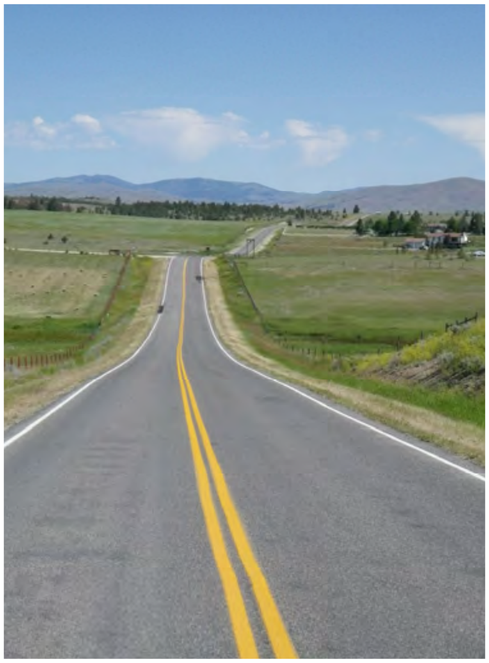
# Preliminary Engineering Report

## BIRDSEYE ROAD—BARRETT ROAD TO LINCOLN ROAD

LEWIS AND CLARK COUNTY

*RPA Project No. 10502.001*



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February 2012

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# Executive Summary

This roadway Preliminary Engineering Report (PER) was developed under contract administered by the Lewis and Clark County Public Works office. The PER is intended to provide an initial evaluation of the Birdseye Road corridor bound by Barrett Road on the southern end and Lincoln Road on the northern end. The PER evaluates road deficiencies and identifies future needs, thereby providing an assessment of improvements necessary to meet or exceed current County road standards. This report is also intended to provide base reconstruction cost estimates to aid the county in funding development.

## *ES.1. Summary of Findings*

The existing roadway does not meet several minimum road design standards set by Lewis and Clark County, or minimum criteria presented as guidance by the American Association of State Highway and Transportation Officials (AASHTO). The width of the roadway is below standards for a facility classified as a Major Collector under the Lewis and Clark County Subdivision Regulations, Appendix J, Road Standards. The aspects of the highway measured from the edge of the traveled way outward to include cut and fill slopes are also below safety standards in some areas. The current surfacing structure components are thinner than minimum County Major Collector standards in some areas and also show some signs of subgrade deterioration.

The horizontal and vertical curvature of Birdseye Road is deficient in numerous locations. Design criteria for assessing roadway curvature is governed in part by the terrain that the roadway traverses. Based on this report’s selected terrain classifications along Birdseye Road, there are a minimum of thirteen spots having horizontal curvature, vertical curvature, or sight distance deficiencies.

Based on the evaluation presented herein, we estimate the cost to reconstruct the road to meet minimum assigned design criteria to be an average of approximately **$1.32 million per mile**. This cost estimate includes further engineering, traffic control during construction, right-of-way acquisition, and other contingencies. Base construction cost is estimated to be an average of approximately $892,000 per mile, excluding costs for additional right-or-way, final engineering, etc.

A Montana Department of Transportation (MDT) Safety Improvement Project let for construction in the fall of 2009, STPHS-HSIP 25(52) Birdseye Road, realigned a 0.40-mile section of Birdseye Road to mitigate a deficient horizontal curve and improve other roadside geometrics. The low bid was approximately $682,000 for the 0.40-mile reconstruction. The project provides a good example of the construction costs associated with realigning the roadway template. The County could similarly improve other segments of Birdseye Road by spot improvement projects. This new section of Birdseye Road meets most applicable County design standards, with only the shoulder width being less than the minimum Major Collector standard. Adding two extra feet to the shoulders would bring the section up to minimum County standards for a Major Collector.

# 1. Introduction

This roadway Preliminary Engineering Report (PER) was prepared by Robert Peccia and Associates (RPA) under contract with Lewis and Clark County, Montana. The contract is administered by the Lewis and Clark County Public Works office. The study segment is a portion of Birdseye Road between Barrett Road and Lincoln Road.

This segment of Birdseye Road is considered a high-priority road by County staff to receive reconstructive improvements. The prioritization is in some part due to increasing roadway maintenance needs indicative of the impacts caused by current traffic use as well as substandard geometrics. Potential future development may add a proportional amount of new traffic, which would continue to contribute to the road's deterioration.

This PER is prepared as an initial task to analyze the deficiencies of the roadway. By evaluating the road's structural and geometric deficiencies or needs, and obtaining an initial snapshot of what improvements are necessary to meet or exceed County road standards, Lewis and Clark County can then better identify funding requirements, and begin subsequent planning for engineering and construction.

In accordance with Chapter XI of the current December 18, 2007 Lewis and Clark County Subdivision Regulations (Amended May 18, 2010), Part H Streets and Roads, the County can also utilize this document to calculate the pro-rata cost share of each new development that contributes traffic impacts to this study segment as a part of its impact corridor. The pro-rata share for each impact will then be reserved to help build the funding needed in part to ultimately reconstruct the roadway as a whole or in separate phases.

RPA has prepared this report with services rendered to meet or exceed those of the practicing consulting engineering industry. No warranty, expressed or implied, is made.

## *1.1. Location and Description*

Birdseye Road lies within the westerly portion of what is locally known as the Helena Valley. The study area begins at intersection with Barrett Road. The project extends to the northwest for approximately 10 miles, terminating at its intersection with Lincoln Road. Lincoln Road is state-maintained and is identified as Highway S-279. Lincoln Road is classified as a Major Collector in the Greater Helena Area Transportation Plan – 2004 Update. Refer to the project area map, **Figure 1.1**.

For the purpose of this study, Milepost [MP] 0.00 is considered the start of the project corridor at Barrett Road. The mileposts increase in a south to north direction. The project corridor terminates at MP 10.05 at the intersection with Lincoln Road.

## 1.2. Methodology to Develop Report

Various field methods were used to obtain existing geometric information to aid in the development of this report. The work conducted is indicative of the preliminary nature of this project's current status and level of design and development. Explicitly, formal survey work of setting control and then completing instrumental topographical survey was not completed. As such, CADD-based design work has not been undertaken, except for some basic diagramming.

Field reviews were completed in July 2011. Most field measurements were taken with a steel tape. Longer measurements were obtained using a wheel tape. For slope or grade estimates, a four-foot long digital smart level was used to record the information in degrees or percent format. This then was converted to approximate slope rates, such as horizontal:vertical (h:v) for describing existing road fill or cut slope rates as an example. For longer measurements, such as checking sight distances, a hand-held laser rangefinder was used. GIS information was used to supplement the field data collection effort as well as minimizing walking and windshield review time.

## 1.3. Reference Standards

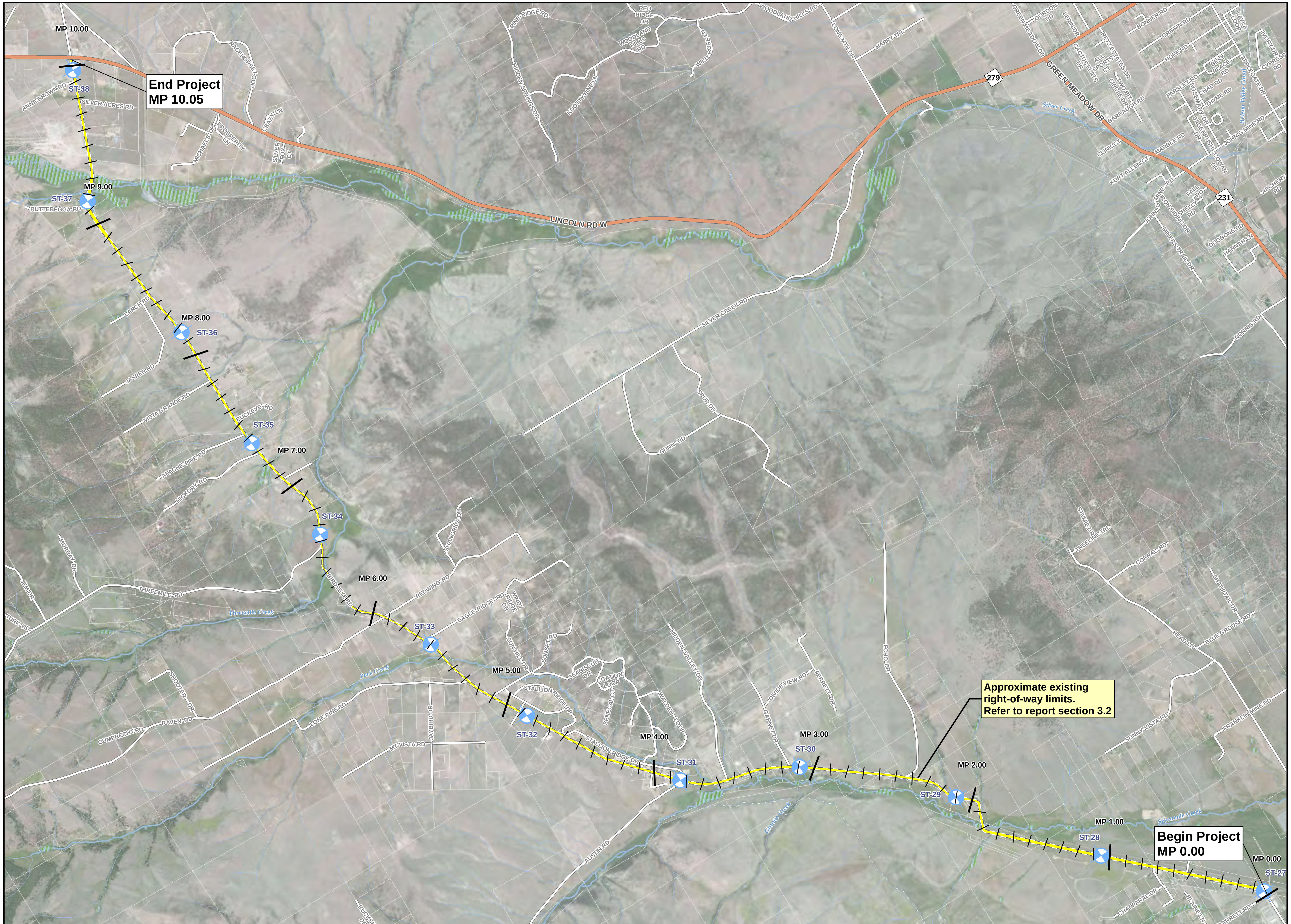
The reference standards used in this study are those specified by the Lewis and Clark County Subdivision Regulations. Specifically, in the regulation's Appendix J, Road Standards, referenced documents include American Association of State Highway and Transportation Officials (AASHTO) and Montana Department of Transportation (MDT) publications among others. These standards were followed, with the County standards governing all others if design information is provided for the specific item being evaluated. If we deemed it appropriate to use other reference materials, then those materials are documented in this report.

# BIRDSEYE ROAD PROJECT AREA

Preliminary Engineering Report

0 1,000 2,000 3,000 4,000 5,000 Feet

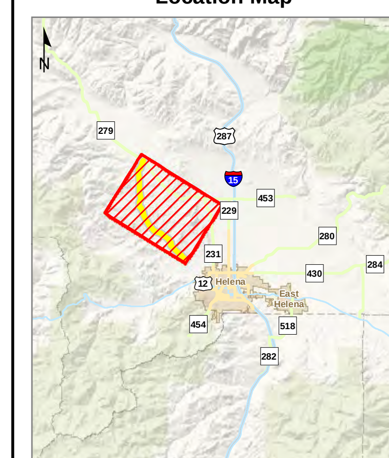
1 inch = 3,000 feet




## Map Legend

- Approximate Existing Right-of-Way
- Soil Boring Location
- Local Route
- On-System Route
- Ownership
- City Boundary
- Wetland
- Waterbody
- Canal / Ditch
- Stream / River - Intermittent
- Stream / River - Perennial

### Location Map




Map Created by:
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**Project:** 10502.001 LewisClarkCo PERs - Birdseye Road
**Printed:** Monday, January 23, 2012 10:20:47 AM
**File Location:** F:\highways\10502_000_LewisClarkCo_PERs\GIS\Maps\BirdseyeRoad_ProjectArea.mxd

**Figure 1.1**

# 2. Background Data

Background data was collected for the project corridor from various sources and was used to supplement the field data collection efforts discussed later in this report. The background data was used in conjunction with the field collected data to help establish baseline conditions and to assess areas deficient to current roadway standards. This section of the report provides a summary and analysis of the available background data.

## *2.1. Traffic*

Lewis and Clark County completes annual traffic counts for roads under their jurisdiction. The County recognizes the importance of methodically collecting traffic data to analyze traffic growth characteristics and help assess each road's maintenance needs.

Abelin Traffic Services (ATS) of Helena has in recent years been contracted with the County to complete their Traffic Count Program. 2009 traffic counts for Birdseye Road north of Barrett Road and north of Austin Road were completed by ATS in August 2009. 2009 data is used in this report as the geotechnical review for this project started at that time. The 2009 traffic data was also the most current available data posted on the Lewis and Clark County website. The County determined to proceed with this PER's preparation in 2010.

An additional 2009 traffic count for the end of Birdseye Road (0.50 miles south of the intersection with Lincoln Road) was available from MDT and was included in this study. ATS and MDT convert the raw data traffic counts into Average Annual Daily Traffic (AADT) to provide a representative traffic volume regardless of which month, day, or hours the counts were performed.

For the road surfacing evaluation part of this PER, heavy vehicle factors were used to develop the proposed surfacing section for Birdseye Road. The factors used were based on vehicle classification counts conducted in 2009 by ATS.

Lewis and Clark County and MDT also provided RPA with historical traffic counts for Birdseye Road. The AADT counts date back 20 years to give a baseline of information to characterize traffic growth. RPA plotted the historical counts to assess the annual growth rate. An exponential growth trend line was established to represent historic traffic conditions and to project out to a future 20-year evaluation period to year 2031. The historic traffic counts, as well as the trend line evaluation, are included in **Appendix A** of this report.

Estimated 2011 AADT values, along with projected 2031 values, were calculated using the exponential growth trend calculated based on the historical traffic data discussed previously. In addition to showing existing and projected AADT traffic values, **Table 2.1** gives the estimated exponential growth rates experienced along each road segment based on the linear trend analysis. A weighted average growth rate combining all traffic count locations along the project corridor is also provided.

**Table 2.1: Average Annual Daily Traffic (AADT)**

| Birdseye Road | | AADT | | | |
|---|---|---|---|---|---|
| **Site ID** | **Location** | **2009** | **2011[(3)]** | **2031[(3)]** | **Growth[(4)]** |
| 7B-42 | N of Barrett Rd[(1)] | 1766 | 1795 | 2756 | 2.17% |
| 7A-25 | N of Austin Rd[(1)] | 1136 | 1063 | 1346 | 1.19% |
| 6-7 | 0.5 mi S of S-279[(2)] | 488 | 379 | 608 | 2.40% |
| *Weighted Average:* | | | | | **1.87%** |

*(1) AADT values from Lewis and Clark County's Traffic Count Program.*
*(2) AADT values from MDT.*
*(3) AADT was projected based on historical counts utilizing an exponential yearly growth rate.*
*(4) Estimated exponential growth rate based on historical traffic count data.*

## *2.2. Crash History*

The MDT Traffic and Safety Bureau provided crash information and data for the approximate 10-mile section of Birdseye Road between Barrett Road and Lincoln Road (S-279). The crash information covers a 5-year time period from July 1, 2005 to June 30, 2010. A total of thirty-two crashes were investigated on this segment of roadway. The crash information was analyzed to identify general crash characteristics and potential roadway deficiencies.

Thirty of the thirty-two crashes were non-junction related, while twenty-six crashes only involved a single vehicle. Six crashes resulted in injuries, one of which resulted in a fatality. The fatality occurred along the sharp curves south of Echo Drive and was a single-vehicle crash with alcohol being a contributing factor.

In general, it appears that the majority of crashes involve a single vehicle, with the most prevalent crash types being related to that of striking objects, ditches/embankment, and overturning. This indicates that highway geometrics and roadside conditions should be considered for improvements to provide a roadside recovery zone.

# 3. Existing Conditions

Existing conditions for the Birdseye Road corridor are based on background data and a field review conducted on July 8th, 2011. During the field review, the road's physical characteristics were analyzed and recorded to help establish existing conditions along the project corridor.

## *3.1. Physical Characteristics*

### 3.1.1. Terrain

Design criteria for assessing proposed roadway improvements are in some part governed by the terrain that the roadway traverses. Terrain classifications are level, rolling, and mountainous. Different design standards exist for each type of terrain. A determination is made during the road design phase as to the type of terrain the road traverses, which then correlates to the standards which the road will be constructed to meet or exceed.

The terrain of the study corridor is generally level from the beginning of the project northerly to MP 1.80 as it parallels the Sevenmile Creek drainage. After a railroad crossing at MP 1.80, the roadway crosses Sevenmile Creek and climbs into the rolling foothills of the Northwest Helena Valley. Birdseye Road contains sections between MP 1.80 and MP 10.05 that are relatively level. But, in general, the rolling roadway alignment is governed by the foothills, switching between climbing up and along the hills and then crossing the drainages in between. Therefore, for the purposes of this report, level terrain design standards apply from Barrett Road (MP 0.00) to the railroad crossing at MP 1.80. From the railroad crossing, rolling terrain design standards apply for the remainder of Birdseye Road to Lincoln Road (MP 10.05). Terrain classifications should be reviewed in more detail before design.

### 3.1.2. Landscape

The area is a mix of irrigated and dry land agricultural tracts between parcels of developed residential properties. The project corridor exhibits primarily dry semi-arid vegetation such as sagebrush and native grasses, interspersed with irrigated agricultural vegetation and developed landscaping. The area has few significant cross-draining structures per mile of road. The predominant drainage is from west to east toward Lake Helena, although sections of the corridor have drainage from the hills on the east side of the road draining to the creeks on the west side of the road.

### 3.1.3. Floodplain

The majority of the project corridor, from approximately MP 0.00 to MP 6.30, is outside of study areas contained in the Lewis and Clark County Flood Insurance Rate Maps (FIRMs). For MP 6.30 to Lincoln

Road, the road is predominantly within a 500-year flood hazard area (Zone X).[1] The Silver Creek crossing at MP 9.30 is likely within a 100-year flood hazard area, although the study area for the FIRM ended just short of Birdseye Road. Since the drainage patterns and terrain along Birdseye Road are relatively constant throughout the entire corridor, it can be assumed that most the road from MP 0.00 to MP 6.30 would also be in a 500-year flood hazard area. The crossings of Threemile, Park, and Sevenmile Creeks would likely be in 100-year flood areas. No evidence of flood damage or overtopping of the road was noted during the field review following the June 2011 flooding in Lewis and Clark County.

### 3.1.4. Roadway Class

The Lewis and Clark County Road Standards describe Minor Collectors as typically carrying traffic volumes of 1,500 to 3,500 AADT, while Major Collectors would typically carry volumes greater than 3,500 AADT. The projected 2031 traffic volumes for Birdseye Road shown in **Table 2.1** are all between 500 and 3,500 AADT. However, Birdseye Road was treated as a Major Collector for the analysis and cost estimates contained in this report, as it is functionally classified as such in the Greater Helena Area Transportation Plan – 2004 Update. This classification serves to collect traffic from abutting properties via local road intersections, and distribute to other roads of equal or higher classification.

## *3.2. Existing Right-of-Way*

Existing right-of-way was approximated based on field review and GIS data. During the field review, measurements were taken where right-of-way fence exists. The existing right-of-way fences appear to be predominantly generated by property owners, with differing levels of accuracy. In addition, Birdseye Road is constantly shifting within the right-of-way to accommodate the curvature of the roadway. For both of these reasons, measurements were only taken at points where the apparent right-of-way corridor narrowed or widened substantially.

A MDT Safety Improvement Project, identified as STPHS-HSIP 25(52), reconstructed Birdseye Road from MP 8.90 to MP 9.30. Portions of this project's plans are included for reference in **Appendix E**. According to the plans, the existing right-of-way at the beginning and end of the Safety Improvement Project is 70 feet. Field observations indicated a right-of-way width of approximately 80 feet at the beginning of STPHS-HSIP 25(52). The difference can be attributed to the accuracy of the existing right-of-way fence used as reference during the field review.

Approximate right-of-way widths, measured from centerline during the field review, are shown in **Table 3.1**. These values are estimates only intended to provide a planning-level assessment related to acquiring additional right-of-way for roadway improvements.

[1] Flood Insurance Rate Maps, Panel 1395, Lewis and Clark County, Montana (unincorporated areas), Revised June 17, 2002.

**Table 3.1: Approximate Right-of-Way Widths**

| Location | | | |
|---|---|---|---|
| MP Begin | MP End | Width (from Centerline) | Comments |
| *East of Centerline* | | | |
| 0.00 | 5.30 | 40' | |
| 5.30 | 6.20 | 30' | |
| 6.20 | 6.55 | 25' | |
| 6.55 | 7.00 | 30' | |
| 7.00 | 8.90 | 40' | |
| 8.90 | 9.30 | 54' (1) | |
| 9.30 | 10.05 | 35'-40' | Tapers from 70' to 80' |
| *West of Centerline* | | | |
| 0.00 | 1.80 | 60' | |
| 1.80 | 4.60 | 40' | |
| 4.60 | 6.20 | 30' | |
| 6.20 | 6.55 | 25' | |
| 6.55 | 8.90 | 40' | |
| 8.90 | 9.30 | 66' (1) | |
| 9.30 | 10.05 | 35'-40' | Tapers from 70' to 80' |

*(1) Per MDT Safety Improvement Project STPHS - HSIP 25(52).*

## 3.3. Design Speed

Design speed is a selected speed used to determine multiple aspects of roadway design criteria. Design speed is selected in relation to topography, vehicle operating speeds, roadside development, and the functional classification of the road or highway. Design speed relates to the driver's comfort and is not the speed at which a vehicle will lose control. The AASHTO publication "A Policy on Geometric Design of Highways and Streets - 2004" (the Green Book as commonly referred to by the industry) states that the selection of the design speed for roads other than constrained local streets, should be made to use the speed that is the highest practical to attain the desired degree of safety, mobility, and efficiency subject to environmental, economic and other social, political or aesthetic constraints. Further, the design speed should be higher than the running speed of a large proportion of drivers.

In Appendix J, Table A, Road Standards, of the Lewis and Clark County Subdivision Regulations, the specified design speed applicable to Birdseye Road is 55 miles per hour (mph) for level terrain and 45 mph for rolling terrain. A copy of Table A is included in **Appendix B**. As noted previously, the functional classification of this road is a Major Collector. AASHTO guidance further states that designs should exceed their criteria where practical. Every effort should be made to obtain the best possible alignment, grade, sight distance, and improved road cross-sectional elements that are consistent with terrain, present and anticipated development, safety and available funds.

Exhibit 6-1 of the AASHTO Green Book, reproduced in **Appendix B**, is a table of suggested minimum design speeds for Rural Collectors. For over 2000 vehicles per day, AASHTO's minimum design speeds are 60 mph for level terrain and 50 mph of rolling terrain. For 400 to 2000 vehicles per day, AASHTO's minimum design speeds are 50 mph for level terrain and 40 mph for rolling terrain. AASHTO recommends, where practical, to consider using design speeds higher than those shown in the exhibit.

The County has established a regulatory speed limit of 55 mph for the project corridor, with advisory speeds posted for sharp horizontal curves. 55 mph is less than the 70 mph daytime and 65 mph nighttime regulatory speed limit established by Montana law for similar facilities. The regulatory speed is the same as the design speed for a Lewis and Clark County Major Collector in level terrain, and is deemed appropriate by the County based on terrain, the road's surfacing condition, traffic volume, driver behavior, and level of roadside development.

County road standards for the design speed of a Major Collector in level and rolling terrain were followed for this report. As such, all design standards noted in this report are based on design speeds of either 55 mph for level terrain or 45 mph for rolling terrain. AASHTO standards are generally more stringent that County standards for these design speeds. Field observations were compared to both standards and are included in the following sections for reference. The MDT Safety Improvement Project utilized a 50 mph design speed.

## 3.4. Alignment

Table A of the County's Road Standards contained in Appendix J of the Subdivision Regulations (see **Appendix B**), lists the minimum centerline curvature for a Major Collector as 575 feet for level terrain and 440 feet for rolling terrain. The County references AASHTO standards for the amount of superelevation the roadway surface should have along horizontal curves.

Exhibit 3-15 of the AASHTO Green Book, reproduced in **Appendix B**, is a table of suggested minimum horizontal curve radii based on design speed and superelevation. Per AASHTO, studies have shown that in areas of ice and snow the maximum superelevation on a horizontal curve is 8% to prevent slipping of vehicles. If a maximum superelevation rate of e = 8.0% and a design speed of 55 mph is used in Exhibit 3-15, the minimum recommended radius of horizontal curvature is 960 feet. For a design speed of 45 mph, Exhibit 3-15 lists the minimum radius as 587 feet. MDT design standards for horizontal alignments call for the same basic minimum radii for e = 8.0% and design speeds of 45 and 55 mph. The County standard of a 440-foot horizontal curve radius in rolling terrain is less than the AASHTO and MDT guidelines of 587 feet. The County standard was given precedence in this study, but any curve not meeting AASHTO standards was also noted for reference.

GIS information and aerial photography were used to approximate the horizontal curvature of Birdseye Road. There are approximately ten horizontal curves with radii less than 960 feet and five curve radii less than 440 feet. The curves are summarized in **Table 3.2** below, along with approximate values for superelevation and sight distance. See **Section 3.5** for sight distance guidelines.

**Table 3.2: Horizontal Alignment Deficiencies**

| Location | Approx. Radius | Superelevation | Approx. Sight Distance | Comments |
|---|---|---|---|---|
| MP 0.05 | 375' | 13.0% | > 500' | 30 mph advisory speed |
| MP 1.80 | 175' | < 8.0% | > 500' | Railroad crossing, 20 mph advisory speed |
| MP 1.95 | 200' | 10.0% | > 500' | 20 mph advisory speed |
| MP 2.10 | 450' | < 8.0% | 150' | 35 mph advisory speed, fatality |
| MP 2.25 | 650' | < 8.0% | > 500' | 35 mph advisory speed |
| MP 5.95 | 700' | < 8.0% | 250' | |
| MP 6.15 | 350' | 9.0% | 300' | 25 mph advisory speed |
| MP 6.45 | 200' | < 8.0% | 250' | 25 mph advisory speed |
| MP 6.75 | 500' | 8.5% | 300’ | |
| MP 6.90 | 700' | < 8.0% | > 500' | |

**Photos 3.1** through **Photo 3.3** show examples of sharp horizontal curves along Birdseye Road. For the purposes of this study, Birdseye Road traverses level terrain between Barrett Road and the railroad crossing (MP 0.00 to MP 1.80) and then traverses rolling terrain for the remainder of the road to Lincoln Road at MP 10.05. Therefore, the curves at MP 0.05, MP 1.80, MP 1.95, MP 6.15, and MP 6.45 are all below County road standards for the classified terrain. The curve at MP 1.80 is along an at-grade railroad crossing and would be difficult to realign without also reconstructing both the railroad crossing and the bridge over Sevenmile Creek at MP 1.83. The locations with superelevation over 8% should also be further assessed during subsequent engineering, as they could compound driving hazards in icy conditions.

A MDT Safety Improvement Project, let for construction in the fall of 2009, reconstructed Birdseye Road from MP 8.90 to MP 9.30 to mitigate a horizontal curve with an approximate existing radius of 400 feet. The radius of the curve was increased, flattening the curve and shifting the roadway to the east. The project was built to meet MDT standards. The new roadway ties back into the existing Birdseye Road near MP 9.30 (**Photo 3.3**). The project was bid for about $682,000, which doesn’t include costs for right-of-way acquisition and design engineering. The project provides a good example of the construction costs associated with realigning a horizontal deficiency in rolling terrain and along a creek crossing.

Seven of the horizontal curves noted in **Table 3.2,** including the five substandard curves**,** are currently signed with advisory speed signs. It should be noted that all seven of the curves appear to meet AASHTO design standards for the advisory speeds that are recommended at those locations.


**Photo 3.1: Curve and railroad crossing at MP 1.80 – Looking Southwest.**

**Photo 3.2: Curve and poor sight distance at MP 6.45 – Looking North.**

**Photo 3.3: End of MDT Safety Improvement Project STPHS-HSIP 25(52) – Looking North.**

Table A of the County's Road Standards, contained in **Appendix B**, references AASHTO standards for the maximum grades in level and rolling terrain. Exhibit 6-4 of the Green Book, also in **Appendix B**, specifies maximum suggested grades, in percent (%), for specified design speeds of Rural Collector highways. For the design speed of 55 mph, the maximum grade for level terrain is 6%. For a design speed of 45 mph, the maximum grade for rolling terrain is 8%.

Grades along Birdseye Road were measured during the field review using a digital smart level. Eight locations along Birdseye Road were noted as having grades greater than 6% and two grades were 8% or greater. The grades are summarized in **Table 3.3** below, along with the approximate sight distance at these locations. Sight distance guidelines are discussed in **Section 3.5**.

**Table 3.3: Vertical Alignment Deficiencies**

| Location | Approx. Grade | Approx. Sight Distance | Comments |
|---|---|---|---|
| MP 2.05 | 7.5% | 150' | 35 mph advisory speed |
| MP 2.15 | 7.5% | 150' | 35 mph advisory speed |
| MP 6.05 | 8.0% | 300' | 25 mph advisory speed |
| MP 6.50 | 6.5% | 200' | |
| MP 7.10 | 9.5% | 250' | |
| MP 7.25 | 6.5% | 150' | |
| MP 7.90 | 7.5% | 300' | |
| MP 9.35 | 7.5% | 450' | |

Based on this report's terrain classifications, Birdseye Road traverses level terrain between MP 0.00 and MP 1.80 and then traverses rolling terrain to MP 10.05. The seven grades at or below 8% in **Table 3.3** would be acceptable because they are within rolling terrain. At a minimum, the grade steeper than 8% at MP 7.10 should be considered for improvement when reconstruction is undertaken.

Three of the grades in **Table 3.3** are currently signed with an advisory speed. All three would appear to meet AASHTO design standards for the advised speed. However, substandard curvature should be addressed when roadway reconstruction is undertaken. **Photo 3.4** shows the steep grade at MP 7.10.

**Photo 3.4: Steep grade near MP 7.10 – Looking North.**

## *3.5. Sight Distance*

The discussions above regarding horizontal and vertical alignment elements focused on whether or not horizontal curvature and vertical grades meet standards. Applicable to these geometric features is the design element of sight distance, previously noted in **Tables 3.2** and **3.3**. The measure of a driver's sight distance is critical to safely avoid collisions with objects. This is measured by stopping sight distance in both horizontal and vertical planes.

Table A of the County's Road Standards references AASHTO standards when considering stopping sight distance. Exhibit 3-2 of the AASHTO Green Book, contained in **Appendix B**, lists the stopping sight distance based on the design speed and grade of the roadway. The stopping sight distance for Birdseye Road on a grade in level terrain ranges from 433 feet for a 9% upgrade to 593 feet for a 9% downgrade. The stopping sight distance for Birdseye Road on a grade in rolling terrain ranges from 320 feet for a 9%

upgrade to 427 feet for a 9% downgrade. The sight distance lengths listed in **Tables 3.2** and **3.3** should be compared to these values.

Stopping sight distance is also applied to the vertical alignment of a roadway by the rate of curvature, K, of each crest or sag vertical curve. Exhibit 6-2 of the AASHTO Green Book, contained in **Appendix B**, lists the various criteria for both crest and sag vertical curves. Based on a design speed of 55 mph, the minimum design K for a crest vertical curve is 114 and a sag vertical curve is 115. For the design speed of 45 mph, the minimum K for a crest vertical curve is 61 and 79 for a sag vertical curve. If the actual K for a crest or vertical curve exceeds these values, then the stopping sight distance as a driver passes over these curves is deemed acceptable.

Sight distance along Birdseye Road was estimated during the field review using a hand-held laser rangefinder. Values of K were calculated for many vertical curves to verify sight distance observations. Fifteen locations along Birdseye Road were noted as having stopping sight distance approximately less than 600 feet and ten were noted as being below 320 feet. The locations are summarized in **Table 3.4** below.

**Table 3.4: Stopping Sight Distance on Birdseye Road**

| Location | Approx. Sight Distance | Comments |
|---|---|---|
| MP 2.10 | 150' | HC w/ 450' Radius , VC w/ K = 30, 35 mph advisory speed, fatality |
| MP 3.90 | 500' | Austin Road intersection, 6.0% vertical grade |
| MP 5.50 | 300' | 6.0% vertical grade |
| MP 6.00 | 250' | HC w/ 700' Radius, VC w/ K = 40 |
| MP 6.15 | 300' | HC w/ 350' Radius, 8.0% grade, cut slope, 25 mph advisory speed |
| MP 6.30 | 450' | VC, between two deficient HC |
| MP 6.45 | 250' | HC w/ 200' Radius, trees and buildings, 25 mph advisory speed |
| MP 6.55 | 200' | VC w/ K = 48, Three Mile Road intersection |
| MP 6.75 | 300' | HC w/ 500' Radius |
| MP 7.05 | 250' | VC w/ K = 55, Alder Road intersection |
| MP 7.28 | 150' | VC w/ K = 23, Hickory Road intersection |
| MP 7.65 | 450' | VC, rolling terrain |
| MP 7.95 | 300' | VC, rolling terrain, 7.5% grade |
| MP 8.15 | 450' | VC, rolling terrain |
| MP 9.35 | 450' | VC w/ HC and guardrail |

HC = Horizontal Curve

VC = Vertical Curve

K = Rate of vertical curvature (length of vertical curve divided by algebraic difference in grades)

The sight distance problems identified were most often caused by the horizontal and vertical curvature of the roadway, but cut slopes, vegetation, and buildings also contributed to the problem in some locations. Lengthening vertical curves and flattening sharp horizontal curves, similar to what was done for the MDT Safety Improvement Project, would fix most sight distance problems. Clearing roadside obstructions would improve roadway safety and may increase sight distance enough in some locations to avoid horizontal or vertical realignment. **Photo 3.5** through **Photo 3.7** depict examples of sight distance problems.

The terrain classifications used in this study, discussed previously, indicate that all locations in **Table 3.4** are within rolling terrain. Therefore, at a minimum, the ten locations with sight distance estimated to be below 320 feet should be addressed when the road was reconstructed.

Some locations in **Table 3.4** have intersecting road approaches. The intersecting sight distance was observed to be questionable for both Birdseye Road and vehicles turning onto Birdseye Road from the intersecting road at these locations. If no vertical curve improvements are undertaken at these locations, signs warning of intersections may be warranted.

**Photo 3.5: Poor hill crest sight distance near MP 2.10 – Looking North.**


**Photo 3.6: Poor sight distance at Three Mile Road intersection near MP 6.55 – Looking Southwest.**

**Photo 3.7: Poor sight distance at Hickory Road intersection near MP 7.30 – Looking South.**

## 3.6. Structures

An existing pre-stressed concrete bridge spans Sevenmile Creek at approximately MP 1.83, just past the railroad crossing. The overall deck width is 30 feet, while the bridge span is approximately 40 feet. The installation includes approximately 78 feet of steel guardrail on each side of the bridge. The guardrails reduce the clear width of the roadway to about 28 feet across the structure. The bridge clear width is approximately equal to the width of the road approaches just before and after the bridge, which undergo widening to match the bridge width from an otherwise 24-foot surfacing width. The bridge was constructed in 2001 and the structure, abutments, and guardrail all appear to be in good condition. MDT completed a bridge inspection in March 2011. The "Initial Assessment Form" from the inspection is attached in **Appendix A** for reference.

An at-grade railroad crossing adjacent to the structure will likely limit any horizontal realignment of the roadway, despite having a horizontal curve well below County and AASHTO standards at the railroad crossing. Due to the railroad crossing, we expect both the horizontal alignment and vertical grades to match the existing structure when the road is reconstructed.

In terms of meeting minimum road width requirements, AASHTO recommends that the bridge clear width be equal to or greater than the approach traveled way width, wherever practical. For a bridge to remain in place with design traffic exceeding 2,000 vehicles per day, AASHTO further recommends a minimum 28-foot clear width as shown in Exhibit 6-7, as contained in **Appendix B**. Thus, the bridge meets AASHTO minimum width criteria to remain in place under current conditions.

However, AASHTO recommends meeting the new road approach width <u>if practical</u>, and the reconstructed road in this segment meets criteria to be built to an overall width of 32 feet wide. The Sevenmile Creek bridge would not meet this criteria (clear width of approximately 28 feet). The discussion on developing the new road typical sections follows in this report. Due to the apparent 4-foot difference in proposed road top-surface width vs. the Sevenmile Creek bridge clear width, the County will need to ascertain the practicality and cost-benefit of widening the structure if road reconstruction to Major Collector standards is undertaken.

## 3.7. Existing Roadway Surfacing

A pavement evaluation for the Birdseye Road corridor was initiated in July 2009 with field work, soil borings, and laboratory analysis. The evaluation concluded with a surfacing design and evaluation report completed on November 3, 2009. A discussion of the results of the pavement evaluation for each road section is provided. **Table 3.5** gives a summary of the pavement evaluation soil boring results. A detailed pavement evaluation report is contained in **Appendix C.**

This pavement analysis is considered to be conservative in nature due to the fact that complete reconstruction was scoped as the service to be completed. Other options such as pulverizing, overlay, or other reconditioning methods were not analyzed.

The Birdseye Road corridor is asphalt-surfaced throughout the entire project length. Twelve soil borings were completed along this section. The borings, identified as ST-27 through ST-38, were completed in approximately one-mile intervals. The thickness of the asphalt surfacing course and base course samples were measured to the nearest ½ inch. The asphalt surfacing course encountered by the boring varied substantially, ranging from ¾ to 7 ½ inches. The asphalt surfacing is a composite of original material supplemented by maintenance blade patching, overlays and chip seal courses applied over the life of the present roadway. The variable asphalt thicknesses can correlate to County surface maintenance activities; in which built up layers of thicker asphalt represent efforts in areas to stabilize potentially soft and unstable subgrade soils or poor gravel bases that may be experiencing permanent deformation from vehicle loadings that exceed what the existing surfacing can support. Base course samples varied to a similar degree, from 1 to 13 inches. Three base course samples were considered to be of poor quality, while the other nine samples were characterized by the geotechnical engineer to be either of fair or good quality. One sample location, ST-37, also had an existing layer of subbase material.

With each boring, soil samples were also obtained for subgrade material directly below the aggregate base material. A wide variation of subgrade soils were encountered. The subgrade soil samples consisted of lean clay, clayey gravel, silty gravel, clayey sand, or silty sand. One-third of samples were measured at below optimum moisture content, one-third were measured at near optimum, and the rest were well over optimum moisture content. The risk of subgrade failure at all locations is generally considered to be moderate to high, with only one sample being characterized as having a low rate of subgrade failure. **Table 3.5** gives a summary of the pavement evaluation soil boring results.

Signs of pavement degradation were observed during the field review. Intermittent areas of alligator cracking and rutting in the driving lanes were noted for the entire length of Birdseye Road and may indicate the progression of subgrade failures along the roadway (**Photo 3.8**).

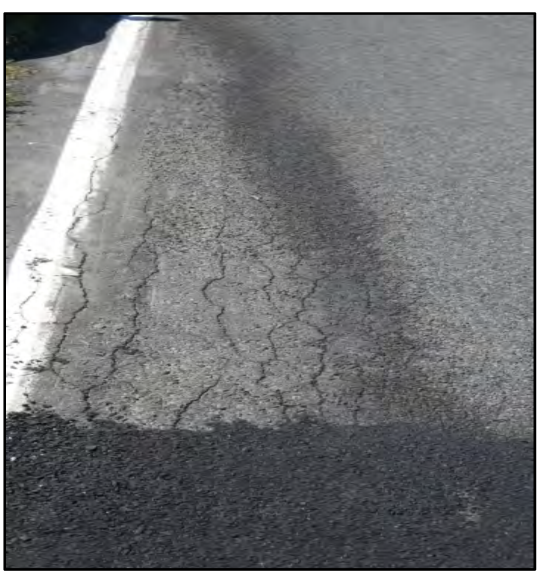


**Photo 3.8: Rutting and cracking of asphalt surface.**

Soil boring ST-37 was taken at MP 9.15 and no longer represents existing conditions due to the construction of the STPHS-HSIP 25(52) MDT project. However, soil borings performed for the MDT project classified the in situ soils to be predominantly clay (sandy fat clay, sandy lean clay, clayey sand, or clayey sand with gravel). The soil boring logs from MDT are included for review in **Appendix E**.

**Table 3.5: Summary of Boring Conditions**

| | ST-27 | ST-28 | ST-29 | ST-30 | ST-31 | ST-32 |
|---|---|---|---|---|---|---|
| Approximate Location | MP 0.05 | MP 1.05 | MP 2.10 | MP 3.09 | MP 3.84 | MP 4.85 |
| Existing Asphalt Thickness | 7 ½" | 4 ¾" | 2 ½" | 4" | 3" | 1 ½" |
| Existing Base Thickness | 4 ½" | 2 ½" (1) | 13" | 8" | 4" | 4" |
| Existing Subbase Thickness | - | - | - | - | - | - |
| Existing Base Quality | Poor | Poor | Good | Good | Good | Good |
| Subgrade | CL | CL | GM | GC | SM | GC |
| Blows Per Foot (BPF) | 16, 10 | 12, 5 | 12, 9 | 12, 5 | 9, 16 | 9, 10 |
| Moisture Condition | Below | Over 1 to 7% | Near | Near | Near | Below |
| Risk of Subgrade Failure | Moderate | High | Low | Moderate | Moderate | Moderate |

| | ST-33 | ST-34 | ST-35 | ST-36 | ST-37 (2) | ST-38 |
|---|---|---|---|---|---|---|
| Approximate Location | MP 5.60 | MP 6.64 | MP 7.36 | MP 8.16 | MP 9.15 | MP 9.97 |
| Existing Asphalt Thickness | 4" | 1" | ¾" | 2 ¾" | 1 ¼" | 1" |
| Existing Base Thickness | 2" (1) | 7" | 4 ¾" | 6 ¼" | 4 ¼" | 1" (1) |
| Existing Subbase Thickness | - | - | - | - | 18 ½" | - |
| Existing Base Quality | Good | Fair | Good | Good | Good | Poor |
| Subgrade | CL | SC | SC | CL | CL | SC |
| Blows Per Foot (BPF) | 9, 6 | 7,18 | 7, 5 | 5, 4 | 26, 6 | 10, 5 |
| Moisture Condition | Over 1 to 7% | Over 1 to 7% | Below | Over 2 to 4% | Below | Near |
| Risk of Subgrade Failure | High | High | Moderate | High | Moderate | High |

*(1) Base too thin to salvage.*
*(2) Boring taken before MDT Safety Improvements Project STPHS – HSIP 25(52).*
*CL = Lean Clay*
*GC = Clayey Gravel*
*GM= Silty Gravel*
*SC = Clayey Sand*
*SM = Silty Sand*

Summary:

- The existing asphalt surfacing thickness for two-thirds of the borings is thin compared to minimum County standards;
- Existing base aggregate varies from poor to good quality and two-thirds of borings have base aggregate thinner than minimum County standards;

- The subgrade in this segment has a moderate to high risk of failure during construction, and if not treated could cause roadway structural issues within the design life of a roadway reconstruction.

# *3.8. Existing Roadway Typical Sections*

This section of the report discusses the primary features of each road segment's existing typical section characteristics. Cross-sectional measurements of Birdseye Road were taken to include surfacing widths, cut and fill slope rates, ditch widths, and the depth of the roadside ditch. The project corridor is comprised of many distinct sections, but can be represented by three simplified composite typical sections.

## 3.8.1. Existing Typical Section E.1: Roadside Ditches

The predominant typical section throughout the project corridor can be represented by Existing Typical Section E.1, except in locations of channel crossings and hillside cuts. Most of Birdseye Road has roadside ditches on either side of the road, where surface runoff is collected and conveyed to an intersecting drainage and cross drain structure. The overall top surface of Birdseye Road was measured to be approximately 24 feet wide, with two 12-foot travel lanes and no distinguishable paved shoulders. Birdseye Road has white shoulder line stripes for the entire length of the road that distinguish the edge of pavement. The MDT Safety Improvement Project area from MP 8.90 to MP 9.30 has two 12-foot travel lanes and 2-foot shoulders.

The average roadside ditch foreslope was observed to be approximately 4:1 (horizontal : vertical, i.e. four feet horizontal distance for each one foot vertical drop) on each side of the roadway. Foreslopes as steep as 3:1 and as flat as 12:1 were observed during the field review, but the majority of Birdseye Road appears to have ditch foreslopes of approximately 4:1. The ditch backslopes varied to the same degree, and were averaged at approximately 3:1.

The roadside ditch depth was observed to vary between 0.5 feet and 4.5 feet on both sides of Birdseye Road. The ditch was triangular in shape in all cases. The depth of the ditch depended greatly on the amount of right-of-way available. The ditch depth increased as the existing right-of-way increased. The average ditch depth was calculated to be 3 feet on both sides.

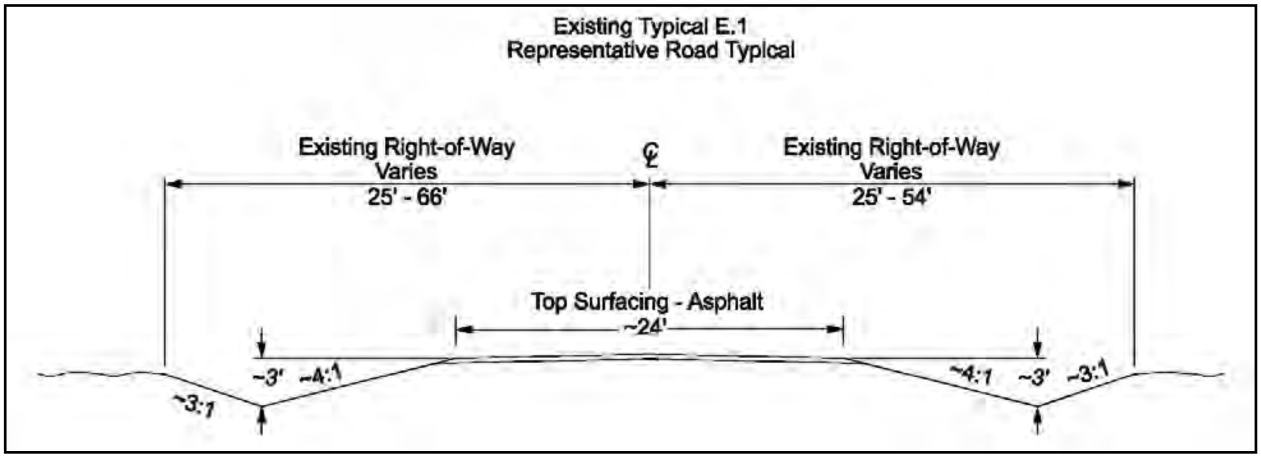



**Figure 3.1: Existing Typical Section E.1 – Looking North.**

**Photo 3.9: Existing Typical Section E.1 – Looking North.**

### 3.8.2. Existing Typical Section E.2: Fill Slopes at Drainages

Existing Typical Section E.2 occurs where Birdseye Road encounters an intermittent drainage channel or stream. The top surface of this section was measured to be approximately 24 feet wide, with two 12-foot travel lanes and, in general, no distinguishable paved shoulders.

The roadside foreslopes were averaged to be approximately 4:1 on both sides of the roadway in these locations for approximately 8 feet. The fill slopes from that point were often steep (as high of a rate as

1.5:1 near MP 2.20), but can be approximated at 3:1 on average. Many of the cross drains in these locations spanned the entire width of right-of-way. Many of the fill slopes would appear to meet current County road standards.

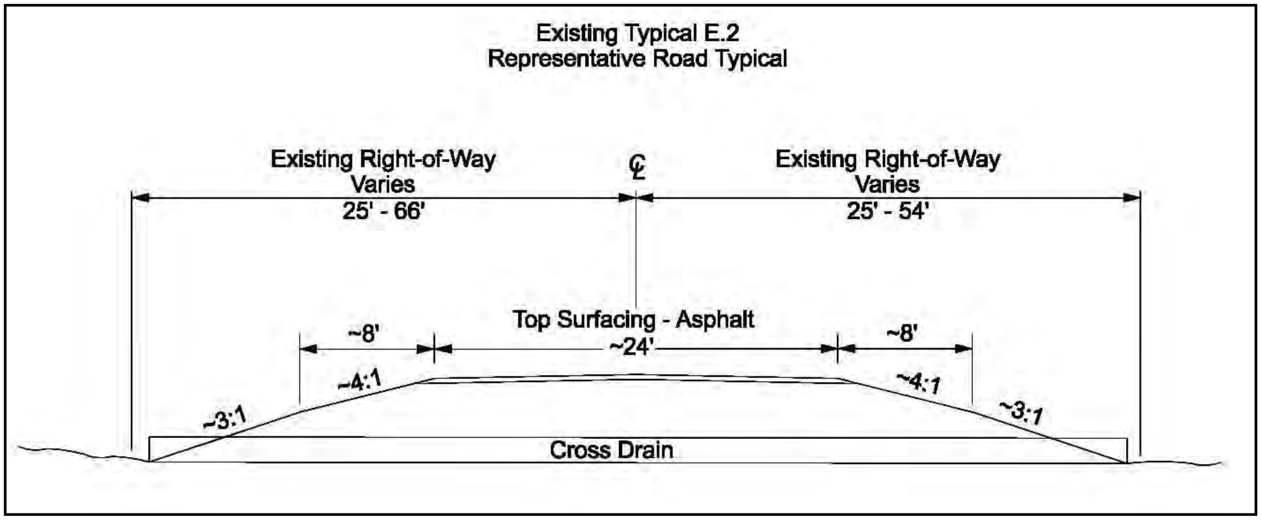



**Figure 3.2: Existing Typical Section E.2 – Looking North.**

**Photo 3.10: Existing Typical Section E.2 – Looking South.**

### 3.8.3. Existing Typical Section E.3: Cut Slopes

Existing Typical Section E.3 occurs where the Birdseye Road alignment cuts into the foothills, often coinciding with a horizontal curve. Typical Section E.3 applies mainly to the horizontal and vertical curves near MP 2.10, MP 6.15, and MP 6.45. The overall asphalt top surface of this section measured to be approximately 24 feet wide, with two 12-foot travel lanes and no distinguishable paved shoulders.

On the uphill side, the roadside ditch foreslopes were measured to be approximately 3:1 with a ditch depth of 1.5 feet or shallower. The ditch backslopes that create the cut slope were averaged to be approximately 2.5:1. On the downhill side, there is an average of about 5 feet of flat ground (approximately 12:1) for curve widening, and then an average slope of 2:1 down from there. The superelevation along curves varied from 2% to 9%, and is shown as an average of 6% in the figure below.

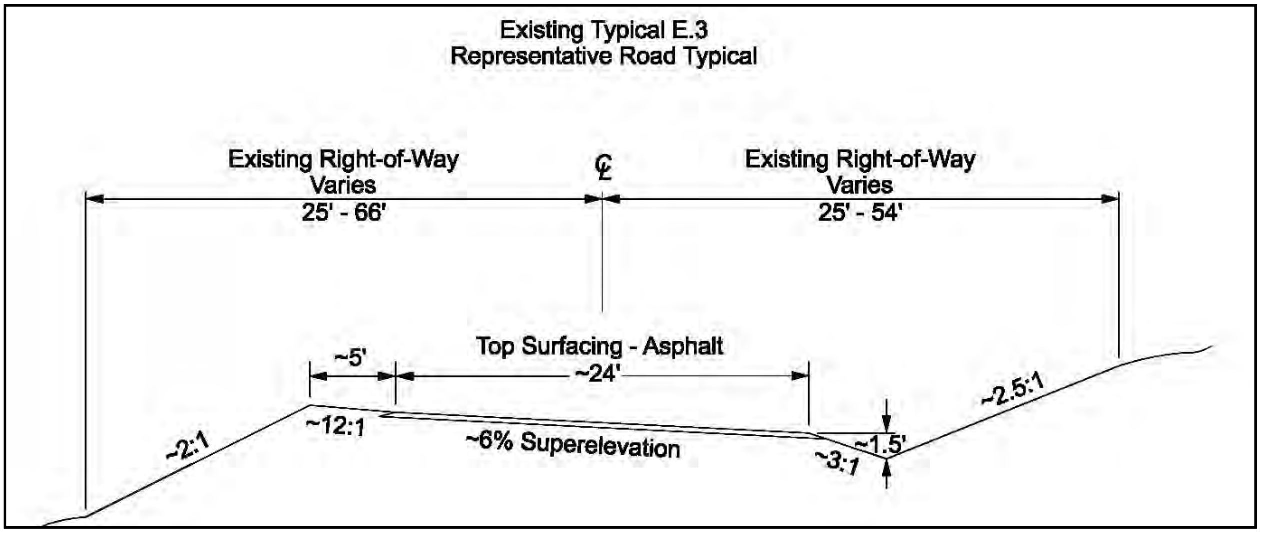



**Figure 3.3: Existing Typical Section E.3 – Looking North.**

**Photo 3.11: Existing Typical Section E.3 – Looking North.**

# 4. Proposed Conditions

This section of the PER discusses the proposed future conditions of the Birdseye Road corridor. Proposed conditions were determined based on applying Lewis and Clark County standards to the existing conditions based on information collected during the field review process.

## *4.1. Proposed Roadway Typical Sections*

The proposed design typical sections are based on the design methodology previously discussed herein. The County's Road Standards serve as the basis which was supplemented by AASHTO guidance as needed. The following sections provide detail as to how the proposed typical sections are developed for the purpose of this report.

### 4.1.1. Preliminary Surfacing Design

For this study, a preliminary surfacing section was developed based on the twelve soil borings and projected traffic data. This pavement design is used within this study to estimate reconstruction impacts and costs. As such, the preliminary surfacing design is developed to also meet or exceed the surfacing requirements of the Lewis and Clark County Road Standards for this Major Collector roadway.

Based on the project-specific input parameters and the approach of analyzing the pavement designs to be in accordance with the County Subdivision Regulations, the recommended reconstruction should have a new pavement section meeting or exceeding the structural integrity of the following (refer to **Appendix C** for the full pavement design evaluation):

- 3" Thick (Compacted) New Asphalt Pavement
- 3" Thick (Compacted) Crushed Top Surfacing
- 6" Thick (Compacted) Select Base Course (3-Inch Minus Gradation)
- 0" thick (Compacted) Subbase Course (3-Inch Minus Gradation)
- **12" Total Thickness**

The proposed surfacing section coincides with the County's minimum allowable surfacing section for a Major Collector, as shown in Figure 4 of Appendix J of the County Subdivision Regulations.

According to the surfacing evaluation contained in **Appendix C**, the subgrade is considered to have a moderate to high risk of failure during construction. Likewise, the subgrade is susceptible to moisture which could reduce its load-carrying capacity during seasonal conditions. As such, some areas may need stabilization as discussed in the surfacing evaluation.

The pavement section for the MDT Safety Improvement Project along Birdseye Road consisted of 0.30 feet (3.6 inches) of plant mix asphalt surfacing and 1.30 feet (15.6 inches) of crushed aggregate for a total thickness of 1.60 feet (19.2 inches). The project was located at the Silver Creek drainage and specified an amount of subgrade subexcavation with subbase backfill to stabilize the subgrade. The proposed typical sections for the MDT project are included for reference in **Appendix E**.

### 4.1.2. Design Clear Zone

Typical highway crashes either involve incidents on the road, or collisions with fixed features off of the road, such as bridge piers, sign supports, overhead utility poles, culverts, and non-traversable ditches or embankments. To counteract the effects of off-road errant vehicles, agencies implement a traversable and unobstructed roadside area beyond the edge of the traveled way for higher volume, rural facilities. Obstacles within the "clear zone" are evaluated to be removed, relocated, redesigned or shielded. The basic parameters to establish the appropriate design clear zone is the road's design speed, design traffic volume, and design roadside cut and fill slope rates.

Lewis and Clark County Road Standards reference roadside clear zone requirements to those recommended by AASHTO. A portion of Table 3.1 of the AASHTO 2006 Roadside Design Guide is reproduced in **Table 4.1**. This shows the recommended clear zones based on the design speed and traffic volume parameters for Birdseye Road. The clear zones shown below are measured in feet from the edge of the traveled way.

**Table 4.1: Roadside Clear Zone Guidelines (Feet)**

| | | Foreslopes | | | Backslopes | | |
|---|---|---|---|---|---|---|---|
| **Design Speed** | **Design ADT** | **6H:1V or Flatter** | **5H:1V to 4H:1V** | **3H:1V** | **3H:1V** | **5H:1V to 4H:1V** | **6H:1V or Flatter** |
| 45 - 50 mph | Under 750 | 10 - 12 | 12 - 14 | - | 8 - 10 | 8 - 10 | 10 - 12 |
| 45 - 50 mph | 750 - 1500 | 14 - 16 | 16 - 20 | - | 10 - 12 | 12 - 14 | 14 - 16 |
| 55 mph | 1500 - 6000 | 20 - 22 | 24 - 30 | - | 14 - 16 | 16 - 18 | 20 - 22 |

As shown in Figure 4 of Appendix J of the County's Subdivision Regulations, a Major Collector requires a minimum foreslope rate of 4:1 and a minimum ditch depth of 3 feet. To develop the proposed road template, we are applying the minimum recommended clear zone for the applicable design life AADT that will maintain the 3-foot roadside ditch at or just outside the clear zone. Doing so will limit construction impacts, road reconstruction costs, and reduce right-of-way acquisition.

A minimum clear zone of 22 feet and a foreslope rate of 6:1 are recommended for areas with a design AADT of 1500 to 6000 and level terrain. This applies to the beginning section of Birdseye Road near Barrett Road (MP 0.00) based on design life AADT. A minimum clear zone of 16 feet and a foreslope rate of 4:1 are recommended for rolling terrain areas with a design AADT of either 750 to 1500 or under 750. This applies to the middle and end sections of Birdseye Road from Austin Road (MP 3.80) to Lincoln Road (MP 10.05) based on design life AADT.

### 4.1.3. Surfacing Width

Figure 4 contained in Appendix J of Lewis and Clark County's Subdivision Regulations depicts the County's minimum standard road typical for a two-lane Major Collector. Each travel lane is to be 12-feet wide. The shoulder width can vary between 4 feet and 8 feet, as measured between the edge of the travel lane to the edge of the surfacing, depending on project-specific circumstances. Since the County standard in itself does not give guidance on what shoulder width to use, we referred to the AASHTO Green Book for guidance.

Exhibit 6-5 of the AASHTO policy specifies the minimum traveled way and shoulder widths for rural collector highways based on the factors of design speed and traffic volume. A copy of this exhibit is included in **Appendix B**. This exhibit recommends a 24-foot traveled way (minimum) for a design speed of 55 mph and 8-foot shoulders on each side (40 feet top width) for AADT over 2000. A design speed of 45 mph recommends a 22-foot traveled way with 5-foot shoulders on each side (32 feet top width) for AADT of 400 to 1500. Based on this, the minimum overall road surfacing width for reconstruction to accommodate two travel lanes and shoulders is 32 feet; accounting for two 12-foot travel lanes and two 4-foot shoulders. For the purposes of this study, 4-foot shoulders are implemented for the design typical sections since the design year AADT more closely matches that of a Minor Collector and wider shoulders are likely cost prohibitive. Substantial roadside safety improvements can be obtained with less than 8-foot shoulders.

The pavement section for the MDT Safety Improvement Project along Birdseye Road consisted of two 12-foot travel lanes and two 2-foot shoulders, for a total top width of 28 feet. The proposed typical sections for the MDT project are included for reference in **Appendix E**.

### 4.1.4. Proposed Typical Section P.1

Proposed Typical Section P.1 (**Figure 4.1**) is for the portion of Birdseye Road between Barrett Road and the railroad crossing (MP 0.00 to MP 1.80). Projected future traffic forecast along this section is between 1500 and 6000 AADT, which according to AASHTO policy suggests a minimum clear zone of 22 feet. The minimum County standard for a Major Collector is 100 feet of right-of-way. The existing right-of-way in this section appears to be 100 feet. The proposed typical should fit within the existing right-of-way with minimal impacts. As discussed in **Section 4.2**, at least one horizontal curve may need to be reconstructed to meet County design standards in this section and may require additional right-of-way. The backslope could be steepened to 3:1 to help narrow the proposed road template, if required.

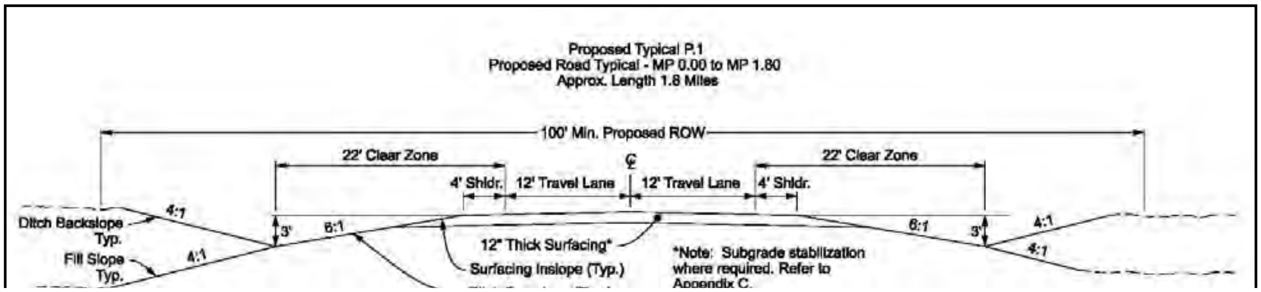



**Figure 4.1: Proposed Typical Section P.1 (MP 0.00 - MP 1.80) – Looking North.**

### 4.1.5. Proposed Typical Section P.2

Proposed Typical Section P.2 (**Figure 4.2**) is for the portion of Birdseye Road between the railroad crossing and Lincoln Road (MP 1.80 to MP 10.05). Projected future traffic forecast along this section is between 600 and 1500 AADT, which according to AASHTO policy suggests a minimum clear zone of 16 feet. A clear zone of 16 feet is utilized to ensure a 3-foot deep roadside ditch, per Figure 4 of the County's Road Standards. The minimum County standard for a Major Collector is 100 feet of right-of-way. The apparent existing right-of-way varies between 50 feet and 120 feet. If the current centerline is maintained, additional right-of-way would be needed on one or both sides of the road from MP 1.80 to MP 10.05, excluding the MDT Safety Improvement Project area. Multiple locations of vertical and horizontal curve improvement will be needed in this section to meet County design standards, as described in **Section 4.2**, and would likely require new right-of-way to flatten the curves.

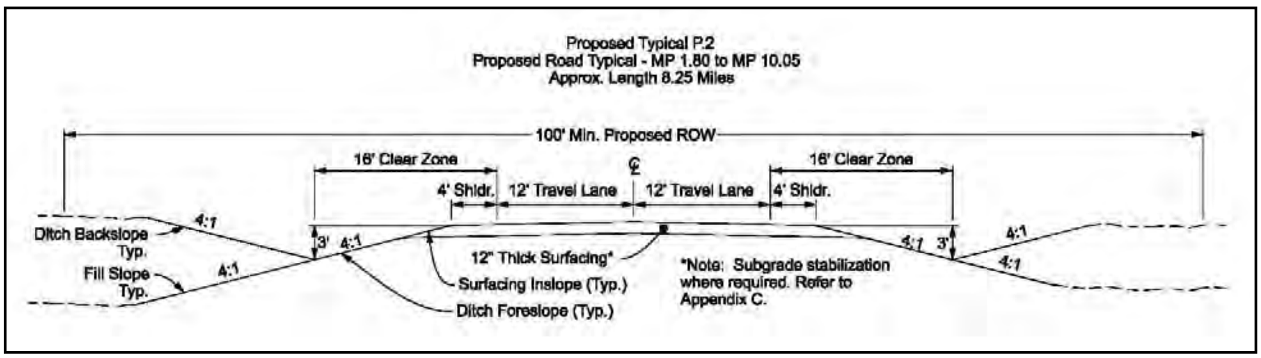



**Figure 4.2: Proposed Typical Section P.2 (MP 1.80 - MP 10.05) – Looking North.**

### 4.1.6. Miscellaneous Grading, Cut and Fill Slopes

To estimate earthwork and miscellaneous other feature impacts to reconstruct the roadway in level terrain, we applied the design typical sections, shown in **Figures 4.1** through **4.2,** over the representative existing road templates shown in **Figures 3.1** through **3.3**. An example of the anticipated level of cut and fill for Birdseye Road is shown in **Figure 4.3**.

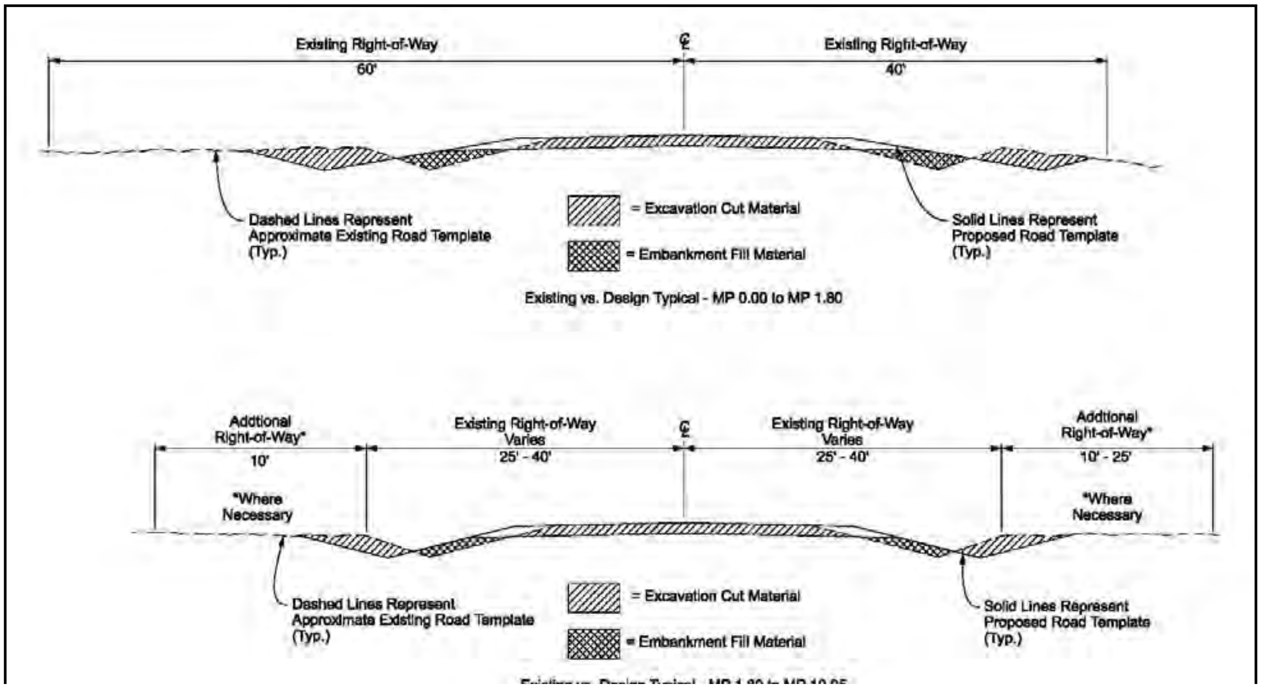



**Figure 4.3: Estimated Reconstruction Cut / Fill Impacts**

### 4.1.7. Geotechnical Considerations

Geotechnical evaluations were not undertaken other than the soil borings and laboratory analysis needed to develop a preliminary pavement design. When further design engineering is undertaken in subsequent tasks to develop the roadway reconstruction project(s), additional geotechnical engineering is recommended to confirm such items as subgrade stabilization limits and techniques.

During the course of developing the pavement designs, eight borings completed along the project corridor encountered subgrades that were near to or over optimum moisture content. The geotechnical engineer evaluated the locations to have moderate to high risks of subgrade failure during construction. The risk was based on the fact that the subgrade was wet and near to or well over optimum moisture content. The preliminary indications therefore are that approximately 50% of the roadway alignment can anticipate the need for some subgrade stabilization during the course of reconstruction. For the purpose of completing the road reconstruction cost estimate, we are including 14 inches of subbase in these locations as recommended in the surfacing evaluation for this application. This additional bridging material will be applied over a geosynthetic fabric to complete the subgrade stabilization. Subgrade stabilization is further discussed in the pavement design contained in **Appendix C**.

The pavement section for the MDT Safety Improvement Project was based on an in-depth geotechnical review. The Safety Improvement Project had approximately 300 feet of subexcavation to remove unstable soils. The subexcavated soils were replaced with one foot of select borrow material and two feet of riprap with an underlying geotextile. The MDT project details are included for reference in **Appendix E**.

## 4.2. Curve Improvement

The terrain classifications of this report indicate that, at a minimum, the horizontal curves at MP 0.05, MP 1.95, MP 6.15, and MP 6.45 are below County road standards for a Major Collector. The curve at MP 0.05 should be reconstructed to meet or exceed County level terrain design standards. The curves at MP 1.95, MP 6.15, and MP 6.45 should be reconstructed to meet or exceed County rolling terrain design standards. It should be noted that while the rolling terrain design criteria appears reasonable based on field observations, the curves along this section would only meet design standards for 45 mph upon reconstruction. If the regulatory speed is maintained at 55 mph, the curves may still warrant advance warning signs. **Figures 4.4** through **4.7** provide a generalized idea of the centerline adjustments required to reconstruct the identified curves to meet minimum County standards.

A sharp curve at MP 1.80 is below level terrain standards but is along an at-grade railroad crossing. This curve would be difficult to realign without also reconstructing both the railroad crossing and the bridge over Sevenmile Creek at MP 1.83. The analysis of this report reflects that this curve will not be changed. If funding is available for a new bridge and railroad crossing, the County should consider improving the curve at this location during reconstruction of Birdseye Road.

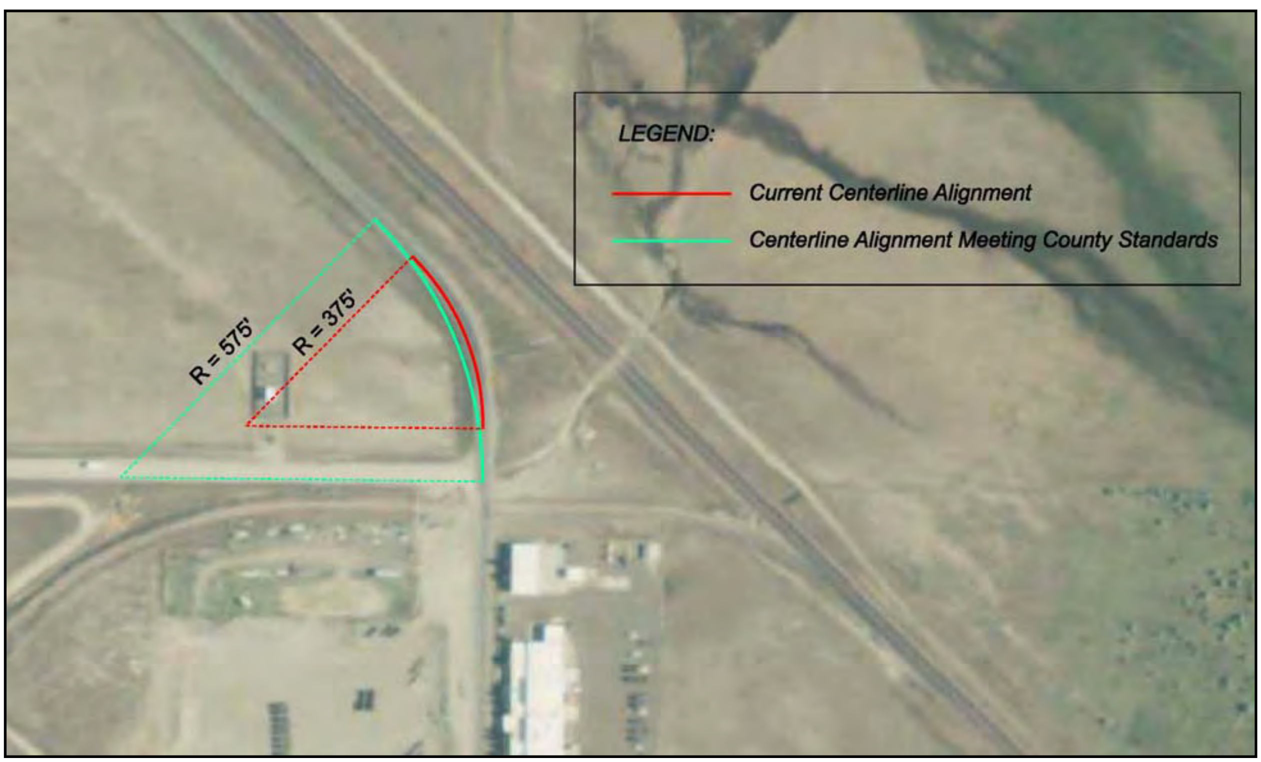



**Figure 4.4: Horizontal Curve Improvement at MP 0.05.**

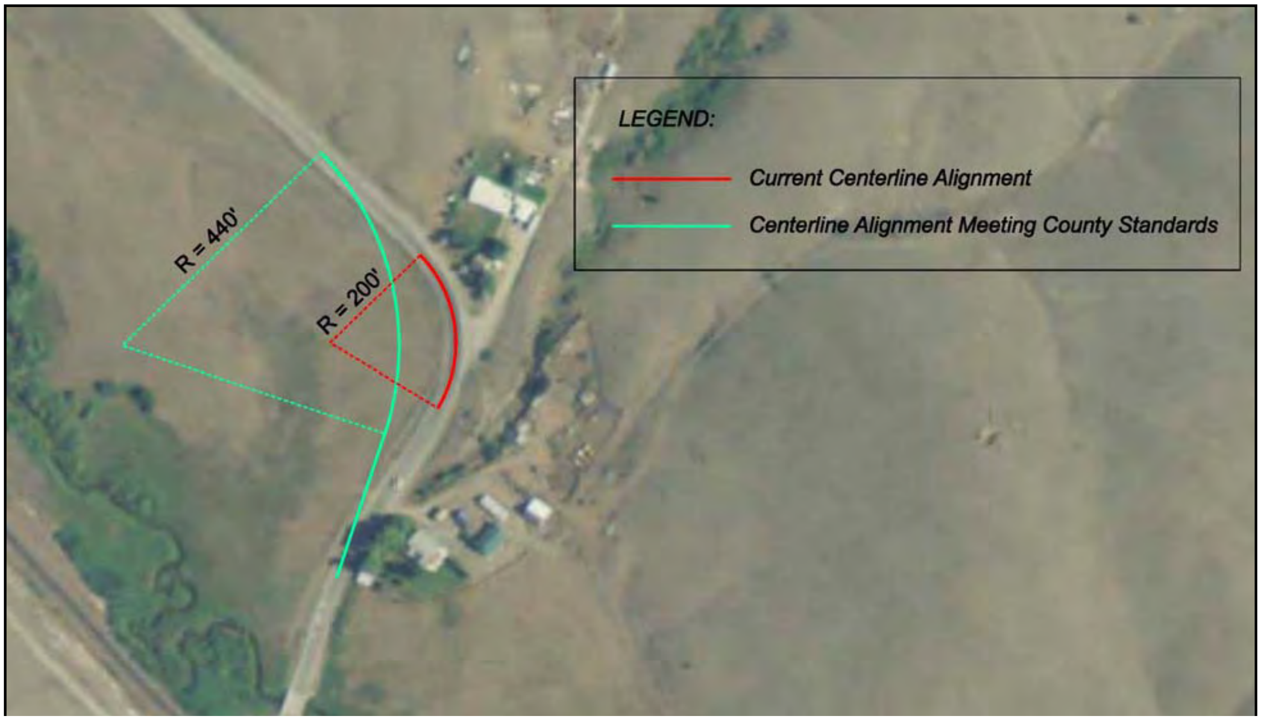



**Figure 4.5: Horizontal Curve Improvement at MP 1.95.**

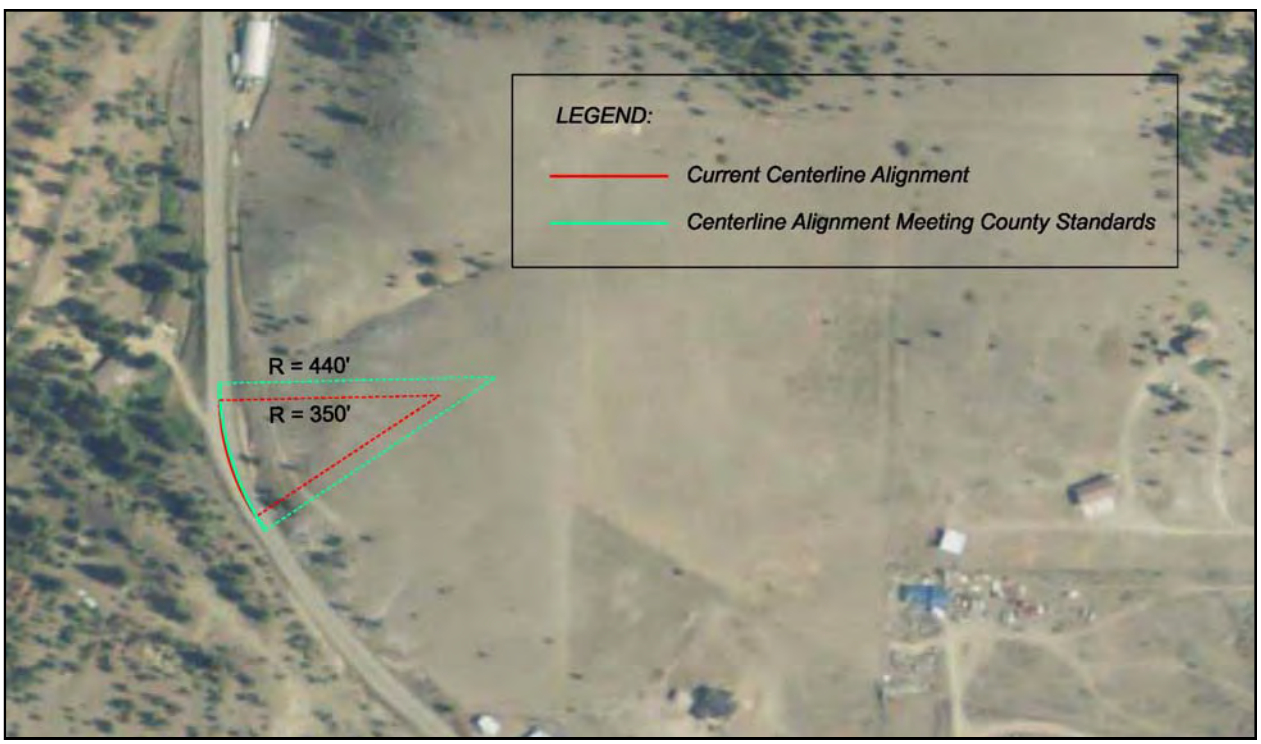



**Figure 4.6: Horizontal Curve Improvement at MP 6.15.**

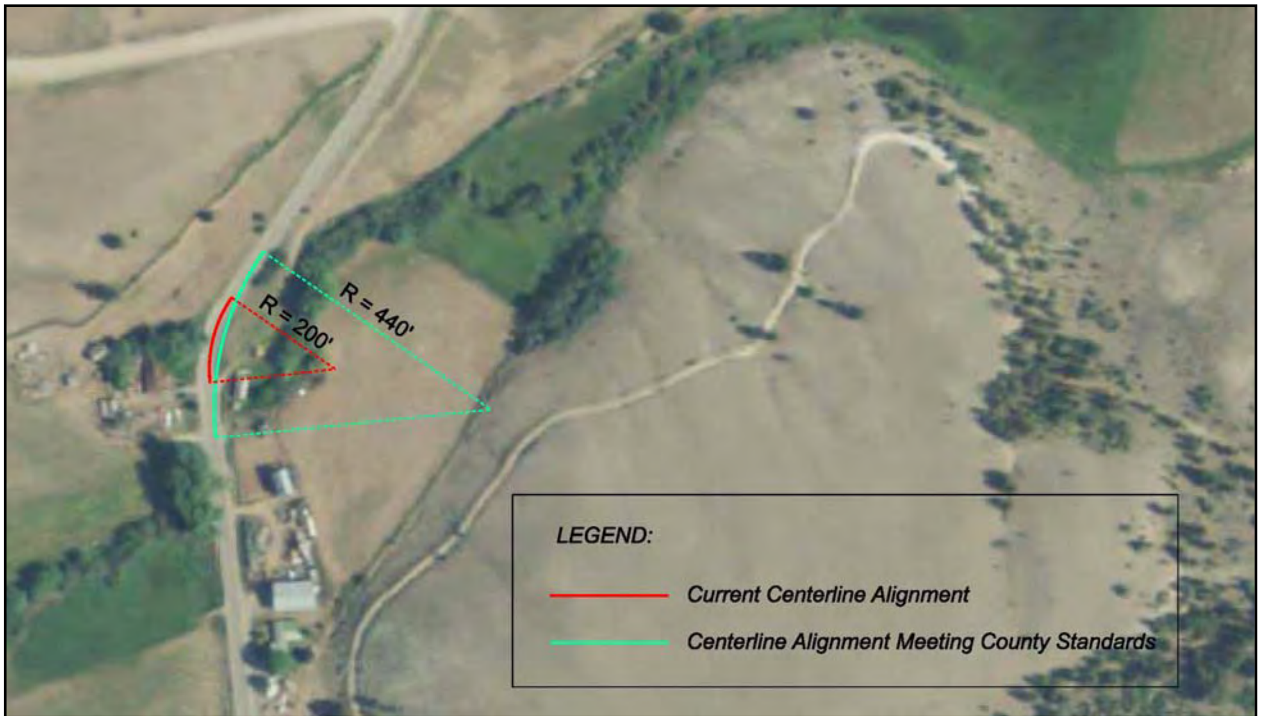



**Figure 4.7: Horizontal Curve Improvement at MP 6.45.**

The steep grade at MP 7.10 should also be improved in order to meet County road standards based on this report's terrain classifications. What appears to be poor sight distance at MP 7.10 may be addressed by raising the grade, but lengthening the vertical curve may also be needed to mitigate apparent sight distance issues.

The remaining six locations from **Table 3.4** that appeared to be below the rolling terrain minimum sight distance standard of 320 feet should be improved. The locations are at MP 2.10, MP 5.50, MP 6.55, MP 6.75, MP 7.28, and MP 7.95. The vertical curves at these locations could be lengthened, effectively flattening the curves (see **Figure 4.8**). The cost estimate of this report reflects curve flattening at the locations noted.

It is projected that most of the locations need to add a few hundred feet to the length of the curve to meet minimum standards. However, the two curves near MP 2.10 and MP 7.28 will have a longer impact due to the greater difference in grades at these locations. In particular, the curve at MP 2.10 is along an existing cut slope and will require a substantial amount of earthwork to lengthen the curve (see **Photo 3.5**).

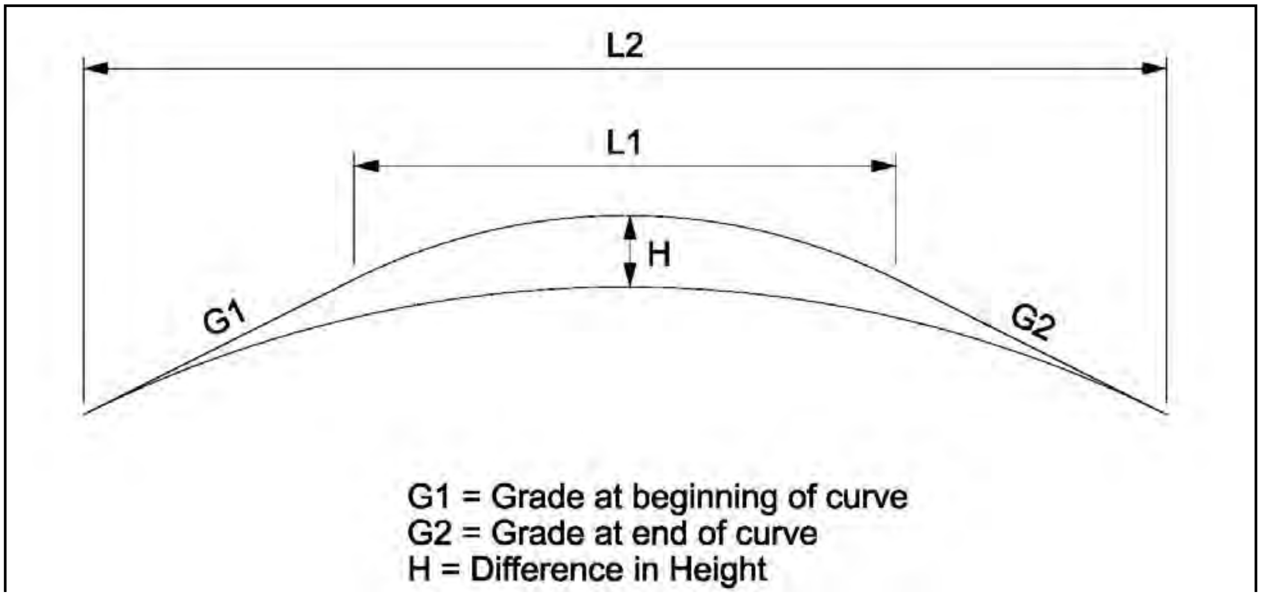



**Figure 4.8: Vertical Curve Improvement.**

## *4.3. Roadway Realignment*

The worst of the sight distance and roadway curvature deficiencies were generally grouped in two locations. The first section is between the railroad crossing (MP 1.80) and Echo Drive (MP 2.45) and the second section is between Raven Road (MP 5.90) and Alder Road (7.05). For this study, spot improvements for horizontal and vertical curves were assumed to mitigate the deficiencies within these sections. However, if funding is available, the best solution may be to completely realign the roadway within these sections, as was done for the MDT Safety Improvement Project.

MDT project STPHS-HSIP 25(52) had a total construction cost of approximately $682,000 for a 0.40-mile section of Birdseye Road. A cost per mile for the project would be around $1.7 million. Costs for right-of-way acquisition and design and construction engineering would be additional costs. Compared to the County's Road Standards, the MDT project required more right-of-way, constructed flatter slopes, and had horizontal curves with a greater than minimum radius. Based on this, the cost of realigning sections of Birdseye Road to meet County road standards may be somewhat less in magnitude. However, the per-mile cost from the MDT project represents a good baseline to help the County estimate what would likely be the upper-end cost threshold of curve realignment constructions.

## *4.4. Property Values*

Previously in this report, we estimated the existing highway right-of-way widths based on field review and GIS data. The section of the report addresses how land valuations were estimated. The predominant land use along this study segment is currently residential or agricultural. We presume the highest and best use of the current agricultural property is that to be developed into a residential subdivision.

To assign fully defendable and accountable costs to right-of-way impacts is outside the scope of this document. To do so would require the preparation of multiple appraisals. By virtue of the amount of parcels adjoining this highway's right-of-way, the appraiser fee to complete this work could amount to over one hundred thousand dollars based on industry rates. Instead, to obtain a reasonable estimate of right-of-way acquisition costs, we utilized rates contained in the Lake Helena Drive PER completed in December 2009. These rates were based on the brief research of a local appraiser for recent comparable sales in the Helena Valley for similar size parcels.

In his brief research, the appraiser found that residential tracts of 1- 5 acres sold for $18,000 to $40,000 per acre for similar properties in mixed-use areas with no zoning. Small tracts of less than one acre did sell for about $250,000 in some locations. These high-end comparable sales were not specifically identified as being within this corridor. For this estimate, we are basing all costs on a per-acre basis with no impacts to property improvements such as landscaping, fencing, lawn, sprinkler irrigation, wells, septic drain fields, etc. With that, it is likely that actual acquisition costs could be substantially higher should residential developments be impacted.

Based on the above, we assumed for this estimate that the cost to acquire land for right-of-way from a parcel to be about $32,000 per acre. To acquire the necessary right-of-way, the property must first be appraised. We estimate the appraiser fees for researching comparable sales history, preparing the property valuations, and obtaining title evidence will cost approximately $2,000 per parcel. An assigned land acquisition agent would then use the appraisals to negotiate and procure the necessary right-of-way. We assigned a cost of $1,500 per parcel for the fees that would be charged by a right-of-way acquisition agent. We used web-based information to estimate the number of properties impacted per segment of road. Overall, we project that approximately 119 properties could be impacted during the course of reconstructing 10.05 miles of this road.

## 4.5. Drainage and Hydraulics

### 4.5.1. Mainline Cross Drains

The project corridor traverses primarily rolling terrain and is intersected by drainages following the northwest-to-southeast natural drainage patterns at this location of the valley. Thirty existing mainline cross drains were identified during the field review. No substantial evidence of flooding or erosion was noted. A review of Flood Insurance Rate Maps (FIRMs) and GIS data was inconclusive as far as the need for additional culverts. The project corridor appears to require very little drainage upgrading besides the development of adequate roadside ditches. It was assumed that any highway cross drain smaller in diameter than 24 inches would be upgraded to a 24-inch pipe. Otherwise, the size of existing cross drains appears to be adequate, subject to further engineering studies.

### 4.5.2. Approach Culverts

For the purposes of this preliminary study, we estimated the number of new approach pipes needed based on a limited windshield review of the number of approaches within each road segment. The windshield review was supplemented by aerial photography and GIS data. Improving the roadside ditches as a part of the reconstruction effort will allow for both an increased ditch capacity and additional structural cover for upsizing small diameter approach culverts, if needed. We presume that most culverts will require replacement due to abundance of crushed ends and other defects observed. The lengths of new approach culverts were estimated by applying a road approach width of 24 feet, with additional inlet and outlet lengths calculated based on ditch elevation and slope. The approach pipes would have to be 18-inch diameter pipes at minimum to meet the County's requirements for a Major Collector.

### 4.5.3. Drainage Summary

Existing culverts that were observed in field reviews are included with the assumption that these will require replacement due to modified construction limits. In addition, a nominal amount of new approach culverts will likely be necessary. Due to the scope of this report, the majority of notable crossings were inspected, but a substantial amount of review was also "windshield." In addition, FIRM maps were reviewed to determine if there were existing floodplains along the project corridor. **Table 4.2** below summarizes hydraulic conveyance features within the study area.

The cross drain improvements noted are based on limited field observations. A detailed hydraulic analysis of the Birdseye Road corridor would be necessary to identify any drainage improvements required and to verify all pipe replacement sizes. Steep fill slopes and issues with structural cover at MP 2.18 and MP 3.62, respectively, will likely be resolved by the new proposed roadway typical. The culverts installed for the MDT Safety Improvement Project should be able to stay in place during reconstruction. If not, extensions to these structures could be utilized instead of replacement.

**Table 4.2: Existing Cross Drain Summary**

| | Existing | | Replacement | | |
|---|---|---|---|---|---|
| Location | Diameter | Length | Diameter | Length | Comments |
| MP 0.00 | 36" | 70' | 36" | 100' | |
| MP 0.04 | 24" | 50' | 24" | 72' | |
| MP 0.72 | 18" | 47' | 24" | 72' | |
| MP 0.75 | 30" | 45' | 36" | 72' | |
| MP 1.42 | 18" | 45' | 24" | 72' | |
| MP 1.72 | 24" | 70' | 24" | 100' | |
| MP 2.18 | 24" (2) | 70' | 36" (2) | 100' | Steep fill slopes, 1.5:1 |
| MP 2.26 | 24" | 45' | 24" | 56' | |
| MP 2.73 | 48" | 50' | 48" | 56' | |
| MP 3.14 | 24" | 70' | 24" | 100' | |
| MP 3.51 | 24" | 45' | 24" | 56' | |
| MP 3.61 | 24" (2) | 50' | 48" | 56' | |
| MP 3.62 | 48" | 75' | 48" | 100' | Poor culvert cover |
| MP 4.44 | 18" | 40' | 24" | 56' | |
| MP 4.92 | 18" | 45' | 24" | 56' | |
| MP 5.48 | 36" | 40' | 36" | 56' | |
| MP 6.29 | 18" | 40' | 24" | 56' | 500-year flood hazard area |
| MP 6.42 | 36" | 75' | 36" | 100' | 500-year flood hazard area |
| MP 7.20 | 24" | 75' | 24" | 100' | 500-year flood hazard area |
| MP 7.41 | 15" | 60' | 24" | 56' | 500-year flood hazard area |
| MP 7.84 | 18" | 75' | 24" | 56' | 500-year flood hazard area |
| MP 8.07 | 15" | 60' | 24" | 56' | 500-year flood hazard area |
| MP 8.26 | 18" | 60' | 24" | 56' | 500-year flood hazard area |
| MP 8.56 | 36" | 80' | 36" | 100' | 500-year flood hazard area |
| MP 8.70 | 15" | 60' | 24" | 56' | 500-year flood hazard area |
| MP 9.10 | 24" | 66' | | | Use as is (1) |
| MP 9.22 | Dbl. 51" x 31" | 70' | | | Use as is (1) |
| MP 9.29 | 90" x 54" | 60' | | | Use as is (1) |
| MP 9.62 | 18" | 45' | 24" | 56' | 500-year flood hazard area |
| MP 9.78 | 15" | 60' | 24" | 56' | 500-year flood hazard area |

*(1) Installed for MDT Safety Improvement Project STPHS-HSIP 25(52)*

## *4.6. Pedestrian and Bicycle Facilities*

There are currently no facilities to accommodate pedestrians or bicyclists within this corridor. Under this study, no costs are being attributed to constructing a shared-use bicycle/pedestrian path as part of the base cost of rebuilding the road. However, an alternative cost of constructing a path on a per-mile basis is included in this report for planning purposes. The estimated cost presented later in this report is for a 10-foot wide asphalt-surfaced path.

Based on field review observations and anecdotal evidence from community members, the Birdseye Road corridor is a popular area for recreational bicycle use. With no existing bicycle facilities or roadway shoulders, bicyclists are forced to travel within the travel lanes of Birdseye Road. Any safety hazards noted for Birdseye Road in this report should be considered hazards for bicyclists as well. Sight distance deficiencies can be especially bad in situations where vehicles cannot see bicyclists in time to avoid them. As such, accommodations for bicycle travel should be considered during reconstruction, which in part would be achieved by road shoulder widening. A cost per mile for a separate 10-foot bicycle/pedestrian path is included in this report. However, providing bicycle lanes by expanding the new roadway shoulders by a few feet would also be a good option, especially if the rolling terrain along Birdseye Road limits the practicality of building a separate bicycle/pedestrian facility.

According to the Greater Helena area Transportation Plan – 2004 Update, an overriding goal for non-motorized transportation in the greater Helena Area is:

> *To develop a living plan for the Greater Helena Area to create and maintain corridors for cyclists and other non-motorized modes of travel and recreation that are safe and effective for their transportation and enjoyment, and to inform and educate motorists, cyclists, and pedestrians in how to safely and respectfully share our roads and other corridors as citizens transport themselves about the community.*

## 4.7. Auxiliary Turn Lanes

The scope of this work does not include completing definitive turn lane warrant studies at key intersections. However, when the highway design is initiated, one or more turn lanes may be warranted. Therefore for the benefit of this study, we have included an estimated cost to construct a left-turn lane serving an approach in a non-signalized intersection. The discussion on traffic control signals follows this section. Turn lanes should be considered at each signalized intersection.

We based the estimated turn lane geometrics for a left-turn lane on the guidelines presented by MDT in their Traffic Engineering Manual. We assume that the shoulder widths in the location of a turn lane will be maintained at 4-feet wide. Using 55 mph design speed criteria, the lane shift bay taper rate will be 55:1 to shift the through lanes outward. An interior bay taper rate of 18:1 is used for vehicles entering the left turn lane. From the left turn bay entry, the recommended deceleration distance is 480 feet. The deceleration is assumed to initiate at the beginning of the left turn bay taper. Since intersection turning movement counts have not been completed as a part of this study, we assume the storage length needed is minimal and left-turning vehicles will complete the maneuver with adequate gaps present in the opposing traffic stream without coming to a stop in most instances. Based on the above, the minimum length left turn lane will require approximately 660 feet of total length for lane shift tapers entering and exiting the left turn area, and 480 feet of auxiliary lane including its bay taper. The total length of road widening for a minimum length left turn lane would then be about 1,140 feet.

## *4.8. Traffic Signals*

A signal warrant analysis was not completed under this study. For purposes of estimating the full potential reconstruction cost of the study area, we presume that signal warrants could eventually be met to consider a signal installation, particularly at the intersection with Lincoln Road, within the design life of Birdseye Road. Therefore, an estimated cost to install signal hardware has been included.

# 5. Reconstruction Cost Estimates

This section summarizes the process used to develop cost estimates for the reconstruction of Birdseye Road between Barrett Road and Lincoln Road. For cost estimation purposes, the Birdseye Road corridor was broken out into five distinct typical sections as listed below. Each typical section had individually unique characteristics that played a role in developing the cost estimates.

- **Typical Section A** – Barrett Road (MP 0.00) to railroad crossing (MP 1.80)
- **Typical Section B** – Railroad crossing (MP 1.80) to Austin Road (3.80)
- **Typical Section C** – Austin Road (MP 3.80) to Raven Road (MP 5.90)
- **Typical Section D** – Raven Road (MP 5.90) to Vista Grande Road (MP 7.80)
- **Typical Section E** – Vista Grande Road (MP 7.80) to Lincoln Road (MP 10.05)

**Table 5.1** summarizes the estimated cost to reconstruct the Birdseye Road project corridor. **Appendix D** provides a detailed cost estimate consisting of a breakout of major work features, quantities, and unit costs. The following sections briefly discuss how some of the number of units were estimated. The units were then multiplied by average unit costs. Average unit costs were based of values used in the Lake Helena Drive PER completed in January 2010. Those average unit costs were based on a review of the bid history of four highway projects currently under construction in the Helena Valley. These projects ranged from full highway reconstructions to spot safety improvement projects. A MDT Safety Improvement Project, STPHS-HSIP 25(52), was bid in 2009 and reconstructed a section of Birdseye Road to correct safety issues. It should be noted that the County could similarly improve Birdseye Road by either several smaller spot improvements projects, or larger-length reconstructions.

**Table 5.1: Reconstruction Cost Estimate**

| Birdseye Road | Typical A | Typical B | Typical C | Typical D | Typical E | Total |
|---|---|---|---|---|---|---|
| Construction Subtotal | $1,200,223 | $2,680,741 | $1,504,485 | $1,968,462 | $1,606,584 | **$8,960,496** |
| Total Estimated Cost | $1,620,302 | $3,916,001 | $2,420,855 | $2,973,443 | $2,382,249 | **$13,312,850** |
| Length (miles) | 1.80 | 2.00 | 2.10 | 1.90 | 2.25 | **10.05** |

## *5.1. Estimating Procedure*

### 5.1.1. Grading

- Excavation – Unclassified quantity is estimated from **Figure 4.3** by calculating the end section cut areas and multiplying by the applied length to generate a volume. Consideration is given that the figures are likely worst-case scenarios and intermittent locations will likely balance with lesser cuts and fills.

- Excavation and embankment were estimated for any section where horizontal and vertical curve improvements were assumed and have been included in the grading quantities. A 20% shrink factor was used for the curve improvement embankment quantities.
- Topsoil Salvage and Placing is calculated based on **Figure 4.3** assuming 3 inches of topsoil depth.

### 5.1.2. Surfacing

- The miscellaneous road surfacing quantities such as the crushed top surfacing, select base, subbase, plant mix asphalt paving, prime, and seal coat are estimated based on the recommended pavement design and the proposed surfacing widths as shown in **Figures 4.1** through **4.2**.
- A nominal amount of Traffic Gravel is included to allow for a temporary wearing course for traffic driving on the unfinished subgrade.
- Interim paint quantities are included to delineate the road centerline and shoulder lines prior to the road receiving a chip seal. Final paint quantities would then be applied after the chip seal.

### 5.1.3. Drainage

- The summarized length of approach pipe lengths is estimated based on the number approaches and their assumed cross-sectional characteristics such as slope rate and depth of cover. Approach top widths are estimated as being an average of 24 feet. The amount of access approaches intersecting the roadway in each applicable segment is based on GIS aerial photographs and limited windshield survey. As noted, the approach pipes would have to be a minimum of 18-inch diameter pipes.
- Cross drain features are listed in **Table 4.2** with the assumed replacement sizes based on field observations. Their new installation lengths are estimated based on the dimensions generated from the proposed road templates. A length of 100 feet was assumed for any existing pipe with a substantial skew angle.

### 5.1.4. Fencing

- It was assumed that new right-of-way fencing would be required along the entire project length. To re-fence the right-of-way, we assume using a typical 5-strand barbwire fence with metal posts.
- It was assumed that fence panel would be needed for every 330 feet of new fence.

### 5.1.5. Roadside Revegetation

- Quantifying seeding, fertilizer and seedbed conditioning is based on sectional measurements taken from the finished slopes shown in **Figure 4.3**.

### 5.1.6. Subgrade Stabilization

- The preliminary pavement designs included with this report identifies subgrade areas having moderate to high risk of failure during construction. However, field conditions could vary from the limited sampling completed under this study. An amount of stabilization gravel was included to be placed over a geotextile fabric based on the recommendations contained in the pavement design. Similarly, we estimated the amount of geotextile needed on a range of digouts based on the subgrade widths derived from **Figures 4.1** through **4.2**.

### 5.1.7. Right-of-Way

- To estimate appraisal costs for right-of-way acquisition, a $2,000 per parcel fee was applied for an assumed 119 parcels. A similar approach is taken to estimate fees for an agent to prepare closing documents, negotiate the right-of-way, and file documents for record.
- $32,000 per acre land valuation is used to estimate the cost to acquire land for right-of-way purposes. This valuation is based on limited coordination with a local appraiser whom completed a brief research of the area to obtain comparable sales history during development of the 2009 PERs. The economic situation and housing industry is assumed to be still very similar. The comparable sales research yielded transactions amounting to $18,000 to $40,000 per acre for residential tracts from 1-5 acres in size. In some cases, highly sought after tracts were much higher in per-acre price. We apply the assumption that agricultural tracts will be negotiated by the owner at residential land values (given the opportunity to subdivide as the highest and best use), and that the cost per acre is based on all similar size parcels.
- The estimated existing right-of-way widths are listed in **Table 3.1** and varied from as little as 50 feet to as much as 120 feet. This is based on existing right-of-way fence observations. It was assumed that the County will likely require that the minimum standard for Major Collectors (100 feet of overall right-of-way width) be maintained. For the sections of Birdseye Road between Barrett Road and the railroad crossing (MP 0.00 to MP 1.80) and within the limits of the MDT Safety Improvement Project (MP 8.90 to MP 9.30), the existing right-of-way was at or over 100 feet and thus minimal right-of-way impacts were assumed. For the remainder of the road, including the sections of curve improvement, right-of-way impacts were estimated based on maintaining a minimum of 50 feet of right-of-way on each side of centerline.

### 5.1.8. Curve Improvement

- The length of the new horizontal and vertical curves after the curvature has been improved was estimated using CADD software. Geometric assumptions based on **Figures 3.1** through **3.3** and the proposed typical shown in **Figure 4.2** were used to estimate additional earthwork necessary to complete the work and the earthwork was added into the excavation or embankment quantities for the applicable sections of Birdseye Road.

## *5.2. Alternate Costs*

A number of additional alternative costs were included as part of the project cost estimate. These costs are separate from those developed for the roadway reconstruction. These costs are provided in the event that separate alternative features are needed from those necessary for standard roadway reconstruction. **Table 5.2** provides a summary of the additional alternative cost estimates. The following sections provide information as to how these costs were derived.

**Table 5.2: Additional Alternate Cost Estimate**

| Major Work Feature | Unit | Unit Cost | Number of Units | Total Cost |
|---|---|---|---|---|
| Traffic Signal | LS | $68,000.00 | 1 | $68,000 |
| Turn Lane | LS | $110,000.00 | 1 | $110,000 |
| Sanitary Sewer Main | MI | $211,200.00 | 10.05 | $2,122,560 |
| Water Main | MI | $396,000.00 | 10.05 | $3,979,800 |
| Bicycle/Ped. Path Reconstruction | MI | $77,825.00 | 10.05 | $782,141 |

### 5.2.1. Traffic Signal

- The estimated cost to install traffic signal hardware for one intersection is based on the bid history of components currently being installed by MDT around the Helena area.

### 5.2.2. Left-Turn Lane Widening

- The estimated cost to widen the roadway to install a single turn lane is based on proportion to that cost to construct the roadway with no turn lane.

### 5.2.3. Miscellaneous

- The estimate includes a per-mile cost to install an 8-inch water main and an 8-inch sanitary sewer main for future services. The estimate is based on an installed cost of $75 per linear foot for the water main, and $40 per linear foot for the sewer main. For planning purposes, the County desires to include an estimate since installing a water main and/or sanitary sewer main would likely be cost-effective to complete at the time the roadway is being reconstructed.

- A per-mile estimate is included to construct an alternate 10-foot wide shared-use bicycle/pedestrian path. The estimate uses 2-inch thick plant mix asphalt surfacing over 4 inches of crushed top surfacing aggregate base. Note that if a pathway is included, land needed for right-of-way could increase beyond the minimum 100 feet assumed by a proportional amount equal to the width of the path plus a desirable offset from the edge of the road's construction limits.

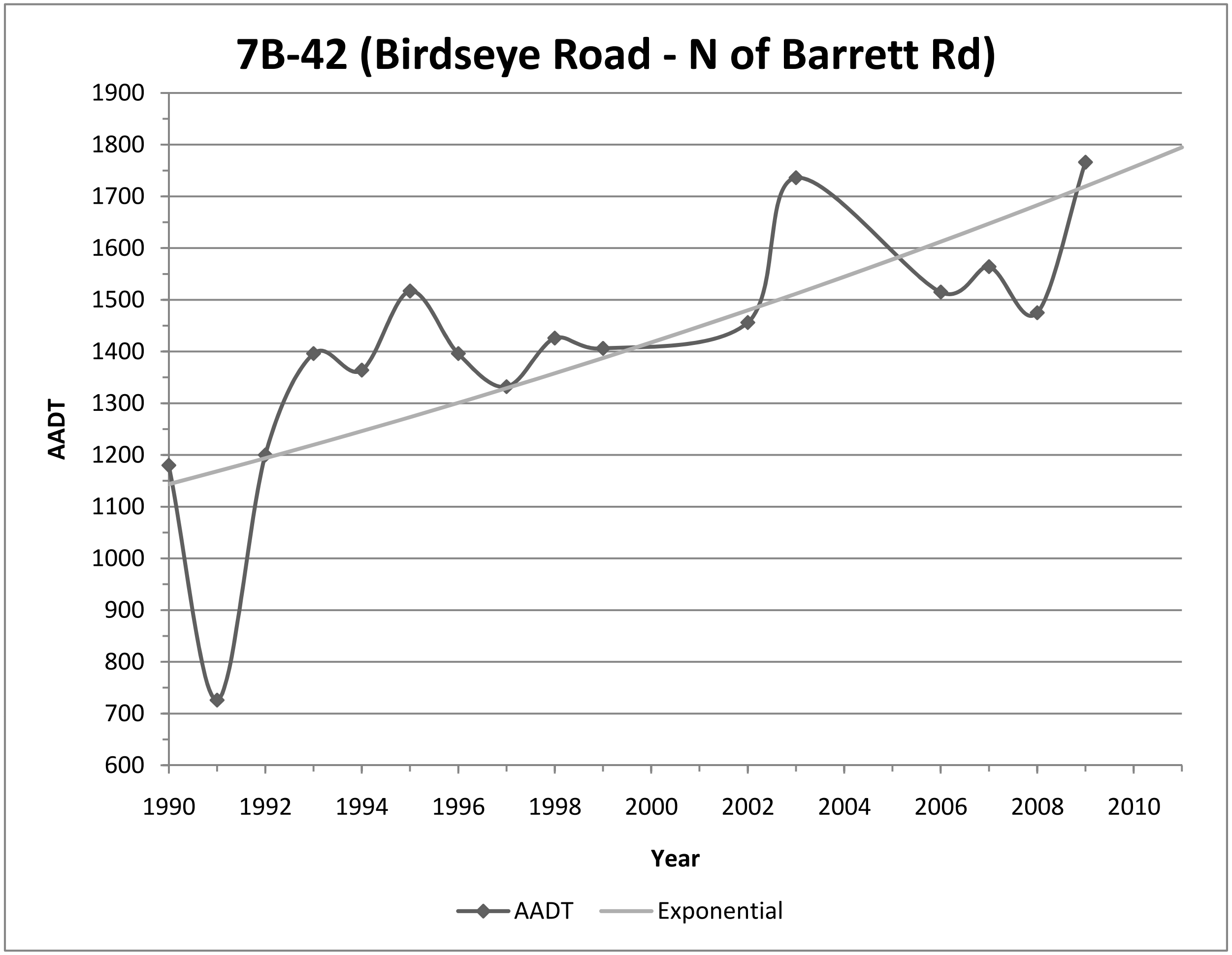
# Appendix A

## Background Data

#

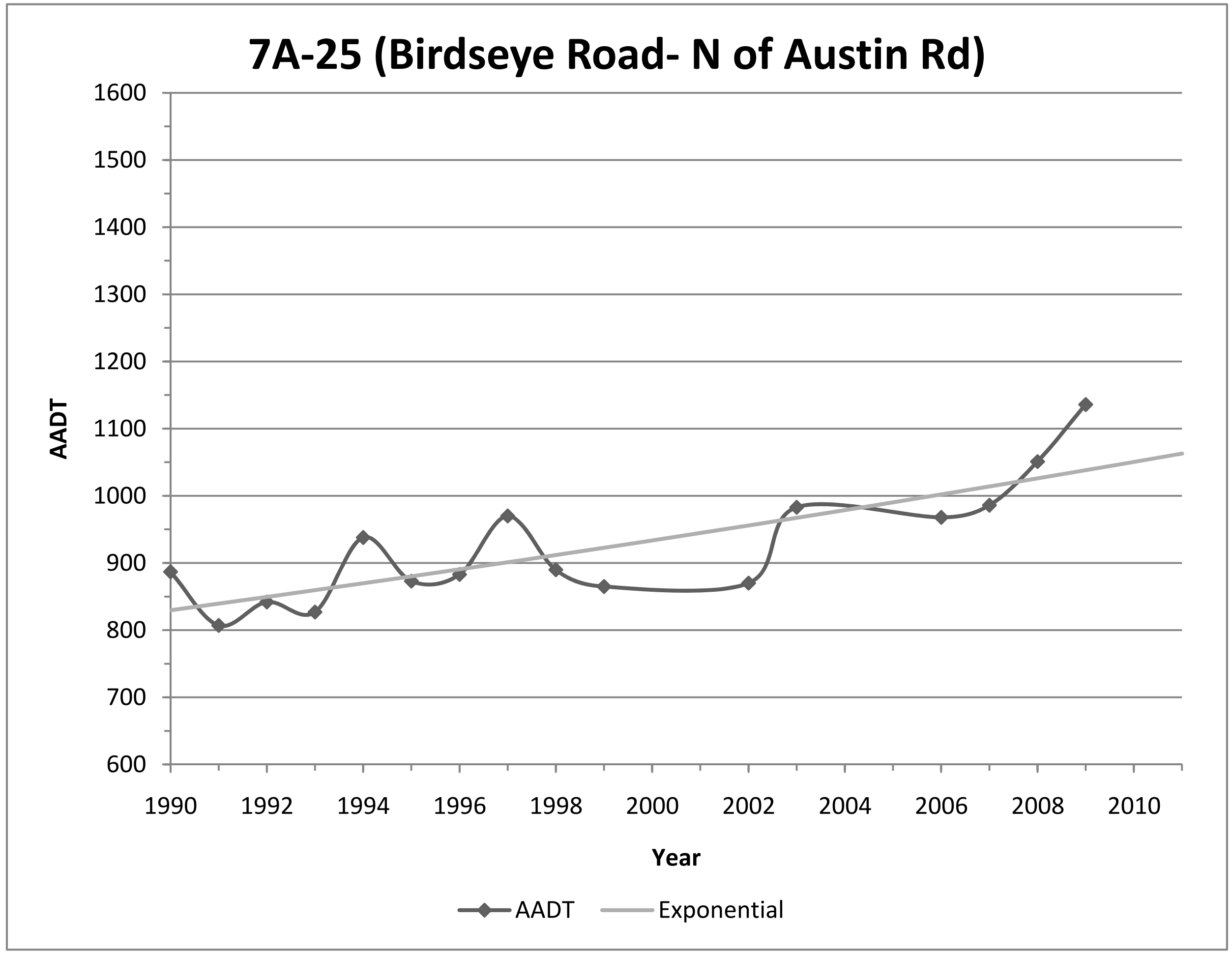
**7B-42 (Birdseye Road - N of Barrett Rd)**

| Year | AADT | Exponential |
|---|---|---|
| 1990 | 1180 | 1144 |
| 1991 | 726 | 1168 |
| 1992 | 1200 | 1194 |
| 1993 | 1396 | 1220 |
| 1994 | 1364 | 1246 |
| 1995 | 1517 | 1273 |
| 1996 | 1396 | 1301 |
| 1997 | 1332 | 1329 |
| 1998 | 1426 | 1358 |
| 1999 | 1406 | 1387 |
| 2002 | 1456 | 1480 |
| 2003 | 1736 | 1512 |
| 2006 | 1515 | 1612 |
| 2007 | 1564 | 1647 |
| 2008 | 1475 | 1683 |
| 2009 | 1766 | 1719 |
| 2011 | - | 1795 |
| 2031 | - | 2756 |
| i | - | **2.17%** |



**7A-25 (Birdseye Road - N of Austin Rd)**

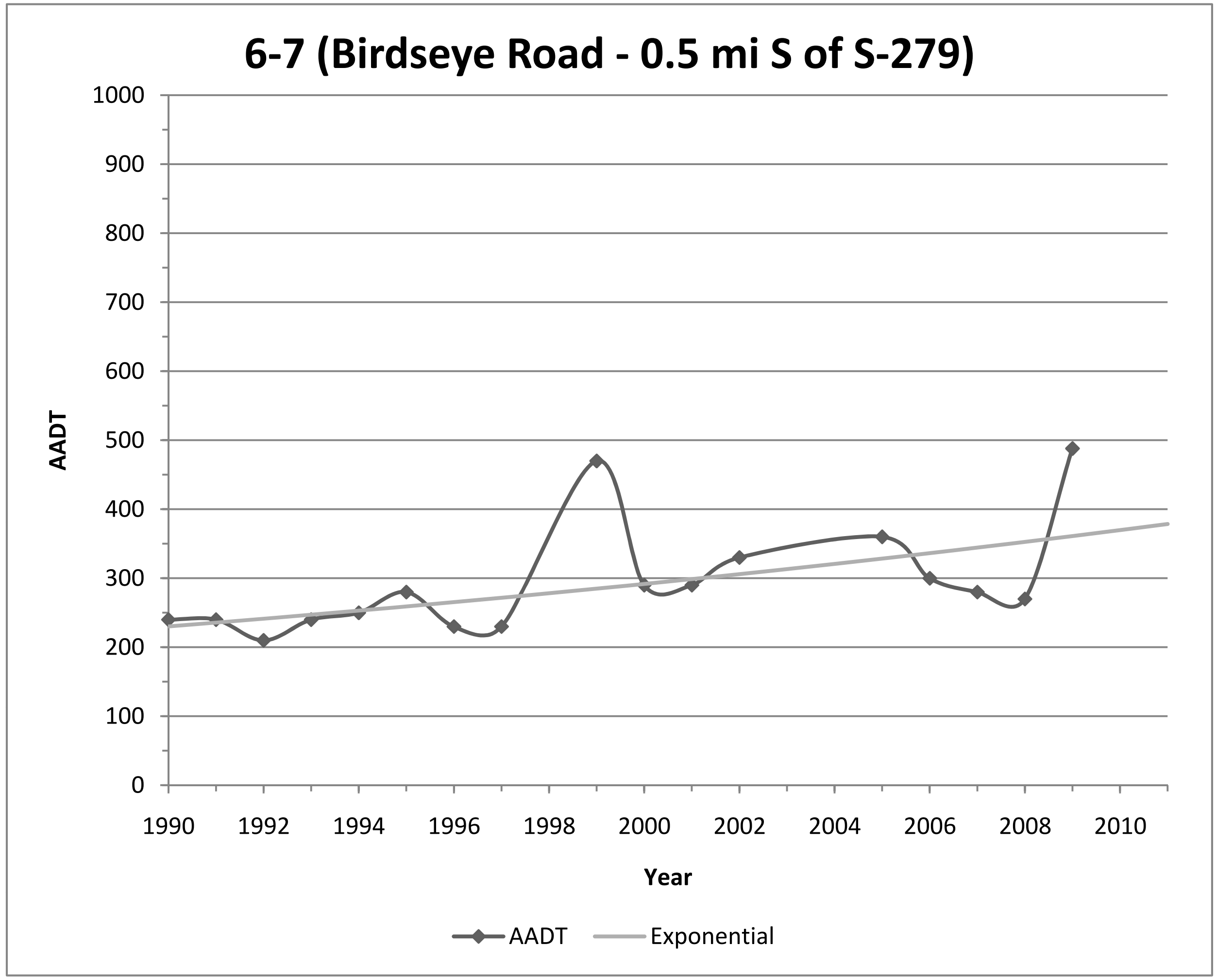
| Year | AADT | Exponential |
|---|---|---|
| 1990 | 887 | 830 |
| 1991 | 807 | 839 |
| 1992 | 842 | 849 |
| 1993 | 827 | 859 |
| 1994 | 938 | 870 |
| 1995 | 873 | 880 |
| 1996 | 883 | 890 |
| 1997 | 970 | 901 |
| 1998 | 890 | 912 |
| 1999 | 865 | 922 |
| 2002 | 870 | 956 |
| 2003 | 983 | 967 |
| 2006 | 968 | 1002 |
| 2007 | 986 | 1014 |
| 2008 | 1051 | 1026 |
| 2009 | 1136 | 1038 |
| 2011 | - | 1063 |
| 2031 | - | 1346 |
| i | - | **1.19%** |



**6-7 (Birdseye Road - 0.5 mi S of S-279)**

| Year | AADT | Exponential |
|---|---|---|
| 1990 | 240 | 230 |
| 1991 | 240 | 236 |
| 1992 | 210 | 241 |
| 1993 | 240 | 247 |
| 1994 | 250 | 253 |
| 1995 | 280 | 259 |
| 1996 | 230 | 265 |
| 1997 | 230 | 272 |
| 1999 | 470 | 285 |
| 2000 | 290 | 292 |
| 2001 | 290 | 299 |
| 2002 | 330 | 306 |
| 2005 | 360 | 328 |
| 2006 | 300 | 336 |
| 2007 | 280 | 344 |
| 2008 | 270 | 353 |
| 2009 | 488 | 361 |
| 2011 | - | 379 |
| 2031 | - | 608 |
| i | - | **2.40%** |

*Source: Montana Department of Transportation*



| Birdseye Road | | AADT | | | |
|---|---|---|---|---|---|
| **Site ID** | **Location** | **2009** | **2011** | **2031** | **Growth** |
| 7B-42 | N of Barrett Rd | 1766 | 1795 | 2756 | 2.17% |
| 7A-25 | N of Austin Rd | 1136 | 1063 | 1346 | 1.19% |
| 6-7 | 0.5 mi S of S-279 | 488 | 379 | 608 | 2.40% |
| *Weighted Average:* | | | | | **1.87%** |


insurance agent or call the National Flood Insurance Progr
N
APPROXIMATE SCALE IN FEE
800
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13
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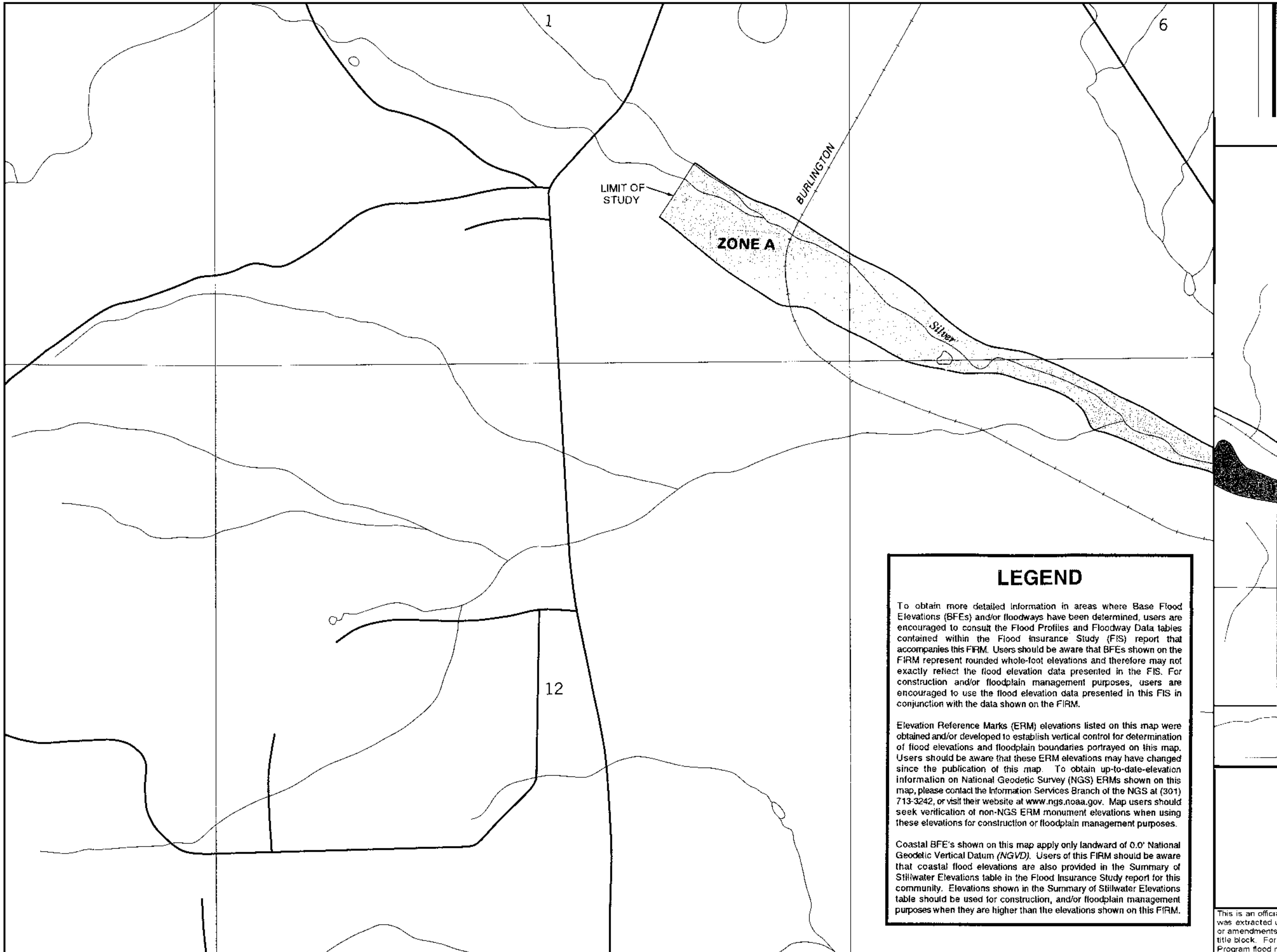
24
19
ZONE X
Creek
R. 5 W.
R. 4 W.
JOINS PANEL 1510
NATIONAL FLOOD INSURANCE PROGRAM
FIRM
FLOOD INSURANCE RATE MAP
LEWIS AND CLARK
COUNTY, MONTANA
(UNINCORPORATED AREAS)
PANEL 1395 OF 1725
(SEE MAP INDEX FOR PANELS NOT PRINTED)
COMMUNITY-PANEL NUMBER
3000381395 C
MAP REVISED:
JUNE 17, 2002
Federal Emergency Management Agency
This is an official copy of a portion of the above referenced flood map. It was extracted using F-MIT On-Line. This map does not reflect changes or amendments which may have been made subsequent to the date on the title block. For the latest product information about National Flood Insurance Program flood maps check the FEMA Flood Map Store at www.msc.fema.gov




# LEGEND

To obtain more detailed information in areas where Base Flood Elevations (BFEs) and/or floodways have been determined, users are encouraged to consult the Flood Profiles and Floodway Data tables contained within the Flood Insurance Study (FIS) report that accompanies this FIRM. Users should be aware that BFEs shown on the FIRM represent rounded whole-foot elevations and therefore may not exactly reflect the flood elevation data presented in the FIS. For construction and/or floodplain management purposes, users are encouraged to use the flood elevation data presented in this FIS in conjunction with the data shown on the FIRM.

Elevation Reference Marks (ERM) elevations listed on this map were obtained and/or developed to establish vertical control for determination of flood elevations and floodplain boundaries portrayed on this map. Users should be aware that these ERM elevations may have changed since the publication of this map. To obtain up-to-date-elevation information on National Geodetic Survey (NGS) ERMs shown on this map, please contact the Information Services Branch of the NGS at (301) 713-3242, or visit their website at www.ngs.noaa.gov. Map users should seek verification of non-NGS ERM monument elevations when using these elevations for construction or floodplain management purposes.

Coastal BFE's shown on this map apply only landward of 0.0' National Geodetic Vertical Datum *(NGVD)*. Users of this FIRM should be aware that coastal flood elevations are also provided in the Summary of Stillwater Elevations table in the Flood Insurance Study report for this community. Elevations shown in the Summary of Stillwater Elevations table should be used for construction, and/or floodplain management purposes when they are higher than the elevations shown on this FIRM.

insurance agent or call the National Flood Insurance Progr

APPROXIMATE SCALE IN FEE

800 0

**NATIONAL FLOOD INSURANCE PROGRAM**

# FIRM
## FLOOD INSURANCE RATE MAP

LEWIS AND CLARK
COUNTY, MONTANA
(UNINCORPORATED AREAS)

**PANEL 1395 OF 1725**
(SEE MAP INDEX FOR PANELS NOT PRINTED)

**COMMUNITY-PANEL NUMBER**
3000381395 C

**MAP REVISED:**
JUNE 17, 2002

Federal Emergency Management Agency


JOINS PANEL 1400
R. 5 W.
R. 4 W.
36
31
ZONE X
1
6
NORTHERN
BURLINGTON
LIMIT OF STUDY
ZONE A
Silver
insurance agent or call the National Flood Insurance Progr
APPROXIMATE SCALE IN FEET
800
0
NATIONAL FLOOD INSURANCE PROGRAM
FIRM
FLOOD INSURANCE RATE MAP
LEWIS AND CLARK COUNTY, MONTANA
(UNINCORPORATED AREAS)
PANEL 1395 OF 1725
(SEE MAP INDEX FOR PANELS NOT PRINTED)
COMMUNITY-PANEL NUMBER
3000381395 C
MAP REVISED:
JUNE 17, 2002
Federal Emergency Management Agency
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Montana Department of Transportation

# INITIAL ASSESSMENT FORM FOR STRUCTURE :

## L25602008+06001

**Location : 6M NW HELENA Structure Name: Lewis and Clark BE 1**

## General Location Data

District Code, Number, Location : **03 Dist 3 GREAT FALLS**

Division Code, Location : **31 GREAT FALLS**

County Code, Location : **049 LEWIS & CLARK**

City Code, Location : **00000 RURAL AREA**

Kind fo Hwy Code, Description : **4 4 County Hwy**

Signed Route Number : **25602**

Str Owner Code, Description : **2 County Highway Agency**

Maintained by Code, Description : **2 County Highway Agenc**

Intersecting Feature : **SEVEN MILE CREEK 034**

Kilometer Post, Mile Post : **13.84 km 8.60**

Structure on the State Highway System : ☐

Latitude : **46°38'57"**

Structure on the National Highway System : ☐

Longitude : **112°07'17"**

Str Meet or Exceed NBIS Bridge Length : X

## Construction Data

Construction Project Number : **MR-TSEP-99-1000**

Construction Station Number : **0+00.00**

Construction Drawing Number : **RECORDS**

Construction Year : **2001**

Reconstruction Year :

## Traffic Data

Current ADT : **100** ADT Count Year : **2003** Percent Trucks : **3 %**

## Structure Loading, Rating and Posting Data

### Loading Data :

| | | |
|---|---|---|
| Design Loading : | | **5 MS 18 (HS 20)** |
| Inventory Load, Design : | **32.6 mton** | **2 AS Allowable Stress** |
| Operating Load, Design : | **32.6 mton** | **2 AS Allowable Stress** |
| Posting : | | **5 At/Above Legal Loads** |

| Rating Data : | Operating | Inventory | Posting |
|---|---|---|---|
| Truck 1 Type 3 : | | | |
| Truck 2 Type 3-S3 : | | | |
| Truck 3 Type 3-3 : | **40** | | |

## Structure, Roadway and Clearance Data

### Structure Deck, Roadway and Span Data :

Structure Length : **12.20 m**

Deck Area : **112.00 m sq**

Deck Roadway Width : **8.45 m**

Approach Roadway Width : **8.45 m**

Median Code, Description : **0 No median**

### Structure Vertical and Horizontal Clearance Data :

Vertical Clearance Over the Structure : **99.99 m**

Reference Feature for Vertical Clearance : **N Feature not hwy or RR**

Vertical Clearance Under the Structure : **0.00 m**

Reference Feature for Lateral Underclearance : **N Feature not hwy or RR**

Minimum Lateral Under Clearance Right : **0.00 m**

Minimum Lateral Under Clearance Left : **0.00 m**

## Span Data

### Main Span

Number Spans : **1**

Material Type Code, Description : **5 Prestressed concrete**

Span Design Code, Description : **22 Channel Beam**

### Approach Span

Number of Spans : **0**

Material Type Code, Description :

Span Design Code, Description :

### Deck

Deck Structure Type : **N Not applicable**

Deck Surfacing Type : **1 Monolithic concrete (concurrently placed with struct**

Deck Protection Type : **0 None**

Deck Membrain Type : **0 None**

(52) Out-to-Out Width : **9.14 m**

(50A) Curb Width : **0.00 m**

(50B) Curb Width : **0.00 m**

Skew Angle : °

### Structure Vertical and Horizontal Clearance Data Inventory Route :

| Over / Under Direction Name | Inventory Route | South, West or Bi-directional Travel | | | North or East Travel | | |
|---|---|---|---|---|---|---|---|
| | | Direction | Vertical | Horizontal | Direction | Vertical | Horizontal |
| Route On Structure<br>BIRDSEYE ROAD | L25602 | Both | 99.99 m | 8.45 m | N/A | | |

Montana Department of Transportation

# INITIAL ASSESSMENT FORM FOR STRUCTURE :

**L25602008+06001**
**Continue**

## Inspection Data

Sufficiency Rating : **99.8**
Health Index : **100**
Structure Status :**Not Deficient**

**Inspection Due Date : 29 March 2013**
(91) Inspection Fequency (months) : **24**

## NBI Inspection Data

| | | | |
|---|---|---|---|
| (90) Date of Last Inspection : | 29 March 2011 | Last Inspected By : | William Lay - 63 |
| (90) Inspection Date : | | Inspected By : | |

| | | | | | | | |
|---|---|---|---|---|---|---|---|
| (58) Deck Rating : | 8 | (68) Deck Geometry : | 6 | (36C) Approach Rail Rating : | N | (62) Culvert Rating : | N |
| (59) Superstructure Rating : | 8 | (67) Structure Rating : | 8 | (36A) Bridge Rail Rating : | 1 | (61) Channel Rating : | 7 |
| (60) Substructure Rating : | 8 | (69) Under Clearance : | N | (36B) Transition Rating : | N | (71) Waterway Adequacy : | 8 |
| (72) App Rdwy Align : | 6 | (41) Posting Status : | A | (36D) End Rail Rating : | 0 | (113) Scour Critical : | 8 |

Unrepaired Spalls : 0 m sq
Deck Surfacing Depth : 0.00 in

## Inspection Hours

| | | | |
|---|---|---|---|
| Crew Hours for inspection : | 2 | Snooper Required : | N |
| Helper Hours : | 0 | Snooper Hours for inspection : | 0 |
| Special Crew Hours : | 0 | Flagger Hours : | 0 |
| Special Equipment Hours : | 0 | | |

| Inspection Work Candidates: Candidate ID | Date Requested | Status | Priority | Effected Structure Unit | Scope of Work | Action | Covered Condition States |
|---|---|---|---|---|---|---|---|

Montana Department of Transportation

# INITIAL ASSESSMENT FORM FOR STRUCTURE :

## L25602008+06001

**Continue**

## Element Inspection Data

********** Span : **Main-0 -** **********

| Element Description | | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|
| Smart Flag | Scale Factor | Env | Quantity | Units | Insp Each | Pct Stat 1 | Pct Stat 2 | Pct Stat 3 | Pct Stat 4 | Pct Stat 5 |
| Element 62 - Bare Top Flang | | | | | | | | | | |
| | 1 | 1 | 112 | sq.m. | X | 100 | 0 | 0 | 0 | 0 |
| | | | | | | % | % | % | % | % |

Previous Inspection Notes :

03/29/2011 - No change from the previous inspections and no problems noted. ZZIZ

04/02/2009 - 12.20 x 9.14 = 111.508 Good condition with the grout between the panels showing some shrinkage cracks with some leakage underneath. CHDZ

Inspection Notes:

| Element 109 - P/S Conc Open Girder | | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|
| | 1 | 1 | 61 | m. | | 100 | 0 | 0 | 0 | |
| | | | | | | % | % | % | % | % |

Previous Inspection Notes :

03/29/2011 - No change from the prevous inspections. ZZIZ

04/02/2009 - No problems noted and in Good condition. CHDZ

03/07/2007 - Girders are in Good condition. Grout between the girders has some shrinkage cracks and leaks in a couple of areas. HBDZ

03/30/2005 - No problems noted. ZZCZ

04/02/2003 - Ok. CPDZ

06/07/2001 - 5 * 12.20 = 61.00m Triple girder girders. KFIR

Inspection Notes:

| Element 215 - R/Conc Abutment 1 and 2 | | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|
| | 1 | 1 | 33 | m. | | 100 | 0 | 0 | 0 | |
| | | | | | | % | % | % | % | % |

Previous Inspection Notes :

03/29/2011 - No change from the prevous inspections. ZZIZ

04/02/2009 - No problems noted and in Good condition. CHDZ

03/07/2007 - Good condition. HBDZ

03/30/2005 - No problems noted. ZZCZ

04/02/2003 - Ok. CPDZ

06/07/2001 - (9.14 * 2) + (4 * 3.60) = 32.68m KFIR

Inspection Notes:

# INITIAL ASSESSMENT FORM FOR STRUCTURE :

## L25602008+06001

**Continue**

********** Span : **Main-0 - (cont.)** **********

| Smart Flag | Scale Factor | Env | Quantity | Units | Insp Each | Pct Stat 1 | Pct Stat 2 | Pct Stat 3 | Pct Stat 4 | Pct Stat 5 |
|---|---|---|---|---|---|---|---|---|---|---|
| Element 334 - Metal Rail Coated T-101 | | | | | | | | | | |
| | 1 | 1 | 24 | m. | | 100 | 0 | 0 | 0 | 0 |
| | | | | | | % | % | % | % | % |

Element Description

Previous Inspection Notes :

03/29/2011 - No change from the prevous inspections. ZZIZ

04/02/2009 - No problems noted with the rail and in Good condition. CHDZ

03/07/2007 - Good condition. Some sanding material packed in the lower portions of the posts. HBDZ

03/30/2005 - No problems noted. ZZCZ

04/02/2003 - Ok. CPDZ

06/07/2001 - T-101 bridge rail. 12.20 * 2 = 24.40m KFIR

Inspection Notes:

## General Inspection Notes

03/29/2011 - Good to Fair markers on all (4) corners. ZZIZ

04/02/2009 - NBI 61, channel, rated a "7" due to cutbanks and fence panel in the channel. CHDZ
Good to Fair markers at all (4) corners of the rail.

03/07/2007 - Fair to Good markers on the ends of the rail at the structure. Some pitting and dirty sign faces. HBDZ

03/30/2005 - None ZZCZ

04/02/2003 - Markers are in Good to Fair condition and on all (4) corners of the structure. CPDZ

# Appendix B

## Design References

#

## TABLE A
### COUNTY ROAD DESIGN CRITERIA

| | Terrain | Major Collector | Minor Collector | Local Road |
|---|---|---|---|---|
| | | | | |
| Design Speed (MPH) | Level | 55 | 50 | 30 |
| | Rolling | 45 | 40 | 25 |
| | Mountainous | 45 | 30 | 20 |
| Curvature - Minimum at Centerline (feet) | Level | 575 | 575 | 250 |
| | Rolling | 440 | 440 | 175 |
| | Mountainous | 330 | 300 | 110 |
| Minimum Stopping Sight Distance (feet) | Level | per AASHTO | 425 | 200 |
| | Rolling | " | 305 | 150 |
| | Mountainous | " | 200 | 110 |
| Maximum Grade | Level | per AASHTO | 6% | 6% |
| | Rolling | " | 8% | 9% |
| | Mountainous | " | 10% | 11% |
| Length of Maximum Grade (feet) | | per AASHTO | per AASHTO | per AASHTO |
| Minimum Grade | | 0.5% | 0.5% | 0.5% |
| Superelevation | | per AASHTO | per AASHTO | N/A |
| Minimum Intersection Spacing (feet) | | 500 | 275 | 150 |
| Driveway Spacing (feet) | | 45 | 45 | 40 |
| Maximum Length of Cul-de-Sac (feet) | | Not Allowed | Not Allowed | See Chapter XI.H.11 |
| Minimum Radius of Cul-de-Sac (feet) | | Not Allowed | Not Allowed | 48 |
| Sight Distance Triangle (feet) | Level | 300 | 255 | 120 |
| | Rolling | 210 | 170 | 95 |
| | Mountainous | 210 | 120 | 80 |
| Minimum Right of Way Width | | 100 | 80 | 60 |
| Minimum Right of Way Radius for Cul-de-sac (feet) | | NA | NA | 48 |
| Vertical Clearance (feet) | | 16.5 | 16.5 | 14.5 |
| Intersection Curb Return Radii (feet) | | 25 | 25 | 15 |
| Minimum Sidewalk Width (feet) | | 5 | 5 | 5 |
| Sidewalk Offset From Back of Curb (feet) | | 5-10 | 5-10 | 5 |
| Bike Lane Width (feet) | | 4-8 | 4-8 | N/A |
| Minimum Culvert Diameter (inches) | | 18 | 15 | 15 |
| Minimum Culvert Cover | | Meet or exceed suppliers recommendations | Meet or exceed suppliers recommendations | Meet or exceed suppliers recommendations |
| Minimum Culvert Grade | | 0.5% | 0.5% | 0.5% |
| Culvert Material | | Support HS-20 Loading | Support HS-20 Loading | Support HS-20 Loading |

| Metric | | | | | | | US Customary | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| Design speed (km/h) | Stopping sight distance (m) | | | | | | Design speed (mph) | Stopping sight distance (ft) | | | | | |
| | Downgrades | | | Upgrades | | | | Downgrades | | | Upgrades | | |
| | 3 % | 6 % | 9 % | 3 % | 6 % | 9 % | | 3 % | 6 % | 9 % | 3 % | 6 % | 9 % |
| 20 | 20 | 20 | 20 | 19 | 18 | 18 | 15 | 80 | 82 | 85 | 75 | 74 | 73 |
| 30 | 32 | 35 | 35 | 31 | 30 | 29 | 20 | 116 | 120 | 126 | 109 | 107 | 104 |
| 40 | 50 | 50 | 53 | 45 | 44 | 43 | 25 | 158 | 165 | 173 | 147 | 143 | 140 |
| 50 | 66 | 70 | 74 | 61 | 59 | 58 | 30 | 205 | 215 | 227 | 200 | 184 | 179 |
| 60 | 87 | 92 | 97 | 80 | 77 | 75 | 35 | 257 | 271 | 287 | 237 | 229 | 222 |
| 70 | 110 | 116 | 124 | 100 | 97 | 93 | 40 | 315 | 333 | 354 | 289 | 278 | 269 |
| 80 | 136 | 144 | 154 | 123 | 118 | 114 | 45 | 378 | 400 | 427 | 344 | 331 | 320 |
| 90 | 164 | 174 | 187 | 148 | 141 | 136 | 50 | 446 | 474 | 507 | 405 | 388 | 375 |
| 100 | 194 | 207 | 223 | 174 | 167 | 160 | 55 | 520 | 553 | 593 | 469 | 450 | 433 |
| 110 | 227 | 243 | 262 | 203 | 194 | 186 | 60 | 598 | 638 | 686 | 538 | 515 | 495 |
| 120 | 263 | 281 | 304 | 234 | 223 | 214 | 65 | 682 | 728 | 785 | 612 | 584 | 561 |
| 130 | 302 | 323 | 350 | 267 | 254 | 243 | 70 | 771 | 825 | 891 | 690 | 658 | 631 |
| | | | | | | | 75 | 866 | 927 | 1003 | 772 | 736 | 704 |
| | | | | | | | 80 | 965 | 1035 | 1121 | 859 | 817 | 782 |

**Exhibit 3-2. Stopping Sight Distance on Grades**

## Decision Sight Distance

Stopping sight distances are usually sufficient to allow reasonably competent and alert drivers to come to a hurried stop under ordinary circumstances. However, these distances are often inadequate when drivers must make complex or instantaneous decisions, when information is difficult to perceive, or when unexpected or unusual maneuvers are required. Limiting sight distances to those needed for stopping may preclude drivers from performing evasive maneuvers, which often involve less risk and are otherwise preferable to stopping. Even with an appropriate complement of standard traffic control devices in accordance with the MUTCD (**6**), stopping sight distances may not provide sufficient visibility distances for drivers to corroborate advance warning and to perform the appropriate maneuvers. It is evident that there are many locations where it would be prudent to provide longer sight distances. In these circumstances, decision sight distance provides the greater visibility distance that drivers need.

Decision sight distance is the distance needed for a driver to detect an unexpected or otherwise difficult-to-perceive information source or condition in a roadway environment that may be visually cluttered, recognize the condition or its potential threat, select an appropriate speed and path, and initiate and complete the maneuver safely and efficiently (**7**). Because decision sight distance offers drivers additional margin for error and affords them sufficient length to maneuver their vehicles at the same or reduced speed, rather than to just stop, its values are substantially greater than stopping sight distance.

Drivers need decision sight distances whenever there is a likelihood for error in either information reception, decision making, or control actions (**8**). Examples of critical locations where these kinds of errors are likely to occur, and where it is desirable to provide decision sight distance include interchange and intersection locations where unusual or unexpected maneuvers are required, changes in cross section such as toll plazas and lane drops, and areas of concentrated

**METRIC**

| Design Speed (km/h) | Maximum $e$ (%) | Maximum $f$ | Total ($e$/100 + $f$) | Calculated Radius (m) | Rounded Radius (m) |
|---|---|---|---|---|---|
| 15 | 4.0 | 0.40 | 0.44 | 4.0 | 4 |
| 20 | 4.0 | 0.35 | 0.39 | 8.1 | 8 |
| 30 | 4.0 | 0.28 | 0.32 | 22.1 | 22 |
| 40 | 4.0 | 0.23 | 0.27 | 46.7 | 47 |
| 50 | 4.0 | 0.19 | 0.23 | 85.6 | 86 |
| 60 | 4.0 | 0.17 | 0.21 | 135.0 | 135 |
| 70 | 4.0 | 0.15 | 0.19 | 203.1 | 203 |
| 80 | 4.0 | 0.14 | 0.18 | 280.0 | 280 |
| 90 | 4.0 | 0.13 | 0.17 | 375.2 | 375 |
| 100 | 4.0 | 0.12 | 0.16 | 492.1 | 492 |
| 15 | 6.0 | 0.40 | 0.46 | 3.9 | 4 |
| 20 | 6.0 | 0.35 | 0.41 | 7.7 | 8 |
| 30 | 6.0 | 0.28 | 0.34 | 20.8 | 21 |
| 40 | 6.0 | 0.23 | 0.29 | 43.4 | 43 |
| 50 | 6.0 | 0.19 | 0.25 | 78.7 | 79 |
| 60 | 6.0 | 0.17 | 0.23 | 123.2 | 123 |
| 70 | 6.0 | 0.15 | 0.21 | 183.7 | 184 |
| 80 | 6.0 | 0.14 | 0.20 | 252.0 | 252 |
| 90 | 6.0 | 0.13 | 0.19 | 335.7 | 336 |
| 100 | 6.0 | 0.12 | 0.18 | 437.4 | 437 |
| 110 | 6.0 | 0.11 | 0.17 | 560.4 | 560 |
| 120 | 6.0 | 0.09 | 0.15 | 755.9 | 756 |
| 130 | 6.0 | 0.08 | 0.14 | 950.5 | 951 |
| 15 | 8.0 | 0.40 | 0.48 | 3.7 | 4 |
| 20 | 8.0 | 0.35 | 0.43 | 7.3 | 7 |
| 30 | 8.0 | 0.28 | 0.36 | 19.7 | 20 |
| 40 | 8.0 | 0.23 | 0.31 | 40.6 | 41 |
| 50 | 8.0 | 0.19 | 0.27 | 72.9 | 73 |
| 60 | 8.0 | 0.17 | 0.25 | 113.4 | 113 |
| 70 | 8.0 | 0.15 | 0.23 | 167.8 | 168 |
| 80 | 8.0 | 0.14 | 0.22 | 229.1 | 229 |
| 90 | 8.0 | 0.13 | 0.21 | 303.7 | 304 |
| 100 | 8.0 | 0.12 | 0.20 | 393.7 | 394 |
| 110 | 8.0 | 0.11 | 0.19 | 501.5 | 501 |
| 120 | 8.0 | 0.09 | 0.17 | 667.0 | 667 |
| 130 | 8.0 | 0.08 | 0.16 | 831.7 | 832 |
| 15 | 10.0 | 0.40 | 0.50 | 3.5 | 4 |
| 20 | 10.0 | 0.35 | 0.45 | 7.0 | 7 |
| 30 | 10.0 | 0.28 | 0.38 | 18.6 | 19 |
| 40 | 10.0 | 0.23 | 0.33 | 38.2 | 38 |
| 50 | 10.0 | 0.19 | 0.29 | 67.9 | 68 |
| 60 | 10.0 | 0.17 | 0.27 | 105.0 | 105 |
| 70 | 10.0 | 0.15 | 0.25 | 154.3 | 154 |
| 80 | 10.0 | 0.14 | 0.24 | 210.0 | 210 |
| 90 | 10.0 | 0.13 | 0.23 | 277.3 | 277 |
| 100 | 10.0 | 0.12 | 0.22 | 357.9 | 358 |
| 110 | 10.0 | 0.11 | 0.21 | 453.7 | 454 |
| 120 | 10.0 | 0.09 | 0.19 | 596.8 | 597 |
| 130 | 10.0 | 0.08 | 0.18 | 739.3 | 739 |
| 15 | 12.0 | 0.40 | 0.52 | 3.4 | 3 |
| 20 | 12.0 | 0.35 | 0.47 | 6.7 | 7 |
| 30 | 12.0 | 0.28 | 0.40 | 17.7 | 18 |
| 40 | 12.0 | 0.23 | 0.35 | 36.0 | 36 |
| 50 | 12.0 | 0.19 | 0.31 | 63.5 | 64 |
| 60 | 12.0 | 0.17 | 0.29 | 97.7 | 98 |
| 70 | 12.0 | 0.15 | 0.27 | 142.9 | 143 |
| 80 | 12.0 | 0.14 | 0.26 | 193.8 | 194 |
| 90 | 12.0 | 0.13 | 0.25 | 255.1 | 255 |
| 100 | 12.0 | 0.12 | 0.24 | 328.1 | 328 |
| 110 | 12.0 | 0.11 | 0.23 | 414.2 | 414 |
| 120 | 12.0 | 0.09 | 0.21 | 539.9 | 540 |
| 130 | 12.0 | 0.08 | 0.20 | 665.4 | 665 |

**US Customary**

| Design Speed (mph) | Maximum $e$ (%) | Maximum $f$ | Total ($e$/100 + $f$) | Calculated Radius (ft) | Rounded Radius (ft) |
|---|---|---|---|---|---|
| 10 | 4.0 | 0.38 | 0.42 | 15.9 | 16 |
| 15 | 4.0 | 0.32 | 0.36 | 41.7 | 42 |
| 20 | 4.0 | 0.27 | 0.31 | 86.0 | 86 |
| 25 | 4.0 | 0.23 | 0.27 | 154.3 | 154 |
| 30 | 4.0 | 0.20 | 0.24 | 250.0 | 250 |
| 35 | 4.0 | 0.18 | 0.22 | 371.2 | 371 |
| 40 | 4.0 | 0.16 | 0.20 | 533.3 | 533 |
| 45 | 4.0 | 0.15 | 0.19 | 710.5 | 711 |
| 50 | 4.0 | 0.14 | 0.18 | 925.9 | 926 |
| 55 | 4.0 | 0.13 | 0.17 | 1186.3 | 1190 |
| 60 | 4.0 | 0.12 | 0.16 | 1500.0 | 1500 |
| 10 | 6.0 | 0.38 | 0.44 | 15.2 | 15 |
| 15 | 6.0 | 0.32 | 0.38 | 39.5 | 39 |
| 20 | 6.0 | 0.27 | 0.33 | 80.8 | 81 |
| 25 | 6.0 | 0.23 | 0.29 | 143.7 | 144 |
| 30 | 6.0 | 0.20 | 0.26 | 230.8 | 231 |
| 35 | 6.0 | 0.18 | 0.24 | 340.3 | 340 |
| 40 | 6.0 | 0.16 | 0.22 | 484.8 | 485 |
| 45 | 6.0 | 0.15 | 0.21 | 642.9 | 643 |
| 50 | 6.0 | 0.14 | 0.20 | 833.3 | 833 |
| 55 | 6.0 | 0.13 | 0.19 | 1061.4 | 1060 |
| 60 | 6.0 | 0.12 | 0.18 | 1333.3 | 1330 |
| 65 | 6.0 | 0.11 | 0.17 | 1656.9 | 1660 |
| 70 | 6.0 | 0.10 | 0.16 | 2041.7 | 2040 |
| 75 | 6.0 | 0.09 | 0.15 | 2500.0 | 2500 |
| 80 | 6.0 | 0.08 | 0.14 | 3047.6 | 3050 |
| 10 | 8.0 | 0.38 | 0.46 | 14.5 | 14 |
| 15 | 8.0 | 0.32 | 0.40 | 37.5 | 38 |
| 20 | 8.0 | 0.27 | 0.35 | 76.2 | 76 |
| 25 | 8.0 | 0.23 | 0.31 | 134.4 | 134 |
| 30 | 8.0 | 0.20 | 0.28 | 214.3 | 214 |
| 35 | 8.0 | 0.18 | 0.26 | 314.1 | 314 |
| 40 | 8.0 | 0.16 | 0.24 | 444.4 | 444 |
| 45 | 8.0 | 0.15 | 0.23 | 587.0 | 587 |
| 50 | 8.0 | 0.14 | 0.22 | 757.6 | 758 |
| 55 | 8.0 | 0.13 | 0.21 | 960.3 | 960 |
| 60 | 8.0 | 0.12 | 0.20 | 1200.0 | 1200 |
| 65 | 8.0 | 0.11 | 0.19 | 1482.5 | 1480 |
| 70 | 8.0 | 0.10 | 0.18 | 1814.8 | 1810 |
| 75 | 8.0 | 0.09 | 0.17 | 2205.9 | 2210 |
| 80 | 8.0 | 0.08 | 0.16 | 2666.7 | 2670 |
| 10 | 10.0 | 0.38 | 0.48 | 13.9 | 14 |
| 15 | 10.0 | 0.32 | 0.42 | 35.7 | 36 |
| 20 | 10.0 | 0.27 | 0.37 | 72.1 | 72 |
| 25 | 10.0 | 0.23 | 0.33 | 126.3 | 126 |
| 30 | 10.0 | 0.20 | 0.30 | 200.0 | 200 |
| 35 | 10.0 | 0.18 | 0.28 | 291.7 | 292 |
| 40 | 10.0 | 0.16 | 0.26 | 410.3 | 410 |
| 45 | 10.0 | 0.15 | 0.25 | 540.0 | 540 |
| 50 | 10.0 | 0.14 | 0.24 | 694.4 | 694 |
| 55 | 10.0 | 0.13 | 0.23 | 876.8 | 877 |
| 60 | 10.0 | 0.12 | 0.22 | 1090.9 | 1090 |
| 65 | 10.0 | 0.11 | 0.21 | 1341.3 | 1340 |
| 70 | 10.0 | 0.10 | 0.20 | 1633.3 | 1630 |
| 75 | 10.0 | 0.09 | 0.19 | 1973.7 | 1970 |
| 80 | 10.0 | 0.08 | 0.18 | 2370.4 | 2370 |
| 10 | 12.0 | 0.38 | 0.50 | 13.3 | 13 |
| 15 | 12.0 | 0.32 | 0.44 | 34.1 | 34 |
| 20 | 12.0 | 0.27 | 0.39 | 68.4 | 68 |
| 25 | 12.0 | 0.23 | 0.35 | 119.0 | 119 |
| 30 | 12.0 | 0.20 | 0.32 | 187.5 | 188 |
| 35 | 12.0 | 0.18 | 0.30 | 272.2 | 272 |
| 40 | 12.0 | 0.16 | 0.28 | 381.0 | 381 |
| 45 | 12.0 | 0.15 | 0.27 | 500.0 | 500 |
| 50 | 12.0 | 0.14 | 0.26 | 641.0 | 641 |
| 55 | 12.0 | 0.13 | 0.25 | 806.7 | 807 |
| 60 | 12.0 | 0.12 | 0.24 | 1000.0 | 1000 |
| 65 | 12.0 | 0.11 | 0.23 | 1224.6 | 1220 |
| 70 | 12.0 | 0.10 | 0.22 | 1484.8 | 1480 |
| 75 | 12.0 | 0.09 | 0.21 | 1785.7 | 1790 |
| 80 | 12.0 | 0.08 | 0.20 | 2133.3 | 2130 |

Note: In recognition of safety considerations, use of $e_{max}$ = 4.0% should be limited to urban conditions.

**Exhibit 3-15. Minimum Radius Using Limiting Values of *e* and *f***

| Type of terrain | Metric: Design speed (km/h) for specified design volume (veh/day) | | | US Customary: Design speed (mph) for specified design volume (veh/day) | | |
|---|---|---|---|---|---|---|
| | 0 to 400 | 400 to 2000 | over 2000 | 0 to 400 | 400 to 2000 | over 2000 |
| Level | 60 | 80 | 100 | 40 | 50 | 60 |
| Rolling | 50 | 60 | 80 | 30 | 40 | 50 |
| Mountainous | 30 | 50 | 60 | 20 | 30 | 40 |

Note: Where practical, design speeds higher than those shown should be considered.

**Exhibit 6-1. Minimum Design Speeds for Rural Collectors**

| Metric: Design speed (km/h) | Design stopping sight distance (m) | Rate of vertical curvature, $K^a$ (m/%) Crest | Sag | US Customary: Design speed (mph) | Design stopping sight distance (ft) | Rate of vertical curvature, $K^a$ (ft/%) Crest | Sag |
|---|---|---|---|---|---|---|---|
| 20 | 20 | 1 | 3 | 15 | 80 | 3 | 10 |
| 30 | 35 | 2 | 6 | 20 | 115 | 7 | 17 |
| 40 | 50 | 4 | 9 | 25 | 155 | 12 | 26 |
| 50 | 65 | 7 | 13 | 30 | 200 | 19 | 37 |
| 60 | 85 | 11 | 18 | 35 | 250 | 29 | 49 |
| 70 | 105 | 17 | 23 | 40 | 305 | 44 | 64 |
| 80 | 130 | 26 | 30 | 45 | 360 | 61 | 79 |
| 90 | 160 | 39 | 38 | 50 | 425 | 84 | 96 |
| 100 | 185 | 52 | 45 | 55 | 495 | 114 | 115 |
| | | | | 60 | 570 | 151 | 136 |

[a] Rate of vertical curvature, K, is the length of curve per percent algebraic difference in the intersecting grades (i.e., $K = L/A$). (See Chapter 3 for details.)

**Exhibit 6-2. Design Controls for Stopping Sight Distance and for Crest and Sag Vertical Curves**

| Metric | | | | | US Customary | | | | |
|---|---|---|---|---|---|---|---|---|---|
| Design speed (km/h) | Minimum width of traveled way (m) for specified design volume (veh/day)[a] | | | | Design speed (mph) | Minimum width of traveled way (ft) for specified design volume (veh/day)[a] | | | |
| | under 400 | 400 to 1500 | 1500 to 2000 | over 2000 | | under 400 | 400 to 1500 | 1500 to 2000 | over 2000 |
| 30 | 6.0[b] | 6.0 | 6.6 | 7.2 | 20 | 20[b] | 20 | 22 | 24 |
| 40 | 6.0[b] | 6.0 | 6.6 | 7.2 | 25 | 20[b] | 20 | 22 | 24 |
| 50 | 6.0[b] | 6.0 | 6.6 | 7.2 | 30 | 20[b] | 20 | 22 | 24 |
| 60 | 6.0[b] | 6.6 | 6.6 | 7.2 | 35 | 20[b] | 22 | 22 | 24 |
| 70 | 6.0 | 6.6 | 6.6 | 7.2 | 40 | 20[b] | 22 | 22 | 24 |
| 80 | 6.0 | 6.6 | 6.6 | 7.2 | 45 | 20 | 22 | 22 | 24 |
| 90 | 6.6 | 6.6 | 7.2 | 7.2 | 50 | 20 | 22 | 22 | 24 |
| 100 | 6.6 | 6.6 | 7.2 | 7.2 | 55 | 22 | 22 | 24 | 24 |
| | | | | | 60 | 22 | 22 | 24 | 24 |
| | Width of shoulder on each side of road (m) | | | | | Width of shoulder on each side of road (ft) | | | |
| All speeds | 0.6 | 1.5[c] | 1.8 | 2.4 | All speeds | 2.0 | 5.0[c] | 6.0 | 8.0 |

[a] On roadways to be reconstructed, a 6.6-m [22-ft] traveled way may be retained where the alignment and safety records are satisfactory.

[b] A 5.4-m [18-ft] minimum width may be used for roadways with design volumes under 250 veh/day.

[c] Shoulder width may be reduced for design speeds greater than 50 km/h [30 mph] as long as a minimum roadway width of 9 m [30 ft] is maintained.

See text for roadside barrier and offtracking considerations.

**Exhibit 6-5. Minimum Width of Traveled Way and Shoulders**

Drivers who inadvertently leave the traveled way can often recover control of their vehicles if foreslopes are 1V:4H or flatter and shoulders and ditches are well rounded or otherwise made traversable. Such recoverable slopes should be provided where terrain and right-of-way conditions allow.

Where provision of recoverable slopes is not practical, the combinations of rate and height of slope provided should be such that occupants of an out-of-control vehicle have a good chance of survival. Where high fills, right-of-way restrictions, watercourses, or other problems render such designs impractical, roadside barriers should be considered, in which case the maximum rate of fill slope may be used. Reference should be made to the current edition of the AASHTO *Roadside Design Guide* (3). For further information, see the section on "Traffic Barriers" in Chapter 4.

Cut sections should be designed with adequate ditches. Preferably, the foreslope should not be steeper than 1V:3H and, where practical, should be 1V:4H or flatter. The ditch bottom and slopes should be well rounded, and the backslope should not exceed the maximum needed for stability.

| Metric | | | US Customary | | |
|---|---|---|---|---|---|
| Design speed (km/h) | Design passing sight distance (m) | Rate of vertical curvature, $K^a$ (m/%) | Design speed (mph) | Design passing sight distance (ft) | Rate of vertical curvature, $K^a$ (ft/%) |
| 30 | 200 | 46 | 20 | 710 | 180 |
| 40 | 270 | 84 | 25 | 900 | 289 |
| 50 | 345 | 138 | 30 | 1090 | 424 |
| 60 | 410 | 195 | 35 | 1280 | 585 |
| 70 | 485 | 272 | 40 | 1470 | 772 |
| 80 | 540 | 338 | 45 | 1625 | 943 |
| 90 | 615 | 438 | 50 | 1835 | 1203 |
| 100 | 670 | 520 | 55 | 1985 | 1407 |
| | | | 60 | 2135 | 1628 |

[a] Rate of vertical curvature, $K$, is the length of curve per percent algebraic difference in the intersecting grades (i.e., $K = L/A$). (See Chapter 3 for details.)

**Exhibit 6-3. Design Controls for Crest Vertical Curves Based on Passing Sight Distance**

| | Metric | | | | | | | | US Customary | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | Maximum grade (%) for specified design speed (km/h) | | | | | | | | Maximum grade (%) for specified design speed (mph) | | | | | | | | |
| Type of terrain | 30 | 40 | 50 | 60 | 70 | 80 | 90 | 100 | 20 | 25 | 30 | 35 | 40 | 45 | 50 | 55 | 60 |
| Level | 7 | 7 | 7 | 7 | 7 | 6 | 6 | 5 | 7 | 7 | 7 | 7 | 7 | 7 | 6 | 6 | 5 |
| Rolling | 10 | 10 | 9 | 8 | 8 | 7 | 7 | 6 | 10 | 10 | 9 | 9 | 8 | 8 | 7 | 7 | 6 |
| Mountainous | 12 | 11 | 10 | 10 | 10 | 9 | 9 | 8 | 12 | 11 | 10 | 10 | 10 | 10 | 9 | 9 | 8 |

Note: Short lengths of grade in rural areas, such as grades less than 150 m [500 ft] in length, one-way downgrades, and grades on low-volume rural collectors may be up to 2 percent steeper than the grades shown above.

**Exhibit 6-4. Maximum Grades for Rural Collectors**

width provided, crash history, traffic volumes, remaining life of the structure, design speed, and other pertinent factors.

| Metric | | | US Customary | | |
|---|---|---|---|---|---|
| Design volume (veh/day) | Design loading structural capacity | Minimum clear roadway width (m)[a] | Design volume (veh/day) | Design loading structural capacity | Minimum clear roadwaywidth (ft)[a] |
| under 400 | MS 13.5 | 6.6 | under 400 | H 15 | 22 |
| 400 to 1500 | MS 13.5 | 6.6 | 400 to 1500 | H 15 | 22 |
| 1500 to 2000 | MS 13.5 | 7.2 | 1500 to 2000 | H 15 | 24 |
| over 2000 | MS 13.5 | 8.4 | over 2000 | H 15 | 28 |

[a] Clear width between curbs or railings, whichever is less, should be equal to or greater than the approach traveled way width, wherever practical.

**Exhibit 6-7. Structural Capacities and Minimum Roadway Widths for Bridges to Remain in Place**

## Vertical Clearance

Vertical clearance at underpasses should be at least 4.3 m [14 ft] over the entire roadway width, with an additional allowance for future resurfacing.

## Horizontal Clearance to Obstructions

For rural collector roads with a design speed of 70 km/h [45 mph] or less, a minimum clear zone of 3 m [10 ft] measured from the edge of the traveled way should be provided. This recovery area should be clear of all unyielding objects such as trees, sign supports, utility poles, light poles, and other fixed objects. The benefits of removing these obstructions should be weighed against any environmental and aesthetic effects.

For rural collector roads with a design speed of 80 km/h [50 mph] or more, the AASHTO *Roadside Design Guide* (3) should be used for guidance in selecting an appropriate clear-zone width.

The approach roadway width (traveled way plus shoulders) should be carried across an overpass or bridge, where practical. Approach roadside barriers, anchored to the bridge rails or parapets, should be provided. Sidewalks should extend across a bridge if the approach roadway has sidewalks or sidewalk areas. To the extent practical, where another highway or railroad passes over the roadway, the overpass structure should be designed so that the pier or abutment supports have lateral clearance as great as the clear zone on the approach roadway. Where a setback beyond the clear zone is not practical, roadside barrier protection should be provided at the piers.

# Appendix C

## Pavement Evaluation

November 3, 2009 Project 09-2560

Mr. Tom Cavanaugh, P.E.
Robert Peccia & Associates
Via Email: *tom@rpa-hln.com*

Dear Tom:

Re: Pavement Evaluation, Birdseye Road, Lewis and Clark County Road Improvement Projects, Helena, Montana

The pavement evaluation for the above-referenced project has been completed. The purpose of the pavement evaluation was to perform soil borings along the alignment and laboratory tests on selected samples to assist Robert Peccia & Associates and Lewis and Clark County to complete initial preliminary engineering analysis for a future reconstruction of a portion of Birdseye Road. The pavement evaluation was performed in general accordance with our Subconsultant Agreement dated June 11, 2009.

## Project Information

It is our understanding Birdseye Road is considered one of Lewis and Clark County's high priority roads to receive reconstructive improvements. Depending on funding availability, the intent will be for whole or parts of the road to be reconstructed to meet or exceed minimum County standards. The portion of road being evaluated in this report is from the intersection of Birdseye Road and Barrett Road extending north and northwest for approximately 10 miles to where Birdseye Road intersects Lincoln Road West (Montana Highway S-279). The Birdseye Road roadway limits considered for this pavement evaluation are shown on the attached Boring Location Sketch. At this time, the engineering evaluation along Birdseye Road is based on a total reconstruction need with a new pavement section to bring the road into compliance of meeting or exceeding the minimum road standards in accordance with the Lewis and Clark Subdivision Regulations dated December 18, 2007. Approaching the preliminary engineering as a total reconstruction project will likely present the most conservative cost analysis to assist the County in earmarking funding.

## Field Procedures

On July 8 and 9, 2009, Borings ST-27 through ST-38 were performed along the 10-mile alignment being considered for reconstruction. Therefore, the borings were located slightly less than 1 mile apart. Boring locations were selected by our personnel and were generally alternated from the northbound and southbound lanes. The locations of Borings ST-27 through ST-38 are shown on the attached sketch. To perform the borings, single lane closure traffic control was performed while drilling.

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2611 Gabel Road
P.O. Box 80190
Billings, MT 59108-0190
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**MISSOULA**
4041 Whippoorwill Drive
P.O. Box 16123
Missoula, MT 59808-6123
P 406.721.3391
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The borings were performed with a truck-mounted core and auger drill. Sampling of the borings was performed in accordance with American Society for Testing and Materials (ASTM) Method of Test D 1586, "Penetration Test and Split-Barrel Sampling of Soils." Using this method, we advanced the borehole with hollow-stem auger to the desired test depth. Then a 140-pound hammer falling 30 inches drove a standard, 2-inch OD, split-barrel sampler a total penetration of 1 1/2 to 2 feet below the tip of the hollow-stem auger. The blows for the 1 1/2-foot of penetration are indicated on the boring logs, and are an index of soil strength characteristics. The last 1-foot portion of each penetration test is the N-value, and referred to as blows per foot (BPF) in this report.

While drilling, our engineering assistant measured the thickness of the existing asphalt pavement and underlying gravel base course to the nearest 1/2 inch. We wish to point out, however, that measuring the existing base thickness to the nearest 1/2 inch can be difficult due to previous construction activities along the roadway. Bag samples of the existing base course and subgrade were collected from some of the borings. The borings were then backfilled by our drill crew, and the pavement surface was patched with cold-mix asphalt.

The soils encountered in the borings were visually and manually classified in accordance with ASTM D 2488, "Standard Practice for Description and Identification of Soils (Visual – Manual Procedures)." A summary of the ASTM classification system is attached. All samples were then returned to our laboratory for review of the field classifications by a geotechnical engineer.

## Results

**General.** Log of Boring sheets indicating the depth and identification of the various soil strata, the penetration resistance, laboratory test data, and water level information are attached. It should be noted that the depths shown as boundaries between the strata are only approximate. The actual changes may be transitions and the depths of changes vary between borings.

Geologic origins presented for each stratum on the Log of Boring sheets are based on the soil types, blows per foot, and available common knowledge of the depositional history of the site. Because of the complex glacial and post-glacial depositional environments, geologic origins are frequently difficult to ascertain. A detailed evaluation of the geologic history of the roadway as well as review of contour maps and cross sections was not performed.

The general profile encountered by the 12 borings was existing pavement underlain by gravel base course over sandy lean clay, silty gravel, clayey gravel, and silty sand subgrades. Table 1 below summarizes the existing pavement and subgrade conditions encountered at the 12 borings.

**Table 1. Summary of Boring Conditions – Birdseye Road**

| Boring | ST-27 | ST-28 | ST-29 | ST-30 | ST-31 | ST-32 | ST-33 | ST-34 | ST-35 | ST-36 | ST-37 | ST-38 |
|---|---|---|---|---|---|---|---|---|---|---|---|---|
| Existing Asphalt Surface | 7½" | 4¾" | 2½" | 4" | 3" | 1½" | 4" | 1" | ¾" | 2¾" | 1¼" | 1" |
| Existing Base Thickness | 4½" | 2½"(1) | 13" | 8" | 4" | 4" | 2"(1) | 7" | 4¾" | 6¼" | 22¾"(2) | 1"(1) |
| Existing Base Quality | Poor | Poor | Good | Good | Good | Good | Good | Fair | Good | Good | Good | Poor |
| Subgrade | CL | CL | GM | GC | SM | GC | CL | SC | SC | CL | CL | SC |
| BPF | 16, 10 | 12, 5 | 12, 9 | 12, 5 | 9, 16 | 9, 10 | 9, 6 | 7, 18 | 7, 5 | 5, 4 | 26, 6 | 10, 5 |
| Moisture Condition | Below | Over 1%-7% | Near | Near | Near | Below | Over 1%-7% | Over 1%-7% | Under | Over 2%-4% | Below | Near |
| Risk of Subgrade Failure | Mod. | High | Low | Mod. | Mod. | Mod. | High | High | Mod. | High | Mod. | High |

(1) Base is too thin to salvage.
(2) Includes subbase course (see log).
CL = Lean Clay
GC = Clayey Gravel
GM = Silty Gravel
SC = Clayey Sand
SM = Silty Sand

**General Statistical Summary**

Existing Base Course: 3 of 12 borings (25%) encountered POOR quality base course
9 of 12 borings (75%) encountered FAIR to GOOD quality base course

Subgrade Conditions: 5 of 12 borings (42%) have HIGH risk to become unstable during construction
6 of 12 borings (50%) have MODERATE risk to become unstable during construction.
1 of 12 borings (8%) has LOW risk to become unstable during construction.

**Existing Pavement Section.** As indicated in Table 1 above, the 12 borings encountered substantially variable asphalt pavement thicknesses, ranging from 3/4 to 7 1/2 inches. Beneath the existing asphalt surfacing, the borings generally encountered good quality base course, which was 1 to 13 inches thick. Penetration tests were performed in the base course directly beneath the asphalt surface while drilling. In general, penetration resistances in the base course typically ranged from 10 to 15 blows for 6 inches of penetration, indicating it was loose to medium dense.

**Subgrade.** Beneath the existing base course, the borings primarily encountered sandy lean clay, clayey gravel, silty gravel, and silty sand subgrades. Fine-grained soil subgrades were encountered in Borings ST-27, ST-28, ST-33, ST-36, and ST-37. Penetration resistances ranged from 4 to 26 BPF, indicating the fine-grained subgrades were rather soft to stiff. Coarse-grained subgrades were encountered in Borings ST-29, ST-30, ST-31, ST-32, ST-34, ST-35, and ST-38. Penetration resistances ranged from 5 to 18 BPF, indicating they were generally loose to medium dense.

Moisture content tests were performed on all of the penetration test samples from the borings. The moisture contents are indicated on the boring logs and were either compared to the optimum moisture content determined by our standard Proctor (described below) or typical optimum moisture contents for these types of soils. Based on these moisture content tests, the subgrade conditions beneath the existing pavement were mostly slightly below to near optimum moisture content and should be considered moist. The moisture contents of about one-third of the subgrades were over optimum, and should be considered wet.

**Groundwater.** Groundwater was not encountered in the four borings to their termination depth of 5 1/2 feet at the time of our fieldwork. We wish to point out that clay subgrades were encountered by the borings. Several days may be required for groundwater levels to develop and stabilize in these types of clay soils. Surface water can also become trapped on top of these clay soils (perched groundwater), and then be encountered during construction.

## Laboratory Tests

Two base course and three subgrade samples were selected for laboratory tests. The results are summarized in Table 2 below and are attached to this report.

**Table 2. Summary of Laboratory Tests**

| Sample | Atterberg Limits | | | P200 | Standard Proctor | | CBR Value |
|---|---|---|---|---|---|---|---|
| | LL | PL | PI | | MDD | OMC | |
| Base Course, ST-27 | 33 | 18 | 15 | 18.9 | --- | --- | --- |
| Base Course, ST-34 | 22 | 16 | 6 | 9.8 | --- | --- | --- |
| Composite Subgrade, ST-27 and ST-28 | 33 | 16 | 17 | 50.4 | 118.7 | 14.0 | 8.9 |
| Subgrade, ST-34 | 38 | 15 | 23 | 39.3 | 115.8 | 12.4 | 7.2 |
| Subgrade, ST-38 | 39 | 19 | 20 | 44.7 | 117.0 | 14.5 | 9.0 |

MDD = Maximum Dry Density (ASTM D 698), pounds per cubic foot (pcf)
OMC = Optimum Moisture Content

A Laboratory Test of Aggregate sheet compares the base samples to Lewis and Clark Top Surfacing and Select Base Course Gradation Requirements. The base sample from Boring ST-27 tested does not meet specification due to the excessive fines, while the base sample from Boring ST-34 does meet the specifications.

Standard Proctors (ASTM D 698) and California bearing ratio (CBR) tests were performed on the three clayey sand and sandy lean clay samples indicated above. The CBR values ranged from 7.2 to 9.0.

## Pavement Analysis and Recommendations

**Available Information.** Robert Peccia & Associates provided us with the traffic information indicated on the attached graphs for Roadway 7B-42, which represents Birdseye Road in this study segment. A linear relationship was used to estimate the increase in AADT over a 20-year period. The yearly growth rate is estimated to be 1.45 percent. Abelin Traffic Services (ATS) performed the recent traffic counts on this and numerous other Lewis and Clark County roads as part of the County's annual traffic count program. The 2009 traffic count summary for this road is attached. This summary shows the relative percentages and daily traffic of the 13 standard classes of vehicles using the road.

**Method.** Pavement sections for the roadway were evaluated using DARWin™, a computer program based on the *1993 AASHTO Guide for Design of Pavement Structures*. The AASHTO Pavement Design Method is based on numerous input parameters, each affecting the required total pavement thickness for a given road. Based on the traffic information provided by Robert Peccia & Associates and ATS, we were able to perform a rigorous traffic analysis to determine the design Equivalent Single 18-kip Axle Load (ESAL). The rigorous traffic analysis is included in the DARWin output. The input parameters and traffic information are summarized in Table 3 below.

**Table 3. Summary of Pavement Design Assumptions and Analysis**

| **Parameter:** | |
|---|---|
| Road Classification | Minor Collector |
| 2009 AADT | 1,690 |
| 2029 AADT | 2,254 |
| Estimated Annual Growth | 1.45% |
| Performance Period | 20 Years |
| Initial Serviceability | 4.2 |
| Terminal Serviceability | 2.5 |
| Reliability | 85 |
| Number of Lanes in Design Direction | 1 |
| Percent All Trucks in Design Lane | 50 |
| Percent Trucks in Design Direction | 100 |
| 18-kip ESALs | 112,008 |

As can be seen above, we calculated a design ESAL of 112,008, which is considered a Minor Collector. For our calculations, vehicle/truck factors were used for the 13 classes of vehicles counted in the ATS traffic classification count. These vehicle/truck factors were obtained from the *washington.edu* website, and the table is attached.

The DARWin pavement design uses roadbed soil resilient modulus ($M_R$) to identify subgrade strength. CBR is another method of representing subgrade strength. Correlations of these subgrade strength parameters are contained in the *1993 AASHTO Design of Pavement Structures* manual. For soils having CBR values less than 10, the manual indicates the following equation can be used.

$$M_R \text{ (psi)} = 1,500 \text{ x CBR}$$

As previously indicated in Table 2, CBR values of 7.2, 8.9, and 9.0 were determined for subgrade samples along this roadway. When considering the relative consistency of the CBR values, it is our opinion the lowest CBR of 7.2 should be used for design. This CBR value results in an $M_r$ equal to 10,800.

**Pavement Sections.** Pavement sections were analyzed in general accordance with the Lewis and Clark Subdivision Regulations dated December 18, 2007. Based on this approach and the above input parameters and design information, our recommended pavement section is summarized in Table 4 below.

**Table 4. Recommended Pavement Section**

| | |
|---|---|
| Asphalt Pavement | 3" |
| Crushed Top Surfacing | 3" |
| Select Base Course* | 6" |
| Subbase Course* | 0" |
| **Total** | **12"** |

*Per Table B-4 of Lewis and Clark Subdivision Regulations dated 12/18/2007, 3-inch minus sandy gravel should be used as Select Base Course. Because the Crushed Top Surfacing is only 3 inches thick, it is undesirable to have a subbase aggregate larger than the thickness of leveling course.

**Constructability.**

**General.** A common problem in roadway construction is encountering unstable subgrades. Unstable subgrades are those subgrade soils that are excessively wet and soft, and cannot support heavy rubber-tired construction equipment as well as cannot be compacted to specification. They commonly occur beneath existing roads where surface water has seeped through cracks and become trapped in the underlying base course and subgrade. This water saturates the clays, reducing their shear strength, and the clay subgrade becomes too soft and wet to support the heavy rubber-tired construction equipment. When this occurs during fast-tracked construction projects, it can cause delays, which then results in change orders.

In previous Table 1, the subgrades were rated as to their general suitability to support construction equipment. We considered 92 percent of the entire alignment to have a "moderate" to "high" risk of subgrade failure during construction.

**Identification of Unstable Areas.** When considering total reconstruction, the best method of determining unstable subgrades is to perform proof rolling observations directly on the exposed subgrade. Proof rolling should be performed with a loaded tandem axle dump truck or equivalent. Unstable areas are those subgrade soils where proof rolling indicates 1/2 inch or more of deflection is occurring. Another method of determining unstable subgrades is whether or not they can be recompacted to specification, typically 95 percent of their standard Proctor maximum dry density. Where unstable subgrades are identified, we recommend installing a stabilized pavement section as described below.

**Stabilized Pavement Section.** Two alternatives for stabilized pavement sections are indicated in Table 5 below. Alternatives 1 and 2 are stabilized pavement sections using geosynthetics, which are available in Montana.

**Table 5. Stabilized Pavement Section for Excessively Soft (Unstable) Subgrade Areas**

| Item | Alternative 1 | Alternative 2 |
|---|---|---|
| Asphalt Pavement | 3" | 3" |
| Crushed Top Surfacing | 3" | 3" |
| Select Base and/or Subbase | 20" | 23" |
| Geosynthetic | Tensar BX 1300 over<br>Class 2 Non-woven Fabric | Mirafi HP 570 |

**Other Alternatives.** We suggest also contacting Lewis and Clark County personnel and/or discussing these types of stabilized pavement sections with the contractor, who may have other alternatives for constructing pavements on unstable subgrades. Another alternative is to allow unstable subgrades to possibly dry out during construction. For this approach, several weeks of warm, windy weather will likely be needed to allow the exposed conditions to dry out and become more stable. We have found, however, that the construction schedule of most contractors does not allow them to wait for these areas to dry out and become stable.

Some consideration can also be given to specifying that all construction activities are performed with low-pressured ground equipment. In Montana, however, this equipment is generally not readily available by most earthwork and paving contractors.

## Specifications

When the Birdseye Road reconstruction project is undertaken, we recommend all earthwork, subgrade preparation, gravel base and subbase, and asphalt pavement be specified and constructed in accordance with Montana Public Works Standard Specifications (MPWSS). The Montana Department of Transportation (MDT) Specifications for Road and Bridge Design can also be used, however, they are slightly more stringent. If geosynthetics are utilized, we recommend they be placed and constructed in accordance with the manufacturer's recommendations.

## Observation and Testing

We recommend the pavement subgrades be observed by a geotechnical engineer or an engineering assistant working under the direction of a geotechnical engineer to see if the materials are similar to those encountered by the borings. During construction, we recommend density tests be taken on the recompacted subgrade and compacted crushed top surfacing, select base, and subbase courses. The thicknesses of crushed top surfacing, select base, and subbase should also be checked to confirm they meet specifications.

We also recommend density testing of the asphaltic concrete surface and Marshall tests on asphaltic concrete mix to evaluate strength and air voids. Cores of asphalt concrete should be taken at intervals to evaluate pavement thickness and compaction. Paving observations should also be performed to confirm the specified thickness of asphalt is provided throughout the roadway.

## General Recommendations

**Basis of Recommendations.** The analyses and recommendations submitted in this report are based upon the data obtained from the borings performed at the locations indicated on the attached sketch. Often, variations occur between these borings, the nature and extent of which do not become evident until additional exploration or construction is conducted. A reevaluation of the recommendations in this report should be made after performing on-site observations during construction to note the characteristics of any variations. The variations may result in additional earthwork and construction costs, and it is suggested that a contingency be provided for this purpose.

It is recommended that when the road is reconstructed, we or another qualified geotechnical engineering firm be retained to perform the observations and testing program for the site preparation. This will allow correlation of the soil conditions encountered during construction to the soil borings.

**Groundwater Fluctuations.** We made water level observations in the borings at the times and under the conditions stated on the boring logs. These data were interpreted in the text of this report. The period of observation was relatively short, and fluctuation in the groundwater level may occur due to rainfall, flooding, irrigation, spring thaw, drainage, and other seasonal and annual factors not evident at the time the observations were made. Design drawings and specifications and construction planning should recognize the possibility of fluctuations.

**Use of Report.** This report is for the exclusive use of Robert Peccia & Associates to use in conjunction with the preliminary road reconstruction analysis being completed by them for the County. In the absence of our written approval, we make no representation and assume no responsibility to other parties regarding this report. The data, analyses and recommendations may not be appropriate for other structures or purposes. We recommend parties contemplating other alignments or purposes contact us.

**Level of Care.** Services performed by SK Geotechnical Corporation personnel for this project have been conducted with that level of care and skill ordinarily exercised by members of the profession currently practicing in this area under similar budget and time restraints. No warranty, expressed or implied, is made.

We appreciate the opportunity to provide these services for you. If we can be of further assistance, please contact us at your convenience.

Sincerely,

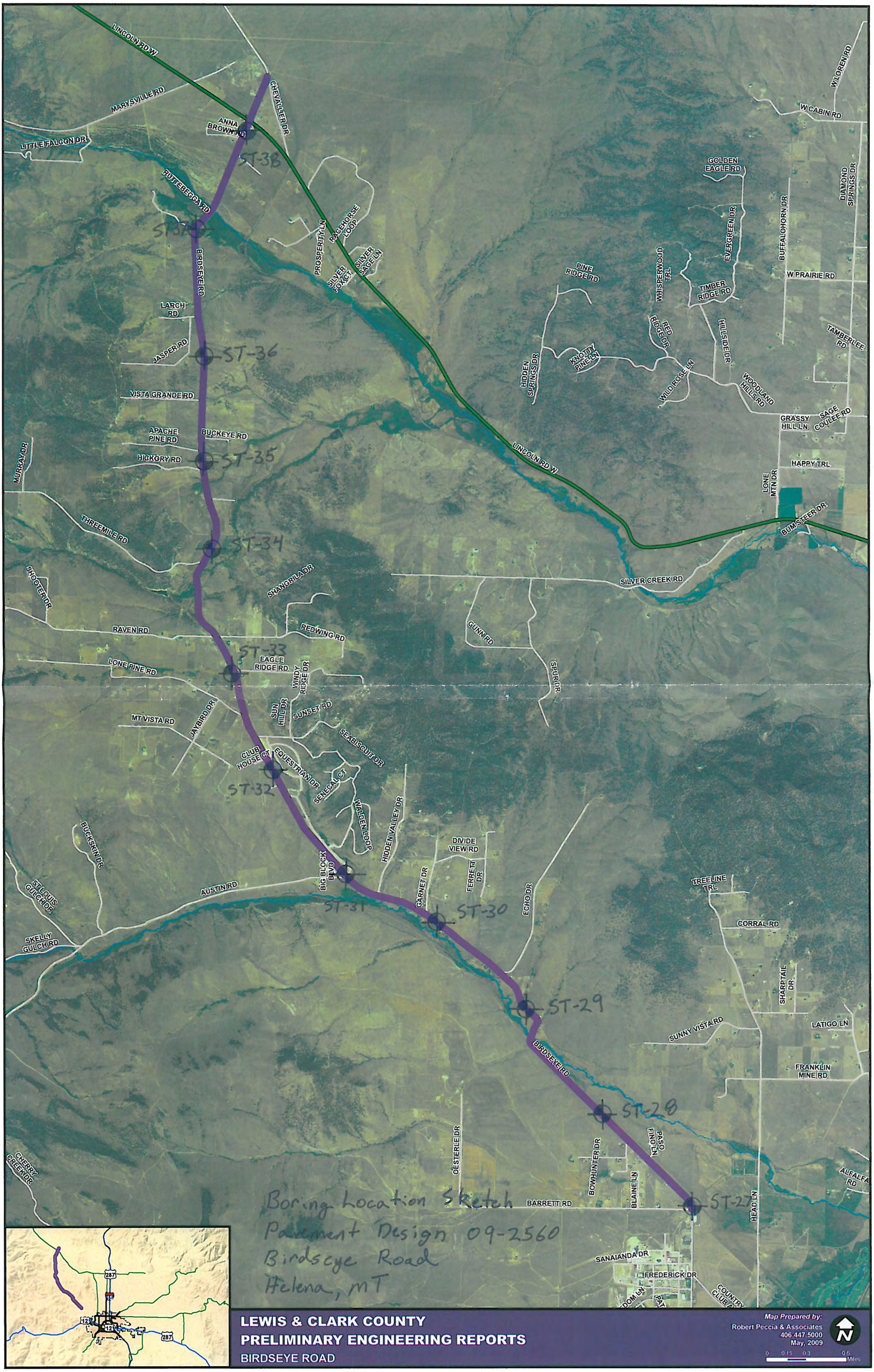
Brett M. Warren, EI
Staff Engineer

**Professional Certification**
I hereby certify that this report was prepared under my direct supervision and that I am a duly Licensed Professional Engineer under the laws of the State of Montana.

MONTANA
GREGORY T.
STAFFILENO
No. 10798 PE
REGISTERED
PROFESSIONAL ENGINEER

Gregory T. Staffileno, PE
Principal Geotechnical Engineer
License Number 10798PE

Attachments:
Boring Location Sketch
Descriptive Terminology
Log of Boring Sheets ST-27 through ST-38
Laboratory Test Results
Laboratory Test of Aggregate
Abelin Traffic Data
RPA Traffic Curve
Washington DOT Vehicle/Truck Factors
DARWin Pavement Analysis




**LEWIS & CLARK COUNTY**
**PRELIMINARY ENGINEERING REPORTS**
BIRDSEYE ROAD

# Descriptive Terminology

## Standard D 2487
## Classification of Soils for Engineering Purposes
## (Unified Soil Classification System)

| Criteria for Assigning Group Symbols and Group Names Using Laboratory Tests [A] | | | | Soil Classification: Group Symbol | Soil Classification: Group Name [B] |
|---|---|---|---|---|---|
| Coarse-Grained Soils More than 50% retained on No. 200 sieve | Gravels More than 50% of coarse fraction retained on No. 4 sieve | Clean Gravels Less than 5% fines [C] | $C_U \geq 4$ and $1 \leq C_C \leq 3$ [E] | GW | Well graded gravel [F] |
| | | | $C_U < 4$ and/or $1 > C_C > 3$ [E] | GP | Poorly graded gravel [F] |
| | | Gravels with Fines More than 12% fines [C] | Fines classify as ML or MH | GM | Silty gravel [F, G, H] |
| | | | Fines classify as CL or CH | GC | Clayey gravel [F, G, H] |
| | Sands 50% or more of coarse fraction passes No. 4 sieve | Clean Sands Less than 5% fines [D] | $C_U \geq 6$ and $1 \leq C_C \leq 3$ [E] | SW | Well graded sand [I] |
| | | | $C_U < 6$ and/or $1 > C_C > 3$ [E] | SP | Poorly graded sand [I] |
| | | Sands with Fines More than 12% fines [D] | Fines classify as ML or MH | SM | Silty sand [G, H, I] |
| | | | Fines classify as CL or CH | SC | Clayey sand [G, H, I] |
| Fine-Grained Soils 50% or more passes the No. 200 sieve | Silts and Clays Liquid Limit less than 50 | Inorganic | PI > 7 and plots on or above "A" line [J] | CL | Lean clay [K, L, M] |
| | | | PI < 4 or plots below "A" line [J] | ML | Silt [K, L, M] |
| | | Organic | Liquid limit – oven dried / Liquid limit – not dried < 0.75 | OL | Organic clay [K, L, M, N]<br>Organic silt [K, L, M, O] |
| | Silts and Clays Liquid limit 50 or more | Inorganic | PI plots on or above "A" line | CH | Fat clay [K, L, M] |
| | | | PI plots below "A" line | MH | Elastic silt [K, L, M] |
| | | Organic | Liquid limit – oven dried / Liquid limit – not dried < 0.75 | OH | Organic clay [K, L, M, P]<br>Organic silt [K, L, M, Q] |
| Highly Organic Soils | | Primarily organic matter, dark in color, and organic odor | | PT | Peat |

[A] Based on the material passing the 3" (75 mm) sieve.

[B] If field sample contained cobbles or boulders, or both, add "with cobbles or boulders, or both" to group name.

[C] Gravels with 5 to 12% fines require dual symbols
GW-GM well-graded gravel with silt
GW-GC well-graded gravel with clay
GP-GM poorly graded gravel with silt
GP-GC poorly graded gravel with clay

[D] Sands with 5 to 12% fines require dual symbols.
SW-SC well-graded sand with clay
SP-SM poorly graded sand with silt
SP-SC poorly graded sand with clay

[E] $C_U = D_{50} / D_{10}$
$C_C = (D_{30})^2 / (D_{10} \times D_{50})$

[F] If soil contains ≥ 15% sand, add "with sand" to group name.

[G] If fines classify as CL-ML, use dual symbol GC-GM or SC-SM.

[H] If fines are organic, add "with organic fines" to group name.

[I] If soil contains ≥ 15% gravel, add "with gravel" to group name.

[J] If Atterberg limits plot in hatched area, soil is a CL-ML, silty clay.

[K] If soil contains 15 to 29% plus No. 200, add "with sand" or "with gravel", whichever is predominant.

[L] If soil contains ≥ 30% plus No. 200 predominantly sand, add "sandy" to group name.

[M] If soil contains ≥ 30% plus No. 200 predominantly gravel, add "gravelly" to group name.

[N] PI ≥ 4 and plots on or above "A" line.

[O] PI < 4 or plots below "A" line.

[P] PI plots on or above "A" line.

[Q] PI plots below "A" line.

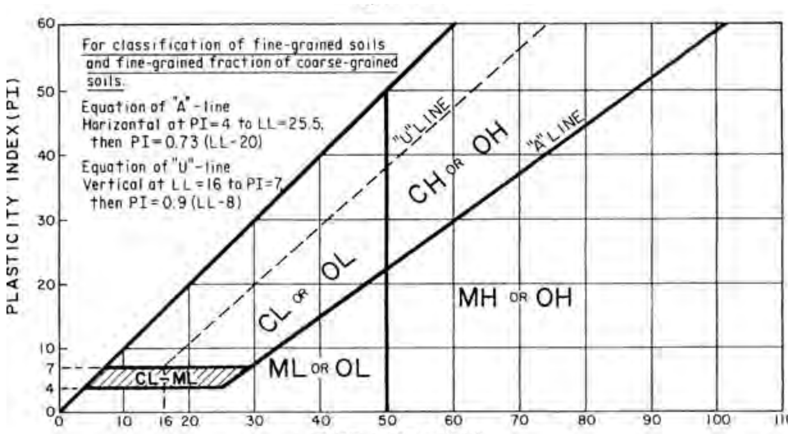


FIG. 4 Plasticity Chart

## Laboratory Tests

| | | | |
|---|---|---|---|
| DD | Dry density, pcf | OC | Organic content, % |
| WD | Wet density, pcf | $P_{200}$ | % passing 200 sieve |
| LL | Liquid limit | PL | Plastic limit |
| PI | Plasticity index | MC | Natural moisture content, % |
| qu | Unconfined compressive strength, psf | | |
| qp | Pocket penetrometer strength, tsf | | |

## Particle Size Identification

Boulders ................................ over 12"
Cobbles ................................ 3" to 12"
Gravel
coarse ................................ 3/4" to 3"
fine ................................ No. 4 to 3/4"
Sand
coarse ........................ No. 4 to No. 10
medium .................... No. 10 to No. 40
fine ........................ No. 40 to No. 200
Silt ...................... No. 200 to .005 mm
Clay ...................... less than .005 mm

## Relative Density of Cohesionless Soils

very loose ........................... 0 to 4 BPF
loose ................................ 5 to 10 BPF
medium dense ................. 11 to 30 BPF
dense .............................. 31 to 50 BPF
very dense ........................ over 50 BPF

## Consistency of Cohesive Soils

very soft ............................. 0 to 1 BPF
soft ..................................... 2 to 3 BPF
rather soft ........................... 4 to 5 BPF
medium ............................... 6 to 8 BPF
rather stiff ......................... 9 to 12 BPF
stiff ................................. 13 to 16 BPF
very stiff ......................... 17 to 30 BPF
hard ................................. over 30 BPF

## Moisture Content (MC) Description

| | |
|---|---|
| rather dry | MC less than 5%, absence of moisture, dusty |
| moist | MC below optimum, but no visible water |
| wet | MC over optimum, visible free water, typically below water table |
| saturated | Clay soils were MC over optimum |

## Drilling Notes

Standard penetration test borings were advanced by 3¼" or 4¼" ID hollow-stem augers, unless noted otherwise. Standard penetration test borings are designated by the prefix "ST" (split tube). Hand auger borings were advanced manually with a 2 to 3" diameter auger to the depths indicated. Hand auger borings are indicated by the prefix "HA."

**Sampling.** All samples were taken with the standard 2" OD split-tube sampler, except where noted. TW indicates thin-walled tube sample. CS indicates California tube sample.

**BPF.** Numbers indicate blows per foot recorded in standard penetration test, also known as "N" value. The sampler was set 6" into undisturbed soil below the hollow-stem auger. Driving resistances were then counted for second and third 6" increments and added to get BPF. Where they differed significantly, they were separated by backslash (/). In very dense/hard strata, the depth driven in 50 blows is indicated.

**WH.** WH indicates the sampler penetrated soil under weight of hammer and rods alone; driving not required.

**Note.** All tests were run in general accordance with applicable ASTM standards.

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# LOG OF BORING

| | |
|---|---|
| PROJECT: 09-2560 **PAVEMENT DESIGN** Lewis and Clark County Roads Helena, Montana | BORING: **ST-27** LOCATION: Birdseye Road, see attached sketch. |
| DRILLED BY: C. Larsen | METHOD: 3 1/4" HSA, Automatic |
| DATE: 7/8/09 | SCALE: 1" = 1' |

| Elev. | Depth | Symbol | Description of Materials | BPF | WL | MC (%) | Remarks |
|---|---|---|---|---|---|---|---|
| | 0.0 | | FILL: 7 1/2" of Asphalt Pavement. | | | | |
| | 0.6 | | FILL: 4 1/2" of Clayey Sand with Gravel Base. | | | | |
| | 1.0 | CL | SANDY LEAN CLAY, low plasticity, brown, moist, rather stiff to hard. (Alluvium) | 5/8/8 | | 7.7 | Base course bag sample: LL=33, PL=18, PI=15 $P_{200}$=18.9% |
| | | | | 6/5/5 | | 10.1 | Composite subgrade bag sample ST-27 and ST-28: LL=33, PL=16, PI=17 $P_{200}$=50.4% |
| | | | | 8/12/18 | | 4.6 | |
| | 5.5 | | END OF BORING<br>Water not observed with 4' of hollow-stem auger in the ground.<br>Water not observed to dry cave-in depth of 1' immediately after withdrawal of auger. | | | | |

BORING BPF WL MC 2560.GPJ LAGNNN06.GDT 10/22/09

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# LOG OF BORING

| | |
|---|---|
| PROJECT: 09-2560<br>**PAVEMENT DESIGN**<br>Lewis and Clark County Roads<br>Helena, Montana | BORING: **ST-28**<br>LOCATION:<br>Birdseye Road, see attached sketch. |

| | | | |
|---|---|---|---|
| DRILLED BY: C. Larsen | METHOD: 3 1/4" HSA, Automatic | DATE: 7/8/09 | SCALE: 1" = 1' |

| Elev. | Depth | Symbol | Description of Materials | BPF | WL | MC (%) | Remarks |
|---|---|---|---|---|---|---|---|
| | 0.0 | | FILL: 4 3/4" of Asphalt Pavement. | | | | |
| | 0.4 | | FILL: 2 1/4" of Gravel Base (very poor quality). | | | | |
| | 0.6 | CL | SANDY LEAN CLAY, low plasticity, brown, moist to wet, soft to rather stiff. (Alluvium) | 5/7/5 | | 13.6 | |
| | | | | 2/3/2 | | 18.4 | Composite subgrade bag sample ST-27 and ST-28: LL=33, PL=16, PI=17 $P_{200}$=50.4% |
| | | | | 1/1/2 | | 21.4 | |
| | 5.5 | | END OF BORING<br><br>Water not observed with 4' of hollow-stem auger in the ground.<br><br>Water not observed to dry cave-in depth of 1' immediately after withdrawal of auger. | | | | |

BORING BPF WL MC 2560.GPJ LAGNNN06.GDT 10/22/09

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# LOG OF BORING

| | |
|---|---|
| PROJECT: 09-2560<br>**PAVEMENT DESIGN**<br>Lewis and Clark County Roads<br>Helena, Montana | BORING: **ST-29**<br>LOCATION:<br>Birdseye Road, see attached sketch. |
| DRILLED BY: C. Larsen / METHOD: 3 1/4" HSA, Automatic | DATE: 7/8/09 / SCALE: 1" = 1' |

| Elev. | Depth 0.0 | Symbol | Description of Materials | BPF | WL | MC (%) | Remarks |
|---|---|---|---|---|---|---|---|
| | 0.2 | | FILL: 2 1/2" of Asphalt Pavement. | | | | |
| | 1.3 | | FILL: 13" of Gravel Base. | 17/11/7 | | 9.2 | |
| | | GM | SILTY GRAVEL, fine- to coarse-grained, brown, moist, loose to medium dense. (Alluvium) | 5/7/5 | | 8.4 | |
| | 5.5 | | | 4/5/4 | | 7.9 | |
| | | | END OF BORING<br><br>Water not observed with 4' of hollow-stem auger in the ground.<br><br>Water not observed to dry cave-in depth of 2' immediately after withdrawal of auger. | | | | |

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# LOG OF BORING

| | |
|---|---|
| PROJECT: 09-2560<br>**PAVEMENT DESIGN**<br>Lewis and Clark County Roads<br>Helena, Montana | BORING: **ST-30**<br>LOCATION:<br>Birdseye Road, see attached sketch. |

| DRILLED BY: C. Larsen | METHOD: 3 1/4" HSA, Automatic | DATE: 7/8/09 | SCALE: 1" = 1' |
|---|---|---|---|

| Elev. | Depth 0.0 | Symbol | Description of Materials | BPF | WL | MC (%) | Remarks |
|---|---|---|---|---|---|---|---|
| | 0.3 | | FILL: 4" of Asphalt Pavement. | | | | |
| | 1.0 | | FILL: 8" of Gravel Base. | | | | |
| | 3.8 | GC | CLAYEY GRAVEL, fine- to coarse-grained, low plasticity, brown, moist, loose to medium dense. (Alluvium) | 11/5/7<br>2/2/3 | | 7.2<br>10.6 | |
| | 5.5 | SM | SILTY SAND, fine- to coarse-grained, brown, moist, very loose. (Alluvium) | 1/1/2 | | 13.4 | |

END OF BORING

Water not observed with 4' of hollow-stem auger in the ground.

Water not observed to dry cave-in depth of 2' immediately after withdrawal of auger.

BORING BPF WL MC 2560.GPJ LAGNNN06.GDT 10/22/09

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# LOG OF BORING

| | |
|---|---|
| PROJECT: 09-2560<br>**PAVEMENT DESIGN**<br>Lewis and Clark County Roads<br>Helena, Montana | BORING: **ST-31**<br>LOCATION:<br>Birdseye Road, see attached sketch. |

| DRILLED BY: C. Larsen | METHOD: 3 1/4" HSA, Automatic | DATE: 7/8/09 | SCALE: 1" = 1' |
|---|---|---|---|

| Elev. | Depth 0.0 | Symbol | Description of Materials | BPF | WL | MC (%) | Remarks |
|---|---|---|---|---|---|---|---|
| | | | FILL: 3" of Asphalt Pavement. | | | | |
| | 0.3 | | FILL: 4" of Gravel Base. | | | | |
| | 0.6 | SM | SILTY SAND with GRAVEL, fine- to coarse-grained, brown, moist, loose to medium dense. (Alluvium) | 8/5/4<br>3/8/8 | | 13.1<br>8.5 | |
| | 4.0 | GC | GRAVELLY CLAY, low plasticity, light brown, moist, stiff. (Alluvium) | 4/8/6 | | 10.6 | |
| | 5.5 | | END OF BORING<br><br>Water not observed with 4' of hollow-stem auger in the ground.<br><br>Water not observed to dry cave-in depth of 2' immediately after withdrawal of auger. | | | | |

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# LOG OF BORING

PROJECT: 09-2560
**PAVEMENT DESIGN**
Lewis and Clark County Roads
Helena, Montana

BORING: **ST-32**

LOCATION:
Birdseye Road, see attached sketch.

DRILLED BY: C. Larsen | METHOD: 3 1/4" HSA, Automatic | DATE: 7/8/09 | SCALE: 1" = 1'

| Elev. | Depth | Symbol | Description of Materials | BPF | WL | MC (%) | Remarks |
|---|---|---|---|---|---|---|---|
| | 0.0 | | | | | | |
| | 0.1 | | FILL: 1 1/2" of Asphalt Pavement. | | | | |
| | 0.3 | | FILL: 4" of Gravel Base. | | | | |
| | | GC | CLAYEY GRAVEL, fine- to coarse-grained, low plasticity, brown, moist, loose. (Alluvium) | 4/5/4 | | 10.9 | |
| | | | | 3/5/5 | | 9.6 | |
| | 4.0 | GM | SILTY GRAVEL, fine- to coarse-grained, light brown, moist, medium dense. (Alluvium) | 5/7/5 | | 6.9 | |
| | 5.5 | | END OF BORING | | | | |

Water not observed with 4' of hollow-stem auger in the ground.

Water not observed to dry cave-in depth of 2' immediately after withdrawal of auger.

BORING BPF WL MC 2560.GPJ LAGNNN06.GDT 10/22/09

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# LOG OF BORING

| PROJECT: 09-2560 **PAVEMENT DESIGN** Lewis and Clark County Roads Helena, Montana | BORING: **ST-33** LOCATION: Birdseye Road, see attached sketch. |
|---|---|

| DRILLED BY: C. Larsen | METHOD: 3 1/4" HSA, Automatic | DATE: 7/8/09 | SCALE: 1" = 1' |
|---|---|---|---|

| Elev. | Depth | Symbol | Description of Materials | BPF | WL | MC (%) | Remarks |
|---|---|---|---|---|---|---|---|
| | 0.0 | | FILL: 4" of Asphalt Pavement. | | | | |
| | 0.3 | | FILL: 2" of Gravel Base. | | | | |
| | 0.5 | CL | SANDY LEAN CLAY, low plasticity, light brown, wet to moist, medium to rather stiff. (Alluvium) | 3/3/6 | | 21.6 | |
| | | | | 3/4/2 | | 13.5 | |
| | | | | 2/2/3 | | 15.0 | |
| | 5.0 | | DECOMPOSED SHALE, high plasticity, dark gray, moist, medium. | | | | |
| | 5.5 | | END OF BORING<br><br>Water not observed with 4' of hollow-stem auger in the ground.<br><br>Water not observed to dry cave-in depth of 1' immediately after withdrawal of auger. | | | | |

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# LOG OF BORING

PROJECT: 09-2560
**PAVEMENT DESIGN**
Lewis and Clark County Roads
Helena, Montana

BORING: **ST-34**

LOCATION:
Birdseye Road, see attached sketch.

DRILLED BY: C. Larsen | METHOD: 3 1/4" HSA, Automatic | DATE: 7/9/09 | SCALE: 1" = 1'

| Elev. | Depth | Symbol | Description of Materials | BPF | WL | MC (%) | Remarks |
|---|---|---|---|---|---|---|---|
| | 0.0 | | FILL: 1" of Asphalt Pavement over 7" of Well Graded Gravel with Silty Clay and Sand Base Course. | | | | |
| | 0.7 | SC | CLAYEY SAND, fine- to coarse-grained, low plasticity, light brown, wet to moist, medium dense. (Alluvium) | 7/3/4 | | 22.0 | Base course bag sample: LL=22, PL=16, PI=6 $P_{200}$=9.8% MC=3.8% |
| | | | -trace Gravel below 2'. | 5/10/8 | | 9.2 | Subgrade bag sample: LL=38, PL=15, PI=23 $P_{200}$=39.3% |
| | 4.5 | GM | SILTY GRAVEL, fine- to coarse-grained, brown, moist, loose. (Alluvium) | 3/1/6 | | 8.0 | |
| | 5.5 | | END OF BORING<br><br>Water not observed with 4' of hollow-stem auger in the ground.<br><br>Water not observed to dry cave-in depth of 2' immediately after withdrawal of auger. | | | | |

BORING BPF WL MC 2560.GPJ LAGNNN06.GDT 10/22/09

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# LOG OF BORING

| | |
|---|---|
| PROJECT: 09-2560<br>**PAVEMENT DESIGN**<br>Lewis and Clark County Roads<br>Helena, Montana | BORING: **ST-35**<br>LOCATION:<br>Birdseye Road, see attached sketch. |

| DRILLED BY: C. Larsen | METHOD: 3 1/4" HSA, Automatic | DATE: 7/9/09 | SCALE: 1" = 1' |
|---|---|---|---|

| Elev. | Depth 0.0 | Symbol | Description of Materials | BPF | WL | MC (%) | Remarks |
|---|---|---|---|---|---|---|---|
| | 0.5 | | FILL: 3/4" of Asphalt Pavement over 4 3/4" of Gravel Base. | | | | |
| | 5.5 | SC | CLAYEY SAND with GRAVEL, fine- to coarse-grained, high plasticity, brown, moist, loose. (Alluvium) | 5/5/2 | | 7.9 | Jar sample: LL=53, PL=26, PI=27 $P_{200}$=46.2% |
| | | | | 3/3/2 | | 2.2 | |
| | | | | 4/4/3 | | 12.5 | |

END OF BORING

Water not observed with 4' of hollow-stem auger in the ground.

Water not observed to dry cave-in depth of 1 1/2' immediately after withdrawal of auger.

BORING BPF WL MC 2560.GPJ LAGNNN06.GDT 10/22/09

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# LOG OF BORING

| PROJECT: 09-2560 **PAVEMENT DESIGN** Lewis and Clark County Roads Helena, Montana | BORING: **ST-36** LOCATION: Birdseye Road, see attached sketch. |
|---|---|

| DRILLED BY: C. Larsen | METHOD: 3 1/4" HSA, Automatic | DATE: 7/9/09 | SCALE: 1" = 1' |
|---|---|---|---|

| Elev. | Depth | Symbol | Description of Materials | BPF | WL | MC (%) | Remarks |
|---|---|---|---|---|---|---|---|
| | 0.0 | | | | | | |
| | 0.2 | | FILL: 2 3/4" of Asphalt Pavement. | | | | |
| | 0.5 | | FILL: 6 1/4" of Gravel Base. | | | | |
| | | SC | SANDY LEAN CLAY with GRAVEL, low plasticity, brown, moist to wet, rather soft to medium. (Alluvium) | 3/2/3 | | 16.7 | |
| | | | | 2/2/2 | | 14.5 | |
| | | | | 2/3/4 | | 22.9 | |
| | 5.5 | | END OF BORING<br><br>Water not observed with 4' of hollow-stem auger in the ground.<br><br>Water not observed to dry cave-in depth of 1 1/2' immediately after withdrawal of auger. | | | | |

BORING BPF WL MC 2560.GPJ LAGNNN06.GDT 10/22/09

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# LOG OF BORING

| PROJECT: 09-2560 **PAVEMENT DESIGN** Lewis and Clark County Roads Helena, Montana | BORING: **ST-37** LOCATION: Birdseye Road, see attached sketch. |
|---|---|
| DRILLED BY: C. Larsen; METHOD: 3 1/4" HSA, Automatic | DATE: 7/9/09; SCALE: 1" = 1' |

| Elev. | Depth 0.0 | Symbol | Description of Materials | BPF | WL | MC (%) | Remarks |
|---|---|---|---|---|---|---|---|
| | 0.5 | | FILL: 1 1/4" of Asphalt Pavement over 4 1/4" of Gravel Base. | | | | |
| | 2.0 | | FILL: 18 1/2" of Gravel Subbase. | 50-4" | | 4.7 | |
| | 3.5 | CL | SANDY LEAN CLAY with GRAVEL, low plasticity, fine- to coarse-grained, brown, moist, very stiff. (Alluvium) | 10/13/13 | | 10.5 | |
| | 5.5 | CL | LEAN CLAY, low plasticity, gray, moist to wet, medium. (Alluvium) | 2/3/3 | | 29.3 | |
| | | | END OF BORING<br><br>Water not observed with 4' of hollow-stem auger in the ground.<br><br>Water not observed to dry cave-in depth of 2' immediately after withdrawal of auger. | | | | |

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# LOG OF BORING

| | |
|---|---|
| PROJECT: 09-2560<br>**PAVEMENT DESIGN**<br>Lewis and Clark County Roads<br>Helena, Montana | BORING: **ST-38**<br>LOCATION:<br>Birdseye Road, see attached sketch. |

| DRILLED BY: C. Larsen | METHOD: 3 1/4" HSA, Automatic | DATE: 7/9/09 | SCALE: 1" = 1' |
|---|---|---|---|

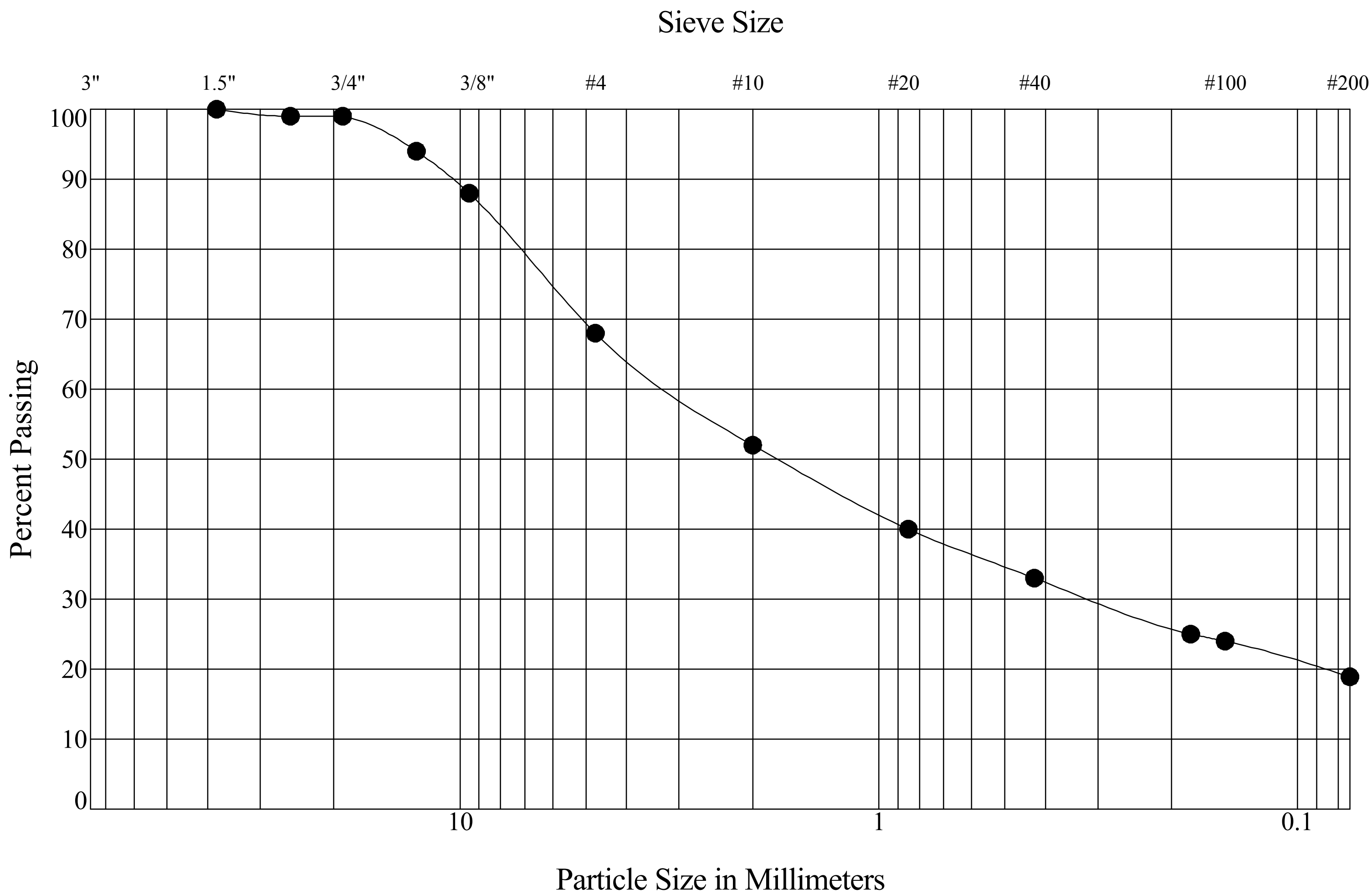
| Elev. | Depth 0.0 | Symbol | Description of Materials | BPF | WL | MC (%) | Remarks |
|---|---|---|---|---|---|---|---|
| | 0.2 | | FILL: 1" of Asphalt Pavement over 1" of Gravel Base. | | | | |
| | 2.5 | SC | CLAYEY SAND, fine- to coarse-grained, low plasticity, brown, moist, medium dense. (Alluvium) | 7/6/5<br>4/3/2 | | 12.9<br>15.1 | |
| | 3.5 | CL | LEAN CLAY, low plasticity, brown, moist, rather soft. (Alluvium) | | | | Subgrade bag sample: LL=39, PL=19, PI=20 $P_{200}$=44.7% |
| | 5.5 | CL | SANDY LEAN CLAY with GRAVEL, low plasticity, brown, moist, very soft. (Alluvium) | 2/2/3 | | 13.6 | |

END OF BORING

Water not observed with 4' of hollow-stem auger in the ground.

Water not observed to dry cave-in depth of 2' immediately after withdrawal of auger.

BORING BPF WL MC 2560.GPJ LAGNNN06.GDT 10/22/09




| Gravel | | Sand | | |
|---|---|---|---|---|
| coarse | fine | coarse | medium | fine |

Percent Passing U.S. Standard Sieve Size

| 3" | 1 1/2" | 3/4" | 3/8" | #4 | #10 | #20 | #40 | #80 | #100 | #200 |
|---|---|---|---|---|---|---|---|---|---|---|
| | 100 | 99 | 88 | 68 | 52 | 40 | 33 | 25 | 24 | 18.9 |

Boring No.: ST-27
Sample No.: ---
Depth: Base Course

Date Received: 07/15/2009

| | |
|---|---|
| Liquid Limit: | 33 |
| Plastic Limit: | 18 |
| Plasticity Index: | 15 |
| Classification: | SC |
| Moisture Content: | 6.3% |

Percent Gravel: 32.0
Percent Sand: 49.1
Percent Silt + Clay: 18.9
ASTM Group Name: CLAYEY SAND with GRAVEL

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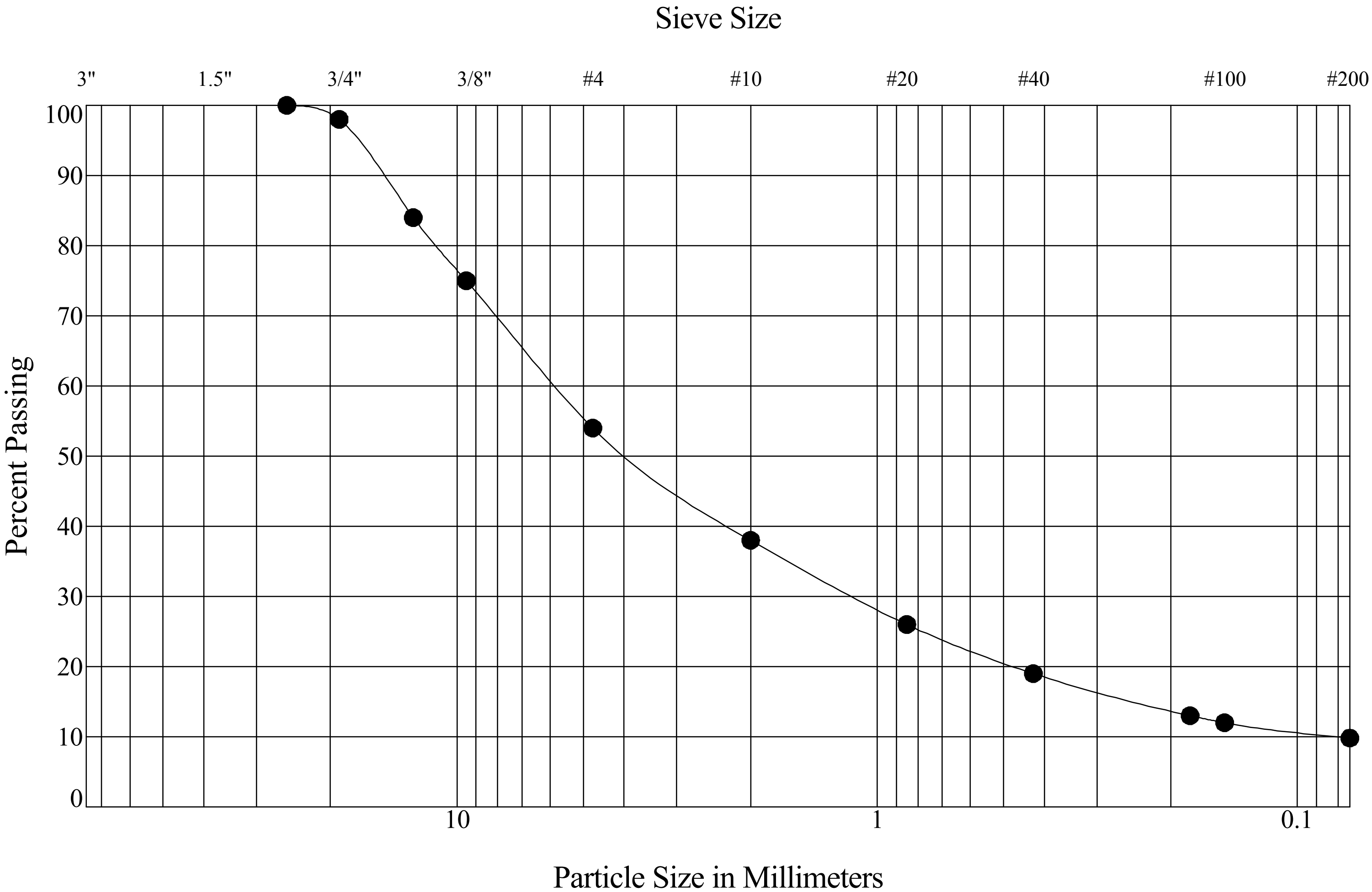
## Sieve Analysis

Project Number: 09-2560
Lewis and Clark County Roads
Helena, Montana

10/22/09




| Gravel | | Sand | | |
|---|---|---|---|---|
| coarse | fine | coarse | medium | fine |

Percent Passing U.S. Standard Sieve Size

| 3" | 1 1/2" | 3/4" | 3/8" | #4 | #10 | #20 | #40 | #80 | #100 | #200 |
|---|---|---|---|---|---|---|---|---|---|---|
| | | 98 | 75 | 54 | 38 | 26 | 19 | 13 | 12 | 9.8 |

Boring No.: ST-34
Sample No.: ---
Depth: Base Course

Date Received: 07/15/2009

| | |
|---|---|
| Liquid Limit: | 22 |
| Plastic Limit: | 16 |
| Plasticity Index: | 6 |
| Classification: | GW-GC |
| Moisture Content: | 3.8% |

Percent Gravel: 46.0
Percent Sand: 44.2
Percent Silt + Clay: 9.8
ASTM Group Name: WELL-GRADED GRAVEL with SILTY CLAY and SAND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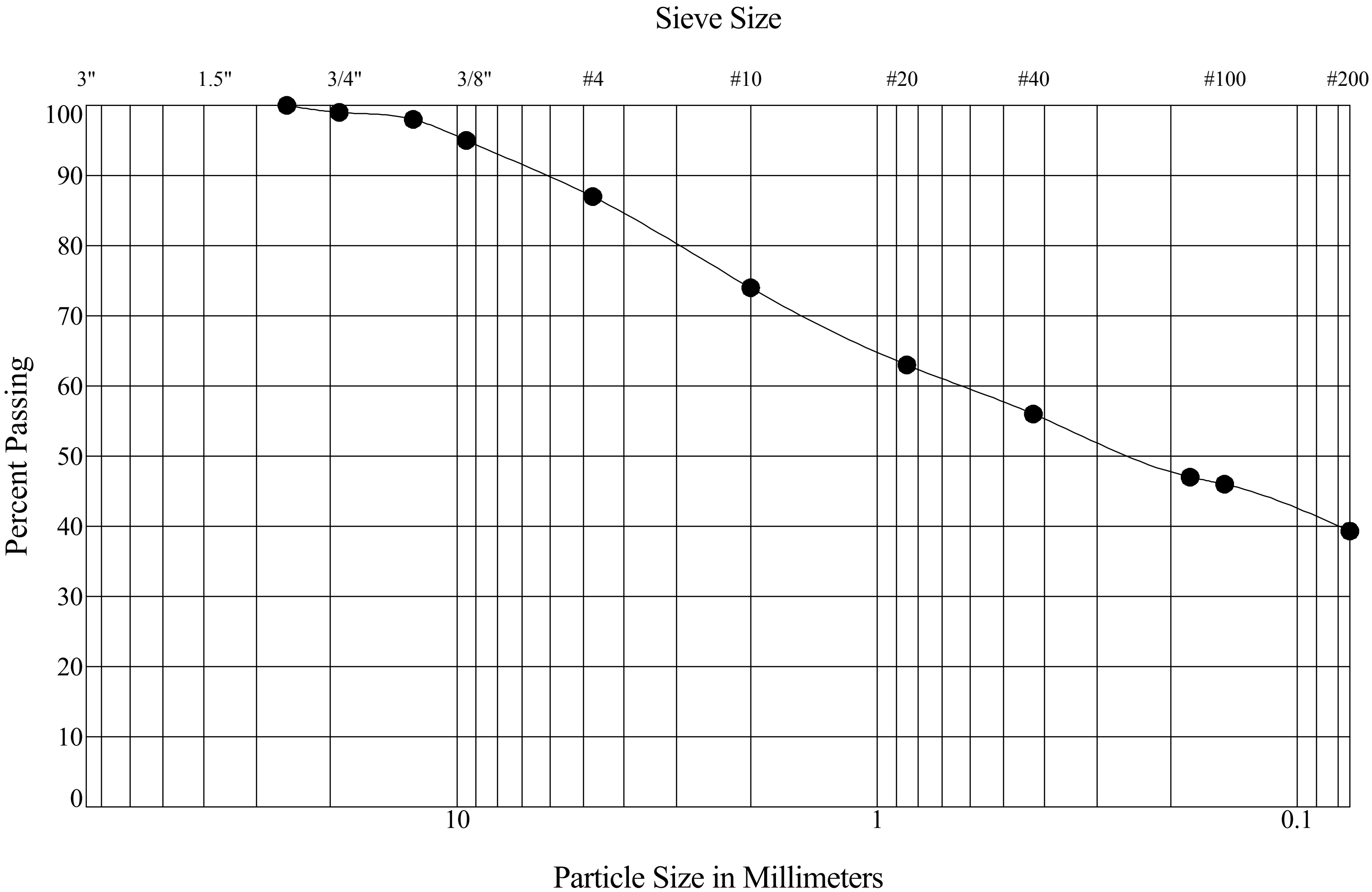
**Sieve Analysis**
Project Number: 09-2560
Lewis and Clark County Roads
Helena, Montana

10/22/09




| Gravel | | Sand | | |
|---|---|---|---|---|
| coarse | fine | coarse | medium | fine |

Percent Passing U.S. Standard Sieve Size

| 3" | 1 1/2" | 3/4" | 3/8" | #4 | #10 | #20 | #40 | #80 | #100 | #200 |
|---|---|---|---|---|---|---|---|---|---|---|
| | | 99 | 95 | 87 | 74 | 63 | 56 | 47 | 46 | 39.3 |

Boring No.: ST-34
Sample No.: P-12
Depth: Subgrade

Date Received: 07/15/2009

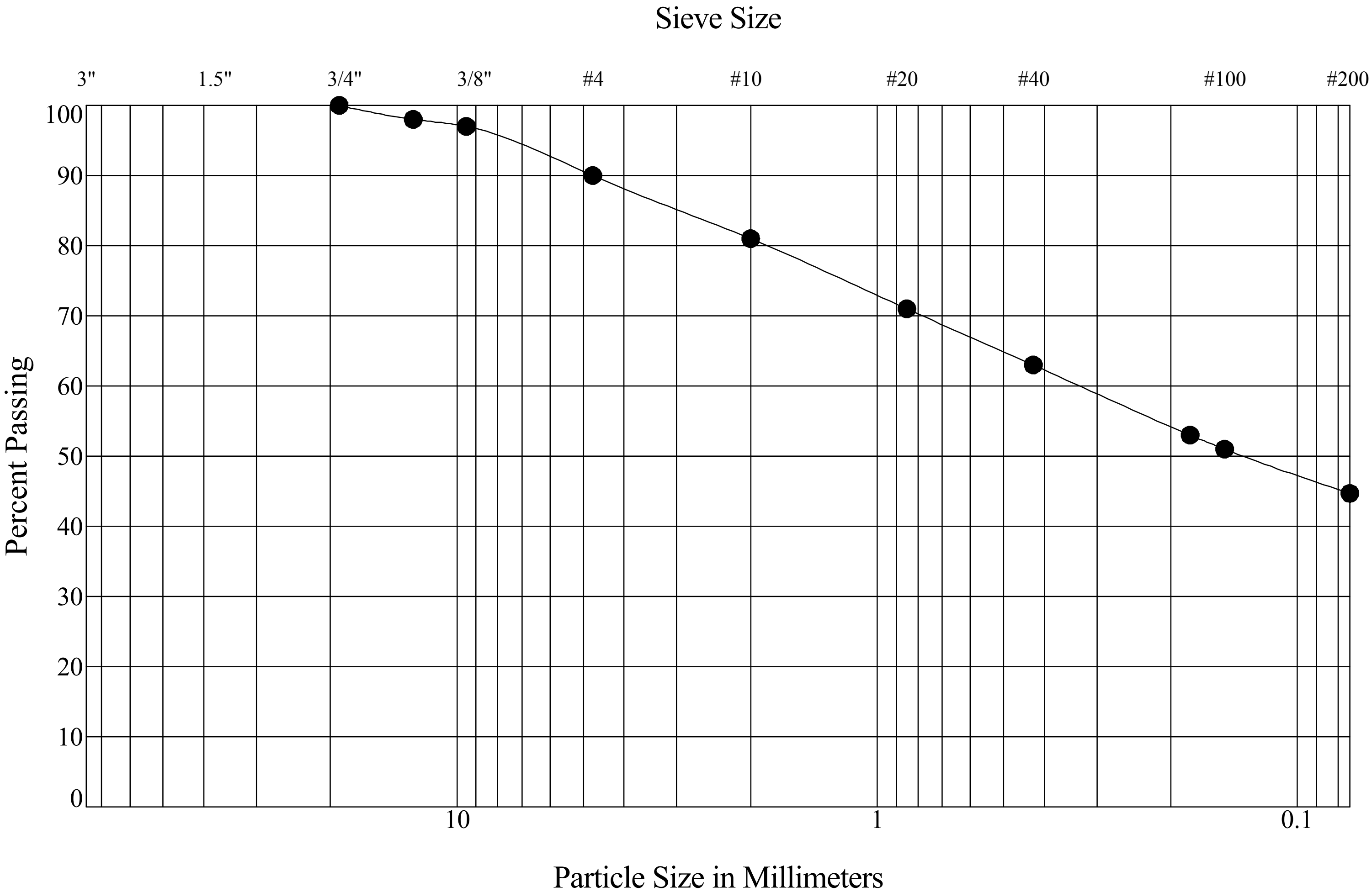
| | |
|---|---|
| Liquid Limit: | 38 |
| Plastic Limit: | 15 |
| Plasticity Index: | 23 |
| Classification: | SC |
| Moisture Content: | |

Percent Gravel: 13.0
Percent Sand: 47.7
Percent Silt + Clay: 39.3
ASTM Group Name: CLAYEY SAND

SK GEOTECHNICAL
2611 Gabel Road
P. O. Box 80190
Billings, MT 59108-0190
Phone: 406.652.3930
Fax: 406.652.3944

**Sieve Analysis**
Project Number: 09-2560
Lewis and Clark County Roads
Helena, Montana

10/22/09




| Gravel | | Sand | | |
|---|---|---|---|---|
| coarse | fine | coarse | medium | fine |

Percent Passing U.S. Standard Sieve Size

| 3" | 1 1/2" | 3/4" | 3/8" | #4 | #10 | #20 | #40 | #80 | #100 | #200 |
|---|---|---|---|---|---|---|---|---|---|---|
| | | 100 | 97 | 90 | 81 | 71 | 63 | 53 | 51 | 44.7 |

Boring No.: ST-38
Sample No.: P-13
Depth: Subgrade

Date Received: 07/15/2009

Percent Gravel: 10.0
Percent Sand: 45.3
Percent Silt + Clay: 44.7
ASTM Group Name: CLAYEY SAND

| | |
|---|---|
| Liquid Limit: | 39 |
| Plastic Limit: | 19 |
| Plasticity Index: | 20 |
| Classification: | SC |
| Moisture Content: | |

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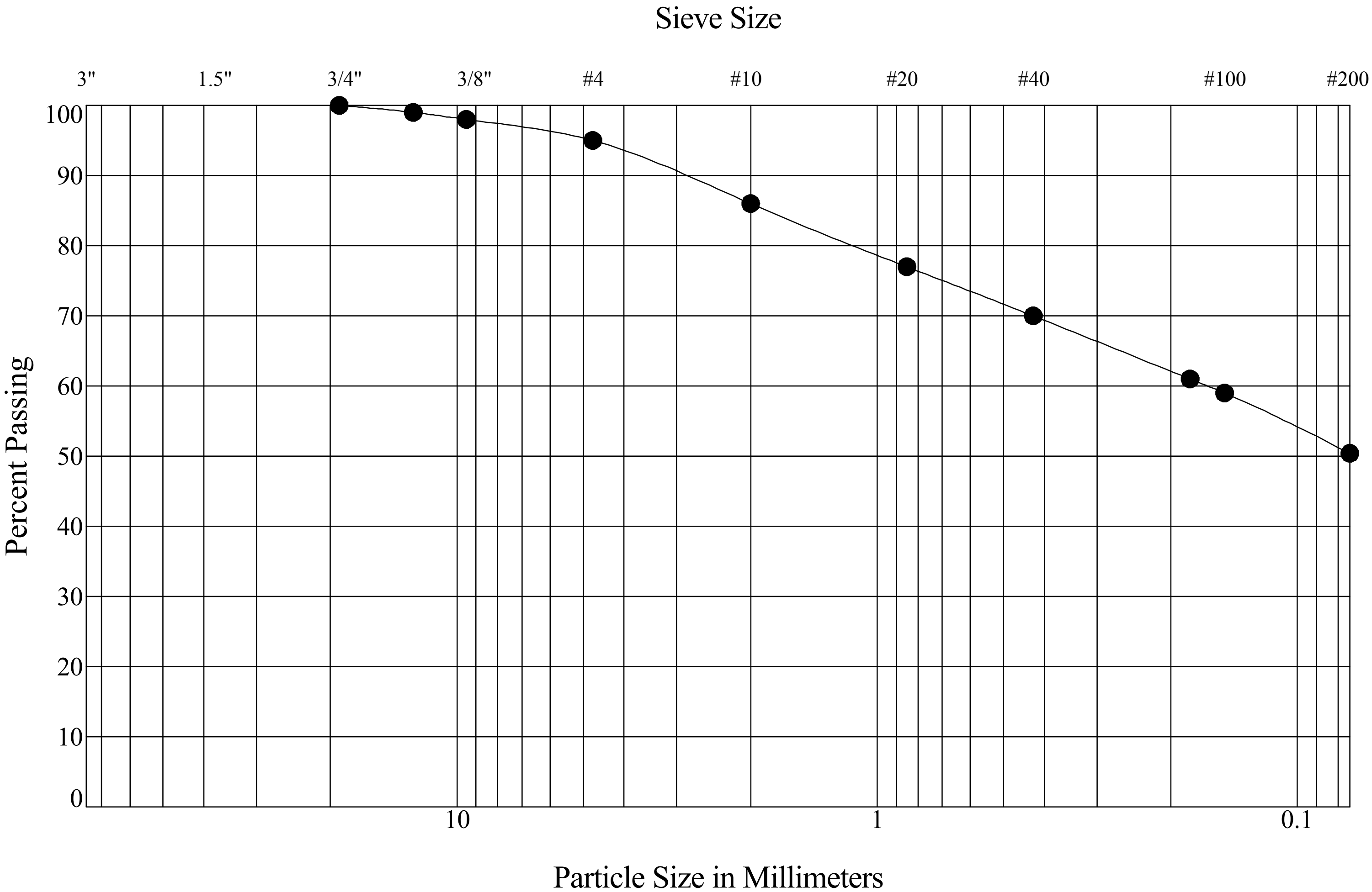
Fax: 406.652.3944

**Sieve Analysis**
Project Number: 09-2560
Lewis and Clark County Roads
Helena, Montana

10/22/09




| Gravel | | Sand | | |
|---|---|---|---|---|
| coarse | fine | coarse | medium | fine |

Percent Passing U.S. Standard Sieve Size

| 3" | 1 1/2" | 3/4" | 3/8" | #4 | #10 | #20 | #40 | #80 | #100 | #200 |
|---|---|---|---|---|---|---|---|---|---|---|
| | | 100 | 98 | 95 | 86 | 77 | 70 | 61 | 59 | 50.4 |

Boring No.: ST-27 and ST-28 Date Received: 07/15/2009
Sample No.: P-11
Depth: Subgrade

Percent Gravel: 5.0
Percent Sand: 44.6
Percent Silt + Clay: 50.4
ASTM Group Name: SANDY LEAN CLAY

| | |
|---|---|
| Liquid Limit: | 33 |
| Plastic Limit: | 16 |
| Plasticity Index: | 17 |
| Classification: | CL |
| Moisture Content: | |

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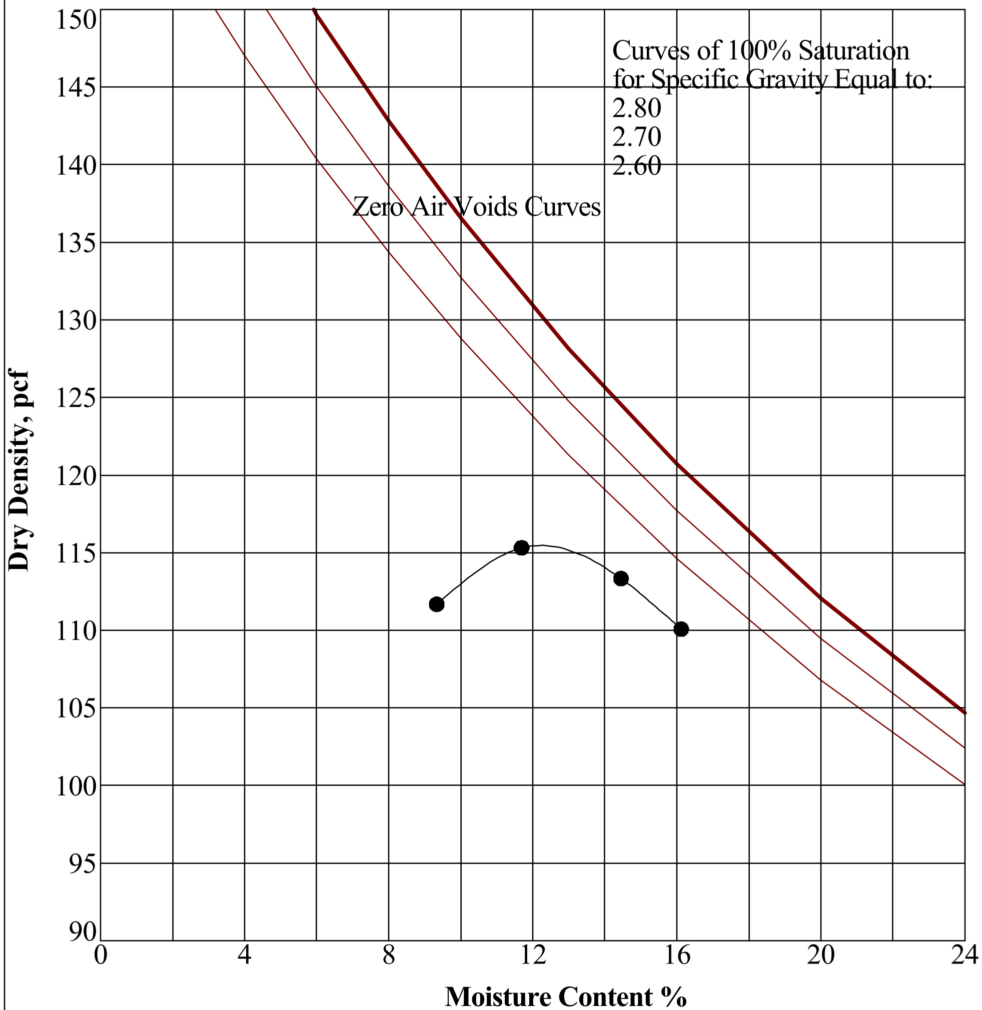
**Sieve Analysis**
Project Number: 09-2560
Lewis and Clark County Roads
Helena, Montana

10/22/09




ASTM D 698 Method C

| Maximum Dry Density, pcf | Optimum Moisture Content % |
|---|---|
| **115.8** | **12.4** |

Rammer Type: Mechanical
Preparation Method: Moist

**Soil Description (Visual-Manual)**

**CLAYEY SAND**, fine- to coarse-grained, low plasticity, light brown, moist.

| Sieve Size | % Retained |
|---|---|
| 1 1/2" | 0 |
| 3/4" | 1 |
| 3/8" | 5 |
| #4 | 13 |

Sample No: ---
Lab Sample No: P-12
Date Sampled: 07/09/2009
Sampled By: Drill Crew
Date Received: 07/15/2009
Sampled From: ST-34
Birdseye Road
Depth: Subgrade
Performed by: MBK/SKG
Date Performed: 08/06/2009

**Comments**

**Remarks**


SK GEOTECHNICAL
2611 Gabel Road
P. O. Box 80190
Billings, MT 59108-0190
Phone: 406.652.3930
Fax: 406.652.3944

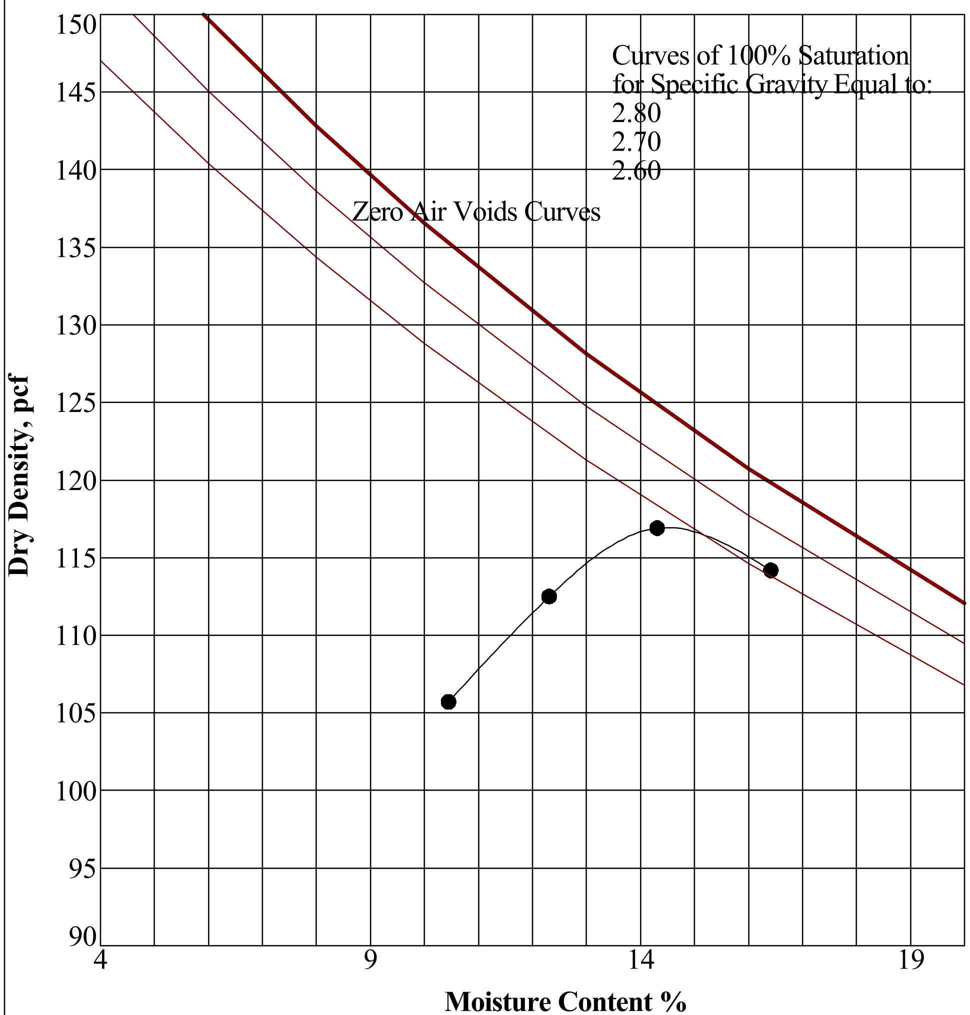

**Laboratory Compaction Characteristics of Soil (Proctor)**

Project No.: 09-2560
Lewis and Clark County Roads
Helena, Montana

**PROCTOR**

P-12

10/22/09




ASTM D 698 Method C

| Maximum Dry Density, pcf | Optimum Moisture Content % |
|---|---|
| **117.0** | **14.5** |

Rammer Type: Mechanical
Preparation Method: Moist

**Soil Description (Visual-Manual)**

**CLAYEY SAND**, fine- to coarse-grained, low plasticity, brown.

| Sieve Size | % Retained |
|---|---|
| 1 1/2" | 0 |
| 3/4" | 0 |
| 3/8" | 3 |
| #4 | 10 |

| | |
|---|---|
| Sample No: | --- |
| Lab Sample No: | P-13 |
| Date Sampled: | 07/09/2009 |
| Sampled By: | Drill Crew |
| Date Received: | 07/15/2009 |
| Sampled From: | ST-38<br>Birsdeye Road |
| Depth: | Subgrade |
| Performed by: | MBK/SKG |
| Date Performed: | 08/06/2009 |

**Comments**

**Remarks**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2611 Gabel Road
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Billings, MT 59108-0190
Phone: 406.652.3930
Fax: 406.652.3944

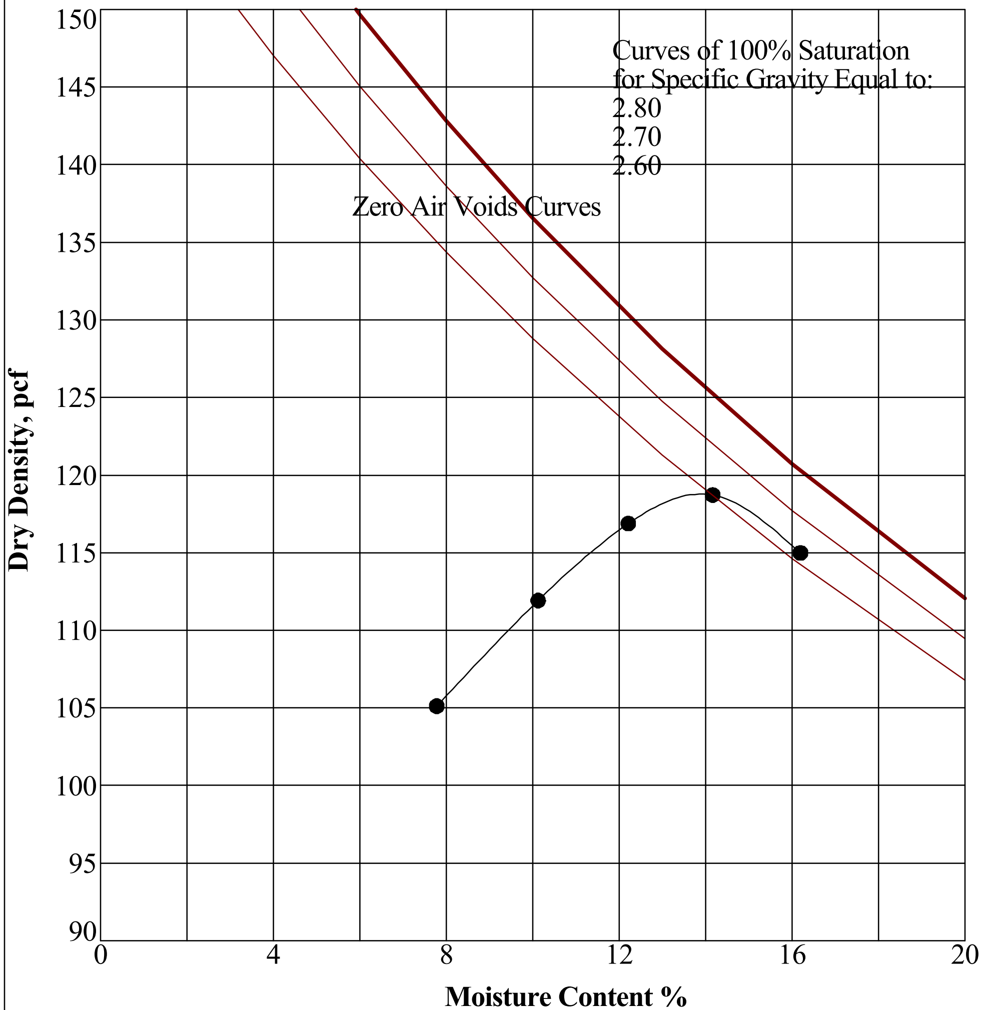

**Laboratory Compaction Characteristics of Soil (Proctor)**

Project No.: 09-2560
Lewis and Clark County Roads
Helena, Montana

**PROCTOR**

P-13

10/22/09




ASTM D 698 Method A

| Maximum Dry Density, pcf | Optimum Moisture Content % |
|---|---|
| **118.7** | **14.0** |

Rammer Type: Mechanical
Preparation Method: Moist

**Soil Description (Visual-Manual)**

**SANDY LEAN CLAY**, low plasticity, brown, moist.

| Sieve Size | % Retained |
|---|---|
| 1 1/2" | 0 |
| 3/4" | 0 |
| 3/8" | 2 |
| #4 | 4.9 |

Sample No: ---

Lab Sample No: P-11

Date Sampled: 07/08/2009

Sampled By: Drill Crew

Date Received: 07/15/2009

Sampled From: ST-27 and ST-28 Birdseye Road

Depth: Subgrade

Performed by: MBK/SKG

Date Performed: 08/06/2009

**Comments**

**Remarks**

SK GEOTECHNICAL
2611 Gabel Road
P. O. Box 80190
Billings, MT 59108-0190
Phone: 406.652.3930
Fax: 406.652.3944

**Laboratory Compaction Characteristics of Soil (Proctor)**

Project No.: 09-2560
Lewis and Clark County Roads
Helena, Montana

**PROCTOR**

P-11

10/22/09

# California Bearing Ratio Test

**(ASTM D 1883 /AASHTO T 193)**

**Project:** 09-2560 Lewis and Clark County Roads
Birdseye Road

**Date:** 10/22/09

**Boring:** ST-34 **Sample:** P-12 **Depth:** Subgrade

**Sample Description:** Clayey Sand, fine- to coarse-grained, low plasticity, light brown, moist.
(Remolded to 95% relative compaction.)
(Sample was submersed in water and allowed to saturate for 96.1 hours.)

Maximum Dry Density: 115.8 pcf Procedure: ASTM D 698 Method C

| **Initial** | | | **Final** | | |
|---|---|---|---|---|---|
| Wt. Specimen + Tare Wet | 689.1 | gms | Wt. Specimen + Tare Wet | 1005.8 | gms |
| Wt. Specimen + Tare Dry | 642.7 | gms | Wt. Specimen + Tare Dry | 886.5 | gms |
| Wt. Tare | 305.1 | gms | Wt. Tare | 242.8 | gms |
| Moisture Content | 13.7% | | Moisture Content | 18.5% | |

Initial Wt. 4255.3 gms Diameter 6.00 in Initial Ht. 4.58 in

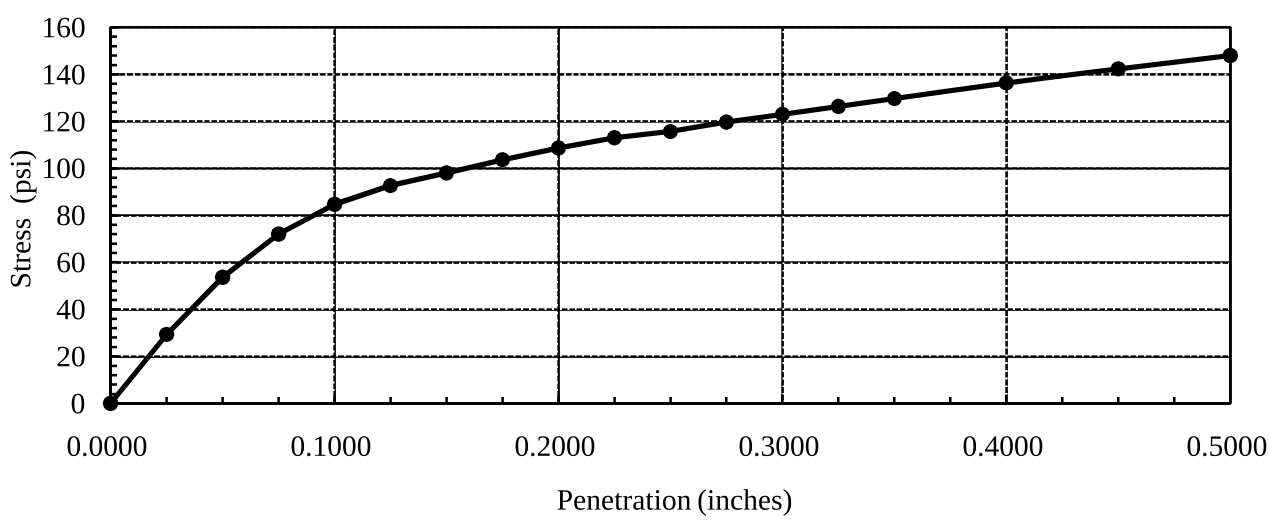
Initial Dry Unit Wt. 110.1 pcf Initial Relative Compaction 95.0%
Final Dry Unit Wt. 109.2 pcf Final Relative Compaction 94.3%

**Swell Test**

Surcharge Weight 22.5 lbs Surcharge Pressure 133.4 psf
Initial Dial Rdg. 0.5000 Final Dial Rdg. 0.5358 Swell 0.8%

**CBR Test**

Surcharge Weight 22.5 lbs Surcharge Pressure 128.1 psf
CBR @ 0.1 in. **8.5** CBR @ 0.2 in **7.2**



# California Bearing Ratio Test

**(ASTM D 1883 /AASHTO T 193)**

**Project:** 09-2560 Lewis and Clark County Roads
Birdseye Road

**Date:** 10/22/09

**Boring:** ST-38 **Sample:** P-13 **Depth:** Subgrade

**Sample Description:** Clayey Sand, fine- to coarse-grained, low plasticity, brown.
(Remolded to 95% relative compaction.)
(Sample was submersed in water and allowed to saturate for 96.4 hours.)

Maximum Dry Density: 117.0 pcf Procedure: ASTM D 698 Method C

| **Initial** | | | **Final** | | |
|---|---|---|---|---|---|
| Wt. Specimen + Tare Wet | 580.0 | gms | Wt. Specimen + Tare Wet | 1072.2 | gms |
| Wt. Specimen + Tare Dry | 545.6 | gms | Wt. Specimen + Tare Dry | 950.8 | gms |
| Wt. Tare | 306.5 | gms | Wt. Tare | 264.8 | gms |
| Moisture Content | 14.4% | | Moisture Content | 17.7% | |

Initial Wt. 4333.4 gms Diameter 6.00 in Initial Ht. 4.58 in

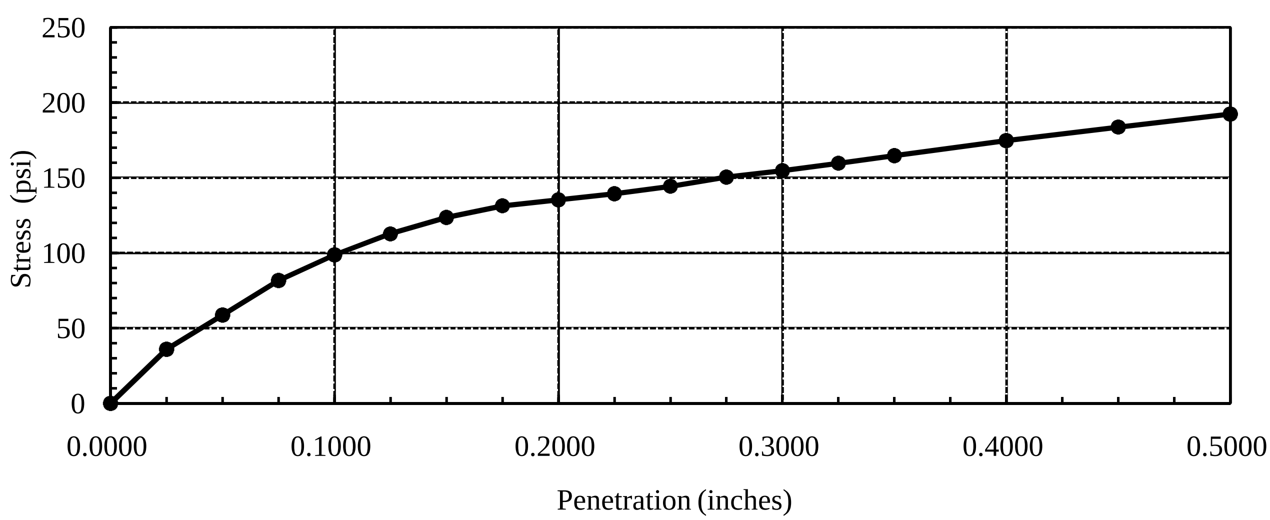
Initial Dry Unit Wt. 111.4 pcf Initial Relative Compaction 95.3%
Final Dry Unit Wt. 111.1 pcf Final Relative Compaction 94.9%

**Swell Test**

Surcharge Weight 22.5 lbs Surcharge Pressure 133.4 psf
Initial Dial Rdg. 0.5000 Final Dial Rdg. 0.5162 Swell 0.4%

**CBR Test**

Surcharge Weight 22.5 lbs Surcharge Pressure 128.1 psf
CBR @ 0.1 in. **9.9** CBR @ 0.2 in **9.0**



# California Bearing Ratio Test

**(ASTM D 1883 /AASHTO T 193)**

**Project:** 09-2560 Lewis and Clark County Roads
Birdseye Road

**Date:** 10/22/09

**Boring:** ST-27 and ST-28 **Sample:** P-11 **Depth:** Subgrade

**Sample Description:** Sandy Lean Clay, low plasticity, brown, moist.
(Remolded to 95% relative compaction.)
(Sample was submersed in water and allowed to saturate for 96.0 hours.)

Maximum Dry Density: 118.7 pcf Procedure: ASTM D 698 Method A

| Initial | | | Final | | |
|---|---|---|---|---|---|
| Wt. Specimen + Tare Wet | 507.5 | gms | Wt. Specimen + Tare Wet | 970.6 | gms |
| Wt. Specimen + Tare Dry | 464.5 | gms | Wt. Specimen + Tare Dry | 871.8 | gms |
| Wt. Tare | 138.8 | gms | Wt. Tare | 292.6 | gms |
| Moisture Content | 13.2% | | Moisture Content | 17.1% | |

Initial Wt. 4342.7 gms Diameter 6.00 in Initial Ht. 4.58 in

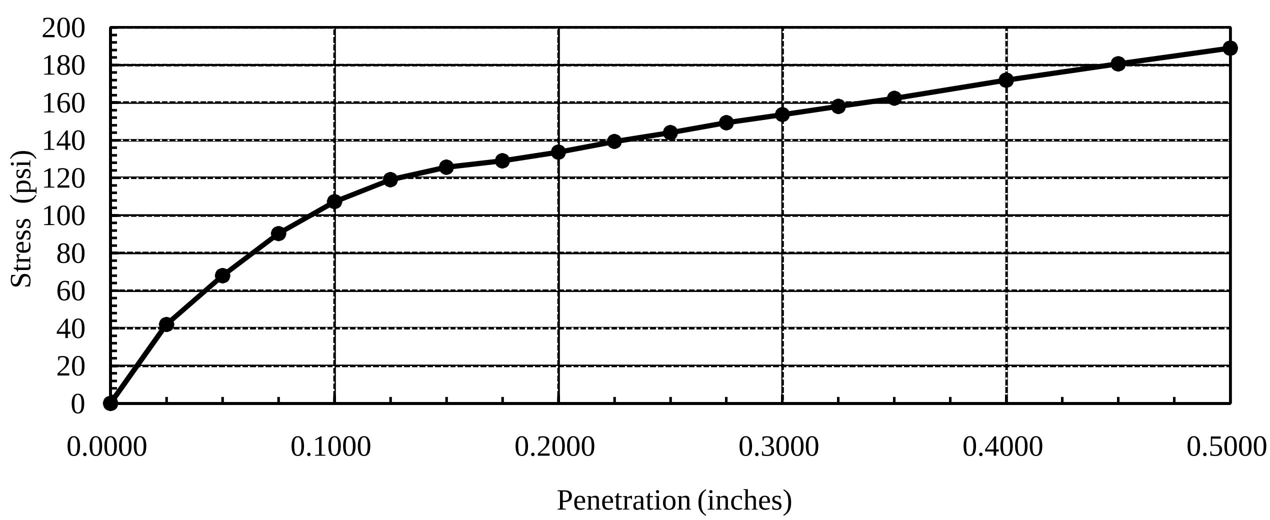
Initial Dry Unit Wt. 112.9 pcf Initial Relative Compaction 95.1%
Final Dry Unit Wt. 112.4 pcf Final Relative Compaction 94.7%

**Swell Test**

Surcharge Weight 22.5 lbs Surcharge Pressure 133.4 psf
Initial Dial Rdg. 0.5000 Final Dial Rdg. 0.5172 Swell 0.4%

**CBR Test**

Surcharge Weight 22.5 lbs Surcharge Pressure 128.1 psf
CBR @ 0.1 in. **10.7** CBR @ 0.2 in **8.9**



# Laboratory Test of Aggregate

**Date:** October 22, 2009

**Project:** **09-2560 Pavement Evaluation**
Birdseye Road
Lewis and Clark County Road
Improvement Projects
Helena, Montana

**To:** Mr. Tom Cavanaugh
Robert Peccia & Associates
P. O. Box 5653
Helena, Montana 59604-5653

**Copies:**

**Gradation (ASTM C 136)**

| | | | 12/18/2007 Lewis and Clark Subdivision | |
|---|---|---|---|---|
| **Sieve Size** | **ST-27 Base Course** | **ST-34 Base Courses** | **Crushed Top Surfacing** | **Select Base Course** |
| 1 1/2" | 100 | 100 | --- | 100 |
| 3/4" | 99 | 98 | 100 | --- |
| 1/2" | 94 | 84 | --- | --- |
| No. 4 | 68 | 54 | 40 – 70 | 25 – 60 |
| No. 10 | 52 | 38 | 25 – 55 | --- |
| No. 40 | 33 | 19 | --- | --- |
| No. 100 | 24 | 12 | --- | --- |
| No. 200 | 18.9* | 9.8 | 2 – 10 | 2 – 12 |

**Remarks:** *Do not meet specifications.

Birdseye Drive



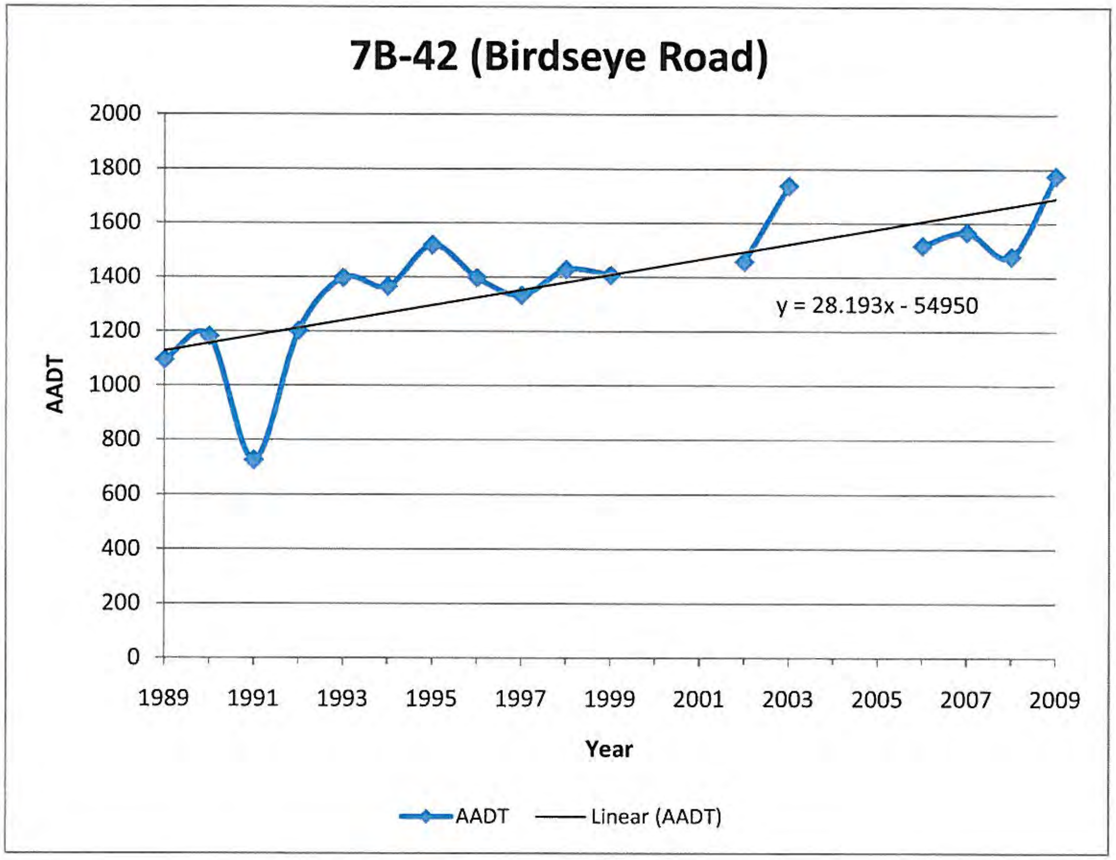
# Basic Axle Class Summary: 7B-42 CLASS

| (DEFAULTB) Description | Lane | #1 Cycle | #2 Cars | #3 2A-4T | #4 Buses | #5 2A-SU | #6 3A-SU | #7 4A-SU | #8 4A-ST | #9 5A-ST | #10 6A-ST | #11 5A-MT | #12 6A-MT | #13 Other | Error | Total |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| TOTAL COUNT : | #1. | 33 | 1014 | 667 | 0 | 5 | 35 | 2 | 5 | 4 | 0 | 0 | 0 | 1 | 36 | 1802 |
| | #2. | 34 | 1146 | 656 | 0 | 3 | 30 | 1 | 14 | 3 | 1 | 2 | 1 | 3 | 33 | 1927 |
| | | 67 | 2160 | 1323 | 0 | 8 | 65 | 3 | 19 | 7 | 1 | 2 | 1 | 4 | 69 | 3729 |
| Percents : | #1. | 2% | 56% | 37% | 0% | 0% | 2% | 0% | 0% | 0% | 0% | 0% | 0% | 0% | 2% | 48% |
| | #2. | 2% | 59% | 34% | 0% | 0% | 2% | 0% | 1% | 0% | 0% | 0% | 0% | 0% | 2% | 52% |
| | | 2% | 58% | 35% | 0% | 0% | 2% | 0% | 1% | 0% | 0% | 0% | 0% | 0% | 2% | |
| Average : | #1. | 1 | 23 | 15 | 0 | 0 | 1 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 1 | 41 |
| | #2. | 1 | 26 | 15 | 0 | 0 | 1 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 1 | 44 |
| | | 2 | 49 | 30 | 0 | 0 | 2 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 2 | 85 |
| Days & ADT : | #1. | 1.8 | 982 | | | | | | | | | | | | | |
| | #2. | 1.8 | 1051 | | | | | | | | | | | | | |
| | | 1.8 | 2033 | | | | | | | | | | | | | |

**7B-42 (Birdseye Road - North of Barrett Road)**

| Year | AADT |
|---|---|
| 1989 | 1094 |
| 1990 | 1180 |
| 1991 | 726 |
| 1992 | 1200 |
| 1993 | 1396 |
| 1994 | 1364 |
| 1995 | 1517 |
| 1996 | 1396 |
| 1997 | 1332 |
| 1998 | 1426 |
| 1999 | 1406 |
| 2000 | |
| 2001 | |
| 2002 | 1456 |
| 2003 | 1736 |
| 2004 | |
| 2005 | |
| 2006 | 1515 |
| 2007 | 1564 |
| 2008 | 1475 |
| 2009 | 1773 |
| **2029** | **2254** |

| | |
|---|---|
| 2009 | 1690 |
| 2029 | 2254 |
| Yearly Growth Rate | 1.45% |



| Class | Type | Description | Typical ESALs per Vehicle[2] |
|---|---|---|---|
| 1 | Motorcycles | All two- or three-wheeled motorized vehicles. Typical vehicles in this category have saddle type seats and are steered by handle bars rather than wheels. This category includes motorcycles, motor scooters, mopeds, motor-powered bicycles, and three-wheel motorcycles. This vehicle type may be reported at the option of the State. | 0,0 negligible |
| 2 | Passenger Cars | All sedans, coupes, and station wagons manufactured primarily for the purpose of carrying passengers and including those passenger cars pulling recreational or other light trailers. | 0,0003 negligible Table 0.4 |
| 3 | Other Two-Axle, Four-Tire Single Unit Vehicles | All two-axle, four tire, vehicles, other than passenger cars. Included in this classification are pickups, panels, vans, and other vehicles such as campers, motor homes, ambulances, hearses, and carryalls. Other two-axle, four-tire single unit vehicles pulling recreational or other light trailers are included in this classification. | 0,004 negligible Table 0.4 |
| 4 | Buses | All vehicles manufactured as traditional passenger-carrying buses with two axles and six tires or three or more axles. This category includes only traditional buses (including school buses) functioning as passenger-carrying vehicles. All two-axle, four-tire single unit vehicles. Modified buses should be considered to be a truck and be appropriately classified. | 0.57 |
| 5 | Two-Axle, Six-Tire, Single Unit Trucks | All vehicles on a single frame including trucks, camping and recreational vehicles, motor homes, etc., having two axles and dual rear wheels. | 0.26 |
| 6 | Three-Axle Single Unit Trucks | All vehicles on a single frame including trucks, camping and recreational vehicles, motor homes, etc., having three axles. | 0.42 |
| 7 | Four or More Axle Single Unit Trucks | All trucks on a single frame with four or more axles. | 0.42 |
| 8 | Four or Less Axle Single Trailer Trucks | All vehicles with four or less axles consisting of two units, one of which is a tractor or straight truck power unit. | 0.30 |
| 9 | Five-Axle Single Trailer Trucks | All five-axle vehicles consisting of two units, one of which is a tractor or straight truck power unit. | 1.20 |
| 10 | Six or More Axle Single Trailer Trucks | All vehicles with six or more axles consisting of two units, one of which is a tractor or straight truck power unit. | 0.93 |
| 11 | Five or Less Axle Multi-Trailer Trucks | All vehicles with five or less axles consisting of three or more units, one of which is a tractor or straight truck power unit. | 0.82 |
| 12 | Six-Axle Multi-Trailer Trucks | All six-axle vehicles consisting of three or more units, one of which is a tractor or straight truck power unit. | 1.06 |

| | | | |
|---|---|---|---|
| 13 | Seven or More Axle Multi-Trailer Trucks | All vehicles with seven or more axles consisting of three or more units, one of which is a tractor or straight truck power unit. | 1.39 |

Note 1: In reporting information on trucks the following criteria should used:

1. Truck tractor units traveling without a trailer will be considered single unit trucks.
2. A truck tractor unit pulling other such units in a "saddle mount" configuration will be considered as one single unit truck and will be defined only by the axles on the pulling unit.
3. Vehicles shall be defined by the number of axles in contact with the roadway. Therefore, "floating" axles are counted only when in the down position.
4. The term "trailer" includes both semi- and full trailers.

Note 2: Based on the overall ESAL per vehicle class for 10 weigh-in-motion (WIM) sites averaged over a one-year period. The averaging method treats all pavements the same (i.e., no separate LEFs for flexible and rigid pavements) and all axles as singles. This approach produces LEFs similar to the 1993 AASHTO Guide's LEFs for single axles assuming SN = 5 and $p_t$ = 2.5.

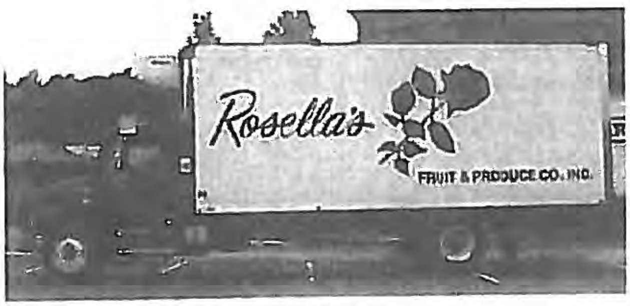



**Figure 4: FHWA Class 5**

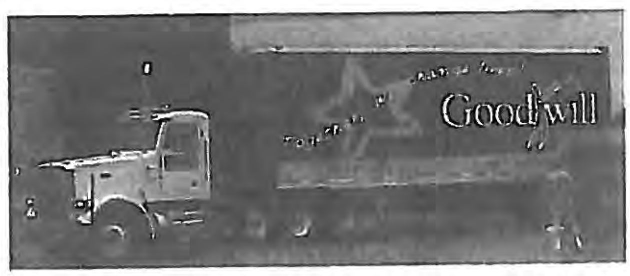



**Figure 5: FHWA Class 8**

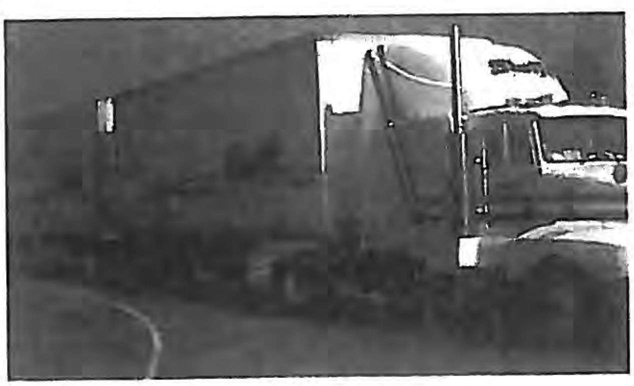


**Figure 6: FHWA Class 11**

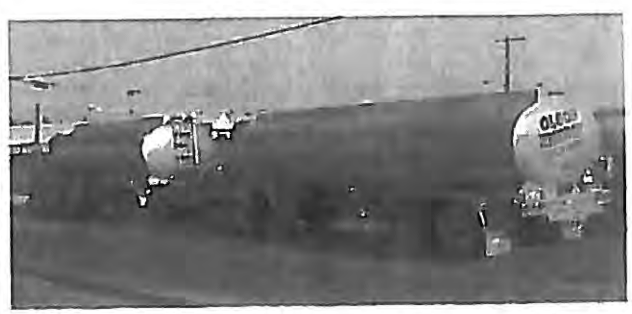


**Figure 7: FHWA Class 10**

==================================================

DARWin(tm) - Pavement Design

A Proprietary AASHTOWARE(tm)
Computer Software Product

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Flexible Structural Design Module

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Project Description
Birdseye Drive, Lewis and Clark County, Helena, Montana

Flexible Structural Design Module Data
18-kip ESALs Over Initial Performance Period: 112,008
Initial Serviceability: 4.2
Terminal Serviceability: 2.5
Reliability Level (%): 85
Overall Standard Deviation: .45
Roadbed Soil Resilient Modulus (PSI): 10,500
Stage Construction: 1

Calculated Structural Number: 2.03

Specified Layer Design
Layer: 1
Material Description: Asphalt Pavement
Structural Coefficient (Ai): .41
Drainage Coefficient (Mi): 1
Layer Thickness (Di) (in): 3.00
Calculated Layer SN: 1.23

Layer: 2
Material Description: Crushed Top Surfacing
Structural Coefficient (Ai): .14
Drainage Coefficient (Mi): 1
Layer Thickness (Di) (in): 3.00
Calculated Layer SN: .42

Layer: 3
Material Description: Select Base Course
Structural Coefficient (Ai): .07
Drainage Coefficient (Mi): .9
Layer Thickness (Di) (in): 6.00
Calculated Layer SN: .38

Layer: 4
Material Description: Subbase Course
Structural Coefficient (Ai): .07
Drainage Coefficient (Mi): .9
Layer Thickness (Di) (in): .00
Calculated Layer SN: .00

Total Thickness (in): 12.00
Total Calculated SN: 2.03

Rigorous ESAL Calculation
Initial Performance Period (years): 20
Initial Two-Way Daily Traffic (ADT): 1,690
Number of Lanes In Design Direction: 1
Percent of All Trucks In Design Lane (%): 50
Percent Trucks In Design Direction (%): 100
Growth: Simple

Class: 1

% of ADT: 1.83
Annual % Growth: 1.45
Average Initial Truck Factor (ESALs/truck): .0001
Annual % Growth in Truck Factor: 0
Accumulated 18K ESALs over Performance Period: 13

Class: 2
% of ADT: 59.08
Annual % Growth: 1.45
Average Initial Truck Factor (ESALs/truck): .0003
Annual % Growth in Truck Factor: 0
Accumulated 18K ESALs over Performance Period: 1,245

Class: 3
% of ADT: 36.14
Annual % Growth: 1.45
Average Initial Truck Factor (ESALs/truck): .004
Annual % Growth in Truck Factor: 0
Accumulated 18K ESALs over Performance Period: 10,152

Class: 4
% of ADT: 0
Annual % Growth: 1.45
Average Initial Truck Factor (ESALs/truck): .57
Annual % Growth in Truck Factor: 0
Accumulated 18K ESALs over Performance Period: 0

Class: 5
% of ADT: .21
Annual % Growth: 1.45
Average Initial Truck Factor (ESALs/truck): .26
Annual % Growth in Truck Factor: 0
Accumulated 18K ESALs over Performance Period: 3,835

Class: 6
% of ADT: 1.77
Annual % Growth: 1.45
Average Initial Truck Factor (ESALs/truck): .42
Annual % Growth in Truck Factor: 0
Accumulated 18K ESALs over Performance Period: 52,209

Class: 7
% of ADT: .08
Annual % Growth: 1.45
Average Initial Truck Factor (ESALs/truck): .42
Annual % Growth in Truck Factor: 0
Accumulated 18K ESALs over Performance Period: 2,360

Class: 8
% of ADT: .51
Annual % Growth: 1.45
Average Initial Truck Factor (ESALs/truck): .3
Annual % Growth in Truck Factor: 0
Accumulated 18K ESALs over Performance Period: 10,745

Class: 9
% of ADT: .19
Annual % Growth: 1.45
Average Initial Truck Factor (ESALs/truck): 1.2
Annual % Growth in Truck Factor: 0
Accumulated 18K ESALs over Performance Period: 16,012

Class: 10
% of ADT: .02
Annual % Growth: 1.45
Average Initial Truck Factor (ESALs/truck): .93
Annual % Growth in Truck Factor: 0
Accumulated 18K ESALs over Performance Period: 1,306

Class: 11
% of ADT: .05
Annual % Growth: 1.45
Average Initial Truck Factor (ESALs/truck): .82
Annual % Growth in Truck Factor: 0
Accumulated 18K ESALs over Performance Period: 2,879

Class: 12
% of ADT: .02
Annual % Growth: 1.45
Average Initial Truck Factor (ESALs/truck): 1.06
Annual % Growth in Truck Factor: 0
Accumulated 18K ESALs over Performance Period: 1,489

Class: 13
% of ADT: .1
Annual % Growth: 1.45
Average Initial Truck Factor (ESALs/truck): 1.39
Annual % Growth in Truck Factor: 0
Accumulated 18K ESALs over Performance Period: 9,762

Total % of ADT (should be 100): 100.00
Cumulative Esals for all Classes: 112,008

# Appendix D

## Cost Estimates

#

## Birdseye Road Reconstruction Cost Estimate

| Major Work Feature | Unit | Unit Cost | Number of Units: Typical A | Typical B | Typical C | Typical D | Typical E | Total | Total Cost |
|---|---|---|---|---|---|---|---|---|---|
| Survey - Staking and Grade Control | MI | $15,000.00 | 1.80 | 2.00 | 2.10 | 1.90 | 2.25 | 10.05 | $150,750 |
| Borrow for Embankment | CY | $7.00 | 280 | 19,460 | 0 | 2,000 | 0 | 21,740 | $152,180 |
| Topsoil - Salvage and Place | CY | $4.05 | 4,400 | 6,844 | 4,107 | 5,573 | 4,400 | 25,324 | $102,564 |
| Excavation - Unclassified | CY | $5.50 | 23,456 | 236,280 | 41,509 | 139,212 | 43,093 | 483,551 | $2,659,531 |
| MPDES Permit Fees | LS | $900.00 | 1 | 1 | 1 | 1 | 1 | 5 | $4,500 |
| Temporary Erosion Control - LS | LS | $4,000.00 | 1 | 1 | 1 | 1 | 1 | 5 | $20,000 |
| Select Base Course | CY | $12.00 | 7,427 | 7,905 | 7,905 | 7,152 | 8,470 | 38,860 | $466,324 |
| Crushed Top Course | CY | $25.41 | 3,465 | 4,038 | 4,078 | 3,659 | 4,167 | 19,407 | $493,132 |
| Aggregate Treatment (Prime) | SY | $0.41 | 37,393 | 42,110 | 42,110 | 38,099 | 45,118 | 204,829 | $83,980 |
| Asphalt Tack Coat | SY | $0.10 | 35,598 | 40,767 | 40,767 | 36,884 | 43,679 | 197,695 | $19,769 |
| Chip Seal & Cover | SY | $2.00 | 33,792 | 39,424 | 39,424 | 35,669 | 42,240 | 190,549 | $381,099 |
| Plant Mix Asphalt Paving | Ton | $81.38 | 5,911 | 6,947 | 6,985 | 6,305 | 7,300 | 33,448 | $2,722,008 |
| Reset Mailbox | Each | $200.83 | 5 | 11 | 12 | 10 | 8 | 45 | $8,937 |
| Traffic Gravel | CY | $19.03 | 2,581 | 3,011 | 3,011 | 2,725 | 3,227 | 14,555 | $276,984 |
| Remove/Reset Signs | Each | $184.30 | 16 | 4 | 2 | 17 | 9 | 48 | $8,846 |
| Interim Striping - Yellow Paint | Gal | $34.18 | 76 | 89 | 89 | 80 | 95 | 429 | $14,654 |
| Final Striping - Yellow Paint | Gal | $34.18 | 76 | 89 | 89 | 80 | 95 | 429 | $14,654 |
| Interim Striping - White Paint | Gal | $34.30 | 76 | 89 | 89 | 80 | 95 | 429 | $14,706 |
| Final Striping - White Paint | Gal | $34.30 | 76 | 89 | 89 | 80 | 95 | 429 | $14,706 |
| Remove Existing Culverts | LF | $12.27 | 838 | 1,147 | 973 | 1,012 | 961 | 4,931 | $60,503 |
| Approach/Relief Drain Pipe - 18/24 In.Dia. | LF | $50.17 | 350 | 735 | 805 | 700 | 525 | 3,115 | $156,280 |
| Drainage Pipe 24 Inch Dia. | LF | $50.00 | 316 | 212 | 112 | 212 | 336 | 1,188 | $59,400 |
| Drainage Pipe 36 Inch Dia. | LF | $96.79 | 172 | 200 | 56 | 100 | 100 | 628 | $60,784 |
| Drainage Pipe 48 Inch Dia. | LF | $134.68 | 0 | 212 | 0 | 0 | 0 | 212 | $28,552 |
| Farm Fence - Type Type 5M | LF | $2.25 | 600 | 22,176 | 22,176 | 20,064 | 23,760 | 88,776 | $199,746 |
| Fence Panel | Each | $145.92 | 2 | 67 | 67 | 61 | 72 | 269 | $39,255 |
| Seeding | Acre | $294.16 | 10.91 | 17.82 | 10.18 | 13.82 | 10.91 | 63.64 | $18,719 |
| Fertilize Seed | Acre | $120.84 | 10.91 | 17.82 | 10.18 | 13.82 | 10.91 | 63.64 | $7,690 |
| Condition Seedbed Surface | Acre | $221.51 | 10.91 | 17.82 | 10.18 | 13.82 | 10.91 | 63.64 | $14,096 |
| Geotextile - Subgrade Stabilization | SY | $1.50 | 21,120 | 9,856 | 22,866 | 22,472 | 28,301 | 104,614 | $156,922 |
| Subgrade Stabilization Gravel (14 - inch Depth) | CY | $8.00 | 8,213 | 3,833 | 8,892 | 8,739 | 11,006 | 40,683 | $325,467 |
| Subexcavation | CY | $5.50 | 8,213 | 3,833 | 8,892 | 8,739 | 11,006 | 40,683 | $223,759 |
| **Subtotal - Construction** | **$/Segment** | | **$1,200,223** | **$2,680,741** | **$1,504,485** | **$1,968,462** | **$1,606,584** | | **$8,960,496** |
| Final Engineering, Geotec. & Survey | LS | 8.00% | $96,018 | $214,459 | $120,359 | $157,477 | $128,527 | | $716,840 |
| Construction QA/QC | LS | 4.00% | $48,009 | $107,230 | $60,179 | $78,738 | $64,263 | | $358,420 |
| Contractor Mobilization | LS | 5.00% | $60,011 | $134,037 | $75,224 | $98,423 | $80,329 | | $448,025 |
| Contingency | LS | 10.00% | $120,022 | $268,074 | $150,449 | $196,846 | $160,658 | | $896,050 |
| Traffic Control During Construction | LS | 8.00% | $96,018 | $214,459 | $120,359 | $157,477 | $128,527 | | $716,840 |
| Right-of-Way Appraisals by Agent | Each | $2,000.00 | 0 | 30 | 46 | 23 | 20 | 119 | $238,000 |
| Right-of-Way Acquisition by Agent | Each | $1,500.00 | 0 | 30 | 46 | 23 | 20 | 119 | $178,500 |
| Purchase Right-of-Way | Acre | $32,000.00 | 0.00 | 6.00 | 7.15 | 7.36 | 4.48 | 24.99 | $799,680 |
| **Total Estimated Cost (2011)** | **$/Segment** | | **$ 1,620,302** | **$ 3,916,001** | **$ 2,420,855** | **$ 2,973,443** | **$ 2,382,249** | | **$13,312,850** |

**Unit Costs are 2010 Estimates. The County may peridically update unit prices.**

## Additional Alternate Costs

| Major Work Feature | Unit | Unit Cost | Number of Units: Typical A | Typical B | Typical C | Typical D | Typical E | Total | Total Cost |
|---|---|---|---|---|---|---|---|---|---|
| Traffic Signal | LS | $68,000.00 | - | - | - | - | - | 1 | $68,000 |
| Turn Lane | LS | $110,000.00 | - | - | - | - | - | 1 | $110,000 |
| Sanitary Sewer Main | MI | $211,200.00 | 1.80 | 2.00 | 2.10 | 1.90 | 2.25 | 10.05 | $2,122,560 |
| Water Main | MI | $396,000.00 | 1.80 | 2.00 | 2.10 | 1.90 | 2.25 | 10.05 | $3,979,800 |
| Bicycle/Ped. Path Reconstruction | MI | $77,825.00 | 1.80 | 2.00 | 2.10 | 1.90 | 2.25 | 10.05 | $782,141 |

# Appendix E

## MDT Safety Improvement Project STPHS-HSIP 25(52)


# MONTANA DEPARTMENT OF TRANSPORTATION

## FEDERAL AID PROJECT NO. STPHS - HSIP 25(52)

## 2002-SAFETY IMPROVEMENTS - LEWIS AND CLARK COUNTY

## BIRDSEYE ROAD
## LEWIS AND CLARK COUNTY

LENGTH 0.3 MILES

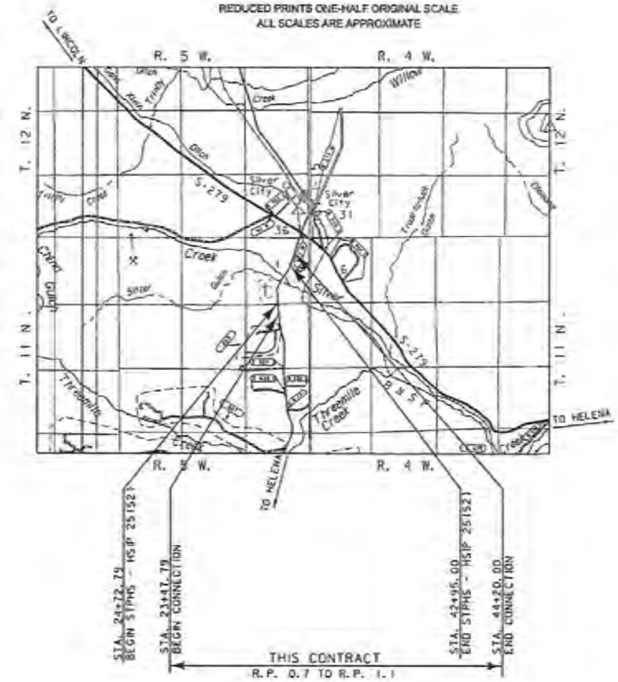
SCALES

HORIZONTAL: 1" = 50'

REDUCED PRINTS ONE-HALF ORIGINAL SCALE
ALL SCALES ARE APPROXIMATE

2005 A.D.T. = 100
2025 A.D.T. = 140
D.H.V. = 20
T. = 5.6%
V. = 50 mph
18 kip ESAL'S = 3
GROWTH RATE = 2.0%

LETTING DATE - ____________




MORRISON-MAIERLE, INC.

BY: [signature]

DATE 8/21/09

SHAHEEN W. SIDDIQUI 16263 PE — MONTANA — PROFESSIONAL ENGINEER

MONTANA DEPARTMENT OF TRANSPORTATION

RECEIVED:

BY [signature] 8/25/09
CONSULTANT DESIGN ENGINEER DATE

U.S. DEPARTMENT OF TRANSPORTATION
FEDERAL HIGHWAY ADMINISTRATION

APPROVED:

DIVISION ADMINISTRATOR DATE

PLANS PREPARED BY

MORRISON-MAIERLE, INC.
1 ENGINEERING PLACE
P.O. BOX 6147
HELENA, MT 59604
PHONE (406) 442-3050
FAX (406) 442-7862

RELATED PROJECTS

| ASSOCIATED PROJECT AGREEMENT NUMBERS | |
|---|---|
| R/W & I.C. | HSIP 25(52) |
| P.E. | STPHS 25(52) |

MONTANA DEPARTMENT OF TRANSPORTATION

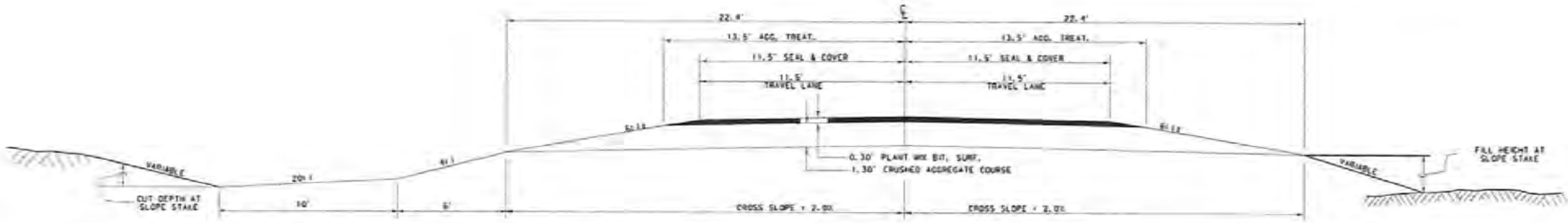
| | | |
|---|---|---|
| \...3284RDT1Ti.Zs1.dgn | DESIGNED BY | |
| 8/21/2009 | REVIEWED BY | |
| 11:18:06 AM | CHECKED BY | |

ROAD PLANS - BIRDSEYE RD
LEWIS & CLARK COUNTY

MORRISON MAIERLE, INC.

# TYPICAL SECTION NO. 1

23+47.79 TYP NO. 1 - BEG. CONNECTION - MATCH EXISTING
23+47.79 TO 24+72.79 TRANS. TYP. NO. 1 TO TYP. NO. 2




| QUANTITIES | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|
| UNIT | AGGREGATE | | | | | UNIT | BITUMINOUS MATERIAL | | AGG. TREAT. |
| | COVER | PLANT MIX | CRUSHED AGGREGATE COURSE | | | | ASPHALT CEMENT | SEAL | |
| AREA SQUARE FEET<br>CUBIC YARDS PER STATION<br>TONS PER STATION<br>SQUARE YARDS PER STATION | <br><br>3.2<br>256 | 7.50<br>27.8<br>53.5 | 46.67<br>172.9 | | | SQUARE YARDS PER STATION<br>TONS PER STATION<br>GALS PER STATION | <br>3.2 | 256<br>0.43 | 300 |

| FILL SLOPES | |
|---|---|
| 0' - 10' | 5:1 |
| 10' - 20' | 4:1 |
| 20' - 30' | 3:1 |
| OVER 30' | 3:1 |

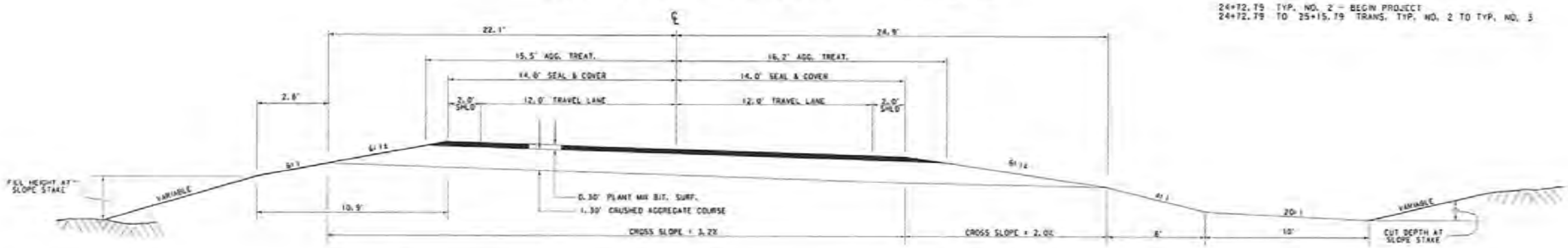
* SEE CROSS SECTIONS FOR DEVIATIONS

| BACK SLOPES | |
|---|---|
| 0' - 5' | 5:1 |
| 5' - 10' | 4:1 |
| 10' - 15' | 3:1 |
| 15' - 20' | 2:1 |
| OVER 20' | 2:1 |

* SEE CROSS SECTIONS FOR DEVIATIONS

# TYPICAL SECTION NO. 2

24+72.79 TYP. NO. 2 - BEGIN PROJECT
24+72.79 TO 25+15.79 TRANS. TYP. NO. 2 TO TYP. NO. 3



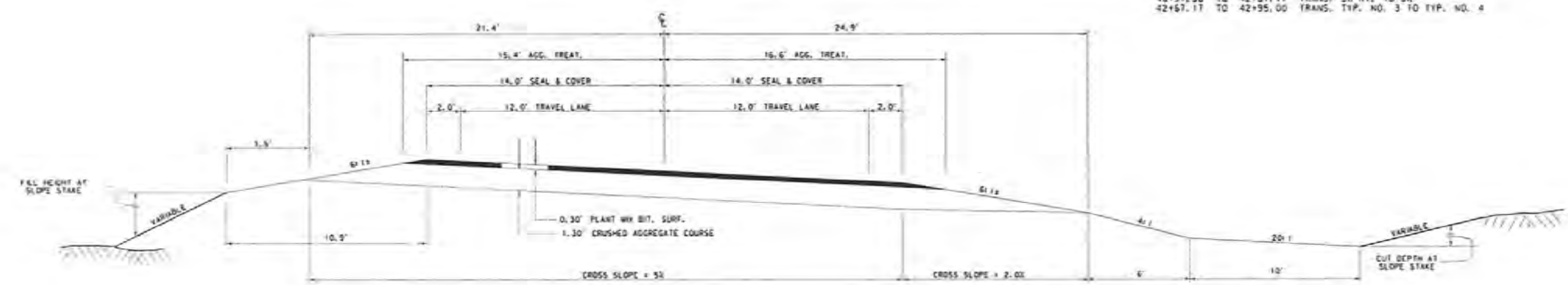

| QUANTITIES | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|
| UNIT | AGGREGATE | | | | | UNIT | BITUMINOUS MATERIAL | | AGG. TREAT. |
| | COVER | PLANT MIX | CRUSHED AGGREGATE COURSE | | | | ASPHALT CEMENT | SEAL | |
| AREA SQUARE FEET<br>CUBIC YARDS PER STATION<br>TONS PER STATION<br>SQUARE YARDS PER STATION | <br><br>3.9<br>311 | 9.00<br>33.3<br>64.3 | 53.17<br>196.9 | | | SQUARE YARDS PER STATION<br>TONS PER STATION<br>GALS PER STATION | <br>3.9 | 311<br>0.53 | 356 |

MORRISON MAIERLE, INC.

| | | | | | |
|---|---|---|---|---|---|
| MONTANA DEPARTMENT OF TRANSPORTATION | 8/28/2003 12:51:15 PM | DESIGNED BY<br>REVIEWED BY<br>CHECKED BY | ROAD PLANS - BIRDSEYE RD<br>LEWIS & CLARK COUNTY | 2002-LEWIS & CLARK COUNTY SAFETY IMPROVEMENTS<br>UPN NUMBER 5384 | HSIP 25(52)<br>SHEET 4 OF 12 |

# TYPICAL SECTION NO. 3

25+15.79 TO 40+97.36 TYP. NO. 3
40+97.36 TO 42+67.17 TRANS. 5% RT. TO 0%
42+67.17 TO 42+95.00 TRANS. TYP. NO. 3 TO TYP. NO. 4




SEE TYPICAL NO. 2 FOR QUANTITIES

| FILL SLOPES | |
|---|---|
| 0' - 10' | 6:1 |
| 10' - 20' | 4:1 |
| 20' - 30' | 3:1 |
| OVER 30' | 3:1 |

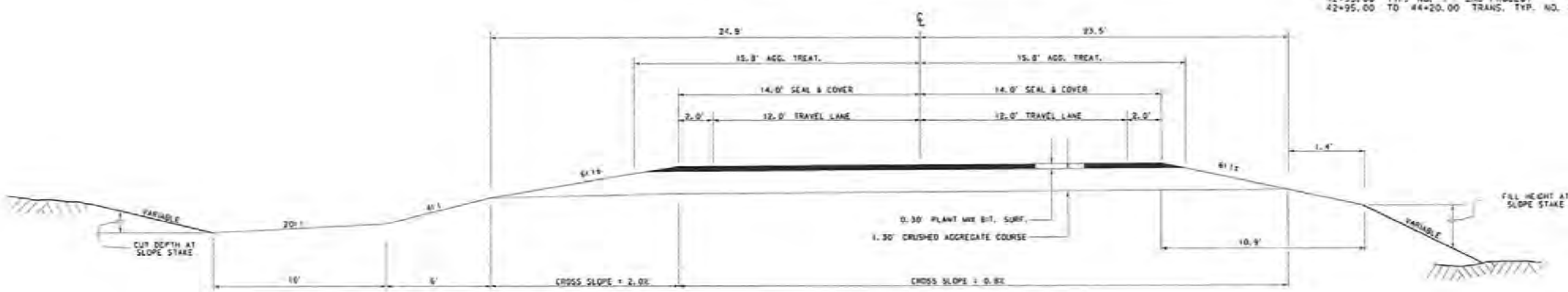
* SEE CROSS SECTIONS FOR DEVIATIONS

| BACK SLOPES | |
|---|---|
| 0' - 5' | 5:1 |
| 5' - 10' | 4:1 |
| 10' - 15' | 3:1 |
| 15' - 20' | 2:1 |
| OVER 20' | 2:1 |

* SEE CROSS SECTIONS FOR DEVIATIONS

# TYPICAL SECTION NO. 4

42+95.00 TYP. NO. 4 / END PROJECT
42+95.00 TO 44+20.00 TRANS. TYP. NO. 4 TO TYP. NO. 5




SEE TYPICAL NO. 2 FOR QUANTITIES

MORRISON MAIERLE, INC.

MONTANA DEPARTMENT OF TRANSPORTATION

DESIGNED BY
REVIEWED BY
CHECKED BY

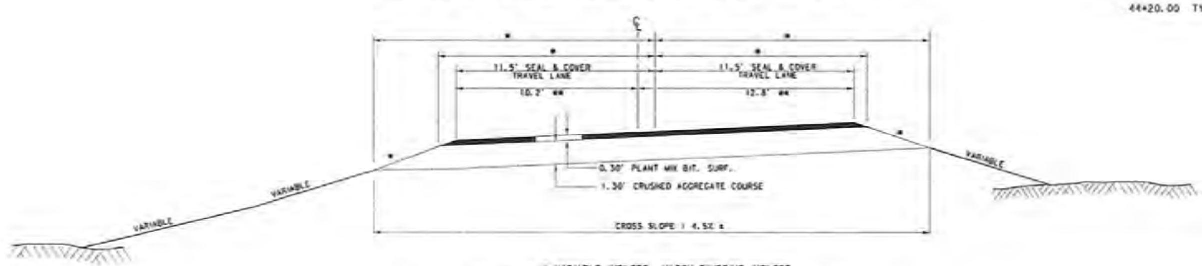
ROAD PLANS - BIRDSEYE RD
LEWIS & CLARK COUNTY

2002-LEWIS & CLARK COUNTY SAFETY IMPROVEMENTS
UPN NUMBER 5384

HSIP 25(52)
SHEET 5 OF 12

# TYPICAL SECTION NO. 5

44+20.00 TYP. NO. 5 - END CONNECTION - MATCH EXISTING




* VARIABLE INSLOPE, MATCH EXISTING INSLOPE

** THE CENTERLINE HORIZONTAL ALIGNMENT IS OFFSET FROM THE ACTUAL CENTER OF THE ROADWAY AT THE PROJECT CONNECTION. PLACE PAVEMENT MARKINGS ON THE ACTUAL CENTERLINE.

NOTE: QUANTITIES ARE BASED ON A 6:1 INSLOPE

SEE TYPICAL NO. 1 FOR QUANTITIES

| FILL SLOPES | |
|---|---|
| 0' - 10' | 6:1 |
| 10' - 20' | 4:1 |
| 20' - 30' | 3:1 |
| OVER 30' | 2:1 |

* SEE CROSS SECTIONS FOR DEVIATIONS

| BACK SLOPES | |
|---|---|
| 0' - 5' | 5:1 |
| 5' - 10' | 4:1 |
| 10' - 15' | 3:1 |
| 15' - 20' | 2:1 |
| OVER 20' | 2:1 |

* SEE CROSS SECTIONS FOR DEVIATIONS

MORRISON MAIERLE, INC.

MONTANA DEPARTMENT OF TRANSPORTATION

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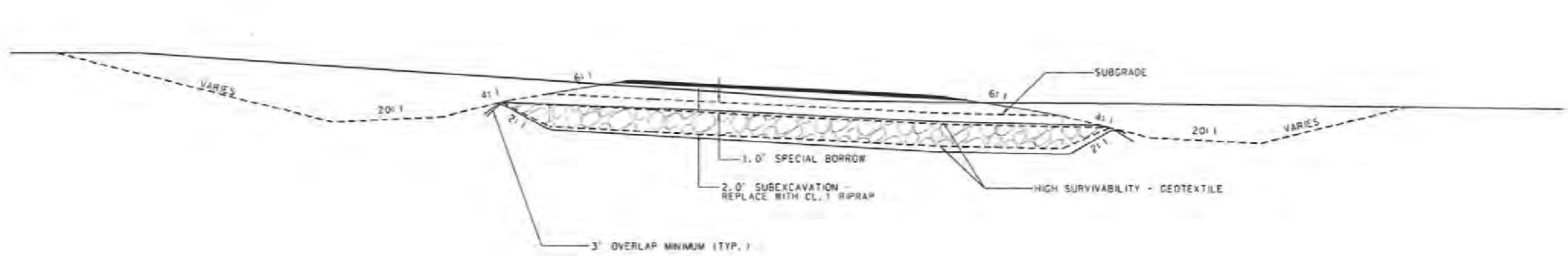
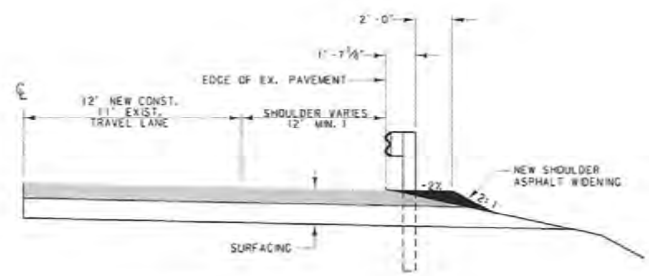
LEWIS & CLARK COUNTY

2002-LEWIS & CLARK COUNTY SAFETY IMPROVEMENTS
HSIP 25(52)
UPN NUMBER 5384
SHEET 6 OF 12




SUBEXCAVATION DETAIL




NOTE: DO NOT DISTURB EXIST. CULVERT AT STA. 44+10. SHORTEN GUARDRAIL POSTS IF NECESSARY

SHOULDER WIDENING 50 : 1 FOR 50'-0" (THIS IS THROUGH THE OPTIONAL TERMINAL SECTION)

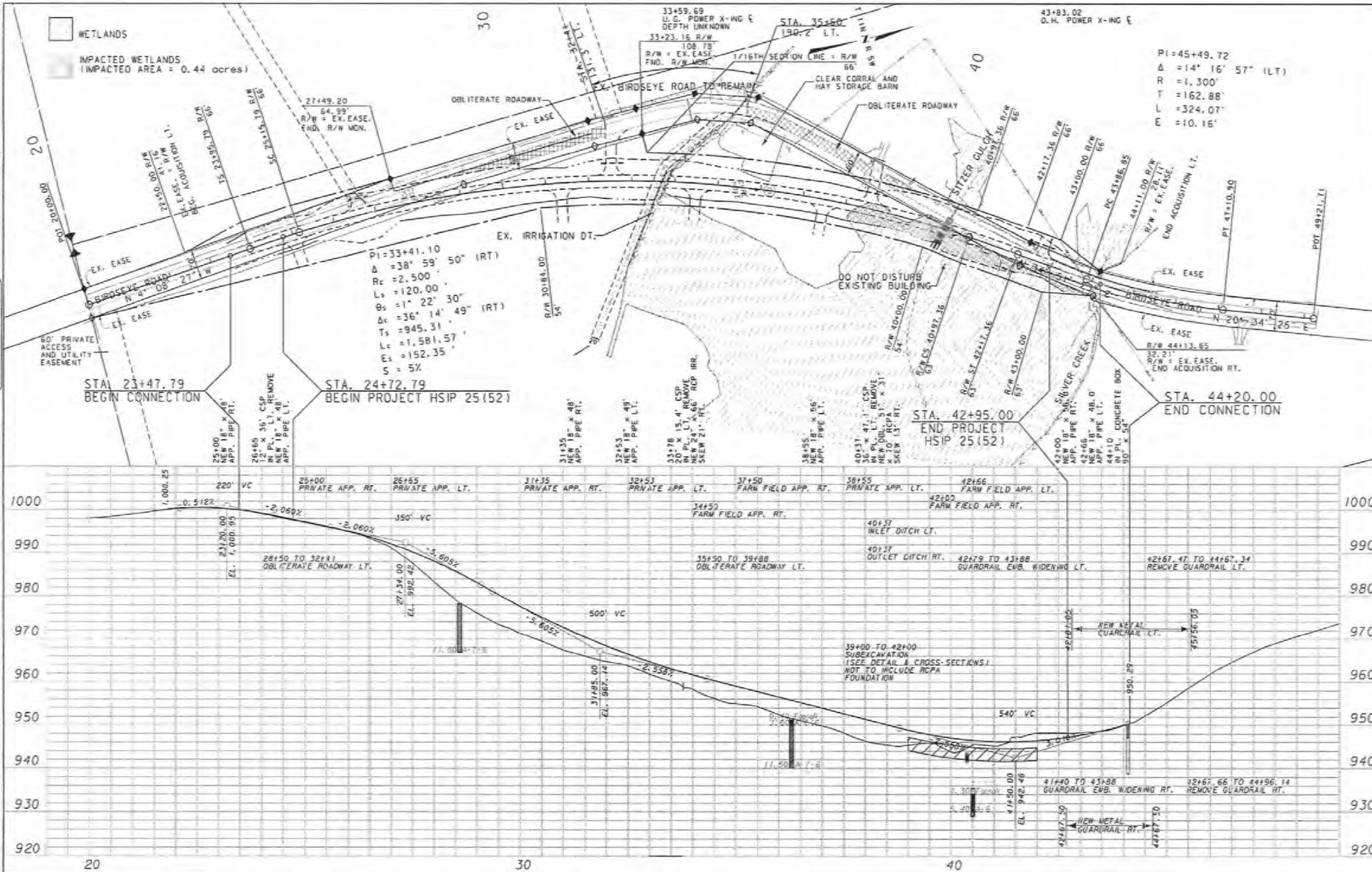
SHOULDER WIDENING DETAIL

SUBEXCAVATION & SHOULDER WIDENING DETAILS

NO SCALE

MORRISON MAIERLE, INC.

| | | | |
|---|---|---|---|
| MONTANA DEPARTMENT OF TRANSPORTATION | ROAD PLANS - BIRDSEYE RD | 2002-LEWIS & CLARK COUNTY SAFETY IMPROVEMENTS | HSIP 25(52) |
| DESIGNED BY / REVIEWED BY / CHECKED BY | LEWIS & CLARK COUNTY | UPN NUMBER 5384 | SHEET 11 OF 12 |




| | | | |
|---|---|---|---|
| MONTANA DEPARTMENT OF TRANSPORTATION | ROAD PLANS - BIRDSEYE RD | 2002-LEWIS & CLARK COUNTY SAFETY IMPROVEMENTS | HSIP 25(52) |
| | LEWIS & CLARK COUNTY | SCALE: 1" = 100' · UPN NUMBER 5384 | SHEET 12 OF 12 |

# MDT Boring Log Descriptive Terminology

*Geotechnical Section*

## Key to Soil Symbols and Terms

### SOIL CLASSIFICATION CHART

| MAJOR DIVISIONS | | | SYMBOLS GRAPH | SYMBOLS LETTER | TYPICAL DESCRIPTIONS |
|---|---|---|---|---|---|
| COARSE GRAINED SOILS<br>MORE THAN 50% OF MATERIAL IS LARGER THAN NO. 200 SIEVE SIZE | GRAVEL AND GRAVELLY SOILS<br>MORE THAN 50% OF COARSE FRACTION RETAINED ON NO. 4 SIEVE | CLEAN GRAVELS (LITTLE OR NO FINES) | | GW | Well-graded gravels, gravel sand mixtures, little or no fines. |
| | | | | GP | Poorly graded gravels, gravel-sand mixtures, little or no fines. |
| | | GRAVELS WITH FINES (APPRECIABLE AMOUNT OF FINES) | | GM | Silty gravels, gravel-sand-silt mixtures. |
| | | | | GC | Clayey gravels, gravel-sand-clay mixtures. |
| | SAND AND SANDY SOILS<br>MORE THAN 50% OF COARSE FRACTION PASSING ON NO. 4 SIEVE | CLEAN SANDS (LITTLE OR NO FINES) | | SW | Well-graded sands, gravelly sands, little or no fines. |
| | | | | SP | Poorly graded sands, gravelly sands, little or no fines. |
| | | SANDS WITH FINES (APPRECIABLE AMOUNT OF FINES) | | SM | Silty sands, sand-silt mixtures. |
| | | | | SC | Clayey sands, sand-clay mixures. |
| FINE GRAINED SOILS<br>MORE THAN 50% OF MATERIAL IS SMALLER THAN NO. 200 SIEVE SIZE | SILTS AND CLAYS | LIQUID LIMIT LESS THAN 50 | | ML | Inorganic silts and very fine sands, rock flour, silty or clayey fine sands or clayey silts with slight plasticity. |
| | | | | CL | Inorganic clays of low to medium plasticity, gravelly clays, sandy clays, silty clays, lean clays. |
| | | | | OL | Organic silts and organic silty clays of low plasticity. |
| | SILTS AND CLAYS | LIQUID LIMIT GREATER THAN 50 | | MH | Inorganic silts, micaceous or diatomaceous fine sandy or silty soils, elastic silts. |
| | | | | CH | Inorganic clays of high plasticity, fat clays. |
| | | | | OH | Organic clays of medium to high plasticity, organic silts. |
| HIGHLY ORGANIC SOILS | | | | PT | Peat and other highly organic soils. |

NOTE: DUAL SYMBOLS ARE USED TO INDICATE BORDERLINE SOIL CLASSIFICATIONS

### Notes

SPT (Standard Penetration Test-ASTM D1586):
The number of blows of a 140 lb (63.6 kg) hammer falling 2.5 ft (750 mm) used to drive a 2 in (50 mm) O.D. Split Spoon sampler for a total of 1.5 ft (0.45 m) of penetration.
Written as follows:
first 0.5 ft (0.15 m) - second 0.5 ft (0.15 m) - third 0.5 ft (0.15 m) (ex: 1-3-9)
Note: if the number of blows exceeds 50 before 0.5 ft (0.15 m) of penetration is achieved, the actual penetration follows the number of blows in parentheses (ex: 12-24-50 (0.09 m), 34-50 (0.4 ft), or 100 (0.3 ft)).
WR denotes a zero blow count with the weight of the rods only.
WH denotes a zero blow count with the weight of the rods plus the weight of the hammer.

**Soil Classifications are Based on the Unified Soil Classification System, ASTM D2487 and D2488. Also included are the AASHTO group classifications (M145). Descriptions are based on visual observation, except where they have been modified to reflect results of laboratory tests as deemed appropriate.**

### Order of Descriptors

- Group Name
- Consistency or Relative Density
- Moisture Condition
- Color
- Particle size descriptor(s) (coarse grained soils only)
- Angularity of coarse grained soils
- Other relevant notes

### Criteria For Descriptors

***Consistency of Fine Grained Soils***

| Consistency | N-Value (uncorrected) |
|---|---|
| Very Soft | < 2 |
| Soft | 2 - 4 |
| Medium Stiff | 5 - 8 |
| Stiff | 9 - 15 |
| Very Stiff | 16 - 30 |
| Hard | > 30 |

***Apparent Density of Coarse Grained Soils***

| Relative Density | N-Value (uncorrected) |
|---|---|
| Very Loose | < 4 |
| Loose | 4 - 10 |
| Medium Dense | 11 - 30 |
| Dense | 31 - 50 |
| Very Dense | > 50 |

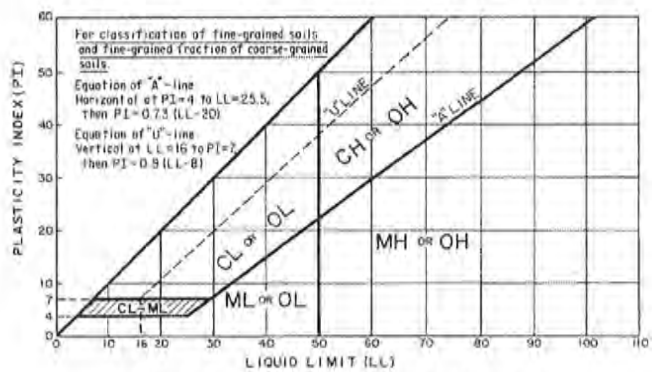
***Moisture Condition***

| | |
|---|---|
| Dry | -Absence of moisture, dusty, dry to the touch. |
| Moist | -Damp, but no visible water. |
| Wet | -Visible free water. |

***Definition of Particle Size Ranges***

| Soil Component | Size Range |
|---|---|
| Boulder | > 12 in (300 mm) |
| Cobble | 3 in (75 mm) - 12 in (300 mm) |
| Gravel | No. 4 Sieve (4.75 mm) to 3 in (75 mm) |
| Sand | No. 200 (0.075 mm) to No. 4 Sieves (4.75 mm) |
| Silt | < No. 200 Sieve (0.075 mm)* |
| Clay | < No. 200 Sieve (0.075 mm)* |

*Use Atterberg limits and chart below to differentiate between silt and clay.




***Angularity of Coarse-Grained Particles***

| | |
|---|---|
| Angular | -Particles have sharp edges and relative plane sides with unpolished surfaces. |
| Subangular | -Particles are similar to angular description, but have rounded edges. |
| Subrounded | -Particles have nearly plane sides, but have no edges. |
| Rounded | -Particles have smoothly curved sides and well-rounded corners and edges. |

Example soil description: Sandy FAT CLAY, soft, wet, brown.

# MDT Boring Log Descriptive Terminology

serving you with pride

Geotechnical Section

## Key to Rock Symbols and Terms

| Rock Type | Symbol | Rock Type | Symbol | Rock Type | Symbol |
|---|---|---|---|---|---|
| Argillite | | Dolomite | | Quartzite | |
| Basalt | | Gneiss | | Rhyolite | |
| Bedrock (other) | | Granitic | | Sandstone | |
| Breccia | | Limestone | | Schist | |
| Claystone | | Siltstone | | Shale | |
| | | Conglomerate | | | |

### Order of Descriptors

- Rock Type
- Color
- Grain size (if applicable)
- Stratification/Foliation (as applicable)
- Weathering
- Field Hardness
- Other relevant notes

### Criteria For Descriptors

#### *Grain Size*

| Description | Characteristic |
|---|---|
| Coarse Grained | Individual grains can be easily distinguished by eye |
| Fine Grained | Individual grains can be distinguished with difficulty |

#### *Stratum Thickness*

| | |
|---|---|
| Thickly Bedded | 3-10 ft (1-3 m) |
| Medium Bedded | 1-3 ft (300 mm - 1 m) |
| Thinly Bedded | 2-12 in (50-300 mm) |
| Very Thinly Bedded | < 2 in (50 mm) |

### *Weathering*

| | |
|---|---|
| Highly Weathered | More than half of the rock is decomposed; rock is weakened so that a minimum 2 inch (50mm) diameter sample can be broken readily by hand across rock fabric |
| Moderately Weathered | Rock is discolored and noticeably weakened, but less than half is decomposed; a minimum 2 inch (50mm) diameter sample cannot be broken readily by hand across rock fabric |
| Slightly Weathered | Rock is slightly discolored, but not noticeably lower in strength than fresh rock |

### *Example Rock Log*

*SANDSTONE, gray, fine grained, thickly bedded, slightly weathered, hard field hardness.*

### *Rock Field Hardness*

| | |
|---|---|
| Very Soft | Can be carved with knife. Can be excavated readily with point of rock hammer. Can be scratched readily by fingernail. |
| Soft | Can be grooved or gouged readily by knife or point of rock hammer. Can be excavated in fragments from chips to several inches in size by moderate blows of the point of a rock hammer. |
| Medium | Can be grooved or gouged 0.05 in (2 mm) deep by firm pressure of knife or rock hammer point. Can be excavated in small chips to pieces about 1 in (25 mm) maximum size by hard blows of the point of a rock hammer. |
| Moderately hard | Can be scratched with knife or pick. Gouges or grooves to 0.25 in (6 mm) can be excavated by hard blow of rock hammer. Hand specimen can be detached by moderate blows. |
| Hard | Can be scratched with knife or pick only with difficulty. Hard hammer blows required to detach hand specimen. |
| Very Hard | Cannot be scratched with knife or sharp rock hammer point. Breaking of hand specimens requires several hard blows of a rock hammer. |

**Notes:**

Qu = Unconfined Compressive Strength obtained from laboratory testing at the given depth.

## Miscellaneous Soil/Rock Symbols and Terms

- Concrete
- Asphalt
- Water
- Boulders and Cobbles
- Coal
- Fill
- Millings
- Topsoil

**Explanation of Text Fields in Boring Logs:**

Material Description: Lithologic Description of soil or rock encountered.

Remarks: Comments on drilling, including method, bit type, and problems encountered.

Notes: Legal Description, explanation of survey method used, and horizontal coordinates.

**General Notes**

- Descriptions on these boring logs apply only at the specific boring, and at the time the time the borings were made. These logs are not warranted to be representative of subsurface conditions at other locations or times.
- Water level observations apply only at the specific boring, and at the time the borings were made. Due to the variability of groundwater measurements given the type of drilling used, and the stratification of the soil in the boring, these logs are not warranted to be representative of groundwater conditions at other locations or times.
- Other terms may be used as descriptors, as defined by the profession.

Operation Types: Auger; Casing Advancer; Core Barrel; Drive Casing

Sample Types: Split Spoon; Shelby; Bulk Sample; Grab Sample; Cone Penetrometer; Vane Shear; Special Samplers; Testpit

**-Soil and Rock descriptions are based on visual observation, except where they have been modified to reflect results of laboratory tests as deemed appropriate.**

# LOG OF BORING B-1



ENGINEERING NTL GEOSCIENCE

| | | | |
|---|---|---|---|
| PROJECT: | Lewis & Clark Safety Improvements<br>Helena, Montana | LOCATION: | Sta. 28+50 CL |
| JOB NO.: | 05-906 | SURFACE ELEVATION: | 979.0 |
| DRILLING METHOD: | CME 75 4-1/4" Hollowstem Augers | GROUNDWATER DEPTH: ∇ | None Observed |
| DRILLER: | Big Sky Drilling | DATE STARTED: | 10/28/05 |
| LOGGED BY: | R. Wade | DATE COMPLETED: | 10/28/05 |

| DEPTH(FT) | MATERIAL SYMBOL | SAMPLE* TYPE | PENETRATION RESISTANCE (BLOWS/FT) | MATERIAL CLASSIFICATION AND DESCRIPTION | MOISTURE (%) | DRY DENSITY (PCF) | LIQUID LIMIT(%) | PLASTICITY INDEX(%) | GRAVEL(%) | SAND(%) | SILT(%) / CLAY(%) |
|---|---|---|---|---|---|---|---|---|---|---|---|
| 0 | | LSS | 58 | **Sandy Fat CLAY, Volcanic Ash,** soft rock - hard soil, slightly weathered, poorly welded, damp, scattered rock fragments, high plasticity, some oxidation, mottled light brown and white (CH) A-7-6(20)<br><br>See Plate Nos. 1, 2, 3 & 6 for Lab Data | 21 | | 71 | 43 | 2 | 43 | 54 |
| 5 | | SSS | 70 | | 27 | | | | | | |
| | | | | | 21 | | | | | | |
| | | | | becoming yellowish brown, less weathered | 28 | | | | | | |
| 10 | | SSS | 37 | | 35 | | | | | | |
| | | | | End of Boring @ 11.5' | | | | | | | |
| 15 | | | | | | | | | | | |

*SAMPLE TYPE KEY:
- SSS - STANDARD SPLIT SPOON (SPT)
- LSS - LARGE SPLIT SPOON
- ST - SHELBY TUBE
- RS - RING SAMPLE
- SK - SACK SAMPLE

REMARKS

# LOG OF BORING B-2



ENGINEERING GEOSCIENCE

PROJECT: Lewis & Clark Safety Improvements, Helena, Montana
JOB NO.: 05-906
DRILLING METHOD: CME 75 4-1/4" Hollowstem Augers
DRILLER: Big Sky Drilling
LOGGED BY: R. Wade

LOCATION: Sta. 36+20 CL
SURFACE ELEVATION: 953.0
GROUNDWATER DEPTH: None Observed
DATE STARTED: 10/28/05
DATE COMPLETED: 10/28/05

| DEPTH(FT) | MATERIAL SYMBOL | SAMPLE* TYPE | PENETRATION RESISTANCE (BLOWS/FT) | MATERIAL CLASSIFICATION AND DESCRIPTION | MOISTURE (%) | DRY DENSITY (PCF) | LIQUID LIMIT(%) | PLASTICITY INDEX(%) | GRAVEL(%) | SAND(%) | SILT(%) | CLAY(%) |
|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | | LSS | 24 | **TOPSOIL, Organic Matter** | | | | | | | | |
| 0.4 | | | | **Sandy Lean CLAY,** hard, slightly moist, slightly blocky, fine sand, some roots, brown (CL) A-7-6 | 12 | | | | | | | |
| 1.6 | | SSS | 11 | **Sandy Fat CLAY,** stiff, damp, fine sand, brown (CH) A-7-6(28) | 17 | | 70 | 42 | 3 | 31 | 66 | |
| | | | | See Plate Nos. 1, 2, 4 & 7 for Lab Data | | | | | | | | |
| 5 | | SSS | 11 | becoming sandier, moist | 27 | | | | | | | |
| 10 | | SSS | 12 | becoming very moist | 38 | | | | | | | |
| | | | | some rock fragments | 23 | | | | | | | |
| | | | | End of Boring @ 11.5' | | | | | | | | |
| 15 | | | | | | | | | | | | |

LABORATORY TEST DATA: MOISTURE through CLAY columns.

*SAMPLE TYPE KEY:
- SSS - STANDARD SPLIT SPOON (SPT)
- LSS - LARGE SPLIT SPOON
- ST - SHELBY TUBE
- RS - RING SAMPLE
- SK - SACK SAMPLE

REMARKS

# LOG OF BORING B-3



NTL ENGINEERING & GEOSCIENCE

| | | | |
|---|---|---|---|
| PROJECT: | Lewis & Clark Safety Improvements<br>Helena, Montana | LOCATION: | Sta. 40+90 CL |
| JOB NO.: | 05-906 | SURFACE ELEVATION: | 946.0 |
| DRILLING METHOD: | CME 75 4-1/4" Hollowstem Augers | GROUNDWATER DEPTH: | ▽ 1.5 10/28/05 |
| DRILLER: | Big Sky Drilling | DATE STARTED: | 10/28/05 |
| LOGGED BY: | R. Wade | DATE COMPLETED: | 10/28/05 |

| DEPTH(FT) | MATERIAL SYMBOL | SAMPLE* TYPE | PENETRATION RESISTANCE (BLOWS/FT) | MATERIAL CLASSIFICATION AND DESCRIPTION | LABORATORY TEST DATA | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | | | | | MOISTURE (%) | DRY DENSITY (PCF) | LIQUID LIMIT(%) | PLASTICITY INDEX(%) | GRAVEL(%) | SAND(%) | SILT(%) | CLAY(%) |
| | | LSS | 6 | **TOPSOIL, Organic Matter** | 37 | | | | | | | |
| 1.3 ▽ | | SSS | 0 | **Clayey SAND**, loose to very loose, very moist to saturated, some organics, grey (SC) A-6(4) See Plate Nos. 1, 2, 5 & 8 for Lab Data | 30 | | 40 | 17 | 4 | 53 | 43 | |
| 5 | | SSS | 11 | | 33 | | | | | | | |
| 5.4 | | | | **Clayey GRAVEL with Sand,** medium dense, saturated, angular gravel, brown (GC) A-2-6 | 9 | | | | | | | |
| | | | | End of Boring @ 6.5' | | | | | | | | |
| 10 | | | | | | | | | | | | |
| 15 | | | | | | | | | | | | |

*SAMPLE TYPE KEY:
- SSS - STANDARD SPLIT SPOON (SPT)
- LSS - LARGE SPLIT SPOON
- ST - SHELBY TUBE
- RS - RING SAMPLE
- SK - SACK SAMPLE

REMARKS