed by departments and agencies that are (a) responsible for operating the roadways and/or (b) planning and implementing roadway improvements that are likely to be impacted by the proposed development. The formal review process is conducted after the report has been submitted by the preparer. This review process should develop a list of the following findings:

- Acceptable analyses and conclusions
- Unacceptable analyses and conclusions
- Acceptability of recommended site access provisions and roadway improvements
- List of required improvements that might be considered to mitigate impacts of the proposed development.

Following the review, the reviewer(s) should send to the preparer a list of requested study revisions.

17.2 Request for Revision

Any requests for study revisions should concisely indicate the findings of the formal review and clearly specify the additional information required. This additional report should normally be in the form of an addendum to the original study. In certain specific cases, a revised report may be requested.

17.3 Acceptance

Following the review, the reviewer(s) should send to the preparer a letter accepting the study. The acceptance letter can be transmitted electronically, and it should be attached to the final report.

REFERENCES

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12. Dey, S. S., and J. D. Fricker. *Manual of Traffic Impact Studies, 3 Volumes: Volume 1 - Final Report, Guidelines for Traffic Analysis of Developments Along State Highways*. Publication FHWA/IN/JHRP-92/04-1. Joint Highway Research Project, Indiana Department of Transportation and Purdue University, West Lafayette, Indiana, 1992. doi: 10.5703/1288284313474.
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14. INDOT. *Indiana Manual on Uniform Traffic Control Devices*. Indiana Department of Transportation, 2011. Accessed June 11, 2013. http://www.in.gov/dot/div/contracts/design/mutcd/mutcd.html.
15. INDOT. *Access Management Guide*. AECOM Transportation for the Indiana Department of Transportation, 2009. Accessed Aug. 13, 2012. http://www.in.gov/indot/files/guide_total.pdf.

APPENDIX A. INITIAL MEETING CHECKLIST

The applicant and reviewer(s) can use this appendix as a worksheet to ensure that no important elements are overlooked. This appendix could be used as a form to follow, crossing out those item that do not apply, with the record of the Initial Meeting (see Section 5.6) describing items decided at that meeting. INDOT's Crawfordsville District has prepared an electronic Initial Meeting Checklist in pdf template format to accomplish the same purpose. The four-page template is shown in Appendix B.

Date and Place of the Initial Meeting

Name and Location of Proposed Development
Which jurisdictions are affected?

Representative(s) of Applicant at Initial Meeting:
Name, Job Title, Organization, Address, Telephone Number, Email
Indicate the name and registration number of the licensed professional engineer who will be responsible for preparation of the Traffic Impact Study, if one is required.

Representatives of Reviewing Agency at Initial Meeting
Name, Job Title, Organization, Address, Telephone Number, Email

Application of Flow Diagram in Figure 3.1 of Applicant's Guide

1. **Does proposed development meet preliminary warrants?** (See Chapter 4)
   The preliminary notification should include:
   - For each land use type (ITE Land Use Code), intensity (Gross Floor Area, etc.)
   - Current zoning at site. Change in zoning needed or pending?
   - The complete site plan, with the site's requested access points in relation to existing access points nearby
   - The nearest signalized intersection in each direction
   - A market study (if applicable)
   - Trip generation values and the method (s) used to compute them

   The preliminary notification should be submitted along with the petition for an access permit.

2. **Are warrants for Traffic Impact Study met?** (See Table 4.1)
   - Define boundaries of Study Area (See Table 5.1 in the Applicant's Guide). Other jurisdictions to contact?
   - Agree on Horizon Year, Non-Site Traffic Forecasts
   - Site Trip Generation method and data sources
   - Reductions in trip rates: pass-by trips, internal trips, transit use
   - Trip distribution method (and software) to be used
   - Traffic assignment method (and software) to be used
   -
3. **Are warrants for Traffic Operations Analysis met?** (See Chapter 7)
   - Crash locations
   - Factors affecting Traffic Operations: Access locations, geometrics, intersection design (including innovative designs), traffic control devices, etc.
   - Data Sources

Traffic Impact Study Report Contents
See Appendix C.

Contact information and signatures for
- Study Preparer(s)
- Reviewer(s)

APPENDIX B. EXAMPLE OF TEMPLATE FOR INITIAL MEETING CHECKLIST

A four-page template Initial Meeting Checklist template is shown in this appendix. The template can be used to facilitate the documentation of items discussed in the initial meeting.

INITIAL MEETING CHECKLIST

Suggestion: Use this document as a worksheet to ensure that no important elements are overlooked. Cross out the items that do not apply.

Date: Time:

Location:

People Attending

Name, title, affiliation, address, phone number

Study Preparer

Preparer's Name and Title

Organization & Telephone Number:

Reviewer(s)

Reviewer's Name & Title:

Organization & Telephone Number:

Reviewer's Name & Title:

Organization & Telephone Number:

Applicant

Applicant's Name, Address, & Telephone Number:

Proposed Development

Name:

Location:

Location within area

___ CBD
___ Urban (Non CBD)
___ Suburban (Non-CBD)
___ Suburban CBD
___ Rural
___ Freeway interchange
___ Other

ITE Land Use Code(s)#

Description:

Proposed number of development units:

Zoning

Existing:

Comprehensive plan recommendation:

Requested:

Findings of the Preliminary Study:

Study Type Needed

___ Complete Study ___ Traffic Operations ___ None

Study Area

Boundaries:

Additional intersections to be analyzed:

Horizon Year(s)

Analysis Time Period(s)

Future Off-Site Developments

Source of Trip Generation Rates

Reduction in Trip Generation Rates

None (check if applicable)

Pass-by trips:

Internal trips (mixed-used developments):

Transit use:

Other:

Horizon Year Roadway Network Improvements

Methodology & Assumptions

Non-site traffic estimates:

Site trip generation:

Trip distribution method:

Traffic assignment method:

Traffic growth rate:

Accident locations:

Sight distance:

Queuing:

Access location & configuration:

Traffic control:

Signal system location & progression needs:

On-site parking needs:

Data sources:

Base maps:

Prior study reports:

Access policy and jurisdiction:

Review process:

Requirements:

Miscellaneous

APPENDIX C. SAMPLE REPORT OUTLINE

As Traffic Impact Analyses have been conducted over the past two decades, the outline shown below has become fairly standard (*5,15*). Use this outline as a checklist to ensure that no important elements are overlooked. The Executive Summary should be concise and in the first section of the report. The use of illustrations and graphics can help the presentation of report contents.

Title Sheet

A. Development Name and Location
B. Preparer's Name, Title, Organization, Address, Telephone Number and Email.
C. Statement of Certification (See *Preparer Qualifications* in this Guide)
D. Date of Original Report
E. Date of Revised Report

Table of Contents, List of Figures, List of Tables, Title Sheet

A. Development Name and Location
B. Preparer's Name, Title, Organization, Address, Telephone Number and Email.
C. Statement of Certification (See *Preparer Qualifications* in this Guide)
D. Date of Original Report
E. Date of Revised Report

Table of Contents, List of Figures, List of Tables, Introduction and Summary

A. Purpose of Report and Study Objectives
B. Executive Summary

    1. Site location and study area
    2. Development description
    3. Principal findings
    4. Conclusions and recommendations

I. Proposed Development

A. Subject Site

    1. Location
    2. Site plan
    3. Land use and intensity
    4. Zoning
    5. Project phasing and timing

B. Off-site Developments

II. Existing Area Conditions

A. Study Area Limits
B. Study Area Land Use

    1. Existing land use
    2. Existing zoning
    3. Anticipated future developments

C. Site Accessibility

    1. Area roadway system
        a. existing
        b. committed and/or proposed
    2. Traffic volumes (data in appendix)
    3. Transit service
    4. Pedestrians and bicyclists
    5. Transportation system management programs

III. Projected Traffic

A. Site Traffic (each horizon year)

    1. Trip generation
    2. Pass-by traffic
    3. Internal trips, if applicable
    4. Trip distribution
    5. Traffic assignment

B. Non-Site Traffic (each horizon year)

    1. Method of projection
    2. Trip generation
    3. Trip distribution
    4. Traffic assignment

C. Total Traffic (each horizon year)

IV. Analysis

A. Capacity and Level of Service for Streets and Intersections within the Study Area
B. Traffic, Pedestrian, and Bicycle Safety
C. Traffic Control Devices
D. Data sources

V. Improvement Analysis

A. Improvements to Accommodate Site Traffic

    1. Physical
    2. Operational
    3. Travel demand reduction

B. Additional Improvements to Accommodate Non-Site Traffic

    1. Physical
    2. Operational

C. Alternative Improvements
D. Status of Improvements Already Funded, Programmed or Planned
E. Evaluation

VI. Findings

A. Site Access: Driveways, Median Cuts
B. Transportation Impacts, Neighborhood Impacts
C. Need for Additional Improvements
D. Compliance with Applicable Local Codes

VII. Recommendations

A. Site Access
B. Roadway Improvements

    1. On-site
    2. Off-site

C. Transportation System Management Actions
D. Other

Conclusion

A. Traffic Impact of Proposed Development
B. Adequacy of Proposed Plan, Including Recommended Improvements

About the Joint Transportation Research Program (JTRP)

On March 11, 1937, the Indiana Legislature passed an act which authorized the Indiana State Highway Commission to cooperate with and assist Purdue University in developing the best methods of improving and maintaining the highways of the state and the respective counties thereof. That collaborative effort was called the Joint Highway Research Project (JHRP). In 1997 the collaborative venture was renamed as the Joint Transportation Research Program (JTRP) to reflect the state and national efforts to integrate the management and operation of various transportation modes.

The first studies of JHRP were concerned with Test Road No. 1—evaluation of the weathering characteristics of stabilized materials. After World War II, the JHRP program grew substantially and was regularly producing technical reports. Over 1,500 technical reports are now available, published as part of the JHRP and subsequently JTRP collaborative venture between Purdue University and what is now the Indiana Department of Transportation.

Free online access to all reports is provided through a unique collaboration between JTRP and Purdue Libraries. These are available at: http://docs.lib.purdue.edu/jtrp

Further information about JTRP and its current research program is available at: http://www.purdue.edu/jtrp

About This Report

An open access version of this publication is available online. This can be most easily located using the Digital Object Identifier (doi) listed below. Pre-2011 publications that include color illustrations are available online in color but are printed only in grayscale.

The recommended citation for this publication is:

Bollinger, G. T., and J. D. Fricker. *Updated Methods for Traffic Impact Analysis, Including Evaluation of Innovative Intersection Designs: Volume III—Reviewer's Guide*. Publication FHWA/IN/JTRP-2013/32. Joint Transportation Research Program, Indiana Department of Transportation and Purdue University, West Lafayette, Indiana, 2013. doi: 10.5703/1288284315338.