Traffic Calming Study
Gaylord Mountain Road
from Deer Hill Road to Handy Road

October 2017

Prepared for:
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Introduction
WSP was retained by the Town of Hamden to assess current operation and safety conditions on Gaylord Mountain Road Corridor between Handy Road and Deer Hill Road, and recommend concepts of improvement for traffic calming, speed reduction and reducing crashes.

1. Study Area and Roadway Classification
The Gaylord Mountain Road Corridor is situated in the northwestern corner of Hamden, in proximity to the towns of Prospect and Bethany. The study corridor includes the intersections of Deer Hill Road, Downes Road, Deer Pond Trail, and Handy Road. Gaylord Mountain Road is classified as Urban Local Roads by CTDOT. Figure 1 below depicts the study area and traffic count locations (shown as yellow lines).

Gaylord Mountain Road connects to Carrington Road (CT Route 69 in Bethany). It extends for 2.9 miles from West Woods Road to Carrington Road. This study only considered a 1.1-mile section, between the intersections of Handy Road and Deer Hill Road. The posted speed limit is 25 mph. Gaylord Mountain Road has a straight alignment with horizontal curves at its intersections. The intersection with Broken arrow road has the smallest horizontal radius of 70 feet. The terrain is varied, with several vertical curves. The low point is 250’ east of the intersection. To the west of that point, the grade is very steep, and to the east of that point, the elevation is rolling.

Broken Arrow Road is a dead-end road that forms a T-intersection with Gaylord Mountain Road along a horizontal curve. Broken Arrow Nursery is located at the intersection of Gaylord Mountain Road and Broken Arrow Road.

Downs Road is a 4-way stop-controlled intersection. Both legs of Downs Road are dead-ends.

Deer Pond Trail is a dead-end road that forms a T-intersection with Gaylord Mountain Road and is controlled by a stop sign.

Deer Hill Road and Handy Road also intersect Gaylord Mountain Road at T-intersections (offset intersection) each controlled by a stop sign.
2. Existing Condition

2.1 Data Collection

2.1.1 Roadway Traffic Volumes

Roadway traffic volumes were recorded by Automatic Traffic Recorder (ATR). They were collected by the Town of Hamden at the location shown as yellow line in figure 1 below. ATR volume data are included in the appendix. Traffic volumes were compiled by direction over a period of 3 days from Wednesday July 12, 2017 to Friday July 14, 2017.

Gaylord Mountain Road daily traffic (measured east of Handy Road intersection) for both directions was 4,220 vehicles. Gaylord Mountain Road in the eastbound direction carried 2,100 vehicles and in the westbound direction carried 2,120 vehicles.

During A.M peak period (8:00 AM-9:00 AM) Gaylord Mountain Road carried 268 vehicles on the eastbound direction and 122 vehicles on the west bound direction. During P.M. peak hour period (5:00 PM-6:00 PM) Gaylord Mountain Road carried 176 vehicles on the westbound direction and 345 vehicles on the eastbound direction. Figures 2 and 3 exhibit 24-hour and peak hour volumes for Gaylord Mountain Road, and Adjacent Streets, respectively.
Figure 3- Traffic Volumes By Hour, Gaylord Mountain Road Project Area
2.1.2 Speed Measurements

Posted speed limit on Gaylord Mountain Road is 25 MPH. Speed Measurements were taken on Todd Street corridor over the same period as the ATR, and at the same locations. The 85th percentile of speed along Todd Street was recorded as 39 mph for the eastbound and 38 mph for the westbound.

As depicted on the speed profile, Figures 4 and 5 below, vehicular speed is shown to varying linearly from data collection point to the next.

**85th Percentile Speed** – The speed at or below which 85 percent of vehicles travel.

**Mean Speed**- Time Mean Speed is the total of speed by individual vehicle divided by the number of vehicles.
Figure 4- Speed, Gaylord Mountain Road Eastbound
Figure 5- Speed, Gaylord Mountain Road Westbound

Speed Gradation On Gaylord Mountain Road (Westbound)
2.1.3 Crash Inventory

A crash data analysis was performed for the intersections, as well as along the roadway within the project limit. The crash data was compiled from the UCONN Connecticut Crash Data Repository. UCONN publishes Crash Data from the CTDOT, as well as the newly adopted standard in Connecticut, the MMUCC or the ‘Model Minimum Uniform Crash Criteria Standard.

Table 1 below is the summary of crash data along Gaylord Mountain Road taken from the available most recent 3-year period. The full crash data set is included in the appendix.

Over half of all crashes occurred on the roadway of Gaylord Mountain Road, as opposed to at intersections. There were no recorded crashes at the intersections of Deer Pond Trail or Downes Road.

Below are typical crash diagrams for all crashes within the past 3 years. Crash data is included in the appendix of this Report.
Table 1- Crash Data Summary on Gaylord Mountain Road

<table>
<thead>
<tr>
<th>Location/Year</th>
<th>Total All Locations</th>
<th>Gaylord Mountain at Deer Hill</th>
<th>Gaylord Mountain at Broken Arrow</th>
<th>Gaylord Mountain at Handy Road</th>
<th>Gaylord Mountain (not at intersections)</th>
</tr>
</thead>
<tbody>
<tr>
<td>2015</td>
<td>10</td>
<td>1</td>
<td>1</td>
<td>3</td>
<td>5</td>
</tr>
<tr>
<td>2016</td>
<td>17</td>
<td>3</td>
<td>1</td>
<td>2</td>
<td>11</td>
</tr>
<tr>
<td>2017</td>
<td>5</td>
<td>1</td>
<td>0</td>
<td>1</td>
<td>3</td>
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<tr>
<td>Totals</td>
<td>32</td>
<td>5</td>
<td>2</td>
<td>6</td>
<td>19</td>
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</table>

Crashes by Intersection Names

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<tr>
<th>Collision Type</th>
<th>Angle</th>
<th>Fixed Object</th>
<th>Rear end</th>
<th>Sideswipe</th>
<th>Rear to Side</th>
<th>Non-Fixed Object</th>
<th>Other</th>
<th>Front to front</th>
</tr>
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<tbody>
<tr>
<td>2015</td>
<td>2</td>
<td>13</td>
<td>3</td>
<td>4</td>
<td>1</td>
<td>3</td>
<td>4</td>
<td>2</td>
</tr>
<tr>
<td>2016</td>
<td>1</td>
<td>13</td>
<td>3</td>
<td>4</td>
<td>1</td>
<td>3</td>
<td>4</td>
<td>2</td>
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<tr>
<td>2017</td>
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<td>3</td>
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<td>3</td>
<td>4</td>
<td>1</td>
<td>4</td>
<td>4</td>
<td>2</td>
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Crash Severity

<table>
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<tr>
<th>Property Damage</th>
<th>Non-fatal Injury</th>
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<tbody>
<tr>
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<td>1</td>
</tr>
<tr>
<td>15</td>
<td>4</td>
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Road Conditions

<table>
<thead>
<tr>
<th>Dry</th>
<th>Snow/Slush</th>
<th>Wet</th>
<th>Light Conditions</th>
</tr>
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<tbody>
<tr>
<td>6</td>
<td>21</td>
<td>5</td>
<td>Daylight</td>
</tr>
<tr>
<td></td>
<td>3</td>
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<td>18</td>
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<tr>
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<td>1</td>
<td>0</td>
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<tr>
<td></td>
<td>2</td>
<td>1</td>
<td>2</td>
</tr>
</tbody>
</table>

Light Conditions

<table>
<thead>
<tr>
<th>Daylight</th>
<th>Dark (lighted road)</th>
<th>Unknown</th>
<th>Dark (not -lighted)</th>
</tr>
</thead>
<tbody>
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<td>18</td>
<td>10</td>
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<td>2</td>
<td>0</td>
<td>0</td>
<td>0</td>
</tr>
<tr>
<td>2</td>
<td>1</td>
<td>1</td>
<td>2</td>
</tr>
</tbody>
</table>
Figures 6-10 -- Typical Collision Diagrams

Crash ID 3167485 (above)

Crash ID 3168344 (above)
Crash ID 3210104 (above)

Crash ID 3237706 (above)
2.2 Assessment of Corridor Conditions

2.2.1 Roadway Alignment
A centerline roadway geometry was developed using Google Earth and GIS maps provided by Town of Hamden. This finds a relationship between speed and the horizontal design of the roadway.

Horizontal Alignment is shown below in Figure 11.

2.2.2 Roadway Profile
Using Google Earth and GIS maps provided by Town of Hamden, a point to point roadway profile was developed. This identifies areas where vehicles increase speed along the roadway. This figure is included in the appendix.

Vertical Alignment is shown below in Figure 12.
Figure 12 - Profile View

Centerline Elevation of Gaylord Mountain Road
Bethany Town Line to Deer Hill Road
2.2.3 Roadway Stopping Sight Distance and Intersection Sight Distance

Field measurements were taken of sight distances at intersections and key points along the roadway regarding vertical and horizontal curvature.

Based on the CTDOT Highway Design Manual, Sections 11-2.03.01 and 11-2.03.02, the required intersection sight distances were determined. The manual states that Passenger Vehicles require 7.5 seconds for Gap Acceptance. It also states that Major Road grade does not affect these calculations.

Based on a posted speed of 25 mph, passenger cars should have 280’ of visible sight distance in both directions. Based on 85th percentile speeds on Gaylord Mountain Road the maximum of which was 39 mph, passenger cars should have 434 feet of visibility in both directions. This value was determined using linear interpolation from Figure 11-2B in the CTDOT Highway Design Manual using peak 85th percentile speed within the corridor.
Figure 13 & 14- Gaylord Mountain Road at Deer Hill Road Intersection Sight Distance

Looking Left
>750’

Looking Right
300’
Figure 15 & 16- Gaylord Mountain Road at Downes Road Northbound Intersection Sight Distance

Looking Left
183’

Looking Right
37’
Figure 17 & 18- Gaylord Mountain Road at Deer Pond Trail Road Intersection Sight Distance

Looking Left
250’

Looking Right
107’
Figure 17 & 18 - Gaylord Mountain Road at Handy Road Intersection Sight Distance

Looking Left
295'

Looking Right
84'
2.2.4 Characterization of Deficiencies

Intersection and Roadway Alignment - As is clear from Page 1 of the appendix, the intersections with Handy Road, Broken Arrow Road, Deer Hill Road, and the bend west of the Handy Road intersection all are associated with horizontal curves with small radii, (as small as 70’ radius at Broken Arrow Road). Additionally, as seen on Page 2 of the appendix, there are simultaneous horizontal and vertical curves at the Handy Road intersection, the Deep Pond Trail intersection, and the Broken Arrow Road intersection.

The danger with these alignments is that, coupled with speed and icy or wet conditions; both of which will be mentioned below, motorists have much increased risk of losing control of their vehicles on this roadway.

Speed - As shown on the Speed Table in the appendix (Page 6), at every location surveyed both on Todd Street and adjacent streets, 85th percentile speeds exceed the Posted limit. Many locations also show exceedances of the 50th percentile, mean, and even 15th percentile speeds above the posted limit, especially at Gaylord Mountain Road, east of Downs Road, where 15th percentile speeds were recorded to be 30 mph in the EB direction (downhill), and 28 mph in the WB direction (uphill); where the posted limit is 25 mph. 85th percentile speeds at this location are 39 in the EB direction, 14 mph above the posted limit.

The speed Gradation charts show that speed is consistent throughout the roadway, with 85th percentile speeds ranging from 39 mph to 29 mph. The most noticeable increase in speed is in the Eastbound direction from the west of Handy Road to east of Handy Road. There is also a clear drop in speed near Broken Arrow Road, as vehicles navigate the curvature of the road.

Sight Distance-

a. Stopping Sight Distance –
   Methodology –
   Per the Connecticut Department of Transportation Highway Design Manual, stopping sight distance (SSD) is the sum of the distance traveled during a driver’s perception/reaction (or brake reaction) time and the distance traveled while decelerating to a stop. The following should also be considered:

1. Height of Eye. When applying the SSD values, the height of eye is assumed to be 3.5 ft.
2. Height of Object. The height of object is assumed to be 2 ft.
3. Grade Adjustments. Because of gravitational forces, downgrades require greater distances for braking and upgrades require lesser distances. Figure 7-1A contained in the CTDOT Highway Design Manual provides adjusted SSD values for grades.

Selection of the appropriate gradient and SSD is be based on the longitudinal gradient at the site of the brake application. Note that, for design exception purposes, only those values that do not meet or exceed the “Level” SSD criteria will require a design exception as discussed in Section 6-6.0. 7-1(2) of the CTDOT Highway Design Manual.
Based on the CTDOT Highway Design Manual for Local Urban Streets with 25 mph design speed and on a level, grade a minimum of 155’ of Stopping Sight Distance is required.

Stopping Sight distance measured in the proximity of Handy Road is approximately 69 Ft., and 112 Ft. near the approach of Broken Arrow. Subsequently, the existing stopping sight distance at is inadequate for the recorded 85th percentile speed of 39 MPH. Based on the CTDOT Highway Design Manual, the minimum Stopping Sight Distance for the for local roadway at design speed of 39 mph on a level grade is between 250 and 305 feet.

<table>
<thead>
<tr>
<th>Design Speed (mph)</th>
<th>Downgrades</th>
<th>Level</th>
<th>Upgrades</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>-9%</td>
<td>-6%</td>
<td>-3%</td>
</tr>
<tr>
<td></td>
<td>(ft)</td>
<td>(ft)</td>
<td>(ft)</td>
</tr>
<tr>
<td>20</td>
<td>130</td>
<td>120</td>
<td>120</td>
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<tr>
<td>25</td>
<td>175</td>
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<td>160</td>
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<td>275</td>
<td>260</td>
</tr>
<tr>
<td>40</td>
<td>355</td>
<td>335</td>
<td>315</td>
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<td>45</td>
<td>430</td>
<td>400</td>
<td>380</td>
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<td>730</td>
<td>685</td>
</tr>
<tr>
<td>70</td>
<td>895</td>
<td>825</td>
<td>775</td>
</tr>
</tbody>
</table>

Table 2--STOPPING SIGHT DISTANCE (Figure 7-1A), from CTDOT Highway Design Manual

b. Intersection Sight Distance –
Methodology - Intersection sight distances were measured based on the CTDOT Highway Design Manual, Sections 11-2.03.01 and 11-2.03.02. The intersection sight distance measurement methodology as described by the CTDOT Highway Design Manual is as following:

“The intersection sight distance is obtained by providing clear sight triangles both to the right and left as shown in Figures below. All legs of the intersections must be addressed similarly. The following discussion assumes a stop-controlled side street entering a major through street:

1. Minor Road. The length of leg along the minor road is based on two parts. The first is the location of the driver’s eye on the minor road. This is typically assumed to be 15 feet from the edge of the major road and in the center of the lane on the minor road; see figure below. In restricted locations, this may be a minimum of 15 ft from the traveled way of the major road. The second part is based on the distance to the center of the vehicle on the major road. For right-turning vehicles, this is assumed to be the center of the closest travel lane from
the left. For left-turning vehicles, this is assumed to be the center of the closest travel lane for vehicles approaching from the right; see Figure below.

2. Height of Eye/Object. The height of eye for passenger cars is assumed to be 3.5 feet above the surface of the minor road. The height of object (approaching vehicle on the major road) is also assumed to be 3.5 feet. An object height of 3.5 feet assumes that a sufficient portion of the oncoming vehicle must be visible to identify it as an object of concern by the minor road driver. If there are enough number of trucks to warrant their consideration, assume an eye height of 7.6 feet for a tractor/semitrailer and 6 feet for single-unit trucks and buses. If a truck is the assumed entering vehicle, the object height will still be 3.5 feet for the passenger car on the major road. The designer must also ensure that adequate ISD for passenger cars is provided, because there are situations where trucks have ISD and smaller vehicles do not.
Within the clear sight triangle, if practical, the objective is to remove, lower any object, trim lower tree branches, etc., that obstruct the driver’s view. These objects may include buildings, parked or turning vehicles, trees, hedges, tall crops and grass, fences, retaining walls and the actual ground line. In addition, where a crossroad intersects the major road near a bridge on a crest vertical curve, items such as bridge parapets, piers, abutments, guardrail or the crest vertical curve itself may restrict the clear sight triangle.

Based on a posted speed of 25 mph, passenger cars require 280' of intersection sight distance in both directions. Based on 85th percentile speeds (39 mph) on Gaylord Mountain Road, passenger cars require approximately 445 feet of intersection sight distance in both directions. This value was determined using Figure 11-2C in the CTDOT Highway Design Manual, as shown in Table 3.

The measured intersection sight distance at Handy Road at Gaylord Mountain Road was 84' to the right (looking to the west). The exiting intersection sight distance is inadequate for the measured 85th percentile speed.

**Table 3—Intersection Sight Distance Requirements, from CTDOT Highway Design Manual**

<table>
<thead>
<tr>
<th>Design Speed ($V_{major}$) (mph)</th>
<th>Passenger Cars</th>
<th>ISD (ft)</th>
<th>Single-Unit Trucks</th>
<th>ISD (ft)</th>
<th>Tractor/Semitrailers</th>
<th>ISD (ft)</th>
</tr>
</thead>
<tbody>
<tr>
<td>20</td>
<td>225</td>
<td>280</td>
<td>340</td>
<td>425</td>
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<td>25</td>
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<td>980</td>
<td>1185</td>
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</tr>
</tbody>
</table>

**Notes:**

1. These ISD values assume a left or right turn onto a 2-lane facility without a median.
2. These ISD values assume a minor road approach grade less than or equal to +3%.
Crash History—This roadway has a history of crashes, with 5 crashes that led to injury in the past 3 years, per the UConn Crash Data Repository. Most crashes on this roadway occur not at the intersections, but on the roadway between intersections (19/32), and these collisions also contribute to much of the injuries (4/5). Wet conditions (Water and Snow) also contribute to the vast majority of crashes, (26/32). Crash records indicate that a vehicle that lost control on the eastbound approach to Handy Road around the horizontal curve, and collided with the vehicle in front of it (3167485), a vehicle entered the opposing lane, sideswiping opposing traffic on Gaylord Mountain Road at the Broken Arrow Road curve (3168344), a vehicle lost control around a curve, and overturned (3210104), and a vehicle ran off the road, and collided with a tree (3210104 AND 3025806).

3. Study Area Recommended Improvements
Based on the evaluation of existing data and findings, there are several recommended improvement strategies, which are shown and described below.

3.1 Speed Reduction Devices: Speed Humps
Guidelines: The FHWA has developed best practices based on recommendations from examples throughout the US, regarding the installation of Speed Humps. They should not be installed in horizontal curves with radii of less than 300’, nor should they be installed with grades greater than 8%. They should be spaced somewhere between 350’ and 600’ apart from one another. No speed hump should be closer than 150’ to a stop sign. Any speed hump that is the first in its series (from either direction) should only be able to be approached at slow speeds.

Based on the above guidelines, four (4) speed humps may be placed on Gaylord Mountain Road at the locations shown below.

The implementation of speed humps and signs would greatly reduce speed on Gaylord Mountain Road.

Figure 13—Speed Hump Example

Source: NACTO
3.2 Shrub Clearing
To improve sight distances, shrubs should be selectively trimmed at the intersections to increase intersection sight distance, especially at the Intersection of Barbara Lane with Todd Street. With improved sight distance, motorists can make better decisions on when to exit Barbara lane and enter Todd Street.

Figure 14—Handy Road

3.3 Sign Placement
To reduce crashed, a variety of signs are recommended to be placed on Gaylord Mountain Road. The placement of these signs are detailed in the improvement recommendations below.

Figures 15-27- Proposed and Existing Signs
Sign B-(Proposed)-SPEED LIMIT, R2-1

Sign C-(Proposed)-HORIZONTAL ALIGNMENT, W1-10R

Sign D-(Proposed)-HORIZONTAL ALIGNMENT, W1-10L

Sign E-(Existing)-CHEVRON, W1-8R
Sign F-(Existing)-LEFT TURN, W1-1L

Sign G-(Proposed)-SLIPPERY WHEN WET, W8-5

Sign H-(Proposed)-T INTERSECTION, W2-2R

Sign I-(Proposed)-T INTERSECTION, W2-2L
Sign J-(Proposed)-ADVISORY SPEED, W13-1P

Sign K-(Proposed)-SPEED HUMP, W17-1

Sign L-(Proposed)-VERTICAL GRADE, W7-1

Sign M-(Proposed)-STOP AHEAD, W3-1A
3.4 Pavement Markings

Pavement markings are recommended at the intersection of Gaylord Mountain Road at Deer Hill Road to make clearer to drivers the curvature of the road, to avoid collisions with fixed objects. A Pavement marking recommendation is drawn below.
4. **Construction Cost Estimate**

The probable cost for the improvements are based on the Connecticut Department of Transportation Cost Estimating Guidelines at this concept level projects and shown in Table 4.

**Table 4—Construction Cost Estimate**

<table>
<thead>
<tr>
<th>Item</th>
<th>Unit</th>
<th>Quantity</th>
<th>Unit Price</th>
<th>Total</th>
</tr>
</thead>
<tbody>
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<td>Speed Humps</td>
<td>EA</td>
<td>4</td>
<td>$7,500.00</td>
<td>$30,000</td>
</tr>
<tr>
<td>Edge Markings (White, 4&quot;)</td>
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<td>490</td>
<td>$0.40</td>
<td>$196</td>
</tr>
<tr>
<td>Edge Markings (Yellow, 4&quot;)</td>
<td>LF</td>
<td>540</td>
<td>$0.40</td>
<td>$216</td>
</tr>
<tr>
<td>Signs</td>
<td>SF</td>
<td>261</td>
<td>$75.00</td>
<td>$19,575</td>
</tr>
<tr>
<td>Trimming Shrubbery</td>
<td>LS</td>
<td>LS</td>
<td>$1,500.00</td>
<td>$1,500</td>
</tr>
</tbody>
</table>

Subtotal $51,487

Subtotal (Rounded) $51,500

Incidentals $7,800.00

Contingency $7,800.00

Grand Total $67,000.00