Guidance for Preparers of
Growth-related, Indirect Impact Analyses

Chapter 1. Introduction

1.1 Purpose and Background

What

This guidance for preparers of growth-related, indirect impact analyses includes the introductory information below and five additional chapters:

- Regulatory Framework and Definitions
- Land Use, Transportation and Growth
- Key Concepts for Growth-related Impact Analyses
- Making the First Cut
- Performing the Analysis

The guidance focuses on growth-related, indirect impact analyses for Caltrans' surface transportation projects in California that are subject to the National Environmental Policy Act (NEPA) and/or the California Environmental Quality Act (CEQA). NEPA and CEQA require that the direct, indirect, and cumulative effects of proposed actions be assessed and disclosed. Indirect effects are generally defined as those that are caused by a project, but unlike direct effects, occur later in time or are farther removed in distance. Indirect effects can range from physical environmental effects, such as downstream sedimentation resulting from project construction, to growth-related effects resulting from changes in accessibility to a previously undeveloped area or a redistribution of growth.

The guidance specifically deals with the subset of indirect effects associated with highway projects that encourage or facilitate land use or development that changes the location, rate, type, or amount of growth—and are referred to in the guidance as "growth-related impacts." Not every project will need a growth-related impact analysis; such an analysis typically will be needed in the environmental document for those highway projects that are built along a new alignment and/or provide new access.

Growth-related impacts and the need for analysis should be considered early in project development. Where such impacts are identified, appropriate and reasonable steps to avoid or minimize such impacts also should be considered early and incorporated into the project and the environmental document. A growth-related impact analysis assists with complying with the requirements of NEPA and CEQA, which include (1) considering environmental consequences of project actions in the planning process as early as possible; and (2) providing a well-documented and sound basis for government decision making.

Who

The Federal Highway Administration (FHWA), the California Department of Transportation (Caltrans), and the U.S. Environmental Protection Agency (USEPA) recognize the importance of thoroughly considering indirect impacts during the preparation of environmental documents. An interagency Work Group representing FHWA, Caltrans, and USEPA[1] developed this guidance to assist Caltrans' practitioners (environmental staff, project managers, and consultants) responsible for preparing environmental documents pursuant to NEPA and CEQA. While FHWA, USEPA, and other agencies nationwide have prepared other guidance papers on this subject, this document was prepared to address growth-related impact analyses expressly for highway projects in California.

Why

This guidance will help practitioners identify whether a growth-related impact analysis is needed for a proposed transportation project. It also will help practitioners prepare an analysis that is sound and well documented. Further, the data developed during the analysis can be used to support other project-related analytical requirements, such as compliance with USEPA's Section 404(b)(1) Guidelines.

When

If the lead agency determines it is needed, a growth-related impact analysis would be developed concurrently with the direct, indirect, and cumulative impact analyses for the proposed transportation project's environmental document.

How

The Work Group intends for this guidance to be practical and flexible, and recognizes that the need for and scope of a growth-related impact analysis will vary according to type and scale of the project proposed, the area where the project is located, and the resources of concern potentially affected (e.g., wetlands, vernal pools, threatened/endangered species, prime farmland, Section 4(f) property, etc). The guidance provides several tools and approaches that can be applied, based on the potential

[1] In June 2000, FHWA, Caltrans, and USEPA entered into a partnership agreement, the "Mare Island Accord," to support concerted, cooperative, effective and collaborative work among the three agencies in the transportation and environmental planning processes. This guidance is a project of the Mare Island Accord.

effects of the proposed project, the type or condition of resources under consideration, and the professional judgment of the practitioner performing the analysis. The guidance is presented in the following chapters:

- **Chapter 1 - Introduction:** Provides background about the guidance, its intended audience, and purpose.
- **Chapter 2 - Regulatory Framework and Definitions:** Provides definitions and discusses the regulatory and policy framework regarding indirect impacts.
- **Chapter 3 - Land Use, Transportation and Growth:** Explores the complex relationship between land use, growth, and transportation projects in a California context.
- **Chapter 4 - Key Concepts for Growth-related Impact Analyses:** Discusses the concepts of "reasonably foreseeable" and "causality" as related to assessing growth-related impacts.
- **Chapter 5 - Making the First Cut:** Provides a screening approach for identifying the need for, and extent of, a growth-related impact analysis.
- **Chapter 6 - Performing the Analysis:** Identifies the suggested steps for conducting a growth-related impact analysis, and some tools that could be used to perform the analysis. It also emphasizes the need to consider avoidance and minimization opportunities for identified resource impacts.

A hypothetical, illustrative example of a growth-related impact analysis, the Canyon City Transportation Improvement Project, follows Chapter 6 of the guidance. The guidance also provides highlighted links to more detailed references, manuals, and policy guidance documents related to growth-related impacts, and to more detailed discussions on specific topics.

1.2 Additional Reference Materials

On September 18, 2002, President George W. Bush signed Executive Order (EO) 13274, *Environmental Stewardship and Transportation Infrastructure Project Reviews.* This EO established an Interagency Task Force to advance environmental stewardship and streamlining efforts, to coordinate expedited transportation decision making, and to address priority projects. The Task Force established an interagency Work Group on indirect and cumulative impacts to evaluate this topic and identify opportunities where greater interagency coordination and collaboration could lead to improvements in the decision-making process for projects. The Task Force Work Group released its Draft Baseline Report on March 15, 2005. The appendices of the Draft Baseline Report include a comprehensive annotated bibliography and links to guidance documents, annotations on case law, and other helpful materials.

1.3 Summary

The Work Group prepared this guidance for environmental professionals with varying degrees of expertise. The modular structure of the guidance provides flexibility so that practitioners can refer to specific topics. To build a foundation for growth-related impact analysis, this guidance provides the following:

- Definitions of terms fundamental to growth-related impact analysis.
- A suggested approach to help determine whether an analysis is needed.
- A suggested step-by-step approach for performing the analysis.
- Examples of best practices and tools to use in the analysis.

The guidance was prepared to address California's specific challenges. The guidance will help practitioners to: (1) identify when an analysis should be performed; (2) identify the appropriate resources to analyze; (3) define the geographic and temporal parameters of the analysis; (4) analyze growth in relation to the project; (5) select the appropriate methods to assess resource impacts; and (6) make supportable impact findings. The guidance emphasizes that early communication, coordination, and involvement among federal, state, and local agencies helps avoid conflict and delay, and allows for the early consideration of avoidance and minimization opportunities to reduce resource impacts.

The material presented in this guidance is meant to be used in conjunction with—but not substituted for—agency policies, regulations, and legal requirements. Each agency contributing to the guidance recognizes that the approach to growth-related impact analysis may vary widely depending on the nature and context of the project proposed, the affected resources, the extent of available data, and other factors. The agencies also recognize that the guidance may be updated to reflect new issues or challenges as they arise. Notwithstanding the project-appropriate variations in method and procedure, FHWA, Caltrans, and USEPA Region IX agree with the advice presented in this guidance document concerning content, methods, analytical approach, and growth-related impact analysis formats.

The agencies that developed this guidance are interested in your views. If you have comments or suggestions, please contact:

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Chapter 2. Regulatory Framework and Definitions

What are Indirect Effects?

Those effects caused by an action and occurring later in time or farther removed in distance, but still reasonably foreseeable. Indirect effects may include growth-inducing effects and other effects related to induced changes in the pattern of land use, population density or growth rate, and related effects on air and water and other natural systems, including ecosystems (40 CFR 1508.8).

According to the Council on Environmental Quality (CEQ) regulations implementing the National Environmental Policy Act (NEPA; 40 CFR 1500-1508), indirect effects may include growth-inducing effects and other effects related to changes in the pattern of land use, population density or growth rate, and related effects on natural systems (40 CFR 1508.8). This guidance refers to a specific type of indirect effect—the effects of growth that can be linked to the development of a Caltrans' transportation project.

NEPA and the California Environmental Quality Act (CEQA) require that direct, indirect, and cumulative effects of proposed actions be assessed and disclosed, but NEPA and CEQA define the term "indirect effects" slightly differently. Section 404 of the Clean Water Act (CWA), as implemented by the Section 404(b)(1) Guidelines (40 CFR 230 subpart B), also provides a framework for identifying indirect effects.

2.1 NEPA Regulatory Framework

Although the NEPA statute does not distinguish among types of environmental effects (42 U.S.C. 4331), its implementing regulations (40 CFR 1500-1508) define environmental effects as having three components: direct, indirect, and cumulative effects.[2]

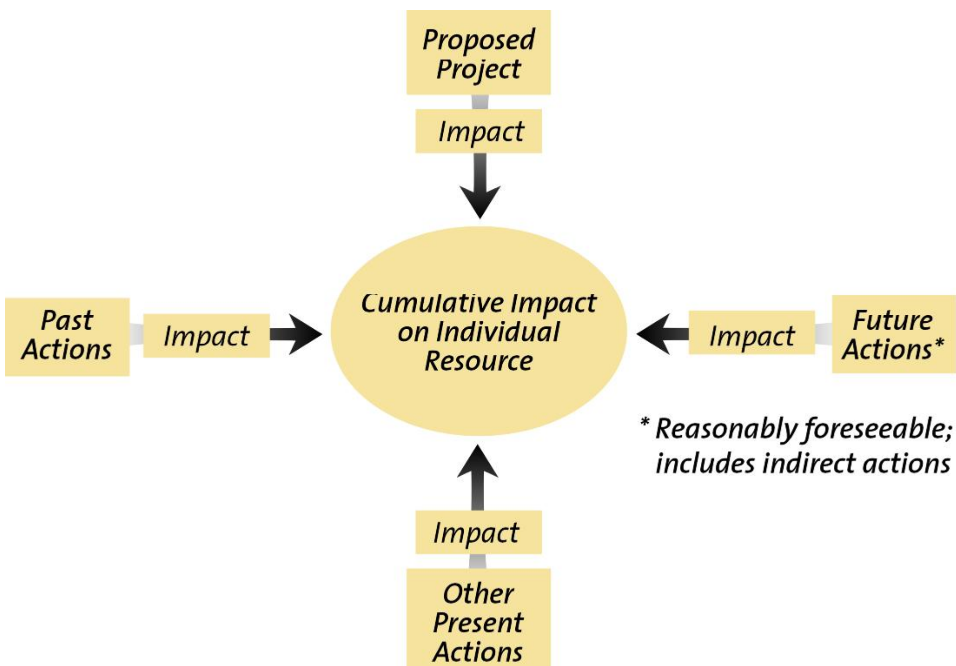
- **Direct Effects**. Those effects caused by the action and occurring at the same time and place (40 CFR 1508.8).
- **Indirect Effects**. Those effects caused by the action and occurring later in time or farther removed in distance, but still reasonably foreseeable. Indirect effects may include growth-inducing effects and other effects related to changes in the pattern of land use, population density or growth rate, and related effects on air and water and other natural systems, including ecosystems (40 CFR 1508.8).
- **Cumulative Effects**. Those impacts on the environment that result from the incremental impact of the action when added to other past, present, and reasonably foreseeable future actions regardless of what agency (federal or non-federal) or person undertakes such other actions. Cumulative impacts can result from individually minor but collectively significant actions taking place over a period of time (40 CFR 1508.7; also see Caltrans Guidance for Preparers of Cumulative Impact Analyses). Cumulative impacts encompass the direct and indirect effects attributable to the proposed project along with the environmental effects of other past, present, and reasonably foreseeable future actions.

[2] The terms "effect" and "impact" are used synonymously in the CEQ regulations (40 CFR 1508.8), the CEQA guidelines, and in this guidance.

A review of case law regarding the evaluation of indirect effects can be found in the National Cooperative Highway Research Program (NCHRP) Report 466, *Desk Reference for Estimating the Indirect Effects of Proposed Transportation Projects* (Course Module 2 – *Review of Case Law on Indirect Effects Evaluation*), and in the *Draft Baseline Report*, Executive Order 13274, Indirect and Cumulative Impacts Workgroup (March 2005).

In its *Interim Guidance: Questions and Answers Regarding the Consideration of Indirect and Cumulative Impacts in the NEPA Process* (January 2003), the Federal Highway Administration (FHWA) discusses the important differences in the meaning and requirements related to indirect and cumulative impacts in the NEPA process. A cumulative impact includes the total effect on a natural resource, ecosystem, or human community due to past, present, and future activities or actions of federal, non-federal, public, and private entities. Cumulative impacts include the total of all impacts to a particular resource that have occurred, are occurring, and will likely occur as a result of any action or influence, including the direct and reasonably foreseeable indirect impacts of a federal activity. This is illustrated in Figure 2-1.

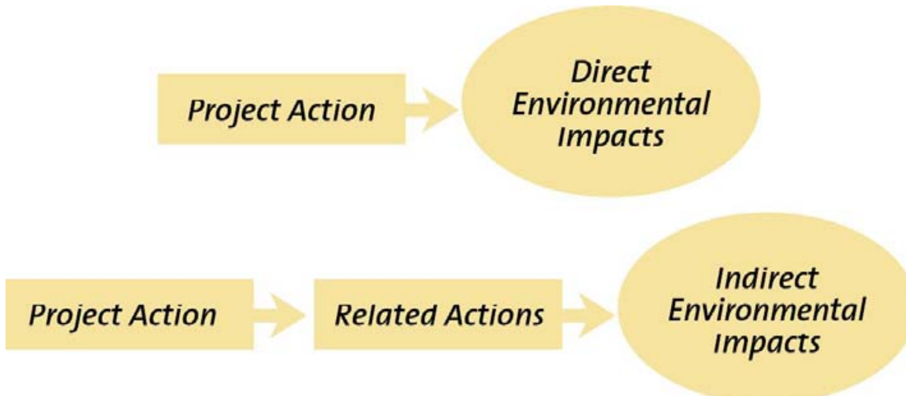
Figure 2-1. Cumulative Impact Diagram



Source: FHWA January 2003

Indirect impacts, as well as direct impacts, can be considered a subset of cumulative impacts but are distinguished by an established cause and effect relationship to a proposed federal action, such as a transportation project. Figure 2-2 is an illustration and comparison of the cause and effect relationship of indirect and direct impacts to a project action. Indirect impacts are caused by another action or actions that have an established relationship or connection to the project (related actions). These induced actions are those that would not or could not occur except for the implementation of a project. These actions are often referred to as "but for" actions and generally occur at a later time or some distance removed from the original action.

Figure 2-2. Direct and Indirect Impact Diagrams



Source: FHWA January 2003

2.2 CEQA Regulatory Framework

The CEQA Guidelines define indirect impacts as:

> "Indirect or secondary effects that are caused by the project and are later in time or farther removed in distance, but are still reasonably foreseeable. Indirect or secondary effects may include growth-inducing effects and other effects related to induced changes in the pattern of land use, population density, or growth rate, and related effects on air and water and other natural systems, including ecosystems [CEQA Section 15358(a)(2)]."

Section 15126.2(d) of the CEQA Guidelines states that a growth-inducing impact could occur if:

> "…the proposed project could foster economic or population growth, or the construction of additional housing, either directly or indirectly, in the surrounding environment. Included in this are projects that would remove obstacles to population growth (a major expansion of a waste water treatment plant might, for example, allow for more construction in the service areas). Increases in the population may tax existing community service facilities, requiring construction of new facilities that could cause significant environmental effects. Also discuss the characteristics of some projects that may encourage and facilitate other activities that could significantly affect the environment, either individually or cumulatively. It must not be assumed that growth in any area is necessarily beneficial, detrimental, or of little significance to the environment."

Additional information on CEQA and indirect impacts can be found in Caltrans Guidance for Preparers of Cumulative Impact Analyses, CEQA Guidelines for Cumulative and Indirect Impacts.

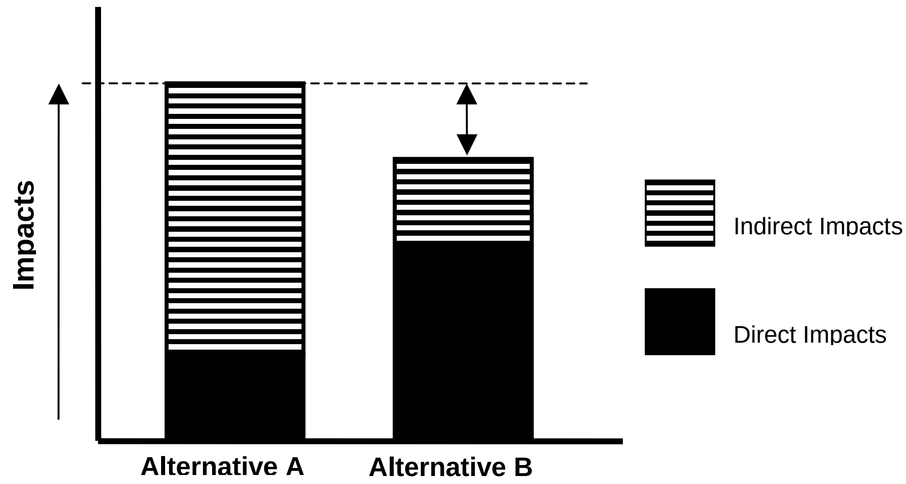
2.3 CWA Regulatory Framework

Section 404 of the CWA regulates the discharge of dredged or fill material into waters of the United States to meet the intent of restoring and maintaining the chemical, physical, and biological integrity of the nation's waters. The U.S. Army Corps of Engineers and U.S. Environmental Protection Agency (USEPA) share responsibility under Section 404. The Corps of Engineers administers the 404 program, including issuing permits, with the USEPA providing oversight.

The USEPA's 404 (b)(1) Guidelines (40 CFR 230 subpart B) specify that a permit can be issued for a discharge of dredged or fill material into waters of the United States only if the discharge is determined to be the least environmentally damaging practicable alternative (LEDPA), so long as the alternative does not have other significant adverse environmental consequences [40 CFR 230.10(a)]. To make this determination, the 404(b)(1) Guidelines require an analysis of cumulative and secondary effects on the aquatic ecosystem. Secondary effects are defined as the effects on an aquatic ecosystem that are associated with a discharge of dredged or fill materials into waters of the United States, but do not result from the actual placement of the dredged or fill material. For the purposes of this guidance, secondary and indirect effects mean the same thing.

The Corps of Engineers makes a LEDPA determination by considering both the direct and indirect impacts of the proposed project, including growth-related, indirect impacts. As shown in Figure 2-3, it is possible for an alternative with greater direct impacts, but fewer indirect impacts (including growth-related impacts) to be selected as the LEDPA (Alternative B). In this example, the alternative with the fewest direct impacts is Alternative A, whereas the alternative with the fewest *total* impacts is Alternative B.

Figure 2-3. LEDPA Determination



Chapter 3. Land Use, Transportation, and Growth

How Transportation May Affect Growth:

Amount—a change in the overall amount of growth.

Pace—a change in the rate of growth.

Location—a change in the direction or location of growth.

Pattern—a change in the type of growth (density and use).

This chapter explores the complex relationship between transportation, land use, and growth in a California context. It describes the causes of growth generally and the link between transportation and growth specifically. Highway projects can affect the location, rate, type, or amount of growth in an area. Some types of development may be directly induced by a project (e.g., projects serving specific types of land development). However, most land use changes in California are not direct consequences of a highway project, but rather occur indirectly due to changes in travel time and increased land accessibility in areas that may be ripe for development. The result may be a change in spatial distribution of development over time, such as commercial development around a new highway interchange. These types of growth-land use-transportation relationships are more complex and difficult to analyze than those for a project specifically designed to encourage or facilitate land use change and development.

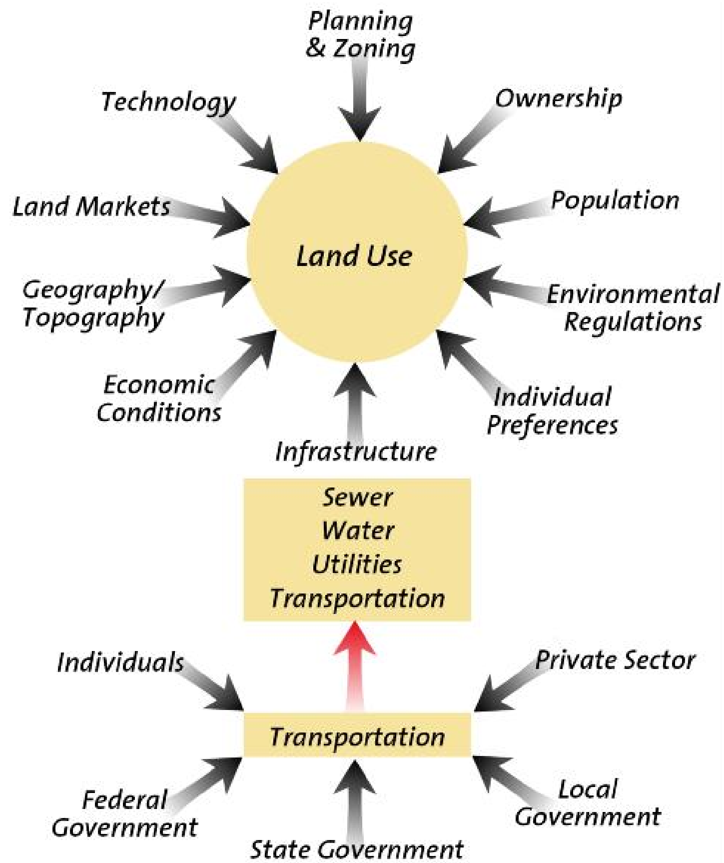
3.1 Factors that Influence Growth

Many factors influence land use and development in an area, as illustrated in Figure 3-1. Factors such as population and economic growth, desirability of certain locations, the costs and availability of developable land, physical and regulatory constraints, transportation, and the costs of sewer and water services all strongly influence where, when, and what type of development takes place.

Many of these factors also influence the policies and decisions associated with land use and growth. The key players include households, businesses, developers, and local governments (see FHWA's *Influence of Transportation Infrastructure on Land Use* and NCHRP Report 423A, *Land Use Impacts of Transportation: A Guidebook*). The interaction of supply and demand for housing and business properties in the land market produces the pattern of development within an area. Within this market, households and businesses create demand for new buildings and locations while developers provide these products within the supply and cost constraints of local government. External factors, such as zoning laws, incentive programs, and proximity of public transit and roadways also influence this relationship.

Households weigh the costs of different locations with their needs and preferences for living space, neighborhood type, quality of schools and other public services, and access to jobs, goods, services, and recreation. Various types of households weigh these factors differently as they consider what type and location of housing will best satisfy their needs and are within their budgets.

Figure 3-1. Factors Influencing Land Use and Development



Source: FHWA May 1999. An Overview: Land Use and Economic Development in Statewide Transportation Planning.

Businesses also balance the costs of various locations with their need to be accessible to workers, customers, supplies, and information, and to be attractive places to work and shop. These needs often lead them to cluster with other businesses in downtowns, suburban activity centers, and office and industrial parks. They also may outbid other uses for the highly accessible and visible places even though space may cost more in these locations.

Real estate developers respond to this market demand by evaluating the needs and preferences of their customers—most often homebuyers and commercial and industrial business tenants—and then by building new development projects that respond to that market. These new developments can compete with the existing stock of buildings for this market. Sometimes new developments augment existing supply in an expanding market; sometimes they compete with existing supply in a stagnant market, drawing tenants and buyers away from older properties.

Local government actions attract or discourage development by influencing the supply of land available for development/redevelopment; the densities at which development can occur; and directly or indirectly the cost of development. Developers' projects also can be constrained by the ability of local governments to provide needed infrastructure.

Further information about the factors that influence growth and a list of possible data sources is found in NCHRP Report 466, *Desk Reference for Estimating the Indirect Effects of Proposed Transportation Projects* (Course Module 4, Step 2 – *Identify Study Area Directions and Goals*).

3.2 What Is It About Transportation?

Land use and transportation are inextricably linked. Everything that happens to land use has transportation implications and transportation actions may affect land use. Transportation agencies such as Caltrans play a role in land use changes by providing infrastructure that can improve mobility to different destinations, and/or open up access to new locations. At the same time, new land development generates travel to that location and this additional travel generates the need for new transportation facilities. The extent that transportation influences development or the extent that land use influences transportation is a matter of ongoing debate (see Re:NEPA[3]).

Accessibility

Accessibility is the most direct link between transportation and land use. The concept of accessibility is key to understanding how transportation and land use relate to one another (NCHRP Report 423A). Transportation promotes spatial interaction between activities or land uses. This interaction is measured by accessibility, which reflects both the attractiveness of potential destinations and ease of reaching them. The pattern of land uses is important because it determines the opportunities or activities that are within range of a given place. The potential for interaction between any two places increases as the cost of movement between them—either in terms of money or time—decreases. Consequently, the structure and capacity of the transportation network affect the level of accessibility.

Transportation projects may reduce the time-cost of travel, thereby enhancing the attractiveness of surrounding land to developers and consumers. When the change in accessibility provided by a transportation project facilitates land use change and growth in population and employment, one outcome can be growth-related impacts to environmental resources.

[3] Re:NEPA is the FHWA's online "community of practice" supporting an open exchange of knowledge, information, experience, and ideas about NEPA, related environmental issues, and transportation decision making.

Research has shown that although accessibility improvements rarely change the rate of growth of a region (such as a county or metropolitan area) changes in accessibility can influence the direction of growth in a region and the rate of growth in local areas.[4] Even in areas where there is no net change in the overall amount of growth, the design or location of a transportation project can alter the patterns of land use and extent of potential impacts to resources. For example, the placement of an interchange may not change the net growth along a stretch of highway, but it could change where the growth occurs. Placing the interchange near a relatively intact wetland, rather than near a brownfield[5], could have very different consequences on environmental resources of concern.

3.3 Transportation and Land Use in California

Growth in California

Rapid population growth continues in California. In 2005, the state's population exceeded 36.8 million persons (Department of Finance Press Release May 2, 2005). The population is expected to increase by an average of 600,000 persons per year for the foreseeable future. If this projection holds, by 2020 the state's population will reach over 45 million, and by 2030 it will be nearly 52 million (*California Transportation Plan 2025*, May 2004).

The Department of Finance projects this population growth and forecasts its distribution around the state. The Department of Housing and Community Development, together with the regional Councils of Government (COG) throughout the state, estimate how many housing units each region and locality will be required to accommodate this growth, although the state's ability to enforce this requirement on local governments is limited.

Caltrans has a 20-year planning horizon consistent with standard FHWA practice for transportation project planning. In addition to Department of Finance projections, Caltrans sizes facilities based on travel demand projections prepared by Metropolitan Planning Organizations (MPO) in urban areas and county projections in rural areas. Travel demand forecasts are developed directly from population projections prepared by COGs, which are often (though not always) the same entities as the MPOs. The population and land use forecasts are based on the local government's general plan.

[4] For example, see the Brookings Institution's 2000 publication, *Do Highways Matter? Evidence and Policy Implications of Highways' Influence on Metropolitan Development*.

[5] Brownfields are real property, the redevelopment or reuse of which may be complicated by the presence of a pollutant or contaminant. Cleaning up and reinvesting in these properties takes development pressures off of undeveloped, open land and improves and protects the environment.

In California, local governments—not Caltrans or FHWA—control the amount, location, and timing of new real estate development. A local government is required by state law to adopt a general plan. This plan should accommodate the jurisdiction's fair share of future housing as determined by the Department of Housing and Community Development and the COG. Although the state's ability to enforce this requirement is limited, most local governments do take this responsibility seriously. The general plan also reflects the community's vision for how and where land is developed, preserved, or redeveloped.

The general plan can be a good source for obtaining information about expected growth and development patterns that are likely to unfold in a community. A general plan addresses the following seven elements (William Fulton and Paul Shigley, *Guide to California Planning*):

- The land use element deals with population density, building intensity and the distribution of land uses within a city or county.
- The circulation element deals with all major transportation improvements. It serves as an infrastructure plan and must address the development patterns expected by the land use element.
- The housing element assesses the need for housing for all income groups and lays out a program to meet those needs.
- The conservation element deals with flood control, water and air pollution, and the need to protect sensitive resources, such as endangered species habitat, wetlands, and prime farmland.
- The open-space element provides a plan for the long-term conservation of open space in the community.
- The noise element identifies noise problems in the community and suggests measures for noise abatement.
- The safety element identifies seismic, geologic, flood, and wildfire hazards and establishes policies to protect the community.

CEQA review is required when general plans are adopted, amended, or updated. NEPA review is not required because preparing or amending a general plan is not a federal action. Caltrans' role in the land-use planning and development review process is limited to intergovernmental review of projects that affect the state highway system.

Land use change and the precise details of new development are not easily predicted and the reliability of land use plans can be variable. Even if a proposed transportation project is in a local agency's general plan, factors at the time of project analysis could create a situation in which the project may contribute to growth-related impacts. In addition, Fulton and Shigley (2005) explain that because general plans are revised every 10 to 15 years at most, the plans may be out of date and market conditions may have changed. Accordingly, *general plans should not be used as the sole source of reliable land use information*.

Key Transportation Growth Issues

Much of the guidance provided by CEQ, FHWA, and other agencies concerning growth-related impact analysis appears to focus on transportation projects whose purpose is to stimulate growth (i.e., growth is a part of the project's purpose). In California, projects are rarely designed to encourage or facilitate growth. Most Caltrans capacity-increasing projects are proposed as a response to traffic congestion that results from growth that has already occurred or will soon occur, rather than attracting new growth to an area that otherwise would not receive it. From this perspective, growth causes the project—the project is not designed to cause growth. Hence, when California projects have growth-related impacts, it is usually an unintended outcome of the project.

Even if the intended effect is to respond to growth that has occurred or is projected to occur, an unintended result of reducing congestion could be to increase accessibility—which could, in turn, affect the timing and location of additional growth and possibly drive growth into areas where growth was not planned or may not otherwise be foreseeable. This growth also could result in increased pressure on resources in the area.

Analyzing these types of growth-transportation relationships can be difficult. Nevertheless, this is an analysis required by NEPA and CEQA. Chapter 5, *Making the First Cut* and Chapter 6, *Performing the Analysis* are designed to help the practitioner evaluate whether and how a transportation project may lead to growth-related impacts. When growth-related impacts are reasonably foreseeable, the guidance emphasizes the need for the Project Development Team (PDT) to consider and incorporate avoidance and mitigation measures for potential resource impacts. Chapter 4, *Key Concepts for Growth-related Impact Analyses*, discusses what makes an action or an impact "reasonably foreseeable."

Chapter 4. Key Concepts for Growth-related Impact Analyses

This chapter discusses the concepts of "reasonably foreseeable" and "causality" as they relate to assessing the growth-related impacts of a transportation project. To be considered reasonably foreseeable, an action, while uncertain, must be probable or likely to occur. In addition, although development and transportation projects are often built in close proximity to each other, this does not necessarily mean that a causal relationship exists between the transportation project and growth.

4.1 "Reasonably Foreseeable"

CEQ provided the following guidance[6] discussing the meaning of the term "reasonably foreseeable:"

> "The EIS must identify all the indirect effects that are known, and make a good faith effort to explain the effects that are not known but are 'reasonably foreseeable' [Section 1508.8(b)]. [I]f there is total uncertainty about the future land owners or the nature of future land uses, then, of course, the agency is not required to engage in speculation or contemplation about their future plans. But, in the ordinary course of business, people do make judgments based upon reasonably foreseeable occurrences. It will often be possible to consider the likely purchasers and the development trends in that area or similar areas in recent years; or the likelihood that the land will be used for an energy project, shopping center, subdivision, farm or factory. The agency has the responsibility to make an informed judgment, and to estimate future impacts on that basis, especially if trends are ascertainable or potential purchasers have made themselves known. The agency cannot ignore uncertain, but probable, effects of its decisions."

In other words, reasonably foreseeable events are those that are likely to occur or are probable, rather than those that are merely possible. This means that those effects that are considered possible, but not probable, may be excluded from NEPA analysis. There is an expectation in the CEQ guidance that judgments concerning the probability of future impacts will be informed ones, rather than based on speculation. At the same time, the agency can and should use its own informed judgment in order to make reasoned predictions.

A review of case law regarding "reasonably foreseeable" actions and effects can be found in NCHRP Report 466, *Desk Reference for Estimating the Indirect Effects of Proposed Transportation Projects* (Course Module 2 – *Review of Case Law on Indirect Effects Evaluation*),

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[6] Forty Most Asked Questions Concerning CEQ's National Environmental Policy Act Regulations (46 Fed. Reg. 18026, March 23, 1981; as amended, 51 Fed. Reg. 15618, April 25, 1986).

and in the *Draft Baseline Report*, Executive Order 13274, Indirect and Cumulative Impacts Workgroup (March 2005).

A confident prediction of whether growth is reasonably foreseeable requires judgment and needs to be based on information obtained from reliable sources. Coordination with local land use agencies and officials, including the review of adopted plans and similar documentation, if available, is important.

Assessing the growth-related impacts of a proposed transportation project can be thought of as a three-part process:

1. What is the reasonably foreseeable growth and land use change without the project? What is it with the project?
2. To what extent will the project influence the overall amount, type, location, or timing of that growth?
3. Will project-related growth put pressure on or cause impacts to environmental resources of concern?

In thinking about this process, it is important to understand that growth *per se* is not really what matters. What matters is the potential impact that this growth may have on resources of concern. For there to be a growth-related impact, the practitioner must find that growth is a reasonably foreseeable consequence of a transportation project (even in combination with other factors)—*and that growth would impact resources of concern*.

Determining whether growth is reasonably foreseeable can be a difficult task. Text Box 1 provides an example discussing the difference between probability and certainty. It illustrates the significance of distinguishing between a prediction (the probability something will happen) and the reliability of that prediction (the level of certainty). Thus, it is not just the predicted probability of something happening that makes it foreseeable, but also the reliability of those predictions. The practitioner should have a qualitative sense of how reliable his/her conclusions are based on the reliability of the source data.

Text Box 1. Distinguishing Between Probability and Certainty

Two amateur weather forecasters estimated the probability that it will rain tomorrow in their city. They both estimate the probability to be 80%. But how certain was each one about his prediction? One is very confident about his prediction, because he referred to current satellite imagery from the National Weather Service. The other is less confident about his prediction, because he used a less reliable data source—his personal journal of the weather during the same week last year.

Both predictions arrive at the same probability that it will rain, but the certainty about the predictions is not the same. Obviously the prediction using satellite imagery would be more certain. Other factors also can influence the level of confidence in a prediction.

4.2 "Causality"

The extent to which land use influences transportation and vice versa is a matter of ongoing debate. Statisticians say, "Correlation does not imply causation" (see Text Box 2). Growth is not necessarily caused by a transportation project. If the potential for growth in an area is inevitable and consistent with local land use plans and current trends, and the transportation project would not influence growth, then there would be no growth-related impacts attributable to the project. The question that must be analyzed is whether the transportation project will change the location, rate, type, or amount of growth. For example, how much of the future growth will occur anyway (no-build) and how much will occur if the transportation project is built? The difference between these two projections is the amount of growth that would not occur "but for" the project and is a growth-related impact.

Text Box 2. Correlation and Causation

Consider the following examples of correlations:

- Ice cream sales and the number of shark attacks on swimmers.
- Skirt lengths and stock prices.
- The number of cavities in school children and their vocabulary size.

Statisticians see a relationship between all of these factors. But a correlation between two things does not necessarily imply causality–that is, the notion that one factor (skirt lengths) caused the other (stock prices) to occur. These correlations *do not* imply causality—they are "common responses" often to unknown factors. For instance, ice cream sales and shark attacks are likely each caused by increases in the number of people who come to the beach.

This example does illustrate why a growth-related impact analysis can be difficult. Sometimes transportation causes growth, sometimes growth causes transportation, and in some ways the correlation between transportation and growth is in response to other factors. Yet the practitioner is tasked with untangling and estimating the causal relationship between transportation and growth.

The practitioner needs to consider these concepts to determine if growth will be a reasonably foreseeable effect of a transportation project. It would be unusual to conclude that a project would have no growth-related impact issues associated with a project without at least performing a "first-cut" screening (see Chapter 5, *Making the First Cut*). Likewise, a practitioner cannot assume a causal relationship exists between future land use changes and the project without further analysis.

Chapter 5. Making the First Cut

Purpose of the First-cut Screening:

To use readily available information about project- and growth-oriented factors to evaluate the extent to which the practitioner will need to consider a growth-related impact analysis for a transportation project.

There is a continuum of transportation projects that range from those having little likelihood of growth-related impacts to those having a high likelihood of growth-related impacts. This chapter describes some "first cut" screening factors that can help determine where a proposed project lies in the continuum. It suggests what factors to consider, how to document the results, and what, if anything, to do after completing the first-cut screening.

It is fairly easy to make the "first-cut" decision for projects that fall at either end of the continuum. For example, it would be appropriate to conclude that growth-related impacts are not reasonably foreseeable for an auxiliary lane project in a highly urbanized area with low growth rates and little remaining development capacity. Once this decision is documented, no further analysis of growth-related impacts would be necessary. In contrast, a new bypass with interchanges adjacent to an urban area (urban fringe) could increase accessibility to undeveloped land. In the presence of other factors such as a growing regional economy, suitable terrain, and favorable development regulations, this project would likely have growth-related impacts and would need further analysis.

For projects in the middle of the continuum, the practitioner will need to make an initial determination. Is further investigation or analysis of growth-related impacts needed? If so, the results of the first-cut screening can help to focus the analysis on potential issues that should be investigated in greater detail. Chapter 6 of this guidance, *Performing the Analysis*, describes the suggested steps for conducting the analysis.

5.1 Caltrans Project Development Process

Consideration of growth-related impacts should begin early in the project development process. The first-cut screening is used to determine whether the potential for growth-related impacts is a project issue that needs to be evaluated in the environmental document. After completing the first-cut screening, the practitioner will have concluded and documented that either: (1) growth-related impacts as a result of the project are not reasonably foreseeable; or (2) further investigation or analysis is required. Any potential for growth-related impacts also should be discussed at Project Development Team (PDT) meetings, so that opportunities for avoidance and minimization can be explored and documented.

At the beginning of the Project Approval and Environmental Document (PA&ED) stage, the practitioner should review the Preliminary Environmental Analysis Report (PEAR) for any preliminary conclusions regarding growth-related impacts. The practitioner also should talk with members of the PDT who worked on the project during the Project Initiation Document (PID) stage, especially the Project Manager and environmental staff. There are three possible outcomes from this review:

- If the PEAR concludes that growth-related impacts are not reasonably foreseeable, the practitioner should examine the basis for this conclusion and verify that this is still the case, taking into consideration any project changes and new information. If the conclusion is still valid, no further analysis is necessary and the conclusion should be stated in the environmental document. If the practitioner determines that a closer look is warranted, then a growth-related impact analysis should be conducted as described in Chapter 6.
- If the PEAR concludes that there is potential for growth-related impacts, the practitioner should conduct a growth-related impact analysis as described in Chapter 6.
- If the PEAR is silent about growth-related impacts, the practitioner should perform a first-cut screening as described below. Based on the outcome of the screening, the practitioner either documents that growth-related impacts are not reasonably foreseeable, or performs a growth-related impact analysis. Chapter 6 of this guidance describes the suggested steps for conducting the analysis.

Objectives of a First-cut Screening

- Screen for growth-related impacts early.
- Consider the potential for the project to contribute to growth-related impacts.
- Think about the geographic area in which the impacts may occur.
- Consider whether potential impacts would affect resources of concern.
- Document the results of the first-cut screening.

5.2 Conducting the First-cut Screening

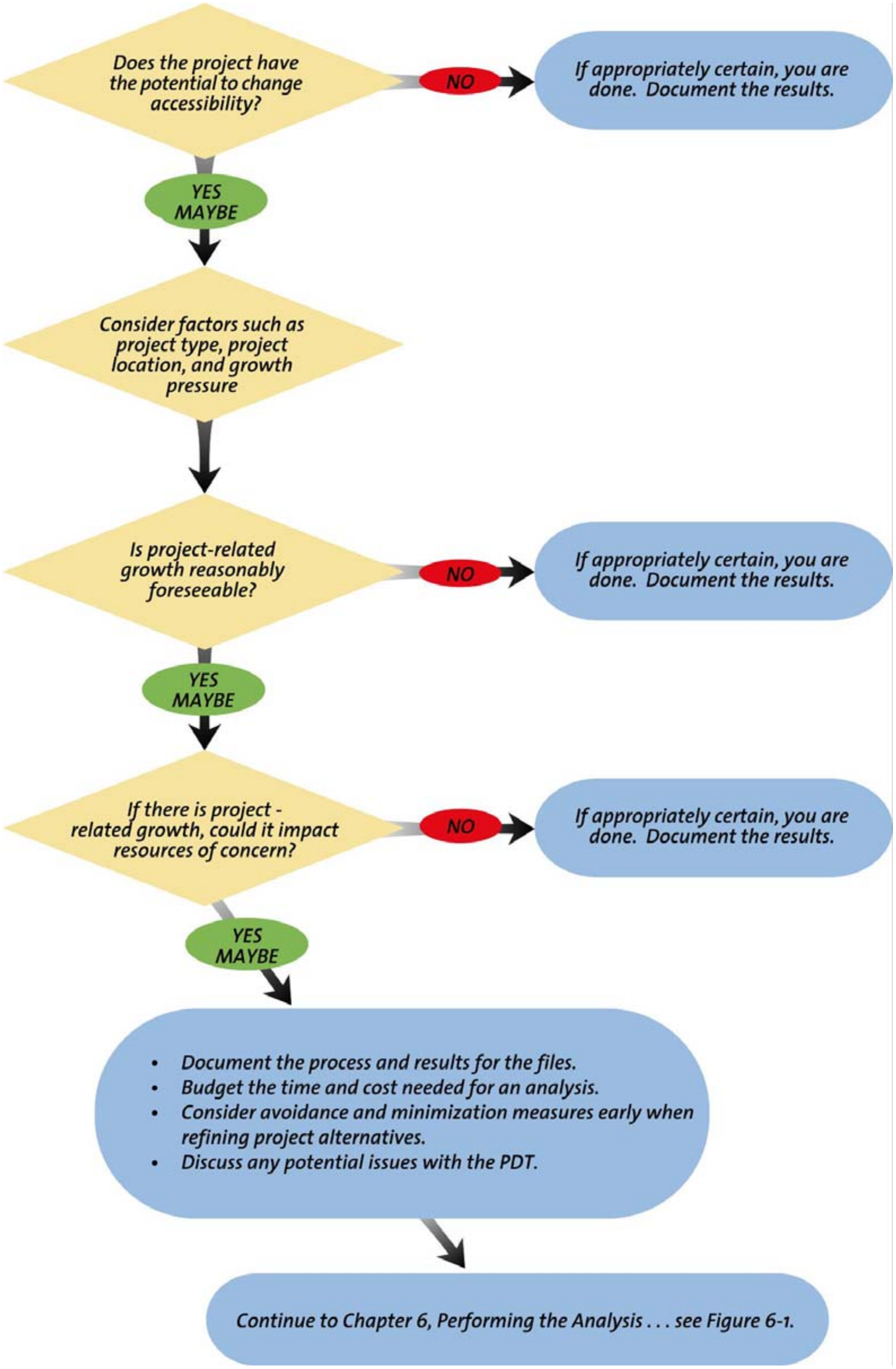
The flowchart in Figure 5-1 provides an overview of the steps used to conduct the first-cut screening. The practitioner uses readily available information to examine a variety of interrelated factors to answer the following questions:

1. To what extent would travel times, travel cost, or accessibility to employment, shopping, or other destinations be changed? Would this change affect travel behavior, trip patterns, or the attractiveness of some areas to development over others?

2. To what extent would change in accessibility affect growth or land use change—its location, rate, type, or amount?

3. To what extent would resources of concern be affected by this growth or land use change?

Figure 5-1. The First Cut



Scoping is an important forum for gathering input on potential growth-related impact concerns and resources of concern. If growth-related impacts are a potential concern, this should be disclosed and explored during scoping for the project. This will provide an opportunity for coordination with agencies such as the U.S. Army Corps of Engineers, U.S. Environmental Protection Agency, U.S. Fish and Wildlife Service, California Environmental Protection Agency, the California Department of Fish and Game, and local agencies on the types of effects to be evaluated and analysis methods that could be used.

As stated in Chapter 4, to be considered reasonably foreseeable, an action, while uncertain, must be probable or likely to occur. Determining whether something is reasonably foreseeable involves predictions about the future, which means there is built-in uncertainty that requires a practitioner to exercise judgment. As with many decisions, the practitioner may not be able to be completely definitive in saying “yes” or “no.” When answering these questions, some screening factors to consider include accessibility, project type, project location, and growth pressures in the area. Although these factors are discussed separately below, they *must be considered in combination, as described in the following sections*.

Accessibility

Changes in land use could result from a transportation project for several reasons (NCHRP Report 423A, *Land Use Impacts of Transportation: A Guidebook*):

- Development that would have occurred anyway could be arranged in a different pattern. For example, new commercial activities might choose sites that the proposed project makes more accessible rather than other sites in the study area.
- The proposed project could cause some businesses or households to locate in the study area instead of other places in the region. For example, if access is improved to land on the urban fringe, developers may capitalize on the improved access and build homes in these areas instead of elsewhere in the region.
- The proposed project could stimulate new real estate development that changes existing land uses and increases intensities in already developed areas. For example, residential properties near a new interchange might be redeveloped into commercial buildings because the changes in accessibility will make the land more attractive to commercial users who will offer higher prices for the land.

Land use change can occur due to a transportation project in a highly urban context. For example, an improvement in accessibility like a transit stop or a new interchange could encourage redevelopment in the urban area at higher densities. In the urban setting, the main effects of land use change are on socio-economic or community conditions. Land use change can cause residential or business displacement, altering the character of a community or changing property values/rents.

Some basic questions to consider when screening a potential project for changes in travel behavior and accessibility include:

- Is the number of trips likely to change?
- Do project alternatives have the potential to affect travel speeds and travel times?
- Are project alternatives likely to change levels of congestion and level of service (LOS)?
- Does it appear that project alternatives may change accessibility to, from, and within the study area?

Early in the Caltrans project development process, it is unlikely that results of the traffic operations analysis will be available to help answer these types of questions. However, a review of existing traffic counts, accident data, traffic forecasts, programming information for the corridor in the Regional Transportation Plan (RTP), and the purpose and need statement will help the practitioner piece together a picture of the project's context. This can help the practitioner conclude whether a potential accessibility change could result from the proposed project.

Project Type

Project types can range on a continuum from those projects having no likelihood of causing growth-related impacts to those projects having a high likelihood of causing impacts. For example:

- Projects not likely to cause growth-related impacts include projects to perform pavement rehabilitation, culvert work, signalization or storm damage repair; to install median barriers, sound walls or landscaping; or to widen existing lanes to standard widths, make curve corrections, or widen shoulders. These are typically projects on an existing facility that do not increase capacity or increase accessibility. These projects will not warrant an analysis of growth-related impacts.
- Adding high occupancy vehicle (HOV) lanes or mixed-flow lanes are examples of projects that could cause growth-related impacts because they add capacity to an existing facility. These projects warrant closer consideration to determine whether an analysis of growth-related impacts will be necessary.
- Projects such as a bypass, new road, or new interchange/intersection are the most likely to have growth-related impacts. These are typically projects that create a new facility or new access. These projects will likely require an analysis of growth-related impacts.

Project Location

Project location, whether urban, suburban, urban/suburban fringe, or rural, is another screening factor that can be used in combination with other factors when considering whether a transportation project could cause growth-related impacts:

- **Urban**. The likelihood of a highway project causing growth-related impacts in an urban area is typically low because of its built-out land use pattern and/or resources of concern may not be present. However, practitioners should not dismiss urban projects without conducting a first-cut screening, as well as considering other factors such as plans for increased land use density and transit-oriented development that could affect socio-economic or community condition resources.
- **Suburban**. A suburban area[7] may have a greater potential for growth-related impact concerns because of a greater presence of open space/vacant land and resources of concern. This is particularly the case in newly developing suburban areas where undeveloped natural areas are planned for human use (e.g., parklands, trails, etc). Transportation projects in these areas may cause growth-related impacts.
- **Urban/Suburban Fringe**. Undeveloped parcels adjacent to an expanding urban/suburban area can be prime growth areas. Fringe areas generally have high land availability and lower land prices. Transportation projects in these areas have a high potential to cause growth-related impacts, particularly if the land is suitable, development regulations are favorable, and the area is in the path of an expanding urban/suburban core.
- **Rural**. Transportation projects in rural areas have traditionally had a lower potential to cause growth-related impacts than suburban areas, because population density and economic activity generates lower demands for conversion of undisturbed lands to developed uses. However, the likelihood of impacts can vary depending on factors such as the distance to existing population centers, the degree of growth pressure, and so on.

There are exceptions to each of these general categories. For example, while highly urbanized, the City of San Diego contains a large number of sensitive plant and wildlife species. Hence, the location of the project area alone is not a completely reliable screening tool. But if used in the first-cut screening, in combination with other factors, project location can be an early indicator of the project's potential to cause growth-related impacts.

[7] A nearby, politically separate municipality with social and economic ties to a central city (urban area).

Growth Pressure

The amount and intensity of development in an area also can be an early indicator when considering growth-related impacts. If there is little active development because of a built-out land use pattern, there is likely low opportunity for growth, whereas proposed or ongoing construction activity, growth-control debates in newspapers, and the presence of tracts of undeveloped land likely indicate a high opportunity for growth.

The general plan, other local plans, and census data are just a few of the data sources that can provide projections of future population, employment growth, and land development for an area. Other potential sources of data regarding growth plans and trends are discussed in NCHRP Report 466, *Desk Reference for Estimating the Indirect Effects of Proposed Transportation Projects* (Course Module 4, Step 2—*Identify Study Area Directions and Goals*). Keep in mind, however, that general plans may be out of date and other factors such as market conditions or developers' plans can change. Even in areas where there is an up-to-date plan and an effective planning process, it is still wise to consult with local and regional planners, real estate experts, and other knowledgeable people in the area to confirm the growth plans and trends expressed in the plan (see the discussion of general plans in Section 3.3, *Growth in California*, and the sample questions in the Data Gathering Issue Paper prepared for the cumulative impact analysis guidance).

Some general circumstances that could influence the likelihood of growth pressure include (see NCHRP Report 466, Course Module 7, Step 5—*Identify Potentially Significant Indirect Effects for Analysis*):

- **Land availability and price**. Development cannot take place without the availability of land at a price suitable for development.
- **Existing infrastructure**. The amount and kind of infrastructure (sewer, water, etc.) existing or planned in an area.
- **Regional economy**. Development is not likely to occur if the regional economy will not support new jobs and households, if credit or financing is not readily available, or if the availability of labor, suppliers, or local markets for goods is not sufficient.
- **Vacancy rates**. High vacancy rates in housing or commercial space would likely be absorbed before any shift in development occurs.
- **Land use controls**. Development is shaped by zoning ordinances and other land use controls that influence the amount of land available, the densities permitted, and the costs of development.

The continuum of the first-cut screening factors described above is illustrated in Figure 5-2. Keep in mind that these factors must be considered in combination when determining whether a proposed project could cause growth-related impacts. The fictional Canyon City Transportation Improvement Project, which follows Chapter 6 of the guidance, illustrates the process for conducting a first-cut screening.

Figure 5-2. Is There a Potential for Project-related Growth?

Analysis Level	Project Type	Project Location	Growth Pressure
Further analysis is not likely	Typical CE-type activity (project on an existing facility and does not increase capacity or accessibility).	Urban: Typically low due to built-out urban setting and the costs associated with redevelopment. Rural: Typically low, particularly in areas that are remote from job and population centers and have experienced low levels of economic activity.	• Highly restrictive land use controls. • Lack of infrastructure to support growth. • High vacancy rates. • Low consumer demand.
Further analysis may be warranted	Capacity-increasing or new/expanded access improvements on an existing facility.	Suburban: Potential for infill development and redevelopment/densification of low density areas.	• Moderate consumer demand. • Moderate vacancy rates. • Presence of infrastructure to support growth.
Further analysis is clearly required	New facility on new alignment providing new access.	Urban/Suburban Fringe: Available undeveloped parcels near expanding urban or suburban areas are prime growth areas.	• High consumer demand. • Low vacancy rates. • Limited land use controls.

Geographic Area

The geographic area selected for evaluating growth-related impacts will generally be larger than the study area for direct impacts because indirect impacts are later in time or farther removed in distance. However, the geographic area should not be so large as to dilute the magnitude of the impacts. For example, many transportation projects originate in regional plans, but considering the whole region may lead to an analysis that diminishes the effects of an individual project. Some tools for determining the geographic area are discussed below (additional information can be found in NCHRP Report 466, Course Module 3, Step 1–*Initial Scoping for Indirect Effects Analysis*).

Political Boundaries. Boundaries based on the limits of political jurisdictions can be used to evaluate growth-related impacts. Many data sources such as demographics, growth projections, and general plans are delineated by political jurisdictions. Examples of political boundaries include counties, planning districts, census tracts, and traffic analysis zones. However, use caution when selecting political boundaries. They can be arbitrary and may not represent the reality of market areas; spillover effects across jurisdictional lines are common. Demographic characteristics and development trends in urban and suburban areas may extend beyond an individual municipality into surrounding communities.

Commuteshed. The geographic area could be sized to coincide with a commuteshed. The commuteshed approach looks to identify key areas of household location (trip generators) and employment/shopping services (trip attractors) to capture origins and destinations most likely to be affected by the transportation improvement. This evaluation is most easily accomplished through the project's travel demand forecast. Using the outputs of the model, such as zone to zone travel times, it is possible to compare changes to travel times for specific trips in the model network. The network boundaries for a particular traffic analysis will be based on an approved travel demand model or a sub-area component of the travel demand model. The area defined for the transportation analysis can be considered the commuteshed.

Growth Boundaries. In jurisdictions with growth management policies, areas suitable for development or expected to see growth may already have been delineated in infrastructure or growth management plans. In some cases, development beyond these urban growth boundaries, or the extension of infrastructure to serve it, is limited or restricted. In these circumstances, it may be appropriate to confine the consideration of growth-related effects to an area coincident with these accepted growth boundaries. But the practitioner should look carefully to ensure that the jurisdiction is actually enforcing growth boundaries. If the political will does not exist to enforce the boundaries, then development may extend over the boundaries, thereby altering the growth-related impact analysis.

The time frame for a growth-related impact analysis is generally 20 years, because the time frame associated with most RTPs is usually 20 years.

Identify the Resources to Consider

Identify the types of resources that are likely to occur in the selected geographic area and their sensitivity. This can be accomplished by referring to information that was gathered during project scoping and during studies of direct project impacts, as well as published information (see the Resource Guide for the Data Gathering Issue Paper prepared for the cumulative impact analysis guidance).

5.3 Document the First-cut Screening

If the first-cut screening concludes that there is *not* a growth-related impact issue with the proposed project, the document the process and conclusions for the file.

If the first-cut screening concludes that a growth-related impact analysis is necessary, the practitioner should: (1) document the process and results of the first-cut screening for the file; (2) budget the time and cost necessary for undertaking the work; (3) consider avoidance and minimization measures early when refining the project alternatives; and (4) discuss any potential issues with the Project Development Team (PDT). Chapter 6, *Performing the Analysis*, describes the steps for conducting a growth-related impact analysis and some tools that could be used to perform the analysis.

Chapter 6. Performing the Analysis

Approach for Developing a Growth-related Impact Analysis:

1. Review previous project information and decide on the approach/level of effort needed for the analysis.

2. Identify the potential for growth for each alternative.

3. Assess the growth-related effects of each alternative to resources of concern.

4. Consider additional opportunities to avoid and minimize growth-related impacts.

5. Compare the results of the analysis for all alternatives.

6. Document the process and findings of the analysis.

Chapter 5 of the guidance provided some project- and growth-related factors that could be used to conduct a first-cut screening to weigh a project's likelihood of causing growth-related impacts. This chapter provides a step-by-step approach for conducting a more detailed growth-related, indirect impact analysis. No single formula is available for determining the appropriate scope and extent of the analysis. Ultimately the practitioner must determine the methods and extent of the analysis based on the location, size, and type of the project proposed, the type of environmental document needed, and the potential to affect resources of concern.

6.1 Developing a Growth-related Impact Analysis

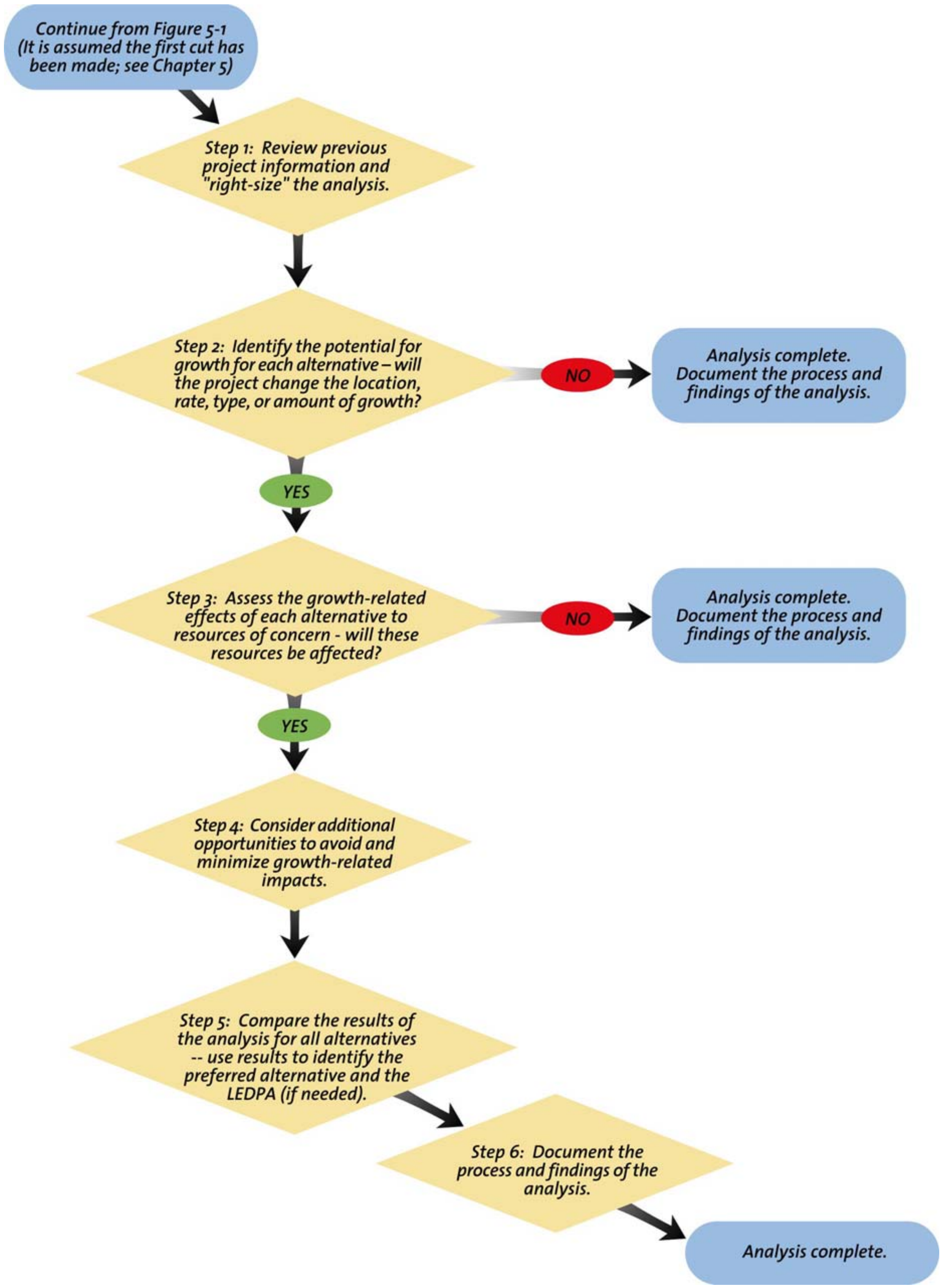
The flow chart in Figure 6-1 provides an overview of the steps used to conduct the growth-related impact analysis. The analysis occurs during the Project Approval and Environmental Document (PA&ED) stage when the direct and cumulative impact analyses are being prepared, and the NEPA/CEQA documents are being developed. The steps involved in the analysis are sequential; however, as more information for the proposed project becomes available, it should be used to refine the analysis.

Key Points to Consider

Data gathering. Data are the foundation of the analysis. Many of the data needed are in existing documents. The Data Gathering Issue Paper, prepared for the cumulative impact analysis guidance, presents ways to identify existing data and the steps to take if data are unavailable. It includes information on tapping Caltrans internal data sources, and which agencies to contact and the types of data they maintain.

Qualitative and quantitative data. When resource issues can be measured, quantitative data are preferable and should be used in the analysis whenever relevant data are available. Using quantitative data is especially valuable when waters of the United States under Section 404 of the Clean Water Act (see Section 2.3) and other biological resources are involved. Quantitative data can be useful for identifying avoidance and minimization opportunities and for preparing permit applications.

Figure 6-1. The Analysis



Role of Regional Planning

Regional planning can provide the forum not only for the growth-related impact analysis, but for powerful avoidance or minimization approaches. In addition to providing the context for defining reasonably foreseeable growth patterns, regional planning efforts can provide practitioners with data sources for conducting the growth-related impact analysis.

Avoidance and minimization opportunities. Identifying avoidance and minimization opportunities for reducing potential growth-related effects is an important theme throughout the analysis. Analysis results will be used as a factor in the identification of the preferred alternative, which attempts to balance all resource impacts (social, economic, and environmental). If a Section 404 permit will be required, analysis results will be used as a factor in identifying the least environmentally damaging practicable alternative (LEDPA, see Section 2.3). Because a Section 404 permit can only be issued for the LEDPA, it is important to consider avoidance and minimization opportunities for growth-related impacts early on and periodically during the analysis.

6.2 Step-by-step Approach for Conducting the Analysis

The growth-related impact analysis is used to determine whether a transportation project could contribute to growth-related impacts that would affect resources of concern. Its purpose is to more clearly identify the relationship between the no-build alternative, the proposed build alternative(s), and foreseeable growth (growth that would not have occurred "but for" the project), as well as to consider ways to avoid or minimize resource impacts should they occur. The following steps serve as guidelines for identifying and assessing growth-related impacts of a proposed transportation project:

1. Review previous project information and decide on the approach and level of effort needed for the analysis ("right-size" the analysis).
2. Identify the potential for growth for each alternative.
3. Assess the growth-related effects of each alternative to resources of concern.
4. Consider additional opportunities to avoid and minimize growth-related impacts.
5. Compare the results of the analysis for all alternatives.
6. Document the process and findings of the analysis.

Why do a Growth-related Impact Analysis?

The primary purpose of doing the analysis is to determine whether there is a growth-related impact issue at all—and if so, then to:

- Disclose unintended effects of the proposed project.
- Avoid and minimize growth-related impacts to resources.
- Use analysis results to help identify the preferred alternative.
- Use analysis results to help identify the LEDPA (if needed).

A hypothetical, illustrative example of a growth-related impact analysis, the Canyon City Transportation Improvement Project, follows Chapter 6. This fictional example was developed to illustrate the process for conducting a first-cut screening (described in Chapter 5), as well as for Steps 1 to 6 of the analysis as described in this chapter.

Step 1: Review Previous Project Information and "Right-size" the Analysis

In this step, the practitioner will need to review information from previous work on the project, particularly the first-cut screening. In addition, the scoping process may have provided information on potential growth-related impact issues and on resources of concern. Also consider the amount of time that has elapsed since the first-cut screening (see Chapter 5) was prepared to account for changing conditions.

"Right-size" the Analysis

Choose the method of analysis, tools, and level of effort based on the:

- Scale of the proposed project.
- Magnitude of potential impacts.
- Available data.
- Resources available.

The first-cut screening will likely need to be supplemented with additional data and analyses, especially if preparing an Environmental Impact Statement (EIS). "Right-sizing" the analysis means choosing an analysis approach and the appropriate tools in order to answer the questions and accomplish the goals of the analysis. The depth of the study should be consistent with the scale of the project and its possible effects. It is not necessary or appropriate to engage in research outside the scope of a NEPA or CEQA analysis. When selecting an analysis approach and the tools to use, keep in mind that a comparison of the build/no-build alternatives will range in complexity depending on project-specific issues. If a project requires the preparation of an EIS, it will likely require a more detailed analysis. The practitioner should aim for a level of effort that is time-efficient but tells the story with clarity and accuracy for decision-makers and the public.

A well-chosen method will be salient (answers the question), valid (accepted by peers), and easily communicated to decision-makers and the public. Some methods may give more certain results as more resources are poured into them, but a point of diminishing returns is usually reached. This does not mean that the best approach is to use a method that is inherently more robust and funded to the point of diminishing returns. Certainty is not a virtue in and of itself. Investing in the right analysis approach to the point that it accomplishes its goal—and goes no further—is the virtue.

A variety of tools can be employed when analyzing growth-related effects. Table 6-1 describes some of the tools that could be used for Steps 2 and 3 the analysis. A link is provided to a summary description of the tool, its typical applications, and its strengths and weaknesses.[8] NCHRP Report 456, *Guidebook for Assessing Social and Economic Effects of Transportation Projects*, describes various techniques for evaluating changes in travel time, accessibility, and social impacts. In addition, NCHRP Report 466 (Course Module 3, Step 1—*Initial Scoping for Indirect Effects Analysis*) provides a discussion of factors to consider when matching methods to project types.

[8] Also see NCHRP Report 466, Course Module 8, Step 6—*Analyze Indirect Effects* and NCHRP Report 423A, *Land Use Impacts of Transportation, A Guidebook*).

Table 6-1. Possible Tools for Conducting a Growth-related Impact Analysis

Tools*	Description	Comment
Qualitative Analysis	Qualitative methods using expert knowledge are used frequently to predict and evaluate land use interactions. One such method, the Delphi method, presents a systematic way to use expert opinions based on an interviewing method that begins with general questions, but focuses the questions and the analysis more precisely as the process continues. Other qualitative methods include meetings with stakeholders or a project task force. Regardless of the method used, experts or stakeholders should be identified and contacted early in the process.	Qualitative process can take a holistic approach that considers all aspects of a system, which can be helpful for large transportation projects. The use of expert opinions and analysis can be helpful in developing forecasts or focusing on known issues.
Transportation Forecasts	Transportation forecasts summarize the transportation planning and traffic engineering processes to identify the size and type of proposed project to be developed.	Transportation forecasts can be especially helpful to determine the capacity associated with transportation facilities, and changes in behavior after new transportation facilities are constructed.
Geographic Information Systems (GIS)	GIS provides the ability to map, display and analyze data with a spatial component such as land use, census data, road networks, etc. It also can be used to identify environmental constraints, demographic data, etc.	GIS is a valuable tool that can provide maps and other data that can be used in land use and regional economic models. GIS is increasingly being used by Caltrans, local agencies, and regional organizations.
Integrated Land Use and Transportation Models	Integrated models are required to simulate the relationships between land use and transportation. The models predict how changes in accessibility influence changes in location of households and businesses, and how congestion created by relocated households and businesses affect accessibility. These models are frequently used by Councils of Governments (COGs) and Metropolitan Planning Organizations (MPOs).	Depending on the type of project, land use and transportation models can provide data that show what has triggered growth in the past, and whether those triggers would provide the same result in the future.
Regression Analysis, Econometric Forecasting Techniques, and Models	Econometric models are statistical and mathematical models that depict the decision making processes of businesses, households, financial institutions and governments, and show how they interact to produce the economy's broad movements. These models can be tailored to specific regions, and are often used by regional planning agencies to forecast employment and population change on regional or statewide levels.	Econometric models are useful for assessing the impacts of transportation investment and policies on a regional economy, and are useful in identifying how changes in the transportation system would affect the regional economy. However, they work best at predicting changes over large areas or corridors with multiple jurisdictions or urban centers. As a result, they are not useful in identifying the effects of a single transportation improvement on a local area. Also, the use of these models can be costly and time consuming.

*Note: Tools are listed from the most qualitative to most quantitative; a link is provided to a summary description of the tool, its typical applications, and its strengths and weaknesses.
Adapted from NCHRP Report 466, Course Modules 7 and 8, and NCHRP Report 423A, Section 2, *Analytical Tools*.

Step 2: Identify the Potential for Growth for Each Alternative

In this step, the practitioner will need to predict the land use and development patterns in the geographic area for each alternative, including the no-build alternative (without project). Initially this evaluation should be done for the no-build alternative. The practitioner should consider producing a future development scenario without the transportation project.

Table 6-2 provides some data sources to use for identifying the patterns, type, rate and location of growth (also see the Data Gathering Issue Paper). Compiling and reviewing these types of data and any available planning documents can help the practitioner determine the following information:

- Is land available for growth in the geographic area?
- What areas are targeted for growth?
- How much of previously designated growth has happened or is in progress?
- Has growth happened outside designated areas?
- What type of zoning is in the geographic area?
- Do proposed zoning changes usually gain approval?
- Is land in the area sought by developers?
- What areas and resources are protected from growth?

Keep in mind that general plans and other planning documents are updated over time and may be out-of-date. Even if there is an up-to-date plan, it is still wise to consult with local experts to confirm growth plans and trends. Another way to gauge how successful previous plans have been in predicting/managing growth is to evaluate how local plans have changed over time and how well the local government has followed the plans (zoning changes, variances).

An additional consideration to take into account is the level of certainty for growth. It should not be assumed that all planned growth will occur. William Fulton, co-author of *Guide to California Planning* (2005), has estimated that approximately 60% to 80% of the development anticipated in a general plan's land use element actually happens (personal communication, January 2006). Talking with local planners and other experts can help identify the degree of certainty associated with growth plans and trends in the geographic area.

Table 6-2. Data Sources for Identifying Growth

Data Source	Data Provided	Comments
Local and Regional Data/Trend Data		
U.S. Census Data	Population, income, age, industry and economic trends, etc	Recent and historical data can be obtained and assembled in time-series for tracts, block groups, or other geographic groupings to reveal trends.
State/Regional Growth Forecasts	Growth forecasts	California Department of Finance, state planning agencies, MPOs, other planning authorities generate growth forecasts.
Bureau of Economic Analysis (BEA) Industry Data	Industry earnings and employment	The BEA maintains time-series data at the county or Metropolitan Statistical Area (MSA) level that can reveal economic development trends.
County/Local Building Permits	Building permits, certificates of occupancy	Yearly data can reveal trends for household growth and location.
Variance/Zoning Changes	Zoning variances, regulation changes	Public records can be consulted to identify trends in the enforcement and stability of land use regulations.
Local Maps	Existing features	Location of residential and commercial areas, town center, parks, schools, etc.
Planning Documents/Comprehensive Plans		
Regional Transportation Plans (RTP)	Long-range plans for transportation improvements in a defined regional area.	Reviewing the RTP can determine whether the proposed project would support the transportation network shown.
Caltrans Transportation Concept Reports (Corridor/Route Concept Reports)	Caltrans' long-range transportation planning vision for projects along a state route, a U.S. highway, or an Interstate highway. May include a discussion of local land use planning issues and an analysis of the environmental baseline.	Transportation concept reports can be used to fill in the data gap between outdated local general plans and the environmental analysis of current roadway development projects. When a transportation corridor extends across multiple local jurisdictions, a concept report also serves as a planning tool to facilitate dialogue among these jurisdictions and resource agencies, regional transportation planning agencies, Caltrans, and other stakeholders.
Planning Documents (e.g., General Plan, Comprehensive Plan, Specific-area Plan)	Identifies planned growth for a designated period.	Planning documents are updated over time and may be out of date. Consult with local experts to confirm growth plans and trends, and to determine the extent to which the planning documents guide development or the assumptions used to prepare plans. For example, do proposed zoning changes usually gain approval? Is land in the area sought by developers? The documents also can help to identify trends and community vision.

Data Source	Data Provided	Comments
Utility Plan or Map	Identifies existing and proposed utility infrastructure capacity, such as sewer, water, power.	Utility plans or maps can help determine whether infrastructure is present within or adjacent to the analysis area to support growth.
Environmental Resource Plans (e.g., California Wildlife Action Plan, Natural Community Conservation Plan, Habitat Conservation Plans, Conservation Easements).	Identifies location of environmental resources, proposed conservation areas.	Environmental resource plans can identify the location and status of existing resources and areas in which growth would be prohibited, such as within designated conservation easements. Consult with local planners and resource agency staff to identify critical environmental issues and the assumptions used for preparing the environmental resource plans.
Private Sector Plans/Development Proposals	Identifies forthcoming development.	Reviewing submitted and approved development applications can help determine growth demand and trends, the local agency's disposition toward development, and whether approved proposals conform to plans.
Local/Regional Development Regulations		
County/Local Zoning Ordinances	Data on zoning area boundaries and regulations.	Zoning regulates and restricts the use of private property in the public interest.
Urban Growth Boundary	Identifies designated areas in which growth is designated.	Urban growth boundaries can help determine infill areas to which growth could be directed. Consult with Local Agency Formation Commission (LAFCO) staff to determine whether a boundary will be extended and whether petitions have been made to do so.
Special Development Districts	Areas where development type is regulated.	Some jurisdictions may have special districts that regulate development. Examples include urban redevelopment areas, business improvement districts, tax increment finance districts, historic preservation districts.

Note: Not all of this data would be useful for every project. The practitioner can use the Preliminary Environmental Analysis Report (PEAR) as a starting point to determine additional information needs, as well as coordinate with the technical specialists who prepare the biology, community impact analysis (CIA), and farmland technical studies. Ongoing coordination with planning staff is invaluable for obtaining information on development proposals and community vision/plans. An effective public involvement program will also yield land use and resource information.

Adapted from NCHRP Report 466, Figure 4-2.

Next, the practitioner will need to determine if and how the land use and development patterns for each build alternative would change from the future development scenario crafted for the no-build alternative. In other words, will there be a change in the location, rate, type, or amount of growth that would *not* have occurred "but for" the project? The practitioner should take into account the following points (also see NCHRP Report 466, Course Module 7, Step 5—*Identify Potentially Significant Indirect Effects for Analysis*):

- Consider how the potential for growth (location, rate, type, amount) varies among the build and no-build alternatives.
- Consider whether the proposed alternatives(s) support previously designated development areas.
- Consider whether the proposed alternative(s) would remove barriers to development.
- Consider whether access provided by the proposed project would affect the desirability of an area for development.

Some analysis approaches for this step could include:

- Contact local planning agencies and business development councils for their input on changes in development with and without the project.
- Develop a future development scenario for each build alternative.
- Ask local or regional land use experts to review and/or contribute to the future development scenarios.
- Use of expert panels, which involves gathering together transportation planners, land use planners, resource agency staff, developers, and other experts to develop estimates of land use and other changes that would occur with and without the project.
- Use of geographic information systems (GIS) to better characterize the geographic scope of project effects.

If the build alternative(s) are found to *not* cause a change in the location, rate, type, or amount of growth, then the analysis of growth-related impacts is complete. The practitioner should document the process and findings of the analysis in the environmental document (see Step 6).

Step 3: Assess the Growth-related Effects of each Alternative to Resources of Concern

In this step, the practitioner will need to identify if and to what extent the change in growth identified in Step 2 for each alternative would affect resources of concern. The practitioner will need to identify the resources to consider in the analysis by gathering input from knowledgeable individuals and reliable information sources. Table 6-2 provides some data sources (planning documents, environmental resource plans) that can be used for identifying resources of concern. Also see Exhibit B, *Resource Guide* from the *Data Gathering Issue Paper*, which presents various types of data that may be available for a specific resource and the source of such data. When resource issues can be measured, quantifiable data, such as an acre-by-acre estimate, is preferred.

If it is determined that a change in growth would not affect resources of concern, then the analysis is complete. The practitioner should document the process and findings of the analysis in the environmental document (see Step 6).

Step 4: Consider Additional Opportunities to Avoid and Minimize Growth-related Impacts

After identifying the possible growth-related impacts of each alternative to resources of concern, it is important to consider whether additional opportunity exists to further avoid or minimize these impacts.

Some key avoidance and minimization measures available in the practitioner's tool box include alignment choices, the location and/or configuration of access points, traffic impact fees, and mode choices. Decisions about alternative alignment choices are often made very early in the project development process to address transportation needs within a particular corridor. However, project alternatives may be modified to avoid or minimize growth-related impacts. Transportation choices that increase accessibility could place pressure on sensitive resources in the vicinity of the access point. Although modifying the location and/or configuration of access points is typically considered as a measure to avoid or minimize direct impacts, this approach also may be effective in redirecting future development that could affect resources in the vicinity of the access point. Also, transit projects, in combination with land use policies, can encourage compact development ("smart growth").

Local governments are best situated to incorporate the types of avoidance and minimization measures typically associated with land use. Transportation agencies can contribute to these measures with technical assistance. Purchasing access rights or conservation easements can prevent or minimize growth by limiting land accessibility and can help protect areas containing sensitive resources. Conservation easements also can be established to protect resources in perpetuity. Similar strategies include land banking and developing habitat conservation plans or resource conservation plans. For more information on these strategies, see the *Guide to California Planning* (2005) by William Fulton and Paul Shigley, and NCHRP Report 466, *Desk Reference for Estimating the Indirect Effects of Proposed Transportation Projects* (Course Module 10, Step 8—*Assess the Consequences and Develop Appropriate Mitigation and Enhancement Strategies*).

Step 5: Compare the Results of the Analysis for All Alternatives

In this step, the practitioner should summarize how and to what extent growth associated with the no-build and build alternatives would affect resources of concern. The results of this comparison will be used to contribute to the identification of the preferred alternative, which attempts to balance all resource impacts (social, economic, and environmental). If a Section 404 permit will be required, the results also will be used for identifying the LEDPA (see Section 2.3).

Also consider the reliability of the results in light of the uncertainties inherent in the analysis process and the data used (see NCHRP Report 466, Course Module 9, Step 7—*Evaluate Analysis Results*).

Step 6: Document the Process and Findings of the Analysis

It is important for the practitioner to clearly document the analysis process and its findings. This will clarify for decision-makers, the public, and resource agencies that all of the issues have been examined. Include information about the methods and assumptions used, the agencies and experts consulted, and any other research. The product of this step will be included in the environmental document.

Describe the Method or Process Used. Briefly state how the analysis was conducted. For example, a specific traffic forecast or a general plan was used, or maps were provided by resource agencies that show known wetland locations. Briefly state the approach that was used, identify the source and year of the data used, and describe any data gaps. If qualitative analytical approaches were used, such as questionnaires or interview panels, describe them.

Explain assumptions used in the analysis. Explain any assumptions used and limitations that were faced when conducting the analysis. Readers will need to know how conclusions were drawn in situations for which there were data gaps, lack of information, or limitations on obtaining data (e.g., data were cost prohibitive). If evaluating significant adverse effects in an EIS, refer to CEQ's regulations at 40 CFR 1502.22 for principles regarding incomplete or unavailable information. If models were used, summarize the assumptions on which the models are based. Also be sure to include any assumptions made with regard to uncertainty or the likelihood of potential development.

State your conclusions. The analysis will result in a conclusion about whether the project will influence growth, and what effect, if any, this growth will have on resources of concern. The conclusions should quantify the effect of each alternative using the data developed during the analysis. Also, describe avoidance and minimization measures incorporated into the project and document any commitments made.

6.3 Mitigation

By CEQ definition (40 CFR 1508.20), mitigation of impacts means avoiding, minimizing, rectifying, reducing and/or compensating with a substitute. This hierarchy is referred to as “sequencing,” which means that actions to avoid and minimize adverse impacts should be considered first. This mitigation sequencing theme is carried forward into the regulations and policies of FHWA and Caltrans, as well as CEQA and the Section 404 regulations.

As discussed earlier in this chapter, there are a number of tools to avoid or minimize growth-related impacts. If avoidance or minimization of adverse effects to resources is not possible, then other mitigation strategies will need to be considered in the environmental document. It is suggested that a dialogue be initiated with the appropriate local agencies and resource agencies regarding other mitigation strategies.

Making a determination that mitigation is required for a growth-related, indirect impact can be complicated because there are many factors that contribute to growth (see Figure 3-1). Because these effects usually occur in combination with other actions by local agencies and private entities, Caltrans is not required to mitigate indirect effects that are outside of its control. Project-induced land development is almost always under the control of local governments and the private sector. The most effective way to mitigate or reduce the potential adverse resource effects from changes in land use is through the application of controls by local governments. Local governments have the authority to reject land use proposals that are inconsistent with local goals, surrounding uses, future plans, or zoning.

Despite these limitations, Caltrans is uniquely qualified to exercise a leadership role in environmental planning and stewardship. The Work Group advocates the following approach for transportation projects to alleviate the need for mitigation (other than avoidance or minimization) of growth-related, indirect impacts:

- Early collaborative planning between federal, state, and local agencies (see FHWA’s web site on scenario planning, an approach that integrates land use and transportation).
- Incorporating reasonable avoidance and minimization opportunities for identified resource impacts.
- Thoroughly documenting analysis results.
- Assuring consistency with regional habitat/restoration planning efforts.
- Identifying opportunities for project stakeholders to become involved in regional planning efforts.

Section 6001 of the 2005 Transportation bill SAFETEA-LU provides support for early collaboration and integrated planning, and requires Metropolitan Planning Organizations to discuss potential mitigation activities and locations in the Regional Transportation Plan. In addition, FHWA's linking of NEPA and planning provides tools for interagency collaborative transportation, land use, and environmental planning.

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Descriptions of Analytical Tools

The following discussions are intended to help the practitioner assess which analytical tool or combination of tools may be appropriate to use when analyzing the growth-related effects of a highway project. Several tools are described – qualitative analysis; transportation forecasts; geographic information systems (GIS); integrated land use and transportation models; and regression analysis, econometric forecasting techniques, and models. The discussions include the basic types of each tool, when they might be applied, their strengths and weaknesses, and sources for additional information.

Qualitative Analysis

Qualitative methods using expert knowledge are used frequently to predict and evaluate land use interactions. There are a variety of qualitative analysis methods that can be applied to growth-related impact analyses. In general, qualitative approaches are most effective if used in conjunction with quantitative and GIS-based methods. Similarly, quantitative methods nearly always require the framework and context that an effective qualitative study provides. Gathering expert opinions and qualitative analysis can be helpful in developing a more focused analysis of known issues and can help frame corresponding quantitative and/or GIS studies.

Basic Types

There are several broad categories of qualitative techniques:

- **Stakeholder and Focus Group Meetings** – This approach uses engagement with locally affected citizens and experts to gather background information, knowledge of key issues and to find what resources are considered most valuable to neighborhoods affected by a given project.

- **Qualitative Inference** – This technique involves a case study description of an area of concern, e.g., habitat or neighborhood, and an identification of resources based on professional judgment of the possible impacts that the proposed project would entail. The case study focuses on the indicators that characterize the area of concern. Techniques involving professional judgment are often combined with other techniques noted here.

- **Literature Review/Comparative Case Analysis** – A comparative study involves comparing a like area where a similar project has been completed to the area of concern where a project is proposed. This is similar to the Qualitative Inference approach, but uses comparisons to enrich the analysis.

- **The Delphi Method** – This is a more systematic way to use expert opinions based on an interviewing method that begins with general questions, but focuses the questions and the analysis more precisely as the process continues. It employs survey research technique directed toward the systematic solicitation and organization of expert intuitive thinking from a group of knowledgeable people. It entails elements of the two methods described above, but is a more structured process.

- **Scenario Writing** – This method creates an outline in narrative form of some conceivable future environment given certain assumptions about the present and a sequence of events in the intervening period. Multiple scenarios can be drafted to include a variety of changing conditions, a spectrum of potential developments, and a series of hypothetical socio-political, ecological, and economic consequences of proposed actions. This technique can develop ideas and identify causal relationships that might not surface in more structured methods. Rather than predictive, scenario writing is a technique which attempts to establish some logical sequence of events to show how, under present conditions and assumptions, a future environment might evolve. Scenarios can also serve to set the upper and lower bounds of potential outcomes.

- **Networks** – Creating system diagrams or networks can be used in classifying, organizing, and displaying problems, processes, and interactions and to produce a causal analysis of the indirect/cumulative effects. This approach is a diagrammatic version of the scenario writing method and assumes a high level of knowledge and expertise by its designer. The Network approach can be both qualitative and quantitative.

- **Matrices** – This technique can assist in the display and interpretation of information developed using many other qualitative and quantitative techniques. The matrix is commonly a grid diagram in which two distinct lists are arranged along perpendicular axes, e.g., actions and environmental characteristics. The interactions between the two that would produce impacts are noted and effects are described in a binary fashion (yes or no) a qualitative fashion (descriptive paragraph) or a quantitative fashion rank or index.

Typical Applications

Qualitative methods can usefully serve to evaluate the context or overall situation wherever little historical data exist or wherever existing data are questionable or inconsistent. In most cases, qualitative approaches to an impacts assessment are part of a larger, multi-pronged approach to doing an analysis. Qualitative approaches are most important for their ability to help frame an impact analysis. This is a most critical function when designing very large and complex analyses.

Strengths and Weaknesses

Strictly qualitative approaches have some limitations and risks. Foremost among these is the risk of slipping into speculation based on limited data or unusual circumstances. Broad participation, including input from local planners, experts, or other stakeholders through surveys, interviews, or task forces can serve as a safeguard against this. Broad and diverse participation also serves to protect against ideological biases, which is a risk when relying heavily on qualitative analyses. The Scenario Writing and Network methods are only as good as the underlying understanding or assumptions of often complex processes and interactions. Similarly, they place a high bar on the knowledge and expertise of the practitioners crafting them.

This summary was adapted from NCHRP Report 466, Course Modules 7 and 8.

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Transportation Forecasts

Transportation planners have long relied on computer-based models to predict how traffic patterns change with improvements to the transportation system. The traditional four-step model estimates how land use results in trips, what type of trips are generated, what mode is used for trips, and where and when those trips occur on the transportation network. Outputs from the travel model can be used to determine to key factors in land use change: accessibility (ease of travel to key destinations) and number of trips (reflecting opportunities for highway oriented or retail businesses).

Basic Types and Typical Applications

There are two basic types of techniques using travel demand models:

- **Screening and Comparative Evaluations** – Outputs of a travel demand model (volumes, level of service estimates, travel times, vehicle miles traveled (VMT) can be used to establish the where a project will have an effect on local traffic and travel times and whether the effect is regional or localized in nature. This involves a forecast of travel demand with a project alternative (build alternative) and without (no-build alternative) and comparison between the two conditions. If a project has a negligible effect on regional travel times, or indicators such as VMT its effect can be determined to be localized. Localized effects can be evaluated by analyzing changes in local traffic conditions in combination with qualitative (e.g., comparative case, scenario writing) or quantitative (e.g., relating traffic levels at a new interchange to types of business that may be supported by that pass-by traffic).

- **Input to Simple Regional Land Use Evaluations** – Outputs of the travel model can also be used as input variables to an accessibility analysis (evaluation of how travel times between key destinations change with and without a project) and a simple gravity model (method for allocating growth in households or employment based on accessibility change) for use in a broader regional analysis.

Strengths and Weaknesses

Transportation Forecasts can provide valuable insight into how a project would affect local and regional patterns of traffic. Analysts can use this information in qualitative or quantitative assessments to establish the location and extent to which changes in accessibility may affect land use change. Traditional models will not provide direct output of the key variables (households and employment) in an indirect impact evaluation and will not capture the dynamic interaction of land use and transportation in feedback loops over time (see the summary for Integrated Land Use and Transportation Models). Travel demand models require special expertise to produce and evaluate results. The expense and complexity of travel models make them appropriate only in situations where an established, calibrated regional or statewide model is in place.

This summary was adapted from NCHRP Report 466, Course Module 8 and NCHRP Report 423A, Section 2, *Analytical Tools*.

For More Information

NCHRP Report 456, Section 2, *Changes in Travel Time* and Section 6, *Accessibility*.

Geographic Information Systems (GIS)

GIS provides the ability to map, display, and, analyze spatial data for evaluations of indirect and cumulative impacts. Although cartographic techniques for evaluating impacts have been in use for many years, GIS allows for the assembly of large databases and automated processing. In most locations, state, regional, and local planning agencies maintain GIS datasets that are useful in indirect impact evaluations. These datasets include roadway networks, political boundaries, topography, vacant land, existing land use, zoning, demographic and employment statistics, historic resources, habitats, and natural resources. GIS is useful for all steps in an evaluation but is often combined with other methods.

Basic Types

There are two basic types of techniques using GIS:

- **Map Overlays** – The McHarg overlay technique (1969), which involves the combination of project design maps and natural and community feature and resource maps, is time-tested and can be readily implemented in GIS. This technique can be particularly useful for visualizing potential indirect/cumulative effects related to alteration of the physical environment, e.g., habitat fragmentation or community segmentation. GIS has greatly enhanced the ability to process and display cartographic information. Cartographic techniques are limited in their ability to reveal the structure, function, and dynamics of areas. However, their utility can be expanded by relating inventoried information about these characteristics via a relational database.

- **Resource Capability Analysis** – Another cartographic technique applicable to identification of indirect/cumulative effects is resource capability analysis (Rubenstein 1987). Similar to the overlay technique, this process involves the preparation of two maps an opportunity map depicting conditions favorable to development (topography, soil types, zoning, and regulatory standards) and a constraint map depicting areas unsuitable for development (wetlands, floodplains, slopes, parklands, or other notable features). Overlaying the two maps produces a land suitability map indicating areas with capacity for potential induced growth. This map could be further modified to indicate areas with the highest potential for complementary development (interchange quadrants) and development shifts (interchanges and feeder roads) under the action alternatives.

Typical Applications

In analyses of growth-related effects, GIS is most often used to catalog resources and identify areas of conflict between features of the project and features of the natural or human environment. These include direct impacts such as property takings or habitat encroachment and indirect impacts to habitats and communities by allowing analysts to determine the location and extant of natural systems and notable community features.

While GIS cannot predict the location of future households or employment, it can be used to determine likely locations for these activities by analyzing the location of existing development, project features, zoning, and natural features and constraints. Some tools are now available which combined GIS input and display capabilities with decision rules or land use modeling techniques to add predictive or scenario evaluation capabilities (see the summary for Integrated Land Use and Transportation Models).

GIS is also particularly effective in displaying the results of evaluations and support data with thematic maps depicting demographics, land use, and socio-economic conditions.

Strengths and Weaknesses

GIS is a widely used, efficient, and effective method for gathering and cataloging data, analyzing spatial data, and documenting assumptions and presenting results. GIS by itself can not be used to develop estimations of land use change and impacts and can not capture the dynamics of many natural and social systems. GIS can be used to support and implement each step in the evaluation process.

This summary was adapted from NCHRP Report 466, Course Module 7.

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Integrated Land Use and Transportation Models

Integrated land use and transportation models represent enhancements to the typical four-step travel demand model used at state and regional agencies. In the traditional models, demographic and land use assumptions used in the estimation of trips are developed outside the model and remain fixed for each forecast year in a model run. Integrated models allow land uses to shift in each forecast year to capture how changes in the transportation system affect land use change, and how land use change will affect volumes on the roadway network. Through an iterative process these integrated models predict an equilibrium land use and traffic pattern for a future year or years in the traffic forecast. Based on region-wide forecasts of population and employment, these models allocate new housing and employment to local areas based on transportation accessibility, land availability, and in some cases land prices and other factors.

Basic Types

There are several basic types of integrated models that vary in their complexity and methods:

- **Scenario Based Models** – These models allow the user to enter information about current land use conditions and the transportation network through Geographic Information System (GIS) maps. Users then input parameters on future land use regulations, and weights for factors that typically influence land use decisions. The models then rate land areas for their suitability for development and allocates regional growth to local areas based on suitability. Factor weights and other parameters can then be altered to create scenarios to be compared for planning or impact analysis purposes. Examples include the commercially available What If? and Smart Growth Index packages.

- **Spatial Interaction/Gravity Models** – These models use Lowry gravity-model formulation to allocate employment and households based on measures of attractiveness for development including availability of land, travel time and cost, and household income. These models can typically be linked to a region's travel modeling system to provide a feedback loop. Parameters for allocation are typically estimated through a process of calibration specific to the location being evaluated. Examples include the widely used DRAM-EMPAL/ITLUP/Metropilus package developed by Steven Putman for the U.S. Department of Transportation and the ULAM system used in Florida.

- **Market Equilibrium Models** – Several modeling systems in use in the United States and Europe base predictions for household and employment location on the demand and supply for these land uses and information on the economic factors in location choices of households and employers developed through discrete choice estimation techniques. Integration with travel demand models allow the land use models to account for increases or decreases in travel time and cost in location decisions. Parameters for allocation are estimated through a process of calibration specific to the location being evaluated. Examples include UrbanSim, Metrosim, TRANUS, and MEPLAN.

- **Cellular Models** – A more recent line of modeling involves making predictions about future land use based on probability modeling developed through time-series observations and decision-rules. One example is LEAM which uses historical series of satellite or aerial photography imagery in combination with maps of attributes and constraints to make predictions on future land uses.

Typical Applications

Most integrated, transportation and land use models require a significant investment in time and money to develop. Most current applications are by academics and Metropolitan Planning Organizations. In areas where these models are already in place and calibrated to local conditions, they can be used to assess the magnitude and location of land use change associated with a transportation improvement. By comparing results using a "no-build" transportation network and a "build" alternative, the analyst can identify the increment of change in households and employment in each area the model analyzes [usually Traffic Analysis Zones (TAZs) made up of census tracts or block groups]. The analyst can evaluate the land use changes in the context of resources and notable features.

Strengths and Weaknesses

Integrated models are based on established theories of location choice and land development. By providing a feedback loop between land use and travel estimation, the models more closely represent reality than tradition travel demand models because they assume a dynamic rather than a static land use/transportation system. Integrated models also allow the analyst to directly estimate the key variables in an induced growth analysis – housing and population. Models available to date, however, have been costly to set-up, implement, and maintain because of their cost, data requirements, and need for calibration to local conditions. For these reasons, these models are used almost exclusively in academic and regional planning settings and there are very limited examples of their use in NEPA/CEQA evaluations of projects.

This summary was adapted from NCHRP Report 466, Course Module 8.

For More Information

FHWA Toolbox for Regional Policy Analysis located at http://www.fhwa.dot.gov/planning/toolbox/index.htm.

FHWA Travel Model Improvement Program (TMIP) located at http://tmip.fhwa.dot.gov/.

Regression Analysis, Econometric Forecasting Techniques and Models

Econometric and statistical models are mathematical equations that can be used to describe natural and social systems. In these models, statistical techniques are used to uncover relationships or correlations between elements of these systems so that analysts can make predictions about the future. These techniques are used often in regional planning to forecast employment and population change and describe the decision-making processes of businesses, households, financial institutions, and governments.

Basic Types

There are three broad categories of statistical analysis techniques:

- **Curve Fitting/Trend Extrapolation** – Trend extrapolation techniques are used to determine how one dependent variable (e.g., population, household size, or number of building permits issued) has varied with a single independent variable (time) in the past, so that a prediction may be made about the future. Spreadsheet software and statistical packages can be used to analyze time-series series data and develop best-fit curves and projections.

- **Econometric Forecasting Models** – Regression and econometric techniques allow an analyst to establish the relationship between a dependent variable and one or more independent variables. For example, by establishing the correlation between past levels of employment in a particular county or city to past national economic indicators (e.g., national employment or industry output), an analyst can make predictions local activity by relying on established projections of the national indicators.

- **Discrete Choice Models** – Discrete choice models can to make predictions on the probability of a decision-maker's choice by establishing the relationship between choices and the characteristics of the decision maker (e.g., age, presence of children, number of workers, housing tenure). Information on the link between choices and the characteristics of decision-makers is often established directly through surveys (stated preference) or through observations of past behavior (revealed preference).

Typical Applications

- **No-action Future Projections** – In doing an evaluation of induced growth impacts the analyst needs to compare the growth of an area's population and employment without the project (No-Action) to the future with project alternatives. Some local areas may not have estimates of future growth available at the level of detail needed (i.e., geography, time). Other areas may have a forecast that explicitly considers the effect of the proposed project in which case a projection based on current trends may be more appropriate for use as the baseline.

- **Explaining Relationships or Developing Assumptions** – By establishing the relative importance of transportation among the other factors influencing past location decisions in a local area (e.g., water/sewer infrastructure, employment base, land use regulation, and ease of obtaining permits) an analyst can predict how a transportation improvement will contribute to future land use change. These types of studies can also involve quantitative evaluations of comparative cases in other regions.

- **Impacts on Property Values and Location Attractiveness** – There is a growing literature in economics and planning relating changes in property values to improvements in transportation access such as interchanges and transit stops. By looking at how accessibility improvements have been capitalized into real estate prices in comparable areas, an analyst can make predictions about the effect of a proposed project on property values and ultimately land use and household or employment growth.

Strengths and Weaknesses

Econometric techniques are widely used in social science and regional planning and, when used correctly, provide an effective and defensible method on which to base conclusions about the "reasonably-foreseeable" future with our without a proposed transportation project. These techniques are often data intensive and may require considerable effort to determine if they will be useful in an evaluation. For example, an analyst may have to conduct a statistical analysis of a dataset before determining whether curve-fitting or econometric methods would produce statistically valid results. In general, econometric and statistical techniques are most applicable on large-scale systems such as regional economies, urban centers, or large corridors where large datasets can be easily obtained and individual events (e.g., business openings or closings, zoning changes) do not obscure broader trends. Although widely available desktop software packages can make the task of econometric and statistical analysis less time consuming, trained-professional judgment is required to ensure that statistical measures are accurately applied, interpreted, and summarized in documentation.

This summary was adapted from NCHRP Report 423A: Section 2, *Analytical Tools*.

For More Information

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