Washington County
Transportation Futures Study
Exploring options • Informing choices

Evaluation Framework Report

Prepared for

Washington County

Prepared by

ECONorthwest and DEA

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1. OVERVIEW

This report summarizes the approach the consulting team will use to evaluate transportation investment packages in the Washington County Transportation Futures Study (Study). It has three sections:

- **Background**: how evaluation fits into the Study
- **Evaluation Framework**: the principles, methodological approaches, and categories of impacts that provide a framework for organizing more-detailed evaluation procedures
- **Evaluation Criteria and Measures**: recommendations about the specific criteria, measurements, and analyses that will be used to evaluate different investment packages.

2. BACKGROUND

In previous phases of the study, the team took a "look back" over the past 30 years to review how the county has grown and what major transportation decisions and investments have been made to respond to that growth. The study is currently focused on identifying alternative transportation investments to evaluate how well they address future challenges and values important to the community. The transportation investments will be evaluated relative to two alternative visions (referred to as scenarios) for how the county might grow in the next 40-50 years. The future scenarios reflect differing factors, or drivers of change, that are likely to influence the amount of population and jobs growth, and land development patterns in the county.

These investments packages will affect the County in different ways. Ultimately, the purpose of the evaluation is to help stakeholders understand the impacts: what they are, how they vary between packages, how severe the differences are, etc. The evaluation will help stakeholders discuss what's most important and decide what types of investments they prefer to explore further.

3. EVALUATION FRAMEWORK

2.1 Standard evaluation principles

2.1.1 What is an evaluation framework?

For the purposes of this work, an evaluation framework is a description of high-level assumptions, principles, and methodological approaches relevant to what is being evaluated. Broadly, an evaluation framework is a structure for assessing trade-offs to inform future planning and policy decision-making.

At the most basic level, policy makers at different government levels have choices about future transportation investments. In considering these choices, they benefit from information about how those choices (also called packages or alternatives) perform with respect to things that most people in their communities care about. These "things we care about" are described in the evaluation literature by many similar terms that get increasingly specific as they move from concepts to measurements:

> Visions > values > purposes > goals > objectives > outcomes > impacts > performance measurements > evaluation criteria.

In essence, an evaluation framework needs to assemble information (measurements, data, facts) about how choices (plans, policies, investments) impact things that decision-makers and the people they represent think are important, and about the relative importance of those things. The things people think are important are reflected in the evaluation criteria, such as safety, reliability, environmental sustainability, and economic vitality.

Exhibit 1 illustrates this concept. Along the top, alternatives or choices are evaluated based on criteria (along the side). In concept, each cell in the matrix (each combination of alterative and criterion) provides facts, data, or measurement related to the performance of the alternative.

Exhibit 1. The basic structure of project, program, or policy evaluation

CRITERIA	ALTERNATIVES			
	A1 (base case)	A2	....	An
C1				
C2	All of the cells in the matrix get filled in with (1) facts about the performance of each A on each C, (2) an evaluation of the relative performance of ALL A's across each C, and (3) an identification and relative weighting of the most important advantages. Each row (criterion) may be supported by a full report.			
....				
Cn				

Source: ECONorthwest, based on Suhr, Jim. 1999. *The Choosing by Advantages Decision-making System*. Westport, Conn.: Quorum Books.

This type of high-level evaluation framework is widely accepted in government and business as the "rational model." In concept, it is transparent. One can imagine a matrix on one page that shows the absolute and relative performance of alternatives on the things that matter (the criteria). Such a matrix would facilitate a public discussion of the pros and cons of choices: Do we have the right criteria and alternatives? The right measurements? Have we measured well? How do the alternatives perform relative to one another on the things we have agreed are important? Given performance across criteria, which alternative seems best? The basis for opinions about pros and cons is documented by quantitative and qualitative information. In other words, opinions have more influence if they are supported by good evidence.

Though easy to explain and to grasp in theory, the practical implementation of the concept in Exhibit 1 can be difficult. The rest of this report explains why, and gives reasons for the choices made about the methods and measurements proposed to conduct such the evaluation for the Study.

2.1.2 Typical principles and methods for evaluation

Many methods can be used to implement this basic framework. Some are highly technical and mathematical in the way they try to model complex relationships assumed to influence future events. Others are more qualitative (e.g., here's a story about how the future might unfold). At least one (usually all) alternative future assumes that some action of interest is taken, so that its impacts on things people care about can be assessed and discussed.

These extremes define a continuum of options. Which evaluation approach is chosen depends on purposes, precedents, available data, skills, schedule, budget, politics, and more. There is no single, best method, but some methods are better suited to specific situations. Any method, however, should be based on an assessment of how well it will address four principles of good evaluation:

1. **Comprehensiveness and mutually exclusivity**. Measuring all effects on all people, at all relevant places, and at all relevant times isn't practical, and evaluators develop a framework that captures what are agreed to be the most significant effects. At the same time, evaluators try avoid double-counting impacts, where two different categories reflect the same impact. Decision-makers cannot accurately compare choices if their benefits are double-counted, and especially if they are unaware that double-counting is occurring.[1]

2. **Practical measurement**. The number of measures can grow rapidly as categories expand to subcategories and alternatives are evaluated against different assumptions about driving forces (scenarios). Adding new measures can become impractical and deliver meager benefits.

3. **Consolidation.** The evidence of experience is clear: people can manage lists of about 6 – 10 items before the list starts becoming confusing. If an evaluation has fewer than 10 measures, they don't need to be consolidated and can remain in their natural units (e.g. VMT per capita, crash rate during AM peak travel period). If one has good measurement, comparing alternatives on a single measurement is not difficult. But most policy evaluations have more than 10, and typically the measures are grouped into categories. The challenge is how to consolidate multiple measures, in different units, into some overall evaluation of performance by each alternative on the broader measurement category / evaluation criterion. Some evaluations do it quantitatively, others qualitatively, others not at all.[2]

4. **Weighting**. People are likely to have different ideas about the *relative importance* of each criterion category. For example, some people may find safety and reliability to be most important, while others find environment, health, and equity most important. Even if each category has consolidated the performance of measures into some type of score, a decision-maker must consider the relative importance of each category. Is a high score in one category worth more (meaning it is more important) than the same score in another category? Even

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[1] Meeting the criterion of mutual exclusivity is extremely difficult in practice because there are so many different ways to measure performance. For example, an ultimate goal of a transportation system is to provide efficient service (an excess of travel benefits to travel costs). But travel benefits may be measured directly as travel time savings or may be inferred from a less direct measure of travel demand (either measured in modeled trips or less directly as population or employment served). And travel costs can be measured directly as capital and operating costs in dollars, or can be inferred from the amount of capacity provided. Thus, some notion of system efficiency can be created by combining other measures of transportation performance: a demand/capacity ratio can serve as a crude proxy for a benefit-cost ratio.

[2]One approach to the problem of too many measures is to try to get agreement on a few comprehensive measures that seem to capture a lot of different things that people care about. This approach can greatly simplify an evaluation exercise, but it is rarely possible to reflect all impacts that stakeholders want to see measured. Another approach is to include many measures, and have a system for consolidating them into high-order measures of performance. Since multiple measures are in different units, the process for consolidation (also called synthesis or "roll up') usually requires some methods for assigning scores and weights.

presenting all scores together without weighting is an implicit decision that all categories are equal.

2.2 Proposed Evaluation Framework for the Study

How do these principles and procedures apply to the evaluation of investment packages in this study? The next sections provide answers and context for those answers.

2.2.1 Goals and Limitations in the Study

The Study is using a travel-demand model to forecast travel: where people are going, how they get there, and how long it takes them to get there. The model will provide useful data about transportation performance. Data about transportation performance do not, however, describe the full picture, and forecasting 40-50 years (for employment, land use, and transportation) introduces a lot of uncertainty.

To address those limitations, at least partially, the Study is using a population and employment forecast and a land-use model to develop two scenarios for the future of the County. These provide base data for the modeling of future travel, but the Study will not revisit the land use model using results from the travel demand model. In that sense, the Study is not evaluating the impacts on development patterns resulting from the transportation investments.

The investment packages are composed of conceptual projects, not designed facilities. The goal is not to evaluate the performance of particular proposed transportation investments—the forecasts of population, employment, land use, and co-existing transportation facilities are too far into the future to be the basis for designing and planning particular facilities. Rather, the goal is for stakeholders to get a sense of the types of impacts that result from the types of future investments. At the end of the Study neither the County nor stakeholders will pick a package of investments and implement them in full. The evaluation will explore options and inform choices for further evaluation and refinement of the types of projects that stakeholders seek to implement. The Study focuses on individual measurements for discussion, not on aggregating those measurements into an overarching decision making criterion like a benefit-cost ratio.

2.2.2 Proposed categories of investment packages

Three different transportation investment packages are proposed for evaluation. The packages are designed to test varying policy options and reflect divergent investment levels of meeting long-term economic health and quality of life in the coming decades. The packages are not detailed facility plans and policies. Rather, they are combinations of transportation projects: technology upgrades, demand management strategies, transit services, bike/pedestrian facilities, treatments to local roads, and changes to regional facilities. The three packages are:

- **Package A** is intended to assess a policy direction that focuses on transit and demand management and assumes investments adopted in current plans for technology, bike and pedestrian facilities, local roadways and regional facilities. Package A projects are included in Package B and Package C making them common to all packages. However, Package A is not a

base case option in the traditional sense of being a benchmark to evaluated needed "build" mitigation. This study does not include a traditional no-build or base case option as the goal of this study is not to meet a specific set of performance standards like a standard community plan or transportation system plan but rather to assess the general ability of policy and investment choices in each package to support community goals.

- **Package B** is intended to assess a policy focus on adding roadway capacity that is not currently in adopted financially constrained plans, but would be consistent with current policy direction, such as new arterials and widening of existing facilities. This package would help assess the effect of an expanded arterial network, access management and widening on Hwy 217 in addition to the other assumptions in Package A.

- **Package C** is intended to assess a policy focus on additional throughway capacity that is not currently in adopted plans and would require changes to existing policies, such as roadway expansion in rural reserves and expansion of throughways beyond those proposed in regional plans. While Package B focuses on arterial expansion and limited throughway widening, Package C focuses on new and expanded throughways as investment priorities. The throughway focus is intended to direct traffic away from existing arterials and provide alternative access opportunities to the north, south and east. It includes the assumptions in Package A.

Sensitivity tests are included in the options to assess the effect of new technology on traffic flow, road pricing on vehicle demand, and freight facility locations on goods movement needs.

Each package includes assumptions for future investments in technology, demand management, transit, bike and pedestrian facilities, local roadways and regional facilities. All three of the packages exceed revenue forecast for the 20-year horizon and would require additional revenue sources even for the longer 40-50 year horizon. The evaluation process will include an assessment of how strategic these investments are and can help set priorities for a future with limited funding. Funding was intentionally not included as a constraint in the initial definition of packages for evaluation. Study findings may indicate that different combinations of Packages A, B or C are worth further refinement and action.

2.2.3 Proposed framework and categories of impacts (evaluation criteria)

The *primary purpose* of any transportation system is to provide good transportation. Thus, a transportation system needs to deliver on outcomes of transportation performance. Broadly, an urban transportation system should do a good job of enabling all people to reach desired destinations safely, reliably, cheaply, with reasonable amounts of travel time.

But any transportation investments or policies will have effects on more than transportation. Some of those effects can be positive (e.g., on the economy), some are negative (e.g., on the environment). Thus, policymakers must consider *secondary impacts* as well as improvements to transportation system performance.

In addition, the *distribution* of those impacts (by location or group) often matters: an investment package that performs less well in the aggregate may be judged preferable because its distribution of impacts is considered more equitable by decision-makers.

In concept, a transportation investment package that delivers the best mix of transportation impacts might be inferior to one that performs not quite as well on transportation, but better on secondary impact or on the distribution of those impacts.

These considerations suggest the framework shown in Exhibit 2 for organizing the impacts of transportation investments and policies.

The categories of primary transportation impacts are logical, simple, typical of transportation evaluations, and different enough that they are not doing major double-counting. The categories of secondary impacts are more difficult. In particular, it is typical for regional planning efforts to have goals of livability, quality of life, and economic vitality. But the evaluation in this Study is about *transportation's* impacts on those things, and about finding measurements of those impacts. That creates some complications that require careful thinking if one cares about the quality of the evaluation.

Take economic vitality as an example. There is little doubt that transportation improvements can have effects (usually, on net, positive) on economic vitality. Travel-time benefits can directly reduce labor and shipping costs, and indirectly reduce the need to compensate employees so that they will stay despite uncomfortable commutes. System reliability allows households and freight users to plan more accurately and can reduce costs associated with scheduling. Great infrastructure supports vibrant, walkable urban districts. The travel performance benefits are what allow the economy to perform better; they allow growth to occur. Lower travel times, higher reliability, fewer crashes: all these allow people and freight to move better, which makes an urban economy work better and grow faster. Dozens of studies have done research to document what is a relatively obvious link: How could a more efficient transportation do anything but improve economic vitality?

But in a transportation evaluation like this one, most measures of economic vitality are typically expressed in terms of transportation performance (e.g., faster travel times for commuters, more reliable travel times for freight). Those are clearly double-counts of transportation performance benefits. Reporting them again as economic vitality measures adds no new information and would have no impact on the overall rankings of investment packages.

There are other, non-transportation measures of economic vitality, but the structure of this Study does not make most of them practical. For example, one might measure jobs, revenues, value added, or GDP. But this Study is not revisiting employment, population, and land use scenarios after modeling transportation investments. Instead, jobs are forecasted and then the investment packages are tested against how well they provide transportation services for the travel those jobs imply.

Similar arguments apply for quality of life. Better transportation directly improves quality of life by getting people to more places, more quickly, reliably, and safely—those benefits are all captured by travel-performance measurements. They also facilitate different development patterns and types of developments that may improve quality of life, but these are captured under the heading of land use.

Thus, Exhibit 2 shows (1) *quality of life* as an overarching heading that is measured by sub-categories of measurements, and (2) *economic vitality* in screened-back (in grey) to suggest that it is reflected in the primary transportation measurements rather than measured independently.

Exhibit 2: Categorizing the impacts of transportation investments or policies:

Primary Impacts: Transportation System Performance	
Safety	Users want to minimize the risk of injury or death. Safety is a critical feature of the transportation system.
Mobility and accessibility	Everyone's time has value, and users prefer to reach destinations sooner rather than later. Congestion, needing to travel longer distances, or taking slower routes can increase travel time.
Reliability	Users value predictability in travel time. If speeds vary too much, research suggests that users often may plan for the worst-case travel time scenario.
Cost	Users want transportation system benefits delivered in a cost-effective manner. Capital investments, operations and maintenance, and policy changes all entail costs. In addition, users pay private costs for the transportation system.
Secondary Impacts: Other Aspects of Quality of Life	
Economic Vitality	Accounting for economic vitality is usually double-counting travel benefits. Accessing destinations quickly, safely, reliably, and cost-effectively *is* economic vitality. For this study, economic vitality can inferred for the primary transportation-performance measurements and is not evaluated with separate measurements.
Environment	Environmental impacts have long-term consequences that are not always accounted for in policy decisions. Transportation investments can change the amount of particulate-matter and greenhouse gas emissions. Impervious surface can affect water quality and local ecosystems if impacts are not abated. Infrastructure development can impact resource lands.
Land Use and Community	Transportation can also affect local community character by making a place unsafe and undesirable through increases in travel speeds, congestion, air quality, and noise levels.[3]
Health	Users can benefit from investments in active transportation to the extent they walk and bike. Health is also related to air quality, which is influenced by vehicle emissions. In addition, safety impacts health, though safety impacts are accounted for above.
Distribution of Primary and Secondary Impacts	
Equity	The distribution of impacts matter. A dictum of public policy is that the beneficiary should pay: in other words, costs should be distributed in the same way benefits are (short-term and long-term). In practice, this is difficult to calculate technically and determine politically, so often policymakers pay attention to the distribution of costs and benefits across socio-economic groups, communities and geographies, and travel modes.

Source: ECONorthwest

These categories encompass the total impacts of the transportation system. They roughly reflect the principle of comprehensiveness and mutual exclusivity. They also reflect the community values

[3] Safety impacts and air quality impacts are accounted for in other categories of impact, but they can be highlighted as specific impacts on land use and communities.

described in the Study. Finally, they reflect recommendations of hundreds of technical studies and the practice of dozens of regional transportation plans.[4]

The categories in Exhibit 2 are relatively simple and understandable, capture most things of importance, and do not overlap a lot. But Exhibit 2 gives the illusion that everything of interest can be reported in a one-page table. It cannot. If each category has sub-categories, each with multiple measures reported for many different geographies and groups (to address distributional concerns), measurement can grow exponentially.[5]

There is an unavoidable tension between the desires for (1) analytical rigor (which implies a lot of data and complicated models to evaluate them) and (2) simplicity and transparency (a one-to-four-page summary for busy decision-makers, the public, and the media).

The consultant team's recommended approach in the Study is to aim for 2 – 3 measures for each measurement category listed in Exhibit 2. With eight categories, this yields 16 – 24 total measures. Since many of the categories can be seen as mutually exclusive, that system reduces double-counting while reflecting the primary impacts people care about.

Section 3 of this memorandum provides more detail about the measures for the eight categories of impacts.

2.2.4 Proposed methods of consolidating of measurements within categories

The previous section suggests the likelihood of about 20 to 30 measures—two to three measures per category.[6] That means the Study must address the issue of consolidating measures (described in section 2.1.2). Assume that measures have been selected and data collected. What method will this study use to deal with consolidating multiple measurements for a category of impact into an overall assessment of how each investment package performs on that impact? Where consolidation is needed, the study team will use professional judgement and input from the Study Advisory Committee to simplify the reporting of multiple measures.

2.2.5 Proposed method of weighting criteria

People are likely to have different ideas about the relative importance of each impact / criterion category. For example, some people may find safety and reliability to be most important, while others

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[4] For example, guidance documents from AASHTO, FHWA, FTA and ODOT on evaluating transportation systems and projects; Metro's Regional Transportation Plans.

[5] For example, safety can be categorized by number of crashes, by type; those could be subdivided into damage to people or property; and damage to people could be measured as deaths or injuries in many ways (per year, per capita, per mile traveled, etc.). Moreover, impacts of crashes on people are a function of crash rate and crash severity. Should one treat all accidents as being equal and look only at crash rates? A high-speed crash that is likely to result in a fatality should be considered worse than a low-speed crash that results only in injury. Transportation investments that greatly reduce crash severity while only marginally reducing crash rate might not appear to be beneficial if one just looked at crash rate. Should one instead only measure crashes that result in at least one fatality, while ignoring non-fatality crashes?

[6] In fact, Section 3 has a total of around 25 measures: the study team may try to reduce that number after review by the Combined Planners Group and the Study Advisory Committee.

find environment, health, and equity most important. This makes rolling-up measurements or scores into an overall assessment of investment packages politically and technically difficult.

But the nature of this Study, unlike most transportation evaluations, is such that weighting among categories is not strictly necessary. Why not?

Most transportation evaluations are done with the intent to adopt a plan or project / investment list. The fact that some type of decision is being made means that decision-makers should want to know which alternative has the best performance overall, which requires weighting the relative importance of different categories of decision-making criteria. But this is a Study not intended to be adopted as a plan. It is investigating futures and project and policy options, and stops there. The intent is the results of the study will help to inform future policy decisions about transportation (e.g., the next Transportation System Plan or Regional Transportation Plan) or even land use.

Thus, the Study will not do formal weighting of measurement categories or individual measurements. It will, however, generate some information about their relative importance based on input from the Study Advisory Committee, other stakeholder groups, and the public as they describe their views about the different transportation investment options through the review of the final report (see next section).

2.2.6 Use of measurements

The Study is not resulting in an adopted plan. It is investigating futures and project and policy options, and stops there.

To facilitate this process, the measures will be used in a public discussion on trade-offs and implications. During this public discussion, it is likely that stakeholders and members of the public will weigh in on the relative importance of these measures to each other. The public conversation is the appropriate forum for people to discuss which of the categories they find to be most important and why, and how this fits into public policy. This will be important input to future decisions based on the Study findings.

4. MEASUREMENTS

Section 2 discussed several issues related to framework and methods. Among its conclusions:

- Evaluation means providing information about things people care about—that means *measurement.*
- For most public policies or investments, people care about dozens or hundreds of things. To make sense of measurements, they have to be grouped *categories of measurements,* which are simultaneously categories of *evaluation criteria.*
- To remain understandable, an evaluation should have no more than about 10 categories of performance measurement / evaluation criteria. For this Study, Exhibit 2 recommended eight categories for assessing the relative performance of combinations of *investment packages* and *growth scenarios.*

- The more measurements there are in each category, the harder it is to assess the overall performance of each alternative (investment package) in that category without having some process for *consolidating measurements* within the category (using either quantitative methods, like scoring, or qualitative methods, like group discussion and consensus).

- Because this study is not making policy decisions, but only trying to understand possible futures in the County and the implications for the performance of its transportation system, it may not need to consolidate measures into category scores. But if it does not, discussion of individual measurements will be easier to the extent their numbers are smaller (20 to 30) rather than larger (50 to 100).

- Social equity is a community value and is applied as an overarching performance measure in the Study to indicate whether all people benefit from the future transportation investments considered. Use of a potential segmentation for areas defined as low-income is one way to comparatively measure the distribution of potential impacts across Washington County.

This section goes into more depth on the measurements for this Study. It is organized by measurement category (per Exhibit 2). For each, it recommends and describes a few specific measurements that the study team believes do as good a job as possible at being simultaneously comprehensive (covering important things that people involved with this Study want to see addressed) and mutually exclusive (reducing the amount of double counting—i.e., of having measurements that are different ways of measuring the same effect). Given eight categories and an objective of 20 to 30 measurements, that means trying to adequately describe each performance category (e.g., safety, economic vitality) with just two or three measurements.

It is no challenge to generate hundreds of measures in theory. It is easy to describe 5 to 10 different measurement in each of the eight categories, and to describe 3 to 5 different ways those measurements could be specified (e.g., as a % of total, as per capita). Moreover, for most measurements people may want sub-measurements of their distributions, that is, how different segments of the county might be impacted differently. In WCTFS, potential segmentations for the measurements include:

- Sub-area/community: Approximately 8-10 combinations of the Washington County transportation analysis zones (TAZs) used in the travel-demand model[7]

- Cut lines or facility: Trips that or use particular roads

- Mode: Auto relative to non-auto trips

- Income: TAZ-based subarea zones that are at 80%-120% of base year (2010) median income

- By roadway classification: arterials, collector

[7] The travel-demand model forecasts travel between hundreds of travel zones in Washington County. Each zone contains a number of households and number of jobs. Our geographic analysis will rely on these zones.

- By trip purpose: work trips relative to non-work and truck trips
- By time of day: all day, am or pm peak

Taking the midpoint of those estimates would mean that one would have over 1,000 individual numbers for each of six combinations of investment packages / scenarios. No one could make sense of that without consolidation of measurements by some scoring algorithm, which would imply weighting the importance of individual measurements.

Thus, the study team sees its task as making recommendations, and providing reasons for those recommendations, on two or three measurements for each of eight categories of measurement that best capture performance on the issue of importance being addressed, and on a few ways such measurements might be most usefully segmented. The sub-sections that follow describe what each measurement category is about, and then describe the recommended measures and segmentations.8 A final table at the end of this section summarizes the recommended measurements. In addition, example matrices at the end of this section show how results and segmentations could be displayed.

3.1 Safety

3.1.1 What is it?

Many elements of the transportation system are dangerous. In 2011, Washington County had an estimated 6,600 crashes resulting in 13 fatalities. Speed, darkness, and wet conditions were the primary contributors, but many other factors also contribute to transportation safety. Washington County has a diversity of vehicle transportation infrastructure conditions: rural roads, downtown streets, wide cul-de-sacs, and leisure boulevards. Cyclists can ride on regional trails, in urban districts, through parks, and next to busy arterials. People walk to and from many places. In the course of travel, people want to feel safe and *be* safe.

3.1.2 Recommended Measures

Risk of crash fatality (VMT over 40mph)	**Possible Segmentations** Sub-area Roadway Classification

Crash severity diminishes with vehicle speed: a 20-mile per hour crash is less likely to severely injure or kill a person than a 60-mile per hour crash. Research suggests that at speeds over 40 miles per hour, risk of fatality increases sharply. Any areas with high travel speeds increase risk of severe injury or death. This measure is the total amount of VMT traveling along roads with average speeds over 40mph during three separate periods throughout the day: AM peak 2-hour, midday 1-hour, and PM peak 2-hour. It reflects total exposure to higher speed travel. Freeways, Arterials and local streets have varying rates of

[8] We have to limit segmentations. Every different way to segment a measurement doubles the number of measurements that must be made and, more difficult, integrated into some overall evaluation. In this Study the problem is a little more manageable because final choices about projects, investments, or policies are not being made. Thus the segmentation measurements do not have to be integrated into a score or weighted. Rather, they are just part of a potentially large database that people can query if they want information about a particular type of segmentation that the database has available.

fatal crashes due not only to the travel speed but also the design of the roadways. To account for this the VMT over 40 mph will weighted by the crash rate for each roadway type.

Potential crash exposure (Total VMT)	**Possible Segmentations**
	Equity Sub-area Roadway Classification

Vehicular activity of any speed increases the exposure of people to the risk of crash. This measure is the total amount of VMT independent of speed on roads during three separate periods throughout the day: AM peak 2-hour, midday 1-hour and PM peak 2-hour. It reflects total exposure to vehicular activity.

3.2.3 Methodological issues

The tools used in the Study do not forecast actual crash rates. The measures will rely on the correlation of vehicular travel to occurrence of crashes and rely on the travel-demand model to output the amount of travel.

A measure of infrastructure seismic resilience was considered—how many bridges might fail in the event of an earthquake? We ultimately recommended against this measure because the number of deaths that might occur as a result of bridge collapse (cars on the bridges) is so uncertain. However, seismic resiliency will be included in the cost analysis for all new transportation facilities.

A measure of systemic resilience was also considered—how well might the system perform in the case of a major catastrophic event? This might reflect the true impacts of a major seismic event: not just how many people were on collapsed bridges but how well could first responders travel if bridges or other arterials failed? This is an important question, and it essentially is a measure of redundancy. We recommended against a new measure for this because we are already measuring benefits from system redundancy in the form of reduced travel times and increased reliability.

Measures of the percentage of improvements to high risk roadway, pedestrian and bicycle facilities was considered—how well is each package addressing existing high risk areas? These measures were dropped as they focus on existing high risk areas that may already be addressed through planned projects and does not address the future needs of the County.

For the two measures on safety investments, the segmentation by sub-areas will reflect where the safety investments are made. Segmentation by travel speeds will reflect exposure to risk, not the physical location of the roadways with high average speeds.

3.2 Mobility and Accessibility

3.2.1 What is it?

In the context of Study, mobility means accessing desired destinations quickly. Ultimately, this is a function of travel time: how much time is needed to travel from one point to another. Congestion on major throughways, needing to travel great distances, or taking slower routes can reduce travel time. Faster transportation means time spent elsewhere: with friends/family, at work, shopping, or otherwise

in leisure. Most places in metropolitan areas are accessible via car in some way, but not all are accessible via transit. Investments that minimize growth in travel times and increase transit accessibility contribute to mobility.

Recommended Measures

Travel time benefits for all trips

Possible Segmentations
Equity
Mode
Regional
Sub-area

This measure reflects the aggregate benefits to all users, in all modes, using the transportation system. Travel time benefits are how quickly people get to desired destinations under one set of transportation conditions relative to another set. This measure represents how much time people spend traveling during the peak periods. If the amount of time doesn't change as a result of changes to the infrastructure, mobility benefits are the same. The measure can be segmented according to geography, and travel mode. Little variation was found at regional and sub-area analysis level. Additional analysis of travel time for specific origin and destination pairs was completed for transit, auto and freight

Transit Coverage (Accessibility to transit)

Possible Segmentations
Equity
Sub-area

Almost all places within the County are accessible via road, though travel times might vary. Not everywhere is accessible via transit, and the different investment packages can offer different levels of access throughout the county. One way to measure transit access is the number of different transit stops, weighted by weekly frequency of service and by number of households and jobs within ¼-mile walking distance of a local bus or HCT service. Overall, more stops served by multiple and frequent route service provides more people greater access via transit. The number of households is an approximation, due to TAZ level reporting, but GIS and Place Palette tools may support more granular analysis.

Active Transportation Accessibility

Possible Segmentations
Equity
Sub-area

One way to measure pedestrian and bike network access is the number of households and jobs within ¼-mile walk or bike ride from the county's planned network of sidewalks, bikeways and multi-use paths. This study is not looking specifically at the quality or performance of bicycle infrastructure. The tools used (50-year population and land use forecast, TAZ-level reporting, County-wide transportation investments) don't support a more granular analysis. However, these tools help understand at an area-wide level how the combination of complete arterial and collector streets and connected pathways and trails provide Washington County residents increased walk and cycling mobility and access to key destinations and daily services.

Roadway Network Completeness

Possible Segmentations
Equity

	Sub-area Roadway Classification

Roadway completeness was a measure the team considered for assessing how well the design of the local and regional transportation network contributes to mobility for travel. For developing a roadway completeness measure for the Study, the team looked to RTP policy for the region and County TSP guidelines that place emphasis on ensuring that arterial networks are fully developed as the region grows, and that accommodate both local circulation and preservation of regional highway capacity. These resources outline general spacing standards for the grid of arterial, collector and local streets to encourage the minimization of local traffic on regional arterial streets and local street connectivity for improved emergency response.

Since the network completeness measure is an assessment of the road network grid down to the local street level, it was determined that the results would not show meaningful differentiation between the Investment Packages since none of them include local street concepts. This measure was therefore dropped from the recommended list for evaluation.

Number of households within 30 min vehicle commute or 30-min transit commute of select employment zones during the 2-hour peak period	**Possible Segmentations** Equity Mode Employment zone Sub-area

Access to a diverse labor force is an attractive resource to employers. It allows them to draw on more potential workers, and it should correlate with overall access to jobs for County residents. For this measure, the County will identify several key employment zones in Washington County in 2055. This measure will reflect the total number of workers within 30-minute commute by auto or transit of these areas. These employment zones will be identified.

Methodological issues

Travel time benefits are an outcome from the travel-demand model. Transit system coverage is a feature of the investment package, not a travel outcome. The model will estimate demand for travel in typical weekday, but it does not account for atypical travel situations in which people might use transit. People are less likely to use transit if it isn't available in their neighborhood.

Mode-share was considered as a measure in this category, but we recommend against a separate measure of mobility and instead measure the benefits of mode share in terms of the environment (reduced GHG emissions) and health (improved air quality and active transportation).

A measure of vehicle-trips reduced was also considered. It's a standard measure, but we recommend measuring the benefits of reduced vehicle trips in other measures. If fewer people drive, it means they found better alternatives, which will be reflected in travel-time benefits. Reduced VMT helps GHG emissions, measured in the Environment category and local air quality, measured in the Health category. In sum, the benefits of reduced vehicle trips will be reflected in the evaluation in other measures.

Assessing roadway completeness can be done by comparing the density of roadways and intersections under each transportation investment package to current Washington County network levels.

All of the measures above can be segmented by low-income community and sub-area. Travel-time benefits and labor-force access can be segmented by mode. Roadway completeness should also be segmented by road classification.

3.3 Travel-Time Reliability

3.3.1 What is it?

People care about the reliability of the transportation system in many different ways. Commuters attempt to plan trips to and from work. Transit riders depend on timely arrivals and departures. Freight users rely on a predictable window of time in which shipments can be quickly made from one place to another. An unreliable transportation system affects everyone.

3.3.2 Recommended Measures

Travel-speed variation for trips on key facilities	**Possible Segmentations** Mode Sub-area Roadway Classification

Travel time variation from day to day greatly frustrates users. Research suggests users plan around the worst-case scenarios, so a highly variable transportation system isn't much better than one consistently slow. Variation in travel speeds will correlate with variation in travel times for the same trips. Variation in travel speeds are a function of congestion levels: highly congested and not congested corridors can offer reliable travel times while moderately congested corridors frequently vary from day to day. This measure will look at travel-speed variation for four key facilities during the 2-hour PM peak. It will be reported as a variation from uncongested free flow travel speeds, that is, a traveler might expect to travel a certain speed when there is very little traffic, but on any given day during peak periods, they might travel much more slowly.

Transit demand-to-capacity ratio for transit during peak PM	**Possible Segmentations** By corridor or subarea

When demand exceeds supply on many transit systems, lines become congested and the system experience delays. Riders may have to wait for future trains or buses. These impacts are separate from impacts created by roadway congestion. Demand-capacity ratios, which show how demand for transit compares to supply, can reflect this. For this measure capacity is considered the achievable capacity per transit vehicle as provided by TriMet. Reliability for transit vehicles that travel in mixed flow with regular traffic is reflected in the previous reliability measure. Ratios above 0.8 indicate that some users may choose not to board the first available transit vehicle. Ratios between 0.8 and 0.5 indicate service is adequate for demand. Ratios below 0.5 indicate additional capacity is available to accommodate increase transit use.

Number of hours during the day in which demand-to-capacity ratios for select gateway areas is below .8	**Possible Segmentations** Gateway facilities

Many businesses in Washington County rely on freight to export goods or import production inputs. Entering or leaving the County with goods requires using several key gateway facilities, such as highway 26, Cornelius Pass, and I-5. When these facilities become too congested, travel times into and out of the county become unreliable. This is particularly problematic for freight users, who plan upstream and downstream production processes around a "freight window," outside of peak travel commute periods when goods can be moved efficiently and reliably. These facilities can experience congestion with can compromise reliability. Reliable travel time during a consistent portion of the day is important for economic efficiency in the county as freight companies can generally plan freight movements outside of peak commute periods when congestion can impact the travel time reliability of the transportation system. Demand to Capacity (D/C) ratio is an estimate of how close travel demand is to the capacity of a given roadway. A roadway operating at capacity would have a D/C ratio of 1.0 and is heavily congested with slow travel speeds. D/C ratios above 1.0 indicates a roadway with demand beyond the capacity of the roadway indicating an inability to serve traffic demand during the time period with congestion extending into adjacent time periods. D/C ratio above 0.9 is generally reliably congested but provides poor travel times unacceptable for freight. D/C ratios between 0.8 and 0.9 may not be able to accommodate variation in travel demand and may breakdown resulting in unreliable travel time. A D/C ratio below approximately 0.8 serves as a reasonable estimate of the available window for reliable freight travel as it generally represents a roadway with enough available capacity to accommodate variations in day to day travel demand and provide a reliable travel time. Some of these gateway facilities are currently known, and future gateways or key travel screenlines will be identified after reviewing travel demand model results.

3.3.3 Methodological issues

Reliability for transit systems separated from regular vehicle traffic (such as light rail or separated bus rapid transit) is a feature of the packages and will be hardcoded into the model.

We considered a measure showing variability throughout the day, such as comparing travel times in the peak AM relative to the PM. We rejected this because this is not the type of reliability that most commuters find frustrating: variation from day to day during their normal routine. Users can plan for different travel times for different types of trips at different hours, but when the same trip at the same time one day takes twice as long one day relative to another day, the system becomes unreliable.

The final measure on the 'freight window' was discussed in depth. While it does not necessarily reflect travel times between different parts of the County, one of the key factors influencing travel-time reliability that the packages will impact are the gateway facilities. The packages will likely not significantly impact travel patterns beyond Washington County, and even the mobility benefits within the County can be negated by poor reliability at the gateway facilities. Moreover, the number of potential port facilities and origin TAZs in Washington County is very high and presents a technical challenge in both measuring and making sense of them. This particular measure serves as a reliable proxy.

A measure of lane miles of congestion was also considered. This might represent total burden on the system and could reflect impacts to freight. However, we recommend measuring that through the mobility and existing reliability measures, because congestion will impact travel times and reliability. It will prevent people from getting where they need to go; that is the heart of mobility benefits. To isolate impacts on good movement, total lane miles of congestion also don't reflect *where* and *when* congestion occurs. Some congestion can be good: slower travel in downtown urban walkable districts is safer and more pleasant. Both have huge impacts on goods movement. Finally, we focused on gateways because existing measures primarily reflect movement within the County, not movement into and out of it. This should capture impacts on freight users in Washington County.

Segmentation of vehicle (private and bus) reliability measures can be done by transportation corridor, but it would be misleading to segment by low-income community or sub-area because not all trips from those places will take those particular routes. Overall reliability for low-income communities is measured in the equity category. Segmentation of the demand-to-capacity ratio for exclusive right-of-way transit would also be misleading, because the ratio reflects a system-wide condition, not necessarily conditions that apply to a particular rider. The modeling tools do not support accuracy at that level of detail.

3.4 Cost

3.4.1 What is it?

Any benefits of an investment should be considered in the context of the investment's cost. The transportation system has public costs and private costs. Public costs cover capital projects, ongoing system maintenance, and transit system operations. These are funded primary through taxes and user fees. This category will reflect capital costs: planning, design and construction. Maintenance, and disposal costs are not included.

3.4.2 Recommended Measures

Capital costs (constant $2016 dollars)	**Possible Segmentations**
	Mode

Most transportation investments have one-time, non-recurring costs associated with the implementation of a plan, project, or action. These costs include right-of-way acquisition, permitting, design and engineering, construction, buying new vehicles and policy advocacy. Costs will be estimated generally as a function of different types of investments in the package: miles of freeway, arterial, collector, LRT tracks, bike lanes, sidewalks, lane management. Each will have a different per-mile, per-vehicle, or per-facility costs that reflects all of the above. Costs will be estimated assuming full build-out in 2055 and will be reported in constant 2016 dollars.

Average annual operating costs as a percentage of regional personal income	**Possible Segmentations**
	Mode

Most transportation investments also have ongoing costs. Roads need to be maintained. Transit systems need drivers and vehicle maintenance. This indicator reflects these annual investments. It will be

reported as a percentage of annual regional personal income to reflect what share of the economy is needed to support ongoing transportation costs. Annual regional personal income can be estimated for each scenario. The measure was eventually dropped because the scope of the study does not include the full regional transportation costs making the comparison incomplete.

3.4.3 Methodological issues

The above costs encompass all relevant costs used in a cost-benefit analysis. Other impacts can be monetized, but they are technically considered benefits, not costs. Forecasting transit fares out fifty years would be misleading, and the total cost of fares is included in operating costs. The amount in total dollars can be reported in per-capita measures or as a percentage of regional Gross Domestic Product.

We considered reporting both costs in constant dollars, but we recommended against this for two reasons. First, readers will be tempted to add up the costs, but such a measure would be misleading because costs haven't been discounted to adjust for inflation. Doing so would require assumptions about when different package elements would be built and over what time period. This is a level of detail not supported in this study. Second, readers might be tempted to develop a per-capita or per-household cost, but this would also be misleading, because transportation system costs are not distributed evenly across the population, nor limited to residents. Revenues throughout the region and the state will contribute to projects. We recommend keeping the measures separate and reported as suggested.

We considered the dollar value of private costs for vehicle operations and maintenance, but recommend against it for two reasons. First, the framework explains the reasoning for not doing a full benefit-cost analysis. In such an analysis, private operations and maintenance costs would be included in the generalized cost function of the transportation model, and they would be considered in the estimates of net travel-time benefits. If they are not considered in a proper benefit-cost framework, then they can easily be misinterpreted. For example, one could reduce private vehicle costs by failing to investment in highway maintenance or construction, or by spending all transportation funds on public transit. Second, savings are relatively modest. Segmentation of costs by low-income community or sub-area would be misleading. Spending in particular areas does not equate to benefits exclusively in those areas. Moreover, spending in particular areas does not mean funding from those areas. Such segmentation would reflect neither benefits of the project, which are captured in many other measures, nor a cost burden to any particular user.

3.5 Environmental Sustainability

3.5.1 What is it?

Transportation impacts the environment in multiple ways, and many areas of policy and engineering focus on mitigating these impacts. Environmental sustainability reflects the transportation investment's ability to reduce pollution levels, reduce the runoff caused by impervious surfaces, and retain natural resource lands. Impacts can be long-term and at a large scale, such as emissions that contribute to climate change. They can also be highly local and near-term. Many transportation projects today can have positive benefits for the environment because they are required to mitigate impacts at stricter

standards than those required in the past. Ecosystem health and storm water runoff are particular examples. In many ways, the legacy transportation system can cause the most damage because those requirements were not in place when the facilities were built.

3.5.2 Recommended Measures

Green House Gas (GHG) Emissions	**Possible Segmentations** Equity Mode Sub-area

Vehicle Miles Traveled (VMT) is a key factor in estimating GHG emissions because the amount of travel (quantified by VMT) is a direct driver of fuel consumption, which is the primary generator of transportation emissions. There are several variables such as vehicle type and fuel source that impact the rate of emissions per mile that emissions models such as MOVES and GreenSTEP can account for if emission estimates are required. For this long-range study, estimating an accurate level of transportation emission would be difficult to do even with such emissions models given the large variability in input factors to those models over a 40 to 50 year time frame. What is more feasible for this long rang study is to estimate if transportation emissions are likely to go up or down from one package to the other, which is primarily driven by VMT. Additionally, other factors that influence emissions such as vehicle type and fuel mix are less likely to vary across the land use scenarios and transportation packages being evaluated.

Impacts to Natural Resources	**Possible Segmentations** By facility type and specific facilities

One of the ways to measure environmental impacts is by determining where critical habitat, riparian areas and wetland areas are impacted by the contributing impervious surface of the investments that are being evaluated for the Study. The amount of surface area contributed by the transportation investments serves as a proxy for the stormwater abatement and any impacts to natural resource areas that will require mitigation. New surface area can be calculated by assigning amounts of new impervious surface to the investment packages based on County standards for roadway width by classification. GIS-based habitat area of Title 13 Inventory lands represent areas of potential impact. Title 13 lands are significant natural areas as defined under Metro's 2014 Growth Concept and Regional Framework Plan.

VMT as a portion of PMT as a measure of efficiency of vehicle trips	**Possible Segmentations** Region Sub-area

One additional way to estimate differences in emissions levels is to look at the portion of total passenger-miles traveled (PMT) that are generated by the amount of vehicles (VMT) occurring in the system. If two people carpool, then VMT is only half of their PMT. If one third of travelers ride the transit system and the two thirds are in single-occupancy vehicles and both groups travel the same distance, then VMT is two thirds of PMT. Moving more people using less VMT is a mechanism for reducing GHG

emissions and other environmental impacts of vehicles. This measure was found to be so close between packages that they are considered identical. As a result, the measure was dropped from the analysis.

3.5.3 Methodological issues

The study can include assumptions about rising fuel efficiency and greater availability of alternative fuel vehicles, but any such assumptions should account for emissions associated with alternative fuel energy generation. Some studies include the amount of impervious surface associated with transportation investments, but the sheer amount of impervious surface does not accurately reflect impacts on water quality.

Segmentation of natural resource impacts by low-income community and sub-area was considered as a means to assess where potential stormwater abatement would take place. The determination was to drop these two segmentations and instead measure natural resource impacts by facility type and compare specific facilities, as certain Investment Package projects classified as regional highway and/or arterial facilities are estimated to require considerably larger amounts of new impervious surface than others. Segmentation using low-income areas and subareas is recommended for the other two measures to reflect the experience of the households in those geographies: their level of GHG emissions and the portion of their PMT that is VMT.

3.6 Land Use and Community

3.6.1 What is it?

Transportation has short-term and long-term impacts on communities. In the short-term, travel can affect community character by increasing danger, noise, and air pollution. These affect residents as they relax in their yards, walk their kids to school, enjoy meals together, play sports, etc. These impacts, in turn, make communities less attractive. In addition, transportation investments themselves can consume agricultural and resource lands. In the long-term, transportation investments have a complex long-term relationship with land use that planners and policymakers have been studying for years. Travel benefits that result from transportation investments can make land more attractive for development, catalyzing land use changes.

3.6.2 Recommended Measures

Cut-through traffic **(ratio of VMT on collectors for preferred routes v. equilibrium)**	**Possible Segmentations** Equity Roadway Classification Sub-area

Cut-through traffic frustrates communities across the US. It can impact suburban communities as people use local streets to avoid congested primary travel routes. It can also impact rural communities as people use rural roads to avoid primary travel routes. These can make roads unsafe, raise noise levels, and change quality of life. This measure will estimate the amount of VMT on collectors that are attributable to normal, expected use by local residents to make their own daily trips. The travel-demand model will have a model state in which all routes are assigned as if no routes were congested. Once the

model reaches equilibrium and all routes are assigned after considering congestion levels, then extra trips on collectors will reflect new trips that resulted from congestion levels. These are the cut-through trips transportation investments might seek to reduce.

Alignment with local land use plans and policies (qualitative assessment)	**Possible Segmentations** Equity Sub-area

The RTP is consistent with local land use plans, but the packages that add facilities beyond that might vary in how well they support or conflict with community visions. There are many reasons that transportation investments can support community visions. This measure will be a score assigned by the County and consultant team that reflects the following factors:

- Alignment with regional transportation policy
- Limits on throughway lanes
- Impacts on designated agricultural land
- Improving access and walkability in mixed-use districts
- Improving roadways designated for heavy use
- Consistency of functional classification in local plans with forecasted demand
- Potential to increase development pressure inconsistent with adopted plans, such as in rural cities and agricultural areas

Mode Split	**Possible Segmentations** Regional Sub-area

Mode Split is a measure of how well the modes (auto, transit, freight, bicycle and pedestrian) of the transportation system serve the land uses. Urban areas with denser land uses are more efficiently served by pedestrian and transit oriented transportation system compared to more rural areas agricultural uses. The travel demand model calculated mode split based on trip types and the attractiveness of the modes of transportation. The County as a whole, as well as sub-area of the county will be evaluated for alignment of the transportation mode choice with land uses.

3.6.3 Methodological issues

The tools used in this study will not model the changes in land use that result from transportation investments, but the investments themselves can offer insight into how development might occur, given transportation investments.

The measure of cut-through traffic discussed above is not 100% accurate, because many collectors are intended to support moderate levels of spillover travel. Not all VMT on these roads from these

measures will be undesirable or unintended cut-through traffic. However, this should not drastically change how the packages score relative to each other.

Both measures can be segmented by the low-income communities and sub-areas that are impacted. This will reflect where the cut-through traffic takes place and where transportation is aligned with land-use.

3.7 Health

3.7.1 What is it?

Transportation systems can influence human health in multiple ways. Particulate matter emissions have highly local effects on respiratory health, and a large body of research has focused on measuring and mitigating these impacts. In addition, active transportation infrastructure can influence physical activity levels in a community. Active transportation modes are generally considered to include all non-motorized modes, such as biking and walking, and to a degree transit (which must often be accessed by foot or bike). Biking to work, shopping on foot, walking to nearby transit stops are all considered physical activity, which has been shown to increase both physical and mental health.

3.7.2 Recommended Measures

Local air quality (vehicle hour of delay)

Possible Segmentations
Equity
Sub-area

Particulate matter from vehicles can lower local air quality and impact residents, particularly children and those with medical conditions. It can also impact resource lands. Air quality impacts will be a function of Vehicle Hours of Delay (VHD): the more hours an engine operates the greater particulate matter generated.

Overall non-auto mode share

Possible Segmentations
Equity
Sub-area

A shift in future walk and bicycle travel brings additional health benefits for users as well as reducing the amount of vehicle trips. As physical activity goes up, related disease rates go down. The overall non-auto mode share is a measure of the daily physical activity in Washington County related to non-auto travel.

Trip Length

Trip length is a measure of how the transportation system to support shorter local trips compared to longer regional trips. Both the development scenarios evaluated in this project are designed to create nodes of development that are less dependent on longer regional trips. This measure will evaluate the transportation packages alignment with the land use patterns in Washington County only.

3.7.3 Methodological issues

The project team will assume some level of electric vehicle (EVs) penetration. EVs do not have the same particulate matter emission dangers that other fuel vehicles do, though the electricity generation itself does generate GHG. The penetration of EVs will impact assumed particulate matter emissions.

A measure of stress was considered to reflect the psychological toll of poor transportation system performance. We recommend against a separate measure because this will be reflected in mobility and reliability measures. Positive travel-time benefits and a reliable system will reduce stress.

Segmentation of particulate matter emissions by low-income community and sub-area will show total emissions occurring within the community, not attributable to trips originating from the community. This will require some assumptions about the distribution of households within each TAZ, because air quality impacts are highly localized. Segmentation by low-income community and sub-area for non-auto mode share will reflect mode share for households within those areas.

A Health Impact Assessment tool may be utilized in the study process and could result in other evaluation measures for health, such as minutes of physical activity.

3.8 Equity

3.8.1 What is it?

Overall measures of system impacts are important, but policymakers care about how these impacts are distributed among different users and different communities. Historically, many marginalized communities have experienced negative impacts of transportation investments while not significantly benefiting from them. The measure reflects the primary benefits of the transportation system: being able to get to desired destinations and can be applied.

3.8.2 Recommended Measures

Low-income communities

Transportation investments that do not benefit low-income communities while benefitting high-income communities are not considered equitable policymaking. This measure will look at how much travel-time benefits accrue to low-income TAZs (lowest quintile) relative to high-income TAZs (highest quintile). The measures are a segmentation evaluation and can be applied to all other measures.

3.8.3 Methodological issues

Travel time benefits cannot be calculated for bicycle and pedestrian modes, but they can be for transit. The models used are not designed to calculate travel times for non-auto, non-transit modes. There are measures that reflect benefits to non-auto and non-transit users, including active transportation and number of bike-lane miles. Moreover, the packages themselves were designed to invest heavily in both bicycle and pedestrian modes.

In the data appendix, almost all measures proposed in this document can be segmented according to Low-income communities. The Recommended Measures above represent particular ways to think about equity that are relevant to evaluation and condense the number of data points needed to evaluate impacts.

The table below summarizes the key measures recommended in this evaluation. All measures will be reported out at 2055, after full buildout. In addition, measures will be reported out relative to Package 1. Absolute measures will be difficult to interpret without a separate baseline value.

Category	Performance Measurement		Tools	
	Concept	Measure and Data Needs		Segmentation
Safety	Risk of crash fatality	Surrogate for fatality risk. Vehicle miles traveled (VMT) with average speeds above 40mph during three time periods (AM peak 2-hour, midday 1-hour, PM peak 2-hour).	Travel-demand Model	Rodway Classification and Sub-area
	Potential crash exposure	Surrogate for crash exposure. Crash rate potential by roadway classification, based on VMT during three time periods (AM peak 2-hour, midday 1-hour, PM peak 2-hour).	Travel-demand Model	Rodway Classification, Equity and Sub-area
Mobility and Accessibility	Travel time benefits	Travel times by package for auto and freight trips into, out of and internal to Washington County during three time periods (AM peak 2-hour, midday 1-hour, PM peak 2-hour). Little variation found at regional and sub-area analysis level. Additional analysis of travel time for specific origin and destination pairs was completed for transit, auto and freight during the PM peak 2-hour to identify differences in packages.	Travel-demand Model	Mode, Equity, Regional and Sub-area
	Transit coverage	Number of households within ¼-mile walking distance of a local bus or HCT service transit stop weighted by transit frequency (frequency as defined in the package).	GIS	Equity and Sub-area
	Active transportation accessibility	Number of households in the county within ¼-mile walk or bike ride from a 'Complete Street' for each Investment package based access to the bike and pedestrian network using Place Palette as surrogate for Active Transportation destinations (land density and mix).	GIS	Equity and Sub-area
	Road network completeness	Proposed road network (using RTP network concept and WaCo TSP network buffer) compared to local and regional system completeness guidelines. Preliminary assessment indicated little or no difference between package and measures was eliminated.	GIS	Equity, Sub-area, Roadway Classification

Category	Performance Measurement		Tools	
	Concept	Measure and Data Needs		Segmentation
Mobility and Accessibility	Labor force access to jobs in Washington County	Number of households within 30-min auto commute or transit commute (travel time at peak) of select employment zones for the PM peak 2-hours.	Travel-demand Model	Mode, Equity and Sub-area
Reliability	Travel time reliability	Surrogate for reliability. Average travel speed variation between uncongested and congested conditions, in mph, within Washington County during 2-hour PM peak travel period.	Travel-demand Model	Mode, Sub-area, Roadway Classification
	Trip reliability for transit users	Surrogate for reliability. Transit demand-to-capacity ratio for specific HCT and bus routes. County-wide measure is composite average D/C ratio for each stop by number of trips serving stop from all routes.	Travel-demand Model	Specific Routes
	Freight reliability to Port of Portland	Surrogate for reliability and duration of congestion on freight routes to PDX. Evaluation of AM 2-hour, Mid-day 1-hour and PM 2-hour demand-to-capacity (D/C) ratios. Freight is movement is considered reliably if D/C ratio is less than 0.8. Modified to include volumes and D/C ratios on screenlines.	Travel-demand Model	Specific Roadway Links, Screenlines
Cost	Capital costs	Estimated cost of building transportation facilities in constant dollars	Metro Cost Spreadsheet	Mode
	Operating and maintenance costs	Estimated annual operating and maintenance costs for package elements in 2055 as a share of annual regional household income in 2055. Preliminary assessment indicated little or no difference between packages and measures was eliminated.	Excel	
Environmental Sustainability	GHG Emissions	Surrogate for direct emissions calculation. Total VMT weighted by vehicle type.	Travel-demand Model	Equity, Mode, Sub-area
	Impacts to natural resources	Analysis of where known critical habitat, riparian areas and wetland areas are impacted by the contributing impervious surface of the Investment Packages. Habitat area overlay taken from Metro-sourced and Washington County-sourced Title 13 Inventory lands to represent areas of potential impact	GIS	Equity and Facility type

Category	Performance Measurement		Tools	
	Concept	Measure and Data Needs		Segmentation
	Efficiency of vehicle trips	Overall personal VMT as a portion of overall PMT. Preliminary assessment indicated little or no difference between packages and measures was eliminated.	Travel-demand Model	Region, Sub-area
Land Use and Community	Cut-through traffic	Ratio of VMT on collectors in congested conditions relative to VMT on collectors assuming no congestion	Travel-demand Model	Equity, Sub-area, Roadway Classification
	Consistency with Land Use Plans	Consistency with local/County land use plans including functional class, agricultural land, urban reserves, and town centers	GIS	Sub-area
	Mode split	Mode split countywide	Travel-demand Model	Sub-area, Regional
Health	Local air quality	Surrogate for air quality. VHD by vehicle class for local emissions	Travel-demand Model	Equity, Sub-area
	Transit and active transportation	Overall non-auto mode share used to calculate changes in the minutes of physical activity. Preliminary assessment indicated little or no difference between packages and measures was eliminated.	Travel-demand Model	Equity, Sub-area, Regional
	Trip length	Short trips that could be shifted to active transportation.	Travel-demand Model	Washington County
Note: All measures evaluated for Washington County				