

Traffic Impact Analysis

In the United States, landmark legislation regarding the environmental impact of federal actions came into effect with the signing of the National Environmental Policy Act (NEPA) on January 1, 1970 [1].

NEPA's procedures apply to all agencies in the executive branch of the federal government and generally require an *environmental assessment* (EA) document that will result in a finding of no significant impact (FONSI) or an *environmental impact statement* (EIS) that includes a detailed process for its development, submission, review, and consequent decision making. The legislation also established the Council on Environmental Quality (CEQ). See Reference 2 for more information on CEQ and its role.

Over the years since 1970, the definition of a "major federal action" by an agency in the executive branch has come to include most things that the agency could prohibit or regulate [3]. This has come to the current state of the practice that a project is required to meet NEPA guidelines whenever a federal agency provides any portion of the financing for the project and sometimes when it simply reviews the project.

An environmental assessment (EA) or consequent EIS includes attention to a full range of potential environmental impacts, and it certainly includes those due to traffic. Indeed, the traffic impact work is generally an important input to the assessment of noise and pollution impacts (due to the related mobile source emissions).

The individual states have generally passed their own environmental legislation, extending the range of needed environmental impact assessments, following a process akin to the federal one. For instance, the State of New York has its State Environmental Quality Review Act (SEQR) [4].

Local governments generally have their own legislation and processes for actions taken at their own level. New York City has a CEQR process [5], and there is a full range of such legislation throughout the United States. It is imperative that a practicing professional be aware of the governing laws in a jurisdiction, including which level of government has purview on a given project and which agency will be the *lead agency* for the specific project or activity.

A traffic impact analysis (TIA) is a common element of both EA and EIS documents required by the relevant level of government, or can be required as a separate submittal by an agency that has jurisdiction. Despite its short form name, the TIA must have information on both impact and proposed mitigation.

Different jurisdictions have their own guidance on what constitutes a significant impact that requires mitigation be evaluated and addressed. In some cases, it is a certain change in v/c ratio at an intersection and/or level of service change on approaches, at intersections, and/or on arterials. Again, it is imperative that the practicing professional have knowledge of the specific requirements on state and local levels, and federal (if applicable).

Generally, all such legislation requires that the environmental impacts be identified and estimated using the current state of the art/state of the practice tools and methods, and that mitigation be investigated and proposed to the extent possible. It is *not* required that full mitigation be achieved, but rather that the impacts and effects be fully disclosed so that the relevant decision maker as established by law can make a fully informed decision on whether the project is permitted to proceed. Indeed, the challenges to a decision tend to be on whether the process was followed rigorously, whether proper methodologies were used, and whether there was full disclosure of impacts. Provided with proper information and following an orderly process, the law explicitly vests the decision authority in a specific agency or designated position, *and the decision itself is not a valid basis for litigation.*¹

As a practical matter, a recommendation that there are impacts that cannot be fully mitigated will be the basis for lively discussion in the review process, and reviews tend to go smoother when full mitigation is feasible.

30.1 Scope of This Chapter

You should not expect to have mastered the ability to conduct full and complete traffic impact assessments after simply reading this chapter, or even this entire text.

Rather, this chapter is intended to focus your attention on how information from the preceding chapters must be brought to bear in executing a traffic impact assessment, and on how you must use this knowledge to create design concepts that can mitigate impacts.

One of the authors has taught a project-based course centered around a traffic impact assessment and has used the *ITE Transportation Impact for Site Development* [6] as a companion text for that course (it was a second course in a sequence, and also covered several chapters from this text and built on the chapters taught in the first course).

This chapter provides an overview of the process and techniques in the next two sections and then provides two case studies that can be used as course projects or as the basis for discussion. The chapter does *not* provide total solutions to either of the case studies, and this is intentional: At this point, the learning is best done by meeting the challenges in a project-based experience, interacting with the instructor. (Issues are identified, and some guidance provided, but a definitive “correct solution” is absent by design.)

¹This last statement, indeed the entire paragraph, is drawn from both the law and the practice, but nuances can be better explained by the attorney on the team.

30.2 An Overview of the Process

This section focuses on the process as shown in Figure 30.1. There are variations on this (and more comprehensive versions, for specific localities), but it can serve the purpose of this chapter. The boxes are numbered for convenience and are referred to as “steps” in this section.

Step 1 is rather self-explanatory, but it is easy to encounter both clients and other professionals who have views and preferences that influence the traffic engineer’s work, simply because each of us knows more of our specialty than all the others. In one enjoyable instance, an architect casually moved 500,000 square feet of one tower across the project to another tower because “it looked more balanced” after the detailed traffic circulation work was done. (To that point, it had been part of the “dominant tower” and “signature building.”)

Step 2 is a working plan for the entire project, and specifically preparation for Step 4. These are the important issues:

- What do the local regulations and practices require, in terms of hours/days of data, analysis tools, required methods (e.g., HCM, CLV, Synchro), triggers for mitigation, and other?
- What do the local regulations and practices require, in terms of site development as it affects traffic? This may include setbacks, buffer zones, mandated allowances for parking and transit, mandated emphasis on traffic calming within the site, and other.
- What days and periods within the day(s) are justified by the project or by local regulations and practices?
 - AM, midday, PM are commonly required.
 - Weekend may be required for some developments.
- What analysis periods are required?
 - The most common are the existing condition, the future no-build (FNB), and future build (FB).
 - On some projects, the period of construction is so large and/or so long that the peak of the construction period must also be analyzed.
- What exactly is the base case for analysis? Is it the future no build (FNB) with existing signalization or the FNB with optimized signals, or other?
- What are the local growth rates to be used, and what if any planned and approved major developments are there? Is there local guidance (i.e., a guidebook or set of tables) on trip generation rates or is the *ITE Trip Generation* publication [7] sufficient?

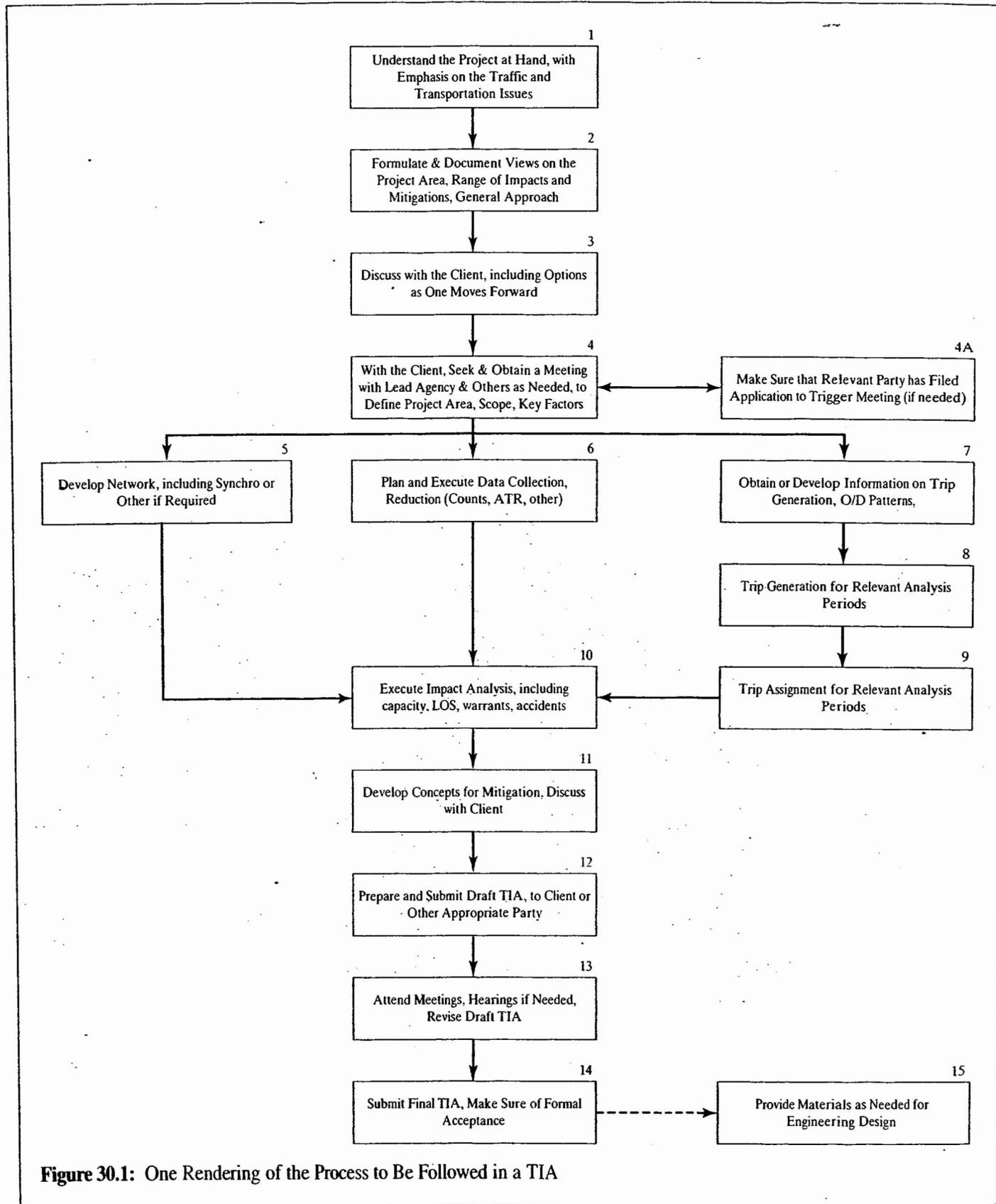


Figure 30.1: One Rendering of the Process to Be Followed in a TIA

- What are the relevant road system and transit facilities? How far will concentrated traffic flow before it disperses into background levels? What intersections and other key points are affected and need analysis?
- What data exists, and how in what form is it available (counts, ATR stations, accident data, other)?

That is not to say that all these questions will be answered in Step 2, but rather that the engineer must get a handle on each of them, particularly with regard to the extent of the project area and the intersections/facilities to be affected.

Step 3 is important, in that the client and/or their team (attorney, architect) must understand the difficulties that are likely to be encountered in the process, and the need for a reasonable project area. If it is obvious to the traffic professional that the impact area is larger than the nearby intersection, it will also be obvious to the professionals who are reviewing the TIA. Some clients may like it to be smaller (sometimes much smaller), but unless they have time to iterate with the reviewing agency, both time and cost will dictate that they be made aware of reality.

Of course, that is *not* to say that the defined project area (i.e., the impact area) *must* be large. In many projects only a small number of key intersections are involved before the traffic distributes into the background levels. Smaller is better, but reasonable is best.

Step 4, the meeting with the cognizant lead agency and other relevant parties (e.g., state, counties, towns), is a defining moment in the project. It is generally a formal step in the local process, needs an agenda, and must seek to arrive at a set of action items covering all points raised in Step 2, but especially these:

- Mutual agreement on the defined impact area (the “project area”) for the analysis.
- Mutual agreement on the supporting data program (data to be collected, amounts, number of days, and so forth), and on the key intersections/facilities to be analyzed.
- Clear understanding of local requirements on growth rates to be used, approved projects that need to be considered beyond the background growth rates, and standard practice documents to be used (many jurisdictions have publications or memoranda specifying these, including tools and techniques to be used).

To avoid wasted effort and awkwardness later, it is best—let us say vital—that the lead agency sign off on the agreed items. This may take the form of a letter accepting the minutes of the meeting but in some cases is an e-mail acknowledging the

discussion and accepting the minutes. Verbal approvals are not really useful, if only because personnel change over the course of a project and because people invariably have slightly different recollections.

The traffic professional must be aware that in some jurisdictions, such a formal meeting and agreement is simply not possible *unless the formal application to start the process has been filed* (Step 4A).² This application generally involves more issues than traffic (including timing issues known only to the client) and has to be filed by the appropriate party with the client’s approval. The NYS SEQR is one such process.

After Step 4, the project tends to kick into high gear. A set of three major activities happen, somewhat concurrently:

1. The network is encoded into the analysis tool(s) to be used, whether they be spreadsheets or computer programs (Step 5); more is said on this in the next section.
2. The agreed data is collected and summarized (Step 6) and made ready for the analysis.
3. The references for trip generation rates that have been agreed, whether based on local practices or ITE [7] or information provided by the traffic professional and sourced, is documented (Step 7), used to establish number of trips generated (Step 8), and then distributed onto the network (Step 9) for each relevant time period (e.g., AM, midday, PM) at each relevant stage (e.g., Existing, FNB, FB).

The next step requires a good bit of careful work but is somewhat anticlimactic, given the above. Step 10 is the actual execution of the analysis that is the heart of the “impact” section of the TIA.

Step 11 is the most creative and demanding part of the entire exercise because design is a creative process as well as an orderly one: The traffic professionals must identify one or more mitigation plans that address the adverse impacts that become clear in the analysis work of Step 10.

The sets of solutions available in Step 11 (the mitigation plans) include the following:

- Retiming of signals, including different phases and cycle lengths, as well as different offset plans.
- Addition of signals as warranted by increased traffic or other factors.
- Addition of driveways for the project as needed, consistent with local access management policies and

²Some dialogue has been known to take place on a conversational basis, but it is not reasonable for the traffic professional or the client to expect these to be binding.

maintenance of arterial flow and function. The drive-ways may include such innovative designs as illustrated in Figure 29.5 (Chapter 29).

- Addition of lanes approaching and departing from intersections, to increase throughput on specific approaches.
- Addition of additional intersection(s) as needed or of additional lanes.
- Use of jug-handles and other solutions to reduce left-turn activity.
- Programs to increase average vehicle occupancy.
- Other traffic demand management (TDM) solutions, such as shifting work hours at the project site and/or sponsoring employee van pooling and/or transit check programs.

For solutions in the last two bulleted items, it is incumbent on the applicant (the client and their traffic professional) to make it clear how such policies and practices will *really* be put into effect. This will be expected by the TIA reviewers if the mitigation depends on them, and approval may be contingent on terms related to the proposed programs.

It is *imperative* in our view that the client be briefed in advance of the draft report about the mitigation options and the related first-cut (i.e., rough cut) estimate of costs. This is for a very practical reason: The client will probably have to pay for some or all of the mitigation and should know what the costs are likely to be.

At this stage (Step 11), there is likely to be some good discussions about the trade-offs among alternative mitigation approaches. These will often involve cost, ease of approval, and speed of the approval process (in some cases, the expression “time is money” is very apt because of the overall project costs and schedule). In some cases, other factors known best to the client will arise, such as work rules for employees, as a cost factor.

Step 12 is the formal preparation of the draft TIA, internal reviews for quality control, client review and comment, and submittal to the lead agency by the appropriate party. This draft may include a CD containing the data files and the input streams for any computer programs used, as well as sample animations.

Step 13 is the review and approval process, which will surely involve meetings convened by the lead agency and may well involve public presentations and hearing, receipt and documentation of comments, and revisions to the TIA.

Step 14 is the submittal of the final TIA document, either as part of another document or a stand-alone document (depending on the required process), leading (one would anticipate) to final, formal acceptance.

Step 15 is internal to the client or their team. The functional designs and traffic loads developed in the course of the TIA are an important input to the engineering design that must generally follow acceptance of the TIA by the cognizant agency.

A final note on time frames: This overall process is not instantaneous. All of the preceding steps can easily consume 6 to 12 months. Following approval of the mitigation plan in the TIA (for that is what acceptance means, as used here), the next steps are detailed engineering design, submittal of permit applications and related approvals, followed by construction. The construction period may be shut down in the winter months, and an Maintenance and Protection of Traffic (MPT) Plan is generally required as part of the permit process. For sizable projects with a reasonable amount of mitigation work, these extra steps can add up to 15 to 18 months *after* the TIA acceptance. It is possible that the total process may move more rapidly, but that needs to be assessed.

30.3 Tools, Methods, and Metrics

This text has presented information on the state of the art and the state of the practice in traffic engineering, with a strong emphasis on the levels of service as defined in the *HCM*. Chapter 23 presented the critical movement analysis (CMA) approach to intersection capacity and timing, as an alternative method advocated or used by some.

But you *must* appreciate that it is the local jurisdiction—usually at the state level—that determines the exact method to be used in that jurisdiction. And some details of design practice (including the acceptance of some design concepts) are sometimes delegated to the local district or regional offices, so that variation within a state can be expected. When roads are solely within the control of a county or town, their rules and procedures may prevail. Therefore, knowledge of local practice and rules is *essential* to the practicing traffic professional.

Fortunately, these rules are usually easily obtained, and they are posted on the official Web sites of the state or local jurisdiction. Equally fortunately, the review process usually involves a *lead agency* that coordinates the information and needs.

At the same time, it is sometimes natural for counties to have different concerns and priorities than states, or for one region to have more precise rules and practices than its neighbor. Most often, the goodwill and professionalism of all concerned overcome potential problems, but there are protocols and practices to respect.

To consider the range of practices with regard to just intersection and arterial evaluation, the following is informative (and based in fact):

- Some require impact to be expressed in terms of *level of service (LOS) changes* by intersection or by lane group, and cite the HCS+ software [8] as the expected tool.
- Some want *both LOS and v/c ratio changes* to be reported, with the HCS+ software for single intersections and Synchro [9] for sets of intersections and arterials.
- Others specifically mandate a *critical lane volume (CLV)* methodology provided by the state (e.g., Maryland). The “not to exceed” CLV is 1450 veh/h. The procedure is rooted in the method introduced in Reference 10 as interim materials to the HCM. Rather than being considered “dated,” it is reemerging as an effective and efficient tool, and it is the logical foundation for the treatment in Chapter 23 of this text.
- Several states accept *Synchro LOS results* as if they were as equally valid (and exactly the same) as the HCM results.
- A number of states require “*Synchro visualizations*” of the traffic conditions, although the actual visualizations are produced by a separate tool (the SIM-Traffic simulator [11]) that is sold as a companion to Synchro.³
- Some states focus on the *intersections rather than the arterial*, primarily by silence on the arterial impacts (i.e., average travel speeds and arterial LOS).
- At least one state had begun to focus on *arterials to the exclusion of intersections*, at least in the initial planning-level review. That has evolved to a more balanced view that includes arterial LOS and intersection LOS and intersection v/c ratio.

In terms of traffic visualizations, other tools are commercially available and have merit, including VISSIM [12] and AIM-SUN [13].

Related to the discussion of the critical movement analysis, consider the values of “maximum sum of critical movement volumes” that can be accommodated for various conditions. The computations are done using a loss time per phase of 4.0 seconds and a discharge headway of 1.9 sec/veh

³As noted in Chapter 26, the two tools sometimes produce radically different results, particularly when intersection spillback and blockage is involved.

Table 30.1: Values of Maximum Sum of Critical Movement Volumes (veh/h), for Various Conditions, Including Cycle Length

h =	1.9 sec/veh,	0% trucks
pce _{TRUCK} =	2.0	5% trucks
t _{LOSS} =	4.0 sec/phase	

Cycle Length (sec)	Number of Phases		
	2	3	4
60	1564	1444	1323
70	1598	1495	1392
80	1624	1534	1444
90	1644	1564	1484
100	1660	1588	1516
110	1673	1608	1542
120	1684	1624	1564

v/c = 0.90

Cycle Length (sec)	Number of Phases		
	2	3	4
60	1408	1299	1191
70	1438	1346	1253
80	1462	1380	1299
90	1480	1408	1335
100	1494	1429	1364
110	1506	1447	1388
120	1516	1462	1408

for passenger cars (consistent with the HCM saturation flow rate of 1900 pcphpl). With 5% trucks, the discharge headway is changed to 2.0 sec/veh and used in Table 30.1.

The upper set of values in Table 30.1 is based on full utilization of the green by the vehicles; the lower set is based on 90% utilization (that is, a v/c = 0.90 on each phase). The lower set, of course, is 10% lower than the upper set, by simple arithmetic.

Some observations are in order, using the lower set:

- For a two-phase signal with a cycle length C = 80 seconds, the number shown (namely, 1,462 veh/h) is comparable to the CLV upper limit cited above (namely, 1,450 veh/h).
- Each additional phase decrease the value by about 5%, using C = 80 seconds as a reference condition.
- This is probably an overstatement because added phases tend to imply longer cycle lengths, so a decrease

of about 2.5% per added phase is a plausible rule of thumb.

- Within the lower set of values, starting with $C = 80$ seconds as the reference, each increase of 10 seconds of cycle length adds 1% to the displayed value. But one must remember discussions in this text that indicate the saturation flow becomes less efficient, so the nominal improvement is probably not significant.
- Using the same starting point, each decrease of 10 seconds in cycle length loses 2% on the displayed value. But the main purpose of doing so would be queue management in congestion, a different priority.

Finally, this little exercise with Table 30.1 is interesting, but not dominant, for two distinct reasons: (1) the traffic professional is governed by the formal procedure adopted locally, not this exercise, in applying corrections, (2) changes to “maximum sum of critical movement volumes” is *not* identical to *capacity* because the nominal losses cited here can be adjusted with shifts of green time (remember, $v/c = 0.90$ is used) to favor approaches with more lanes and thus more vehicles *and* because a measure such as added phases is generally taken to correct a problem that already degraded the base number.

30.4 Case Study 1: Driveway Location

This case study only addresses one fragment of a traffic impact analysis, namely the effect of driveway location on quality of flow along the arterial. The lessons to be learned by this exercise include:

1. The new driveway will add flows to both the NB and SB arterial flows, and do so “between main street platoons,” thus making coordination less effective.
2. The new driveway will take vehicles from the passing platoons, thus leaving holes in them and making them less cohesive, also making coordination less effective.
3. The new driveway can totally disrupt the NB and/or SB green bandwidths if it is poorly placed within the block.

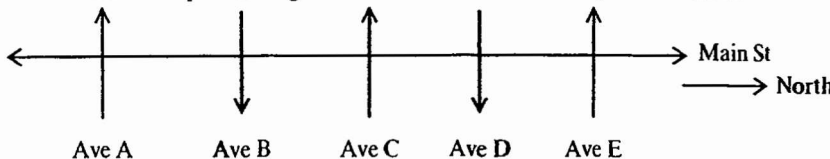
The case to be considered by the reader is the same basic case shown toward the end of Chapter 26, so the solution shown there in Figure 26.29 is available as a starting point.

You are expected to use the information in Table 30.2, which is the same as Table 26.5. A significant development is

Table 30.2: Inputs for Case Study 1

		Hourly Flows (vph)											
		NB			EB			SB			WB		
Link Length (ft)		L	T	R	L	T	R	L	T	R	L	T	R
Main St & Avenue E	1500	70	1460						800	50	100	600	100
Main St & Avenue D	1500		1480	50	50	600	50	50	850				
Main St & Avenue C	1500	70	1430						850	50	100	600	100
Main St & Avenue B	1500		1450	50	50	600	50	50	900				
Main St & Avenue A	1500	70	1400						900	50	100	600	100

- 2 lanes per direction on Main St
- left turn bays on Main St, 250 ft, both directions
- RTOR prohibited everywhere
- 60 fps free flow speed, Main Street
- All avenues have 2 moving lanes, but are one-way streets
- PHF = 0.91
- Minimum ped crossing times = 17 sec across side streets, 30 sec Main St



proposed for a site on the east side of Main Street, between Avenues B and C. Here are the specifics:

- The development will add “X” vehicles per hour to the Main Street traffic heading NB and “X” vehicles per hour to the Main Street traffic heading SB. Each of these flows will turn into the driveway(s) provided.
- At the same time, the development will generate “X” exiting vehicles per hour exiting and heading SB on Main Street and another “X” vehicles per hour exiting and heading NB on Main Street.
- The preferred driveway (pair) is to be the configuration shown in Figure 29.5. The signalized intersection is to be located “N” feet north of Avenue B.

Using Synchro and SIMTraffic, you are asked to analyze the impacts for four scenarios. It is not necessary to propose mitigation at this stage, unless the instructor makes that an addition part of the assignment.

You may choose to use VISSIM or AIMSUN for the visualizations; that is acceptable. The choice can be made based on tools available to the college or to you (limited student versions of some tools are available at low cost).

You should be aware that the emphasis is on *relative* impacts of the four scenarios. However, some of the tools may model some effects different than others, and the signal optimization program (i.e., Synchro) may consider some queuing effects differently than the simulation models. You may have to fine-tune the signal timing results. Also, some of the simulation models may give metrics such as arterial travel time more easily than others.

30.5 Case Study 2: Most Segments of a Traffic Impact Analysis

Case Study 2 is much more comprehensive than the first case study but is less intense than a full traffic impact study, in that (1) the trip assignment paths are specified in detail, (2) the project area is defined, (3) the data are provided and are balanced so that it is internally consistent,⁴ (4) applicable local rules are provided, in terms of requirements.

⁴In general, traffic counts provide numbers that simply do not add up. This may be due to parking lots or generators within individual links, but it can also be due to simple random errors in the field work. In the latter case, and assuming reasonable variations, the counts are then balanced by the analyst to reflect a more realistic snapshot.

Some of you may believe that the specified requirements on buffer zones, parking spaces per unit of activity, and other elements are very restrictive. They were, however, assembled from real requirements in real locations within the United States. There are locations that have most if not all of these requirements.

The only major embellishment is the requirement that the site allow for both (1) transit access as if 20% of the trips were using public transportation, and (2) parking that recognizes that 95% of the trips will arrive by auto. Although this is unrealistic *in the short term* and might be viewed by some as a burden, we believe it could represent good long-term planning on the part of the local jurisdiction. For instance, it provides a critical part of the enabling infrastructure that will lead to a future transit use of 20% (other parts include a bus route system that is sufficiently complete to enable the trips and sufficiently frequent to make them attractive).⁵

Some information is *not* provided. Actual trip generation rates are not provided but can be obtained from Reference 7 or 8 or from a Web search that will give you the specific numbers used in certain jurisdictions. Spatial requirements for parking are not provided but can be found or estimated as suggested in Problem 30-3. Other needed information can be found in various sources or provided by the instructor.

30.5.1 The Project Area and the Existing Condition

Figure 30.2 shows the project area, including the two parcels that will be of interest in this case study. Table 30.3 provides details on the streets (number of lanes, etc.) and the available right-of-way.

Table 30.4 provides the hourly *volumes* for four periods that may be relevant to the project at hand. Other important information, such as the PHF, is included in Table 30.5.

Figure 30.3 shows the sources of *new* traffic attracted to the developments at the site(s) of interest. Trips return from the site(s) to these destinations. Note that the *magnitude* of the traffic is *not* specified, either as arriving traffic or departing traffic in each of the four analysis periods (AM, midday, PM, and weekend).

⁵There was a time when fully accessible transportation was questioned on a cost-effectiveness basis, given that the full set of requirements did not exist for a meaningful number of trips. Those requirements included curb cuts, accessible entrance, accessible rest rooms, legible signage, and then accessible buses and rail transit. Policy decisions to build this infrastructure systematically over decades has resulted in accessible *systems* in a number of locales.

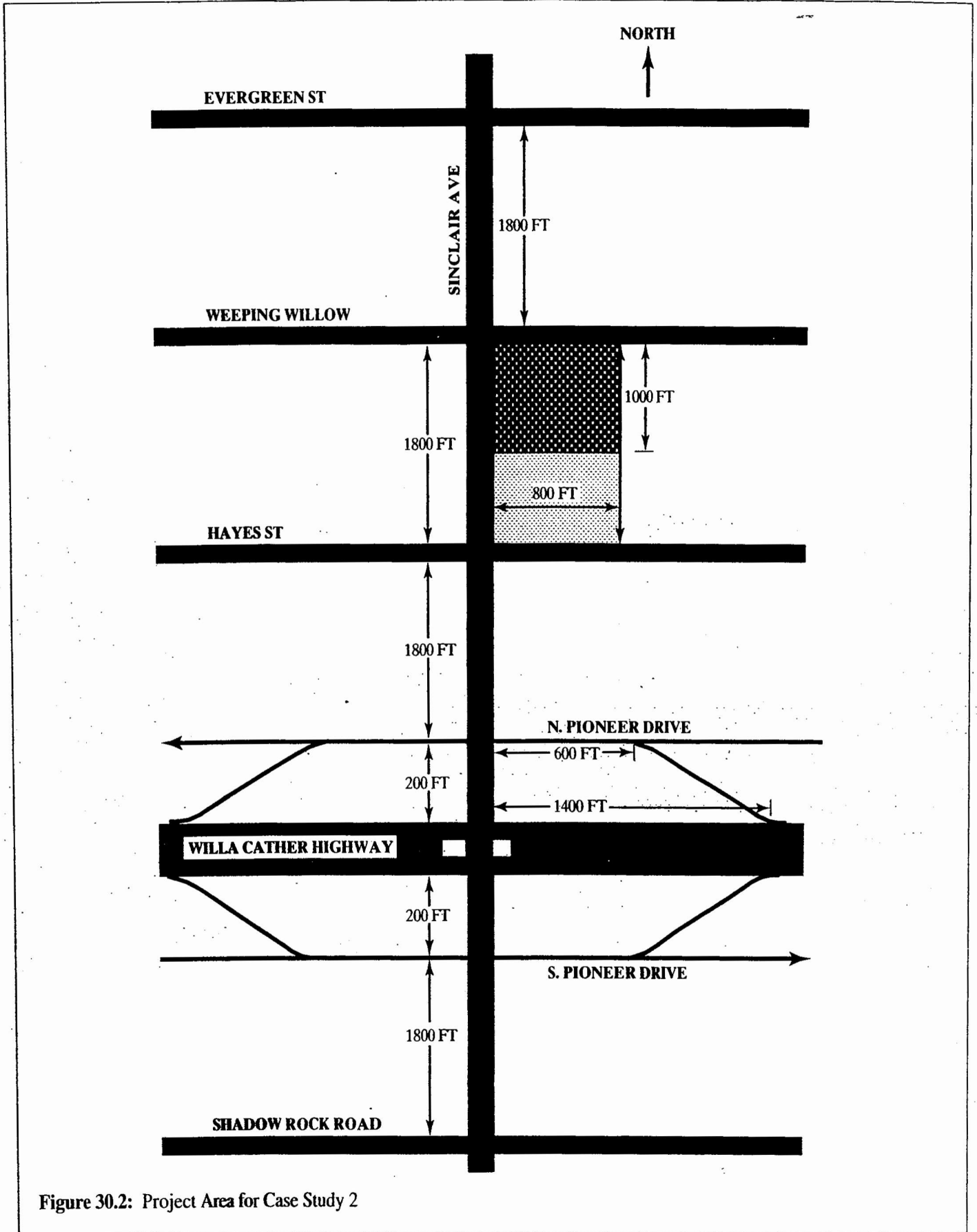


Figure 30.2: Project Area for Case Study 2

Table 30.3: Details of Streets Within the Project Area, Case Study 2

	R.O.W.	Lanes
SINCLAIR AVE	100ft	2 12-ft lanes each direction; 10-ft shoulders; grass median, including 12-ft left turn bay, 150 ft long plus taper
EVERGREEN ST	80ft	1 12-ft lane each direction; 10-ft shoulders; grass median, including 12-ft left turn bay, 150 ft long plus taper
WEeping WILLOW	80ft	1 12-ft lane each direction; 10-ft shoulders; grass median, including 12-ft left turn bay, 150 ft long plus taper
HAYES ST	80ft	1 12-ft lane each direction; 10-ft shoulders; grass median, including 12-ft left turn bay, 150 ft long plus taper
N. PIONEER DR	60ft	2 12-ft lanes WB, highway exit added as 3rd 12-ft lane (on left), then dropped as highway entrance; minimal shoulders
S. PIONEER DR	60ft	2 12-ft lanes WB, highway exit added as 3rd 12-ft lane (on left), then dropped as highway entrance; minimal shoulders
SHADOW ROCK RD	80ft	1 12-ft lane each direction; 10-ft shoulders; grass median, including 12-ft left turn bay, 150 ft long plus taper
WILLA CATHER HWY	Note 1	Note 2

Note 1 = All land between highway & service roads is part of the right of way; Highway is presently 2 12 ft lanes each direction, 10 ft shoulders, 40 ft grass median; Highway bridges over sinclair ave are a pair, each with 50 ft of roadway.

Note 2 = All ramps are single lanes, tapered; measurements shown on figure are to the gore area or the R.O.W. boundary.

Signal phasing = Protected lefts required, no permissive lefts allowed; lefts can be lead or lag; rtor generally permitted.

Distances = All distances shown along sinclair ave are measured to the R.O.W. boundaries, and do not include the R.O.W. itself.

Discussion Point 1

You must find an appropriate source of trip generation rates for the uses proposed (see next subsection). This includes consideration of both entering and departing traffic in each time period that is relevant.

Note that Figure 30.3 applies only to new traffic; it may be true (depending on the land use at the site of interest) that some percentage of the traffic arriving at the site is drawn from existing traffic that passes the site. The practical implication is that the *existing* traffic that goes to the site does not add to the volumes for the purpose of impact assessment. It does, however, use parking that needs to be provided within the site, and this must be taken into account.

Discussion Point 2

Clearly, there is less impact (and therefore less mitigation) if a good percentage of the traffic using the site is diverted from traffic that would pass in any case. This point is made in some cases for gas stations and for breakfast shifts at fast-food operations. But for other uses, the percentage is probably small. You must obtain information for the specific uses and/or argue the case.

30.5.2 Proposed Use(s) of the Two Site(s)

Refer to Figure 30.2. The plan is to develop the northern property as commercial space, specifically a suburban shopping mall, and the southern property as a multiplex theater. The multiplex is to have eight theaters, of which four will have 400 seats and four will have 200 seats. The shopping mall is to be built out to the limits of the local code (more on this later).

If it suits this plan, the two properties can be combined and considered as one.

Discussion Point 3

At the risk of getting ahead of ourselves, the local code requirements in the next subsection will require buffer zones between the two sites if they remain on the records as two distinct parcels. This may use space that could be dedicated to parking or other uses. However, there may be other issues of interest to the client (i.e., the owner of the parcels), such as future flexibility allowed by keeping them distinct or even some tax implications (none of us are knowledgeable in this area).

Table 30.4: Traffic Counts in the Project Area, Existing Condition, Case Study 2

PFH = 0.85 % TRUCKS = 5.0%

	NB			SB			EB			WB		
	L	T	R	L	T	R	L	T	R	L	T	R
	SINCLAIR AVE & EVERGREEN ST	120	960	50	60	650	50	60	270	40	80	360
SINCLAIR AVE & WEEPING WILLOW	40	970	60	60	660	50	80	280	60	80	320	80
SINCLAIR AVE & HAYES ST	60	990	60	60	690	80	40	320	40	40	280	40
SINCLAIR AVE & N. PIONEER DR	90	1010			630	100				60	600	100
SINCLAIR AVE & S. PIONEER DR		1040	120	100	590		60	550	100			
SINCLAIR AVE & SHADOW ROCK RD	90	1060	60	60	590	60	40	320	40	60	340	60

WILLA CATHER HWY

HOURLY	COUNT STATION AT EAST END OF SKETCH	EB	WB
	AT RAMP TO N. PIONEER	5200	
	FROM N. PIONEER	4850	
	TO S. PIONEER	300	
	FROM S. PIONEER	250	
	FROM S. PIONEER	270	
	FROM S. PIONEER	300	

EXISTING CONDITION, MIDDAY WEEKDAY

	NB			SB			EB			WB		
	L	T	R	L	T	R	L	T	R	L	T	R
	SINCLAIR AVE & EVERGREEN ST	84	672	35	42	455	35	42	189	28	56	252
SINCLAIR AVE & WEEPING WILLOW	28	679	42	42	462	35	56	196	42	56	224	56
SINCLAIR AVE & HAYES ST	42	693	42	42	483	56	28	224	28	28	196	28
SINCLAIR AVE & N. PIONEER DR	63	707			441	70				42	420	70
SINCLAIR AVE & S. PIONEER DR		728	84	70	413		42	385	70			
SINCLAIR AVE & SHADOW ROCK RD	63	742	42	42	413	42	28	224	28	42	238	42

WILLA CATHER HWY

HOURLY	COUNT STATION AT EAST END OF SKETCH	EB	WB
	AT RAMP TO N. PIONEER	3640	
	FROM N. PIONEER	3395	
	TO S. PIONEER	210	
	FROM S. PIONEER	175	
	FROM S. PIONEER	189	
	FROM S. PIONEER	210	

(Continued)

Table 30.4: Traffic Counts in the Project Area, Existing Condition, Case Study 2 (Continued)

PFH = 0.85 % TRUCKS = 5.0%

**ALL VOLUMES IN HOURLY VPH
EXISTING CONDITION, PM PEAK**

	NB			SB			EB			WB		
	L	T	R	L	T	R	L	T	R	L	T	R
	SINCLAIR AVE & EVERGREEN ST	40	660	80	40	960	60	50	360	120	50	270
SINCLAIR AVE & WEeping WILLOW	60	670	80	80	1030	80	50	320	40	60	280	60
SINCLAIR AVE & HAYES ST	40	670	40	40	970	40	80	280	60	60	320	60
SINCLAIR AVE & N. PIONEER DR	100	650			1010	60				120	550	100
SINCLAIR AVE & S. PIONEER DR		650	60	100	1070		100	600	90			
SINCLAIR AVE & SHADOW ROCK RD	40	590	60	60	1060	40	60	340	90	60	320	60

WILLA CATHER HWY

HOURLY	COUNT STATION AT EAST END OF SKETCH	EB	WB
		4850	
		5200	
	AT RAMPS TO N. PIONEER	300	
	FROM N. PIONEER	270	
	TO S. PIONEER	250	
	FROM S. PIONEER	300	

EXISTING CONDITION, SATURDAY

	NB			SB			EB			WB		
	L	T	R	L	T	R	L	T	R	L	T	R
	SINCLAIR AVE & EVERGREEN ST	120	960	50	60	650	50	60	270	40	80	360
SINCLAIR AVE & WEeping WILLOW	40	970	60	60	660	50	80	280	60	80	320	80
SINCLAIR AVE & HAYES ST	60	990	60	60	690	80	40	320	40	40	280	40
SINCLAIR AVE & N. PIONEER DR	90	1010			630	100				60	300	100
SINCLAIR AVE & S. PIONEER DR		1040	120	100	590		60	250	100			
SINCLAIR AVE & SHADOW ROCK RD	90	1060	60	60	590	60	40	320	40	60	340	60

WILLA CATHER HWY

HOURLY	COUNT STATION AT EAST END OF SKETCH	EB	WB
		5200	
		4850	
	AT RAMPS TO N. PIONEER	300	
	FROM N. PIONEER	250	
	TO S. PIONEER	270	
	FROM S. PIONEER	300	

Table 30.5: Requirements from Local Ordinances

1. Each property must be at least 5 acres in this zoning, and have at least 300 ft of frontage on the main road. Building heights may not exceed 35 feet. The building(s) cannot cover more than 30% of the property.
2. There must be 100 feet of buffer facing all roads and other properties, except that the buffer may be reduced to 50 feet if the use on the other property is nonresidential. If the use on the other property is residential,⁶ a 6-foot barrier wall must be constructed of stone or heavy timber and of appearance consistent with like construction in the jurisdiction.
3. For the shopping mall and like uses, 5 parking spaces per 1000 square feet of gross floor area (GFA) must be provided.
4. For the motion picture theater(s), 1 parking space per 3 seats must be provided.
5. The design must allow for up to 20% of the trips arriving by bus transit, for anticipated mode shifts over coming decades.⁷ However, in assigning trips to modes, no more than 5% of the anticipated trips can be assigned to transit, given current realities.
6. Access management principles must be strongly considered and used to the maximum extent feasible, consistent with state requirements.⁸
7. Adequate loading bays for goods delivery and pickup must be provided, generally separated from the visitors to the site(s).
8. Entrances/exits for goods vehicles need to accommodate large tractor-trailers. All entrances/exits must accommodate a hook-and-ladder fire truck.
9. Internal circulation at any site shall be such that safe pedestrian and transit uses are encouraged, and that traffic calming principles are used.
10. Mitigation plans are expected (a) if the v/c ratio on any approach at any existing intersection is increased by more than 0.03, (b) if the LOS on any approach at any existing intersection is decreased (made poorer) by one level of service, and (c) if the arterial LOS of service on any arterial is decreased (made poorer) by one level of service.
11. If additional intersection(s) is/are proposed, the intersection v/c and LOS at each such intersection must be comparable to nearby existing intersections *and* the arterial level of service cannot be decreased (made poorer).
12. The future no-build and future build traffic levels are to be taken as 10 years from the present (i.e., existing) condition.
13. A section of the impact analysis shall address the construction phase. This section may be qualitative and descriptive, *if* no significant impact is anticipated to peak hour traffic, but the means for achieving this shall be described.

30.5.3 Local Code & Local Ordinance Requirements

Table 30.5 contains requirements that are extracted from various local codes, so that you will have a reasonable set of design considerations for this case study.

30.5.4 Other Given Conditions

With regard to *basic traffic engineering*, the local practice dictates:

- Use a loss time of 4.0 seconds per phase.

⁶The adjacent properties to the east are zoned commercial in this case study.

⁷Assume the primary (sole) bus routes run north-south on the main arterial.

⁸Use the State of Florida guidelines or practices, if needed.

- For saturation flow rates, use 1900 pchpl for the through lanes.
- All left turns at signalized intersections are to be protected.
- RTOR at signalized intersections is prohibited, except if there is appropriate channelization in a separate lane, with at least YIELD sign control.

The *background traffic*, exclusive of these sites, is to be taken as 3.0% per year (and is to be compounded). No other planned or approved developments of note exist or are assumed to be incorporated in the background growth.

The local *topography* has no significant elevation changes.

With regard to *tools and references*, you are expected to use *at least* the following tools, references, and practices in the course of this case study:

1. Signal timing (including alternate phase plans) for both existing and all future conditions is to be done using Synchro.

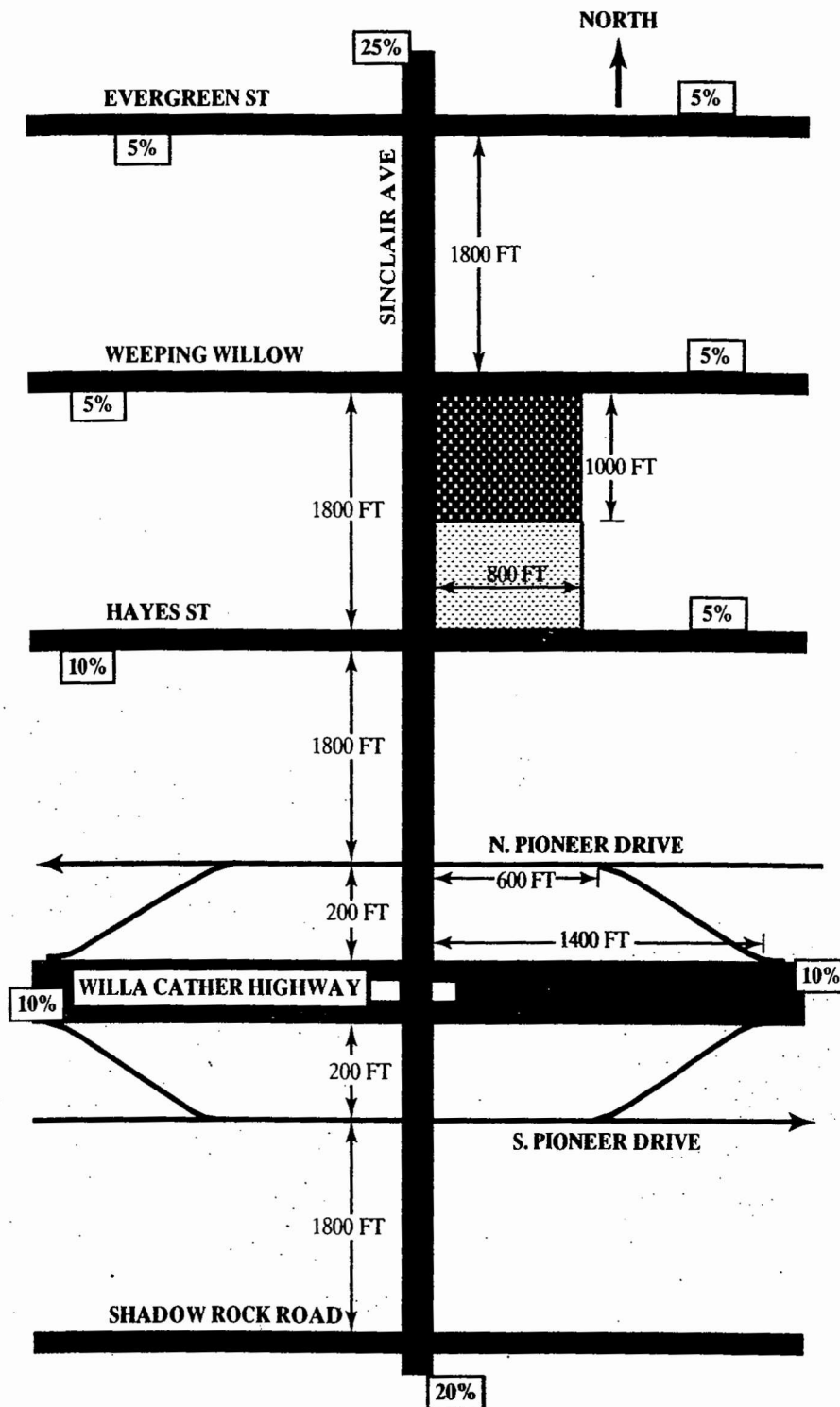


Figure 30.3: Source of New Traffic Added Because of the Development(s), Case Study 2

2. Given that the existing signal timings are not available (they usually are) and given that the local jurisdiction had scheduled signal retiming work in any case, "existing" signal timings are to be determined using Synchro optimization for the

most suitable cycle length (more on this in the next subsection).

3. Simulations and visualizations are to be done with a tool such as SIMTraffic, VISSIM, or AIMSUN.

4. Levels of service and *v/c* ratios for intersections and arterials⁹ may be obtained from Synchro results, unless the simulations/visualizations indicate there is a clear inconsistency.
5. Trip generation rates will be based on References 6 or 7 or other documented source.
6. Parking layout and internal circulation using relevant ITE or other documents, or the approach suggested in Problem 30-3.
7. For this particular case study, this textbook may be used as a reference document.

If the traffic professional uses HCS+ or other such tool for capacity analysis or signal timing, that traffic professional must submit a reasoned argument on why these results are more relevant than Synchro, recognizing that this particular jurisdiction prefers and is accustomed to receiving Synchro results.

Note: The remaining subsections divide the traffic impact and mitigation work into a set of “elements” so that they can be easily assigned in parts, generating discussion and learning as the course progresses. The schedule used by one of the authors is shown below, merely as a suggestion. Periodic presentations by the student groups are to be encouraged, and a final presentation of the impact and proposed mitigation is an essential experience. (Work submitted at the intermediate due dates was evaluated on the basis of the learning experience, but the final comprehensive report and presentation was viewed with a higher level of expectation.)

Element	Due Date, Relative to the Week the Case Study Was Begun
1	1
2	2
3	4
4	5
5	6
6	7
7	9
8	10

⁹Remember that arterial LOS is based on the average travel speed of the through vehicles.

30.5.5 Element 1: System Cycle

Recommend a system cycle length along Sinclair Avenue, considering signal spacing, a reasonable vehicle speed, traffic volumes, and number of signal phases.

30.5.6 Element 2: The Developer’s Favorite Access Plan

Consider the following hypothetical situation: The developer is very interested in a design that combines the two parcels, centers the development, and uses only two major driveways for public access, including transit. Refer to Figure 30-3. (Details of parking lot and internal circulation are not shown; they would remain for the traffic professional to work out within the overall concept.)

Clearly, this creates two five-legged intersections that need a multiphase signal plan.

You are to evaluate the operational needs of these intersections and the required flow patterns given the arrival/departure suggested within Figure 30.4. Table 30.5 provides the existing flows, and the growth rate is known. For the added traffic, you may have to make some assumptions (just to get started) or use the trip generation references already cited.

Keep in mind that (1) the client really wants this “innovative” approach, and (2) you have to be the responsible professional, sometimes achieving what is desired by creative design and sometimes presenting a reality that serves the client well while disappointing their initial notions.

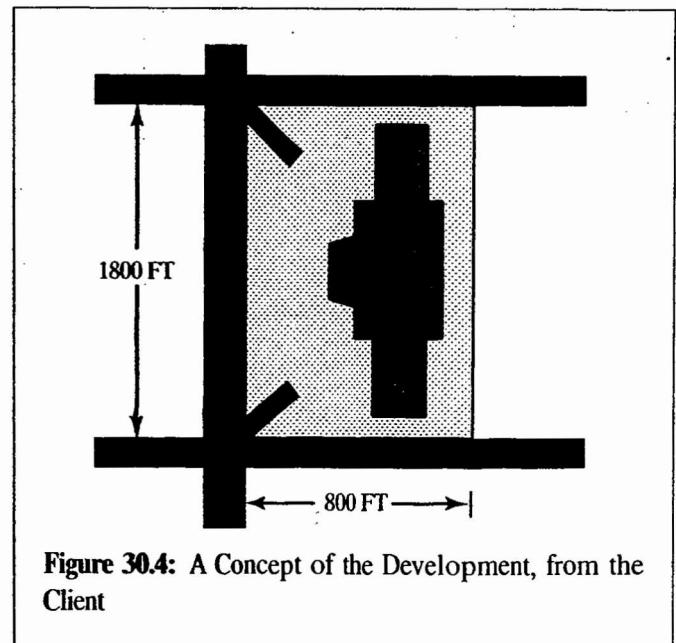


Figure 30.4: A Concept of the Development, from the Client

Discussion Point 5

Yes, the authors have revealed they are pessimistic about making the five-leg intersections work, given the flow rates and patterns. However, the obligation is for *you* to find a successful solution *or* to clearly explain to the client why the concept is not in their best interests.

Discussion Point 6

Remember that in *Element 1*, you recommended a system cycle length. That cycle length may be inconsistent with the values needed at the proposed five-leg intersections.

your peers and a nonspecialist can understand. Use no more than five slides.

30.5.7 Element 3: Existing Conditions, Capacity, and LOS Analyses

Use Synchro (and other tools, as needed) to estimate the existing and future no-build (FNB) conditions at each intersection, and for each lane group at each intersection, and for the overall arterial.

Summarize the results in the format of Table 30.6. (The future build [FB] column will be completed in a later element of this work.)

The end product of the work on Element 2 should be a Power-Point presentation explaining your findings, in terms that both

Table 30.6: Format to Be Used in Element 3 Work

v/c			LOS		
Existing	FNB	FB w/o Mitigation	Existing	FNB	FB w/o Mitigation

Intersection	v/c			LOS		
	Existing	FNB	FB w/o Mitigation	Existing	FNB	FB w/o Mitigation

Intersection	Lane Group	v/c			LOS		
		Existing	FNB	FB w/o Mitigation	Existing	FNB	FB w/o Mitigation

Arterial	Average Travel Speed (mph)			LOS		
	NB	SB	WB	Existing	FNB	FB w/o Mitigation

Note: FB not done in Element 3.

One table is needed for each time period of interest. If it is less than the four periods for which data has been provided, indicate why the period is irrelevant to the analysis, given the anticipated uses.

Discussion Point 7

Before this analysis is begun, the instructor will have to specify the system cycle length to be used by all teams in the course. This can be assigned after the submission and discussion of the Element 1 work.

Anticipate what traffic improvements will be needed due solely to the "Future No-Build" traffic levels.

Discussion Point 8

It is logical that some operational problems will arise, due simply to the annual growth of traffic. In some cases, these would logically require some attention/action, independent of the added traffic due to the specific new development (i.e., the two sites at hand). It is good to know this, in discussions with the local jurisdiction.

Given that you were not provided with existing signal timing, you may want to use the critical movement analysis as a reasonable method of determining the initial signal timing and phasing. This can be refined by using Synchro.

Discussion Point 9

This work is part of this student assignment, but existing signal plans generally exist and are available from the local jurisdiction or state.

Discussion Point 10

In the same spirit of a limited student assignment, the application of the *traffic signal warrants* from the state's MUTCD^{10,11} is not part of this assignment. In some applications, there are unsignalized intersections that may need to be signalized, due to a combination of background growth and the project at hand. There may also be new intersections due to driveways, and these will have to be evaluated for signalization. The instructor may wish to require a warrant analysis for at least these new prospective intersections.

¹⁰Remember that the simple satisfaction of one or more traffic signal warrants does *not* mandate the installation of a signal. Rather, the sense of the MUTCD is that a signal should not be installed *unless* one or more warrants are satisfied, and the satisfaction of warrants is simply the trigger that allows this evaluation (an engineering study, involving many factors) to proceed.

¹¹Some states specify that certain warrants are not used determining whether a signal is justified (e.g., the peak hour volume warrant).

Discussion Point 11

Again, in the same spirit of a limited student assignment, this particular case study does not require you to acquire and analyze the accident experience in the project area.

30.5.8 Element 4: Trip Generation

You have already been guided to the sources from which to obtain trip generation *rates*. These will often be expressed in terms of trips per hour for the peak hour and other hours. The "peak hour" for the development's traffic may however *not be the same as the general peak hour*. This depends on the proposed use (e.g., supermarket, shopping center, multiplex cinema). The traffic professional must take care that the terminology used in the trip generation source refers to the traditional peak hour or the peak activity hour (and day) of the specific use.

Likewise, the construction phase—if it has a noticeable impact on traffic levels at all—may actually define the peak hour for analysis.¹²

In this Element 4, you are expected to generate estimates of the number and routes of the trips generated *based on the desired maximum build-out of the site(s)*.

Discussion Point 12

The emphasis in the preceding sentence is intentional. Given local rules as stated in Table 30-6, there are clearly limits imposed by available square footage of the "footprint" of the development. This does not necessarily mean that the rest of the site can support this maximum development. But it is a starting point.¹³

Discussion Point 13

The local rule on building height may tempt the architect or the traffic professional to think in terms of a two-story shopping mall, with stores on both levels. However, if one is inclined to go down this path, it is important to discuss how many *successful and attractive* malls in the region are two-story designs. At the time of this writing, many malls are characterized by large open spaces, common areas, and generally one-story operation. That is

¹²For many projects, the construction phase workers will arrive and depart in off-peak hours (relative to the existing peaks), and not create intense loads. In some cases, materials delivery may need to be noted and considered.

¹³The traffic professional must recognize that the developer and perhaps the architect may well focus on the maximum that can be done. It falls to the traffic professional to point out that the support functions also mandated by local rules (e.g., required parking spaces, internal circulation, space for transit and for goods deliveries) actually impose constraints that limit the size of the development, by the arithmetic imposed.

not to say a two-story design cannot be found that would succeed, but rather that it should be a discussion point in class. Even with such a design, there are still likely to be significant open spaces and common areas that use up part of the footprint, leaving less gross floor area (GFA) than twice the footprint.

Estimate the required parking, consider the overall properties, and start forming opinions on whether the available space can accommodate the parking requirement.

Discussion Point 14

This is an exercise in arithmetic, but an important one. The underlying issues were discussed earlier and in related footnotes. Remember that local rules express parking requirements in terms of spaces per 1,000 square feet of GFA or spaces per seats (in the theaters). GFA includes common areas, hallways, and such.

It is recognized that the parking layout is going to be a bit of a challenge for you, unless you are drawing on other knowledge (i.e., other sources than this textbook). Fortunately, such sources exist, in print or on the Web. Real-world examples based on actual developments are also available from Google Earth or other tools.

Discussion Point 15

An area of lively discussion is sometimes the average vehicle occupancy for the different uses at the site. This is rendered moot by the local codes. At the same time, the numbers used in the codes implicitly assume average vehicle occupancies and percentage trips by auto. As the years pass, the age of these implicit assumptions may be a basis for discussion, if more recent data prove inconsistent.

Determine whether combining the sites provides any advantages.

Discussion Point 16

This point has already been raised, but this is a logical point to remind you of it.

Likewise, take into account the special local requirement on building now to accommodate future transit usage of 20% of the trips.

Discussion Point 17

Note that this is a mandate and related to the long-term planning of the local jurisdiction. The spirit and intent is that this transit service be accommodated on-site, in attractive and efficient areas. Simply depending on bus stops on the local arterial will *not* suffice in this submittal.

30.5.9 Element 5: Determine the Size of the Development, Trips Generated, and Internal Circulation

Continue the work begun in Element 4, with special attention to the needs of internal circulation, parking, transit, safe pedestrian travel, and space for goods vehicles. If the overall requirements dictate a smaller build-out than the maximum *nominally* allowed by the zoning, be prepared to address this.

Of necessity, internal circulation will depend on driveway location(s) and on any special design features on the arterial. Although these are nominally Element 6 of the project, there is an overlap.

30.5.10 Element 6: Driveway Locations and Special Arterial and Intersection Design Features

Taking into account the mandate for access management to the extent feasible, develop recommendations on driveway locations, special arterial features, and intersections (present or proposed). Consider the “lessons learned” in Case Study 1 with regard to driveway locations.

Remember the needs of goods delivery, which is addressed in the local rules. Consider the possibility (likelihood) of separate driveways for these deliveries, and remember that any “behind” the building has to allow sufficient space to turn and/or maneuver large trucks (some truck bay designs may affect this also).

30.5.11 Element 7: Mitigation Measures

Return to Table 30.6. Complete the “Future Build” (FB) sections, assuming no mitigation. Highlight all entries that are determined to have an impact, in accord with local rules.

Develop ideas on mitigation in detail. The teams working on the project will need to be creative while recognizing that improvements cost money and will probably be paid by the client.

A guiding principle sometimes overlooked at this stage is that the mitigation and related design is not simply intended to meet the minimum requirements of local rules, but also to assure that the development operates smoothly into the future and is/remains attractive to the public and the occupants of the businesses. It is sometimes useful for the traffic professional to have this discussion with the client and their team, and to develop a minimal “Plan A” and a “Plan B” so the client can

see the costs and benefits of any enhancements the traffic professional believes can serve the overall success.

Add columns to Table 30-6 for Plans A and B. Prepare presentation materials. Be ready to engage in discussion on the plan(s) recommended.

Discussion Point 18

Whereas Plans A and B may be for internal discussion, with only one included in the Draft Final Report of Element 8, in this student assignment, both plans will be included in the Draft Final Report.

Discussion Point 19

Because this assignment will culminate in the presentation of the Draft Final Report and not include the usual next round of agency review and hearings, culminating in a Final Report submittal, the word "Draft" is dropped in Element 8.

Discussion Point 20

You are reminded of the list of possible mitigation actions enumerated in Step 11 of Section 30.2, and invited to add to the list as needed for this specific project.

30.5.12 Element 8: Final Report and Presentation

Each group will have 20 minutes to present their findings and recommendations. Business attire is required. The group need not assign everyone a speaking role (although there is merit to that), but the instructor may (i.e., will) direct questions to any group member, so *all* group members have to be fully prepared.

A final report not exceeding 30 pages is required 24 hours prior to the class, sent by e-mail to the instructor in PDF format. The PowerPoint slides for the presentation have to be sent at the same time.

30.6 Summary

This chapter introduced you to the topic of traffic impact studies, including an overview of the process and emphasizing the need for creative design in meeting mitigation needs associated with a significant development. (Minor projects may result in a finding or no significant impact, although some estimates of future traffic load and a permitting process are still involved.)

Case Study 2 was used by one of the authors as the basis for a second course in traffic engineering. Reference 6 was specified as a required companion text, in this mode. Early lectures

covered other chapters of this textbook and Case Study 1. A presentation and a work session on computer tools was included. When Case Study 2 was begun, the class time was devoted to additional chapters of this textbook, discussion of each Element when it was initiated and when it was due, and ad hoc discussions based on information requests from the students.

Case Study 2 can also be used as the basis of a few lectures in a course that is not project based, with emphasis on the discussion points enumerated throughout.

References

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11. VISSIM 5.0 User's Guide, PTV, 2007. <http://www.ptvamerica.com/vissim.html>
12. AIMSUN Users Manual v6, TSS-Transport Simulation Systems, October 2008. <http://www.aimsun.com>

Problems

Note: The instructor may prefer that all problems in this chapter be done as group or team assignments, with the team not to exceed three members (perhaps four in a very large class).

- 30-1. Do the analysis and impact assessment as specified in Case Study 1.

- 30-2.** For the higher value of “X” and the better value of “N” in Case Study 1 as determined in Problem 30-1, recommend any additional mitigation measures appropriate and provide the supporting analysis.
- 30-3.** For Case Study 1 and the higher value of “X,” lay out a functional design of the parking lot, allowing for both the entering and departing values of “X” and recognizing that they may be competing for internal roadway use and for parking spaces over the hour of analysis.
- If you are not provided with information on the parking requirements and do not have access to a reference providing that information, you should either (a) consult sources on the Web, using a search engine, or (b) use a tool such as Google Earth to “visit” a known suburban parking lot, and estimate the space per parked vehicle (taking into account space needed to travel to the parking spaces and any separation between or at the end of rows of cars).
- 30-4.** For Case Study 2, execute and submit Element 1 in accord with the schedule in the chapter or the instructor’s specification. Submit an analysis for the group, not to exceed three pages.
- 30-5.** For Case Study 2, execute and submit Element 2 in accord with the schedule in the chapter or the instructor’s specification.
- 30-6.** For Case Study 2, execute and submit Element 3 in accord with the schedule in the chapter or the instructor’s specification.
- 30-7.** For Case Study 2, execute and submit Element 4 in accord with the schedule in the chapter or the instructor’s specification.
- 30-8.** For Case Study 2, execute and submit Element 5 in accord with the schedule in the chapter or the instructor’s specification.
- 30-9.** For Case Study 2, execute and submit Element 6 in accord with the schedule in the chapter or the instructor’s specification.
- 30-10.** For Case Study 2, execute and submit Element 7 in accord with the schedule in the chapter or the instructor’s specification.
- 30-11.** For Case Study 2, execute and submit Element 8 in accord with the schedule in the chapter or the instructor’s specification.