CHAPTER 3 – Section 3: Traffic Impact Studies

3.3.00 Overview

This Section is intended to give guidance to those involved in the preparation of Traffic Impact Study (TIS) or Transportation Impact Analysis (TIA) reports and to ODOT staff who are responsible for reviewing them. Assignment of reviewing responsibilities will vary by Region, except that a TIS submitted as part of an Approach Permit application will be reviewed by the Region Access Management Engineer (RAME). For purposes of the Chapter the term “TIS” includes TIAs.

The following discussion provides general information to be applied to typical TIS reports, but is not intended to be exhaustive. Although this guidelines document is primarily directed to the development review process, this section is intended to have broader application because TISs are used in a variety of situations. Staff who review TISs have requested that this section go beyond the subset of TIS issues that apply directly to development review to include access and other issues. In so doing, it is believed that the development of TISs can be more efficient, with fewer surprises later in the development process. This approach will also help to ensure that the various issues likely to arise in the development process will be assessed based upon the same data sets, time frames and upon consistent assumptions.

At this writing, an Analysis Procedures Manual is being drafted that will provide additional technical support for the development of TISs.

Every development proposal presents a unique set of issues to address, so professional judgment must be used along with the information in this chapter.

3.3.01 Purpose of Traffic Impact Studies

Traffic Impact Studies develop and document technical studies that assess the effects of land use and infrastructure changes on the transportation system. A TIS will usually be necessary to determine whether a development proposal will have a “significant effect” on a transportation facility as spelled out in TPR section 0060 and discussed in Chapter 3.2. Conclusions reached in a TIS are based on transportation engineering assumptions and calculations that must be performed by or under the direct supervision of an Oregon Registered Professional Engineer with an expertise in traffic, and documentation must bear his or her seal and signature.

A TIS is often required of developers by local jurisdictions in conjunction with review of a proposed development, zone change, plan amendment, or changes to the transportation system itself. The TIS provides information used to assess compliance with approval criteria in the local jurisdiction’s development code. If the TIS shows that the transportation system is inadequate to accommodate a proposed land use action, then the TIS also identifies and recommends improvements to mitigate conditions so that adequacy can be achieved. A system is "adequate" if it meets the minimum requirements set forth in the Oregon Highway Plan for both efficiency and safety of travel.

For long-range studies, such as those required for zone changes and plan amendments, adequacy is often determined relative to the amount of remaining capacity on the transportation system. Remaining capacity should also be considered for some short-range studies.

The results and recommendations of the TIS are used by ODOT and local jurisdictions to support decisions regarding the denial, approval or conditions of approval of local land use proposals and highway approach permit applications. A TIS may also be developed to determine signal warrants, to generate data for modeling and other analysis, and to establish facility needs for the highway system itself. At best, a TIS anticipates all of the traffic and facility issues related to the proposed activity and uses a methodology and assumptions that allow consistent application of the study conclusions across all of these issues.

3.3.02 Authority to Require a Traffic Impact Study

The legal authority for ODOT's involvement in Local Land Use Review is summarized in Chapter 1. The authority to require a TIS as part of a local land use review comes from the local government's development code and is derived from the statewide land use program (ORS 197). Typically, the local public facilities or development codes include a requirement that a TIS be included as part of certain types of local land use applications submitted to the local government. The requirement may be express or implied. As discussed in Chapter 1, section 1.1.06, the applicant has the burden of proof to satisfy the local approval criteria. A TIS is intended to satisfy the burden of proof to demonstrate that public facilities are adequate or can be made adequate to serve the proposed land use.

The state Transportation Planning Rule (which is required to be implemented through locally adopted policies and ordinances) requires a transportation analysis for certain land use actions. The Transportation Planning Rule OAR 660-012-0060, as amended in 2005, states that:

> "Where an amendment to a functional plan, an acknowledged comprehensive plan, or a land use regulation would significantly affect an existing or planned transportation facility, the local government shall put in place measures as provided in section (2) of this rule to assure that allowed land uses are consistent with the identified function, capacity, and performance standards (e.g,. level of service, volume to capacity ratio, etc.) of the facility."

For cases where direct highway access has been proposed and an Application for a State Highway Approach (for a new approach or a change of use of an existing approach) has been received, the legal authority to require a TIS comes from OAR 734-051 (Division 51). While the state and local processes are separate, the same TIS may sometimes be used for both if all the requirements of each have been met in the study.

Specifically, section OAR 734-051-0070 authorizes a TIS requirement in the following circumstances when an applicant applies for approval of a State Highway Approach Permit:

> (6)(e) (The Region Manager) may require a Traffic Impact Study for:
>
> > (A) Proposed developments generating vehicle trips that equal or exceed 600 daily trips or 100 hourly trips; or
> >
> > (B) Proposed zone changes or comprehensive plan changes; and
>
> (f) Shall require a Traffic Impact Study for proposed developments or land use actions where the on-site review indicates that operational or safety problems exist or are anticipated.

A TIS may also be required when an applicant requests a deviation to ODOT's access management Spacing standards.

3.3.03 Traffic Impact Study Review and Oversight

Ideally, ODOT, the local jurisdiction, and the applicant will discuss and agree on the TIS's scope, analysis methods, and assumptions prior to the study's preparation. The TIS is submitted by the applicant to ODOT as part of an ODOT approach application or to the local government as part of a land use application for land use applications. If the TIS is part of a local land use application, copies of the TIS should be forwarded to ODOT by the local government or provided directly by the applicant. It is preferable to have the applicant's consultant send copies directly to the appropriate ODOT office at the same time the TIS is submitted to the local jurisdiction to provide ample review time.

The assigned ODOT Development Review staff person is responsible for seeing that TIS reports are distributed to the appropriate ODOT staff for review and comment as soon as possible, advising other reviewers when comments must be received to be included in the ODOT response letter. The ODOT traffic engineer/staff person conducting the TIS review may need to coordinate and confer with the District office, State Traffic Engineer, the Transportation Planning Analysis Unit, Rail Division Crossing Safety Section and/or the Region Traffic Operations Supervisor. Coordination with local government staff should also be undertaken; it may be desirable for ODOT and local staff to share draft technical reviews. It is beneficial to inform and gain the support of local government staff for any proposed mitigation.

If ODOT staff determines the TIS is incomplete or inadequate, ODOT's ability to have the applicant revise it depends on the nature of the application and the time available for review. When the TIS is reviewed as part of a local land use application, the ability to require revisions also depends on the local jurisdiction's review process. The best opportunity to identify critical issues is during the scoping stage. The best time to get the TIS revised is typically during the pre-application stage or prior to the local staff accepting the application as complete. In any case, when only the local jurisdiction has decision authority (for example, there is no highway approach permit under review, and/or the applicant does not request a traffic signal in conjunction with development), the support of the local staff is needed before revisions to the TIS can be required. ODOT can assist local staff in making that decision by making it very clear why the TIS does not fulfill local approval criteria intended to ensure that reasonable transportation facilities exist to serve the proposed development. If the TIS contents clearly fail to comply with the criteria for approval of a project, the applicant may agree to suspend the "120-day rule" in order to have time to further refine the TIS to establish compliance.

When the TIS is reviewed as part of an ODOT approach application, the ability to require revisions depends on the stage of the application and the requirements of Division 51. In any case, if the applicant and ODOT agree to suspend the regulatory time limits for approach permitting, revisions to a TIS may be done to get sufficient information to allow an approval where the application would otherwise have been denied.

3.3.04 Scope of Work

The purpose of providing a scope of work for a TIS is to define the study area boundaries, establish the analysis requirements, and convey specific concerns to be addressed. The scope of work should be created with the goal of identifying the proposed development's impacts to the transportation system, as well as the potential improvements necessary to mitigate capacity, operational and safety impacts of the development. The effectiveness of the final TIS in evaluating impacts and associated mitigation options is directly related to the quality of the initial scoping. If the proposal is located within 500 ft of a rail crossing, contact the Rail Division Crossing Safety Section for direction on what they need to be included in the TIS scope. More direction on what issues should be analyzed for a particular TIS will be found in the Analysis Procedures Manual at the TPAU website, as mentioned and linked in 3.3.00, above.

It is important to note that Division 51 gives ODOT some flexibility regarding the extent of a scope of work for a TIS related to an approach permit application. In any case, under the discretion of the reviewing engineer, a scope should be developed in a way that avoids unnecessary data collection and analysis, subsequently reducing costs and time commitments for the applicant, ODOT and the local government. On the other hand, the scope should be broad enough to anticipate other issues that are likely to arise later in the development process. Applicants should be encouraged to direct their engineers to contact the appropriate ODOT staff to discuss the scope of work prior to initiating work on the TIS to avoid the need for supplementary work later. A sample scope of work letter is located in Appendix 7.

Additional Considerations for Approach Permits:

- Where an approach permit onto the highway is requested for a property that has alternate access, the TIS should include analyses both with and without site driveway/s onto the highway, whether or not the highway approach(es) already exist.
- The TIS could also include analysis of an approach with a restriction (e.g. right-in / right-out only) on the highway, but should still include analysis of the proposal with no site driveway(s) onto the highway.
- If the applicant applies for more than one approach onto the highway, an analysis should be conducted decrementally, as in the following example: An applicant applies for two driveways onto an Oregon District Highway. The property has alternate access. Analysis needs to be done in the TIS with two driveways onto the highway, with one driveway onto the highway, and no driveway onto the highway. All analyses with and without site driveway(s) onto the highway should show how these scenarios impact the highway, local streets, and other transportation modes (e.g. a nearby rail crossing).

The scope of work must include, at a minimum:

- The basis for establishing the analysis area and a description of the analysis area, typically covering the following:
    - Both sides of the highway along the entire frontage of the property(ies) involved;
    - All state highways and major city or county streets that directly serve the proposed development or land use change;
    - Any interchange ramps within the analysis area,
    - All existing and proposed approaches to the subject property;
    - Any public approach or private approach intersection where the proposed development can be expected to add 300 vehicle trips in a single day or more than 50 additional vehicle trips in any single hour;
    - Any road segment or intersection where the additional traffic created by the proposed development is greater than 10 percent of

the current traffic volume for road segments or the current entering volume for intersections.

- The alternative scenarios to be compared; and
- The years for which the future year analysis will be done. Table 3.3.1 below suggests rule-of-thumb thresholds for determining the year of future year analysis, based upon Access Management program practice.

Table 3.3.1 Future Year Analysis: Suggested Time Lines

Proposed Development Daily Trip Generation	Single-Phase Development Horizon Years	Multi-Phased Development Horizon Years
Up to 999 ADT	Year of Opening	Year of Each Phase Opening
1,000 - 2,999 ADT	Year of Opening and at 5 Years	Year of Each Phase Opening and 5 Years Beyond Buildout
3,000 – 4,999	Year of Opening and 10 Years	Year of Each Phase Opening and 10 Years Beyond Buildout
5,000 or More	Year of Opening and Year of Planning Horizon for the Transportation System Plan or 15 Years, Whichever is Greater	Year of Each Phase Opening and Year of Planning Horizon for the Transportation System Plan or 15 Years, Whichever is Greater
Plan Amendments and Zone Changes	Year of Planning Horizon for Transportation System Plan or 15 Years, Whichever is Greater[1]	Year of Planning Horizon for Transportation System Plan or 15 Years, Whichever is Greater[1]

[1]This is policy: see OHP Action 1F.2

3.3.05 Components of Traffic Impact Studies

The general outline of a TIS document should follow the format below.

1. Executive Summary
2. Introduction
3. Existing Area Conditions
4. Traffic Volumes – Year of Opening without the Development
5. Traffic Operations – Year of Opening without the Development
6. Site Trip Generation, Distribution and Assignment

7. Traffic Volumes – Year of Opening with the Development
8. Traffic Operations – Year of Opening with the Development
9. Traffic Volumes – Future Year without the Development
10. Traffic Operations – Future Year without the Development
11. Traffic Volumes – Future Year with the Development
12. Traffic Operations – Future Year with the Development
13. Mitigation Alternatives
14. Conclusions and Recommendations
15. Appendices including all data sheets

3.3.06 Executive Summary

The TIS report may begin with an executive summary if desired. These summaries are particularly useful on larger, more complex applications to provide a general overview of the proposal. The executive summary should briefly describe the purpose of the report and the study objectives, as well as provide a description of the site location, the study area, the proposed development and/or land use action, and the principal findings, recommendations and conclusions of the report. The executive summary should be written to be understood by a local government decision maker who is not a planner or an engineer.

3.3.07 Introduction

The Introduction of a TIS should include a brief description of the proposal including the site location, existing and proposed land uses and development intensities (e.g. number of units, square feet, whether the site is raw land or already has development, etc.), and the anticipated timing of development phases where applicable. In addition, the written description should be accompanied by a vicinity map, plat map with tax map identification (township, range, section and tax lot numbers), and a site plan illustration. An example of a typical vicinity map is shown in Figure 3.3.1 at the end of this chapter. Site plans should be drawn to scale and should show the proposed site approaches, approaches to adjacent properties and to properties across the highway from the subject site, building locations, parking lot layout, and internal circulation routes. Examples of simple site plans can be found in Chapter 3.1 (Figures 3.1.2 and 3.1.3).

3.3.08 Existing Area Conditions

An existing conditions analysis should identify site conditions and the operational and geometric characteristics of roadways within the study area for the current year. In addition to detecting existing transportation system deficiencies, the existing condition analysis provides a baseline for comparison to the proposed development's traffic impacts found later in the TIS.

Typical information provided in a study of existing conditions includes:

Existing Area Conditions:

- Study area description:
    - Area of potentially significant traffic impact;
    - Existing, planned and proposed street network;
    - Planned future street and highway improvements;
    - Committed future street and highway improvements;
    - Existing traffic volumes and conditions;
    - Public transit availability;
    - Existing transportation system management programs;
    - Local policy and regulations;
    - High accident locations and accident type(s), as pertinent; and
    - Known operational problems (e.g., long queues, high percentage of truck traffic, sight distance issues)
    - Any unique geometric characteristics; and
- Study area land use(s):
    - Existing land uses;
    - Existing zoning and comprehensive plan designations;
    - Anticipated/ Planned future development; and
    - Proposed zoning or plan amendments.

Some information, such as a description of the subject property, location, and surrounding land uses, may have been previously discussed in the Introduction, but can be covered in more detail in this section.

Physical descriptions of each roadway included in the study area should be provided to aid in the assessment of the available transportation infrastructure. At a minimum, this should include: roadway names; roadway classifications; road authority; posted speeds; roadway cross-section dimensions; number of lanes; transit services; existence of bike lanes; existence of sidewalks; and existence of on-street parking.

Identification of existing lane configurations and traffic control devices should be shown on a diagram of the study area that also shows the number of through lanes and turn lanes and the type of traffic control (e.g., stop sign, traffic signal, etc.), on each intersection approach to be analyzed. An example of such a diagram can be found in Figure 3.3.2 at the end of this chapter. The amount of available vehicle storage in the left and right turn lanes could also be provided in this diagram.

Traffic flow diagrams, such as the one shown in Figure 3.3.3 at the end of this chapter, should be prepared and included in the report illustrating the existing traffic volumes – average daily traffic (ADT) on the links, and the appropriate peak hour or 30th highest hour turning movements at each study intersection and site approach location.

In general, ODOT requires the use of the 30th highest hourly volume (30 HV) of the year for design purposes. In large urban areas, the 30 HV can often be closely approximated by using the weekday peak hour volume from the peak month of the year. The weekday peak hour typically occurs during the work-related commute period, usually between 7-9 a.m. or 4-6 p.m. Seasonal factors can be applied to the counts obtained to model conditions during the peak month of the year.

In rural or recreational areas, the time of the 30 HV may be less predictable. Historical data from Automatic Traffic Recorded (ATR) stations can be very useful in determining the 30 HV in these situations.

Complete instruction for determining the 30 HV in both urban and rural areas can be found in the document titled, “Developing Design Hour Volumes” published by ODOT’s Transportation Planning Analysis Unit.

The dates of the traffic counts should be stated and the actual count data must be included in the report. Traffic counts should not be more than a year old from the date the report is prepared. Counts between one and three years old must be factored to the current year. In areas where significant amounts of development or regional traffic growth have recently occurred, it may be preferable to require the collection of current count data to accurately capture these changes. Counts should not be taken within a week of state or federal holidays, unless directed by ODOT. Counts on the weekday should be conducted either on a Tuesday, Wednesday, or Thursday, unless directed by ODOT. The presence of schools in the area should be considered when determining the date of counts. It is preferable to count when schools are in session.

Using the above information, an analysis of existing study area intersection operations during the time periods specified in the scope of work should be provided. The results should be clearly presented in tables or figures (see Table 3.3.2). Most jurisdictions measure intersection operational performance by Level of Service (LOS) or delay. ODOT measures the performance of the highway using volume to capacity (v/c/) ratios. The performance of each intersection analyzed should be reported using the measuring criteria preferred by the jurisdiction having authority over that intersection. Having both LOS and v/c data helps to get a more accurate picture of how well an intersection is functioning. For example, for a minor approach to a major roadway that is not signalized, the v/c may be well within standards while the LOS (or delay) is unacceptable.

Table 3.3.2 Example: 2001 Existing Intersection Capacity Analysis

Intersection	Signalized Intersection		Unsignalized Intersection			Level of Service
	v/c	Average Delay (sec)	Critical Movement	Movement v/c	Movement Delay (sec)	
Hwy 213 @ Hwy 211	0.45	26.3				C
Hwy 213 @ Barnards Rd			EBLT	0.02	17.7	C
Site Access @ Barnards Rd						
Hwy 213 @ Macksburg Rd			EB	0.87	77.5	F

It is also important to identify existing or potential safety hazards in the analysis area. Traffic crash data should be obtained from the appropriate jurisdictions and analyzed to locate trends and compare existing conditions to similar highway segments in the state. No fewer than three years of the most current data should be used for this analysis. Recent or upcoming improvement projects that may have changed or will change the transportation infrastructure should be accounted for in evaluating hazardous locations (see next web link, below).

In addition, thorough field observations of the subject intersection(s) are to be conducted in order to identify any existing or potential traffic operational problems. Items of concern would include, but may not be limited to, excessive queuing and/or delay, location and spacing of adjacent intersections and driveways, sight distance and deficiencies related to geometry, etc.

Finally, committed and planned transportation improvements in the area, (both ODOT and local government) that affect or are affected by the development proposal need to be identified. This will include projects identified in adopted local and regional transportation system plans as well as corridor plans or projects from ODOT's Statewide Transportation Improvement Program (STIP) or the local jurisdiction's Capital Improvement Program (CIP). To research planned and proposed highway facility construction projects in the TIS study area, use the search feature on the STIP website.

3.3.09 Traffic Volumes – Year of Opening without the Development

When the existing 30th highest hour (or other peak hour(s) if appropriate) and average daily traffic data have been identified and developed, the year of opening traffic volumes can be projected. This traffic is typically referred to as the background traffic and represents the non-site traffic during the anticipated year of opening for the development. The background traffic consists of the existing traffic plus the traffic generated by nearby “in-process” developments (currently approved but not yet operational) and projected regional growth affecting the analysis area.

There are several methods for projecting the background traffic. The three most common methods are described below. The method used to develop the background traffic should be approved by the Region Manager or his/her designee.

- **Transportation Models**. These are most suitable for use in urban areas and for long time frames. The traffic analyst should understand the origin of the input and the limitations of the model. The transportation analysis zone (TAZ) containing the proposed development should be investigated closely to ensure the appropriate land use is included. If modifications to this land use are necessary, all changes shall be clearly documented. Transportation models of the current time period may be compared with a future year to arrive at an annual growth rate. The growth rate is then applied to the counted traffic volumes over the number of years into the future appropriate for that proposal. Because the models are typically developed in conjunction with a transportation system plan and comprehensive plan, this method can provide a reliable forecast for growing urban areas. Significant changes to the transportation network, such as the addition of a new arterial or the deletion of a link, are also captured well by a model.

  Note: Nearly all computerized system level traffic assignments require that further post-processing take place prior to their being used for transportation project planning and design. Model numbers represent employment and households, and only indirectly represent trips, so modeled volumes have to be compared on a relative basis. The recommended methodology for refining trip assignments obtained from computerized transportation models comes from NCHRP Report 255, “Highway Traffic Data for Urbanized Area Planning and Design”. See also a new White Paper at the TPAU web page, due to be published summer of 2005.

- **Cumulative Analysis**. This methodology is most suitable to smaller urban areas or to a portion of a large urban area, and for short time frames where there is good local information about future projects. This method projects future traffic volumes by adding the estimated traffic generated by all approved but not yet opened developments in a study area to the existing traffic. Long-term forecasts should also include the effects of future developments on undeveloped lands. An additional amount may be added to account for increases in through trips.

If a cumulative analysis is conducted, a table listing the anticipated developments and corresponding trip generation rates must be provided.

- **Growth Trends**. This method is most suitable for rural areas with stable growth rates. This methodology involves estimating growth rates based on regression analysis of traffic volumes covering, typically, the past 20 years. It is usually assumed when projecting future traffic demands based on this methodology that site traffic is included in these projections. Again, caution has to be used to verify whether site traffic would be over- or under-estimated using this method. (For example, a particularly large use such as a destination resort may not fit the past 20-year trend.)

  When background traffic volumes for the year of opening have been determined, updated traffic flow diagrams reflecting this condition must be provided (see Figure 3.3.4).

3.3.10 Traffic Operations – Year of Opening without the Development

When background traffic volumes for the year of opening have been established, an operational analysis of study area intersections must once again be conducted. This analysis should incorporate any transportation system improvements anticipated to be completed by the represented year. Again, results should be clearly presented in tables or figures and the performance of each intersection analyzed should be reported using the measuring criteria preferred by the jurisdiction having authority over that intersection (see Table 3.3.3).

Table 3.3.3 Example: 2003 Background Traffic Study Intersection Capacity Analysis

Intersection	Signalized Intersection		Unsignalized Intersection			Level of Service
	v/c	Average Delay (sec)	Critical Movement	Movement v/c	Movement Delay (sec)	
Hwy 213 @ Hwy 211	0.48	26.7				C
Hwy 213 @ Barnards Rd			EBLT	0.02	18.6	C
Site Access @ Barnards Rd						
Hwy 213 @ Macksburg Rd			EB	1.02	118.5	F
Hwy 213 @ Union Mills Rd			WB	0.85	76.1	F

3.3.11 Site Trip Generation, Distribution and Assignment

Site trip generation, distribution and assignment provides information about how many new trips can be expected to be created by the proposed development and where they will occur on the surrounding transportation system. Generation, distribution and assignment should be agreed upon with ODOT staff **before** proceeding with the TIS.

3.3.12 Trip Generation

An estimate of the amount of trips originating from and destined to a proposed development is essential in evaluating that development's impacts to the transportation system. A few of the more common methods used to make these estimates are described below.

- **Institute of Transportation Engineers (ITE) Trip Generation Manual.** This published document contains information provided by engineering and planning professionals in the United States and Canada about the trip generation characteristics of a variety of land uses. The Manual is updated periodically, so the most recent edition should be used. The data for a specific land use in this manual can often be applied to a proposed development if the uses are reasonably similar.
- **Local Data.** There may be times when ODOT or a local jurisdiction will have information about the trip generation characteristics for certain land uses. Information such as this may be more appropriate for use than that from the ITE manual, which typically does not account for local conditions.
- **Data from Similar Sites.** If no other information source is available or believed to be appropriate for the subject land use, data collected from existing sites found to be reasonably similar to that proposed can often be used.
- **Estimates for Site Specific Characteristics.** A times, when there is no documented information available, and no similar sites can be found, trip generation may be estimated by closely examining the operating characteristics of the proposed development. To do this, information such as the number of employees, visitors, and deliveries must be known, as well as the time of day they are expected to be entering and leaving the site.

In the case of a local land use proposal where specific uses have not been identified, a reasonable worst-case land use should be assumed based on the uses allowed outright under the current or requested zoning. For example, if a 20-are site was proposed to be re-zoned from industrial use to commercial use, but no specific type of size of commercial development had been identified yet, it should be assumed that the property would develop to the highest trip generating potential under the new zoning. High trip generating uses such as retail, a fueling station, and fast food with drive-through window should be assigned to the property in quantities appropriate for the size of the site. When analyzing the potential land use mix for the site, it is prudent to consider whether these high trip-generating uses are appropriate to the site, given its location and surrounding land uses.

Similarly, where a zone change is being requested and a specific development that would be allowed under the requested zoning has been identified, the trip generation assumptions must still be based on a reasonable worst-case land use rather than on the desired use. This assumption helps assure that transportation facilities will be planned to accommodate any future developments allowed under the adopted zoning of the land.

The report needs to contain a table showing the daily trips generated, as well as the hourly trips generated for all time periods analyzed. Both entering and exiting volumes need to be displayed for the hourly periods. In addition, weekend trip generation may need to be included for some land uses. The trip generation for each proposed use included in the development is to be shown. Table 3.3.4 provides a typical display of trip generation data for an example development including 124 single-family detached homes.

Table 3.3.4 Example: Site Trip Generation

Land Use	ITE Code	Size	Daily Trips	30th Highest Hour		
				Total	Inbound	Outbound
Single-Family Detached	210	124 Dwelling Units	1265	130	85	45

Variations or adjustments may be required to account for local conditions. All assumptions for adjustments must be documented and discussed in the report. Further discussion on trip generation adjustments can be found below.

- **Trip Generation Adjustments.** The forecast trip generation from the ITE Trip Generation Manual for the proposed development may be adjusted under certain circumstances. Some of the more common circumstances are described below.

    1. **Pass-by Trips**: Pass-by trips are made as intermediate stops on the way from an origin to a primary destination without a route diversion. They are attracted from traffic passing the site on an adjacent roadway that offers direct access. Reductions in trip generation on the adjacent system accounting for pass-by trips may be allowed based on the following factors:
        - Type of development

- Existing traffic composition
- Existing population distribution
- Location(s) of competing developments

  Caution! – While this assumption may reduce the trips distributed to the transportation system, the full site traffic generation is still based on the site approach(es) and land use assumptions. Recognizing pass-by trios does not reduce the driveway entering and exiting turning volumes.

2. **Diverted Link Trips**: Diverted linked trips are trips that are attracted from the traffic on roadways within the vicinity of the site but that require a diversion from that roadway to gain access. Note that diverted linked trips will add traffic to the streets adjacent to a site, but may not add traffic to the area's major travel routes.
3. **Internal Trips**: Where multi-use developments are proposed that offer the potential for interaction among the individual uses (such as a mix of office, retail, and multi-family housing), a reduction in the vehicle trip generation between the overall development and the external street system may be applied to account for internal, or captured, trips. These captured trips are made entirely within the site by either walking or driving between buildings using the internal street system or pathways.

The most recent *Trip Generation Handbook, ITE*, should be consulted for a complete explanation of when and how to use these and other trip generation refining factors. The Region Manager or his/her designee should review all proposed trip generation adjustments **before** proceeding with the TIS.

- **Mode Split.** Mode split is the process of estimating the number of travelers from the development that are anticipated to use modes other than automobiles in the site impact analysis. If this percentage is low, the step can be skipped. As transit and other non-motorized alternatives become available, mode split analysis may be required. If transit or ridesharing is anticipated to be a factor, data from similar developments within the area should be used to refine the mode split estimates.

The non-automobile portion of the project's traffic should be deducted from the trip generation estimates. Data must be presented to support any significant use of alternative modes. It should be noted that the Transportation Planning Rule section of OAR 660-012-0060(6) allows, and in some cases requires, local governments to give full credit for potential reduction in vehicle trips for uses located in mixed-use, pedestrian-friendly centers and neighborhoods.

As of this writing, amendments to the TPR are under way. Amendments are available at the Department of Land Conservation and Development web site before they are incorporated into the text at the above link. See Transportation Planning Rule (TPR) – DLCD.

3.3.13 Trip Distribution

The purpose of trip distribution is to analyze the trip-making characteristics of the proposed development and off-site areas. The level of effort involved in this step is a function of the intensity and type of development, adjacent land uses, and the time of day being evaluated.

A trip distribution diagram, such as the one shown in Figure 3.3.5, is required to be included in the TIS report to illustrate the percentage of trips in and out of the site through all study area intersections. Project-generated trips and pass-by trips should have separate trip distributions.

In cases where ODOT is the lead review agency, ODOT must approve of the trip distribution methodology used in the study. A common method of determining trip distribution is to analyze existing area travel patterns. However, when using this method care must be taken to consider the types of trips associated with the proposed land use and how site generated trips are likely to interact with surrounding land uses.

The Analogy, Transportation Model and Surrogate Data methods described below are methods of establishing trip distribution acceptable to ODOT and recognized by the Institute of Transportation Engineers.

- **Analogy Method.** The analogy method uses a similar existing development to predict distribution. This can be accomplished by various methods including driver surveys, license plate origin-destination studies, and driveway turning movement counts. The gathered information can then be applied to the location of the proposed development. Judgment needs to be exercised with this method by evaluating other influencing factors such as population distribution, location and competing attractions.
- **Transportation Model.** A transportation model can be effective in estimating traffic distribution patterns. Because these types of models are typically developed in conjunction with a transportation system plan and comprehensive plan, they can provide a reliable forecast for growing urban areas. The transportation analysis zone containing the proposed development should be investigated closely to ensure land uses, development densities, and trip making characteristics are modeled accurately. Significant changes to the transportation network, such as the addition of a new arterial or the deletion of a link, are captured well by most models.

The recommended approach for model development and application in Oregon is detailed in the ODOT Travel Demand Model Development and Application Guidelines and the ODOT Travel Demand Model Development Procedure Manual.

Post processing of the model trip assignment for use in projecting trip distribution is necessary, and should follow the guidance of NCHRP Report 255, “Highway Traffic Data for Urbanized Area Planning and Design.”

- **Surrogate Data.** Surrogate data involves using one piece of information and applying it to another. An example is using employment as a surrogate for residential trips. Generally, residential use will serve as a good surrogate for office, retail, and entertainment trips. This method can accurately estimate trip distribution when used cautiously and for appropriate land uses. This method requires an extensive database of usable socioeconomic and demographic information for various regions of the city.

3.3.14 Trip Assignment

Trip Assignment is the process that estimates the volume of traffic that will use certain routes on the existing roadway system. Trip assignments can be developed with the aid of a computer model or by manual calculations. The most common method is to manually calculate the actual volumes of trips on each study area intersection movement using the trip generation estimates and the previously established trip distribution diagram.

Prior to using the model trip assignment for planning or project analysis, post processing will be necessary. The recommended methodology is found in NCHRP Report 255, “Highway Traffic Data for Urbanized Area Planning and Design.”

Traffic flow diagrams illustrating the site traffic volumes on study intersection movements during each time period analyzed must be included in the TIS. An example is provided in Figure 3.3.6.

3.3.15 Traffic Volumes – Year of Opening with the Development

With background traffic volumes estimated and site generated trips assigned to the transportation system, “total” traffic volumes during the anticipated opening year of the development can be calculated by adding the two together. Again, an updated traffic flow diagram must be provided for each time period analyzed showing these new volumes on each study intersection movement (see Figure 3.3.7).

3.3.16 Traffic Operations – Year of Opening with the Development

For all analysis years, two analyses must be performed, one with and one without the proposed development site-generated traffic, or with and without the proposed zone change/plan amendment, to compare the impacts of the proposal to the otherwise existing or planned conditions. Once total traffic volumes for the year of opening have been established, an operational analysis of study area intersections must once again be conducted. This analysis should incorporate any transportation system improvements anticipated to be completed by the represented year. For purposes of comprehensive plan and zone changes, the categories of planned improvements that can be taken into consideration to mitigate future impacts are set out in the TPR, OAR 660-012-0060. Improvements anticipated to be constructed as mitigation for the proposed development shall not be considered in this part of the analysis.

Again, results should be clearly presented in tables or figures and the performance of each intersection analyzed should be reported using the measuring criteria preferred by the jurisdiction having authority over that intersection (see Table 3.3.5).

Table 3.3.5 Example: 2003 Total Traffic Study Intersection Capacity Analysis

Intersection	Signalized Intersection		Unsignalized Intersection			Level of Service
	v/c	Average Delay (sec)	Critical Movement	Movement v/c	Movement Delay (sec)	
Hwy 213 @ Hwy 211	0.49	26.8				C
Hwy 213 @ Barnards Rd			EBLT	0.15	23.1	C
Site Access @ Barnards Rd			SB	0.04	9.2	A
Hwy 213 @ Macksburg Rd			EB	1.16	171.5	F
Hwy 213 @ Union Mills Rd			WB	0.95	105.7	F

3.3.17 Traffic Volumes – Future Year without the Development

Local code, statewide planning regulations, or the rules in Division 51 may require analyses of future years beyond the year of opening of the proposed development. The future years to be analyzed should be established in the scope of work and may depend upon the level of trip generation, phasing of the development, or whether or not a zone change/plan amendment is proposed. Table 3.3.1 above shows recommended thresholds for determining years of analysis based on current practice in access management.

Background traffic volumes for future year analysis should be developed using one of the methods described in the previous section, *Traffic Volumes – Year of Opening without the Development*. In the future year forecasts, transportation improvements that appear in a fiscally constrained transportation system plan can be assumed to be in place as applicable. The estimated background traffic volumes for the future years must be displayed on traffic flow diagrams (see Figure 3.2.9).

3.3.18 Traffic Operations – Future Year without the Development

When background traffic volumes for the future year(s) have been established, the operational analysis of study area intersections must be conducted. This analysis should incorporate any transportation system improvements anticipated to be completed by the represented year. For purposes of comprehensive plan and zone changes, the categories of planned improvements that can be taken into consideration to mitigate future impacts are set out in the TPR, OAR 660-012-0060. This should not include improvements anticipated to be constructed as mitigation for the proposed development. Again, results should be clearly presented in tables or figures and the performance of each intersection analyzed should be reported using the measuring criteria (LOS or v/c) preferred by the jurisdiction having authority over that intersection and/or the decision process (see Table 3.3.6). It is instructive to have both measurements whenever possible.

Table 3.3.6 Example: Background Traffic Study Intersection Capacity Analysis

Intersection	Signalized Intersection		Unsignalized Intersection			Level of Service
	v/c	Average Delay (sec)	Critical Movement	Movement v/c	Movement Delay (sec)	
Hwy 213 @ Hwy 211	0.55	27.5				C
Hwy 213 @ Barnards Rd			EBLT	0.11	26.3	D
Site Access @ Barnards Rd						
Hwy 213 @ Macksburg Rd			EB	1.59	368.2	F
Hwy 213 @ Union Mills Rd			WB	1.43	300.2	F

3.3.19 Traffic Volumes – Future Year with the Development

Future year traffic volumes from the site should be based on the described methods of trip generation, distribution, and assignment. For most land uses, travel patterns will not change substantially from year of opening to the future year, so the project-related volumes obtained for the year of opening may be used for the future year. If area land uses, transit usage, transportation infrastructure, or other factors are expected to change, then the estimates of the future traffic volumes may need to be adjusted as well.

The future year total traffic hourly and ADT volumes must be shown in traffic flow diagrams (see Figure 3.3.9).

3.3.20 Traffic Operations – Future Year with the Development

When total traffic volumes for the future year(s) have been established, an operational analysis of study area intersections must once again be conducted. This analysis should incorporate any transportation system improvements anticipated to be completed by the represented year. This should not include improvements anticipated to be constructed as mitigation for the proposed development. Again, results should be clearly presented in tables or figures and the performance of each intersection analyzed should be reported using the measuring criteria preferred by the jurisdiction having authority over that intersection (see Table 3.3.7).

Table 3.3.7 Example: 2020 Total Traffic Study Intersection Capacity Analysis

Intersection	Signalized Intersection		Unsignalized Intersection			Level of Service
	v/c	Average Delay (sec)	Critical Movement	Movement v/c	Movement Delay (sec)	
Hwy 213 @ Hwy 211	0.56	27.5				C
Hwy 213 @ Barnards Rd			EBLT	0.28	35.0	E
Site Access @ Barnards Rd			SB	0.04	9.3	A
Hwy 213 @ Macksburg Rd			EB	1.021.83	118477.0.5	F
Hwy 213 @ Union Mills Rd			WB	0.851.65	401.076.1	F

3.3.21 Mitigation Alternatives

Upon completing the engineering analysis for each time period examined with and without the proposed development traffic, the proposal's impact to the transportation system is evaluated. The operational and safety characteristics of the transportation system for each time period should be compared to all standards and thresholds relevant to the applicable approval criteria. Failure to comply with any applicable criteria can now be identified.

If the analysis finds the transportation system is inadequate to support the development, the applicant must identify mitigation so the development can meet the local approval criteria. Mitigation alternatives may include geometric improvements, alternative approach configurations, installation of traffic control devices, Transportation Demand Management strategies, and other methods.

Any mitigation considered for the proposed project must be included in a revised traffic operational and safety analysis. This analysis must show that the mitigation is sufficient to meet the local approval criteria for any time period in which it had failed to meet the criteria in the earlier analysis. In addition, the feasibility of implementing any recommended mitigation must be examined and addressed in the TIS. This will typically include considerations such as availability of right-of-way, design standards, Oregon Highway Plan policies, Oregon Administrative Rules and statutes, and local transportation system plans.

In the case that access to a state highway is proposed, OAR 734-051-0145 provides a complete description of ODOT's authority to require mitigation.

3.3.22 Conclusions and Recommendations

The report's conclusion should summarize existing and future conditions, discuss the development's impacts, identify any operational or safety deficiencies, recommend mitigation if needed, and describe the effectiveness of the mitigation proposed. The TIS should also clearly state whether the proposed development would comply with all operational and safety standards in the applicable approval criteria.

3.3.23 TIS Appendix

An appendix to the TIS shall be submitted with the report that includes, at a minimum, the traffic count data sheets used and the capacity analysis worksheets. Other information that is typically enclosed includes:

- Trip Generation Calculations;
- Queuing Analysis Worksheets;
- Crash Data;
- Traffic Signal Warrant Worksheets;
- Turn Lane Warrant Worksheets;
- ODOT's staff letter setting out or accepting the scope of work;
- Software input sheets for verification of defaults and input parameters.

3.3.24 Technical Analysis

This section is intended to provide additional information for those responsible for reviewing TIS reports for ODOT, as well as for those responsible for conducting the technical analysis for a TIS report scoped by ODOT. Below are sections on several types of analysis to be considered in a typical TIS, as well as descriptions of methodologies generally acceptable to ODOT. The analysis needs for each development proposal must be determined individually. Furthermore, analysis methodologies and parameters other than those identified below may only be used with approval from the Region Manager or his/her designee.

3.3.25 Capacity Analysis

Volume to capacity (v/c) ratios shall be used as the measure of mobility on state facilities. Traffic impact studies shall list the v/c ratios for all intersections (or for critical movements of unsignalized intersections) during each time period and analysis year and shall clearly show the v/c ratios with and without the proposed development.

The v/c ratios from the TIS must be compared to OHP Policy 1F, *Highway Mobility Standards,* and the v/c ratios provided in OHP Tables 6 (general) and 7 (Metro), as amended. The v/c ratios from the OHP tables establish the standards of mobility for the various classifications of state highways and the standards should not be exceeded. Metropolitan Planning Organizations (MPOs) can establish “alternative mobility standards” as has occurred in the Rogue Valley MPO and is proposed in other areas. Where an alternative mobility standard has been adopted by an MPO and by the OTC, that standard supersedes Table 6.

The performance of each ODOT intersection analyzed should be reported using the measuring criteria listed in the two Mobility Standard White Papers in Appendix 8 of these guidelines. If a development proposal’s impacts will degrade the performance of a state highway to a degree that the v/c ratios would be exceeded, mitigation must be implemented to bring v/c ratios back to or below the standard for the facility.

Some local jurisdictions may have adopted operational standards for state highways that are more conservative than those from the *1999 Oregon Highway Plan*. While ODOT should not consider these standards when evaluating system adequacy, the local jurisdiction may use them to require mitigation on state facilities. Of course, as the owner of the facilities, ODOT must approve of any proposed mitigation.

In situations where the mobility standards are already exceeded prior to the addition of the proposed development’s traffic, where transportation improvements are not planned that would bring performance levels back to the mobility standard, the standard is to avoid further degradation of the facility, pursuant to OHP Action 1F.6. If the development’s impacts increase the v/c ratios further, mitigation must be implemented to return the v/c ratios back to the levels they were before the development traffic was added.

For further explanation of ODOT’s policies on implementing mobility standards during the review of development and approach permit applications, see the white papers titled, *Highway Performance and the 1999 Mobility Standards*, and

Application of Oregon Highway Plan Mobility Standards that are attached in Appendix 8.

Capacity analysis of signalized intersections, unsignalized intersections, rural two-lane highways, arterials, multilane highways, and weaving sections in the study area should generally follow the established methodology of the current Highway Capacity Manual (HCM). For these features, the capacity analysis should be completed with actual measured values, standard default values listed in the HCM, or other department-approved input values. Default values selected for use in the analysis should remain constant through each analysis year and each alternative as applicable. The calculations may be done by hand or with the use of computer software.

Application of computer software should closely follow an ODOT approved analysis methodology. The appropriate use of computer software, such as HCS or the current version of Synchro for capacity analysis, is discussed on the web page of ODOT's Transportation Planning Analysis Unit (TPAU). For additional information on accepted analysis methods, link to the Analysis Data Resources portion of that webpage.

A complete listing of input and output parameters must be included in the report. A printout from a computerized analysis program should list all parameters necessary for the reviewer to make a determination that the analysis is accurate and complete. Printouts should indicate the number of lanes, lane configurations, saturation flow rate and adjustments, volumes and adjustments, intersection traffic control and timing data as applicable, approach v/c ratios. Copies of the field saturation flow study sheets, lost time measurements, or other capacity analysis inputs should be attached to the report.

3.3.26 Signalized Intersections

Signalized intersections may be evaluated with the methodology of the current HCM, or the Intersection Capacity Utilization (ICU) procedure. Results from an ICU analysis should be considered "ballpark" numbers, and will often indicate that further analysis is needed. Analysis of signalized intersections shall follow an approved method with the standard default input values or with locally measured values. Table 3.3.8 lists the ODOT default values for use with signalized intersection analysis.

Methods and default values selected for use in the analysis should be consistent through each analysis year and each alternative. Peak hour factor for the analysis of existing traffic should be taken from counts of current volumes; future year analysis peak hour factors should tend toward the standard default values.

Computer software used should closely follow an ODOT-approved analysis methodology. The appropriate use of computer software such as HCS or

Synchro for capacity analysis may be further explored using resources available on the web page of ODOT's Transportation Planning Analysis Unit (see link above). Summary output sheets for the capacity analysis must be attached to the traffic study.

Intersection Capacity Utilization (ICU) is a capacity analysis methodology developed by Trafficware Corporation, authors of the Synchro software. The ICU provides a relatively easy-to-calculate volume to capacity ratio for critical movements. It is timing plan independent. The methodology assumes a 120-second cycle length, and some operational phasing schemes may not be accurately evaluated by the methodology. The traffic analysis package, Synchro, includes the ICU estimates as well as HCM-based estimates. These software applications are included here only as examples, not as recommended applications. Any software shown to be consistent with HCM methodology may be used.

3.3.27 Unsignalized Intersections

Two-way and four-way stop-controlled intersections may be evaluated with the methodology of the current HCM or other department-approved methods. The v/c of the most interest will be for the critical movement. As with other default input values of the HCM analysis method, revisions to the acceptable gap times and follow-up times should only be done after conducting thorough field investigation study. Default peak hour factors for future year analysis may follow the values previously given for signalized intersections. In addition, v/c and LOS should be analyzed for access from a minor roadway to a major roadway.

3.3.28 Roundabouts

Analysis of roundabouts should be coordinated with the ODOT Traffic staff in Salem. The ODOT Traffic Manual contains guidelines, standards, and siting criteria for roundabouts on state highways. The methodology of aaSIDRA and the German 'G2' linear regression formulas have been found by ODOT to be most representative of roundabout operations on Oregon's state highways. Proposed roundabouts should meet most, if not all, of the siting criteria. The siting criteria include consideration of the following capacity analysis issues:

- Maximum volume to capacity ratio of 0.80 using both the aaSIDRA and German 'G2' methods;
- Should not have high volumes of trucks;
- Should not have high pedestrian volumes.

Table 3.3.8 ODOT Default Parameters for Use With Signalized Intersection Analysis Methodologies

Total Lost Time	4 seconds per phase minimum for typical intersections, more for large or complex intersections.
Peak Hour Factor	For future year analysis: ▪ 0.85 for local and collector street approaches ▪ 0.90 for minor arterial approaches, ▪ 0.95 for major arterial approaches, ▪ unless better information is available, such as for a school or industrial use.
Ideal Saturation Flow Rate	Field measurement should be consistent with methodology laid out in the HCM. Saturation flow rate worksheets must be included in the documentation. Where field measurements are not done, Outside of MPO urban areas, 1800 passenger cars per hour of green per lane (pcphgl) shall be used Inside MPO urban growth boundaries, 1900 passenger cars per hour of green per lane (pcphgl) may be used, unless one or more of the following conditions are present, in which case 1800 pcphgl shall be used ▪ Parking ▪ Greater than 5% trucks ▪ Other than ninety degree intersection skew angle ▪ Accesses are present upstream or downstream ▪ Poor signal spacing or observed queue spillbacks between signals during the peak hour, or Less than 12 foot travel lanes

Other siting criteria for Oregon's first roundabouts such as limiting the number of legs to four, building only single-lane approaches and circulatory roadway, and achieving good sight distance are identified. The criteria are intended to assist in the decision making on whether the site is optimal for a roundabout.

3.3.29 Capacity Analysis Documentation Requirements

The input data and output results of capacity analysis work shall be included in an appendix to the TIS. A one- to two-page summary of each intersection will document the following:

- Lane configurations,
- stop-controlled approaches (for unsignalized intersections),
- cycle length (for signalized intersections),
- assumed ideal saturation flow rates and all adjustment factors,
- traffic volumes,

- peak hour factor,
- lost time, and
- v/c ratios for each approach and the entire intersection.

The HCM allows and encourages field measurements of traffic flow parameters such as ideal saturation flow rate and lost time. ODOT will accept substitution of field measured values only when accompanied by appropriate worksheets showing data collected and calculations made. See the two Mobility Standards White Papers attached in Appendix 8 for more details.

3.3.30 Queue Length Analysis

Intersection operations analysis should include the effects of queuing and blocking. Estimates of queue lengths should be based on the anticipated arrival patterns, duration of interruptions, and the ability of the intersection to recover from momentary heavy arrival rates. The average queue length and the 95^{th} percentile queue lengths should be shown in the report. The 95^{th} percentile queue length shall be used for design purposes. Average vehicle storage length to be used in the analysis shall be 25 feet or 7.6 m unless a local study indicates otherwise (SigCAP2, an ODOT analysis program useful for “back-of-the-envelope calculations, uses 7.5 m).

A queue analysis should be conducted in the TIS that contrasts the background queues versus the total traffic queues after development for all movements. In this analysis, the TIS should provide the length of storage lanes and distance from other intersections or rail crossing. The queue analysis should consider three different types of queues:

- **Overflow** - The storage lane for a turn movement exceeds capacity creating an overflowing queue onto the mainline.
- **Spillback** - Queue from a downstream intersection uses up all the capacity in a roadway segment between two signalized intersections where the queue spills back onto the upstream intersection.
- **Storage Blocking** – through traffic queues extend upstream past the opening of a storage lane preventing vehicles from accessing the lane.

If traffic from the proposed development adds to or creates an overflowing storage lane and/or spills back into another intersection or rail crossing, the TIS should explore if there is potential mitigation to fix these overflow or spillback problems. The same goes for storage blocking queues.

In cases where a TIS includes a queue analysis for an Interstate or Expressway off-ramp, vehicles should have enough stopping sight distance (determined from the recent AASHTO *A Policy on Geometric Design of Highways and Streets*) to decelerate from the beginning of the off-ramp to stop at the end of the 95th-percentile queue. If the total traffic does not allow reasonable stopping sight distance, the TIS should state whether any mitigation can be introduced to reduce the queue on the off-ramp.

Any methodology used to determine queue lengths must be approved by the Region Manager or his/her designee. It should be noted that queue lengths subject to over-capacity conditions can only be adequately assessed through the use of simulation software. Simulation software should be used to calculate 95th percentile queues when operational conditions are greater that 0.70 v/c and must be used if the v/c exceeds standards.

3.3.31 Intersection Sight Distance

Adequate intersection sight distance should be verified for all study intersections and highway approaches. Intersection sight distance should meet the standards of the most recent AASHTO *A Policy on Geometric Design of Highways and Streets*. See also the ODOT Highway Design Manual, Chapter 5. Intersection sight distance will vary depending which of the following types of at-grade intersections is under consideration:

- No control, but allowing vehicles to adjust speed;
- Yield control;
- Minor street stop control; and,
- Signal control where all legs of the intersection are required to stop by either a stop sign or where the intersection is controlled by a signal.

To determine if a proposed approach or an existing approach meets Division 51, see *Intersection Sight Distance Measurements Standards for On-Site Review of Approaches* in Access Management Manual Volume 2, Section 2.

3.3.32 Right/Left Turn Lane Warrants

Proposed right or left turn lanes at unsignalized intersections and private approach roads must meet the installation criteria contained in the 2001 Highway Design Manual (HDM) (web link in 3.3.31) Locations that meet the HDM criteria for a right or left turn lane should be noted in the traffic study and may be recommended as mitigation for project traffic. Meeting the criteria does not mean a turn lane has to be installed. Engineering judgment must be used to determine if an installation would be unsafe or impractical. The ODOT Traffic Manual provides further guidance on the use of right and left turn lanes.

At signalized intersections, improvements must be consistent with the requirements in the Traffic Signal Guidelines.

3.3.33 Traffic Signal Installations/Modifications

Analysis and recommendations related to traffic signals shall follow ODOT's Traffic Signal Policy and Guidelines. Modification or installation of a traffic signal shall be based on documentation that satisfies the requirements of OAR 734-020. If the proposed signal installation/modifications are within 500 ft of a rail crossing, contact the Rail Division Crossing Safety Section to determine additional analysis requirements.

If a new signal is being proposed, the traffic impact study shall provide a traffic signal investigation that shall:

- Clearly indicate the need for a traffic signal;
- Assess the ability of existing, planned, and proposed public roads to accommodate the traffic away from the state facility;
- Describe in detail how a specific development will affect study area intersections; and,
- Provide documentation of traffic volumes and document whether appropriate signal warrants are met.
- Apply right turn discounting where applicable, consistent with MUTCD methodology.

A traffic signal shall not be installed unless one or more of the eight warrants identified in the current edition of the Manual on Uniform Traffic Control Devices (MUTCD), Chapter 4C, Sections 1 through 9 are met (or as amended), or will be met consistent with the requirements of OAR 734-020-0490. Only MUTCD warrant 1 Case A and B may be used to project a future need for a traffic signal. It should be noted that meeting one or more signal warrants is not a mandate to install a signal.

For future year analysis, ODOT's Transportation Planning Analysis Unit has created preliminary signal warrants. These can be very useful tools because they provide an assessment of MUTCD warrant 1 Case A and B through the use of manual turning movement counts. It is important to note that the preliminary signal warrants are not an acceptable substitute for the warrants in the MUTCD when traffic volumes can be obtained by counting. The preliminary signal warrants should be used as a planning tool to project future signalization needs (five years or more). The preliminary signal warrants may be used as a basis for approval when it is not possible to measure volumes (such as projected traffic from a development) and only with approval of the State Traffic Engineer. Signal requests addressed to the State Traffic Engineer for approval of near-term installation must be accompanied by an assessment of the signal warrants from the MUTCD, typically based on fourteen hours of manual turning movement counts.

When evaluating signal warrants (preliminary or MUTCD), it is important to include only the appropriate lane configurations and traffic volumes. Incorrect modeling of intersections is a very common mistake and can make a significant difference to the outcome of the analysis. Direction for proper modeling of intersections when analyzing signal warrants has been included in the preliminary signal warrants paper provided by the Transportation Planning Analysis Unit (link above).

Installation, relocation, or modification of a traffic signal is subject to the requirements of OAR 734-020-480 (link in first paragraph of this section) regarding progression analysis. This OAR states that a traffic signal progression analysis shall be completed for all new or revised traffic signals on state highways that are located within 800 m (1/2 mile) of an existing or possible future traffic signal (15 to 20 years in the future).

To implement the requirements of OAR 734-020, analysts may use any of the coordinated system software programs that have been pre-approved by ODOT (for a list, see web-site for Transportation Planning Analysis Unit). Hand calculations and time-space diagrams are also acceptable. Progression bandwidth shall be determined under the following guidelines:

- Green and yellow time for the through phases may be used in the progression band;
- System cycle length must be adequate to accommodate pedestrian crossing times;
- The progressed band speed shall be no more than 5 mph below the existing posted speed in off-peak hours or more than 10 mph below the existing posted speed in the peak hours, unless lower speeds are approved by the State Traffic Engineer. Progression speeds should never be set higher than posted speed.

Complete time-space diagrams are required for each of the analysis scenarios, including the existing coordinates system. They should indicate the offsets, phasing, and split times for each of the signals in the system. If using Synchro, the bandwidth shall be reported for the maximum green times or the 90^{th} percentile arrival rates.

It must be shown that the proposed signal system is capable of maintaining a progression bandwidth as large as that required, or as presently exists, for through traffic on the state highway at the most critical intersection within the roadway segment. The carrying capacity of the progression bandwidth should be estimated with the following equation:

$$\text{Bandwidth Capacity} = \frac{(\text{Bandwidth(sec)} - 4) \times (\text{Adj. Sat. Flow Rate})}{3600}$$

(Results in vehicles per mile)

This capacity ratio should be compared with the average platoon size expected to arrive at the most critical intersection for both directions of travel. The average platoon size may be found by the following simplified calculation.

$$\text{Average Platoon Size} = \frac{C \ * \ V}{3600}$$

Where: C = cycle length
V = hourly volume

3.3.34 Transportation Demand Management

Goal 4 of the 1999 Oregon Highway Plan is "To optimize the overall efficiency and utility of the state highway system through the use of alternative modes and travel demand management strategies". Techniques to reduce a development's vehicle trip generation should be evaluated and recommended as part of the traffic study where appropriate. These techniques are referred to as "Transportation Demand Management" (TDM). Some TDM techniques to reduce vehicle trips during peak hours are listed below.

- Quality transit service to place of trip origins. Reliance on transit to mitigate a significant effect (see Chapter 3.2) is only appropriate where transit service is currently available.
- Ride-sharing and vanpool programs
- Carpool incentives, such as preferred parking
- Modified work schedules
- Mixed uses connected by a quality pedestrian environment
- Internal shuttle transportation in a major development
- Reduction in parking availability or substantial increase in parking prices
- Trip-reduction ordinances.

These TDM techniques may be effective, alone or in combination, under a variety of conditions. For example, an increase in parking prices is most effective in reducing peak hour vehicle trips when accompanied by quality carpool, transit, or other alternative modes that provide good service to the travelers.

Enforcement of TDM agreements is an issue where the measure requires long term commitment to maintaining a service or participation by private parties. Conditions of approval requiring TDM measure need to be very clear about expectations and about consequences if commitments are not followed through.

For instance, a different mitigation measure may be required as a default where an agreed-upon rideshare program is not in place within a certain period of time. Any reliance on TDM for mitigation should be approved by either the participating ODOT planner or the Region TDM specialist.

In the case of transit, ODOT defers to the local transit authority to determine if the land use proposal has a significant effect per the Transportation Planning Rule, and whether adopted transit service standards are met.

3.3.35 Turning Conflict Analysis

When a proposed development adds ingress and/or egress trips onto or from the highway from an unsignalized, existing or proposed, pubic/private approach, a turning conflict analysis should be conducted to ensure that there are no turning conflicts with other approaches on the highway. The analysis should also establish v/c and LOS for the intersection. Turning diagrams should be drawn that include the proper intersection geometry, the distances of any queues, and the proper turning radius for the design vehicle.

3.3.36 Access Management

When developed in conjunction with an application for a Highway Approach Permit, the TIS should document the manner in which a proposed site approach meets the minimum spacing criteria of OAR 734-051 or fits into an access management plan already adopted by ODOT. The approach permit application will be subject to the approval criteria of OAR 734-051-0080, et.al. If a deviation to the spacing standards will be requested, the TIS must establish the basis for granting the deviation.

Of particular interest to ODOT are the possible need for median control and any driveway conflicts with nearby intersections. If the driveway is in an Interchange Management Area, special considerations apply as defined in the 1999 OHP and Division 51.

3.3.37 Mitigation Approval

Mitigation approval typically involves all of the members of the Development Review Team (Traffic Analysts, Planners, and Permit Specialists) as well as consultation with additional ODOT staff as necessary. Depending on the type and locations of the mitigation proposed, approval may be required from sources such as the Region Traffic Engineer, State Traffic Engineer, Region Access Management Engineer, Roadway Engineering, or Right-of-Way, and other local stakeholders. For example, in cases where the installation of a traffic control device is proposed, the ODOT Traffic Manual provides a complete discussion of the State Traffic Engineer's authority and requirements for installation. Care should be taken to ensure that all needed approvals have been or can be obtained prior to making recommended mitigation plans into conditions of approval.

In situations where the mitigation proposed would be on a state highway routed over city right-of-way, coordination with the local jurisdiction will be required as well.

The legal considerations to keep in mind when determining how much and what types of mitigation are appropriate are discussed in Chapter 2.

3.3.38 Conclusions and Recommendations

Traffic Impact Study Review Findings: A typical memorandum of findings should begin with a brief description of the proposal and all affected state facilities. This should be followed by an evaluation of the proposed development's impacts on the transportation system, a detailed description of any inadequate conditions, and an assessment of the proposal's ability to comply with the approval criteria. Based on these findings, recommendations should be made regarding necessary mitigation, if any, and whether to approve or deny the proposed action.

If there is a disagreement about any aspect of the TIS, such as an assumption, calculation, assessment of conditions, or recommended mitigation, a thorough explanation of the discrepancy should be provided along with a detailed justification for ODOT's position on the matter.

ODOT staff conclusions resulting from the review of a TIS should be written in a memorandum addressed to the ODOT staff person(s) responsible for corresponding with the local jurisdiction and/or applicant (may be more than one staff person). The memorandum should be written in a clear and professional manner so it can be enclosed with the letter to the local jurisdiction to be submitted as part of the local decision record, if desired.