# Preliminary Engineering Report

## VALLEY DRIVE

LEWIS AND CLARK COUNTY

*RPA Project No. 10502.003*

*Prepared For:*

**LEWIS AND CLARK COUNTY**

3402 Cooney Drive
Helena, MT 59602

*Prepared By:*


**ROBERT PECCIA & ASSOCIATES**

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February 2012

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Tom Cavanaugh, PE
Project Manager

Approval

Date: 01/10/2012

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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 Valley Drive corridor bound by Lewis Street on the southern end and York 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 to meet the purpose and need for the desired road improvements.

## *ES.1. Summary of Findings*

The existing roadway does not meet several minimum design criteria presented as guidance by the American Association of State Highway and Transportation Officials (AASHTO), or the minimum standards set by Lewis and Clark County. Likewise, the current pavement structure is deficient to meet the needs of the projected loadings it will experience within the study's evaluation period. Although the horizontal and vertical alignments are within minimum accepted standards, the aspects of the highway measured from the edge of the traveled way outward to include cut and fill slopes are below safety standards for a facility classified in the Greater Helena Area Transportation Plan – 2004 Update as a Minor Collector.

Based on the evaluation presented herein, we estimate the cost to reconstruct the road to meet assigned design criteria to be approximately **$1.15 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 approximately $773,000 per mile, excluding costs for additional right-or-way, final engineering etc. In comparison, an American Recovery and Reinvestment Act (ARRA) safety improvement project was constructed in 2009 along a segment of Wylie Drive, one mile west of Valley Drive. This project was administered by the Montana Department of Transportation (MDT). The bids received on this 0.81 mile reconstruction project ranged approximately $847,000 to $996,000; equivalent to $1,046,000 to $1,230,000 per mile.

# 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 Valley Drive between Lewis Street and York Road, north of the City of East Helena. The study segment is further described in the following section.

This segment of Valley Drive 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. Proposed development will add a proportional amount of new traffic, which will 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 will 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 under similar budget and time restraints. No warranty, expressed or implied, is made.

## *1.1. Location and Description*

Valley Drive lies within the easterly portion of what is locally known as the Helena Valley. The study area begins at the intersection with Lewis Street. The project extends northerly for approximately 3.5 miles, terminating at its intersection with York Road. Refer to the project area map, **Figure 1.1**.

For the purpose of this study, Milepost [MP] 0.00 is considered as the start of the project corridor at the intersection with Lewis Street. The mileposts increase in a south to north direction. From Milepost 0.00, Valley Drive continues due north along the section lines. The project corridor terminates at MP 3.50 at the intersection with York Road. It should be noted that the portion of Valley Drive from MP

0.00 to approximately MP 0.75 lies within the East Helena city limits. As such, this section of the corridor is not in County jurisdiction.

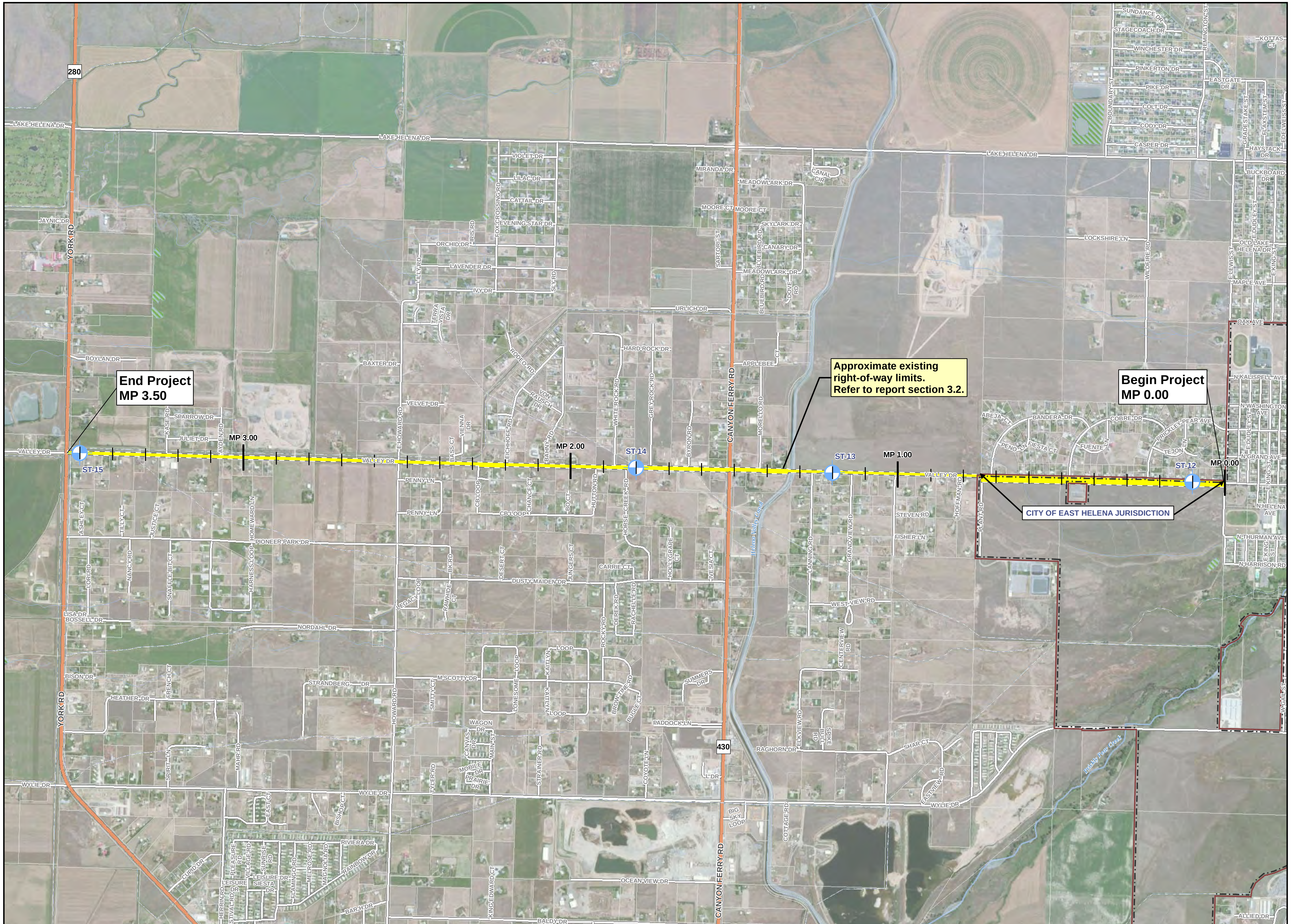
## 1.2. Methodology to Develop Report

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 March 2011. For on-site field reviews, most 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 amongst 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.




# VALLEY DRIVE PROJECT AREA

Preliminary Engineering Report

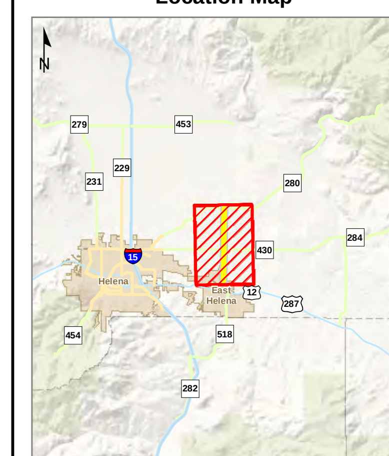
500 0 500 1,000 1,500 Feet

1 inch = 1,500 feet

## Map Legend

- Approximate Existing Right-of-Way
- 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:** 10502.003 LewisClarkCo PERs - Valley Drive

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**File Location:** F:\highways\10502_000_LewisClarkCo_PERs\GIS\Maps\ValleyDrive_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 the recent years been contracted with the County to complete their Traffic Count Program. 2009 traffic counts for segments of this road study were completed by ATS in August 2009. 2009 data is used in this report as geotechnical review for this project started at that time. The 2009 traffic data was 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.

ATS converts the raw data traffic counts into Average Annual Daily Traffic (AADT) to provide an accurate traffic volume regardless of which month, day or hours the counts were performed. For the purpose of this study, a 3.1% heavy vehicle factor was assumed for Valley Drive based on vehicle classification counts conducted on the nearby Lake Helena Drive which ranged between 3.1% to 5.9% heavy trucks. This then was used to complete a road surfacing evaluation as a part of this PER.

Lewis and Clark County also provided RPA with the historical traffic counts for Valley Drive. 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.

It should be noted that construction was ongoing along Canyon Ferry Road during the 2009 data collection. It appears that the ongoing construction significantly skewed 2009 traffic values. As such, a comparison of 2008 and 2009 AADT values is shown in **Table 2.1**. 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)**

| Valley Drive | | AADT | | | | |
|---|---|---|---|---|---|---|
| **Site ID** | **Location** | **2008** | **2009 (1)** | **2011 (2)** | **2031 (2)** | **Growth (3)** |
| 7B-72 | S. of York Rd | 345 | 684 | 393 | 469 | 0.89% |
| 7B-73 | N. of Howard Rd | 386 | 709 | 548 | 1505 | 5.18% |
| 7B-74 | N. of Canyon Ferry Rd | 1423 | 878 | 1663 | 3285 | 3.46% |
| 7B-75 | S. of Canyon Ferry Rd | 1836 | 2963 | 2302 | 3000 | 1.33% |
| *Weighted Average:* | | | | | | **2.45%** |

*(1) 2009 AADT values appear to be significantly skewed due to ongoing construction along Canyon Ferry Road.*
*(2) AADT was projected based on historical counts assuming an exponential yearly growth rate.*
*(3) 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 3.6 mile section of Valley Drive between the East Helena city limits and York Road (S-280). The crash information covers a 5-year time period from July 1, 2005 to June 30, 2010. A total of fifteen crashes were investigated on this segment of roadway. The crash information was analyzed to identify general crash characteristics and potential roadway deficiencies.

Twelve of the fifteen crashes occurred in intersections or were intersection related, while twelve crashes involved multiple vehicles. Nine crashes resulted in injuries, none of which resulted in a fatality. The most apparent cluster of crashes occurred at the intersection with Canyon Ferry Road where eleven crashes occurred. It should be noted that this intersection was signalized in 2009 as part of the Montana Department of Transportation STPS 430-1(6)1 project. Signalizing this intersection was identified as the appropriate improvement to mitigate the crash cluster at that intersection.

Other than the cluster of crashes at the intersection with Canyon Ferry Road, only four crashes were reported along Valley Drive during the 5-year analysis period. Of those four, one occurred at the intersection with York Road while the other three were single vehicle crashes. No additional crash trends were identified.

# 3. Existing Conditions

Existing conditions for the Valley Drive corridor are based on background data and a field review conducted on March 10th, 2011. During the field review, existing physical characteristics were analyzed and recorded to help establish existing conditions along the project corridor. During the field review, snow was not present on the ground along the project corridor and weather conditions were favorable.

## *3.1. Physical Characteristics*

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. The terrain of this roadway is level for the entire project length. The road grades slope south to north and are very moderate at about 1.0%. The area is semi-arid with few significant cross-draining structures. The road generally parallels the natural south to north/northwesterly drainage pattern of the valley in this location.

The area is a mix of irrigated and dry land agricultural tracts between parcels of developed suburban residential subdivisions. Valley Drive is functionally classified by the County as a Minor Collector. 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 determined based on field review and GIS data. During the field review, measurements were taken where right-of-way fence exists. This information supplemented available Cadastral GIS data.

Approximate right-of-way widths, measured from centerline, are shown in **Table 3.1**. These values are estimates and are only intended to provide a planning-level assessment to help determine potential roadway reconstruction costs.

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

| Location | | Width (from Centerline) | Comments |
|---|---|---|---|
| MP Begin | MP End | | |
| *East of Centerline* | | | |
| 0.00 | 1.33 | 25' | |
| 1.33 | 1.50 | 35' | |
| 1.50 | 1.86 | 36' | |
| 1.86 | 2.50 | 24' | |
| 2.50 | 3.50 | 24' | |
| *West of Centerline* | | | |
| 0.00 | 0.75 | 82' - 102' | Tapers from 82' at MP 0.00 to 102' at MP 0.75 |
| 0.75 | 1.33 | 25' | |
| 1.33 | 1.50 | 50' - 35' | Varies from 50' to 35' |
| 1.50 | 3.50 | 36' | |

## *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. The American Association of State Highway and Transportation Officials (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 Valley Drive in this segment is 50 miles per hour (mph) for level terrain. A copy of Table A is included in **Appendix B**. As noted previously, the functional classification of this road is a Minor 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; for 400 to 2000 vehicles per day, AASHTO's minimum design speeds are 50 mph for level terrain. In reference to this, the County's design speeds may be somewhat low when taking into consideration 20-year AADT growth. AASHTO recommends, where practical, to consider using design speeds higher than those shown in the exhibit.

Exhibit 6-4 of the Green Book, contained in **Appendix B**, specifies maximum suggested grades, in percent (%), for specified design speeds of Rural Collector highways. For 50 mph design speeds, level terrain can have recommended highway grades not to exceed 6%. For 60 mph in the same terrain, the maximum recommended grade is 5%. For the project corridor, there are no existing grades exceeding those recommended based on the terrain criteria, and the exhibit suggests that the higher design speed of 60 mph for level terrain in this study area is appropriate.

The County has established a regulatory speed limit of 35 mph for the project corridor. The regulatory speed is less than the County standard design speeds, and is deemed appropriate by the County based on terrain, the road's surfacing condition, geometrics, and level of roadside development.

Based on the above comparisons, we believe the County's standard design speeds are appropriate for this facility. The 50 mph design speed is higher than the current regulatory speed, which is indicative of improving conditions to those of highest practical to attain the desired degree of safety, mobility, and efficiency subject to environmental, economic and other social, political or aesthetic constraints. The County does not intend to change the regulatory speed limit of 35 mph for the project corridor.

## *3.4. Alignment*

The horizontal road alignment of Valley Drive is tangential in a north/south direction. The tangent sections of the road are primarily a result of the road following the section lines. There are no horizontal curves along the project corridor. The vertical alignment of Valley Drive is very flat with grades much lower than those identified in the County road regulations.

The existing road alignment appears to exceed minimum County, MDT and AASHTO standards for horizontal and vertical curvature. Not withstanding other geometric features related to the alignment, no substantial adjustments to the horizontal and vertical alignments are expected when this highway's design for reconstruction is to be undertaken.

## *3.5. Sight Distance*

Applicable to horizontal and vertical alignment geometric features is the design element of sight distance. 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. In addition, to promote efficiency of the highway facility relative to its functional classification, an amount of passing sight distance for drivers to enter the opposing lane to pass vehicles is desired.

As noted previously, the roadway lies on straight tangent sections for the entire project length. There do not appear to be any issues related to sight distance along vertical or horizontal curves. Therefore we do not envision any substantial improvements to be required to the present road grade and its associated sight distance.

# 3.6. Structures

An existing pre-stressed concrete bridge on Valley Drive spans the Helena Valley Canal at approximately MP 1.3, south of Canyon Ferry Road. The overall deck width is 30 feet, while the bridge span is approximately 43 feet. The installation includes approximately 69 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. However, the clear width between the guardrails is approximately 4 feet wider than the road approaches, which offers approximately 2 feet of shy offset distance between the edge of traveled lane and the face of guardrail for each lane.

The bridge was constructed in 2000 and the structure, abutments and guardrail all appear to be in good condition. The Montana Department of Transportation (MDT) completed a bridge inspection in January 2011. The "Initial Assessment Form" from the inspection is attached in **Appendix A** for reference.

Due to the level terrain in this area, 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 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**. The existing bridge meets AASHTO minimum width criteria to remain in place. 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 (4 feet wider than the clear width of the bridge). 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 bridge clear width, the County will need to ascertain the practicality and cost-benefit of widening the structure. One means of determining need, or practicality, is by reference to the crash history. In the five-year crash data obtained for this report there were no reported incidents in which the bridge has contributed to the circumstances of a crash.

# 3.7. Existing Roadway Surfacing

A pavement evaluation for the Valley Drive 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. The corridor consists of four distinct sections with regard to surfacing. A discussion of the results of the pavement evaluation for each road section is provided. **Table 3.2** gives a summary of the pavement evaluation soil boring results. A detailed pavement evaluation report is contained in **Appendix C.**

It should be noted that this pavement analysis is conservative in nature due to the fact that complete reconstruction was assumed. Other options such as pulverizing, overlay, or other reconditioning methods were not analyzed. However, reconditioning and overlay methods may not be appropriate based on the existing conditions of the roadway. In addition, portions of the road have been constructed with chip seals only. This in itself does not meet current County standards for plant mix surfacing.

**Table 3.2: Summary of Boring Conditions**

| | ST-12 | ST-13 | ST-14 | ST-15[2] |
|---|---|---|---|---|
| Approximate Location | MP 0.10 | MP 1.20 | MP 1.80 | MP 3.50 |
| Existing Surfacing Thickness | 3 ¼” | 3 ½” | 1" | 3 ½” |
| Existing Base Thickness | 1" [1] | 2" [1] | 2" [1] | 4 ½” |
| Existing Base Quality | Good | Moderate | Good | Moderate |
| Subgrade | GC | GC | GC | GC |
| Blows Per Foot (BPF) | 15 | 12 | 14, 12 | 11, 14 |
| Moisture Condition | Over 7% - 8% | Over 5% - 6% | Over 6% - 7% | Over 6% - 7% |
| Risk of Subgrade Failure | Moderate | Moderate | Moderate | Moderate |

*[1] Base is too thin to salvage.*
*[2] This section is the only true paved portion of the project corridor. Other sections consist of chip seal and cold patching techniques.*
*GC = Clayey Gravel with Sand*

### 3.7.1. Lewis Street to Canyon Ferry Road

This section of Valley Drive runs from MP 0.00 to MP 1.50 with the surfacing comprised of chip seals and surface patches. Two soil borings were completed along this section. The borings, identified as ST-12 and ST-13 were completed approximately one mile apart. The thickness of the surfacing varies slightly between the two samples from 3 ¼ to 3 ½ inches. One of the base course samples qualifies as good material, while the other qualifies as moderate. However, existing base thickness is 1 to 2 inches thick and is comparably thin to the County’s specifications.

With each boring, soil samples were also obtained for subgrade material directly below the aggregate base material. The subgrade soil consists of clayey gravel with sand at both boring locations. The moisture content is considered to be over optimum, and thus considered wet. The risk of subgrade failure at both locations is considered to be moderate at both locations.

It should be noted that from the East Helena City Limits to Canyon Ferry Road, an existing weight limit restriction exists due to the poor existing roadway condition.

Summary MP 0.00 to MP 1.50:

- The existing surfacing thickness meets or exceeds minimum County standards;
- Existing base aggregate is of moderate to good quality but is 7 to 8 inches less in thickness than minimum County standards;
- The subgrade in this segment has a moderate risk of failure.

- Surfacing is comprised of chip sealing and cold patching and does not meet current paved road standards.

### 3.7.2. Canyon Ferry Road to Howard Road

This section of Valley Drive, between MP 1.50 and MP 2.50, also consists of surfacing comprised of chip seals and surface patches. A boring, identified as ST-14, was taken at approximately MP 1.80. The asphalt surfacing thickness was 1 inch at this location. Existing base course thickness is 2 inches and is considered good quality. Both the base course and surfacing thicknesses are comparably thin to County specifications.

Soil samples taken from subgrade material directly below the aggregate base material indicates a subgrade soil of clayey gravel with sand. The subgrade is considered to be wet due to the moisture content being over optimum. The risk of subgrade failure at this location is moderate.

Summary MP 1.50 to MP 2.50:

- The existing asphalt surfacing thickness is 2 inches below minimum County standards;
- Existing base aggregate is of good quality but is 7 inches less in thickness than minimum County standards;
- The subgrade in this segment has a moderate risk of failure.
- Surfacing is comprised of chip sealing and cold patching and does not meet current paved road standards.

### 3.7.3. Howard Road to Beginning of Pavement

This section of Valley Drive, between MP 2.50 and 3.00, has gravel surfacing. Borings were not taken along this portion of the corridor.

### 3.7.4. Beginning of Pavement to York Road

This section of Valley Drive is between MP 3.00 and MP 3.50. The surfacing consists of asphalt pavement between Ayden Road and York road and of chip sealing and surfacing patching between Canyon Ferry Road and Ayden Drive. The asphalt section was paved in preparation of the Sparrow Subdivision.

A boring, identified as ST-15, was taken at approximately MP 3.50. The asphalt surfacing thickness was 3 ½ inches at this location. Existing base course thickness is 4 ½ inches and is considered moderate material. The base course thickness is comparably thin to County specifications.

Soil samples taken for subgrade material directly below the aggregate base material indicates a subgrade soil of clayey gravel with sand. The subgrade is considered to be wet due to the moisture content being over optimum. The risk of subgrade failure at this location is moderate.

Summary MP 3.00 to MP 3.50:

- The existing asphalt surfacing thickness meets or exceeds minimum County standards for the paved section between York Road and Ayden Road;
- The section between Ayden Drive and Canyon Ferry Road has surfacing which is comprised of chip sealing and cold patching and does not meet current paved road standards.
- Existing base aggregate is of moderate quality but is 4 ½ inches less in thickness than minimum County standards;
- The subgrade in this segment has a moderate risk of failure.

## *3.8. Existing Roadway Typical Sections*

This section of the report discusses the primary features of each road segment's existing typical section characteristics. As with the roadway surfacing, the project corridor is comprised of four distinct sections. Cross-sectional measurements of Valley Drive were taken to include surfacing widths, cut and fill slope rates, ditch widths and depth of the roadside ditch.

### 3.8.1. Existing Typical Section E.1: Lewis Street to Canyon Ferry Road

Existing Typical Section E.1 runs from MP 0.00 to MP 1.50. The overall top surface of this section measured to be approximately 24 feet wide, with two 12-foot travel lanes and consists of chip seals and surface patches. There are no distinguishable paved shoulders.

The roadside ditch foreslopes were measured to be approximately 3:1 (horizontal : vertical, i.e. three feet horizontal distance for each one foot vertical drop) on both sides of the roadway. The ditch backslopes were measured to be approximately 6:1 on each side. The roadside ditch depths were approximately two feet deep on the east side and 1½ feet deep on the west side and do not meet current county standards.

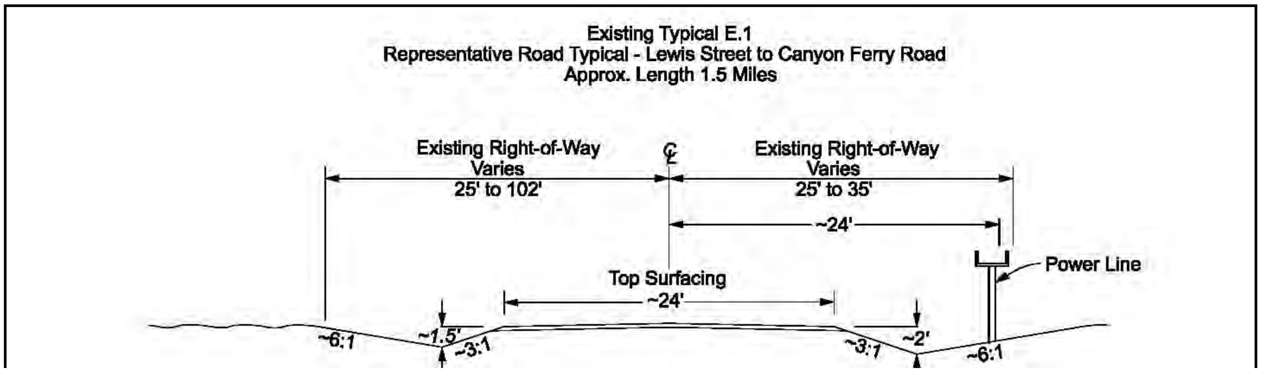



**Figure 3.1: Existing Typical Section E.1 (MP 0.00 – MP 1.50) – Looking North**

**Photo 3.1: Existing Typical Section E.1 looking north.**

## 3.8.2. Existing Typical Section E.2: Canyon Ferry Road to Howard Road

Existing Typical Section E.2 runs from MP 1.50 to MP 2.50. The overall top surface of this section measured to be approximately 22 feet wide, with two 11-foot travel lanes and consists of surface patching and chip sealing. There are no distinguishable paved shoulders.

The roadside ditch foreslopes were measured to be approximately 3:1 on both sides of the roadway. The ditch backslopes were measured to be approximately 6:1 on each side. The roadside ditch depths were approximately 1 foot deep on each side and do not meet current county standards. This section of road is narrow with reduced width travel lanes. The ditches are shallow in depth and do not provide adequate cover over approach ditches.

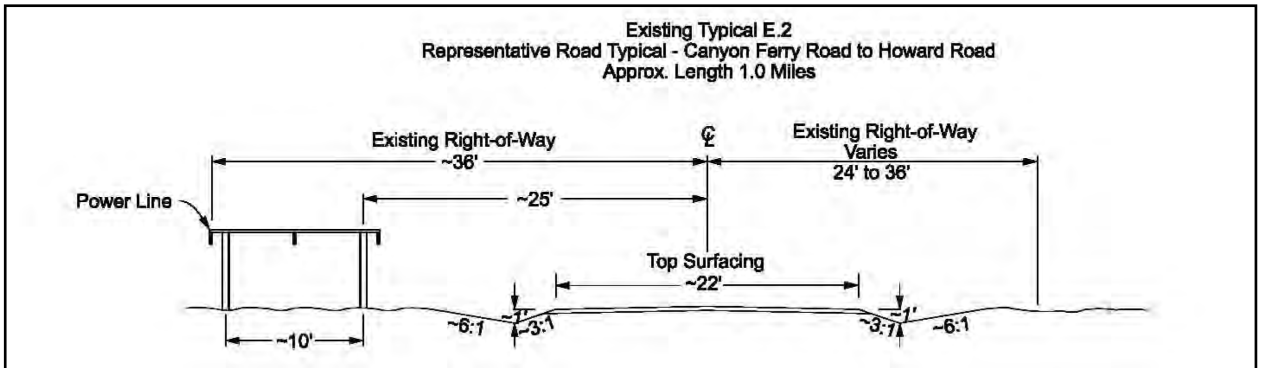



**Figure 3.2: Existing Typical Section E.2 (MP 1.50 - MP 2.50) – Looking North**

**Photo 3.2: Existing Typical Section E.2 looking south.**

## 3.8.3. Existing Typical Section E.3: Howard Road to Beginning of Pavement

Existing Typical Section E.3 runs from MP 2.50 to MP 3.00. The overall gravel top surface of this section measured to be approximately 24 feet wide, with two 12-foot travel lanes.

The roadside ditch foreslopes were measured to be approximately 3:1 on both sides of the roadway. The ditch backslopes were measured to be approximately 6:1 on each side. The roadside ditch depths were approximately one foot deep on each side. Similar to the preceding road section, ditches on this section of road are shallow in comparison to the county standards.

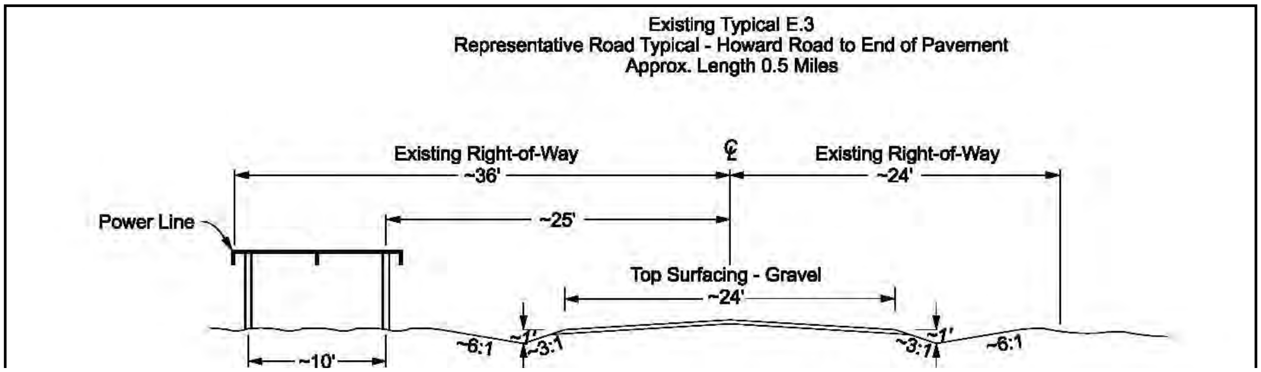



**Figure 3.3: Existing Typical Section E.3 (MP 2.50 - MP 3.00) – Looking North**

**Photo 3.3: Existing Typical Section E.3 looking south.**

### 3.8.4. Existing Typical Section E.4: Beginning of Pavement to York Road

Existing Typical Section E.4 runs from MP 3.00 to MP 3.50. The overall top surface of this section measured to be approximately 24 feet wide, with two 12-foot travel lanes. There are no distinguishable paved shoulders. The top surfacing consists of chip seals and surfacing patching between Canyon Ferry Road and Ayden Road and is asphalt surfaced from Ayden Road to York Road.

The roadside ditch foreslopes were measured to be approximately 3:1 on both sides of the roadway. The ditch backslopes were measured to be approximately 6:1 on each side. The roadside ditch depths were approximately 1 ½ feet deep on the east side and two feet deep on the west side and do not meet current county standards.

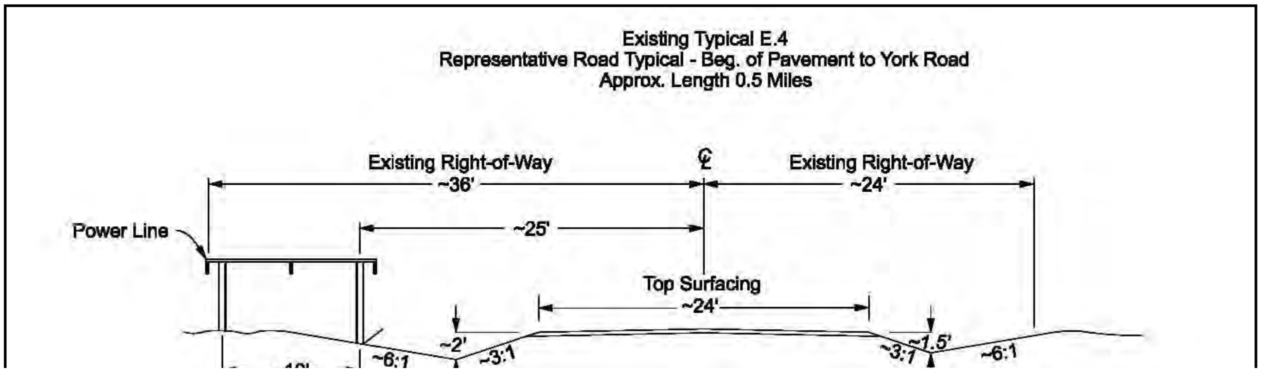



**Figure 3.4: Existing Typical Section E.4 (MP 3.00 - MP 3.50) – Looking North**

**Photo 3.4: Existing Typical Section E.4 looking south.**

# 4. Proposed Conditions

This section of the PER discusses the proposed future conditions of the Valley Drive 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 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.

### 4.1.1. Preliminary Surfacing Design

For this study, a preliminary surfacing section was developed based on the four 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 Regulations for this Minor Collector roadway.

Based on the 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**

As discussed previously, the soil borings taken along the project corridor indicated that the existing subgrade was wet and well over optimum moisture content. According to the surfacing evaluation contained in **Appendix C**, the subgrade is considered to have a "moderate" risk of failure during construction. As such, some areas may need stabilization as discussed in the surfacing evaluation.

### 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 references 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 Valley Drive. The clear zones shown below are measured in feet from the edge of the traveled way.

**Table 4.1: Roadside Clear Zone Requirements (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 | 750 - 1500 | 14 - 16 | 16 - 20 | - | 10 - 12 | 12 - 14 | 14 - 16 |
| 45 - 50 mph | 1500 - 6000 | 16 - 18 | 20 - 26 | - | 12 - 14 | 14 - 16 | 16 - 18 |

Pursuant to County standards, the 50 mph design speed is applicable to Valley Drive traversing level terrain. A minimum foreslope rate of 4:1 is required as shown in Figure 3 of Appendix J of the County's Subdivision Regulations.

Based on these values, a minimum clear zone of 20 feet is recommended along the roadside foreslope for areas with a design ADT of 1500 to 6000. This applies to the section of Valley Drive between Lewis Street (MP 0.00) and Howard Road (MP 2.50) based on design life AADT.

A minimum clear zone of 16 feet is recommended along the roadside foreslope for areas with a design ADT of 750 to 1500. This applies to the section of Valley Drive between Howard Road (MP 2.50) and York Road (MP 3.50).

For the purposes of this study, we are applying the minimum recommended design clear zones to develop the proposed road template. This minimum recommended clear zone will limit construction impacts, road reconstruction costs, and reduce right-of-way acquisition.

### 4.1.3. Surfacing Width

Figure 3 contained in Appendix J of Lewis and Clark County's Subdivision Regulations depicts the County's minimum standard road typical for a two-lane Minor Collector. Each travel lane is to be 12-feet wide. The shoulder width can vary between 2 feet and 4 feet, as measured between the edge of the travel lane to the edge of the surfacing. 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 shoulder width of 8 feet for over 2,000 vehicles per day with a design speed of 50 mph and 22-foot traveled way (minimum) with 6-foot shoulders on each side (34 feet top width) for AADT 1500 – 2000 vpd. However, for Minor Collector highways the County has adopted 4 feet as the maximum required shoulder width. Based on this, the recommended 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.

### 4.1.4. Proposed Typical Section P.1

Proposed Typical Section P.1 (**Figure 4.1**) is for the portion of Valley Drive between Lewis Street and Canyon Ferry Road. This road section has existing power lines running along the east side of the roadway and are expected to act as construction limits for the east side. As such, the road alignment would need to be shifted to the west to accommodate the proposed typical section. If the current road alignment is used additional costs for utility relocation would need to be considered. In addition, there are several houses along the east side of the road that may be impacted by expanding the eastern right-of-way. Projected future traffic forecast along this section is approximately 3000 AADT, which according to AASHTO policy suggests a minimum clear zone of 20 feet.

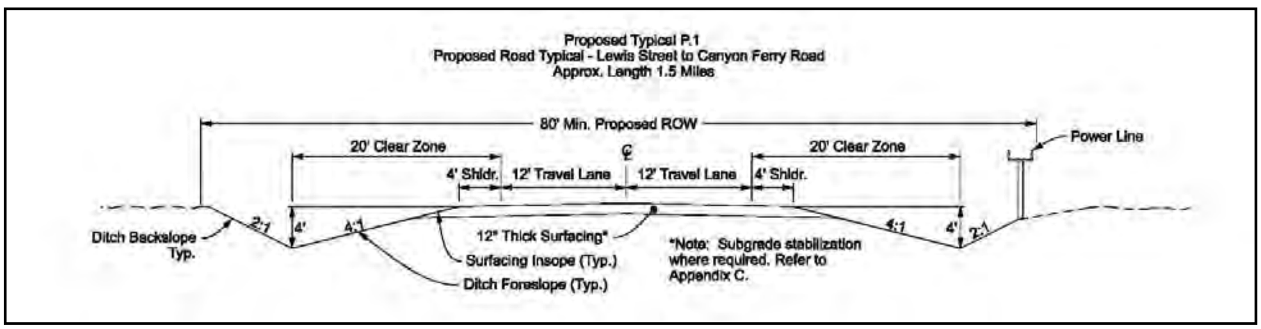



**Figure 4.1: Proposed Typical Section P.1 (MP 0.00 - MP 1.50) – Looking North**

### 4.1.5. Proposed Typical Section P.2

Proposed Typical Section P.2 (**Figure 4.2**) was developed for the portion of Valley Drive between Canyon Ferry Road and Howard Road. This road section has existing power lines running along the west side of the roadway and are expected to act as construction limits for the west side. In order to accommodate the proposed typical section, and to not impact the existing power lines, the road alignment would need to be shifted to the east. If the current road alignment is used additional costs for utility relocation would need to be considered. Projected future AADT along this section is also approximately 3000 vpd; very similar to Typical Section P.1 meeting the same guidelines.

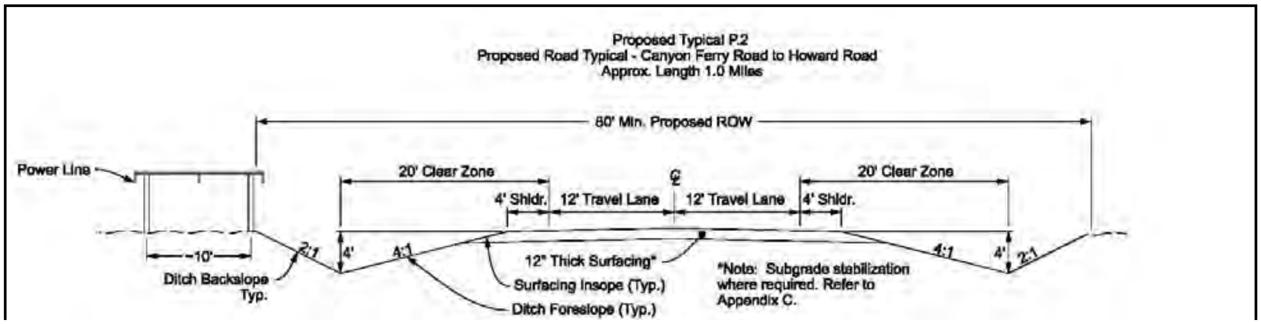



**Figure 4.2: Proposed Typical Section P.2 (MP 1.50 - MP 2.50) – Looking North**

### 4.1.6. Proposed Typical Section P.3

Proposed Typical Section P.3 (**Figure 4.3**) was developed for the portion of Valley Drive north of Howard Road to York Road. As with Typical Section P.2, this road section has existing power lines running along the west side of the roadway and are expected to act as construction limits for the west side. An existing irrigation ditch exists along the east side of the roadway. The toe of the irrigation ditch embankment slope is expected to serve as the eastern construction limit. Projected future traffic along this section is approximately 500 to 1500 AADT. The AASHTO guide suggests a minimum clear zone of 16 feet based on the conditions presented to meet design year need.

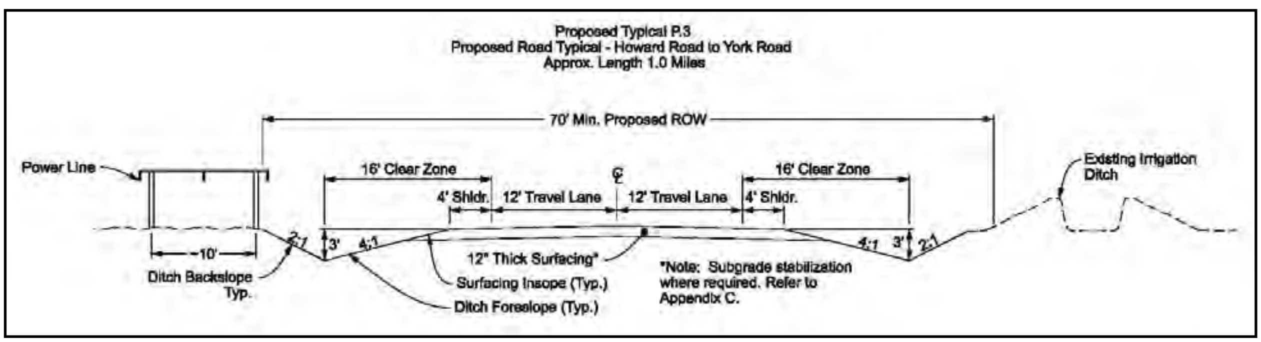



**Figure 4.3: Proposed Typical Section P.3 (MP 2.50 - MP 3.50) – Looking North**

### 4.1.7. 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 **4.3** over the existing road templates estimated from field measurements, **Figures 3.1** through **3.4**.

The estimate is based on the reconstruction staying inside existing construction boundaries such as power lines and irrigation ditches while closely following existing vertical alignments. The superimposed typical sections are shown in **Figure 4.4**.

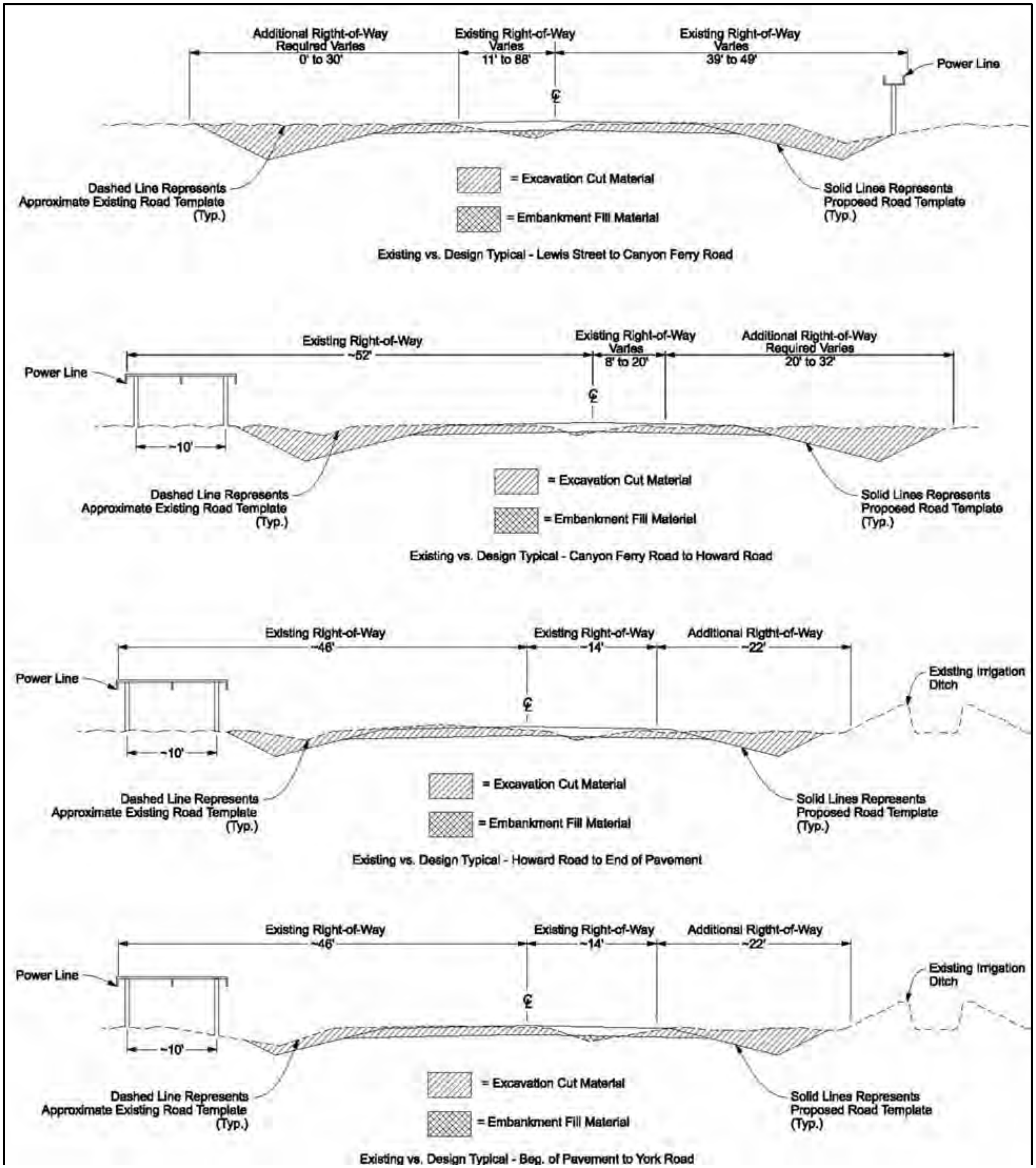



**Figure 4.4: Estimated Reconstruction Cut / Fill Impacts**

### 4.1.8. 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, all four borings completed along the project corridor encountered clayey gravel with sand subgrade that was over optimum moisture content. The geotechnical engineer evaluated these locations to have “moderate” risks of subgrade failure during construction. The “moderate” risk was based on the fact that the borings indicate that the subgrade was wet and 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. 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**.

## *4.2. 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 irrigated 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 and budget 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 38 properties could be impacted during the course of reconstructing 3.5 miles of this road.

## *4.3. Drainage and Hydraulics*

### 4.3.1. Mainline Cross Drains

The project corridor traverses level terrain following the direction of the south-to-north natural drainage patterns. Four existing mainline cross drains were identified during the field review. The first cross drain is located at MP 0.62 and appears to serve an existing irrigation ditch based on field observation and Flood Insurance Rate Maps (FIRM). The existing diameter of this drain is 24 inches. As a conservative estimate for cost estimating, it was assumed that this culvert would be reconstructed as a 36-inch diameter pipe.

The second and third cross drains, located at MP 1.02 and 1.25 respectively, appear to serve an existing 100-year Zone A floodplain. The cross drain located at MP 1.02 is 24 inches in diameter, while the one located at MP 1.25 is 18 inches in diameter. It was assumed that both of these culverts would be replaced as 24-inch diameter pipes during the reconstruction effort.

The fourth cross drain on the Valley Drive corridor is located at MP 1.75 and is 24 inches in diameter. This cross drain appears to serve the Valley Drive Branch of the Prickly Pear Creek drainage and is in a floodplain Zone X according to FRIM #300381542D. It was assumed that this culvert would be reconstructed as a 36-inch diameter pipe since it provides relief for the existing Valley Drive Branch floodplain.

The project corridor appears to require very little drainage upgrading other than that discussed previously. Runoff picked up in this area is conveyed primarily along the roadside, crossing under roads that intersect Valley Drive by the means of small-diameter approach drains. As previously discussed, the roadside ditches in this segment are very shallow with issues of not having adequate cover between the top of the pipe and the approach surfacing. Widening the roadside ditch in this area will provide not only an improved clear recovery area for motorists, but will also increase the ditch depth to allow for improved installation of culverts and increased ditch flow capacity. Culverts with adequate depth of cover will experience less structural damage from vehicles crossing over the culvert, and lessen crushing the ends of the pipes due to running over the inlets and outlets while turning in or out of approaches.

**Photo 4.1: Existing cross drain located at MP 1.02.**

### 4.3.2. Approach Culverts

As noted previously, the terrain that runs south to north parallel to the highway governs much of this road's drainage characteristic. As such, approach culverts play an important role. Improving the roadside ditches as a part of the reconstruction effort will allow for both an increased ditch capacity, and upsizing small diameter culverts as needed while still providing adequate structural cover. For the purposes of this preliminary study, we estimated the number of new approach pipes needed based on a limited windshield review of quantifying the number of approaches within each road segment. The windshield review was supplemented by review of aerial photography and GIS data. We presume that most culverts will require replacement due to abundance of crushed ends and other defects observed at approaches. 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.

### 4.3.3. 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 based on the unusable condition for many pipes observed in the field.

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.

**Table 4.2: Existing Cross Drain Summary**

| | Existing | | Replacement | | |
|---|---|---|---|---|---|
| **Location** | **Diameter** | **Length** | **Diameter** | **Length** | **Comments** |
| MP 0.62 | 24" | 50' | 36" | 56' | Irrigation ditch, no floodplain |
| MP 1.02 | 24" | 50' | 24" | 56' | 100-year flood area (Zone A) |
| MP 1.25 | 18" | 50' | 24" | 56' | 100-year flood area (Zone A) |
| MP 1.75 | 24" | 50' | 36" | 56' | Valley Drive Branch drainage - Zone X |

## *4.4. Pedestrian and Bicycle Facilities*

There are currently no facilities to accommodate pedestrians or bicyclists within this corridor. As such 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.

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.*

## *4.5. Auxiliary Turn Lanes*

The only existing auxiliary turn lanes along the Valley Drive corridor exist at the intersection with Canyon Ferry Road. Northbound and southbound designated left-turn lanes were installed at this intersection during the MDT STPE 430-1(6)1 reconstruction project along Canyon Ferry Road in 2009.

The scope of this work does not include completing definitive turn lane warrant studies at key intersections. However, when the highway design is initiated, it can be reasonably ascertained that 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 50 mph design speed criteria, the lane shift bay taper rate will be 50:1 to shift the through lanes outward. An interior bay taper rate of 10:1 is used for vehicles entering the left turn lane. From the left turn bay entry, the recommended deceleration distance is 435 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 600 feet of total length for lane shift tapers entering and exiting the left turn area, and 435 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 1035 feet.

## *4.6. 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 of York Road and Valley Drive within the design life of Valley Drive. 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 Valley Drive from Lewis Street north to York Road. The Valley Drive 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** – Lewis Street to East Helena City Limits (MP 0.00 to MP 0.75)
- **Typical Section B** – East Helena City Limits to Canyon Ferry Road (MP 0.75 to MP 1.50)
- **Typical Section C** – Canyon Ferry Road to Howard Road (MP 1.50 to MP 2.50)
- **Typical Section D** – Howard Road to beginning of pavement (MP 2.50 – MP 3.00)
- **Typical Section E** – Beginning of pavement to York Road (MP 3.00 – MP 3.50)

**Table 5.1** summarizes the estimated cost to reconstruct Valley Drive from Lewis Street north to York Road. **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. It should be noted that the County could similarly improve Valley Drive by either several smaller spot improvements projects, or larger-length reconstructions.

**Table 5.1: Reconstruction Cost Estimate**

| Valley Drive | Typical A | Typical B | Typical C | Typical D | Typical E | Total |
|---|---|---|---|---|---|---|
| Construction Subtotal | $629,819 | $596,758 | $778,794 | $337,567 | $363,568 | **$2,706,507** |
| Total Estimated Cost | $850,256 | $910,857 | $1,220,236 | $505,003 | $554,105 | **$4,040,457** |
| Length (miles) | 0.75 | 0.75 | 1.00 | 0.50 | 0.50 | **3.50** |

## *5.1. Estimating Procedure*

### 5.1.1. Grading

- The Excavation – Unclassified quantity is estimated from **Figure 4.4** 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.

- Topsoil Salvage and Placing is calculated based on **Figure 4.4** 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 is estimated based on the recommended pavement design and the proposed surfacing widths as shown in **Figures 4.1** through **4.3**.
- 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. The approach pipes would be 15-inch diameter at minimum to meet the County's requirements for a Minor Collector. A quantity of 24-inch diameter cross drains is included in the estimate. This quantity is to serve as highway relief pipes for minor terrain breaks, such as small cross-draining gullies and draws in localized drainage basins, or for those locations were no other pipe was observed but terrain reasonably dictates. Other major drainage features are listed as observed in the field. Their new installation lengths are estimated based on the dimensions generated from the proposed road templates.

### 5.1.4. Fencing

- For this project, we assume most right-of-way acquisition will occur only on the west side of the roadway from Lewis Street to Canyon Ferry Road and only on the east side of the roadway from Canyon Ferry Road to York Road. This then would preserve the majority of the overhead utilities along the right-of-way where possible. 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 4.4**.

### 5.1.6. Subgrade Stabilization

- The preliminary pavement designs included with this report identifies all areas as having moderate quality subgrade material. We included an amount of stabilization gravel 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 **4.3**.

### 5.1.7. Right-of-Way

- To estimate appraisal costs for right-of-way acquisition, we applied a $2,000 per parcel fee for an assumed 38 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.
- The existing right-of-way width appears to generally be 60 feet wide for most of the project. This is based on field review and Cadastral GIS data. It was assumed that the County will likely require that the minimum standard for Minor Collectors (80 feet of overall right-of-way width) be maintained. The exception to this is between Canyon Ferry Drive and Howard Road where it is estimated that a total R/W width of 90 feet is needed due to the double power lines along the west side of the roadway. The power lines are separated by 10 feet, with the eastern most pole likely serving as the construction limit for the project.
- $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 1/4 – 4 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.

## *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 | $100,000.00 | 1 | $100,000 |
| Sanitary Sewer Main | MI | $211,200.00 | 3.50 | $739,200 |
| Water Main | MI | $396,000.00 | 3.50 | $1,386,000 |
| Bicycle/Ped. Path Reconstruction | MI | $77,825.00 | 3.50 | $272,388 |

### 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 80 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.

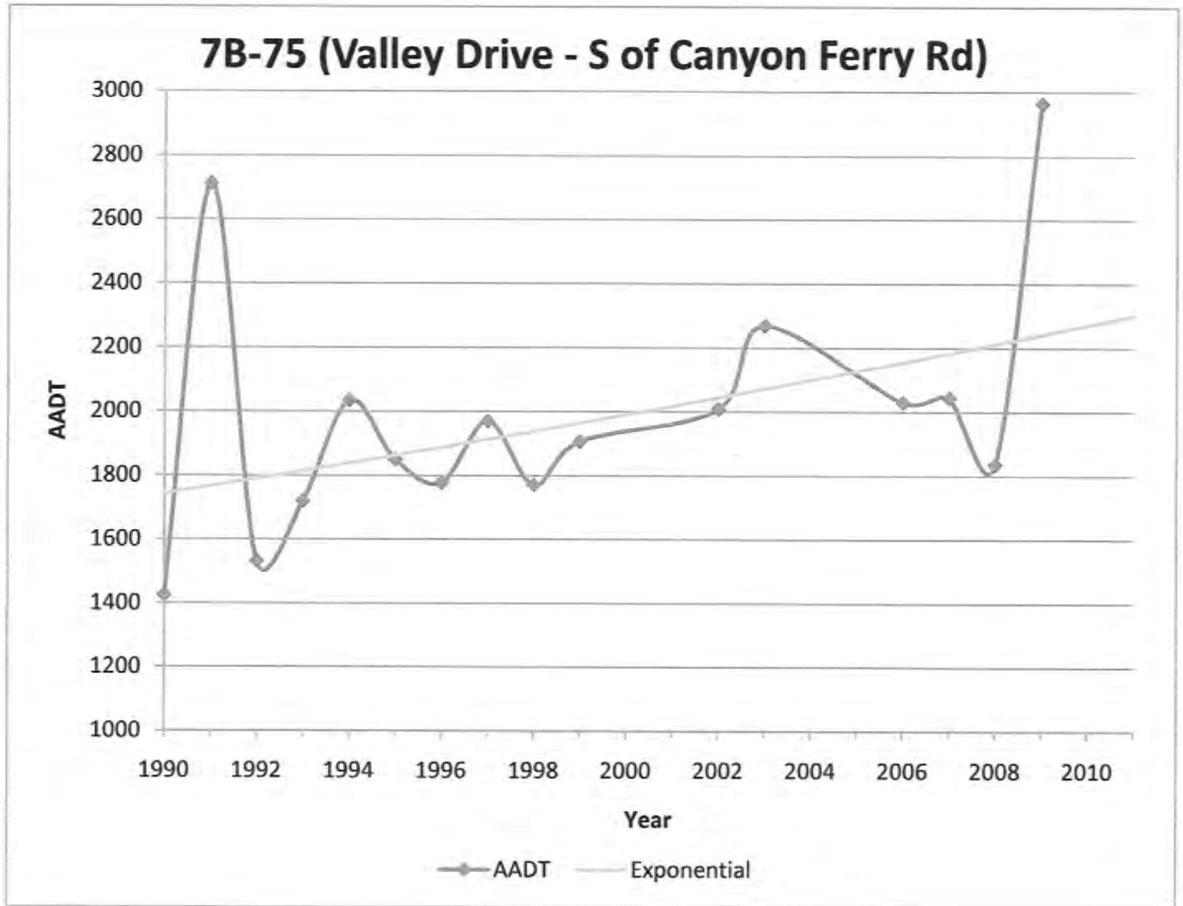
# Appendix A

## Background Data

#

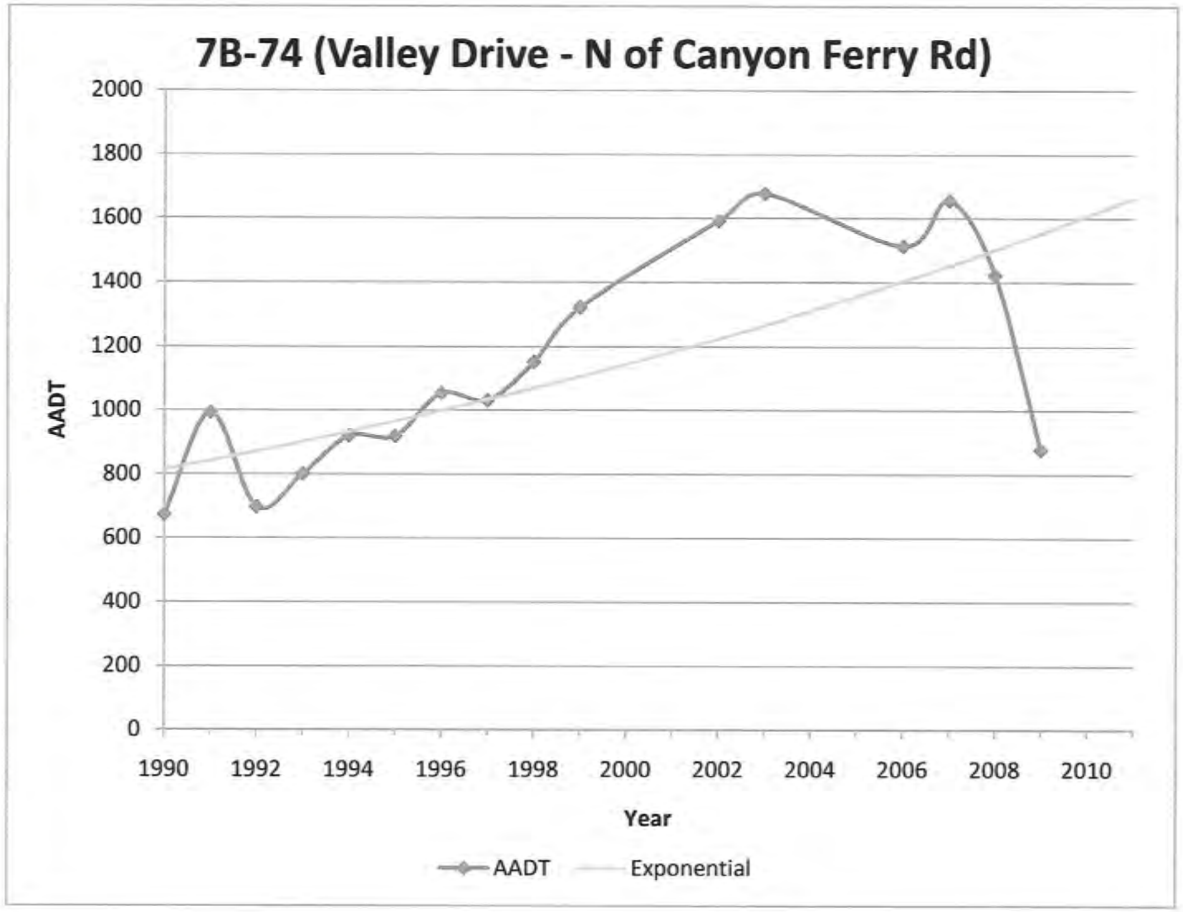
**7B-75 (Valley Drive - S of Canyon Ferry Rd)**

| Year | AADT | Exponential |
|---|---|---|
| 1990 | 1425 | 1743 |
| 1991 | 2712 | 1767 |
| 1992 | 1532 | 1790 |
| 1993 | 1720 | 1814 |
| 1994 | 2034 | 1838 |
| 1995 | 1849 | 1863 |
| 1996 | 1777 | 1888 |
| 1997 | 1970 | 1913 |
| 1998 | 1770 | 1938 |
| 1999 | 1907 | 1964 |
| 2002 | 2008 | 2044 |
| 2003 | 2269 | 2071 |
| 2006 | 2029 | 2155 |
| 2007 | 2043 | 2184 |
| 2008 | 1836 | 2213 |
| 2009 | 2963 | 2242 |
| 2011 | - | 2302 |
| 2031 | - | 3000 |
| i | - | **1.33%** |



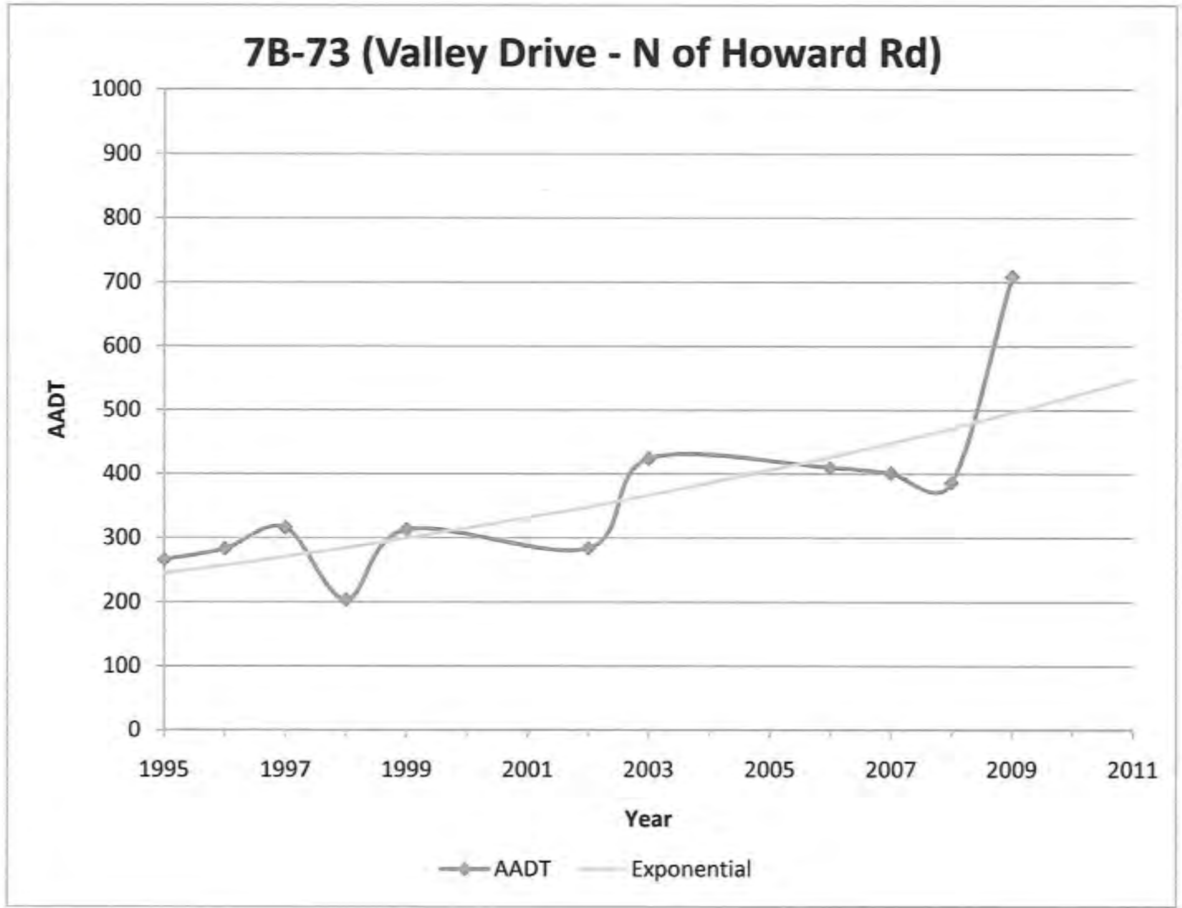
**7B-74 (Valley Drive - N of Canyon Ferry Rd)**

| Year | AADT | Exponential |
|---|---|---|
| 1990 | 673 | 814 |
| 1991 | 993 | 842 |
| 1992 | 697 | 871 |
| 1993 | 801 | 902 |
| 1994 | 920 | 933 |
| 1995 | 919 | 965 |
| 1996 | 1053 | 998 |
| 1997 | 1031 | 1033 |
| 1998 | 1152 | 1069 |
| 1999 | 1322 | 1106 |
| 2002 | 1592 | 1225 |
| 2003 | 1678 | 1267 |
| 2006 | 1513 | 1403 |
| 2007 | 1656 | 1452 |
| 2008 | 1423 | 1502 |
| 2009 | 878 | 1554 |
| 2011 | - | 1663 |
| 2031 | - | 3285 |
| i | - | **3.46%** |



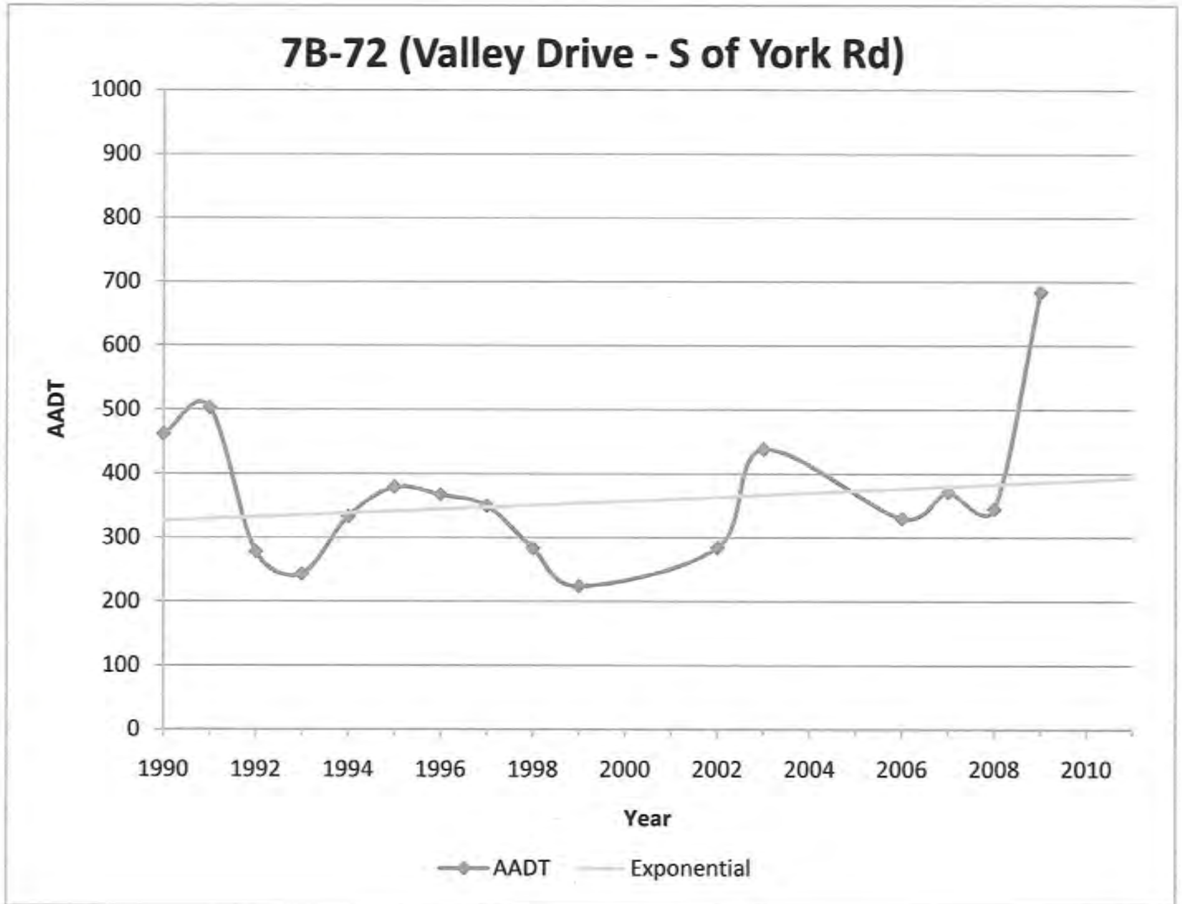
**7B-73 (Valley Drive - N of Howard Rd)**

| Year | AADT | Exponential |
|---|---|---|
| 1995 | 266 | 245 |
| 1996 | 283 | 257 |
| 1997 | 316 | 270 |
| 1998 | 204 | 284 |
| 1999 | 313 | 299 |
| 2002 | 284 | 348 |
| 2003 | 424 | 366 |
| 2006 | 410 | 426 |
| 2007 | 401 | 448 |
| 2008 | 386 | 471 |
| 2009 | 709 | 496 |
| 2011 | - | 548 |
| 2031 | - | 1505 |
| i | - | **5.18%** |



**7B-72 (Valley Drive - S of York Rd)**

| Year | AADT | Exponential |
|---|---|---|
| 1990 | 462 | 327 |
| 1991 | 503 | 330 |
| 1992 | 278 | 332 |
| 1993 | 243 | 335 |
| 1994 | 333 | 338 |
| 1995 | 379 | 341 |
| 1996 | 367 | 344 |
| 1997 | 350 | 348 |
| 1998 | 283 | 351 |
| 1999 | 224 | 354 |
| 2002 | 284 | 363 |
| 2003 | 438 | 366 |
| 2006 | 330 | 376 |
| 2007 | 371 | 380 |
| 2008 | 345 | 383 |
| 2009 | 684 | 386 |
| 2011 | - | 393 |
| 2031 | - | 469 |
| i | - | **0.89%** |



| Valley Drive | | AADT | | | | |
|---|---|---|---|---|---|---|
| Site ID | Location | 2008 | 2009 | 2011 | 2031 | Growth |
| 7B-72 | S. of York Rd | 345 | 684 | 393 | 469 | 0.89% |
| 7B-73 | N. of Howard Rd | 386 | 709 | 548 | 1505 | 5.18% |
| 7B-74 | N. of Canyon Ferry Rd | 1423 | 878 | 1663 | 3285 | 3.46% |
| 7B-75 | S. of Canyon Ferry Rd | 1836 | 2963 | 2302 | 3000 | 1.33% |
| *Weighted Average:* | | | | | | **2.45%** |

# INITIAL ASSESSMENT FORM FOR STRUCTURE :

**L25049002+02001**

**Location : 2M N EAST HELENA Structure Name: Lewis and Clark VD 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 :**25049**

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

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

Intersecting Feature : **HELENA VALLEY CANAL 074**

Kilometer Post, Mile Post : **3.54 km 2.20**

Structure on the State Highway System : [ ]

Latitude : **46°36'51"**

Structure on the National Highway System : [ ]

Longitude : **111°54'53"**

Str Meet or Exceed NBIS Bridge Length : [X]

## Construction Data

Construction Project Number :

Construction Station Number : **0+00.00**

Construction Drawing Number : **RECORDS**

Construction Year : **2000**

Reconstruction Year :

## Traffic Data

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

## Structure Loading, Rating and Posting Data

### Loading Data :

| | | |
|---|---|---|
| Design Loading : | | 0 Unknown |
| Inventory Load, Design : | 19.1 mton | 2 AS Allowable Stress |
| Operating Load, Design : | 27.2 mton | 2 AS Allowable Stress |
| Posting : | | 5 At/Above Legal Loads |

| Rating Data : | Operating | Inventory | Posting |
|---|---|---|---|
| Truck 1 Type 3 : | 26 | 18 | |
| Truck 2 Type 3-S3 : | 39 | 41 | |
| Truck 3 Type 3-3 : | 50 | 45 | |

## Structure, Roadway and Clearance Data

### Structure Deck, Roadway and Span Data :

Structure Length : **13.11 m**

Deck Area : **119.00 m sq**

Deck Roadway Width : **8.35 m**

Approach Roadway Width : **7.32 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 : **9.10 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 | L25049 | Both | 99.99 m | 8.35 m | N/A | | |
| VALLEY DRIVE | | | | | | | |

Montana Department of Transportation

# INITIAL ASSESSMENT FORM FOR STRUCTURE :

## L25049002+02001

Continue

## Inspection Data

Sufficiency Rating : **83.2**
Health Index : **99.47**
Structure Status :**Not Deficient**

**Inspection Due Date : 11 January 2013**
(91) Inspection Fequency (months) : **24**

## NBI Inspection Data

(90) Date of Last Inspection : 11 January 2011
Last Inspected By : Charles Pepos - 107
(90) Inspection Date :
Inspected By :

| | | | | | | | |
|---|---|---|---|---|---|---|---|
| (58) Deck Rating : | 7 | (68) Deck Geometry : | 6 | (36C) Approach Rail Rating : | N | (62) Culvert Rating : | N |
| (59) Superstructure Rating : | 7 | (67) Structure Rating : | 5 | (36A) Bridge Rail Rating : | 1 | (61) Channel Rating : | 7 |
| (60) Substructure Rating : | 7 | (69) Under Clearance : | N | (36B) Transition Rating : | N | (71) Waterway Adequacy : | 8 |
| (72) App Rdwy Align : | 8 | (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 | | Status | Priority | Effected Structure Unit | Scope of Work | Action | Covered Condition States |
|---|---|---|---|---|---|---|---|
| Candidate ID | Date Requested | | | | | | |

# INITIAL ASSESSMENT FORM FOR STRUCTURE :

## L25049002+02001

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 | 2 | 119 | sq.m. | X | 100 | 0 | 0 | 0 | 0 |
| | | | | | | % | % | % | % | % |

Previous Inspection Notes :

01/11/2011 - Good condition, Some tight cracks in the grout between the panels.

01/08/2009 - Wear in the wheel paths. Some cracking of the grout between the panels. Lots of leakage at both of the Abutments. One piece of the guard angle on the South end has been torn off; spalling and damaged concrete.

Inspection Notes:

| 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 109 - P/S Conc Open Girder | | | | | | | | | | |
| | 1 | 1 | 66 | m. | | 100 | 0 | 0 | 0 | |
| | | | | | | % | % | % | % | % |

Previous Inspection Notes :

01/11/2011 - Good condition. Same on the staining from leakage.

01/08/2009 - Beam stems at the ends are stained at both Abutments from leakage. Tight cracks at a couple of the attaching angles areas. Rusty spots on the angles use to attach the girders to the cap with the rubber pads looking Good. Generally in good condition.
01/15/2003 Second girder from the Left/West has a small section of concrete spalled off on under side near the North Abutment.
04/20/2001 5 * 13.11 = 65.55m (5) new three girder girders. Page A-7 - 2nd from the bottom.

Inspection Notes:

| 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 215 - R/Conc Abutment 1 and 2 | | | | | | | | | | |
| | 1 | 2 | 22 | m. | | 95 | 5 | 0 | 0 | |
| | | | | | | % | % | % | % | % |

Previous Inspection Notes :

01/11/2011 - Cracks in both of the caps. SE wingwall has a small spall on its' outer edge.

01/08/2009 - Both caps have some minor cracking. South cap has a wider cap near centerline.

01/03/2007 - Same as 2005 report and leakage is very apparent on the backwalls and caps.

01/27/2005 - Water from the roadway is is running onto the cap. Water is running from the girder to roadway joint. Ponding on the cap and around the anchor plates. Vertical crack in South Abutment near centerline.

01/15/2003 - Same as previous report for water. Vertical crack in South Abutment near centerline.

04/20/2001 - (9.11 * 2) + (4 * 0.95) = 22.02m Env. State #2 as wet or in mud part of the year.
Water from the roadway is is running onto the cap. Water is running from the girder to roadway joint. Ponding on the cap and around the anchor plates.

Inspection Notes:

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

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 334 - Metal Rail Coated T-101 | | | | | | | | | | |
| | 1 | 2 | 26 | m. | | 95 | 5 | 0 | 0 | 0 |
| | | | | | | % | % | % | % | % |

Previous Inspection Notes :

01/11/2011 - Minor rubs on both rails Minor fading to the galvanized coating on the posts and T-101 tubes. Generally in Good condition.

01/08/2009 - Minor fading of the galvanized coating. Generally in Good condition.

01/03/2007 - No changes.

01/27/2005 - Same as the previous report.

01/15/2003 - Minor areas of thin paint in the web areas of several posts. Ends of T-101 bars have rust on the unpainted areas.

04/20/2001 - 13.11 * 2 = 26.22m T-1101 rail with metal posts.

Inspection Notes:

## General Inspection Notes

01/11/2011 - NBI 61, channel, rated a "7" as banks on both sides of the bridge are undercut some.
Fair to Good markers on all (4) corners.
01/08/2009 - Markers on all but the NE corner and the sign faces are Good. NE marker is ok, but needs to be put back up.

01/03/2007 - None

01/27/2005 - NBI 58, deck, rated at a "7" due to wear to the driving surface and some leakage along the girder joints.
NBI 59, superstructure, rate a "7" due to the rusting of the bearings.
NBI 60, substructure, rated at a "7" due to cracks in the South Abutment cap and water coming through the backwalls.
Markers on all (4) corners of the bridge and in Good to Fair condition.
01/15/2003 - Markers on all (4) corners of the bridge and in Good condition.

04/20/2001 - No change in the markers.

# Appendix B

## Design Reference Exhibits

#

## 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 |

| 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) | 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**

| 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.

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
Valley Drive

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

Dear Tom:

Re: Pavement Evaluation, Valley Drive, 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 Valley Drive. The pavement evaluation was performed in general accordance with our Subconsultant Agreement dated June 11, 2009.

## Project Information

It is our understanding Valley Drive 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 northern city limits of East Helena at East Lewis Street extending northward for 3 1/2 miles to York Road. The Valley Drive roadway limits considered for this pavement evaluation are shown on the attached Boring Location Sketch. At this time, the engineering evaluation along Valley Drive 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 10, 2009, Borings ST-12 through ST-15 were performed along the 3 1/2-mile alignment being considered for reconstruction. Boring locations were selected by our personnel and were generally alternated from the northbound and southbound lanes. The locations of Borings ST-12 through ST-15 are shown on the attached sketch. To perform the borings, single lane closure traffic control was performed while drilling.

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 four borings was existing pavement underlain by gravel base course over clayey gravel subgrades. Table 1 below summarizes the existing pavement and subgrade conditions encountered at the four borings.

**Table 1. Summary of Boring Conditions – Valley Drive**

| Boring | ST-12 | ST-13 | ST-14 | ST-15 |
|---|---|---|---|---|
| Existing Pavement | 3¼" | 3½" | 1" | 3½" |
| Existing Base Thickness | 1" (1) | 2" (1) | 2" (1) | 4½" |
| Existing Base Quality | Good | Moderate | Good | Moderate |
| Subgrade | GC | GC | GC | GC |
| BPF | 15 | 12 | 14, 12 | 11, 14 |
| Moisture Condition | Over 7%-8% | Over 5%-6% | Over 6%-7% | Over 6%-7% |
| Risk of Subgrade Failure | Moderate | Moderate | Moderate | Moderate |

(1) Base is too thin to salvage.
GC = Clayey Gravel with Sand

**General Statistical Summary**

Existing Base Course: 2 of 4 borings (50%) encountered MODERATE quality base course
2 of 4 borings (50%) encountered GOOD quality base course

Subgrade Conditions: 4 of 4 borings (100%) have MODERATE risk to become unstable during construction.

**Existing Pavement Section.** As indicated in Table 1 above, the four borings encountered existing asphalt pavement to depths ranging from 1 to 3 1/2 inches. Beneath the existing pavement, the borings encountered moderate to good quality base course, which extended to a depth of only 3 to 8 inches (corresponding thicknesses of only 1 to 4 1/2 inches).

**Subgrade.** Beneath the existing base course, Borings ST-12 and ST-15 encountered clayey gravel with sand to depths ranging from 2 to 3 feet underlain by poorly graded gravel. Penetration resistances in the clayey gravel subgrade typically ranged from 12 to 15 blows per foot (BPF), indicating these materials were medium dense. The penetration resistances in the underlying gravels ranged from 30 BPF to 50 blows for 3 inches of penetration, indicating these gravels were medium dense to very 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 compared to the optimum moisture content determined by our standard Proctors (described below). Based on these moisture content tests, the subgrade conditions at the borings indicated the clayey gravels were 5 to 8 percent over optimum moisture content, and would be considered wet. The moisture contents in the underlying gravels indicated they were rather dry to moist.

**Groundwater.** Groundwater was not encountered in the four borings to their termination depth of 3 to 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 clayey gravel 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 two 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-13 | Nonplastic | | | 11.2% | --- | --- | --- |
| Base Course, ST-15 | Nonplastic | | | 5.4% | --- | --- | --- |
| Composite Subgrade, ST-12 and ST-13 | 29 | 14 | 15 | 17.8% | 137.6 | 6.8% | 15.4 |
| Composite Subgrade, ST-14 and ST-15 | 29 | 16 | 13 | 18.8% | 140.6 | 6.3% | 14.4 |

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

As can be seen above, the base course samples tested from Borings ST-13 and ST-15 were nonplastic and the percent-finer-than-a-200-sieve (P200) of these samples were 11.2 and 5.4 percent, respectively. The base course from Boring ST-13 classifies as a well graded sand with silt and gravel (SW-SM) and the base from Boring ST-15 classifies as a poorly graded gravel with silt and sand (GP-GM). A Laboratory Test of Aggregate sheet compares these base samples to the Lewis and Clark crushed top surfacing and select base course gradation requirements. The base samples tested almost met the specifications and would be considered moderate quality. However, the existing base is generally too thin to salvage.

Standard Proctors (ASTM D 698) and California bearing ratio (CBR) tests were performed on the two subgrade samples indicated above. CBR values for these samples were 14.4 and 15.4.

## Pavement Analysis and Recommendations

**Available Information.** Robert Peccia & Associates provided us with the traffic information indicated on the attached graph for Valley Drive. As can be seen, the projected 2009 AADT count is 1,743 and the projected 2029 AADT is 2,804. A linear relationship was used to estimate the increase in AADT over this 20-year period. Based on the AADT trend line, the yearly growth rate within the 20-year performance period is approximately 2.41%.

**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 provided traffic information, we performed a simple traffic analysis to determine the design Equivalent Single 18-kip Axle Load (ESAL). The simple 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 | 1,743 |
| 2029 AADT | 2,804 |
| Estimated Annual Growth | 2.41 |
| Assumed Percent Heavy Trucks | 3.1% |
| 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 | 242,540 |

As can be seen above, we calculated a design ESAL of 242,540 for Valley Drive. We assumed 3.1 percent heavy trucks. Traffic data for Lake Helena Drive in the same area indicated about 3.1 to 5.9 percent heavy trucks. We assumed the lowest value for our pavement design.

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 between 10 and 20, we used the following relationship.

$$M_R \text{ (psi)} = 1{,}100 \times \text{CBR}$$

As previously indicated in Table 2, CBR values of 14.4 and 15.4 were determined for subgrade samples along this roadway. It is our opinion a design CBR of one standard deviation below the mean should be used. This results in a CBR of 14.2, which results in an $M_r$ equal to 15,600.

**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.

As previously indicated in Table 1, the borings indicated the clayey gravel subgrade was wet and well over optimum moisture content. We considered this subgrade to have a "moderate" 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 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 Valley Drive reconstruction project(s) are 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,

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

MONTANA
GREGORY T.
STAFFILENO
No. 10798 P.E.
REGISTERED
PROFESSIONAL ENGINEER

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

Cory G. Rice, PE
Reviewing Engineer

gts/cgr:khr

Attachments:
Boring Location Sketch
Descriptive Terminology
Log of Boring Sheets ST-12 through ST-15
Laboratory Tests
Laboratory Test of Aggregate
RPA Traffic Curve
DARWin Pavement Analysis


ST-15
ST-14
ST-13
ST-12
BORING LOCATION SKETCH
Pavement Design
Valley Drive
Lewis and Clark Co. Roads
Helena, MT
09-2560
YORK RD
VALLEY DR
HOWARD RD
E HOWARD RD
CANYON FERRY RD
COTTAGE RD
GRAND VIEW RD
LANNING RD
HOFFMAN RD
PLANT RD
WILDFIRE RD
LAKE HELENA DR
E LEWIS ST
E GROSCHELL ST
W GROSCHELL ST
W RIGGS ST
W PACIFIC ST
E PACIFIC ST
E PORTER ST
E CLARK ST
WHITE ROCK RD
GREY ROCK RD
BYRON RD
VIENNA DR
ROCKY RD
BUGLE CT
HOMEWARD LN
FRANCIS RD
NANCY RD
JUSTICE CT
ANDERS RD
FOXHOLLOW DR
HELENA REGULATING RESERVOIR
BOUNDARY ST
REMINGTON ST
LONE PRAIRIE RD
LEWIS & CLARK COUNTY
PRELIMINARY ENGINEERING REPORTS
VALLEY DRIVE

SK GEOTECHNICAL

# 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] 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] 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 $C_U = D_{60} / D_{10}$
$C_C = (D_{30})^2 / (D_{10} \times D_{60})$
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.

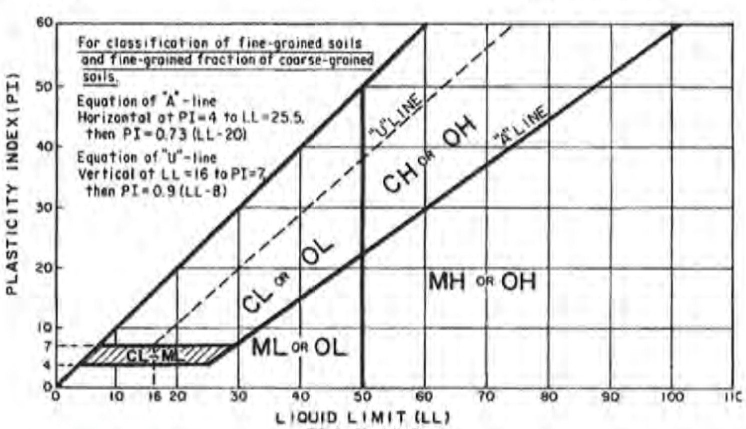



FIG. 4 Plasticity Chart

### 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-12 LOCATION: Valley Drive, see attached sketch. |
|---|---|

| DRILLED BY: C. Larsen | METHOD: 3 1/4" HSA, Automatic | DATE: 7/10/09 | SCALE: 1" = 1' |
|---|---|---|---|

| Elev. | Depth 0.0 | Symbol | Description of Materials | BPF | WL | MC (%) | Remarks |
|---|---|---|---|---|---|---|---|
| | 0.3 | | FILL: 3 1/4" of Asphalt Pavement. | | | | |
| | 0.4 | | FILL: 1" of Gravel Base. | | | | |
| | 2.0 | GC | CLAYEY GRAVEL with SAND, fine- to coarse-grained, low plasticity, brown, wet, medium dense. (Alluvium) | 6/9/7 | | 15.4 | Composite subgrade bag sample ST-12 and ST-13: LL=29, PL=14, PI=15 $P_{200}$=17.8% |
| | 3.0 | GP | POORLY GRADED GRAVEL with SAND, fine- to coarse-grained, with Cobbles, gray, rather dry, very dense. (Alluvium) | 49/50-3" | | 1.7 | |
| | | | | 50-5" | | 1.3 | |
| | | | END OF BORING - Auger Refusal<br><br>Water not observed with 3' 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<br>**PAVEMENT DESIGN**<br>Lewis and Clark County Roads<br>Helena, Montana | BORING: **ST-13**<br>LOCATION:<br>Valley Drive, see attached sketch. |

| DRILLED BY: C. Larsen | METHOD: 3 1/4" HSA, Automatic | DATE: 7/10/09 | SCALE: 1" = 1' |
|---|---|---|---|

| Elev. | Depth | Symbol | Description of Materials | BPF | WL | MC (%) | Remarks |
|---|---|---|---|---|---|---|---|
| | 0.0 | | FILL: 3 1/2" of Asphalt Pavement. | | | | |
| | 0.3 | | FILL: 2" of Well Graded Sand with Silt and Gravel Base Course. | | | | Base course bag sample: $P_{200}$=11.2% |
| | 0.5 | GC | CLAYEY GRAVEL with SAND, fine- to coarse-grained, low plasticity, gray, wet to moist, medium dense. (Alluvium) | 6/6/10 | | 13.5 | Composite subgrade bag sample ST-12 and ST-13: LL=29, PL=14, PI=15 $P_{200}$=17.8% |
| | 2.0 | GP | POORLY GRADED GRAVEL with SAND, fine- to coarse-grained, trace Cobbles, gray, rather dry, very dense. (Alluvium) | 10/21/37 | | 2.0 | |
| | | | | 23/40/42 | | 2.0 | |
| | 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 1 1/2' immediately after withdrawal of auger. | | | | |

BORING BPF WL MC 2560.GPJ LAGNNN06.GDT 10/12/09

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# LOG OF BORING

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

BORING: **ST-14**
LOCATION: Valley Drive, see attached sketch.

DRILLED BY: C. Larsen | METHOD: 3 1/4" HSA, Automatic | DATE: 7/10/09 | SCALE: 1" = 1'

| Elev. | Depth | Symbol | Description of Materials | BPF | WL | MC (%) | Remarks |
|---|---|---|---|---|---|---|---|
| | 0.0 | | | | | | |
| | 0.1 | | FILL: 1" of Asphalt Pavement. | | | | |
| | 0.3 | | FILL: 2" of Gravel Base. | | | | |
| | | GC | CLAYEY GRAVEL with SAND, fine- to coarse-grained, low plasticity, brown, wet, medium dense to dense. (Alluvium) | 6/8/9 | | 13.9 | Composite subgrade bag sample ST-14 and ST-15: LL=29, PL=16, PI=13 $P_{200}$=18.8% |
| | | | | 6/21/24 | | 7.2 | |
| | 2.5 | GP | POORLY GRADED GRAVEL with SAND, fine- to coarse-grained, gray, rather dry, dense. (Alluvium) | 8/20/24 | | 1.6 | |
| | 5.5 | | END OF BORING - Auger Refusal<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. | | | | |

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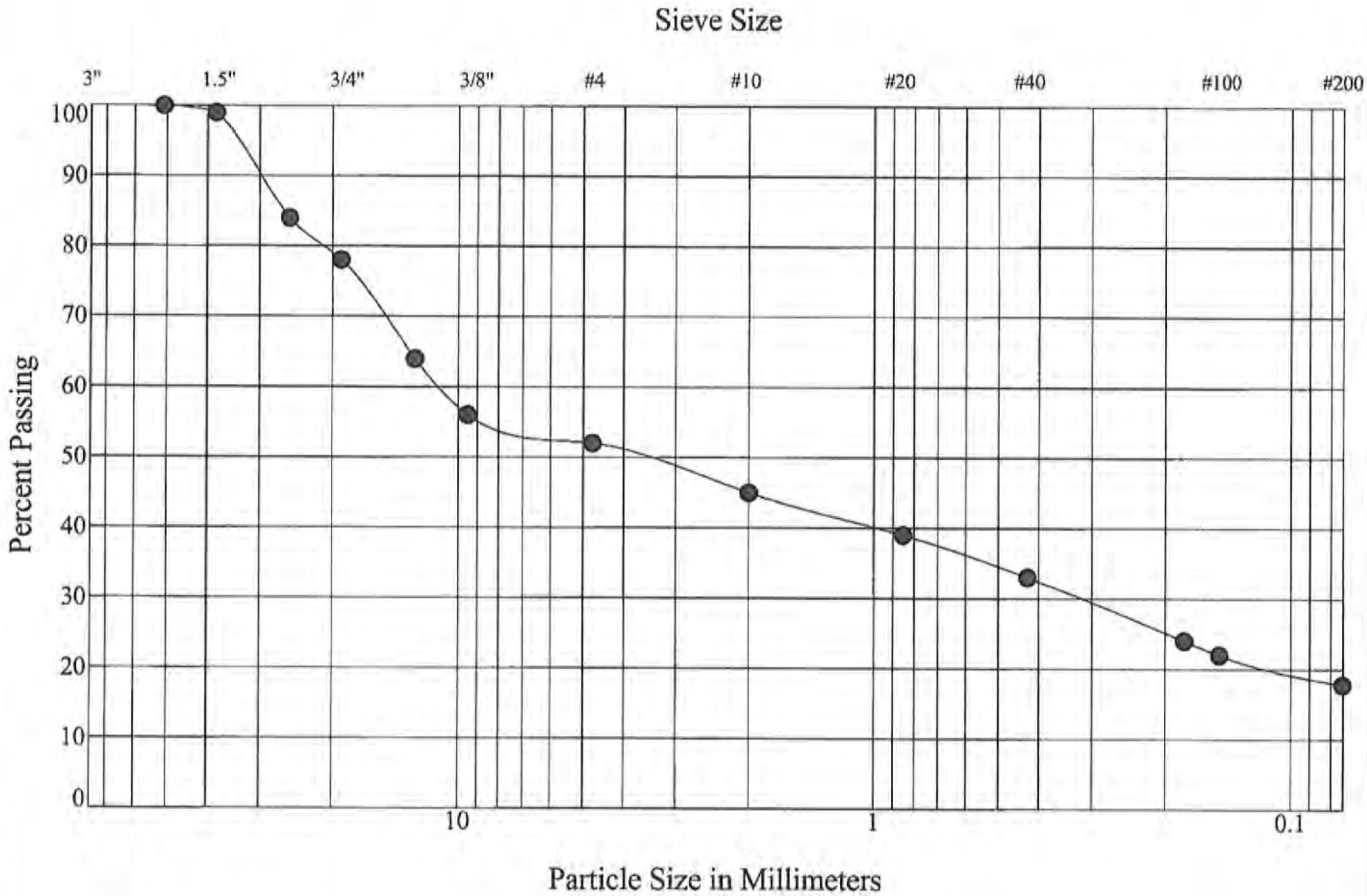
# LOG OF BORING

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

BORING: **ST-15**
LOCATION:
Valley Drive, see attached sketch.

DRILLED BY: C. Larsen | METHOD: 3 1/4" HSA, Automatic | DATE: 7/10/09 | SCALE: 1" = 1'

| Elev. | Depth | Symbol | Description of Materials | BPF | WL | MC (%) | Remarks |
|---|---|---|---|---|---|---|---|
| | 0.0 | | FILL: 3 1/2" of Asphalt Pavement. | | | | |
| | 0.3 | | FILL: 4 1/2" of Poorly Graded Gravel with Silt and Sand Base Course. | | | | Base course bag sample: $P_{200}$=5.4% |
| | 0.7 | GC | CLAYEY GRAVEL with SAND, fine- to coarse-grained, low plasticity, brown, wet to moist, medium dense to dense. (Alluvium) | 7/6/5 | | 14.1 | Composite subgrade bag sample ST-14 and ST-15: LL=29, PL=16, PI=13 $P_{200}$=18.8% |
| | | | | 7/19/27 | | 3.9 | |
| | 3.0 | GP | POORLY GRADED GRAVEL with SAND, fine- to coarse-grained, gray, rather dry, dense. (Alluvium) | | | | |
| | | | | 9/21/18 | | 1.3 | |
| | 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. | | | | |




| 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 | 78 | 56 | 52 | 45 | 39 | 33 | 24 | 22 | 17.8 |

Boring No.: ST-12 and ST-13 Date Received: 07/15/2009
Sample No.: P-6
Depth: Subgrade

| | |
|---|---|
| Liquid Limit: | 29 |
| Plastic Limit: | 14 |
| Plasticity Index: | 15 |
| Classification: | GC |
| Moisture Content: | |

Percent Gravel: 48.0
Percent Sand: 34.2
Percent Silt + Clay: 17.8
ASTM Group Name: CLAYEY GRAVEL with SAND

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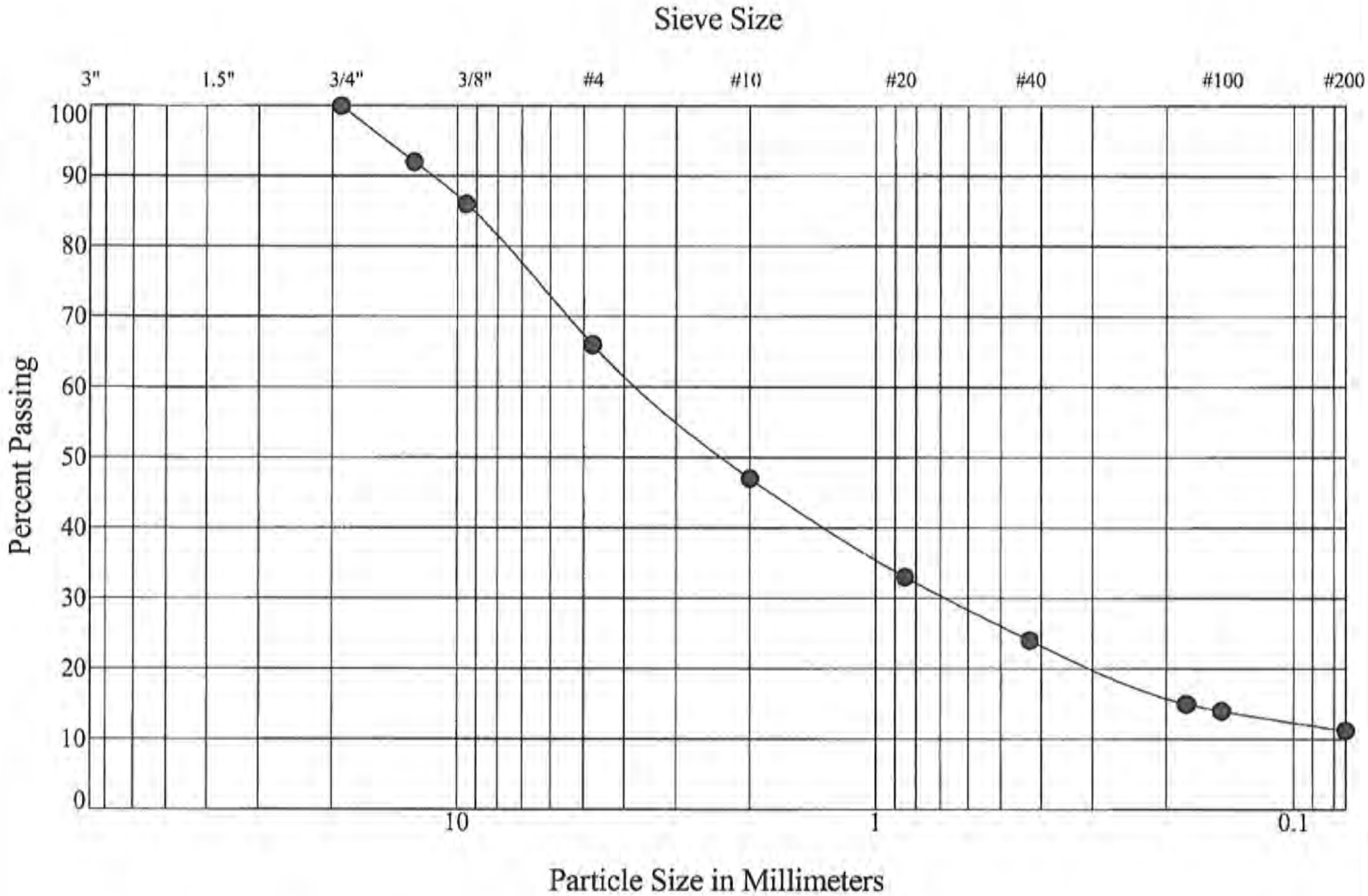
P. O. Box 80190
Billings, MT 59108-0190
Phone: 406.652.3930
Fax: 406.652.3944

## Sieve Analysis

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

10/12/09




| 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 | 86 | 66 | 47 | 33 | 24 | 15 | 14 | 11.2 |

Boring No.: ST-13  Date Received: 07/15/2009
Sample No.: Base Course
Depth: Base Course

| | |
|---|---|
| Liquid Limit: | NP |
| Plastic Limit: | NP |
| Plasticity Index: | NP |
| Classification: | SW-SM |
| Moisture Content: | 3.9% |

Percent Gravel: 34.0
Percent Sand: 54.8
Percent Silt + Clay: 11.2
ASTM Group Name: WELL-GRADED SAND with SILT and GRAVEL

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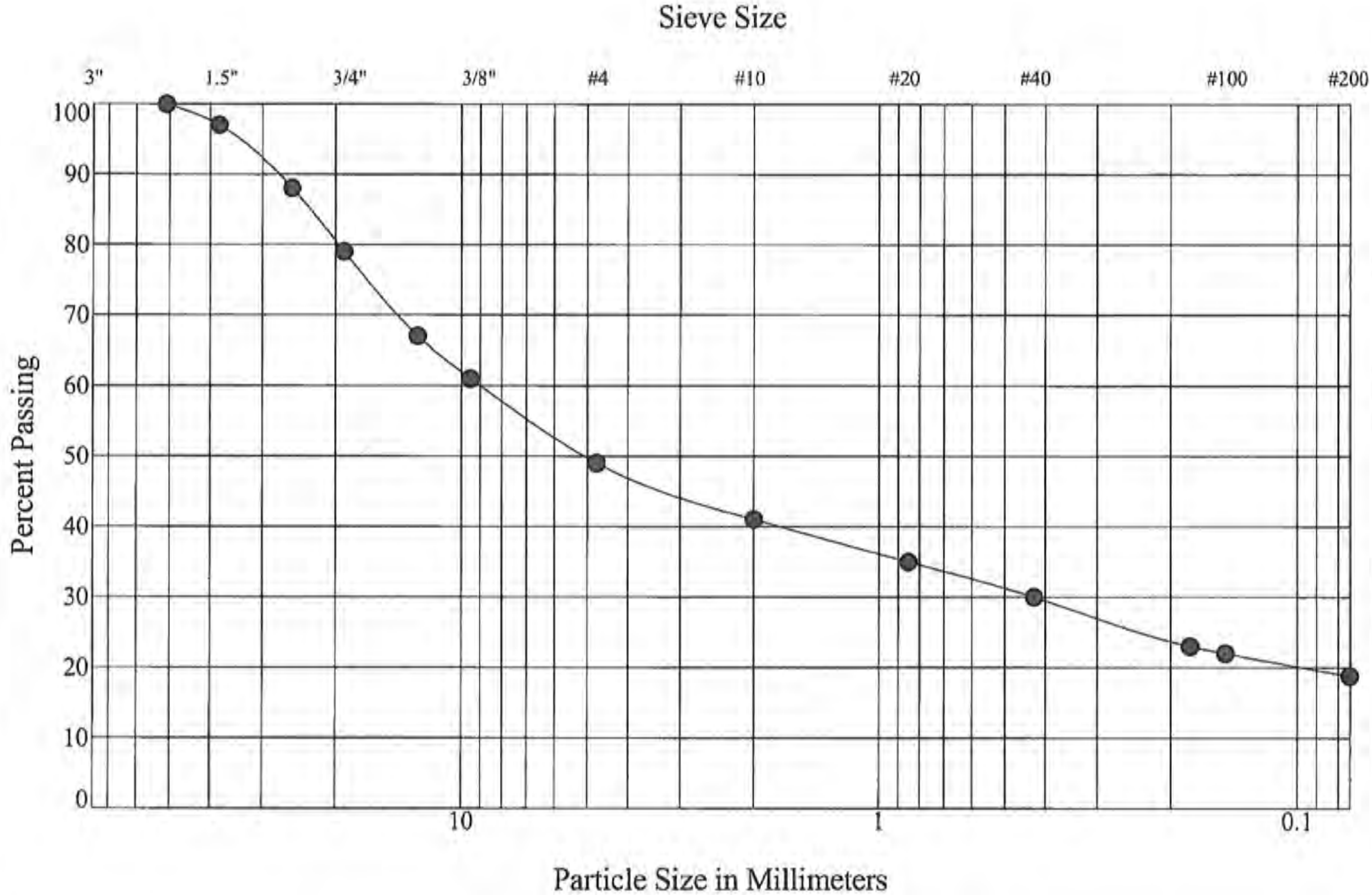
## Sieve Analysis

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

10/12/09




| 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 |
|---|---|---|---|---|---|---|---|---|---|---|
| | 97 | 79 | 61 | 49 | 41 | 35 | 30 | 23 | 22 | 18.8 |

Boring No.: ST-14 and ST-15  Date Received: 07/15/2009
Sample No.: P-7
Depth: Subgrade

| | |
|---|---|
| Liquid Limit: | 29 |
| Plastic Limit: | 16 |
| Plasticity Index: | 13 |
| Classification: | GC |
| Moisture Content: | |

Percent Gravel: 51.0
Percent Sand: 30.2
Percent Silt + Clay: 18.8
ASTM Group Name: CLAYEY GRAVEL with SAND

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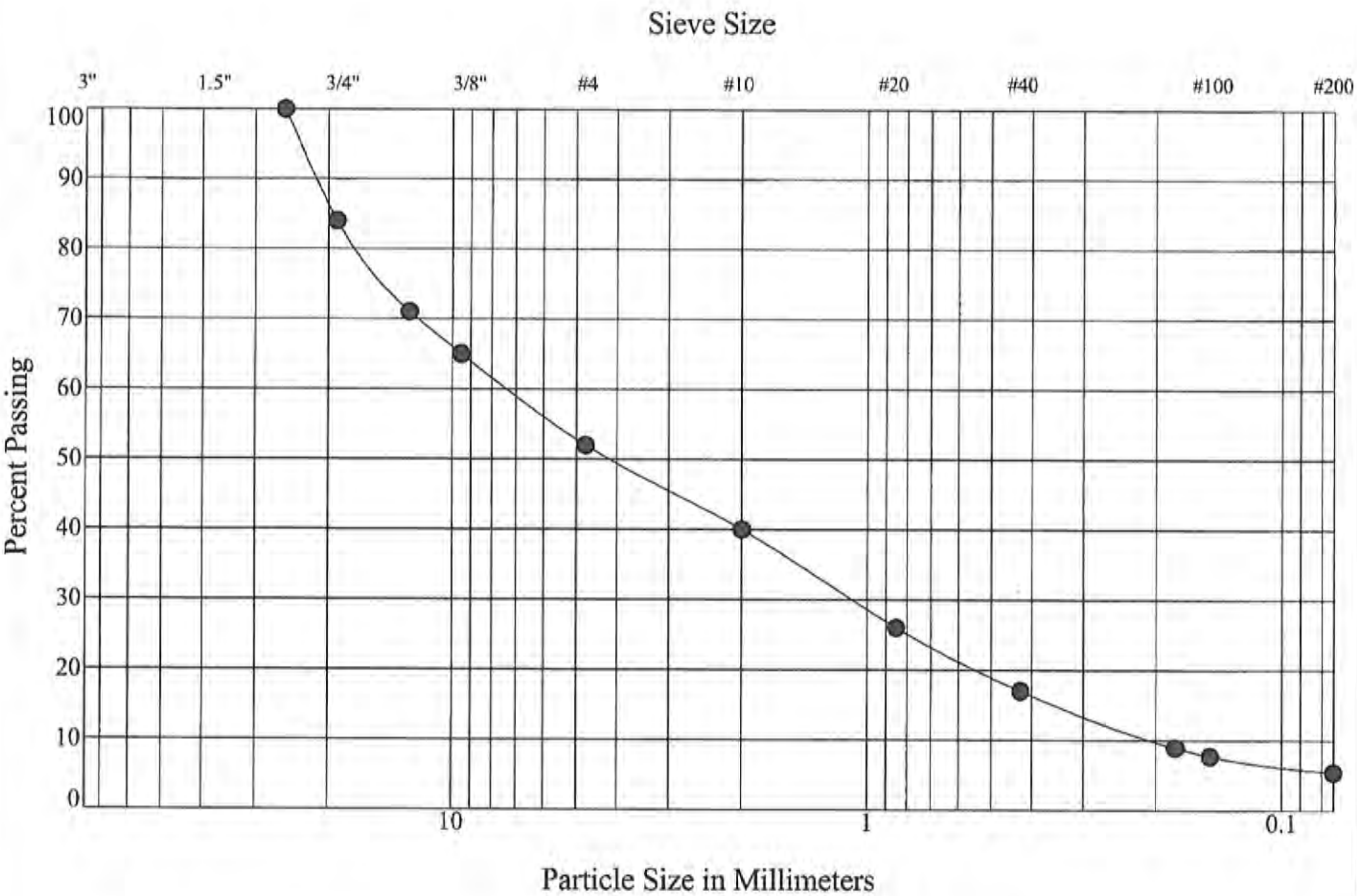
## Sieve Analysis

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

10/12/09




| 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 |
|---|---|---|---|---|---|---|---|---|---|---|
| | | 84 | 65 | 52 | 40 | 26 | 17 | 9 | 8 | 5.4 |

Boring No.: ST-15
Sample No.: Base Course
Depth: Base Course

Date Received: 07/15/2009

| | |
|---|---|
| Liquid Limit: | NP |
| Plastic Limit: | NP |
| Plasticity Index: | NP |
| Classification: | GP-GM |
| Moisture Content: | 2.2% |

Percent Gravel: 48.0
Percent Sand: 46.6
Percent Silt + Clay: 5.4
ASTM Group Name: POORLY GRADED GRAVEL with SILT and SAND

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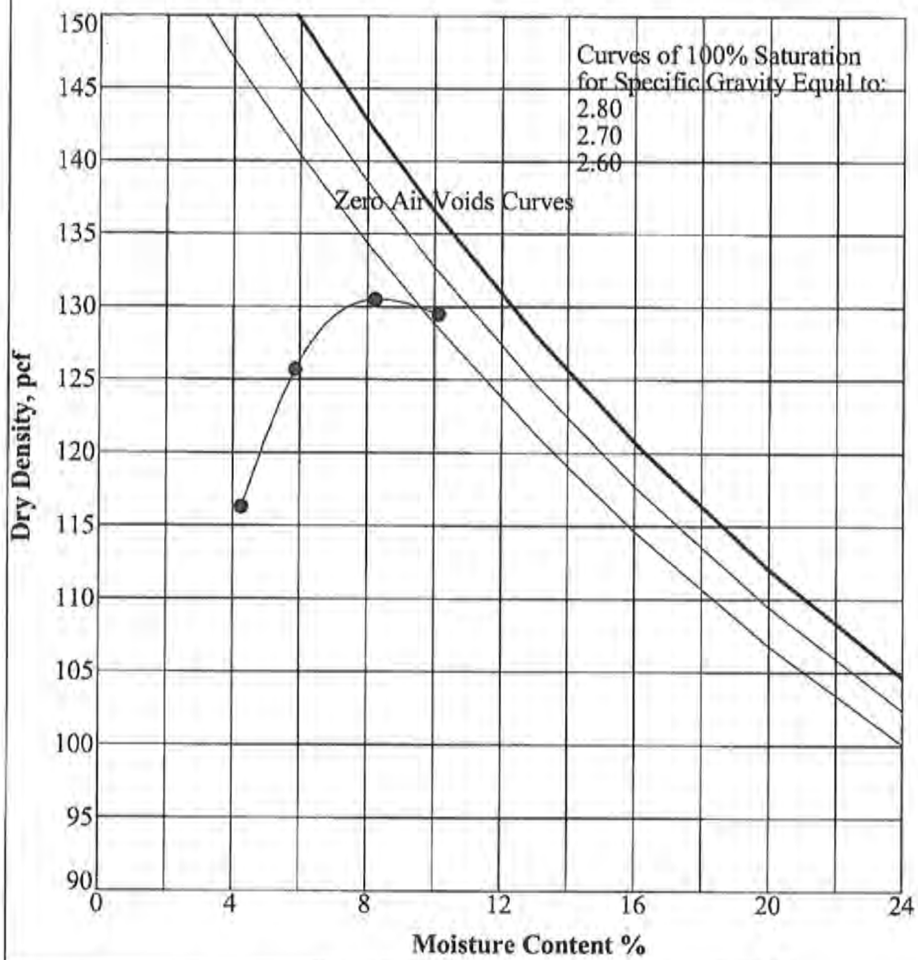
**Sieve Analysis**
Project Number: 09-2560
Lewis and Clark County Roads
Helena, Montana

10/12/09




***ASTM D 4718 Oversize Correction***

| ***Maximum Dry Density, pcf*** | ***Optimum Moisture Content %*** |
|---|---|
| *137.6* | *6.8* |

***ASTM C 127***

***Course Specific Gravity = 2.74***
***Absorption = 0.7%***

Fine Portion

ASTM D 698 Method C with Correction

| Maximum Dry Density, pcf | Optimum Moisture Content % |
|---|---|
| 130.5 | 8.5 |

Rammer Type: Mechanical
Preparation Method: Moist

**Soil Description (Visual-Manual)**

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

| **Sieve Size** | **% Retained** |
|---|---|
| 1 1/2" | 1 |
| 3/4" | 21.6 |
| 3/8" | 44 |
| #4 | 48 |

| | |
|---|---|
| Sample No: | --- |
| Lab Sample No: | P-6 |
| Date Sampled: | 07/10/2009 |
| Sampled By: | Drill Crew |
| Date Received: | 07/15/2009 |
| Sampled From: | ST-12 and ST-13 Valley Drive |
| Depth: | Subgrade |
| Performed by: | MBK/SKG |
| Date Performed: | 08/03/2009 |

**Comments**

**Additional Remarks**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Billings, MT 59108-0190
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Fax: 406.652.3944

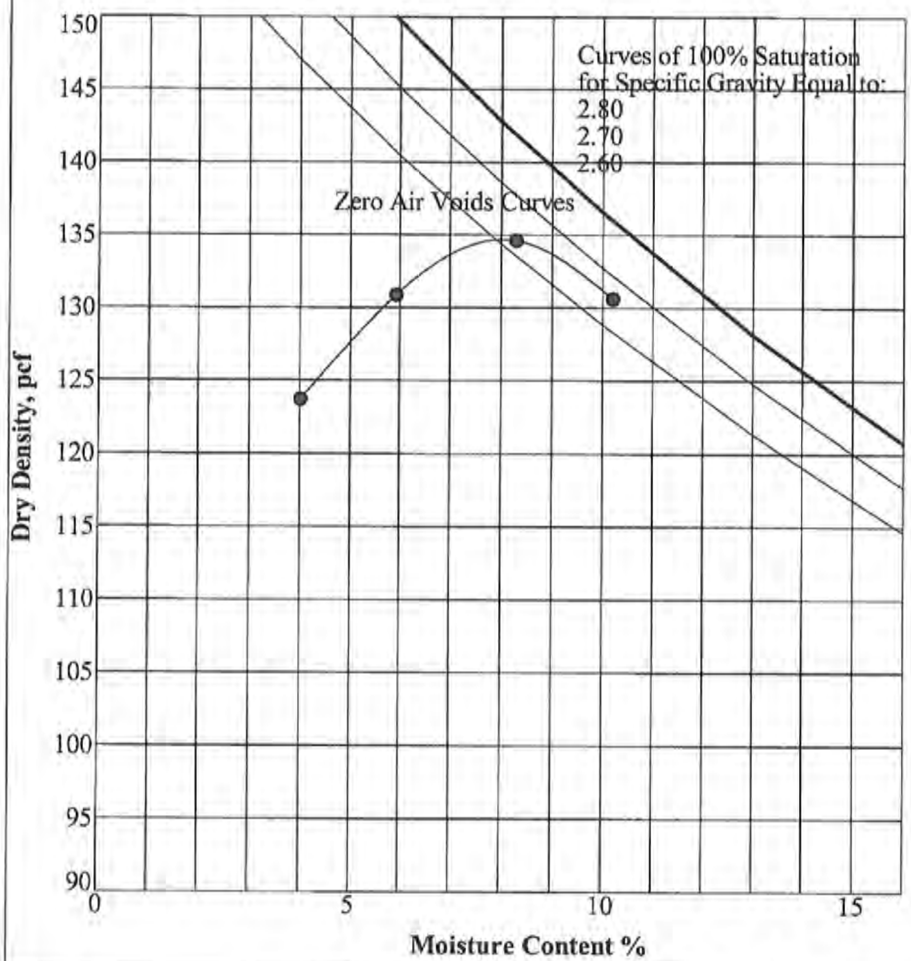

**Laboratory Compaction Characteristics of Soil (Proctor)**

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

**PROCTOR**

P-6

10/12/09




***ASTM D 4718 Oversize Correction***

| ***Maximum Dry Density, pcf*** | ***Optimum Moisture Content %*** |
|---|---|
| *140.6* | *6.3* |

***ASTM C 127***

***Course Specific Gravity = 2.69***
***Absorption = 1.0%***

Fine Portion

ASTM D 698 Method C with Correction

| Maximum Dry Density, pcf | Optimum Moisture Content % |
|---|---|
| 134.8 | 7.7 |

Rammer Type: Mechanical
Preparation Method: Moist

**Soil Description (Visual-Manual)**

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

| **Sieve Size** | **% Retained** |
|---|---|
| 1 1/2" | 3 |
| 3/4" | 20.6 |
| 3/8" | 39 |
| #4 | 51 |

| | |
|---|---|
| Sample No: | --- |
| Lab Sample No: | P-7 |
| Date Sampled: | 07/10/2009 |
| Sampled By: | Drill Crew |
| Date Received: | 07/15/2009 |
| Sampled From: | ST-14 and ST-15 Valley Drive |
| Depth: | Subgrade |
| Performed by: | MBK/SKG |
| Date Performed: | 08/03/2009 |

**Comments**

**Additional Remarks**

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Fax: 406.652.3944

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

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

**PROCTOR**

P-7

10/12/09

# California Bearing Ratio Test

(ASTM D 1883 /AASHTO T 193)

**Project:** 09-2560 Lewis and Clark County Roads
Valley Drive

**Date:** 10/12/09

**Boring:** ST-12 and ST-13 **Sample:** P-6 **Depth:** Subgrade

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

Maximum Dry Density: 130.5 pcf Procedure: ASTM D 698 Method C

| **Initial** | | | **Final** | | |
|---|---|---|---|---|---|
| Wt. Specimen + Tare Wet | 461.0 | gms | Wt. Specimen + Tare Wet | 1135.7 | gms |
| Wt. Specimen + Tare Dry | 431.6 | gms | Wt. Specimen + Tare Dry | 1048.0 | gms |
| Wt. Tare | 117.7 | gms | Wt. Tare | 263.2 | gms |
| Moisture Content | 9.4% | | Moisture Content | 11.2% | |

Initial Wt. 4614.1 gms Diameter 6.00 in Initial Ht. 4.58 in

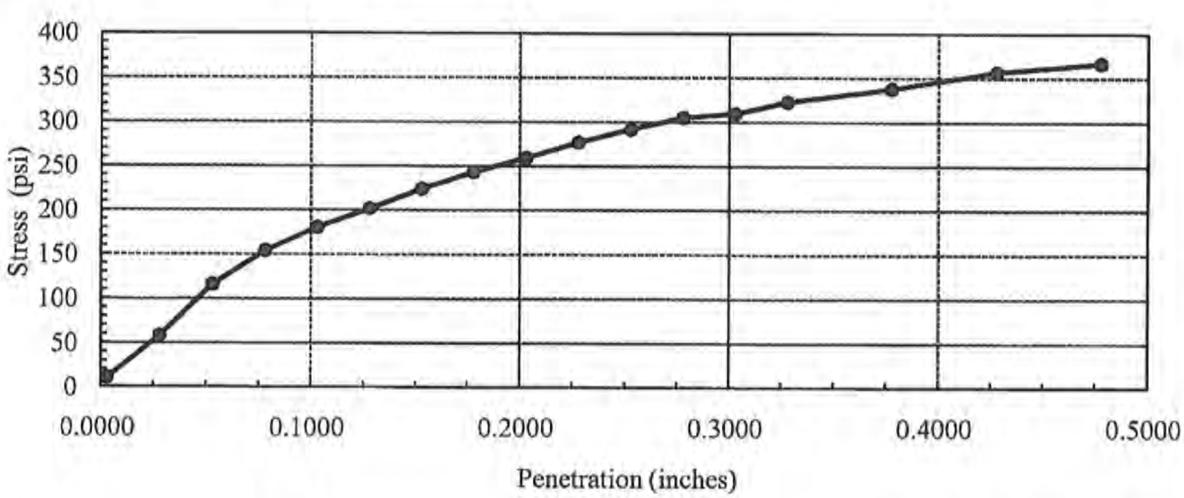
Initial Dry Unit Wt. 124.1 pcf Initial Relative Compaction 95.1%
Final Dry Unit Wt. 123.9 pcf Final Relative Compaction 94.9%

**Swell Test**

Surcharge Weight 22.5 lbs Surcharge Pressure 133.4 psf
Initial Dial Rdg. 0.5000 Final Dial Rdg. 0.5092 Swell 0.2%

**CBR Test**

Surcharge Weight 22.5 lbs Surcharge Pressure 128.1 psf
CBR @ 0.1 in. **15.4** CBR @ 0.2 in **16.2**

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# California Bearing Ratio Test

(ASTM D 1883 /AASHTO T 193)

**Project:** 09-2560 Lewis and Clark County Roads
Valley Drive

**Date:** 10/12/09

**Boring:** ST-14 and ST-15 **Sample:** P-7 **Depth:** Subgrade

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

Maximum Dry Density: 134.8 pcf Procedure: ASTM D 698 Method C

| **Initial** | | | **Final** | | |
|---|---|---|---|---|---|
| Wt. Specimen + Tare Wet | 519.6 | gms | Wt. Specimen + Tare Wet | 1297.8 | gms |
| Wt. Specimen + Tare Dry | 495.3 | gms | Wt. Specimen + Tare Dry | 1217.3 | gms |
| Wt. Tare | 189.1 | gms | Wt. Tare | 349.2 | gms |
| Moisture Content | 7.9% | | Moisture Content | 9.3% | |

Initial Wt. 4700.8 gms Diameter 6.00 in Initial Ht. 4.58 in

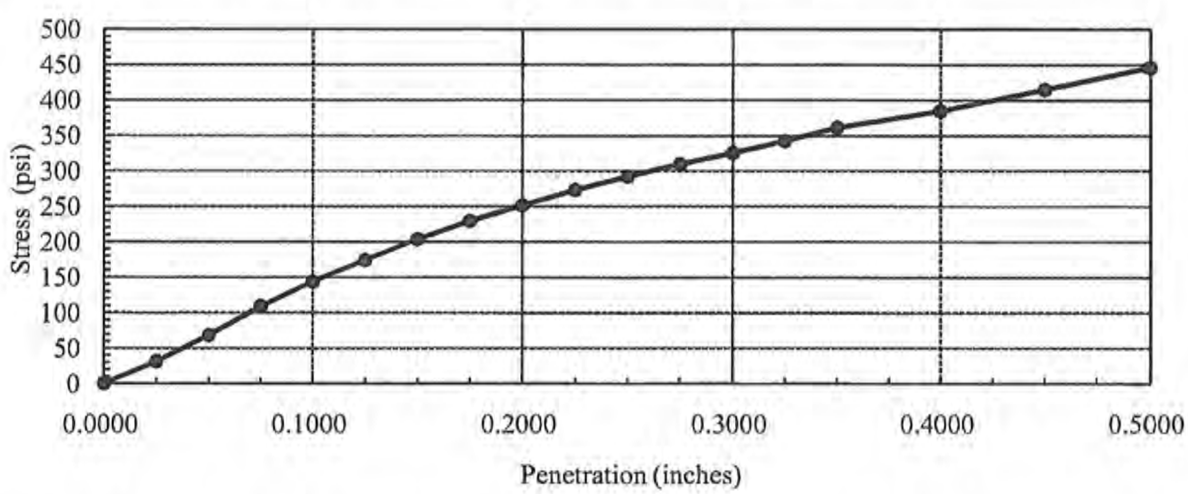
Initial Dry Unit Wt. 128.1 pcf Initial Relative Compaction 95.0%
Final Dry Unit Wt. 128.0 pcf Final Relative Compaction 95.0%

**Swell Test**

Surcharge Weight 22.5 lbs Surcharge Pressure 133.4 psf
Initial Dial Rdg. 0.5000 Final Dial Rdg. 0.5027 Swell 0.1%

**CBR Test**

Surcharge Weight 22.5 lbs Surcharge Pressure 128.1 psf
CBR @ 0.1 in. **14.4** CBR @ 0.2 in **16.8**

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SK GEOTECHNICAL

# Laboratory Test of Aggregate

**Date:** October 13, 2009

**Project:** **09-2560 Pavement Evaluation**
Valley Drive
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:**

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**Gradation (ASTM C 136)**

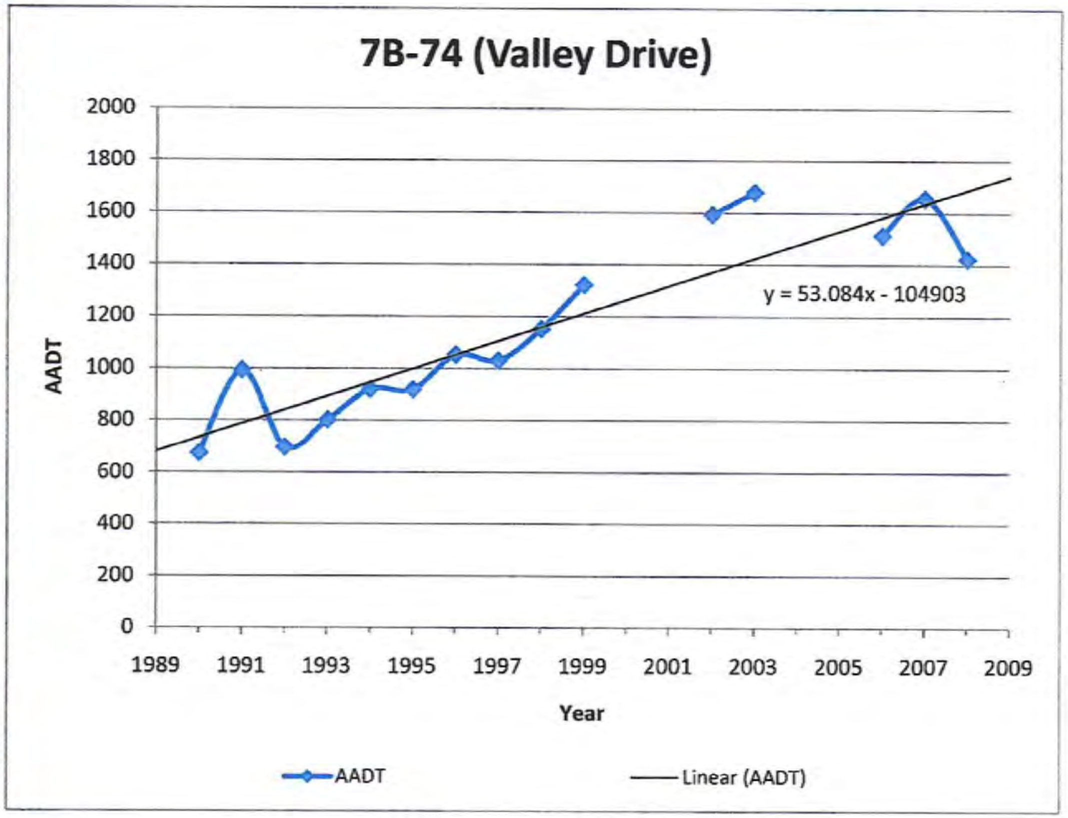
| | | | 12/18/2007 Lewis and Clark Subdivision | |
|---|---|---|---|---|
| **Sieve Size** | **ST-13 Base Course** | **ST-15 Base Course** | **Crushed Top Surfacing** | **Select Base Course** |
| 1 1/2" | --- | 100 | --- | 100 |
| 3/4" | 100 | 84 | 100 | --- |
| 1/2" | 92 | 71 | --- | --- |
| No. 4 | 66* | 52 | 40 – 70 | 25 – 60 |
| No. 10 | 47 | 40 | 25 – 55 | --- |
| No. 40 | 24 | 17 | --- | --- |
| No. 100 | 14 | 8 | --- | --- |
| No. 200 | 11.2* | 5.4 | 2 – 10 | 2 – 12 |

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

**7B-74 (Valley Drive - North of Canyon Ferry Road)**

| Year | AADT |
|---|---|
| 1989 | |
| 1990 | 673 |
| 1991 | 993 |
| 1992 | 697 |
| 1993 | 801 |
| 1994 | 920 |
| 1995 | 919 |
| 1996 | 1053 |
| 1997 | 1031 |
| 1998 | 1152 |
| 1999 | 1322 |
| 2000 | |
| 2001 | |
| 2002 | 1592 |
| 2003 | 1678 |
| 2004 | |
| 2005 | |
| 2006 | 1513 |
| 2007 | 1656 |
| 2008 | 1423 |
| 2009 | |
| **2029** | **2804** |

| | |
|---|---|
| 2009 | 1743 |
| 2029 | 2804 |
| **Yearly Growth Rate** | **2.41%** |



```
======================================================
                 DARWin(tm) - Pavement Design

                 A Proprietary AASHTOWARE(tm)
                  Computer Software Product

               ----------------------------------------

                Flexible Structural Design Module

       ------------------------------------------------------

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

Flexible Structural Design Module Data
   18-kip ESALs Over Initial Performance Period: 242,540
                      Initial Serviceability: 4.2
                     Terminal Serviceability: 2.5
                       Reliability Level (%): 85
                  Overall Standard Deviation: .45
         Roadbed Soil Resilient Modulus (PSI): 15,600
                          Stage Construction: 1

                Calculated Structural Number: 1.98

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

Simple ESAL Calculation
            Initial Performance Period (years): 20
           Initial Two-Way Daily Traffic (ADT): 1,743
% Heavy Trucks (of ADT) FHWA Class 5 or Greater: 3.1
           Number of Lanes In Design Direction: 1
       Percent of All Trucks In Design Lane (%): 50
         Percent Trucks In Design Direction (%): 100
     Average Initial Truck Factor (ESALs/truck): 1
           Annual Truck Factor Growth Rate (%): 0
```

Annual Truck Volume Growth Rate (%): 2.41
Growth: Simple

Total Calculated Cumulative Esals: 242,540

# Appendix D

## Cost Estimates

# Valley Drive Reconstruction Cost Estimate

| | | | Number of Units | | | | | | |
|---|---|---|---|---|---|---|---|---|---|
| **Major Work Feature** | **Unit** | **Unit Cost** | **Typical A** | **Typical B** | **Typical C** | **Typical D** | **Typical E** | **Total** | **Total Cost** |
| Survey - Staking and Grade Control | MI | $15,000.00 | 0.75 | 0.75 | 1.00 | 0.50 | 0.50 | 3.50 | $52,500 |
| Topsoil - Salvage and Place | CY | $4.05 | 2,017 | 2,017 | 2,787 | 1,051 | 1,027 | 8,898 | $36,036 |
| Excavation - Unclassified | CY | $5.50 | 14,665 | 14,665 | 21,402 | 6,873 | 6,494 | 64,099 | $352,546 |
| 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 | 2,826 | 2,826 | 3,768 | 1,884 | 1,884 | 13,189 | $158,271 |
| Crushed Top Course | CY | $25.41 | 1,829 | 1,710 | 2,200 | 996 | 1,092 | 7,826 | $198,866 |
| Aggregate Treatment (Prime) | SY | $0.41 | 15,039 | 15,039 | 20,052 | 10,026 | 10,026 | 70,183 | $28,775 |
| Asphalt Tack Coat | SY | $0.10 | 14,560 | 14,560 | 19,413 | 9,706 | 9,706 | 67,945 | $6,794 |
| Chip Seal & Cover | SY | $2.00 | 14,080 | 14,080 | 18,773 | 9,387 | 9,387 | 65,707 | $131,413 |
| Plant Mix Asphalt Paving | Ton | $81.38 | 2,854 | 2,739 | 3,576 | 1,692 | 1,788 | 12,648 | $1,029,304 |
| Reset Mailbox | Each | $200.83 | 14 | 11 | 12 | 4 | 6 | 46 | $9,138 |
| Traffic Gravel | CY | $19.03 | 1,076 | 1,076 | 1,434 | 717 | 717 | 5,019 | $95,512 |
| Remove/Reset Signs | Each | $184.30 | 3 | 3 | 4 | 2 | 2 | 14 | $2,580 |
| Interim Striping - Yellow Paint | Gal | $34.18 | 32 | 32 | 42 | 21 | 21 | 148 | $5,053 |
| Final Striping - Yellow Paint | Gal | $34.18 | 32 | 32 | 42 | 21 | 21 | 148 | $5,053 |
| Interim Striping - White Paint | Gal | $34.30 | 32 | 32 | 42 | 21 | 21 | 148 | $5,071 |
| Final Striping - White Paint | Gal | $34.30 | 32 | 32 | 42 | 21 | 21 | 148 | $5,071 |
| Remove Existing Culverts | LF | $12.27 | 1,568 | 1,288 | 1,400 | 392 | 672 | 5,320 | $65,276 |
| Approach/Relief Drain Pipe - 18/24 In.Dia. | LF | $50.17 | 1,512 | 1,176 | 1,344 | 392 | 672 | 5,096 | $255,666 |
| Drainage Pipe 24 Inch Dia. | LF | $50.00 | 0 | 112 | 0 | 0 | 0 | 112 | $5,600 |
| Drainage Pipe 36 Inch Dia. | LF | $96.79 | 56 | 0 | 56 | 0 | 0 | 112 | $10,840 |
| Farm Fence - Type Type 5M | LF | $2.25 | 3,960 | 3,960 | 5,280 | 2,640 | 2,640 | 18,480 | $41,580 |
| Fence Panel | Each | $145.92 | 12 | 12 | 16 | 8 | 8 | 56 | $8,172 |
| Seeding | Acre | $294.16 | 3.64 | 3.64 | 4.85 | 1.82 | 1.82 | 15.76 | $4,635 |
| Fertilize Seed | Acre | $120.84 | 3.64 | 3.64 | 4.85 | 1.82 | 1.82 | 15.76 | $1,904 |
| Condition Seedbed Surface | Acre | $221.51 | 3.64 | 3.64 | 4.85 | 1.82 | 1.82 | 15.76 | $3,490 |
| Geotextile - Subgrade Stabilization | SY | $1.50 | 5,170 | 5,170 | 6,894 | 3,447 | 3,447 | 24,127 | $36,191 |
| Subgrade Stabilization Gravel (14 - inch Depth) | CY | $8.00 | 2,011 | 2,011 | 2,681 | 1,340 | 1,340 | 9,383 | $75,063 |
| Subexcavation | CY | $5.50 | 2,011 | 2,011 | 2,681 | 1,340 | 1,340 | 9,383 | $51,606 |
| **Subtotal - Construction** | **$/Segment** | | **$629,819** | **$596,758** | **$778,794** | **$337,567** | **$363,568** | | **$2,706,507** |
| Final Engineering, Geotec. & Survey | LS | 8.00% | $50,386 | $47,741 | $62,304 | $27,005 | $29,085 | | $216,521 |
| Construction QA/QC | LS | 4.00% | $25,193 | $23,870 | $31,152 | $13,503 | $14,543 | | $108,260 |
| Contractor Mobilization | LS | 5.00% | $31,491 | $29,838 | $38,940 | $16,878 | $18,178 | | $135,325 |
| Contingency | LS | 10.00% | $62,982 | $59,676 | $77,879 | $33,757 | $36,357 | | $270,651 |
| Traffic Control During Construction | LS | 8.00% | $50,386 | $47,741 | $62,304 | $27,005 | $29,085 | | $216,521 |
| Right-of-Way Appraisals by Agent | Each | $2,000.00 | 0 | 13 | 15 | 3 | 7 | 38 | $76,000 |
| Right-of-Way Acquisition by Agent | Each | $1,500.00 | 0 | 13 | 15 | 3 | 7 | 38 | $57,000 |
| Purchase Right-of-Way | Acre | $32,000.00 | 0.00 | 1.87 | 3.64 | 1.21 | 1.21 | 7.93 | $253,673 |
| **Total Estimated Cost (2011)** | **$/Segment** | | **$ 850,256** | **$ 910,857** | **$ 1,220,236** | **$ 505,003** | **$ 554,105** | | **$4,040,457** |

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

## Additional Alternate Costs

| | | | Number of Units | | | | | | |
|---|---|---|---|---|---|---|---|---|---|
| **Major Work Feature** | **Unit** | **Unit Cost** | **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 | $100,000.00 | - | - | - | - | - | 1 | $100,000 |
| Sanitary Sewer Main | MI | $211,200.00 | 0.75 | 0.75 | 1.00 | 0.50 | 0.50 | 3.50 | $739,200 |
| Water Main | MI | $396,000.00 | 0.75 | 0.75 | 1.00 | 0.50 | 0.50 | 3.50 | $1,386,000 |
| Bicycle/Ped. Path Reconstruction | MI | $77,825.00 | 0.75 | 0.75 | 1.00 | 0.50 | 0.50 | 3.50 | $272,388 |