# Memorandum

Sterling Highway - Shadow Analysis
August 8th 2011 – HDR Alaska Inc.

**To** File 07072-170-249

**From** Michael Davis

**Date** August 6, 2011

**Subject** Sterling Highway MP 45 to 60 Shadow Analysis

In November of 2001 HDR Alaska performed a shadow analysis of alignment alternatives for MP 45 to MP 60 of the Sterling Highway. This analysis determined the area of each alternative in shadow for four dates: September 21 (equinox), October 21, November 21, and December 21 (winter solstice). For each date shadows were calculated for three time periods (see table 1): one hour after sunrise, solar noon, and one hour before sunset. In the original analysis effects of surrounding terrain was not taken into account in the shadowing. In some cases the previous analysis greatly underestimated the percentage of the alternatives in shadow. The new analysis, including the effects of shadows cast from surrounding terrain, provides a more realistic assessment of real-world lighting conditions for each alternative. HDR recalculated shadows (with all current alignments); this memo will explain the difference in modeling, and provide corrected data (see table 3 and 4) for the current alternatives under consideration.

## Previous Methodology

The initial analysis utilized the ArcGIS Spatial Analyst extension to create shadows for a given time period via the hillshade function. According to the Shadow Analysis Report dated November 16th 2001:

> *ArcGIS 8.1 was used to determine areas in shadow based on the digital elevation model. The altitude angle and azimuth angles listed in Table 2 were used to generate the shadows. The effects of local illumination angles were not included in this analysis. The length of the alternative lying in shadow for each of the days and times was then computed.*

This description of the analysis is somewhat confusing given the functionality of the Spatial Analyst hillshade function. When performing a hillshade operation Spatial Analyst provides the option of using local illumination, or both local illumination and modeled shadows. It is not possible to perform the hillshade operation without local illumination angles. After analyzing the results of the 2001 report, it appears that the hillshade operations were performed using *only* local illumination angles. This produced results that did not accurately account for shadows cast by surrounding terrain.

## Corrected Methodology

In revaluating the shadow analysis for MP 45 to MP 60 the methodology was kept as similar as possible. The same sun angles and altitudes (see table 1) were used, for the same dates chosen in the original report. These variables were used to generate a hillshade from a 30-meter Digital Elevation Model (DEM) using the Spatial Analyst extension in ArcGIS 10. In this analysis, all hillshades were created with modeled shadows for each date and time period specified in the original report. Once these hillshades were generated, the model created in ArcGIS 10 (see figure 1) calculated the areas in light or shadow for

each alternative. Tables 3 shows the final results for the shadow analysis for each time modeled time step.

## Table 1. Time and Date Parameters, Calculated Altitude Angle, and Azimuth Angle.

| Date | Time of Angles | Altitude | Azimuth |
|---|---|---|---|
| 21-Sep | 8:41 | 6.5 | 100 |
| | 13:52 | 30.1 | 180 |
| | 19:03 | 6.4 | 260 |
| 21-Oct | 9:55 | 5.8 | 124 |
| | 13:43 | 18.7 | 180 |
| | 17:32 | 5.7 | 236 |
| 21-Nov | 10:15 | 4 | 145 |
| | 12:45 | 9.5 | 180 |
| | 15:14 | 4.1 | 215 |
| 21-Dec | 11:06 | 3.1 | 155 |
| | 12:57 | 6.1 | 180 |
| | 14:48 | 3.1 | 205 |

## Table 2. Total Length of Each Alternative.

| Alternative | Length (ft) |
|---|---|
| Juneau Creek | 81334 |
| G South | 74295 |
| Cooper Creek | 74992 |
| Juneau Creek T | 75473 |
| JC Alt. 3 | 74676 |
| No Build | 74552 |

## Table 3. Approximate Length (ft) of Each Alternative in Morning Shadow, Noon Shadow, and Evening Shadow

| | 21-Sep | | | 21-Oct | | | 21-Nov | | | 21-Dec | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | AM | NOON | PM | AM | NOON | PM | AM | NOON | PM | AM | NOON | PM |
| **Cooper Creek** | | | | | | | | | | | | |
| Light | 17,213 | 22,858 | 20,939 | 2,933 | 19,078 | 5,849 | 3,822 | 7,577 | 1,102 | 3,182 | 3,687 | 183 |
| Shadow | 5,644 | | 1,918 | 19,924 | 3,779 | 17,008 | 19,035 | 15,280 | 21,755 | 19,675 | 19,170 | 22,674 |
| **G South** | | | | | | | | | | | | |
| Light | 18,507 | 22,645 | 20,490 | 6,307 | 21,226 | 8,351 | 4,955 | 9,807 | 1,102 | 3,306 | 5,237 | 183 |
| Shadow | 4,137 | | 2,155 | 16,338 | 1,418 | 14,293 | 17,690 | 12,838 | 21,542 | 19,339 | 17,408 | 22,461 |
| **JC_Alt3** | | | | | | | | | | | | |
| Light | 18,405 | 22,761 | 21,782 | 9,495 | 22,761 | 12,422 | 6,931 | 13,962 | 3,709 | 4,582 | 6,799 | 1,179 |
| Shadow | 4,356 | | 979 | 13,266 | | 10,339 | 15,830 | 8,799 | 19,052 | 18,179 | 15,962 | 21,581 |
| **Juneau Creek** | | | | | | | | | | | | |
| Light | 19,424 | 23,728 | 22,765 | 10,741 | 23,728 | 15,547 | 6,903 | 14,630 | 3,711 | 4,582 | 7,031 | 1,212 |
| Shadow | 4,304 | | 963 | 12,987 | | 8,181 | 16,825 | 9,097 | 20,017 | 19,146 | 16,697 | 22,516 |
| **Juneau Creek T** | | | | | | | | | | | | |
| Light | 17,358 | 23,004 | 21,046 | 2,935 | 19,225 | 5,995 | 3,823 | 7,579 | 1,10 | 3,183 | 3,688 | 183 |
| Shadow | 5,645 | | 1,958 | 20,069 | 3,779 | 17,009 | 19,181 | 15,425 | 21,901 | 19,821 | 19,316 | 22,820 |
| **No Build** | | | | | | | | | | | | |
| Light | 17,487 | 22,724 | 21,306 | 3,462 | 19,607 | 5,851 | 3,889 | 6,961 | 1,067 | 3,252 | 3,659 | 173 |
| Shadow | 5,236 | | 1,418 | 19,261 | 3,116 | 16,872 | 18,834 | 15,762 | 21,656 | 19,471 | 19,064 | 22,550 |

## Table 4. Approximate Percentage of Each Alternative in Morning Shadow, Noon Shadow, and Evening Shadow

| | 21-Sep | | | 21-Oct | | | 21-Nov | | | 21-Dec | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|
| **Row Labels** | AM | NOON | PM | AM | NOON | PM | AM | NOON | PM | AM | NOON | PM |
| **Cooper Creek** | | | | | | | | | | | | |
| Light | 75% | 100% | 92% | 13% | 83% | 26% | 17% | 33% | 5% | 14% | 16% | 1% |
| Shadow | 25% | | 8% | 87% | 17% | 74% | 83% | 67% | 95% | 86% | 84% | 99% |
| **G South** | | | | | | | | | | | | |
| Light | 82% | 100% | 90% | 28% | 94% | 37% | 22% | 43% | 5% | 15% | 23% | 1% |
| Shadow | 18% | | 10% | 72% | 6% | 63% | 78% | 57% | 95% | 85% | 77% | 99% |
| **JC_Alt3** | | | | | | | | | | | | |
| Light | 81% | 100% | 96% | 42% | 100% | 55% | 30% | 61% | 16% | 20% | 30% | 5% |
| Shadow | 19% | | 4% | 58% | | 45% | 70% | 39% | 84% | 80% | 70% | 95% |
| **Juneau Creek** | | | | | | | | | | | | |
| Light | 82% | 100% | 96% | 45% | 100% | 66% | 29% | 62% | 16% | 19% | 30% | 5% |
| Shadow | 18% | | 4% | 55% | | 34% | 71% | 38% | 84% | 81% | 70% | 95% |
| **Juneau Creek T** | | | | | | | | | | | | |
| Light | 75% | 100% | 91% | 13% | 84% | 26% | 17% | 33% | 5% | 14% | 16% | 1% |
| Shadow | 25% | | 9% | 87% | 16% | 74% | 83% | 67% | 95% | 86% | 84% | 99% |
| **No Build** | | | | | | | | | | | | |
| Light | 77% | 100% | 94% | 15% | 86% | 26% | 17% | 31% | 5% | 14% | 16% | 1% |
| Shadow | 23% | | 6% | 85% | 14% | 74% | 83% | 69% | 95% | 86% | 84% | 99% |

**Figure 1. Shadow Analysis Model**