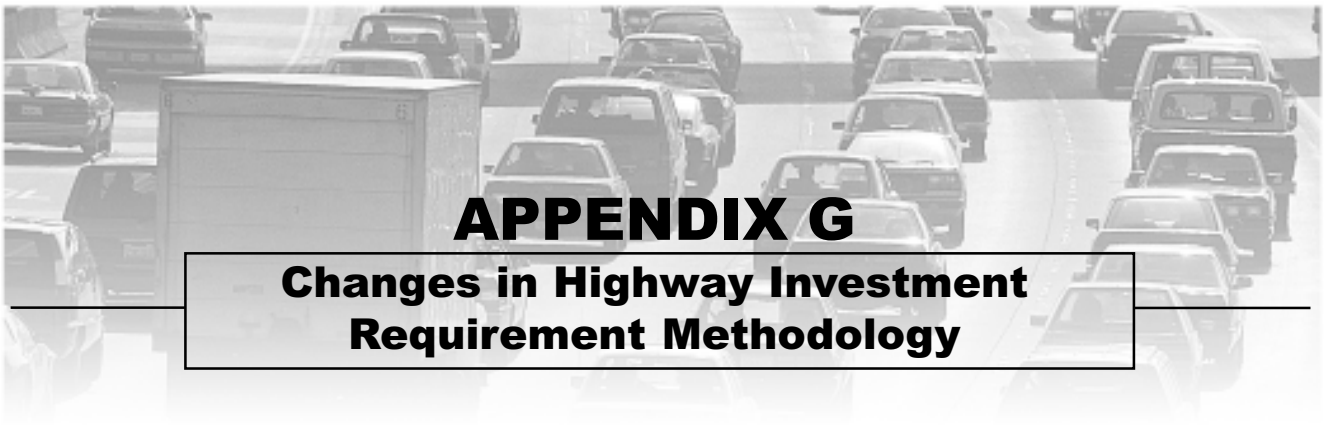

APPENDIX G

Changes in Highway Investment Requirement Methodology

Introduction

The projected average annual highway investment requirements for 1998-2017 shown in this report are not directly comparable to those shown for 1996-2015 in the 1997 C&P report. Since the release of the "1997 Status of the Nation's Surface Transportation System—Condition and Performance" (C&P Report), the FHWA has conducted a series of outreach meetings with members of the academic community, congressional staff and other transportation professionals on the report and the HERS model. As a result of this process, the FHWA has reevaluated several of the procedures used in the development of previous reports.

As discussed in the introduction to Chapter 7, in previous C&P reports, separate external adjustments were made to account for some types of capital improvements, but other improvement types were omitted completely. Based on recommendations received during the C&P report outreach process, in this report, the scope of the investment requirements has been streamlined, and expanded to cover all types of highway capital outlay.

During the preparation of the last report, the State travel forecasts for some highway sections were manually reduced to match MPO forecasts. During this process, some errors were inadvertently introduced into the highway database that had an effect on the results, primarily for the Maximum Economic Investment scenario. The Maintain User Costs scenario results were also affected, but to a lesser degree. When these data issues were resolved, it became apparent that they had been masking some undesirable interactions between the new travel demand elasticity features in HERS, and some HERS settings and external adjustment procedures that had previously been in place. To address these problems, a number of changes have been made to the analytical procedures used to develop the investment requirements in this report. The "high cost lane" feature in HERS, that allowed the model to consider adding lanes in locations where it normally would not be feasible has been turned off. Some external model adjustments that formerly offset some of the high cost lanes have been eliminated, or folded into the streamlined adjustment process mentioned above.

Based on the recommendation of an expert panel that reviewed the HERS model, the emissions cost module in HERS has been utilized in this report, so the benefit cost analysis now considers this factor. The travel demand elasticity values used have also been increased. This change suppresses some travel demand in congested urbanized areas, which offsets an increase in the base VMT forecasts used in this report.

Some other modifications have been made to the HERS model that also have an impact on the results, most notably the development of new safety analysis procedures. The new procedures make increased use of specific highway characteristics affecting safety, and better reflect the effects of highway improvements on safety.

Summary

Exhibit G-1 compares the original investment requirements reported in the 1997 C&P report with the values obtained by analyzing the same data with the current analytical procedures. The effects of inflation, expanding the scope of the investment requirements, and revisions to the data and model are shown separately.

Exhibit G-1

Impact of Analytical Changes on Amounts Reported in the 1997 C&P Report (Billions of Dollars)

	Maintain User Costs	Maximum Economic Investment
Amounts reported in 1997 C&P report based on 1995 data ($1995)	**40.5**	**70.2**
Convert to 1997 Dollars	3.0	5.2
Expand scope to include all improvements ($1997)	5.3	9.2
Data Corrections and Model Changes ($1997)	-0.7	-2.0
Revised estimates based on 1995 data ($1997)	**48.2**	**82.6**

Based on 1995 HPMS data, the 1997 C&P report projected average annual highway investment requirements for 1996-2015 would be $40.5 billion in 1995 dollars under the Maintain User Costs scenario (excluding bridges) and $70.2 billion in 1995 dollars under the Maximum Economic Investment scenario (excluding bridge). Revised projections based on 1995 HPMS data using the analytical procedures developed for this report show an increase of 19 percent to $48.2 billion in 1997 dollars for the Maintain User Costs benchmark, and an increase of 18 percent to $82.6 billion in 1997 dollars for the Maximum Economic Investment scenario.

The increase in investment requirements is primarily due to inflation, and an expansion in the types of capital improvements included. The remainder is caused by data corrections, analytical changes and model enhancements, which largely offset each other.

Effect of Inflation

The bid price index, which is used to calculate the costs of highway improvements, rose between 1995 and 1997. The rural index increased by 9.0 percent and the urban index rose by 6.8 percent. Converting the investment requirements from 1995 dollars to 1997 dollars causes them to increase by approximately 7.5 percent for both the Maximum Economic Investment scenario, and the Maintain User Costs benchmark.

Expanding the Scope of the Investment Requirements

In previous reports, separate external adjustments were made to account for some types of capital improvements not captured in the modeling process, but other improvement types were omitted completely. To allow for comparisons between investment requirements and current capital spending, a “C&P-related capital outlay” figure was used that excluded current spending on items not included in the investment requirements. A significant problem with this approach is that it makes it difficult to relate the investment requirements to other commonly available figures for current and future

spending (i.e. the increase in funding under TEA-21 compared to ISTEA). To make this comparison accurately, it would be necessary to deduct all amounts estimated to be used for safety, traffic operations, environmental enhancements, or for new construction related to economic development. Unfortunately, the raw data required to make this type of adjustment is not commonly accessible, which has led to erroneous use of the C&P report investment requirements. This problem was noted by some participants at the C&P report outreach sessions.

Another concern expressed at the outreach meetings was that excluding safety, traffic operations facilities, and environmental enhancements from the analysis implies that this type of spending is not considered to be important by the agency. On the contrary, this type of investment is critical to allow FHWA to achieve its strategic goals.

Based on these comments, the "report-related capital outlay" concept has been dropped from this report, and the investment requirements in this report have been expanded to include all types of highway capital outlay. To accomplish this, the external adjustment process has been streamlined, and is now based on an underlying assumption that the overall percentage of capital investment that is used for types of capital improvements that are not modeled are likely to remain roughly the same in the future. Expanding the scope of the investment requirements to include all types of capital outlay increases both the Maximum Economic Investment scenario, and the Maintain User Costs benchmark by approximately 13.1 percent.

This modification does not increase or reduce the gap between current spending and investment requirements, since investment requirements and the spending figures they are compared to both have been increased by the same percentage. The relationship between current spending and investment requirements is discussed more fully in Chapter 8.

Data Corrections, Changes in Analytical Procedures and Model Enhancements

During the preparation of the 1997 C&P report, VMT growth rates for all highway sections in urbanized areas over one million in population were factored downward from the values reported in HPMS, to be consistent with an aggregate growth rate compiled from rates developed by the MPOs. In the process of making this adjustment, some errors were introduced into the data. A number of stop signs, intersections and traffic signals that had originally been coded were inadvertently eliminated. As a result, when HERS processed this data, it overestimated the capacity and travel speed on a number of sections, reducing the potential benefits of adding lanes. If this problem had not occurred, the investment requirements under the Maximum Economic Investment scenario would have been higher, as HERS would have found more potential projects to be economically justified. The investment requirements under the Maintain User Costs scenario would have been reduced somewhat, as HERS would have had a broader range of possible improvements to choose from, when selecting the best mix of projects to maintain user costs at baseline levels.

When these data issues were resolved, it became apparent that the new travel demand elasticity features were interacting with some other HERS settings and external adjustment procedures in ways that had not been fully anticipated. To address this problem, the FHWA expanded the scope of its previously scheduled review and outreach efforts to consider more aspects of the C&P report and HERS. This effort has led to the revision of the methodology used to develop the investment requirements.

As shown in Exhibit G-1, the combined effect of the data corrections, analytical changes and model enhancements was to reduce the Maintain User Cost scenario by $0.7 billion (1.7 percent) and to reduce the Maximum Economic Investment scenario by $2.0 billion (2.9 percent).

High Cost Lanes

For each highway section in HPMS, States code a Widening Feasibility rating. The investment requirements analysis in previous versions of the C&P report treated this rating as a measure of the number of lanes that could be added at "normal" cost. It was assumed that if additional lanes were justified, they could be added at "high" cost, representing the cost required to double-deck a freeway, build a parallel route, or acquire expensive right-of-way. For highway investment requirement scenarios developed using the HPMS Analytical Process model, the widening costs projected by the model were increased externally to account for high cost lanes. When HERS was developed, the high cost lane procedure was built into the model as an optional setting. In this report, it has been assumed that highway sections can not be widened beyond the width specified as feasible by the States, and the high-cost lane feature in HERS has been turned off. This change was made for two reasons, one related to the underlying HPMS data, and one related to the operation of the HERS model.

The number of HPMS sections coded by States as infeasible to widen has declined over time. While States once appeared to be taking a narrow view of feasibility, limiting the number of sections where widening was coded as feasible, they now appear to be taking a more expansive view, and only rating widening as infeasible if it would be close to impossible to accomplish. Based on this, it is more appropriate to treat these sections as being impossible to widen, rather than simply very expensive to widen.

Another factor in the decision to change this procedure was that the new travel demand elasticity features in HERS appeared to be combining with the high-cost lane feature to add an excessive number of lanes in urbanized areas. As currently implemented, HERS considers an all-or-nothing approach to widening; the model calculates the number of lanes required to fully accommodate projected future traffic, and then chooses between adding all of them, or adding no new lanes. Since travel demand elasticity causes future travel to increase in some scenarios, this makes HERS more likely to add additional high cost lanes, rather than simply not widening at all. Procedures are now being developed to allow HERS to consider adding variable numbers of lanes, so the model will not be faced with an all-or-nothing choice and can evaluate the optimal number of lanes (if any) to add to any given section. It is likely that this modification will reduce the number of high cost lanes that HERS would add, which might allow the high cost lanes feature to be turned back on in the future, without risk of distorting the data.

External Adjustment Procedure Changes

The HERS results are supplemented by external adjustments to account for functional classes and types of capital investment that are not currently modeled. Rural minor collectors and rural and urban local roads are not represented in the HPMS sample database, so HERS cannot estimate investment requirements for these systems. The 28 improvement options that HERS considers primarily address pavement and capacity deficiencies on existing highway sections. Currently, HERS does not directly consider new roads and bridges, or system enhancements (improvements primarily related only to safety, traffic operations, or environmental enhancements).

As indicated earlier, the external adjustment process in this report has been changed. A number of external adjustments made to the HERS results in recent reports have been discontinued. Most of these are now captured in the streamlined external adjustment procedure, which assumes that types of improvements that are not currently modeled will need to continue to be funded in the future, and will consume the same overall percentage of highway capital investment. Separate adjustments for TSM/ITS, metropolitan expansion, local roads, and rural minor collectors are no longer included. The new external adjustment process also captures some of the investment requirements for new roads that were formerly modeled as part of the high-cost lane feature in HERS.

Metropolitan Expansion Adjustment

In the 1997 C&P Report, the Metropolitan expansion adjustment added about $10 billion to both scenarios. The logic behind this adjustment was that as the population of the Nation increases, additional facilitates are required to accommodate the growth, especially in expanding urban areas. The costs of these additional facilities were therefore factored into the total improvement costs. This adjustment received some criticism following the last report, since it was viewed as not wholly consistent with the relatively low 20-year travel growth projections used in the report. As new construction is factored into the streamlined adjustment process, this separate adjustment is no longer required.

TSM/ITS Adjustment

During the development of the highway investment requirements for the 1997 C&P report, a number of the high-cost lanes added by HERS were offset by more efficient use of existing lanes, via investments in such things as freeway surveillance and control, high occupancy lanes, ramp metering, incident management, and signalization improvements. Since the high-cost lane feature in HERS has been turned off in this report, this special adjustment is no longer required. The TSM/ITS investment requirements are now factored in the streamlined external adjustment procedure. The benefits of ITS are most apparent in changes in system reliability. At the moment, HERS does not measure the benefits of reliability, so the model could not easily incorporate ITS options. Future plans for HERS include the development of new ways to incorporate system reliability into the analytical framework of the model, and allow ITS improvements to be considered and evaluated directly.

Local Roads and Rural Minor Collectors Adjustments

In the 1997 report, investment requirements for local roads were based on an old Department of Agriculture study, that has not been updated. Investment requirements for rural minor collectors were estimated based on 1993 data, the last time HPMS sample section data was collected for this functional class. Continuing to rely on these old data does little to add to the quality of these estimates so these separate adjustments have been replaced with the streamlined external adjustment procedure.

Emissions Costs Module

An emissions cost module has been added to HERS as a first step in addressing the societal costs of highway improvements. This module was not utilized in the preparation of the 1997 C&P report, since there is a great deal of uncertainty about the proper values to assign to the societal costs of different pollutants, and about the best method to apply them in a section-by-section analysis.

In June 1999, an independent panel of experts reviewed the new travel demand elasticity and emissions costs procedures in HERS. The panel concluded that the simplifications HERS uses to allow section-by-section analysis of social costs as a result of pollutant emissions probably overstate the negative impacts of emissions overall, particularly in rural areas. However, they indicated that the HERS procedures would tend to underestimate social costs in some non-attainment areas. The panel recommended a number of enhancements that should be made to the HERS emissions module to refine its analysis. The emissions costs figures are derived in part from the Environmental Protection Agency's MOBILE5a and PART5 models, which are scheduled to be supplanted shortly by updated versions.

Posed with the question as to whether it would be better to start utilizing the existing emissions module in the C&P report, or wait until a next-generation module can be developed, the expert panel suggested that it would be better to include the emissions costs analysis in the C&P report, with caveats about the appropriateness of the data and the underlying air quality models, rather than to simply continue to exclude emissions costs from the HERS benefit cost analysis.

The emissions costs used in HERS for this report appear to be in the same order of magnitude, but generally higher than those used in the March *1999 Addendum to the 1997 Federal Highway Cost Allocation Study Final Report*. Due to the differences between the scope of the two reports, the Cost Allocation Study approach is not directly transferable to the HERS model. The HERS emissions module was developed before the release of EPA's *The Benefits and Costs of the Clean Air Act, 1970-1990* report, so this report does not reflect any of that report's findings. The Department of Transportation plans to work with the EPA to develop a better approach for reflecting emissions costs in the HERS analysis for use in future C&P reports.

Travel Demand Elasticity

The travel demand elasticity features in HERS recognize that as a highway becomes more congested, travel volume on the facility is constrained, and that when lanes are added to a facility, the volume of travel may increase. Travel demand elasticity is introduced in Chapter 7. Some implications of this model feature are discussed in Chapters 7, 9, and 10.

For the 1997 C&P report, short term elasticity was set at -0.8, with an additional -0.2 (total, -1.0) used for long term elasticity. In June 1999, an independent panel of experts reviewed the new travel demand elasticity and emissions costs procedures in HERS. One of their recommendations was that these values be increased.

Since HERS is a segment-level analytical tool, its elasticity values need to take into account the diversion of traffic to and from other road segments, rather than simply considering new/suppressed trips, or shifts to and from other modes of transportation. When a highway segment is widened, it may attract a significant amount of traffic from parallel routes, in addition to causing some shift from transit, and some new trips that would not have otherwise occurred. If a highway segment becomes severely congested, but is not widened, some trips will be suppressed entirely, some people will shift to transit, and others will shift to parallel highway routes if they are available, and less congested. The panelists indicated the values used in HERS were too low, since they were supposed to reflect route diversion. **For network-level analytical tools, it would be more appropriate to use lower elasticity values than HERS, since these network-level analyses should be able to handle route diversion directly.**

For this report, short term elasticity was set at -1.0, with an additional -0.6 (total, -1.6) used for long term elasticity. Increasing the elasticity values has the effect of suppressing travel on congested routes, and inducing additional travel on non-congested routes.

Travel Growth in Large Urbanized Areas

In the 1995 C&P report, and earlier editions, the highway investment requirements were developed based on static VMT growth projections. The models available at that time did not have the capability of projecting the effects that changes in the condition or future performance of a highway section could have on future travel growth. This made it critically important that the VMT projections fed into the models accurately predicted the most likely level of future travel growth. Although the concepts of demand and system management were introduced in the 1991 and 1993 C&P reports, the basic State-supplied travel demand forecasts in HPMS were accepted as given.

During the preparation of the 1995 C&P report, it was judged that individual HPMS sample section travel growth projections provided by the States were not adequately incorporating the effects that aggressive Transportation System Management (TSM) and Transportation Demand Management (TDM) strategies would have on reducing future travel demand. Regional traffic growth forecasts developed by Metropolitan Planning Organizations projected an aggregate average annual growth rate of 1.5 percent over 20 years. To be consistent with these forecasts, the travel growth rates for all highway sections over one million in population were factored downward, to force their average growth rate for the 1994-2013 period to be 1.5 percent, rather than the 2.23 percent projected for these sections in HPMS.

The addition of travel demand elasticity features to the HERS model makes the VMT growth projections dynamic. HERS recognizes that changes in the costs of using a highway facility will affect future travel growth on that facility. As discussed in Chapter 9, one implication of travel demand elasticity is that each different scenario and benchmark developed using HERS results in a different projection of future VMT. As indicated in Chapter 10, the accuracy of the highway investment requirements projected by HERS is no longer fully dependent on the accuracy of the travel demand forecasts fed into the model. Instead, the accuracy of the investment requirements depends on the accuracy of the input forecast, as modified by the travel demand elasticity features in HERS. The introduction of travel demand elasticity into HERS changes the factors that should be considered in determining what baseline forecast should be entered into the model. It is no longer critical to determine which forecast is more likely to be “right”. Instead, the baseline forecast needs to be compatible with the travel demand elasticity features in HERS, to allow the model to accurately produce a spread of travel growth projections for different possible levels of investment.

As discussed in Chapter 7, the HERS model assumes that the VMT growth projections entered for each sample section represent the travel that will occur if the pavement and capacity improvements made on the segment during the next 20 years are sufficient to maintain highway-user costs at current levels. While this assumption may not be valid for all State-supplied HPMS sample forecasts, the State-supplied values appear to meet this assumption better than the MPO regional forecasts. The MPO forecasts already build in the effects of TDM programs, which the HERS travel demand elasticity features are designed to mimic. Therefore, using the MPO forecasts raises the risk of double counting the same effects.

Because the State-supplied travel forecasts are more consistent with the assumption HERS makes about the baseline forecasts, they were utilized for all HPMS sample sections in this report. The weighted average growth rate for all sections in urbanized areas over 1 million in population for 1998-2017 was 1.86 percent. As pointed out in Chapter 9, at current funding levels, HERS modifies this projection down to 1.66 to 1.70 percent. This is consistent with the most recent survey of MPO's, which indicates their 20-year regional forecasts currently project a growth rate of 1.68 percent, up from 1.5 percent four years ago. The MPO's are more likely to consider funding constraints in developing their regional travel growth projections than the States are in developing their projections for HPMS.

In the 1997 report, the State-supplied travel growth rates for sections in urbanized areas were factored down manually and elasticity was applied. The baseline average annual travel growth rates for 1996-2015 were factored down from the 1.88 percent projected by the States to 1.5 percent. For the Highway Maintain User Costs scenario in the 1997 report, the effective travel growth rate remained approximately 1.5 percent, after elasticity was applied. For the Maximum Economic Investment scenario the travel demand elasticity features in HERS increased the effective travel growth rate above this level. Subsequent analysis of the travel demand elasticity procedures in HERS, and comments from the independent panel that review the model suggest that the approach used in the development of the 1997 report may have double-counted the impacts of some MPO policies to control travel growth. However, since the expert panel also concluded that the elasticity values used in the 1997 report were too low, any potential double-counting may have been offset.

Chapter 10 explores the effects of reducing the State-supplied growth projections for highway sections in large urbanized areas. Exhibit 10-1 shows that reducing the baseline growth projection down to the level of the latest MPO forecasts would only reduce investment requirements by 1 to 2 percent.

Q. **Since State-supplied growth forecasts are utilized for large urbanized areas in this report, does this imply that the State forecasts are more accurate than the MPO regional forecasts?**

A. No. As a point estimate of future travel growth, the MPO regional forecasts may well be more accurate. The MPO forecasts tend to consider more factors than the State-supplied forecasts, which improves their reliability. However, the MPO forecasts tend to have built-in adjustments for factors that the travel demand elasticity features in HERS also account for.

The State-supplied HPMS forecasts are utilized in this report because they are more compatible with the HERS travel demand elasticity procedures. This does not imply they are more accurate than the MPO forecasts. At current funding levels, the travel demand elasticity features in HERS reduce the baseline HPMS travel growth projections down to a level that is consistent with the latest survey of MPO's. This would indicate that the travel demand elasticity features in HERS compensate for the differences in the underlying assumptions between the MPO forecasts and the State-supplied forecasts.

Q. **Could the travel demand elasticity features in HERS be modified to be more compatible with the MPO growth forecasts?**

A. Yes. In the long term, the model could be modified to assume the baseline forecasts fed into it already take into account TDM effects. A short term solution would be to lower the elasticity values, which would reduce the risk of double-counting TDM effects.

However, using the original values coded on the HPMS segments is a better approach from a technical perspective. The MPO travel growth rates are not section-specific, and an arbitrary external adjustment must be made to the HPMS segment data in order to make it line up. This approach reduces the accuracy of the individual highway segment analyses, and creates the potential for introducing errors into the data.

Deficiency Levels

As described in Chapter 7, HERS identifies potential improvements by forecasting future conditions and performance, and identifying deficiencies in eight highway section characteristics: pavement condition, surface type, volume/capacity (V/C) ratio, lane width, right shoulder width, shoulder type, horizontal alignment (curves) and vertical alignment (grades). When HERS determines a section's pavement or capacity is deficient, it will identify potential improvements to correct some or all of the section's deficient characteristics. Based on a benefit/cost analysis, HERS may either implement one of the improvements identified, or leave the section unchanged.

Different "Deficiency Levels" can be set in HERS to regulate when the model will identify a section as deficient, and which types of improvements the model will consider to address the deficiencies. HERS has 28 distinct types of improvements to choose from, but for an individual section the model only evaluates the potential improvements it deems to be most appropriate. For this version of the report, the deficiency levels in HERS have been modified to allow the model to consider up to six alternative improvements for each section at a time; one or two aggressive improvements that would address all of the section's deficiencies, and three or four less aggressive improvements that would address only some of the section's deficiencies. In previous C&P reports, the model only actively considered one or two alternatives at a time. The result of this change is that HERS now implements lower-cost less aggressive improvements on some highway sections, in lieu of the higher-cost improvements it may have otherwise implemented.

Revised Safety Module

The most significant enhancement to HERS since the release of the 1997 C&P report has been the development of new safety analysis procedures. The new procedures make increased use of specific highway characteristics affecting safety, and better reflect the effects of highway improvements on safety. The new relationships between highway characteristics and crash rates in the HERS safety procedures cause the safety effects of potential highway improvements play a more noticeable role in the evaluation of improvements. By increasing the safety benefits of widening lanes, improving alignments, and/or widening shoulders, the new procedures make it more likely that HERS will implement these types of improvements. The new equations also project that the safety benefits of reducing congestion will be higher than the levels previously predicted by HERS.

The new HERS safety module allows the user to input forecast reductions in future injury and fatality rates due to factors not directly considered in the HERS analysis, such as changes in vehicle designs, emergency care, and driver behavior. This adjustment is made to avoid having HERS claim full credit for injury and fatality reductions in its benefit cost analysis of potential projects, when some of these reductions will probably be driven by factors exogenous to the HERS model. However, this feature was not used for the main scenarios in this report, pending further research on the appropriate values for these reductions. The impact of including some preliminary values in the analysis is explored in the sensitivity analysis in Chapter 10.

Other HERS Enhancements

The capacity calculations in HERS have been updated to conform to the 1997 revisions to the Highway Capacity Manual. The effect of these changes is to increase the estimated capacity of some highway sections, which tends to delay or eliminate the implementation of widening improvements. While these changes are not as significant as the adjustments made previously to conform to the 1994 Highway Capacity Manual discussed in previous C&P reports, they do tend to reduce improvement costs.

The value of time procedures have been revised to make them more consistent with the Department of Transportation standard. A number of other parameters have also been modified to incorporate newly available data. Several other minor upgrades have been made to the model, but do not significantly affect the overall investment requirement projections.