THE COSTS OF ALTERNATIVE LAND USE PATTERNS

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1.0 INTRODUCTION

Transportation planning professionals today are being challenged not only to perfect their transportation plans, but also to put those plans into the larger context of community development. Just as transportation projects are subject to scrutiny for their costs and benefits, so are the community development plans of which these projects are a part.

This paper offers a way for planning professionals to think about this larger context. We introduce an accounting framework, which we believe offers planners and policymakers a summary of the costs and benefits associated with infrastructure investments, including but not limited to transportation. Costs include both public and private costs, and both capital and operating costs. Some of these may be denominated in dollars; others cannot.

In subsequent sections we describe in more detail a simple spreadsheet model which enables planners to estimate, track and summarized these types of costs. The growing interest on the part of planners and policymakers in sustainable development requires this type of accounting. This framework serves as an introduction to the subject.

We are not offering a completed, calibrated model, but rather an accounting framework within which such a model can be developed and calibrated. The spreadsheet software, available through FHWA and cited at the end of this paper, is only a point of departure for analysts; it is not ready to be used without careful review and meaningful enrichment. It does represent, however, a way for planners to understand much more completely the full set of costs and benefits associated with alternative forms of metropolitan development, and this understanding, we believe, will improve substantially the practice of metropolitan planning.

2.0 A FRAMEWORK FOR EVALUATION

Regional transportation and land use planners' get to general goals without much difficulty. Where they have problems is in the plan evaluation stage. They lack a framework for thinking about the impacts of policies.

This paper focuses on such a framework, one that is comprehensive (all significant benefits and costs are counted) and mutually exclusive (they are counted only once). It addresses such questions as: What are the impacts (benefits and costs) of alternative urban forms? What are the causal relationships among those impacts? How do public goals and policies about urban form interact with market forces?

Many of the costs of different urban forms can be measured by adding up the market costs of the resources the different forms of development use up. Supplying sewer and water to new residential development takes labor (planning, design, and construction), concrete, steel, machinery and so on. The costs can be added and expressed in dollars. Many of the benefits and costs of public projects, however, are ones not typically registered through market transactions. Some of these benefits and costs are not internalized in the prices paid for the goods and services needed to build and operate the project - for example, the costs of air pollution on people and property near highways where automobiles generate that pollution.

Economists call such costs spill-overs or externalities, and argue that society should consider them in its evaluation of a project since they result in real gains or losses.

Without an acquaintance with the fundamental concepts and methodological issues associated with a full-cost framework, planners and policymakers will be unable to take the first steps towards a more comprehensive evaluation of alternative urban forms, and the policies and investments that cause them to occur. Some of the main concepts and issues include:

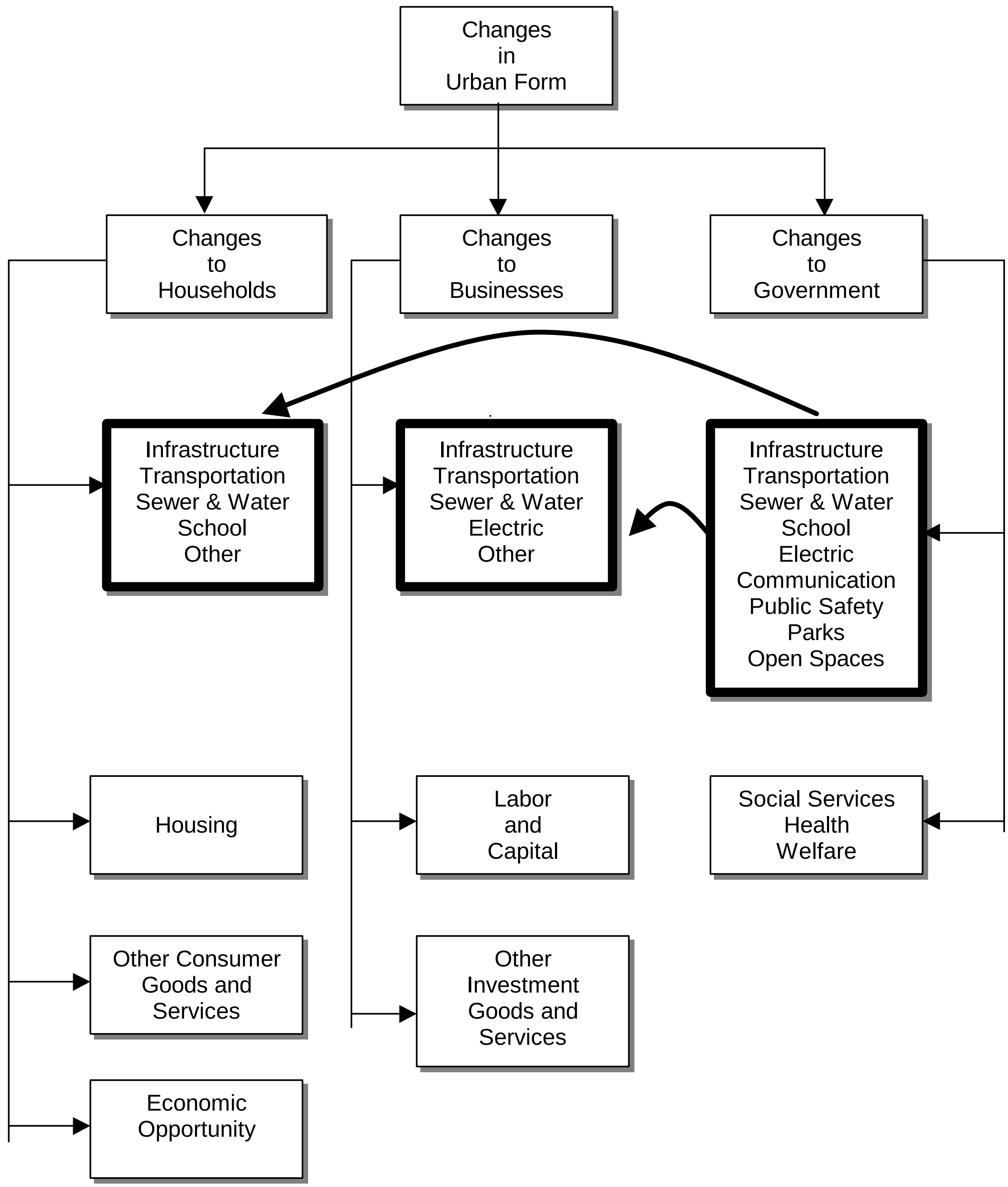
- *Costs are real economic resources used by a policy or project.*
- *Benefits are negative costs; costs are negative benefits*.
- *Benefits and costs must be defined in a way that is both comprehensive and mutually exclusive*.
- *Measuring all benefits and costs means considering some that do not have obvious market prices.*
- *A full-cost accounting framework must look at all impacts, both benefits and costs, that result from a defined change in the state of the world (in the case of this study, either a change in urban form or, more correctly, from a change in policy that attempts to change urban form).*
- *A full-cost accounting framework must consider all the people affected by the change. Many people may feel the change not just as residential consumers, but also in their capacities as employees of businesses and government.*

These points lead to a number of frameworks, including that shown in Figure 1 for analyzing the impacts of alternative development patterns.

Figure 1 shows our assumption that the main effects of a change in form should be captured through changes in the costs of providing infrastructure services. As the title of Figure 1 implies, an important and defensible assumption is that the effect of urban form on households, businesses, and governments occurs mainly through a derived demand for infrastructure, an intermediate good.

Our operating assumption is that the impact of changes in urban form on the cost of infrastructure is probably the single most important impact to evaluate. That approach, with infrastructure as the sole concern, does not cover everything, either technically or politically. However, as a reasonable basis for an accounting framework, Figure 1 is appropriate and useful.

Figure 1: Markets Where Policies to Change Urban Form are Likely to Have Direct (Internalized) Effects on Prices



2.1 A PROTOTYPE ACCOUNTING MODEL

How might we convert this framework into a model which planners and policymakers can use in metropolitan planning? The balance of this paper contains the organization and implementation of such a prototype model, for estimating the Full Social Cost of Alternative Land Development Scenarios (SCALDS) at the regional level. The model has been developed by Parsons Brinckerhoff Quade & Douglas, Inc. using software that is commonly available to most MPO's, the computer spreadsheet (EXCEL). The prototype model consists of 18 interconnected spreadsheets, which produce an aggregate estimate of the full costs of regional land use scenarios.

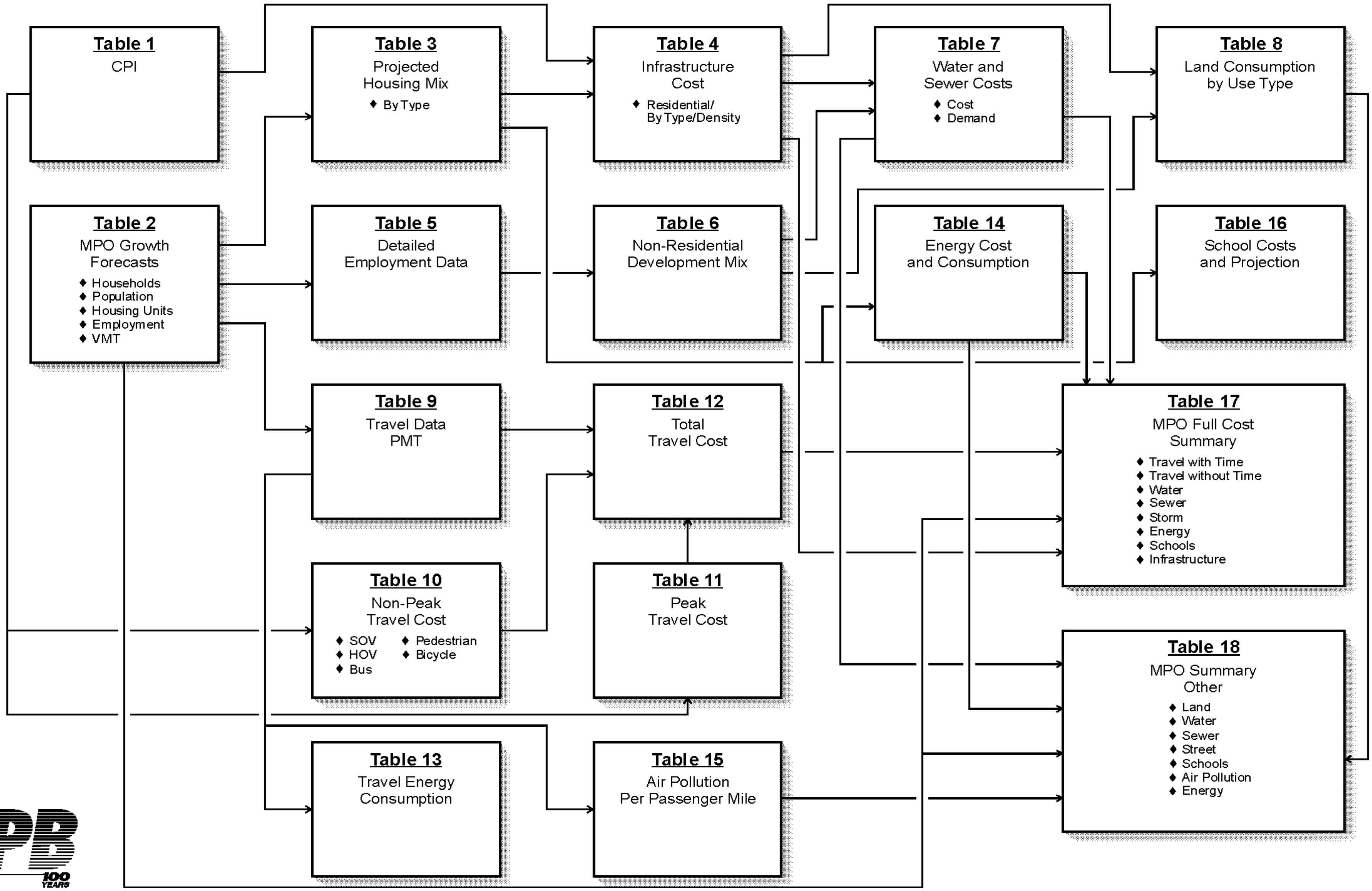
This model builds on three components, which we consider to be essential to a full cost framework that has potential for practical application. First, this model pays particular attention to infrastructure costs, since these are the costs with which many citizens and elected officials are most familiar. Secondly, it acknowledges both public and private costs. (While an ideal framework would further differentiate private costs into those borne by businesses and consumers, this model affords opportunities for further development in these directions at a future date.) Third, it deals with both internal and external costs, with external costs being accounted for through several elements of the model.

The development of alternative land use scenarios requires that the MPO have several copies of the spreadsheet files, each named for the scenario that it estimates. The individual scenario files need to be appropriately modified so that they will calculate the cost of the alternative land use pattern based on the appropriate modifications of model variables. To compare the relative cost of two or more scenarios, it is necessary to summarize the results from these two files outside the model process.

The SCALDS Model is not intended to be the definitive solution or the cookbook for estimating costs, but a guide to how a metropolitan area might approach this project. Additional tables can be added and local cost factors substituted for the national averages used in several situations. One approach to starting the modeling process is to estimate a full cost base scenario using the default national cost estimates. Then additional scenarios can be developed, possibly using selected local costs if available.

The SCALDS Model has three general calculation paths. (See Figure 2) The physical development path (Tables 3 through 8) models the consumption of land, the projected mixture of new housing units, the local infrastructure cost and annual operating cost of services for sewers, water and storm water. It is also possible to project the average amount of non- residential building space needed to support new development. The total travel cost path (Tables 9 through 12) models the annual operating cost of peak and non-peak travel on a passenger miles traveled (PMT) basis.

Figure 2: Full Cost of Alternative Land Use Model Schematic



PB 100 YEARS

The third path (Tables 10 through 16) models the air pollution produced by transport mode, the energy consumption by transportation and the energy consumed by residential land use in non-dollar units. The residential energy consumption contains a factor that approximates the non-residential energy consumption. This path also estimates the cost of the energy consumed by transport and residential land use. However the transport related energy costs are not carried forward to the summary Table 17 and 18 because this cost has already been included in the model elsewhere.

Finally, the third path has an illustrative table, number 16, that shows a short term projection of the increase in new students from the construction of new housing units. This table estimates the marginal change in the number of school age children and the marginal change in school operating cost. The results from this table are not carried forward to the summary tables because the marginal cost change estimates are only good for the short run. In order to get a good estimate of these projected changes in school age children and school operating cost it will be necessary to undertake a separate modeling process outside of the SCALDS Model framework and then add the results of this process back into the SCALDS Model.

The balance of this paper is devoted principally to an explanation of each of the steps or elements in the model.

2.2 DEMOGRAPHICS IN THE SCALDS MODEL: SOME CAVEATS

The SCALDS Model is not designed to show the demographic variations that occur within sub-areas of a metropolitan area and which can produce jurisdictional or sub-area variations in the estimated full cost of development. The estimation of sub-area or jurisdictional marginal costs needs to approached more rigorously than the estimation of MPO level estimates.

The population of a metropolitan area as a whole has distinct age/sex/household size characteristics that do not change in response to policy variables such as the projected mixture of housing unit types. On the contrary, the mixture of new housing units constructed is directly related to the demographics of the population purchasing or renting new housing units.

The model itself does not forecast changing demographic patterns over time. If a metropolitan area expects a major or systematic shift in regional demographic patterns to occur during the forecasting period, exogenous adjustment should be made to the model inputs to reflect the predicted changes, and these adjustments should be well documented. An alternative approach to this problem would be to estimate the full cost of development using constant demographic patterns and then estimate the cost making the anticipated changes in the region’s demographic patterns. This will allow the analyst to approximate the impact of the change in cost.

A good population forecast is an invaluable resource for the SCALDS Model. It allows the analyst to make informed adjustments to policy variables, such as the new housing mix, which affect the total cost of development in a metropolitan area. In the same vein, good inventories of the existing developed environment improve the overall operation of the model. However, the analyst should remember that it is possible to make changes in the housing mix that mathematically implies changes to the age structure of the population or the average household size in the region. The demographic pattern of the region is not changed by simply changing the mixture of new housing types built in the region. Therefore the analyst should adjust the mix of new housing units within the context of the expected average household size and projected rate of household formation.

MPO's have a substantial body of research that they can draw on to modify the unit costs used in the SCALDS Model or to enhance the model by adding new cost calculation modules to the Model. MPO's also have access to large amounts of data from the US Census, various state agencies, city and county governments. Data sources are numerous. We have incorporated data from many different sources in the Model. MPOs have the option to carry this process further and adapt the SCALDS Model to more closely match local conditions.

3.0 DESCRIPTION OF MODEL ELEMENTS

All the elements of the SCALDS Model are shown in Figure 2. Further, the links between the different elements are diagrammed. Figure 2 should be a quick guide or "road map" to the discussion, which follows.

3.1 CONSUMER PRICE INDEX - TABLE 1

The starting point for the SCALDS Model is Table 1 – Consumer Price Index (CPI). The Model uses default cost data from a number of different years to estimate the cost of alternative land use patterns. It is, therefore, necessary to adjust the costs used in the model to remove the effects of inflation. This is done by means of an inflator factor or deflator factor, which adjusts the costs taken from different national studies to base year dollars. The Base Year is the year (1995) that is used as the base in the analysis. The default cost in the model has been adjusted to base year of 1995. If an analyst wishes to use a different base year for the value of money, it will be necessary to deflate or inflate the cost in various portions of the spreadsheet model to the new base year.

The CPI used in the model is the Consumer Price Index for All Urban Consumers for All Goods. This index was chosen because it is a general national indicator of inflation and it smoothes out local economic fluctuations. The CPI shown in Table 1 is from January of each year. The CPI contains a unique CPI factor for each month in the year. A CPI for a different month could be substituted if this meets some other MPO criteria. The CPI for All Urban Consumers for all Goods (1982-1984=100) is available from the Bureau of Labor Statistics on their web site *(http://stats.bls.gov/cgi-bin/surveymost - Series ID CUUR0000SA0).* This site contains the CPI on a monthly basis for the time periods from 1913 to present.

Indexing costs from different years to the base year is done using the following equation. In this example the base year is 1995 and the original year or the year of the cost estimate is 1987.

$$\text{Base Year Cost 1995} = \text{Original Year Cost 1987} * \left(\frac{\text{Base Year CPI1995}}{\text{Original Year CPI1987}} \right)$$

There are a few options available for adjusting costs to base year values. A metropolitan area could elect to use one of the other forms of the CPI such as the Engineering News Record material price index which is very good for forecasting capital intensive infrastructure cost. Other cost indexes exist but none of them address overall issues of inflation in urban cost as well as the CPI.

The CPI requires very little effort on the part of the MPO in terms of data maintenance. It can be updated as necessary by down loading the newest data from BLS. This is only necessary if the MPO wishes to use a cost data estimated for a year for which the MPO does not currently have a CPI factor. The other possible use of the CPI is to move all of the costs in the Model to a new base year such as 1997. The MPO simply needs to insure that it has adjusted each of the costs described in the following sections from its original year costs to the new base year cost to accomplish this transition.

CPI cost adjustments are not made automatically in the prototype model. It is necessary to apply the cost indices to data from the base year cost used by an MPO.

3.2 MPO GROWTH FORECASTS – TABLE 2

The MPO Growth Forecast is a key portion of the SCALDS Model. All of the remaining spreadsheets in the model are linked directly or indirectly to the data entered into this table and all of the cost estimates flow from these projections.

Table 2 contains much of the basic planning data that a metropolitan area develops during the normal course of creating a transportation-planning model for an urban area. These data are developed exogenously or outside of the SCALDS Model and are brought into the model by the MPO. All of the data are aggregated at the MPO level. This aggregation can mask local or sub-regional demographic changes, trends and differences.

The data needed to fill this table can be divided into the following general categories:

- Total Population and related aggregate factors such as average household size for the MPO.
- Total Number of Housing Units, the MPO average vacancy rate and the MPO multifamily / single family housing split.
- Total MPO employment and the retail / non-retail employment split.
- Total Vehicle Miles Traveled (VMT) – VMT is needed for some portions of the travel costing modules such as the Federal/State Highway Investment portion of total travel cost. Travel costs, however, are modeled on a Passenger Mile Traveled basis in most portions of the model.
- Road system summary data at the MPO level including a factor to estimate the consumption of land for the road right of way.

Housing and population data used by the Model is expected to be at about the same level of generalized detail as the data that is maintained by the MPO. It is particularly important to have an accurate inventory of the existing building stock by type before making projections of future growth. There is little that can be done to substantially change the nature of the existing housing stock in the short run. It is also unlikely that new development will completely change the nature of the housing stock during a twenty-year planning period. The existing housing stock, like existing demographic patterns, is a given in the modeling process. New development and new growth create only marginal changes in both population and housing.

The Model allows the analyst to divide the projected housing stock into several categories by building type. These categories facilitate the estimation of different costs of development associated with different land use patterns. The categories are one of the areas where local government policy can influence the nature of development and the full cost of development. The ability of the model to estimate the cost of development depends in large part on the data supplied to it in these modules.

NOTE: The use of different housing stock types in this model is for convenience in the calculation of aggregate, regional impacts. Because different types of housing stock have been linked with different types of costs, it is convenient and appropriate for use in the aggregate level of analysis. However, use at a sub-regional or local level is likely to be misleading or wrong for several reasons. First, local costs vary within regions. Secondly, since housing stock is a supply variable (not a demand in itself), it is not possible to vary regional costs by varying the regional housing stock. While local policies governing housing type, density and amenities may affect the demographic characteristics of local or neighborhood residents, at the regional level differences disappear; the forces that control regional demographic changes are not influenced (and certainly not influenced easily) by manipulating housing unit size or the number of bedrooms.

It is appropriate to note again that the population forecasts used in the model are summary forecasts that show general trends, such as a decline in average household size. The model assumes that any demographic trends that are occurring in the metropolitan area population are occurring outside the model process and will not be affected by the model's assumptions (e.g., about housing stock).

Data for this model is available from the MPO itself, and from secondary data sources such as the US Census (population and housing), the state employment agency (ES202 files on covered employment), local planning agencies on land areas, housing units, miles of street etc. It is likely that most of this information exists in a metropolitan area. But the MPO may need to invest considerable effort in the process of gathering, inventorying, classifying and organizing the available data, if this process has not already been accomplished. The MPO should establish a standardized set of databases based on relatively stable geographic boundaries such as census tracts. It is important to have agreements with local governments on the continuous collection of the data on new development. While it is a problem to constantly maintain databases, it is harder to rebuild them from scratch whenever it is necessary to undertake a new study. Attention to database design and maintenance is one of the best long-run investments that an agency can make.

3.3 PROJECTED HOUSING MIX - TABLE 3

This table contains the detailed housing mix for the region that is the basis for residential infrastructure cost and land consumption. The table is an elaboration of the basic housing data added to the model in Table 2.

The model will work with a housing mix that designates housing units only as single family or multifamily. However, the model will provide a significantly better estimate of the cost of a particular land use pattern if it has a more detailed mixed of housing unit types and densities to work with.

The accurate and detailed inventory of the existing housing stock is also a key component used in several other tables to estimate regional operating costs. If local data on the housing mix in the metropolitan area is not readily available, a good place to start looking for data is the decennial census of housing. Local government building permit data is also a valuable source of data on the changes that have occurred since the last census.

Data on the details of the housing mix can be obtained from the decennial census (1990 Census of Housing) and from city and county building permit data. An additional distribution of housing type has been estimated from the Public Urban Microdata Sample for a metropolitan area. Local homebuilder organizations may be able to provide some additional detailed information on the composition of new single family housing construction trends.

Numerous national studies have reviewed the cost of development by housing type and logically concluded that the cost of development and the infrastructure required to support a particular type of development is directly related to the density of development and the type of unit constructed. The different studies produce different estimates of the cost per unit depending on the assumptions and the details of the cost included in the analysis. The costs used in the SCALDS Model are taken from a study by the Urban Land Institute that is cited in the discussion on Table 4.

There are two elaborations of the SCALDS Model, which could be developed and connected to the model through the housing mix data in Table 3. The first elaboration is the estimation of the cost of new residential construction associated with different land development patterns. To estimate the cost of new construction it would be necessary to develop construction average costs per square foot or per unit for each type of housing. If average cost per square foot is used, then it is necessary to also estimate the average size of the new units constructed.

NOTE: The types of new housing units constructed and their size is going to be driven by the demographics of the purchasers and renters of new housing. For example an urban area which is experiencing a significant in-migration of retired couples will not contain many new single family houses with three or more bedrooms.

A second elaboration could involve estimating the number of housing units needed by number of bedrooms per unit. This is a variation on the cost of housing because the more bedrooms in a housing unit, the larger and more costly the unit. This type of analysis would again be directly linked to a detailed demographic forecast that is exogenous to the SCALDS Model. Such a forecast would provide a more detailed picture of the projected housing need and would be more sensitive to the demographics of the future urban population. But this type of forecast needs to be the subject of additional research before a clear methodology is available to add to this model.

NOTE: The model does not address housing price issues (relationships between supply, demand and price) or any issue related to the income distribution of the existing or future population of a metropolitan area. While these issues are important they are also too complex to be addressed in a basic model like the SCALDS Model.

3.4 INFRASTRUCTURE COST BY HOUSING TYPE – TABLE 4

This table estimates the cost of infrastructure associated with residential construction. The construction of new local government infrastructure in most urban areas is focused in developing residential areas. Substantial portions of the annual expenditures for new streets, sewers, water line and storm drainage facilities are made by the development community during the land development process. It is difficult to estimate the average expenditures for infrastructure per new housing unit by structure type using local data because these expenditures are not normally made directly by local governments; but if good local records are available, a metropolitan area may wish to estimate the cost of this infrastructure based on local information. The SCALDS Model uses average costs for infrastructure by housing unit type. Table 4, Columns C and D, contain cost factors that express the differences in development costs associated with compact development and leapfrog development. Columns E and F contain additional costs associated with development located some distance from major infrastructure facilities such as sewer trunk lines or water transmission mains. At the MPO level these variations in cost are difficult to use. They will be more useful in future model extension at the subregional level.

NOTE: The MPO using the SCALDS Model needs to review the infrastructure cost estimates for the low density and very low density single family residential uses. It is not uncommon for these land uses to be developed using septic tank instead of public sewer, and wells instead of public water facilities. The model does not currently contain an estimate of the capital cost of installing these private systems. If this type of development is commonly supported by private infrastructure such as wells or septic tanks, a metropolitan area should obtain estimates of the average cost for the installation of these systems from installers of these systems who work in and around the urban area, and use those estimate for the average capital cost of this form of development. Operational cost of these services (wells and septic tanks) also differs from the operating cost of water service in Table 7, and thus it should be estimated based on local well and septic tank service costs.

The best sources of local data on the cost of infrastructure related to local residential development is city and county planning and engineering offices. These records should provide an estimate of how much infrastructure was installed with each new residential development. If there are large variations in the cost estimates for these improvements, the MPO could collect the data on the quantity of materials used by type and estimate the cost of the infrastructure using the cost factors found in the ENR (Engineering News Record). These cost estimates are updated continually and provide a third party source for determining the cost of infrastructure.

The collection and maintenance of data on infrastructure cost can be a relatively formidable task in an urban area. One method to collect and maintain this type of data is creation of a GIS based facilities management system. The maps and data bases developed as part of such a system are a valuable resource to the local water, sewer and storm water service providers and a good source of basic planning data at the MPO level. The development of a cooperative or intergovernmental GIS system can help spread the cost of developing and maintaining a GIS. The collection of data is not adequate justification by itself for the cost and effort that is required to create a GIS system. It is merely another use of the data that can be developed from this type of system.

3.5 DETAILED EMPLOYMENT DATA – TABLE 5

This table is a more detailed presentation of the regional employment projections, which are the basis for non-residential land consumption and water and sewer demand estimates.

These data are all developed locally by the MPO. The economic growth of the urban area is the driving force behind overall regional growth. Historic data in this table is available from a variety of sources including the US Census, County Business Patterns, and state data on covered employment (ES 202 file). Projected employment is available from the Bureau of Economic Analysis. These data sources are all good starting points for a metropolitan area employment forecast.

This particular data set does not lend itself to local maintenance of data. The one exception is site level data from the ES 202 files. MPO's may be able to obtain these data, subject to agreements on confidentiality. The ES 202 files commonly require some level of data clean up and geocoding before they are usable by a metropolitan area. The ES 202 file commonly has data on about 90 percent of the employment in an urban area. If a MPO decides to use these data it should be updated at regular intervals such as annually, biannually or every 5 years in order to provide time series data for future employment projections.

3.6 NON RESIDENTIAL DEVELOPMENT MIX – TABLE 6

This table converts the employment by sector into building area and land area needed to support development. The conversion factors for this process vary a great deal from industry to industry. There are no definitive national data for these estimated ratios.

The process of converting employment to building area demand and land area demand will benefit from the use of local data. However this information can be difficult to obtain locally. If there is a local GIS system that has building size data by parcel, and parcel data, the MPO could geocode firm-level employment data from the ES 202 file in order to obtain local building and land demand ratios. Time series employment data and building areas would allow the tracking of these demand ratios over time and could show long term change in the demand for land and building space by industry group. The other approach that could be used is a survey of existing employers. The main drawback to the survey approach is the fact that the data is only good for one point in time.

Vacancy rates were not used in the model. They will increase the amount of building space demand and the amount of land consumed. This should be done during any local elaboration of the SCALDS Model.

3.7 WATER AND SEWER COSTS – TABLE 7

This table estimates the demand for water and sewer service and the cost of water, sewer and storm water services for the urban area. A number of the issues related to infrastructure cost and availability were previously discussed during the discussion on Table 4.

NOTE: Water and sewer demand calculations need to be reviewed for very low density and low density residential. These residential areas may not be served by public water and/or sewer systems in the MPO area.

Non-residential water and sewer demand do not include water and sewer demands for industrial processes and as such these estimates are lower than the expected demand from non-residential uses. The industrial process demand for water and sewer services varies greatly for non-residential uses such as food processing, microprocessor manufacturing, restaurants, hotels, offices etc.

3.8 LAND CONSUMPTION BY TYPE – TABLE 8

This table marks the end of the physical development path in the SCALDS Model. From here the Model is linked to Summary Tables 17 and 18. It begins the travel cost path in Table 9.

Land consumption forecasts are based on the data in two tables, Table 3 (Housing Mix) and Table 6 (Non-Residential Development Mix). The calculation of residential land consumption is very simple. The number of units is multiplied by the density of units per acre to estimate the residential land consumption. Table 6 contains a calculation of the number of employees per gross acre. The demand for non-residential land is estimated by dividing the total employment by the number of employees per acre.

Acres are gross acres that include the area for any public rights of way. If a metropolitan area wishes to change the land area basis to net acres (acres less public rights of way) it will be necessary to recalculate the density factors used in the Model.

The one type of land use which is not estimated directly by this model is public land. These lands include schools, parks, public buildings and public open spaces. A place holder number has been put into the model for this type of land use. Private non-profit uses such as churches, private schools, fraternal and civic organizations are not explicitly addressed by the model. They are assumed to be in the non-residential land uses based on the employment, but the Model probably underestimates them. The MPO should develop an estimate of the amount of land consumed by public uses and put it into the Model under the other land category. This process could also include the estimation of the amount of private nonprofit lands consumed in the urban area.

3.9 TRAVEL DATA – PERSON MILES OF TRAVEL - TABLE 9

This table is the beginning of the travel cost path in the SCALDS Model and is linked back to Table 2 in order to estimate the total number of person trips at the regional level.

The total number of person trips is derived from the total number of households and the average number of trips per household. Total number of trips are allocated to individual modes based on the percentage of trips made by vehicle type. Total daily person miles traveled is then calculated by multiplying the total number of trips by their average trip length. Finally, annual personal miles traveled are estimated by multiplying the daily total by 330. The result is a calculated annual and daily estimate of person or passenger miles traveled by mode.

An MPO with an up-to-date travel forecasting model or local travel data will use these local data instead of nationally estimated values. Model runs can produce better estimates of differences in trip lengths and mode shares for alternative land development scenarios. The MPO may wish to use locally derived per-capita and/or per-household trip estimates and local mode split data to derive the data in these tables.

3.10 TRAVEL COST (NON PEAK) - TABLE 10 [1]
TRAVEL COST (PEAK) - TABLE 11
TOTAL TRAVEL COST - TABLE 12

These three tables are the heart of the travel cost-estimating path in the SCALDS Model. Tables 10 and 11 contain the estimate of the cost per passenger mile for peak and off-peak travel by all modes except truck. (Truck costs are assumed to be the same as bus cost for this initial analysis). Table 12 is the table in which the number of miles traveled and the cost per mile are combined to produce a total travel cost estimate.

The data used to estimate the cost of transportation is not generally available at the MPO level. MPO's do not need to maintain these data but do need to know where to look for updates of national cost numbers. MPO's do need to maintain information on basic transportation measures such as annual average vehicle miles traveled and average vehicle occupancy at the regional level if they wish to use numbers that reflect local trends rather than national trends.

3.10.1 Depreciation and Financing Costs

Vehicle depreciation was estimated using the following equations.

$$\text{SOV \& HOV Costs} = \frac{\left(\dfrac{(\text{Annual Finance Cost} + \text{Annual Depreciation Cost})}{\text{Average Annual VMT}}\right)}{\text{Vehicle Occupancy}}$$

$$\text{Bicycle Cost} = \frac{\left(\dfrac{(\text{Purchase Cost} - \text{Resale Value})}{\text{Vehicle Life}}\right)}{\text{Average Annual VMT}}$$

$$\text{Pedestrian Cost} = \frac{\text{Average Shoe Cost}}{\text{Average Shoe Life in Miles}}$$

[1] All travel costs used by the prototype model were developed for Boulder Colorado. MPOs using the prototype model should consider the appropriateness of these costs for their environment. It is our intent to extend this model in future work to provide a mechanism to calculate local travel costs based in part on the data from local travel demand models.

3.10.2 Vehicle Insurance Cost

Insurance cost estimates were developed for single occupancy vehicles and high occupancy vehicles. No insurance costs were estimated for bicycle and pedestrian travel because this type of insurance is generally not available. Insurance costs for truck and buses were not estimated.

$$\text{SOV \& HOV Costs} = \frac{\left(\dfrac{\text{Annual Insurance Cost}}{\text{Average Annual VMT}}\right)}{\text{Vehicle Occupancy}}$$

3.10.3 Registration and Licensing [2]

Registration and licensing costs are expected to vary on a state by state basis. Each MPO needs to determine the registration and licensing cost for its own state. Truck and bus registration and licensing costs should also be estimated and added to the Model. These fees are more complex than auto registration fees and will require more knowledge of the composition of the local truck and bus fleet and their registration costs.

$$\text{SOV \& HOV Costs} = \frac{\left(\dfrac{\text{Annual Registration Fees}}{\text{Average Annual VMT}}\right)}{\text{Vehicle Occupancy}}$$

$$\text{Bicycle Cost} = \frac{\text{Annual Registration Fee}}{\text{Average Annual VMT}}$$

3.10.4 Gasoline Cost

Gasoline costs are among the most visible of the costs paid by the drivers of cars. In addition, these costs can and do change frequently during the course of a year. Differences in fuel economy can produce substantial variation in the cost of fuel consumed by an individual. The gasoline costs used in the model were derived from national average costs in order to represent an overall average. If local gasoline prices are consistently higher or lower than the national average cost for gasoline, the MPO may wish to adjust this cost estimate.

$$\text{SOV \& HOV Costs} = \frac{\left(\left(\dfrac{1}{\text{Fuel Economy MPG}}\right) * \text{Fuel Cost per Gallon}\right)}{\text{Vehicle Occupancy}}$$

[2] Registration Fees included in this cost factor are the portion of fees not used to fund construction or maintenance projects.

3.10.5 Maintenance Cost

Vehicle maintenance costs are subject to considerable variation in a metropolitan area. Some of this variance is the result of personal preferences and some of it is the result of the characteristics of the vehicles in the urban area. Accordingly, national cost estimates were used for this variable. Truck and bus maintenance costs were not estimated or included in the Model.

$$\text{SOV \& HOV Costs} = \frac{\left(\dfrac{\text{Annual Maintenance Costs}}{\text{Average Annual VMT}}\right)}{\text{Vehicle Occupancy}}$$

$$\text{Bicycle Cost} = \frac{\text{Annual Maintenance Cost}}{\text{Average Annual VMT}}$$

3.10.6 Transit Fares

Transit fares are set by local governing bodies and are normally set at a level that is intended to provide the transit provider with a percentage of the total transit operating budget. The amount of the transit system budget that is collected from the fare box varies substantially from urban area to urban area. This cost should be revised by the MPO to account for local conditions. The local transit agency should be able to provide the other necessary data needed to estimate this cost.

$$\text{Transit Fare} = \frac{\text{Total Annual Fares}}{\text{Total Annual Passenger Miles}}$$

3.10.7 Residential Parking Cost [3]

The estimation of residential parking cost will require the collection of a large amount of local data. These data also are sensitive to fluctuations in the type and amount of local development and local cost variations. Several alternative cost estimation methodologies are possible. A more complex formulation of this methodology would estimate these costs using an arithmetic moving average of costs to allow for year to year variations. However, all of the alternative methodologies substantially increase the complexity of the cost estimation process with no assurances of a better estimate of the costs. MPOs will need to work with city and county building departments and with county assessors to estimate this cost locally.

[3] Parking costs are derived for Boulder Colorado using local data. Future extensions of the prototype model will provide a method for calculating these cost directly. This may result in the creation of a single parking cost category to replace the three cost categories presently used in the prototype model. Users of the model should carefully evaluate the parking cost estimates produced by different land use scenarios.

$$\text{SOV \& HOV Costs} = \frac{\left(\frac{\left(\left(\begin{matrix} \text{Number} \\ \text{Garages} \\ \text{Constructed} \end{matrix} \right) * \left(\left(\begin{matrix} \text{Land} \\ \text{Value} \end{matrix} \right) + \left(\begin{matrix} \text{Construction} \\ \text{Cost} \end{matrix} \right) \right) \right) * \left(\left(\begin{matrix} \text{Number} \\ \text{Surface} \\ \text{Parking} \\ \text{Spaces} \end{matrix} \right) * \left(\left(\begin{matrix} \text{Land} \\ \text{Value} \end{matrix} \right) + \left(\begin{matrix} \text{Construction} \\ \text{Cost} \end{matrix} \right) \right) \right)}{\text{Annual VMT}} \right)}{\text{Vehicle Occupancy}}$$

3.10.8 Non-Residential Parking Cost User Paid

Non-residential parking costs that are paid by the user are out-of-pocket costs. These costs are normally paid by users that park in a small portion of an urban area. Parking costs are most common in central business districts. There are no good national sources for these data. The data must be developed locally. There will be variations in the cost of on-street paid parking and off-street paid parking depending on variations in public policy and local market conditions. An MPO will need to develop a methodology for collecting and maintaining these data. The cost estimated by the following equation will produce a regional average cost. This will however understate the cost for those individuals actually paying for parking and overstate the cost for those individuals who never pay for parking.

$$\text{SOV \& HOV Costs} = \frac{\left(\frac{\text{Annual User Parking Cost}}{\text{Annual VMT}} \right)}{\text{Vehicle Occupancy}}$$

3.10.9 Non-Residential Parking Cost – Societal Costs

This cost includes the cost of all of the non-residential “free” off street parking spaces in an urban area. This cost estimate adds the average cost paid by business and industry to provide free parking to their customers and employees. The methodology used in this calculation might be improved through the use of an arithmetic moving average, but this type of a process would require substantially more data collection and maintenance.

$$\text{SOV \& HOV Costs} = \frac{\left(\frac{\left(\left(\text{New Non Residential Spaces Constructed} \right) * \left(\left(\text{Land Value} \right) + \left(\text{Construction Cost} \right) \right) \right) + \left(\left(\text{Number Existing Non Residential Parking Spaces} \right) * \left(\text{Annual Maintenance Costs} \right) \right)}{\text{Annual VMT}} \right)}{\text{Vehicle Occupancy}}$$

3.10.10 Accident Costs Not Covered by Insurance

Estimating accident cost from local data is a difficult process at best. Our SCALDS Model uses national data to estimate these costs and MPO's should consider sticking with the national and state level data when estimating these costs. The costs estimated by this formula do not include the costs previously attributed to insurance (3.10.2).

$$\text{All Modes} = \left(\left(\left(\left(\text{Fatal Accident Rate} \right) * \text{PMT} \right) * \left(\text{Fatal Accident Cost} \right) \right) + \left(\left(\left(\text{Injury Accident Rate} \right) * \text{PMT} \right) * \left(\text{Injury Accident Cost} \right) \right) + \left(\left(\left(\text{Property Damage Only Accident Rate} \right) * \text{PMT} \right) * \left(\text{Property Damage Only Accident Cost} \right) \right) \right) * \left(\text{Share of Accident Cost Burden} \right)$$

3.10.11 Travel Time

The key element in estimating the cost of travel is determining the value of time. This cost is normally assumed to be a percentage of the average wage in an urban area. If local data is not available, the US Bureau of Labor Statistics has an average for most urban areas. Average costs are calculated for each mode using the mode's individual travel speed and the value of time.

$$\text{All Mode Costs} = \left(\frac{1}{\text{Speed MPH}} \right) * \text{Value of Time}$$

3.10.12 Federal /State Highway Investment

Federal and state capital cost and operating expenditures per VMT are estimated at the state level due to limitations of the available data. In our model the amount of state and federal gas taxes is deducted from the total expenditures because gas taxes are included in the model under the section on gasoline costs. This deduction removes a potential double counting of costs.

Cost factors are used for each mode to reflect the magnitude of the damage done to the transportation infrastructure by each of the travel modes. The result is a weighted estimate of the highway operating and capital cost by mode.

$$\text{All Mode Cost} = \frac{\left(\left(\frac{\text{Fed State Capital Costs}}{\text{VMT}}\right) * \left(\text{Vehicle Cost Factor}\right)\right) + \left(\left(\frac{\text{Fed State Operating Costs}}{\text{VMT}}\right) * \left(\text{Vehicle Cost Factor}\right)\right) - \left(\text{Federal State Gas Tax}\right)}{\text{Vehicle Occupancy}}$$

The vehicle cost factors used in this process, representing the relative damage caused by individual vehicle by mode, are as follows:

Mode	Capital Expenditures	Maintenance
SOV/HOV	0.683	0.719
Transit Bus	1.810	3.420
Bicycle	0.034	0.014

3.10.13 Municipal Services

There are a few municipal development costs that have not already be accounted for directly or indirectly in previous tables. Public safety is one of these costs. In Boulder, the portion of the public safety budget that was directly related to traffic and travel was estimated using the following equation.

$$\text{SOV \& HOV Costs} = \frac{\left(\frac{\left(\text{Annual Police Budget}\right) * \left(\text{\% Trans Calls}\right)}{\text{Annual VMT}}\right) + \left(\frac{\left(\text{Annual EMS Budget}\right) * \left(\text{\% Trans Calls}\right)}{\text{Annual VMT}}\right) + \left(\frac{\left(\text{Annual Court Budget}\right) * \left(\text{\% Trans Cases}\right)}{\text{Annual VMT}}\right)}{\text{Vehicle Occupancy}}$$

MPO's will need to work with local governments to obtain the cost estimates included in this equation. Once a budget allocation process has been developed, it should be relatively easy for the MPO update this information as needed. Additional research into local, state and federal expenditures should be undertaken to insure that all of the appropriate governmental costs have been include in this model.

3.10.14 Government Net Transit Costs (Total Cost – Fare Box Revenues)

This cost variable was developed to estimate the transit costs that are not paid for by transit fares. The methodology for estimating this cost is relatively simple. However, depending on the source of the revenue that supports these operational costs, additional analysis may be required to insure that no double counting of cost has occurred.

The estimation of this operational cost leaves only one transit cost that may not have been included in the SCALDS Model - transit capital cost. Transit capital cost can vary greatly from year to year and the normal problems related to the timing of construction. These capital costs are a candidate for the use of an arithmetic moving average methodology or some other methodology that explicitly works with variations in expenditures / cost over time.

$$\text{Net Transit Cost} = \left(\frac{\left(\begin{pmatrix} \text{Total} \\ \text{Transit} \\ \text{Costs} \end{pmatrix} - \begin{pmatrix} \text{Transit} \\ \text{Fares} \end{pmatrix} \right)}{\begin{matrix} \text{Annual} \\ \text{Transit} \\ \text{Passenger} \\ \text{Miles} \end{matrix}} \right) * \begin{pmatrix} \text{Peak} \\ \text{NonPeak} \\ \text{Adjustment} \\ \text{Factor} \end{pmatrix}$$

3.10.15 Deferred Maintenance Cost [4]

This estimated cost is an attempt to capture an often hidden cost associated with development. State and local infrastructure maintenance often does not keep up with growth. It is not uncommon in an urban area to find places where development has occurred and existing infrastructure is not maintained to standards, due to the demands placed on state and local governments to expand facilities rather than facilities maintenance. Most urban areas have an estimate of the order of magnitude of this deferred maintenance cost.

The data needed to estimate these costs are normally available from local governments and normally include estimates of the number of years that maintenance is expected to remain unfunded given the current level of available resources. A cost allocation factor is

[4] The authors recommend that the MPO estimate the deferred maintenance cost of the existing road system and substitute this cost for the 1to 2 cents per passenger mile included in the model to avoid any double counting of costs. This estimate should not include capital costs of projects, since cost of delay associated with congestion are already included in Tables 10 and 11.

used to allocate the unfunded need to individual modes This methodology provides a minimum estimate of the deferred cost. MPOs should estimate this cost for the local urban area when implementing the SCALDS Model.

$$\text{Total Vehicle Cost} = \frac{\left(\left(\frac{\left(\frac{\text{Local Unfunded Maintenance Need}}{\text{Years of Need}}\right)}{\text{Local Annual VMT}}\right) + \left(\frac{\left(\frac{\text{State Unfunded Maintenance Need}}{\text{Years of Need}}\right)}{\text{State Annual VMT}}\right)\right) * \left(\text{Cost Allocation Factor}\right)}{\text{Average Vehicle Occupancy}}$$

$$\text{Pedestrian Cost} = \frac{\left(\frac{\text{Unfunded Need}}{\text{Years of Need}}\right)}{\text{Pedestrian VMT}}$$

3.10.16 Air Pollution Cost

Air pollution costs are one of several transportation externalities that have been studied extensively during the last two decades. Substantial data on the cost of air and other forms of pollution can be obtained from separate work recently completed by Litman (1995) and Mark Delucchi (1996) on the social costs of transportation. The methodology used in the SCALDS Model is expressed in the following equation.

$$\text{Vehicle Cost} = \frac{(\text{Emissions Per Vehicle Mile} * \text{Cost of Pollutant Per Gram})}{\text{Vehicle Occupancy}}$$

A metropolitan area can use a different formulation of this equation but it will still need to rely on the various national estimates of the external cost of pollution in order to calculate the costs.

3.11 TRAVEL ENERGY CONSUMPTION – TABLE 13

The cost of energy is included in the estimates of peak and non-peak travel cost in Tables 10 and 11. The non-dollar-denominated estimates of energy consumed directly by transportation are estimated in this table. The energy consumption data is derived from the information in National Transportation Statistics, 1996, Tables 105, 106, and 107. The total annual energy usage is calculated in a straightforward manner using the estimated total passenger miles by vehicle type as derived in Table 9. Estimated energy consumption can be converted into gallons of fuel consumed by using the factor in the table if a metropolitan area needs this information.

The total energy consumption is calculated in this table; it accounts for approximately 7 percent of total travel cost excluding the value of time. However, while the total energy consumption is calculated here for illustrative purposes, they are not passed on to the cost summary in Table 17 in order to avoid double counting of costs.

3.12 ENERGY COST AND CONSUMPTION – TABLE 14

Table 14 estimates the cost of energy and the amount of energy consumed by urban land uses. The energy consumption estimates include all the energy consumed by all land uses in an urban area. These estimates do not include any industrial process energy used by large energy consumptive industries such as aluminum smelters.

The energy consumption estimates in this table are derived from an approach used in the "Place^{3}s" model the US Department of Energy. The energy consumption numbers are derived by modifying the values presented in the report, The Energy Yardstick, Allen (1996). The energy consumption values in the DOE report were modified to remove energy consumption associated with transportation. The result is an approximation of the energy consumed by various residential land use types.

The Place^{3}s energy consumption methodology is a first generation effort. It is probable a more complete integration of the Place^{3}s methodology and the SCALDS Model could be accomplished after some additional study of the operational details of the two models.

It is possible for a metropolitan area to use the Place^{3}s model to develop estimates of energy consumption at a regional level. These estimates can be maintained over time and entered into the SCALDS Model exogenously. Cost estimates can be converted to the base year for the SCALDS Model using the CPI factors.

The Place^{3}s data was derived from the report by Allen, Elliot, Michael McKeever and Jeff Mithcum, (1996) The Energy Yardstick: Using Place^{3}s to Create More Sustainable Communities, DE-FG49-94R900027, Salem, Oregon, Oregon Department of Energy.

3.13 AIR POLLUTION PER PASSENGER MILE - TABLE 15 [5]

The cost of air pollution is included in the estimates of peak and non-peak travel cost in Tables 10 and 11. The non-dollar cost estimates of air pollution produced directly by transportation is estimated in this table. The pollution estimates are denoted in tons of pollutant per year.

There are other models that can be used by a metropolitan area to estimate the amount of air pollution produced by traffic in an urban area outside the SCALDS Model framework. If the MPO wishes to use one of these models, the resulting estimates can be entered into the SCALDS Model exogenously. The alternative is to use the average air pollution per passenger mile figures from this table to estimate the total level of air pollution.

3.14 SCHOOLS COSTS AND PROJECTION – TABLE 16

Table 16 is included in the SCALDS Model as a placeholder. At this point in time, the cost estimates and estimates of the number of new students produced in this table is not connected to the cost and non cost summaries in Table 17 and 18. Table 16 estimates average number of new pupils and average education costs.

NOTE: This type of estimate performs well only for short term, local projections of growth because it is based on two assumptions. First, the demographics of an urban area will not change very much in the short term (less than 5 years). Second, the number of students that will be generated from a particular type of housing unit will be the same as recently generated from existing housing units of the same type.

Over time it is necessary to use a different model - cohort survival - to estimate the number of school children at a regional level. This model takes into account changes in the demographic patterns of the region and provides better long-term estimates of the number of students that are expected regionally.

MPO analysts need to take care when using new households to estimate the number of school age children. It is possible for the analyst to make changes in the housing mix that mathematically would appear to change the number of school age children. However this is not the case in reality. The demographics of the region are not changed by changing the housing mix. The analyst should adjust the mix of new housing units within the context of the expected average household size and projected rate of household formation.

The MPO needs to adjust these figures to match local conditions. The cost factors used in this prototype model are the average cost for students in the State of Oregon in 1995. The number of school age children per unit is taken from Burchell (1997a), page IV – 2, estimated from 1990 US Census PUMS data for new non-central city housing in Michigan. While these numbers are a starting point for the SCALDS Model they cannot be expected to produce good estimates when applied to demographically different situations. A metropolitan area can choose to use projections from a local school district, instead of

[5] The air pollution production rates used in this table are taken from a study by the Greater Vancouver (BC) Regional Council. In subsequent enhancements, we will replace this data with other values.

using this type of projection factor, to develop the data exogenously and then enter it into the Model.

One area of further analysis that would improve the operation of this model would be an estimation of the number of school age children by housing unit type by number of bedrooms. These ratios should perform better in the short term than a simple number of students per household. However, to use these data it is necessary to have better data on the composition of the housing stock. These data will require more effort to collect and more effort to maintain. If this type of data is available, the SCALDS Model can be easily be modified to allow the estimations to be made by using these more detailed data.

4.0 SAMPLE MODEL APPLICATION

In the previous section we have explained the elements of our SCALDS Model, their relationships, the sources of data on which they are based and in some cases the limitations of application. In this section and the associated tables we present the results of several sample applications of the SCALDS Model.

Because this model is in the very preliminary stages of development, the results of the simulations presented below are merely illustrations of order of magnitude impact estimates. They indicate the general direction and magnitude of changes that can be expected in various costs, and the distribution of these costs.

Since the sources of data used in this sample application come from a variety of national as well as local sources, they represent in many cases “placeholders” for more accurate parameters, to be furnished by metropolitan area planners.

4.1 SUMMARY TABLES – TABLE 17 AND 18

Tables 17 and 18 contain the summaries of the cost and non-cost estimates developed in the preceding sixteen tables of the SCALDS Model. These two tables can be used to develop scenario comparisons such as the ones contained in the following examples. The scenarios are intended to be illustrative and not a definitive analysis of the cost of alternative land use patterns in any one metropolitan area.

The two scenarios presented are identified as Metro Regional Plan and Metro Sprawl. The only differences in these two spreadsheets are the number of single family housing units assigned to the Conventional SFD / Small Lot SFD and a small difference in the average trip length for auto trips to reflect the differing densities of the new single family housing areas.

The creation of these scenarios began with two copies of the same set of spreadsheets containing the data for the Metro Regional Plan scenario. The spreadsheet for the Metro Sprawl Scenario was then modified by shifting single family residences from the small lot single family land use type to the conventional single family land use type and by making a small increase in average trip length for the SOV and HOV vehicle types. The scenario costs were then compared and are shown in the Table below.

Total Annual Scenario Cost by Year

Year 1990 Base Year	Metro Regional Plan	Metro Sprawl	Difference (Sprawl – Plan)
1995 5 Model Years	$7,833,550,569	$9,010,519,641	***$1,176,969,073***
2005 15 Model Years	$9,594,617,050	$11,069,634,947	***$1,475,017,897***
2015 25 Model Years	$11,540,873,445	$13,322,601,691	***$1,781,728,246***
Change 1995 to 2015	***$3,707,322,876***	***$4,312,082,050***	

It is apparent that the lower density development pattern has higher operating costs, in excess of $1 Billion per year, after the first five year time period. These cost differences increase to nearly $2 Billion per year by 2015. A more complete comparison of the cost estimates for the scenarios are presented in the following Figures 3 and 4, for three illustrative years.

4.2 ADAPTING THE PROTOTYPE MODEL FOR YOUR MPO

For this model to be useful to an MPO it must be adapted to reflect the conditions in the local urban area. The process is straightforward for experienced spreadsheet users. The first step is to make a copy of the spreadsheet and enter the basic data needed by the prototype model. These data include historic and projected values at the MPO level for population, number of households, single family / multifamily household split, total employment, retail / non-retail employment split and projected travel (Table 2). It also includes detailed housing mix (Table 3) and employment at the two digit SIC level (Table 5). When these data are entered, an analyst is ready to begin the cost estimation process.

The next step is to determine the base year for the analysis and to manually adjust all cost variables to the new base year cost. Policy variables that are adjustable in the prototype model are identified by the gray shading in a cell. These cells should be adjusted to reflect the present conditions in the MPO. All other cells are protected and cannot be changed. Constructing scenarios from existing conditions is a matter of making a copy of the existing condition file and then making adjustments to the policy variable cells. By comparing the results of the two spreadsheets, as depicted in Tables 17 and 18, the analyst will be able to examine the relative costs of the two scenarios that have been created.

Figure 3: Annual Cost Summary: Metro Regional Plan Scenario

COST SUMMARY	1995	2005	2015
Annual Full Cost of Transportation - Without the Value of Time	$4,357,448,808	$5,373,106,876	$6,563,069,023
Total Annual Water Costs	$543,776,669	$669,106,720	$799,205,555
Total Annual Sewer Costs	$551,749,657	$679,942,299	$813,527,620
Total Annual Storm Water Costs	$55,174,766	$67,994,029	$81,352,561
Annual Non-Transportation Energy Cost	$2,325,400,669	$2,804,467,127	$3,283,718,686
Total Annual Costs	**$7,833,550,569**	**$9,594,617,050**	**$11,540,873,445**

NON COST SUMMARY	1995	2005	2015
Population	1,596,100	1,920,264	2,205,800
Households	627,937	774,300	917,000
Housing Units	642,380	792,109	938,091
Total Employment	988,915	1,228,500	1,486,600
Total Developed Land in Acres	299,842	340,398	382,841
Water Demand - Gallons / Day	129,470,160	159,310,646	190,286,557
Sewer Demand - Gallons per Day	99,621,106	122,766,997	146,886,568

Figure 4: Summary: Metro Sprawl Scenario

COST SUMMARY	1995	2005	2015
Annual Full Cost of Transportation - Without the Value of Time	$5,520,271,497	$6,806,966,654	$8,272,657,946
Total Annual Water Costs	$543,776,669	$669,106,720	$799,205,555
Total Annual Sewer Costs	$551,749,657	$679,942,299	$813,527,620
Total Annual Storm Water Costs	$55,174,766	$67,994,029	$81,352,561
Annual Non-Transportation Energy Cost	$2,339,547,053	$2,845,625,245	$3,355,858,010
Total Annual Costs	**$9,010,519,641**	**$11,069,634,947**	**$13,322,601,691**

NON COST SUMMARY	1995	2005	2015
Population	1,596,100	1,920,264	2,205,800
Households	627,937	774,300	917,000
Housing Units	642,380	792,109	938,091
Total Employment	988,915	1,228,500	1,486,600
Total Developed Urban Land in Acres	307,779	361,789	419,091
Water Demand - Gallons / Day	129,470,160	159,310,646	190,286,557
Sewer Demand - Gallons per Day	99,621,106	122,766,997	146,886,568

5.0 SUMMARY AND CONCLUSIONS

In this paper we describe in some detail a set of costs (and, by definition, benefits) associated with alternative forms of metropolitan development. We suggest that planners engaged in infrastructure evaluation view public (and private) infrastructure investments in a context which enables them to examine not only the capital, but also the operating costs; not only costs faced by government but also the costs paid by others; not only today's costs but also long run costs, including those external costs which must be accounted for in any comprehensive evaluation.

Those wishing more information on the methods for estimating costs in these spreadsheets should consult the full report from which this summary is taken. Entitled “The Full Social Costs of Alternative Land Use Patterns," the report can be found on the Internet at *http://www.ota.fhwa.dot.gov/scalds/.* In addition the user may obtain there a copy of the spreadsheets, as well as instructions for their calibration.

For further information on related work sponsored by FHWA, readers may contact: Patrick DeCorla-Souza of the Federal Highway Administration, Metropolitan Planning Division, 400 Seventh Street SW, Washington, D.C., (202) 366-4076.

Those seeking to apply this accounting framework must review carefully the assumptions contained in it. *For results to be useful, planners must commit to a process of data collection and model calibration, using local inputs* rather than relying on generalized estimates such those embedded in the spreadsheets in their current form.

FHWA is proposing to support additional modifications and refinements to this framework. These enhancements may focus on improving estimation of costs related to transportation and making them consistent with procedures used in FHWA's STEAM software. (For more information on STEAM, see the STEAM web site at http://www.ota.fhwa.dot.gov/steam/) . Also, the calculation paths for other utilities, energy and land consumption are rudimentary. In addition, since successful use of this framework requires additional instructional material, FHWA may support the development of a user's handbook. Lastly, since many citizens, elected officials and staff are looking to apply these concepts at a smaller geographic scale than that developed to date, FHWA may support enhancements for that purpose as well.

The authors hope through this paper to contribute to the ongoing dialogue concerning the best ways to plan for the communities in which we live, and the costs and benefits that define quality of life there.

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