The traditional approach for reconstructing rural highways in the United States has been to subdivide roads into 5-10 mile segments, and to successively redesign and reconstruct these segments. As a result, a 50-mile highway might require 5 to 10 years to completely rebuild, thus leading the public to conclude that roads are always under construction, with the completion of one project coinciding with the start of the next. More critically, the expected project benefits, including reduced road-user costs, enhanced safety, and economic development are delayed.

In a significant departure from this practice, the New Mexico Department of Transportation utilized innovative financing, design, and construction practices to reconstruct a 118-mile section of a two-lane highway to a four-lane highway over a period of three years. The department estimates that it would have taken over 20 years to reconstruct this road using their standard procedures. The prolonged project would have cost more and benefits would have been postponed.

This research examines the actual safety benefits resulting from the reconstruction of this extended roadway segment, finding some unexpected results. It also evaluates the safety consequences of the expedited construction process, which minimized the duration of traffic disruption and potential for work zone crashes, while providing the public with a safer road in three, rather than 20, years.

**Abstract**

The traditional approach for reconstructing rural highways in the United States has been to subdivide roads into 5-10 mile segments, and to successively redesign and reconstruct these segments. As a result, a 50-mile highway might require 5 to 10 years to completely rebuild, thus leading the public to conclude that roads are always under construction, with the completion of one project coinciding with the start of the next. More critically, the expected project benefits, including reduced road-user costs, enhanced safety, and economic development are delayed.

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Achieving Safety Benefits Sooner Rather Than Later –
A Before and After Study of US 550/NM 44

Final Report

by

J. W. Hall
Professor, Civil Engineering
University of New Mexico

A Report on Research Sponsored by

New Mexico Department of Transportation
Research Bureau

in cooperation with
U.S. Department of Transportation
Federal Highway Administration

September 2006
PREFACE

The research in the body of this report examines the accident experience on NM 44 for three years before its reconstruction and renaming as US 550, and for two years afterward. The information in the Appendix, developed gratis after the completion of the sponsored research, incorporates a third year of after data.

NOTICE

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DISCLAIMER

This report presents the results of research conducted by the author and does not necessarily reflect the views of the New Mexico Department of Transportation. This report does not constitute a standard or specification.
Acknowledgments

The crash data used in this report were provided by James Davis at the University of New Mexico Division of Government Research. The traffic volume data used in the latter, unfunded stages of this work were provided by Becky Valencia in the NMDOT Transportation Planning Division. The assistance of these individuals and offices is appreciated.
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Background

NM 44, a 151-mile road on the National Highway System, connects Bernalillo in north-central New Mexico to Bloomfield in the four-corners area. Thirty years ago, this important commercial and recreational two-lane route had many roadway and roadside features that did not comply with modern design standards - narrow lanes, non-existent shoulders, limited sight and passing distances, narrow bridges, non-forgiving roadsides, and similar features (See Figure 1). It also had the reputation of being one of the least safe rural highways in New Mexico. The road’s accident rate in 1978 was 1.56 accidents/million vehicle miles (acc/mvm). Between 1976 and 1984, the New Mexico State Highway and Transportation Department (NMSHTD) reconstructed much of NM 44, remedying the most serious deficiencies:

- Narrow lanes were replaced by 12-foot lanes
- Shoulders, typically 10 feet wide, were provided
- Seven bridges were reconstructed to provide full-width shoulders
- Significant earthwork and realignment improved sight distance and safe curve speeds
- Many fixed objects were eliminated and roadsides were flattened

A 1986 evaluation (1) found that the effect of these highway design and operational changes, coupled with any other changes (e.g., enforcement, weather, vehicle design, improved drivers), resulted in the accident rate being cut nearly in half, to 0.83 acc/mvm. The reduced accident rate compared very favorably with those on other rural New Mexico arterials. Nevertheless, the route continued to experience some high-speed collisions, some resulting in multiple fatalities, thus retaining its poor safety reputation. Indeed, vehicles of frequent users of this NM 44 often sported bumper stickers reading “I survived my drive on NM 44.”
Following a statewide study in 1995, Governor Gary Johnson’s Citizen Highway Assessment Task Force (CHAT) recommended several New Mexico corridors where two-lane roads should be reconstructed as four-lane divided roads. NM 44 was designated as one of these corridors. Legislation to fund all these improvements failed to pass the Democrat-controlled legislature in 1996 and again in 1997 (2).

Using standard state highway funds, the NMSHTD reconstructed the 22-mile segment of two- and three-lane highway between Bernalillo and San Ysidro (see Figure 2) to four lanes. The department estimated that it would take over 20 years using its standard reconstruction procedures to upgrade the 118-mile segment north of San Ysidro. However, the time dimension was immaterial because there simply was no funding available to accomplish the reconstruction.
The NMSHTD Secretary and the Federal Highway Administration (FHWA) New Mexico Division Administrator sought advice from experts in highway design, construction, and financing on innovative ways to fund the project and dramatically shorten the construction period. The

Figure 2. Reconstructed Portion of NM 44/US 550 (source: Mesa PDC)
experts concluded that the typical “five-mile” construction projects were inefficient. As a result, the corridor was subdivided into eight design segments, averaging about 15 miles in length. The NMSHTD management chose to reduce costs and expedite construction by using the same cross section along the entire corridor and to build within the existing right-of-way. Financing posed more of a problem, but was accomplished when:

- The NMSHTD utilized the Grant Anticipation Revenue Vehicles (GARVEE) federal bonding process, which allows states to pledge a portion of their future federal funding.
- The FHWA was willing to accept the state funds spent on the initial 22 miles as a match for federal fund for the remaining 118 miles.
- The NM match was further reduced by the large amount of federal lands along this corridor, nearly half of which was tribal lands belonging to the sovereign nations of the Zia and Jemez Pueblos, the Jicarilla Apache Nation and the Navajo Nation.
- The NMSHTD request for proposals (RFP) sought a Public-Private mechanism for the design, construction, and management of the corridor. In addition, the RFP required that the contractor provide a long-term warranty, for up to 20 years or a specified number of axle loadings.
- The entire ‘final design’ and reconstruction project was completed in three years, 1999-2001.

In July 1998, a contract was executed with Mesa PDC to serve as the project development contractor. Design of the shortest section was accomplished within 10 months, and the initial construction contract was signed in June 1999. Reconstruction of the entire corridor was completed in late November 2001; the official ribbon cutting ceremony was held on December 8, 2001.
The 2.5-year reconstruction period for this highway corridor affords several opportunities for improved safety. The most obvious is that whatever benefits may result from reconstruction will be achieved within a few years rather than being phased in over a period of 20 years. A more subtle effect was that most of the corridor was under construction at one time, leaving no doubt in the mind of motorists that they were in a construction zone, often with speed limits of 45 mph. Although crashes during construction were not examined in this study, some evidence suggests that crashes actually decreased while the corridor was being reconstructed.

On the other hand, the reconstructed NM 44 (redesignated as US 550) has at least two characteristics that contraindicate enhanced safety. To reduce initial construction costs, the roadway was rebuilt within the existing right-of-way, in part because of the difficulty in negotiating with sovereign Indian Pueblos/Nations for additional land. Although the reconstructed road has four lanes and adequate right-hand shoulders, the “median” is only six-feet wide, albeit with rumble strips. Secondly, the roadway was designed with a 65 mph design speed, but at the insistence of politicians, it was posted with a 70 mph speed limit. This matter is easily treated on two critical horizontal curves, where standard curve signs with 65 mph advisory signs are posted. The resolution of this problem at seven vertical curves that only meet stopping sight distance requirements for 65 mph is more troublesome. Figure 3 shows the sign that the NMSHTD used to alert approaching motorists; the symbol sign is considered experimental and has not been approved for inclusion in the MUTCD (3).
Figure 4 shows a typical, tangent section of US 550 prior to the installation of median rumble strips. Figure 5 shows the transition at the northern end of the reconstructed route near MP 143, with rumble strips, to the previously reconstructed roadway with a 30-foot median.

**Figure 4.** Typical Cross Section without Rumble Strips  
**Figure 5.** Transition from 6-foot median with rumble strips to 30-foot median at MP 143 NB.

**Crash Data**

The NMSHTD, in cooperation with state, local, and tribal agencies, facilitates the coordination of crash data collection and the entry of data into a computerized databases. Reconstruction of NM 44 began in mid-1999; state officials subsequently found problems with incomplete reporting and incorrect coding for crash data for the last quarter of 1999. As a result, the *before* crash database for this study is for the three-year period 1996-1998. The *after* crash database for this preliminary safety review of the NM 44/US 550 reconstruction is for 2002-2003. Because of the different durations of the *before* and *after* periods, numbers of crashes cannot be compared. Instead, comparisons will be made using the percentage distribution by severity, manner of
collision, weather, etc. A comparison will also be made between the annual before and after cost of crashes.

**Safety Analysis**

Reconstruction of NM 44/US 550 had multiple objectives, including economic development, travel time improvements, and safety. Figure 6 advertises the project’s innovative nature. This section will compare the crash experience for the three calendar years prior to construction with the two years following the construction.

The analysis is limited to the portion of the route between milepost 23.7 in San Ysidro and milepost 143 south of Bloomfield, excluding a 1.3 mile segment through Cuba, NM (See Figure 2). Although this route had relatively good posted mileposts during both before and after periods, some crash reports in both periods do not cite mileposts. All such reports were excluded from the analyses that follow.

<table>
<thead>
<tr>
<th>Table 1</th>
<th>Year</th>
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<tbody>
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<td>1998</td>
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</tr>
<tr>
<td>2002</td>
<td>122</td>
<td></td>
</tr>
<tr>
<td>2003</td>
<td>91</td>
<td></td>
</tr>
</tbody>
</table>

Crash experience on any corridor varies from year to year due to factors such as weather, enforcement, travel, and chance variation. Table 1 shows the crash counts on the corridor for the before and after periods. The three-year before period averaged 85 crashes annually; the two-year after period averaged 106 crashes annually. At first glance, this improvement appears to be negative. But it is essential to consider some mitigating factors. At the most basic
level, the more complete placement of milepost references in the after condition enhanced the likelihood that crashes were properly located. Previously, accident reports with insufficient locational information were coded with a milepost of either 0000 or 9999, neither of which would be included in the study section.

Although the number of reported crashes increased, the severity of these crashes decreased in the after period. The share of crashes resulting in a fatality dropped from 3.9% in the before period to 3.3% in the after period. Likewise, the proportion of crashes resulting in an injury decreased from 37.9% to 30.0%. Overall, the severity index (SI), which is the proportion of the crashes resulting in a fatality or injury, dropped from 0.42 to 0.33. The severity distribution is shown in Figure 7.

The primary reason for the decrease in crash severity is a change in the pattern of crashes occurring in the before and after periods. In particular, there was a decrease in the proportion of crashes involving overturning, other vehicles, and other manners of collision (e.g., other non-collision, parked vehicle). A previous study of crashes on New Mexico’s rural highways found that overturning crashes had a SI of 0.61. Prior to the reconstruction, 43% of the other vehicle collisions on NM 44 involved opposite direction head-on and sideswipe impacts; this decreased
to 11% in the *after* period. At the same time, less severe same-direction rear-end and sideswipe impacts increased from 25% of the other vehicle collisions in the *before* period to 60% of the collisions in the *after* period. As shown in Figure 8, there was an increase in the proportion of impacts involving fixed objects, but the increase primarily involved *softer* fixed objects, such as guardrail and fences.

Consistent with the results cited above, the proportion of the crashes where the traffic control was listed as “No Passing Zone” dropped from 18% in the *before* period to 3% in the *after* period.

There were some interesting changes between the *before* and *after* periods in the contributing factors cited by the investigating officers. “Excessive speed/speed too fast for conditions” increased from 19% of all crashes to 30%, “driver inattention” grew from 10% to 14%, and “avoid other item” jumped from 1% to 13%. At the same time, “driving left of center” dropped from 10% to 1%, “alcohol involvement” dropped from 12% to 7%, and “None/no error” dropped from 33% to 20%.

Changes in other crash characteristics were fairly modest, and could be attributed to factors other than the reconstruction of the route. For example, crashes in clear weather dropped from 79% to 72%, but this is more likely due to the relative frequency and severity of weather conditions between the two periods. The proportion of crashes under daylight/dawn/dusk conditions dropped marginally.

**Accident Costs**

A previous paper (4) reported on the development of accident costs on New Mexico streets and highways as a function of manner of collision and type of area (rural or urban). That study
examined the severity consequences of over 250,000 traffic accidents in New Mexico, and then used FHWA cost estimates and the distribution of injury levels to determine expected costs for various crash types. Table 2 presents results for selected crash types on state-administered roads. The costs shown in the table are logical: crashes that are known to have high severities, such as pedestrian collisions or opposite-direction impacts have high expected costs, whereas those that tend to be less severe, such as impacts with animals or rear-end collisions have lower expected costs.

The data in Table 2 were used to estimate the before and after crash costs on the route. This was accomplished by summing the products of the number of crashes of a particular type and the costs of that manner of collision. If $C_i$ represents the expected cost of Collision Type $i$, and $N_i$ represents the actual number of Type $i$ crashes in the before period, then:

$$\text{Total before crash cost} = \sum_{i=1}^{n} C_i \times N_i$$

The average cost of before accidents is calculated by dividing the

<table>
<thead>
<tr>
<th>Collision Type</th>
<th>State</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>Rural</td>
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<tr>
<td>Pedestrian</td>
<td>1,101,000</td>
</tr>
<tr>
<td>Overturning</td>
<td>247,000</td>
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<tr>
<td>Intersection, ≥2 vehicle a</td>
<td>125,000</td>
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<tr>
<td>Angle, Straight</td>
<td>177,000</td>
</tr>
<tr>
<td>Angle, 1 Left-turn</td>
<td>162,000</td>
</tr>
<tr>
<td>SD, 1 Left-turn</td>
<td>97,000</td>
</tr>
<tr>
<td>Other</td>
<td>72,000</td>
</tr>
<tr>
<td>Non-Intersection, ≥2 veh a</td>
<td>168,000</td>
</tr>
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<td>Opposite-direction</td>
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</tr>
<tr>
<td>Same-direction</td>
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<tr>
<td>Other</td>
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</tr>
<tr>
<td>Fixed Object a</td>
<td>70,000</td>
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<tr>
<td>Embankment</td>
<td>131,000</td>
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<td>Abutment, Utility Pole</td>
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</tr>
<tr>
<td>Culvert, Ditch</td>
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<td>Guardrail</td>
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<tr>
<td>Other</td>
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<tr>
<td>Driveway-related</td>
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<td>114,000</td>
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<tr>
<td>Animal</td>
<td>11,000</td>
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<tr>
<td>Other Accidents</td>
<td>18,000</td>
</tr>
</tbody>
</table>

Costs in these three rows represent the weighted averages for all crashes within the heading; they should be used only when more detailed information about crash type is unavailable.

Table 2. New Mexico Traffic Accident Costs

The severity consequences of over 250,000 traffic accidents in New Mexico, and then used FHWA cost estimates and the distribution of injury levels to determine expected costs for various crash types. Table 2 presents results for selected crash types on state-administered roads. The costs shown in the table are logical: crashes that are known to have high severities, such as pedestrian collisions or opposite-direction impacts have high expected costs, whereas those that tend to be less severe, such as impacts with animals or rear-end collisions have lower expected costs.

The data in Table 2 were used to estimate the before and after crash costs on the route. This was accomplished by summing the products of the number of crashes of a particular type and the costs of that manner of collision. If $C_i$ represents the expected cost of Collision Type $i$, and $N_i$ represents the actual number of Type $i$ crashes in the before period, then:

$$\text{Total before crash cost} = \sum_{i=1}^{n} C_i \times N_i$$

The average cost of before accidents is calculated by dividing the
total cost by the 256 crashes in the before period. The calculations are identical for the after period. The total crash cost in the three-year before period was $37.1 million. Opposite-direction two-vehicle collisions and single vehicle overturning crashes each accounted for 35% of the total cost. Total costs for the two-year after period were $22.4 million, with single vehicle overturning crashes accounting for 43% of the total; the next largest categories, pedestrians and same direction two-vehicle collisions, each accounted for less than 10% of the total cost. Average cost per collision dropped from $145,000 in the before period to $105,000 in the after period. Even with the increase in average crashes per year, the annual cost of accidents dropped from $12.4 million to $11.2 million, an annual saving of $1.2 million.

Discussion

At first glance, a 25% increase in the number of accidents between the old NM 44 and the reconstructed US 550 suggests that the roadway reconstruction has not generated benefits. However, the initial benefits arise from the replacement of the higher severity and more costly crashes in the before period with the lower severity and less costly crashes in the after period. The comparison may not capture all of the benefits, however, because the roadsides are now much more forgiving. This can be seen by comparing the before (1990 condition) in Figure 9 with the rebuilt roadside in Figure 4.

Figure 9. Typical roadside before construction
There was concern that the 6-foot median on the reconstructed roadway, albeit with ground-in rumble strips, was not going to be sufficient to reduce two-vehicle opposite direction impacts. However, the data show that these collisions dropped from an average of 10 annually in the *before* period to 2 annually in the *after* period.

**Results with Three Years of *After* Crash Data**

This project and its funding ended on June 30, 2005 and the NMDOT elected not to extend it. Computerized crash data for calendar year 2004, the third year of the *after* period, did not become available from UNM’s Division of Government Research until late August 2005, nearly two months after the completion date for the project. Nevertheless, the PI felt a commitment to exploring the potential improved safety of US 550, and in this spirit, conducted a gratis study of the route using three years of *before* and *after* data. Without any financial support, the PI performed an analysis and used the findings to prepare a PowerPoint presentation. The 30-minute presentation was delivered on January 9, 2006, to an audience of about 100 engineers from governmental agencies and private-sector firms at UNM’s Paving and Transportation Conference. The most relevant slides from this presentation are shown in Appendix A.

On a positive note, the proportion of crashes involving fatalities is down marginally and the proportion involving injuries is down about 8%. The proportion of crashes involving other vehicles, other events, and overturning are down, while those involving animals and fixed objects are up. With respect to officer-reported *contributing factors*, the proportion of crashes involving alcohol dropped from 12% to 7% of all crashes and the proportion of *driving left of center* crashes dropped dramatically from 10% in the *before* period to 1% in the *after* period.

These statistics are particularly impressive because the officers decreased the proportion of cases...
in which they reported *None/No Error* as a contributing factor from 33% to 20%. Another positive sign is that the average crash cost remains virtually unchanged from the results given for the two year after period on page 11.

On the negative side, the number of reported crashes has jumped 36%, from 85 per year in 1996-1998 to 116 per year in 2002-2004. The PI now has a complete set of traffic volume data for this route to help assess how much of this change is attributable to an increase in volume.

Currently, a student working with the PI identified 190 miles of highway segments on three routes (US 60, US 64, US 491) that have remained virtually unchanged during the period 1996-2004. With the assistance of UNM’s Division of Government Research and the NMDOT’s Transportation Planning Division, we’ve obtained traffic accident and traffic volume data for these highway segments. As part of a Master’s project, the student will use NM 44/US 550 as the *treatment site*, and the other three sites as *comparison sites*. This will help account for other factors, such as enforcement, legislation, and human behavior changes, that may have changed over the period examined in this study.

The researchers expect that these continuing studies will provide useful information and will be presented in a future technical forum.

**References**


APPENDIX A

Comparison of 1996-1998 with 2002-2004

See Text, page 12
The following presentation was given at UNM’s Paving and Transportation Conference in January 2006. It documents the improvements over the past 30 years on NM 44/US 550, and compares the crash experience for 1996-98 with that for 2002-2004.

Safety Consequences of NM 44 Reconstruction

Jerry Hall
UNM
January 9, 2006
**NM 44 Improvements 1976-84**

- Widen lanes to 12 feet
- Provide 10-ft shoulders
- Reconstruct bridges w/ shoulders
- Earthwork and realignment
  - Enhance sight distance
  - Increase safe curve speed
- Roadside
  - Remove fixed objects
  - Flatten sideslopes
  - Shield obstacles

**NM 44 near San Ysidro, 1986**
NM 44 Crash Experience
1994-99

- San Ysidro to Bloomfield, excluding Cuba
- 557 total accidents
  - 41 Intersection or driveway
  - 68% single-vehicle
    - 24% Animal
    - 23% Overturning
    - 17% Fixed Object
    - 1.3% Pedestrian
Distribution of Accidents on NM 44, 1994-99

Accidents

Hour of the Day
Potential Safety Benefits of 4-lanes to the 4-corners

- Reduce opposite direction crashes
- Decrease same-direction sideswipe crashes
- Intersection crashes
  - TL help with turning crashes
  - Not obvious for angle crashes
- Could increase SVROR crashes due to speed
US 550, 2002

LT Lanes at Intersections
Treating SVROR crashes

Roadside Treatments
Limited Sight Distance

Alcohol-involved crashes
### Contributing Factors (CF)

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<td>14</td>
</tr>
<tr>
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<td>33</td>
<td>20</td>
</tr>
<tr>
<td>Alcohol</td>
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### Before-and-After Crashes

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<td></td>
</tr>
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<td>2004</td>
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### New Mexico Crash Costs (1000) State-Administered Roads

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<td>10</td>
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### US 550 Crash Costs (est)

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<td>$105K</td>
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<tr>
<td>Total Annual</td>
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<td>$11.2M</td>
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