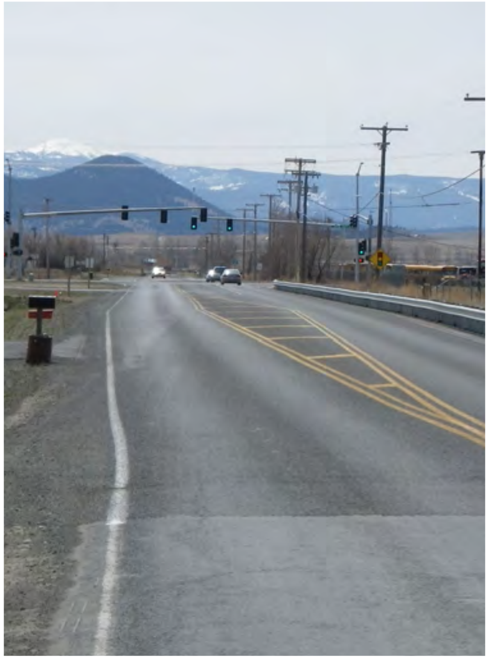
Preliminary Engineering Report

WYLIE DRIVE—CANYON FERRY ROAD TO YORK ROAD

Lewis and Clark County

RPA Project No. 10502.002



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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 Wylie Drive corridor bound by Canyon Ferry Road 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 used 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 as a Major Collector.

Based on the evaluation presented herein, we estimate the cost to reconstruct the road to meet assigned design criteria to be approximately **$1.33 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 $900,000 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 outside of this project limits, south of Canyon Ferry Road. 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 Wylie Drive between Canyon Ferry Road and York Road, north of the City of East Helena. The study segment is further described in the following section.

This segment of Wylie 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 May18, 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

Wylie Drive lies within the easterly portion of what is locally known as the Helena Valley. The study area begins at the intersection of Canyon Ferry Road. Canyon Ferry Road is a state (MDT) maintained highway, identified as Secondary Highway 430. The project extends northerly for approximately 2.0 miles, terminating at its intersection with York Road. York Road is also state maintained and is identified as Secondary Highway 280. Similar to Wylie Drive, both Canyon Ferry Road and York Road are functionally classified as Major Collectors. 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 Canyon Ferry Road. The mileposts increase in a south to north direction. From

Milepost 0.00, Wylie Drive continues due north with only slight alignment deflections. The project corridor terminates at MP 2.00 at the intersection with York Road.

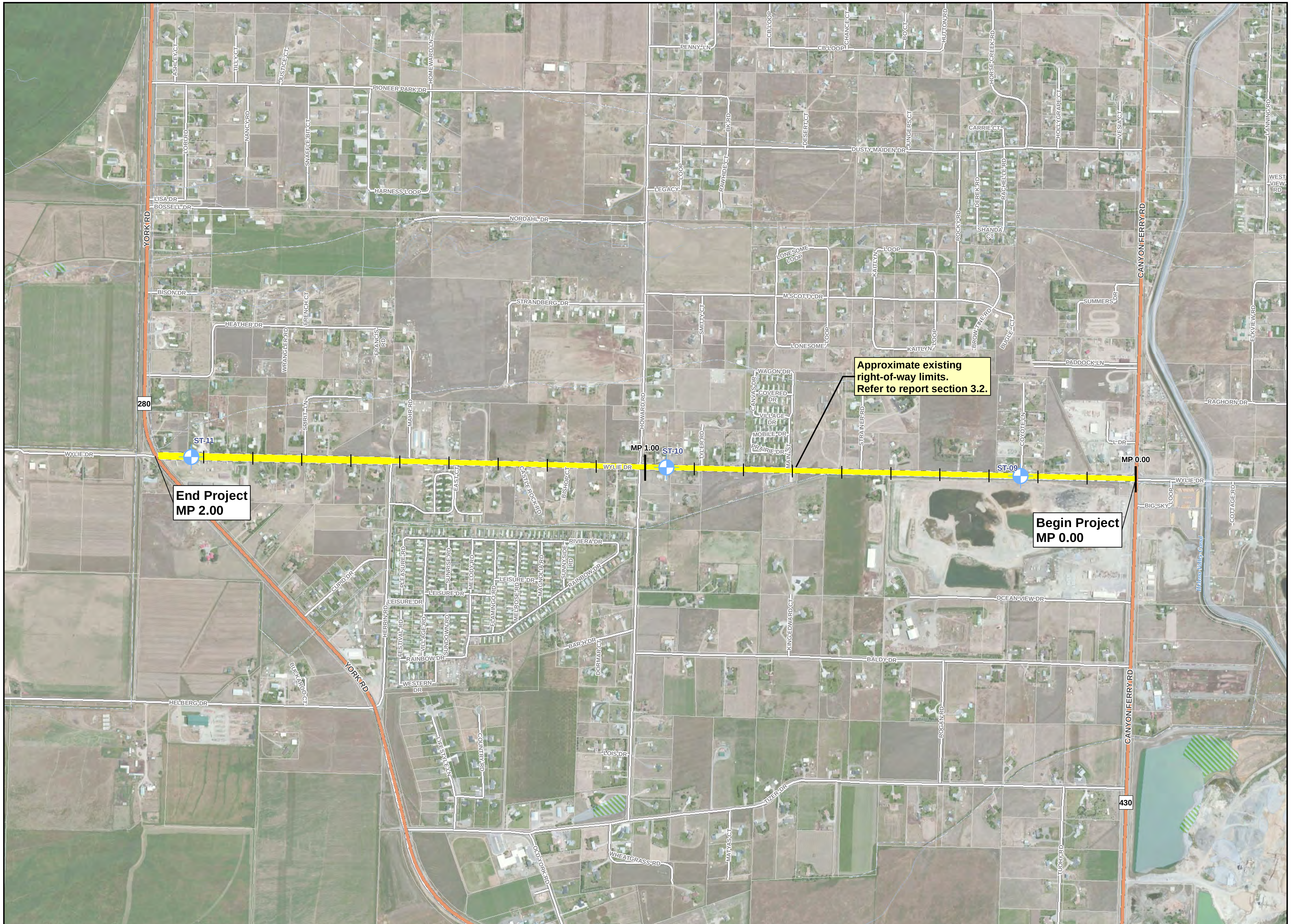
1.2. Methodology to Develop Report

The field methods used to obtain existing geometric information were 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, but instead basic hand-held instruments were used to expedite the process to meet the scope of work. The work is as such, CADD based design work has not been undertaken, except for some basic diagramming.

Field reviews were completed in April 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 and compare that to design guidelines expressed in that format. 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, reference 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.



WYLIE DRIVE PROJECT AREA

Preliminary Engineering Report

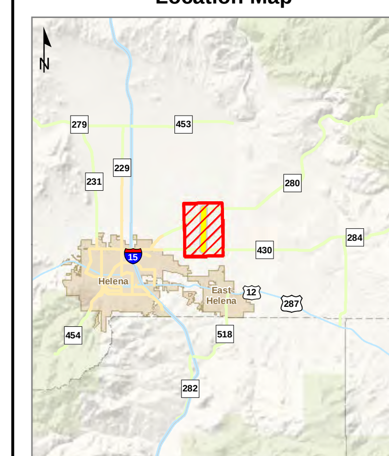
0 500 1,000 1,500 Feet

1 inch = 1,000 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



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Project: 10502.002 LewisClarkCo PERs - Wylie Drive

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File Location: F:\highways\10502_000_LewisClarkCo_PERs\GIS\Maps\WylieDrive_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 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 3.3% heavy vehicle factor was used for Wylie Drive based on vehicle classification counts conducted for design of the 2009 Wylie Drive safety improvement project by MDT south of Canyon Ferry Road MDT Project ARRA 25(50). This percent heavy vehicle factor 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 Wylie 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.

2011 AADT values, along with projected 2031 values, were estimated 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 in the table.

Table 2.1: Average Annual Daily Traffic (AADT)

Wylie Drive		AADT[1]			
Site ID	**Location**	**2009**	**2011**	**2031**	**Growth[2]**
7B-62	S. of York Rd	795	969	1314	1.54%
7B-63	N. of Canyon Ferry Rd	2592	3136	4602	1.94%
Weighted Average:					**1.84%**

*(1) AADT was projected based on 20-year historical counts using an exponential yearly growth rate of historical data (**Appendix A**).*
(2) 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 2.0 mile section of Wylie Drive between Canyon Ferry Road (S-430) and York Road (S-280). The crash information covers a five-year time period from July 1, 2005 to June 30, 2010. A total of twenty-eight crashes were investigated on this segment of roadway. The crash information was analyzed to identify general crash characteristics and potential roadway deficiencies.

Nineteen of the twenty-eight crashes occurred in intersections or were intersection related, while nineteen crashes involved multiple vehicles. Seven 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 twelve 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.

In addition to the intersection with Canyon Ferry Road, a cluster of crashes occurred at the intersection with York Road where six crashes were reported. As shown on **Figure 1.1**, Wylie Drive intersects York Road on a curve at this intersection making it difficult to see vehicles along the west leg. The intersection geometry likely contributes to the high rate of crashes at this location.

The non-junction related crashes were generally the result of driver error or were crashes involving animals. There does not appear to be a trend of crash occurrences other than those at the major intersections discussed previously.

3. Existing Conditions

Existing conditions for the Wylie Drive corridor are based on background data and a field review conducted on April 19th, 2011. During the field review, existing physical characteristics were analyzed and recorded to help establish existing conditions along the project corridor.

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. However, the east side of the highway along its approximate northern 1.5 miles adjoins a 100-year flood hazard area, and flood overtopping has occurred over the road approximately 0.6 miles north of Canyon Ferry Road.[1] 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 subdivisions. The area has a mix of both residential and commercial businesses (e.g. storage units, auto and boar repair). A heavy highway construction operation has an equipment yard and gravel pit located in the northwest corner of the Canyon Ferry Road and Wylie Drive intersection (accessed by Canyon Ferry Road).Wylie Drive is functionally classified as a Major Collector according to the Greater Helena Area Transportation Plan – 2004 Update. This classification serves to distribute traffic to the east-west Canyon Ferry Road and York Road major collectors, local roads, as well as providing access to abutting properties. South of Canyon Ferry Road, Wylie Drive distributes traffic to US Highway 12.

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.

There exists approximately 60 feet of total right-of-way (30 feet on each side measured from center-line) from the intersection with Canyon Ferry Road (MP 0.00) to the intersection with Herrin Road (MP 1.50). From Herrin Road north to the intersection with York Road (MP 2.00) the right-of-way appears to widen to approximately 80 feet (40 feet on each side measured from center line).

[1] Flood Insurance Rate Maps Panels 1534 and 1542 of 1725, Lewis and Clark County, Montana (unincorporated areas), Revised June 17, 2002.

It should be noted that these values are estimates and are only intended to provide a planning-level assessment to help determine potential roadway reconstruction costs and impacts that may occur due to reconstruction to widen the road template beyond existing right-of-way.

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 Wylie Drive in this segment is 55 miles per hour (mph) for a Major Collector roadway with level terrain. A copy of Table A is included in **Appendix B** for reference.

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. AASHTO guidance 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 6-4 of the Green Book, contained in **Appendix B**, specifies maximum suggested grades, in percent (%), for specified design speeds of Rural Collector highways. For 55 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, without otherwise considering other factors such as the degree of roadside development, 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 55 mph for the project corridor. The regulatory speed is equal to the County standard design speed for this road's classification. Based on field observations, intended use, and other adjacent roads, the current speed limit for Wylie Drive appears to be high. Valley Drive, which parallels Wylie Drive, has a speed limit of 35 mph for example. In addition, as traffic increases along Wylie Drive the risk factors associate with the high speeds will likely increase.

Based on these factors a design speed of 50 mph was used for this report with the assumption that the regulatory speed limit will be reduced as some point in the design life of the roadway's reconstruction.

Within this subject of discussion, Canyon Ferry Road has similar characteristics to that of Wylie Drive, in terms of roadside development and density of access points. Canyon Ferry Road was reconstructed in 2009 based on a 55 mph design speed, albeit much of the reconstruction from the roadside outward had included design exceptions indicative to a lesser design speed to lessen impacts that would have otherwise been associated with much more right-of-way being required.

3.4. Alignment

The horizontal road alignment of Wylie 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 Wylie 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. Notwithstanding 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 with the exception of improving alignment deflections and eliminating rolls and dips.

It should be noted that Wylie Drive intersects York Road on a skewed angle. Wylie Drive itself has a straight alignment at this location; however, the intersection occurs along a horizontal curve on York Road.

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 as well as intersection sight distance to establish the necessary period to perceive and react to vehicles.

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 curves. Therefore we do not envision any substantial improvements to be required to the present road grade and its associated sight distance.

As was discussed previously, the intersection of Wylie Drive and York Road presents some geometric issues due to the skewed intersection angle. The intersection geometrics at this location create difficult sight angles which may contribute to the crash cluster identified at this intersection.

3.6. Existing Roadway Surfacing

A pavement evaluation for the Wylie 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. A detailed pavement evaluation report is contained in **Appendix C.** This section provides a summary of the findings of the pavement evaluation.

The Wylie Drive corridor is asphalt surfaced throughout the entire project length. Three soil borings were completed along this section. The borings, identified as ST-09, ST-10, and ST-11 were completed in approximately one-mile intervals. The thickness of the asphalt surfacing varies slightly between the three samples from 3/4 inches to one inch. All three base course samples qualify as good material. However, existing base thickness is 2 to 2 ¼ inches thick and is comparably thin to the County's specifications. Each boring encountered over 2 feet of subbase material.

With each boring, soil samples were also obtained for subgrade material directly below the aggregate base material. The subgrade soil consists of poorly graded sand with gravel at two locations, and as poorly graded gravel with sand at the other boring location. The moisture content is considered to be over optimum, and thus considered wet at one location, and as below optimum at the other two locations. The risk of subgrade failure at all three locations is considered to be low. **Table 3.2** gives a summary of the pavement evaluation soil boring results.

Table 3.1: Summary of Boring Conditions

	ST-09	ST-10	ST-11
Approximate Location	MP 0.25	MP 0.95	MP 1.90
Existing Pavement Thickness	3/4"	1"	1"
Existing Base Thickness	2 1/4"	2"	2"
Existing Subbase Thickness	27"	27"	27"
Existing Base Quality	Good	Good	Good
Subgrade	SP	GP	SP
Blows Per Foot (BPF)	24	24	28
Moisture Condition	Over 3% - 5%	Below 1% - 3%	Below 1% - 2%
Risk of Subgrade Failure	Low	Low	Low

- *GP = Poorly Graded Gravel with Sand*
- *SP = Poorly Graded Sand with Gravel*

<u>Summary</u>:

- The existing asphalt surfacing thickness is thin compared to minimum County standards;
- Existing base aggregate is of moderate to good quality but is 6 ¾ to 7 inches less in thickness than minimum County standards;
- The subgrade in this segment has a low risk of failure.

3.7. Existing Roadway Typical Section

This section of the report discusses the primary features of each road segment's existing typical section characteristics. The project corridor is comprised of two distinct sections as discussed below. Cross-sectional measurements of Wylie Drive were taken to include surfacing widths, cut and fill slope rates, ditch widths and depth of the roadside ditch.

3.7.1. Existing Typical Section E.1: Canyon Ferry Road to Herrin Road

Existing Typical Section E.1 runs from MP 0.00 to MP 1.50. The overall asphalt 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 roadside ditch foreslopes were measured to be relatively flat with approximate 12:1 (horizontal : vertical, i.e. twelve feet horizontal distance for each one foot vertical drop) foreslopes on each side of the roadway. There were no discernible backslopes within the road right-of-way. The roadside ditch depths were approximately 1½ feet deep on each side which are comparatively shallow to County Standards.

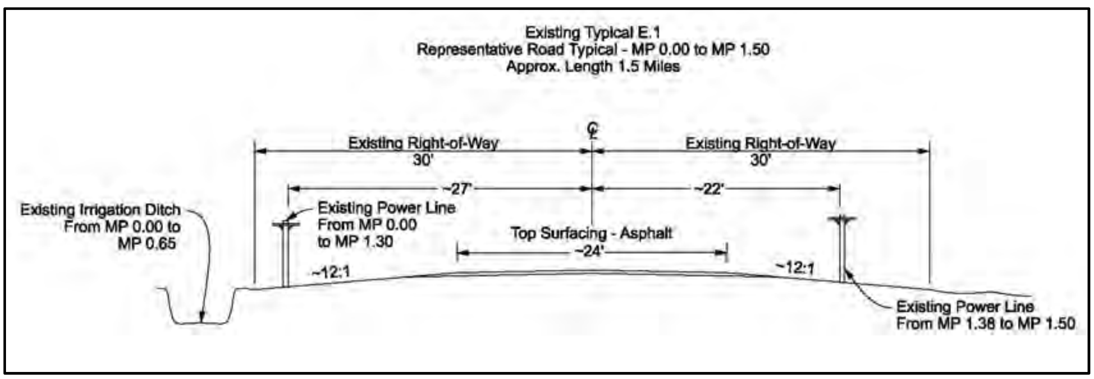


Figure 3.1: Existing Typical Section E.1 (MP 0.00 – MP 1.50) – Looking North

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

3.7.2. Existing Typical Section E.2: Herrin Road to York Road

Existing Typical Section E.2 runs from MP 1.50 to MP 2.00. The overall asphalt top surface of this section is identical to Existing Typical Section E.1 and is approximately 24 feet wide, with two 12-foot travel lanes. As with the previous typical section, there are no distinguishable paved shoulders.

The roadside ditch foreslopes were measured to be approximately 6:1 on both sides of the roadway. The ditch backslopes were measured to be approximately 4:1 on each side. The roadside ditch depths were approximately 3 feet deep on each side.

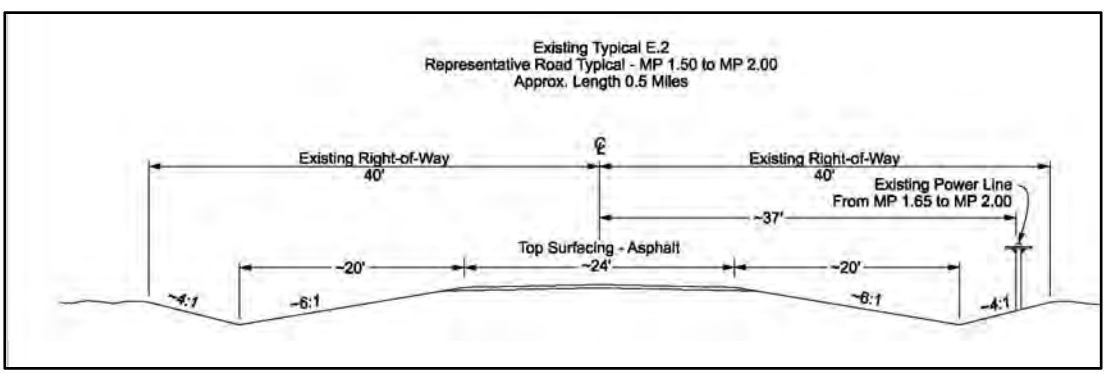


Figure 3.2: Existing Typical Section E.2 (MP 1.50 - MP 2.00) – Looking North

Photo 3.2: Existing Typical Section E.2 looking north.

4. Proposed Conditions

This section of the PER discusses the proposed future conditions of the Wylie Drive corridor. Proposed conditions were determined by 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 three 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 Major 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
- 8” Thick (Compacted) Select Base Course (3-Inch Minus Gradation)
- 0” thick (Compacted) Subbase Course (3-Inch Minus Gradation)
- **14” Total Thickness**

By comparison, the 2009 Wylie Drive reconstruction and curve improvement project south of Canyon Ferry Road, completed by the Montana Department of Transportation (MDT) under the 2000-SFTY-WYLIE DR.-N. EAST HLNA Project ARRA 25(50) utilized a slightly thicker typical section design. That project is just south of this PER limits. That project placed 3.5 inches of new asphalt pavement over 13 inches of new aggregate base. This is likely indicative of the slightly higher amount of heavy truck traffic utilizing the segment of the corridor south of Canyon Ferry Road. Representative typical sections constructed in that 2009 MDT project are included in the end of **Appendix A** for reference.

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 Wylie 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
55 mph	750 - 1500	16 - 18	20 - 24	-	10 - 12	14 - 16	16 - 18
55 mph	1500 - 6000	20 - 22	24 - 30	-	14 - 16	16 - 18	20 - 22

Based on anticipated future conditions, a 50 mph design speed under this study was deemed applicable to the Wylie Drive corridor traversing level terrain. A minimum foreslope rate of 4:1 is required as shown in Figure 4 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.

For the purposes of this study, we are applying the minimum recommended design clear zones for a design speed of 50 mph 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 4 contained in Appendix J of Lewis and Clark County’s Subdivision Regulations depicts the County’s minimum standard road typical for a two-lane Major Collector. Each travel lane is to be 12-feet wide. The shoulder width can vary between 4 feet and 8 feet, as measured between the edge of the travel lane to the top edge of the paved 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 each side 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 Major Collector highways the County has adopted 4 feet as the minimum 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.

A 4-foot shoulder would provide uniformity within the corridor's recent reconstruction as the 2009 Wylie Drive safety improvements project south of Canyon Ferry Road also used a 4-foot wide shoulder in its reconstruction.

4.1.4. Proposed Typical Section P.1

Proposed Typical Section P.1 (**Figure 4.1**) is for the portion of Wylie Drive from Canyon Ferry Road (MP 0.00) to approximately MP 0.65.This proposed typical section meets minimum Major Collector standards as defined by the County. This road section has an existing irrigation ditch that runs along the west edge of the road right-of-way. Relocating the ditch would be costly due to constraints caused by the existing gravel pit. Based on these factors, it is proposed that a curb and gutter section along the west side of the roadway be constructed to reduce construction width.

Projected future traffic forecasts along this section call for approximately 4600 AADT in 2031. Based on the discussion provided in **Section 4.1.2**, a minimum clear zone of 20 feet is recommended. This proposed typical would only require additional right-of-way along the east side of the road. We estimate that the proposed typical section would fit within 70 feet of right-of-way. Minimum County standard for a Major Collector is 100 feet of right-of-way, however.

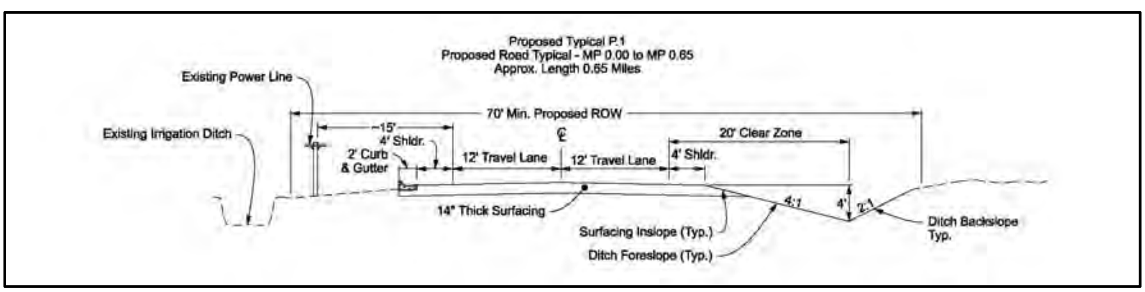


Figure 4.1: Proposed Typical Section P.1 (MP 0.00 - MP 0.65) – Looking North

4.1.5. Proposed Typical Section P.2

Proposed Typical Section P.2 (**Figure 4.2**) was developed for the portion of Wylie Drive from MP 0.65 to York Road (MP 2.00).This proposed typical section meets minimum Major Collector standards as defined by the County. In order to accommodate the proposed typical section, a number of existing power lines will need to be relocated. Associated costs for utility relocation were not included as part of the cost estimate presented later in this report.

Projected future AADT along this section is expected to be between 4600 vpd and 1300 vpd for the 20-year design life evaluation. As with Typical Section P.1, a minimum clear zone of 20 feet is recommended. The proposed typical section would require additional right-of-way along both sides of the roadway between MP 0.65 and MP 1.50. It appears that the existing right-of-way between MP 1.50 and MP 2.00 could accommodate the proposed section.

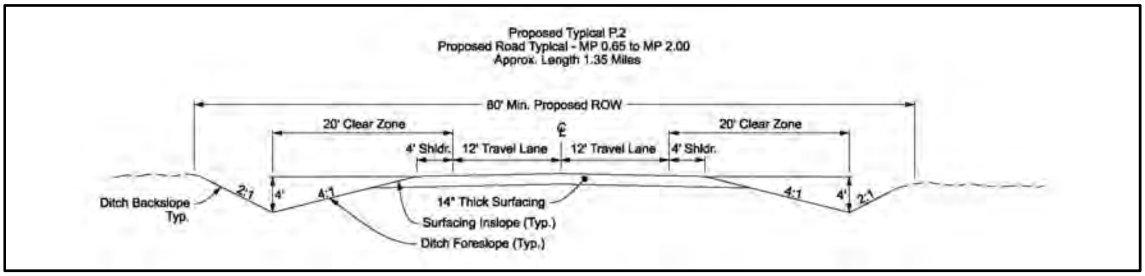


Figure 4.2: Proposed Typical Section P.2 (MP 0.65 - MP 2.00) – Looking North

4.1.6. Miscellaneous Grading, Cut and Fill Slopes

To estimate earthwork and miscellaneous other feature impacts to reconstruct the roadway in level terrain, we applied the design typical sections, shown in **Figures 4.1** through **4.2** over the existing road templates estimated from field measurements, **Figures 3.1** through **3.2**. The estimate is based on proposed roadway centerlines following existing centerlines. The superimposed typical sections are shown in **Figure 4.3**.

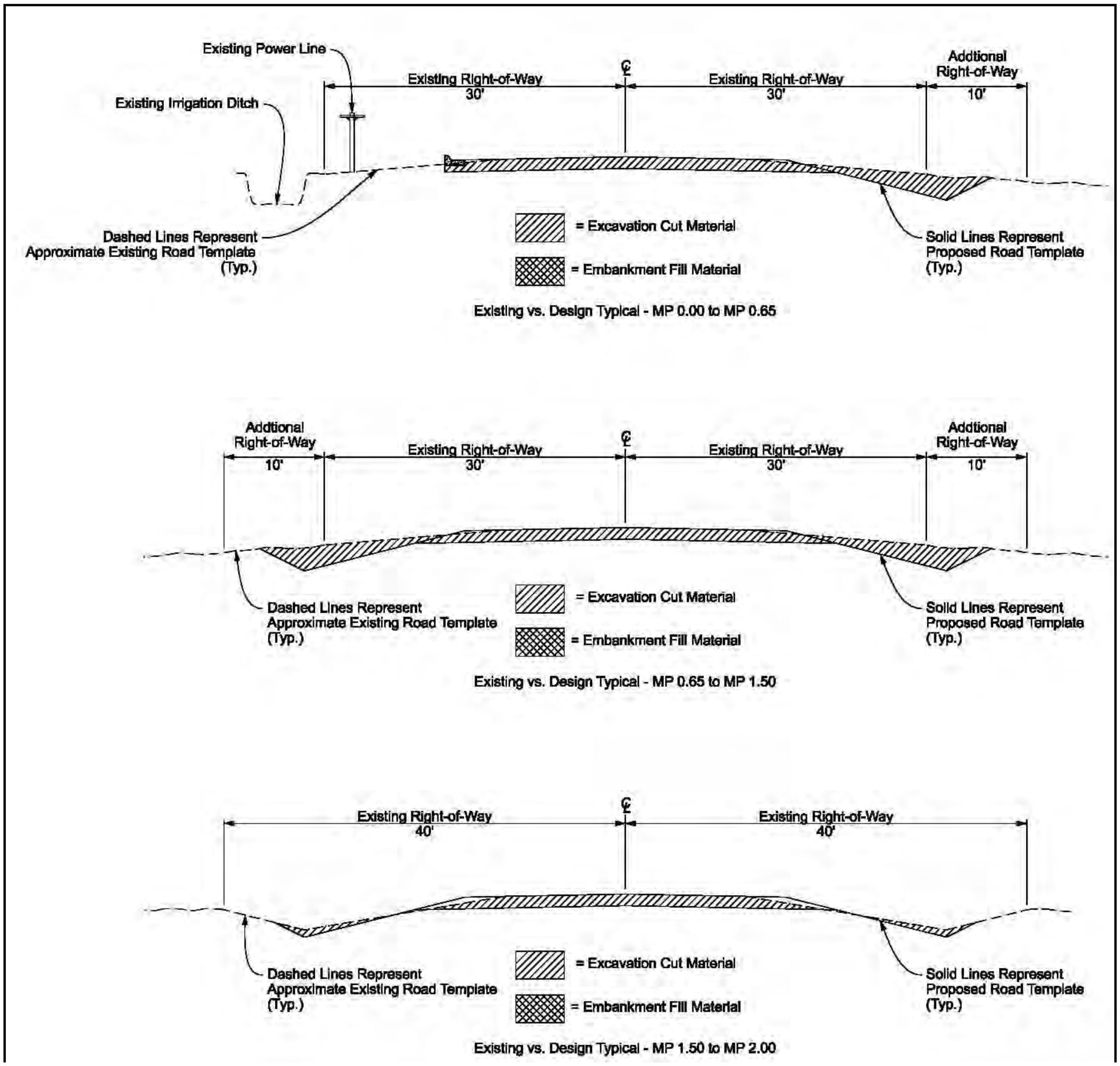


Figure 4.3: Estimated Reconstruction Cut / Fill Impacts

4.1.7. Geotechnical Considerations

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

During the course of developing the pavement designs, all three borings completed along the project corridor indicated "good" quality existing base/subbase. The geotechnical engineer evaluated these locations to have low risks of subgrade failure during construction. The preliminary indications therefore are that approximately 25% of the roadway alignment may 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 12 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 agricultural intermixed with small business commercial. We presume the highest and best use of the current agricultural property is that to be developed into a residential subdivision.

To assign fully defendable and accountable costs to right-of-way impacts is outside the scope of this document. To do so would require the preparation of multiple appraisals. By virtue of the amount of parcels adjoining this highway's right-of-way, the appraiser fee to complete this work could amount to several 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 estimate that approximately 40 properties could be impacted during the course of reconstructing 2.0 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. One existing mainline cross drain was identified during the field review. The cross drain exists along the south leg of the intersection with York Road (MP 2.00). The cross drain was measured to have an approximate diameter of 60 inches. The drain serves an existing irrigation ditch and lies in a "Zone A" floodplain based on Flood Insurance Rate Maps (FIRM).

The project corridor appears to require some drainage upgrading. Runoff picked up in this area is conveyed primarily along the roadside, crossing under roads that intersect Wylie 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. In addition, the east side of the road lies within a Zone A floodplain as delineated on FIRM panels 1534 and 1542 (of 1725) of Community-Panel Numbers 3000381534D, and 3000381542D, respectively. 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. During design, further engineering will determine the full amount of drainage improvements required.

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.

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 Wylie Drive corridor exist at the intersection with Canyon Ferry Road. Northbound and southbound designated left-turn lanes, as well as a northbound right-turn lane, were installed at this intersection during the MDT STPE 430-1(6)1 reconstruction project along Canyon Ferry Road in 2009.

The report did not complete turn lane warrant analysis. However, when the highway design is initiated, it can be reasonably ascertained that one or more turn lanes may be warranted, particularly at the intersection with York Road. 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 with York Road, within the design life of Wylie Drive. Therefore, an estimated cost to install signal hardware has been included later in this report.

5. Reconstruction Cost Estimates

This section summarizes the process used to develop cost estimates for the reconstruction of Wylie Drive from Canyon Ferry Road north to York Road. For cost estimation purposes, the Wylie Drive corridor was broken out into three 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** – Canyon Ferry Road (MP 0.00) to MP 0.65
- **Typical Section B** – MP 0.65 to Herrin Road (MP 1.50)
- **Typical Section C** – Herrin Road (MP 1.50) to York Road (MP 2.00)

Table 5.1 summarizes the estimated cost to reconstruct the Wylie Drive project corridor. **Appendix D** provides a detailed cost estimate consisting of a breakout of major work features, quantities, and unit costs. The following sections briefly discuss how some of the number of units were estimated. The units were then multiplied by average unit costs. Average unit costs were based on 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 under construction in the Helena Valley at that time. These projects ranged from full highway reconstructions to spot safety improvement projects. It should be noted that the County could similarly improve Wylie Drive by either several smaller spot improvements projects, or larger-length reconstructions.

Table 5.1: Reconstruction Cost Estimate

Wylie Drive	Typical A	Typical B	Typical C	Total
Construction Subtotal	$693,581	$701,631	$406,052	**$1,801,264**
Total Estimated Cost	$1,000,047	$1,114,641	$548,171	**$2,662,858**
Length (miles)	0.65	0.85	0.50	**2.00**

5.1. Estimating Procedure

5.1.1. Grading

- The Excavation – Unclassified quantity is estimated from **Figure 4.3** by calculating the end section cut areas and multiplying by the applied length to generate a volume. Consideration is given that the figures are likely worst-case scenarios and intermittent locations will likely balance with lesser cuts and fills.
- Topsoil Salvage and Placing is calculated based on **Figure 4.3** assuming 3 inches of topsoil depth.

5.1.2. Surfacing

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

5.1.3. Drainage

- The summarized length of approach pipe lengths is estimated based on the number approaches and their assumed cross-sectional characteristics such as slope rate and depth of cover. Approach top widths are estimated as being an average of 24 feet. The amount of access approaches intersecting the roadway in each applicable segment is based on GIS aerial photographs and limited windshield survey. The approach pipes would be 18-inch diameter at minimum to meet the County's requirements for a Major Collector. 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

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

5.1.5. Roadside Revegetation

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

5.1.6. Subgrade Stabilization

- The preliminary pavement designs included with this report identifies all areas as having good quality subgrade material with low risk of failure. However, field conditions could vary from the limited sampling completed under this study. Therefore, 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 **4.2**.

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 40 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 from Canyon Ferry Road (MP 0.00) to Herrin Road (MP 1.50) and 80 feet wide from Herrin Road to York Road (MP 2.00). In order to accommodate the proposed typical section, a minimum of 10 feet of additional right-of-way acquisition would be needed along the east side of the roadway from Canyon Ferry Road to MP 0.65. No additional right-of-way is needed along the west side of the roadway for this portion of the corridor due to the existing irrigation canal acting as a construction limit. An additional 10 feet of right-of-way is needed along each side of the road from MP 0.65 to Herrin Road. From Herrin Road to York Road (MP 2.00) it appears that there is adequate existing right-of-way for the proposed typical section. However, the County standard minimum right-of-way width for a major collector highway is 100 feet. During the course of improvements, the County could consider acquiring additional right-of-way to preserve the transportation corridor for future need.
- $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	2.00	$422,400

Water Main	MI	$396,000.00	2.00	$792,000
Bicycle/Ped. Path Reconstruction	MI	$77,825.00	2.00	$155,650

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.

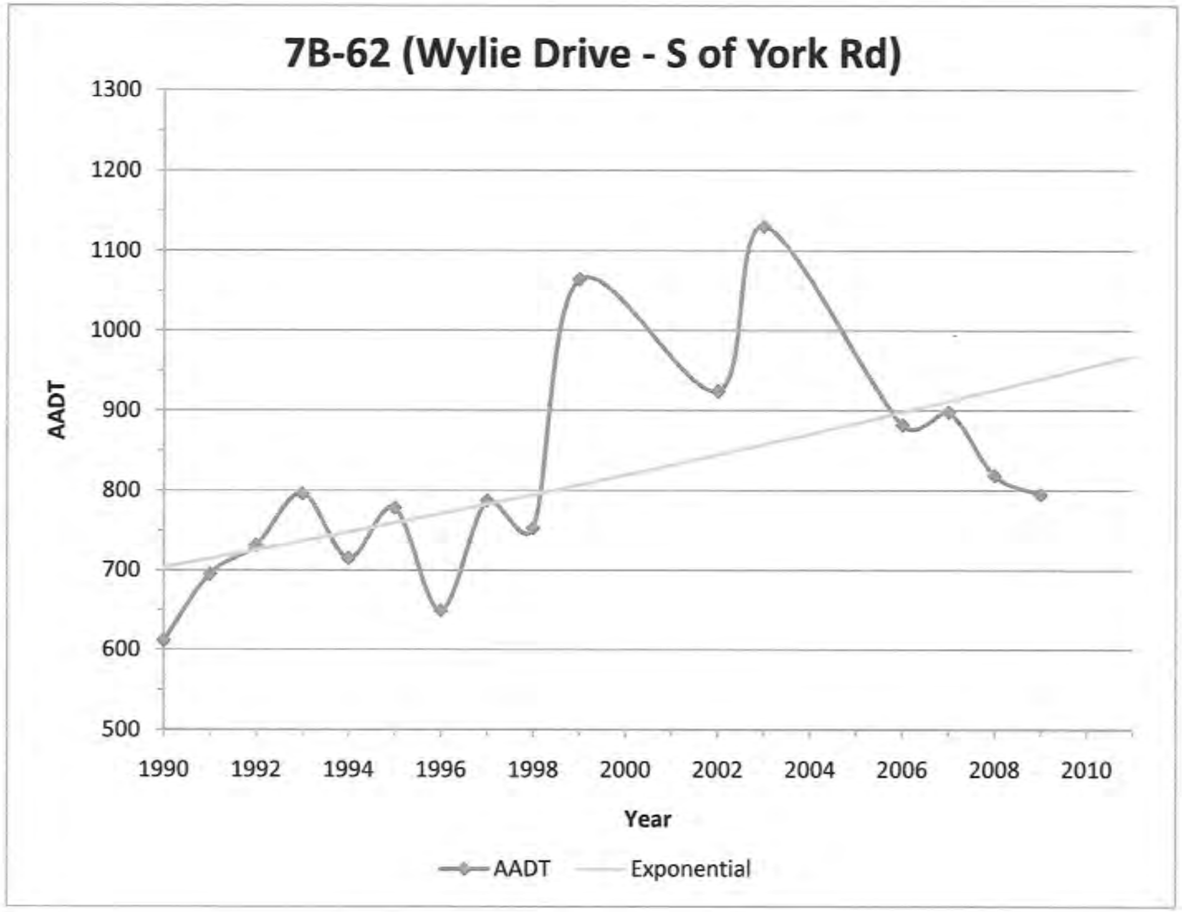
Appendix A

Background Data

#

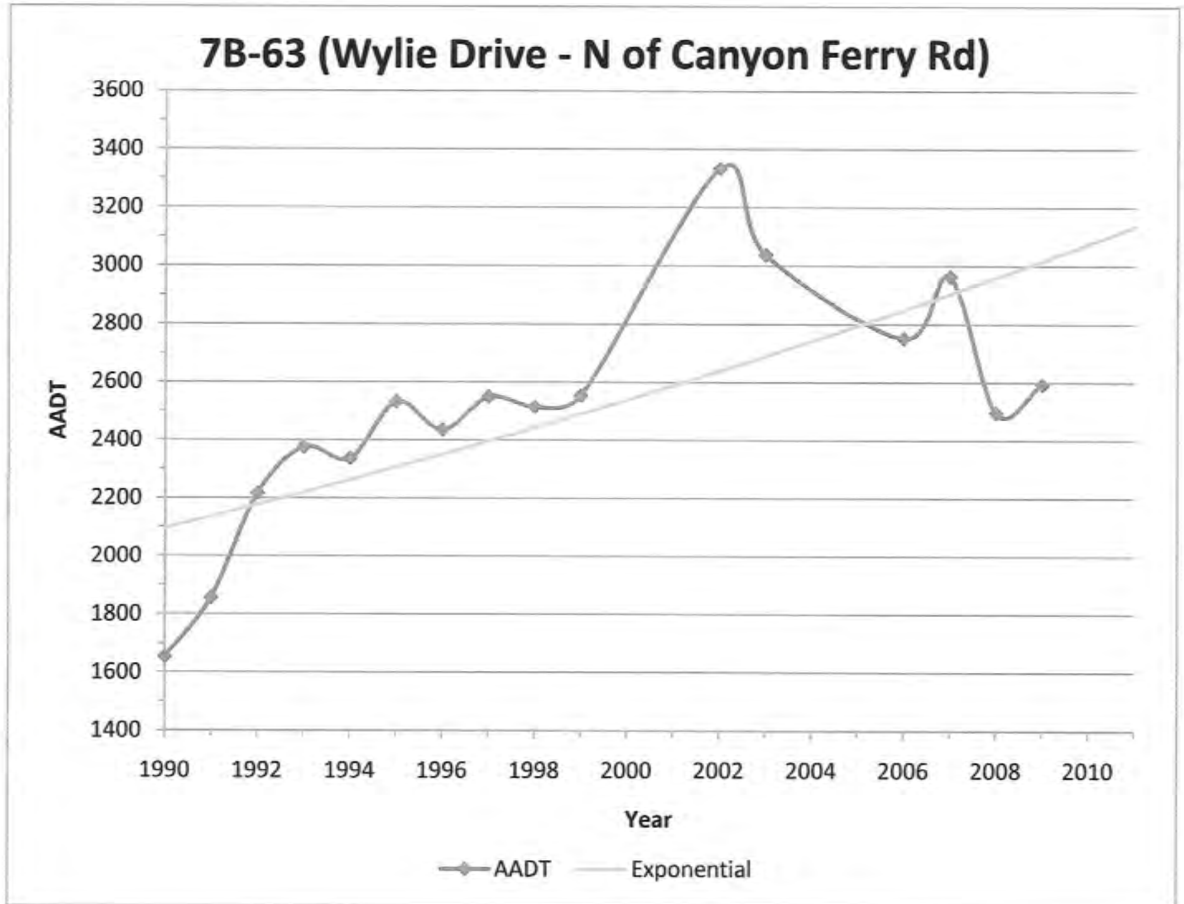
7B-62 (Wylie Drive - S of York Rd)

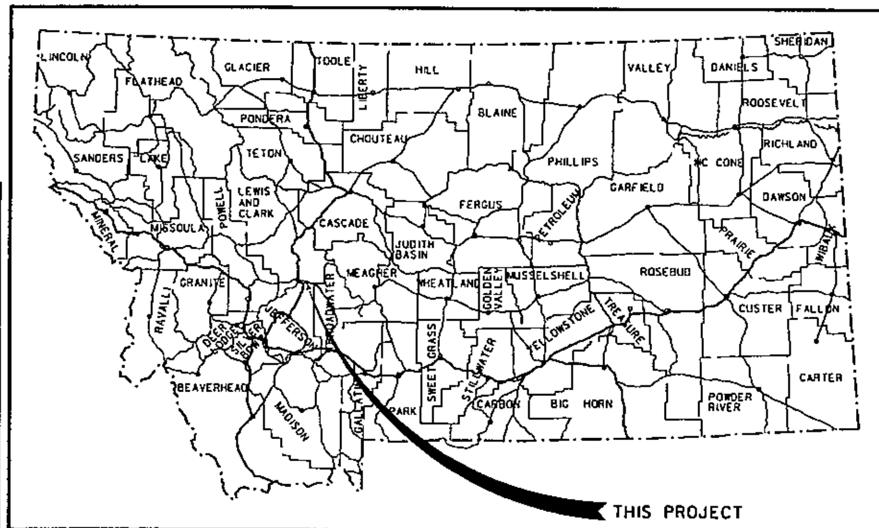
Year	AADT	Exponential
1990	611	703
1991	695	714
1992	731	725
1993	796	736
1994	715	748
1995	778	759
1996	649	771
1997	787	783
1998	753	795
1999	1064	807
2002	924	845
2003	1130	857
2006	882	898
2007	898	911
2008	819	925
2009	795	940
2011	-	969
2031	-	1314
i	-	**1.54%**



7B-63 (Wylie Drive - N of Canyon Ferry Rd)

Year	AADT	Exponential
1990	1653	2096
1991	1856	2137
1992	2216	2178
1993	2376	2220
1994	2337	2263
1995	2532	2307
1996	2435	2352
1997	2549	2397
1998	2515	2444
1999	2553	2491
2002	3333	2639
2003	3038	2690
2006	2752	2849
2007	2964	2904
2008	2496	2960
2009	2592	3018
2011	-	3136
2031	-	4602
i	-	**1.94%**





MONTANA DEPARTMENT OF TRANSPORTATION

FEDERAL AID PROJECT ARRA 25 (50)
GRADE, GRAVEL, PL. MIX, & REPLACE STRUCTURE
2000–SFTY–WYLIE DR.–N. EAST HLNA
LEWIS & CLARK COUNTY

DESIGN DATA		
PRESENT	2006 A.D.T. =	4 830
LETTING	2008 A.D.T. =	5 120
DESIGN	2028 A.D.T. =	9 250
	D.H.V. =	1 110
	T. =	3.3%
	V. =	100
	80 kN ESAL'S =	77
	GROWTH RATE =	3.0% (ANNUAL)

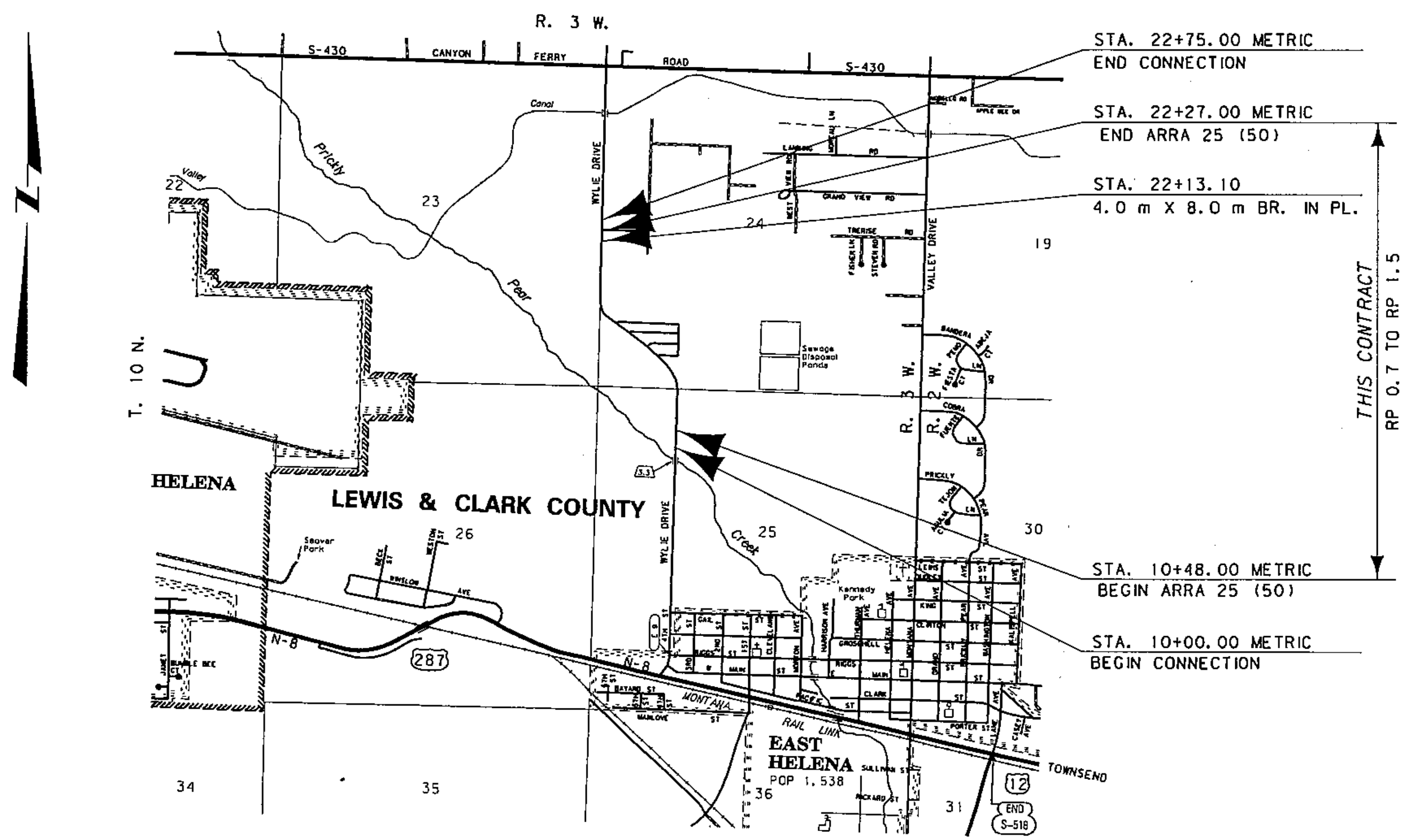
LETTING DATE – ____________

CSF • 0.99923680

LENGTH 1.3 kilometers

SCALES
VERTICAL: 1 : 100
HORIZONTAL: 1 : 1000
CROSS SECTION – HORIZONTAL & VERTICAL: 1 : 100
REDUCED PRINTS ONE-HALF ORIGINAL SCALE
ALL SCALES ARE APPROXIMATE

SURFACING SOURCES -
CONTRACTOR FURNISHED



RELATED PROJECTS

ASSOCIATED PROJECT AGREEMENT NUMBERS	
R/W	HSIP 25 (60)
I.C.	HSIP 25 (61)
P.E.	STPHS 25 (37)

CONTROL NO. 4724

MONTANA
DEPARTMENT OF TRANSPORTATION

APPROVED : April 21 2009
JIM LYNCH
DIRECTOR OF TRANSPORTATION
BY ____________
HIGHWAYS ENGINEER

MONTANA
PAUL R. FERRY
8425E
REGISTERED PROFESSIONAL ENGINEER

U.S. DEPARTMENT OF TRANSPORTATION
FEDERAL HIGHWAY ADMINISTRATION

APPROVED :
DIVISION ADMINISTRATOR ____ DATE ____

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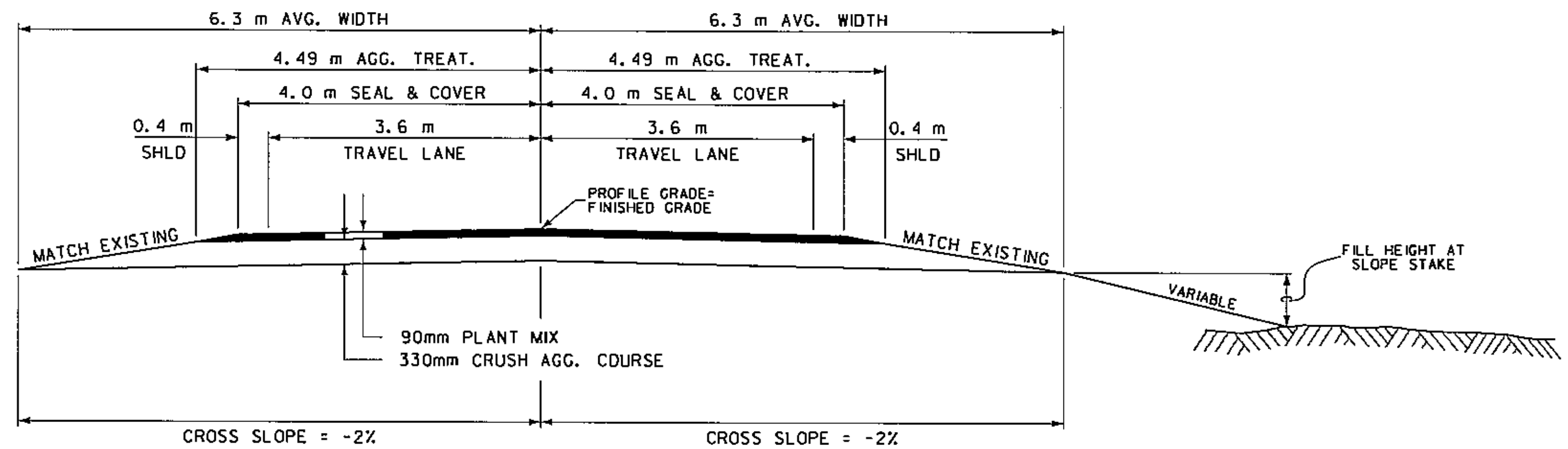
MONTANA CADD

MONTANA DEPARTMENT OF TRANSPORTATION

STATE	PROJECT NUMBER	SHEET NO.
MONTANA	ARRA 25 (50)	4

TYPICAL SECTION NO. 1
(CONNECTION TYPICAL)

10+00.00 ONLY
10+00.00 TO 10+48.00 TRANS. TYP. NO. 1 TO TYP. NO. 2
22+75.00 ONLY



SURFACING SECTION DESIGN BASED ON THE TOP 0.6 METERS OF SUBGRADE HAVING AN R-VALUE OF 15

QUANTITIES

UNIT	AGGREGATE					UNIT	BITUMINOUS MATERIAL			AGG. TREAT.
	COVER	PLANT MIX	CR. AGG. COURSE					SEAL		
AREA square meters		0.764	3.561			square meters PER STATION		800		898
cubic meters PER STATION		76.4	356.1			tons PER STATION		1.55		
tons PER STATION		174.7				liters PER STATION				
square meters PER STATION	800									

BACK SLOPES *	
0 - 1.5 m	5:1
1.5 - 3 m	4:1
3 - 4.5 m	3:1
4.5 - 6 m	2:1
OVER 6 m	1.5:1

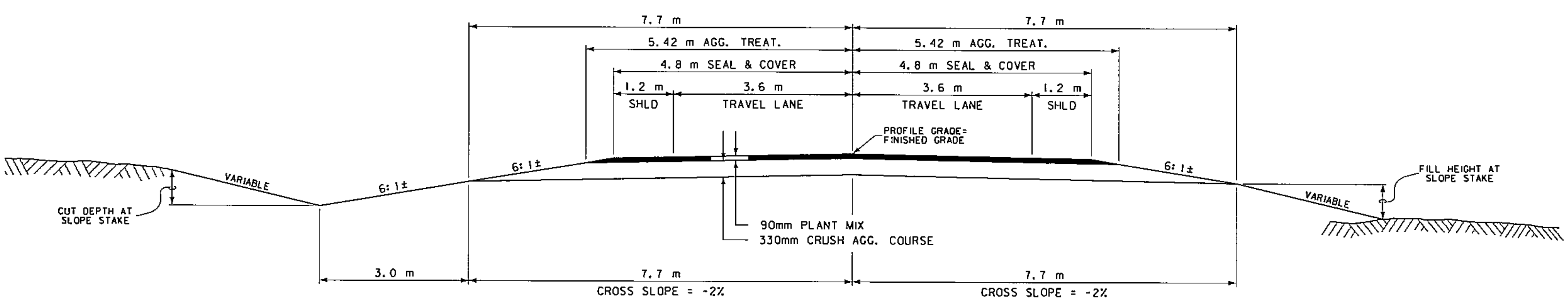
* SEE CROSS SECTIONS FOR DEVIATIONS

FILL SLOPES *	
0 - 3 m	6:1
3 - 6 m	4:1
6 - 9 m	3:1
OVER 9 m	2:1

* SEE CROSS SECTIONS FOR DEVIATIONS

TYPICAL SECTION NO. 2

10+48.00 TO 10+57.41
10+57.41 TO 11+29.41 TRANS. TYP. NO. 2 TO TYP. NO. 3
20+75.11 TO 22+27.00
22+27.00 TO 22+75.00 TRANS. TYP. NO. 2 TO TYP. NO. 1



SURFACING SECTION DESIGN BASED ON THE TOP 0.6 METERS OF SUBGRADE HAVING AN R-VALUE OF 15

QUANTITIES

UNIT	AGGREGATE					UNIT	BITUMINOUS MATERIAL			AGG. TREAT.
	COVER	PLANT MIX	CR. AGG. COURSE					SEAL		
AREA square meters		0.920	4.330			square meters PER STATION		960		1 084
cubic meters PER STATION		92.0	433.0			tons PER STATION		1.86		
tons PER STATION		210.4				liters PER STATION				
square meters PER STATION	960									

MONTANA DEPARTMENT OF TRANSPORTATION
MONTANA CADD

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Appendix B

Design Reference Exhibits

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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	Design stopping sight distance	Rate of vertical curvature, K^a (m/%)		US Customary: Design speed	Design stopping sight distance	Rate of vertical curvature, K^a (ft/%)	
(km/h)	(m)	Crest	Sag	(mph)	(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.

Appendix C

Pavement Evaluation

November 3, 20009

Project 09-2560
Wylie Drive

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

Dear Tom:

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

Project Information

It is our understanding Wylie Drive from the city limits of East Helena north to York Road is considered one of Lewis and Clark County's high priority roads to receive reconstructive improvements. Depending on funding availability, the intent will be for whole or parts of the road to be reconstructed to meet or exceed minimum County standards. The portion of road being evaluated in this report is from about 600 feet north of Canyon Ferry Road, then extending northward for 1 3/4 miles to York Road. This report does not evaluate the segment of Wylie Drive south of Canyon Ferry Road. The Montana Department of Transportation (MDT) is currently completing a safety improvements project in a portion of this segment, and the future reconstruction in this segment, if undertaken, will likely utilize a similar surfacing section as the MDT project. The Wylie Drive roadway limits considered for this pavement evaluation are shown on the attached Boring Location Sketch. At this time, the engineering evaluation along Wylie Drive north of Canyon Ferry Road is based on a total reconstruction need with a new pavement section to bring the road into compliance of meeting or exceeding the minimum road standards in accordance with the Lewis and Clark Subdivision Regulations dated December 18, 2007. Approaching the preliminary engineering as a total reconstruction project will likely present the most conservative cost analysis to assist the County in earmarking funding.

Field Procedures

On July 10, 2009, Borings ST-9 through ST-11 were performed along the 1 3/4-mile alignment being considered for reconstruction. Therefore, the borings were located slightly under 1 mile apart. Boring locations were selected by our personnel and were generally alternated from the northbound and southbound lanes. The locations of Borings ST-9 through ST-11 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 three borings was a very thin layer of existing pavement underlain by gravel base and subbase over poorly graded sand and gravel subgrades. Table 1 below summarizes the existing pavement and subgrade conditions encountered at the borings.

Table 1. Summary of Boring Conditions – Wylie Drive

Boring	ST-9	ST-10	ST-11
Existing Asphalt Pavement	¾"	1"	1"
Existing Base Thickness	2¼"	2"	2"
Existing Subbase Thickness	27"	27"	27"
Existing Base/Subbase Quality	Good	Good	Good
Subgrade	SP	GP	SP
BPF	24	24	28
Moisture Condition	Over 3%-5%	Below 1%-3%	Below 1%-2%
Risk of Subgrade Failure	Low	Low	Low

SP = Poorly Graded Sand with Gravel
GP = Poorly Graded Gravel with Sand

General Statistical Summary
Existing Base Course: 3 of 3 borings (100%) encountered GOOD quality base and subbase courses
Subgrade Conditions: 3 of 3 borings (100%) have LOW risk to become unstable during construction

Existing Pavement Section. As indicated in Table 1 above, the three borings encountered a relatively thin section of existing asphalt pavement ranging from only 3/4 to 1 inch thick. (Pavement this thin will generally crack under all types of vehicle traffic.) Beneath the existing pavement, the borings encountered 2 inches of good quality base course over 27 inches of good quality gravel subbase. Penetration tests were performed in the base/subbase courses directly beneath the asphalt surface while drilling. In general, penetration resistances in the base/subbase courses typically ranged from 24 to 48 blows per foot (BPF), indicating it was medium dense to dense.

Subgrade. Beneath the existing subbase, Borings ST-9 and ST-11 encountered relatively fine-grained silty gravel, poorly graded gravel, and poorly graded sand subgrades. Penetration resistances in the sands and gravels typically ranged from 24 to 66 BPF, indicating these materials 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 Proctor (described below) or typical optimum moisture contents for these types of soils. Based on these moisture content tests, the subgrade conditions in Boring ST-9 indicated the existing subbase and underlying poorly graded sand were over optimum moisture content, and would be considered moist. Moisture contents in subbase and sand/gravel subgrades in Borings ST-10 and ST-11 were below optimum moisture content.

Groundwater. Groundwater was not encountered in the four borings to their termination depth of 5 1/2 feet at the time of our fieldwork.

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-10	Nonplastic			7.4%	---	---	---
Base Course, ST-11	Nonplastic			6.4%	---	---	---
Composite Subgrade, ST-9 and ST-10	Nonplastic			14.9%	143.3	6.7%	17.0
Subgrade, ST-10	Nonplastic			5.4%	---	---	---
Subgrade, ST-11	Nonplastic			8.6%	141.3	5.6%	41.6

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-10 and ST-11 were nonplastic, and had 7.4 and 6.4 percent-finer-than-a-200-sieve (P200), respectively. These results indicate the base course classifies as well graded sand and poorly graded gravel, and would be considered relatively good quality base courses. 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 primarily met specifications.

Standard Proctors (ASTM D 698) and California bearing ratio (CBR) tests were performed on the two sand/gravel subgrade samples indicated above. The composite sample from Borings ST-9 and ST-10 classified as a silty gravel with sand and had a CBR value of 17.0. The subgrade sample from Boring ST-11 classified as poorly graded sand with silt and gravel and had a CBR value of 41.6.

Pavement Analysis and Recommendations

Available Information. Robert Peccia & Associates provided us with the traffic information indicated on the attached graph for Wylie Drive. As can be seen, the projected 2009 AADT count is 3,097 and the projected 2029 AADT is 4,175. 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 1.50%.

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	Major Collector
2009 AADT	3,097
2029 AADT	4,175
Estimated Annual Growth	1.50%
Assumed Heavy Trucks	3.3%
Performance Period	20 Years
Initial Serviceability	4.2
Terminal Serviceability	2.5
Reliability	90
Number of Lanes in Design Direction	1
Percent All Trucks in Design Lane	50
Percent Trucks in Design Direction	100
18-kip ESALs	426,483

As can be seen above, we calculated a design ESAL of 426,483 for Wylie Drive, which is considered a major collector. Traffic data for Lake Helena Drive in the same area indicated about 3.1 and 5.9 percent heavy trucks. A safety improvement project by MDT south of Canyon Ferry Road indicated 3.3 percent heavy trucks, which was used for our analysis.

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 greater than 20, we used the following relationship.

$$M_R \text{ (psi)} = 740 \times CBR$$

As previously indicated in Table 2, CBR values of 17.0 and 41.6 were determined for subgrade samples along this roadway. This is a fairly wide range of values. Based on our experience, CBR values for these types of soils typically range from 25 to 35. Being conservative, a CBR value of 25 was selected, which correlates to an M_r equal to 18,500.

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*	8"
Subbase Course*	0"
Total	**14"**

*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.

As can be seen on the DARWin analysis, 2 inches of subbase was necessary. When considering that Select Base Course is 3-inch minus material, this 2 inches of subbase was added to the Select Base Course minimum of 6 inches, resulting in 8 inches.

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 along Wylie Drive encountered medium dense sand and gravel subgrades, which in our opinion, have a "low" risk of subgrade failure during construction. Even so, some clays could be present, which will likely be wet, i.e., well over optimum moisture content. These clays could be unstable.

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 Wylie 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.

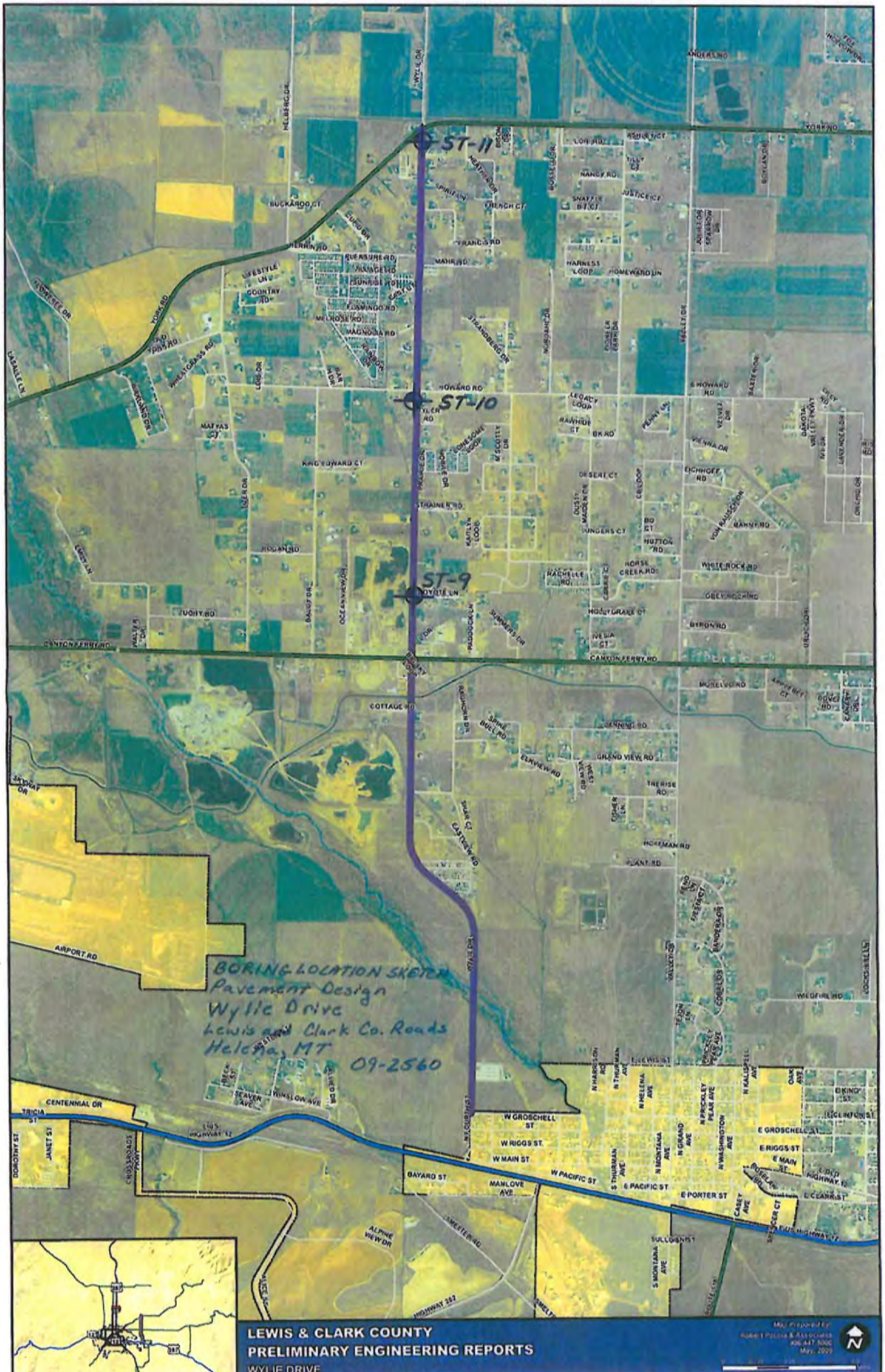
MONTANA
GREGORY T. STAFFILENO
No. 10798 PE
REGISTERED PROFESSIONAL ENGINEER

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-9 through ST-11
Laboratory Tests
Laboratory Test of Aggregate
RPA Traffic Curve
DARWin Pavement Analysis


ST-11
ST-10
ST-9
BORING LOCATION SKETCH
Pavement Design
Wylie Drive
Lewis and Clark Co. Roads
Helena, MT
09-2560
WYLIE DR
YORK RD
CANYON FERRY RD
AIRPORT RD
HIGHWAY 12
LEWIS & CLARK COUNTY
PRELIMINARY ENGINEERING REPORTS
WYLIE 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.

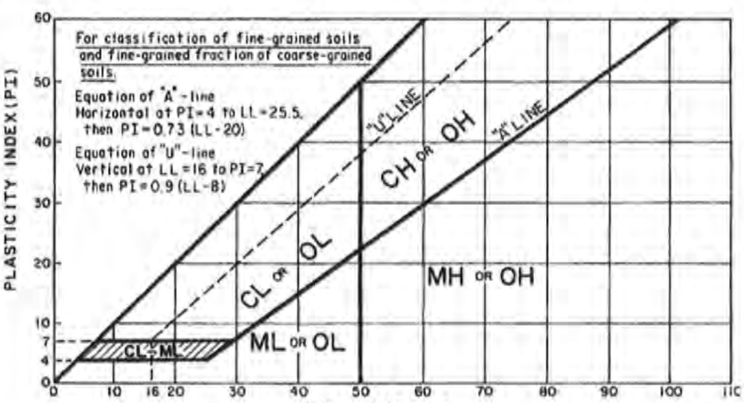


FIG. 4 Plasticity Chart

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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Fax: 406.652.3944

LOG OF BORING

PROJECT: 09-2560 **PAVEMENT DESIGN** Lewis and Clark County Roads Helena, Montana	BORING: **ST-9** LOCATION: Wylie 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: 3/4" of Asphalt Pavement.				
	0.3		FILL: 2 1/4" of Gravel Base.				
			FILL: 27" of Gravel Subbase.	20/18/17		9.3	
				10/14/13		10.3	
	2.5	GM	SILTY GRAVEL with SAND, fine- to coarse-grained, brown, moist, medium dense to dense. (Alluvium)	5/21/24		5.9	
	5.5		END OF BORING Water not observed with 4' of hollow-stem auger in the ground. Water not observed to dry cave-in depth of 1' immediately after withdrawal of auger.				

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LOG OF BORING

PROJECT: 09-2560 **PAVEMENT DESIGN** Lewis and Clark County Roads Helena, Montana	BORING: **ST-10** LOCATION: Wylie 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*.				*Gravel Base classified as Well Graded Sand with Silt and Gravel. Base course bag sample: P_{200}=7.4%
			FILL: 27" of Gravel Subbase.	8/16/10		2.3	
	2.5	GP GM	POORLY GRADED GRAVEL with SILT and SAND, fine- to coarse-grained, brown, moist, medium dense to very dense. (Alluvium)	6/15/9		3.5	Subgrade bag sample: P_{200}=5.4%
				15/32/34		1.3	
	5.5		END OF BORING				

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

Water not observed to dry cave-in depth of 4' 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-11** LOCATION: Wylie Drive, see attached sketch.

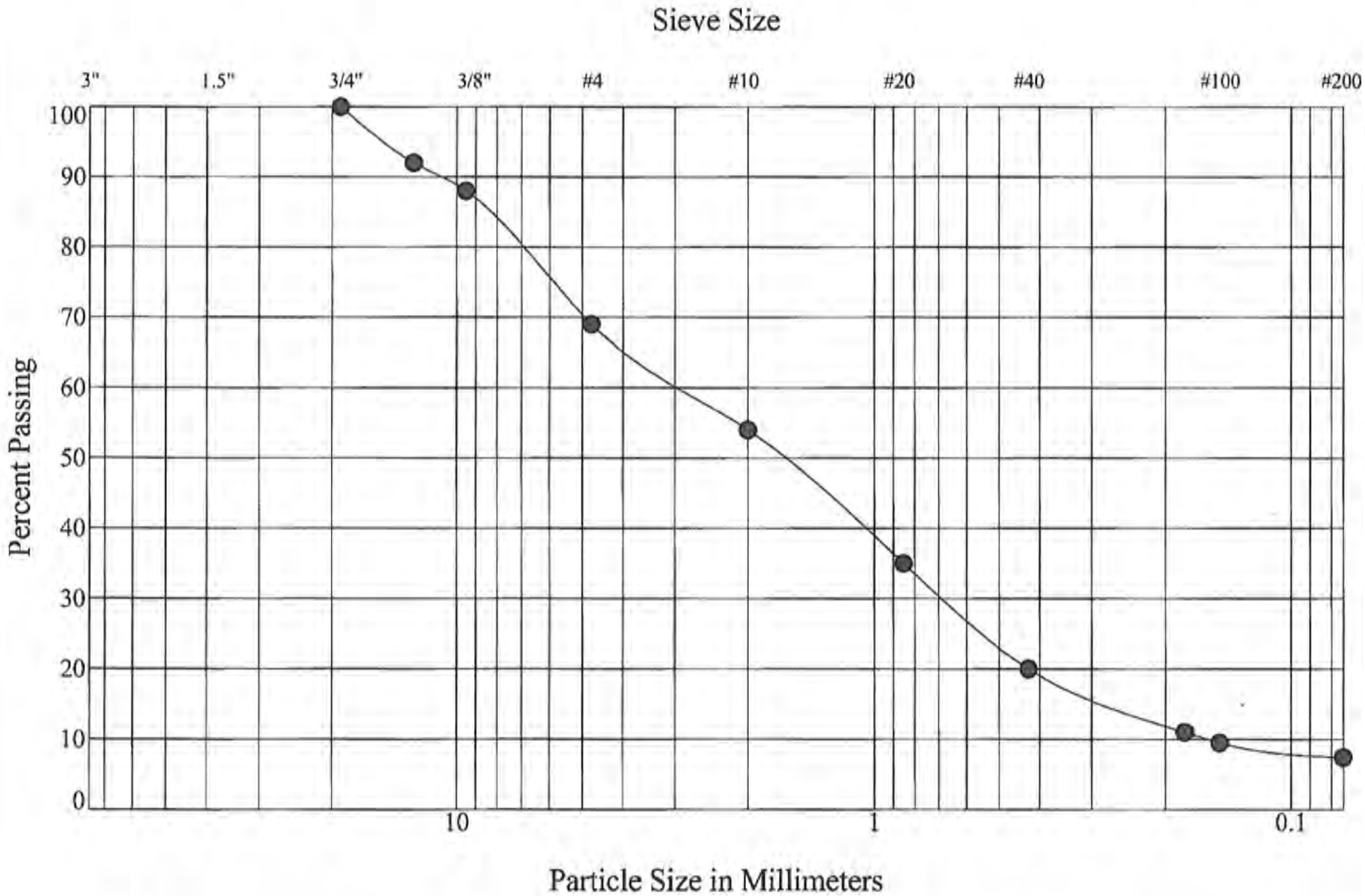
DRILLED BY: C. Larsen	METHOD: 3 1/4" HSA, Automatic	DATE: 7/10/09	SCALE: 1" = 1'

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*.				*Gravel Base classified as Poorly Graded Gravel with Silt and Sand.
			FILL: 27" of Gravel Subbase.	16/21/22		3.0	Base course bag sample: P_{200}=6.4%
				13/15/13		3.9	
	2.5	SP SM	POORLY GRADED SAND with SILT and GRAVEL, fine- to coarse-grained, brown, moist, medium dense. (Alluvium)				Subgrade sample: LL=NP,PL=NP,PI=NP P_{200}=8.6%
				7/15/15		2.3	
	5.5		END OF BORING				

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

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

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



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	88	69	54	35	20	11	10	7.4

Boring No.: ST-10
Sample No.: Base Course
Depth: Base Course

Date Received: 07/15/2009

Percent Gravel: 31.0
Percent Sand: 61.6
Percent Silt + Clay: 7.4
ASTM Group Name: WELL-GRADED SAND with SILT and GRAVEL

Liquid Limit:	NP
Plastic Limit:	NP
Plasticity Index:	NP
Classification:	SW-SM
Moisture Content:	2.9%

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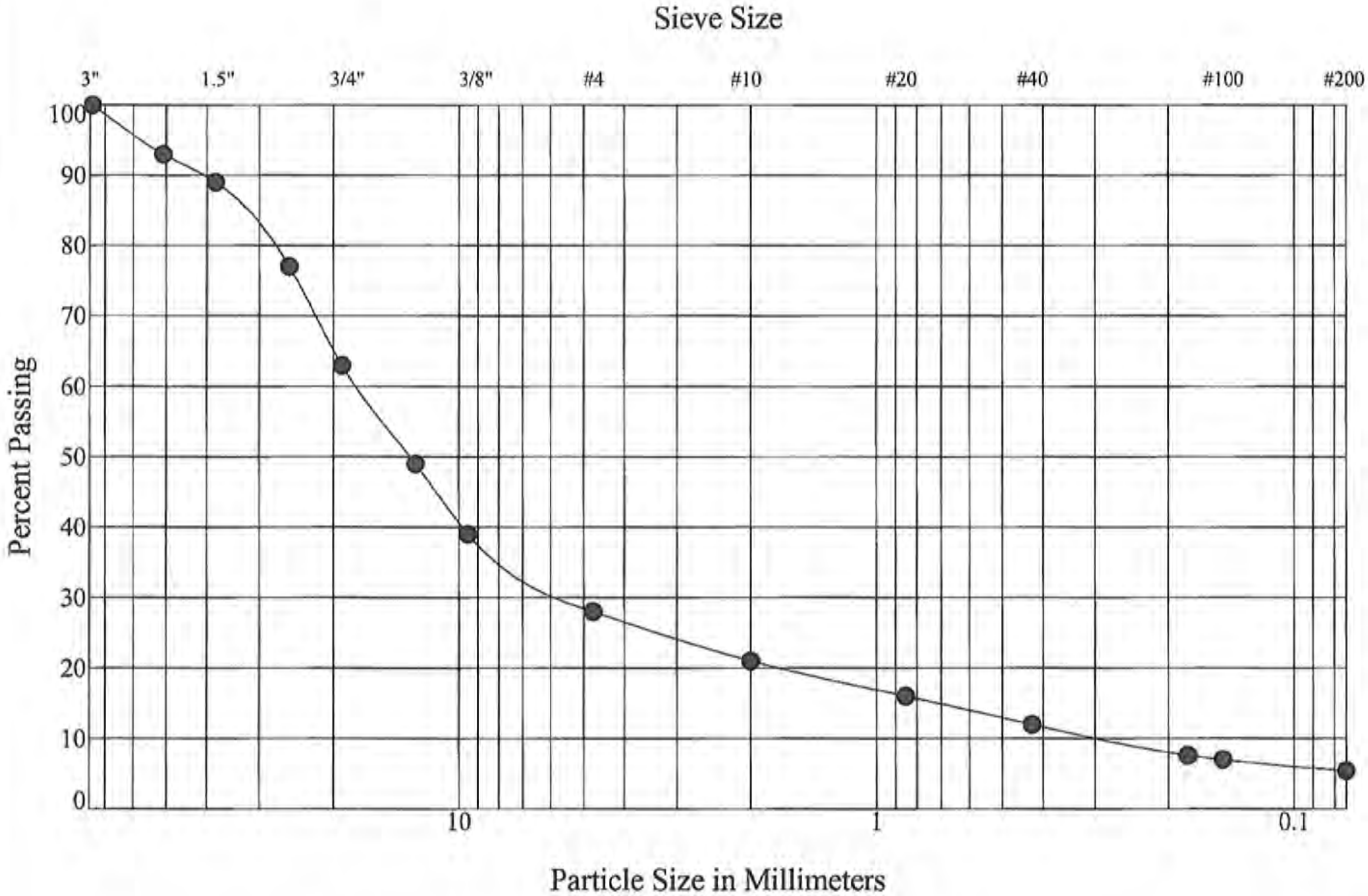
Sieve Analysis
Project Number: 09-2560
Lewis and Clark County Roads
Helena, Montana

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
100	89	63	39	28	21	16	12	8	7	5.4

Boring No.: ST-10
Sample No.: Subgrade
Depth: Subgrade

Date Received: 07/15/2009

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

Percent Gravel: 72.0
Percent Sand: 22.6
Percent Silt + Clay: 5.4
ASTM Group Name: POORLY GRADED GRAVEL with SILT and SAND

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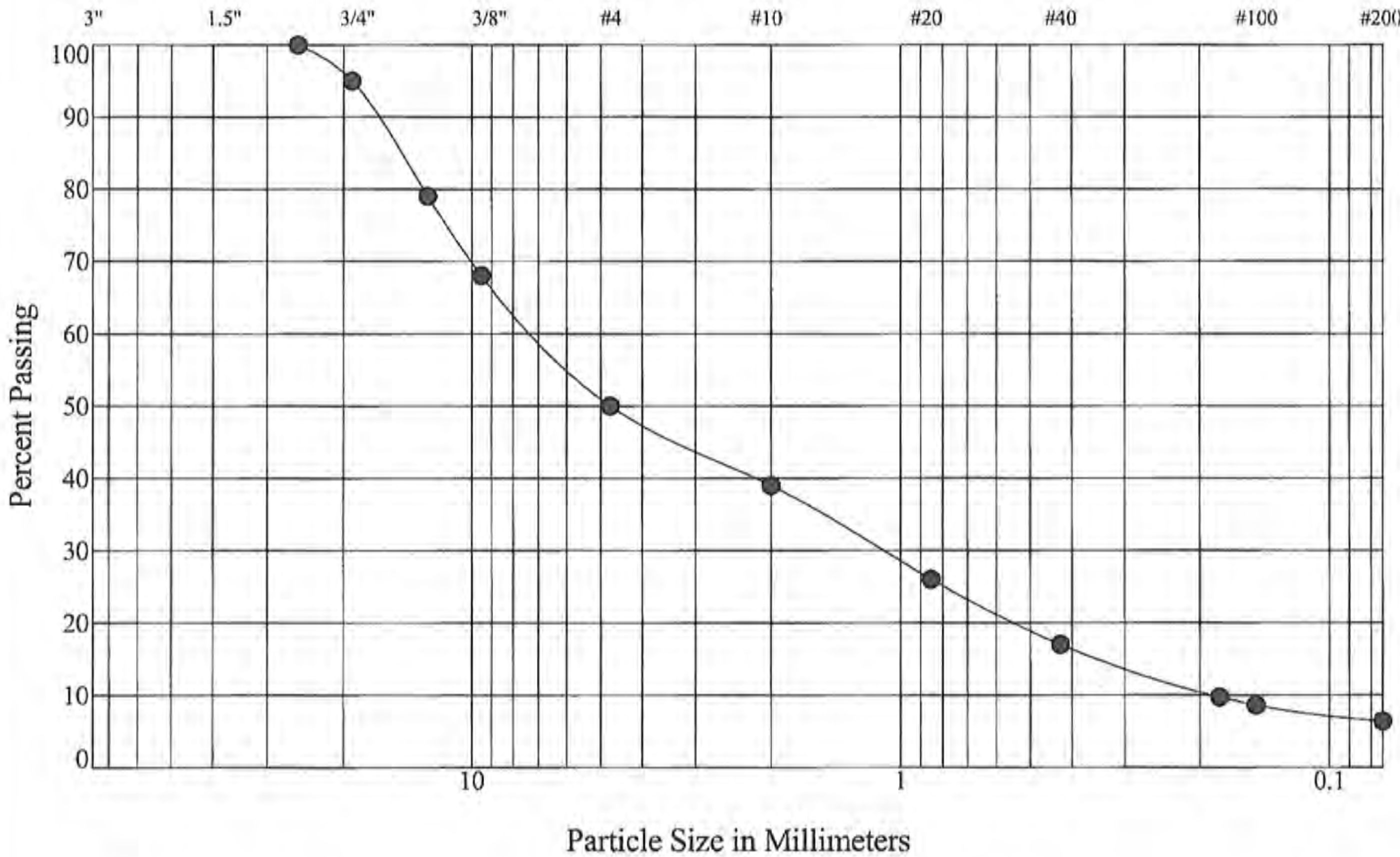
Sieve Analysis

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

10/12/09

Sieve Size



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
		95	68	50	39	26	17	10	9	6.4

Boring No.: ST-11
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:	3.1%

Percent Gravel: 50.0
Percent Sand: 43.6
Percent Silt + Clay: 6.4
ASTM Group Name: POORLY GRADED GRAVEL with SILT and SAND

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Sieve Analysis
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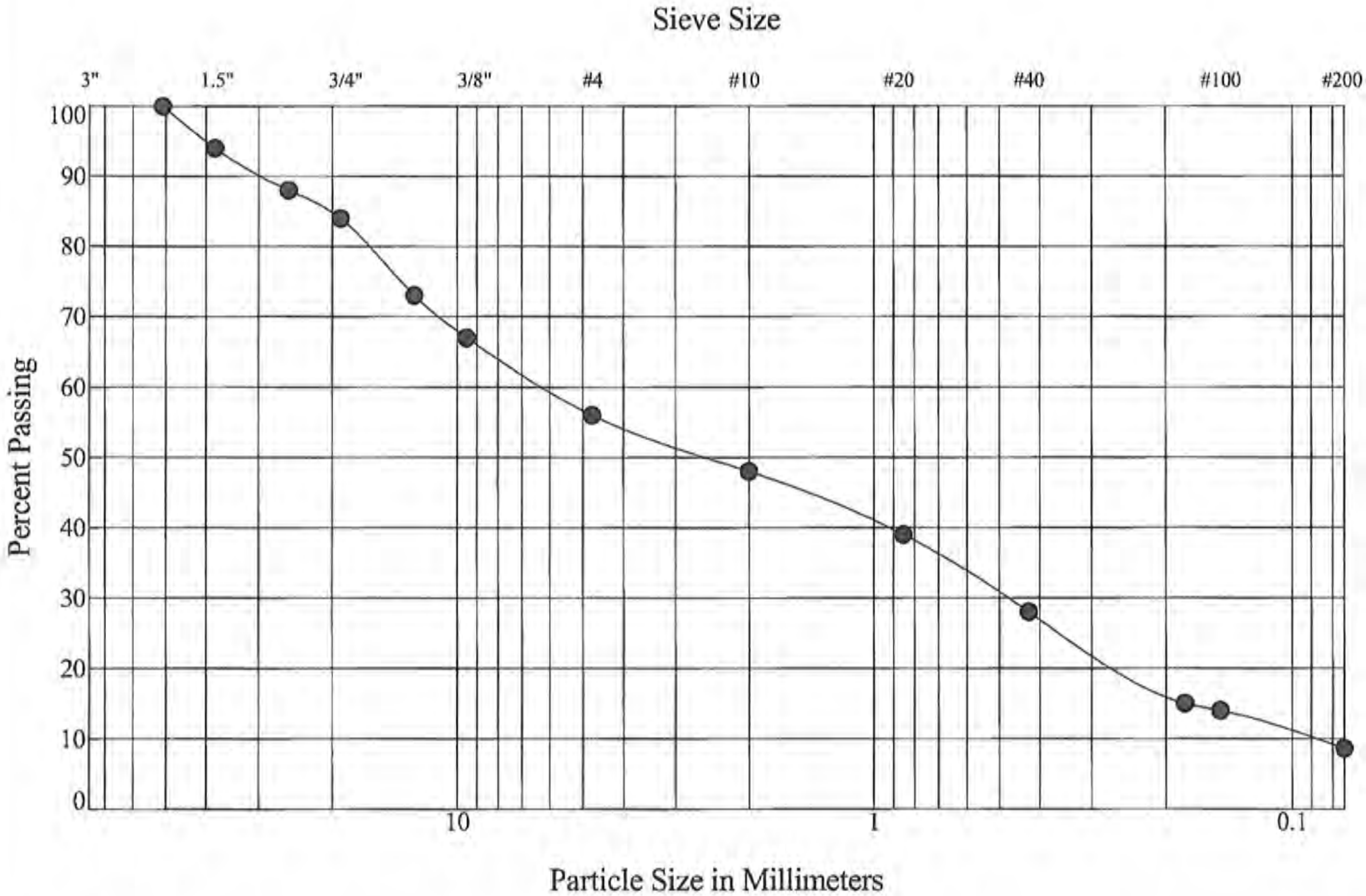
10/12/09



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
	94	84	67	56	48	39	28	15	14	8.6

Boring No.: ST-11
Sample No.: P-5
Depth: Subgrade

Date Received: 07/15/2009

Liquid Limit:	NP
Plastic Limit:	NP
Plasticity Index:	NP
Classification:	SP-SM
Moisture Content:	

Percent Gravel: 44.0
Percent Sand: 47.4
Percent Silt + Clay: 8.6
ASTM Group Name: POORLY GRADED SAND with SILT and GRAVEL

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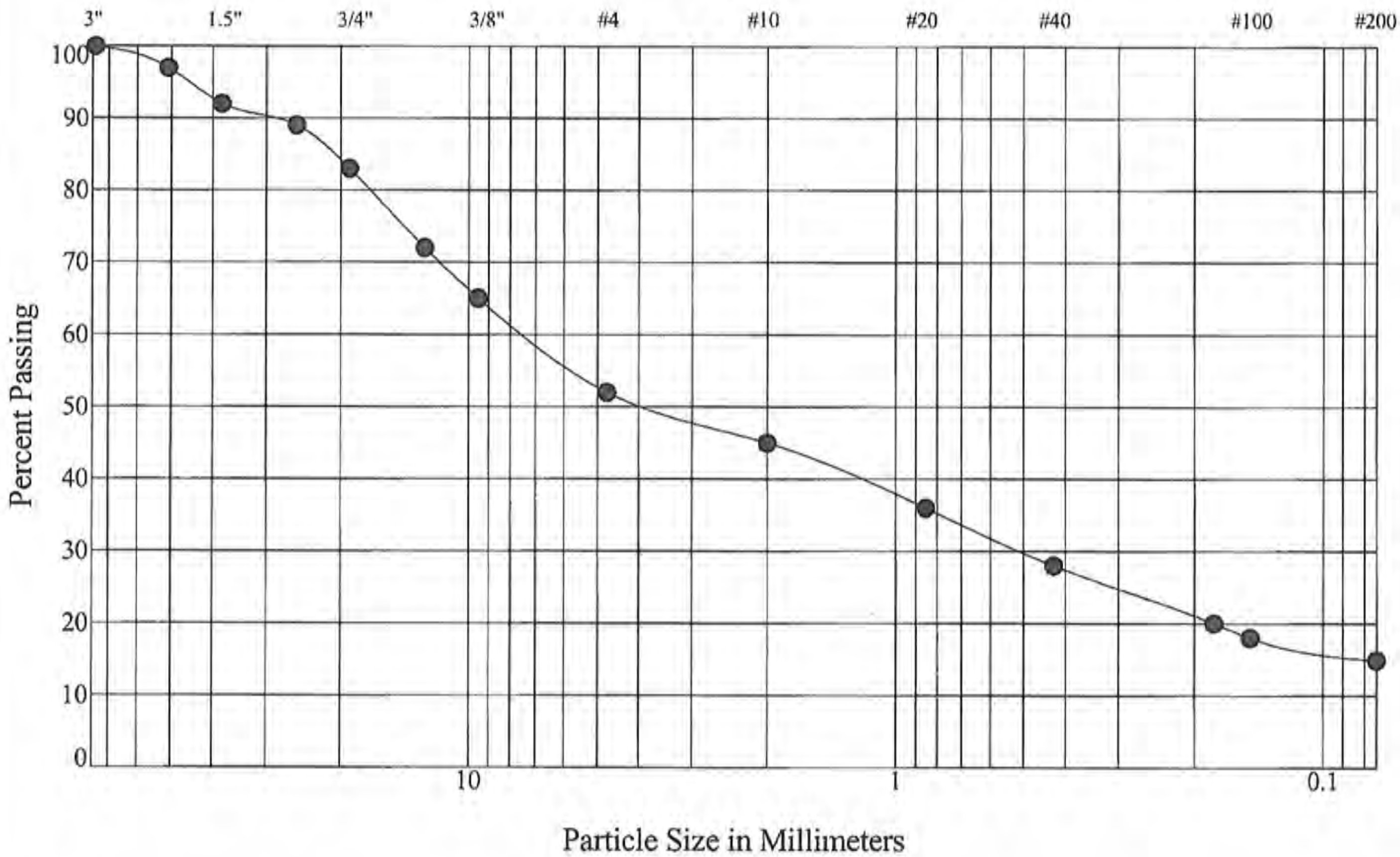
Sieve Analysis

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

10/12/09

Sieve Size



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	92	83	65	52	45	36	28	20	18	14.9

Boring No.: ST-9 and ST-10 Date Received: 07/15/2009
Sample No.: P-4
Depth: Subgrade

Liquid Limit:	NP
Plastic Limit:	NP
Plasticity Index:	NP
Classification:	GM
Moisture Content:	

Percent Gravel: 48.0
Percent Sand: 37.1
Percent Silt + Clay: 14.9
ASTM Group Name: SILTY GRAVEL with SAND

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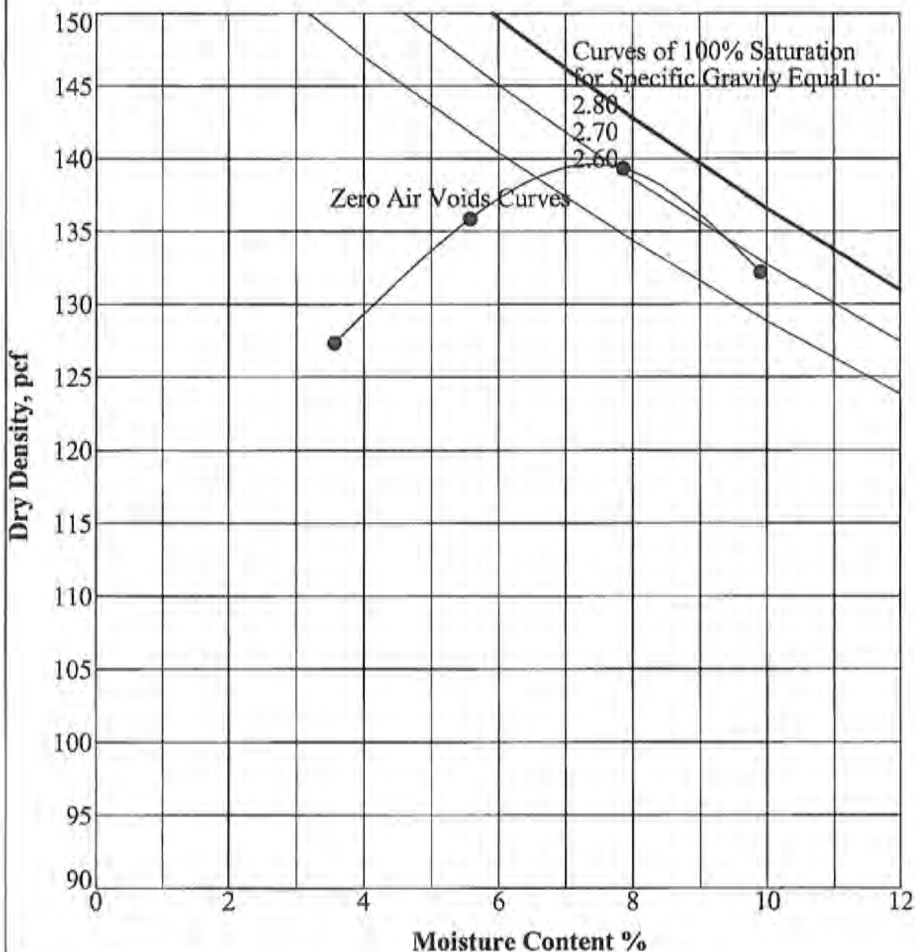
Sieve Analysis
Project Number: 09-2560
Lewis and Clark County Roads
Helena, Montana

10/12/09



ASTM D 4718 Oversize Correction

Maximum Dry Density, pcf	***Optimum Moisture Content %***
143.3	***6.7***

ASTM C 127

Coarse Specific Gravity = 2.66
Absorption = 1.0%

Fine Portion

ASTM D 698 Method C with Correction

Maximum Dry Density, pcf	Optimum Moisture Content %
139.3	7.9

Rammer Type: Mechanical
Preparation Method: Moist

Soil Description (Visual-Manual)

POORLY GRADED SAND with SILT and GRAVEL, fine- to coarse-grained, brown, moist.

Sieve Size	**% Retained**
1 1/2"	8
3/4"	17.2
3/8"	35
#4	48

Sample No:	---
Lab Sample No:	P-4
Date Sampled:	07/10/2009
Sampled By:	Drill Crew
Date Received:	07/15/2009
Sampled From:	ST-9 and ST-10 Wylie Drive
Depth:	Subgrade
Performed by:	MBK/SKG
Date Performed:	07/29/2009

Comments

Additional Remarks

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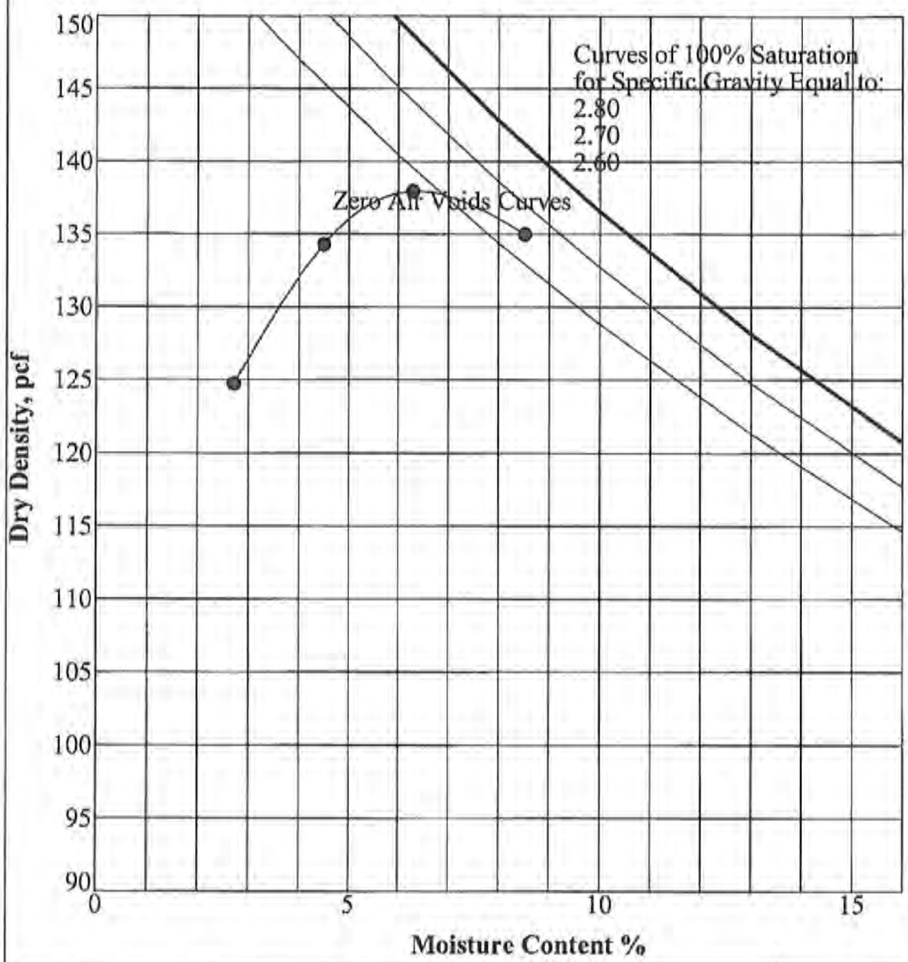
Laboratory Compaction Characteristics of Soil (Proctor)

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

PROCTOR

P-4

10/12/09



ASTM D 4718 Oversize Correction

Maximum Dry Density, pcf	***Optimum Moisture Content %***
141.3	***5.6***

ASTM C 127

Coarse Specific Gravity = 2.61
Absorption = 1.0%

Fine Portion

ASTM D 698 Method C with Correction

Maximum Dry Density, pcf	Optimum Moisture Content %
137.8	6.4

Rammer Type: Mechanical
Preparation Method: Moist

Soil Description (Visual-Manual)

POORLY GRADED SAND with SILT and GRAVEL, fine- to coarse-grained, brown, moist.

Sieve Size	**% Retained**
1 1/2"	6
3/4"	15.7
3/8"	33
#4	44

Sample No:	---
Lab Sample No:	P-5
Date Sampled:	07/10/2009
Sampled By:	Drill Crew
Date Received:	07/15/2009
Sampled From:	ST-11 Wylie Drive
Depth:	Subgrade
Performed by:	MBK/SKG
Date Performed:	08/03/2009

Comments

Additional Remarks

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Laboratory Compaction Characteristics of Soil (Proctor)

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

PROCTOR

P-5

10/12/09

California Bearing Ratio Test
(ASTM D 1883 /AASHTO T 193)

Project: 09-2560 Lewis and Clark County Roads
Wylie Drive

Date: 10/12/09

Boring: ST-9 and ST-10 **Sample:** P-4 **Depth:** Subgrade

Sample Description: Poorly Graded Sand with Silt and Gravel, fine- to coarse-grained, brown, moist.
(Remolded to 95% relative compaction.)
(Sample was submersed in water and allowed to saturate for 96.7 hours.)

Maximum Dry Density: 139.3 pcf Procedure: ASTM D 698 Method C

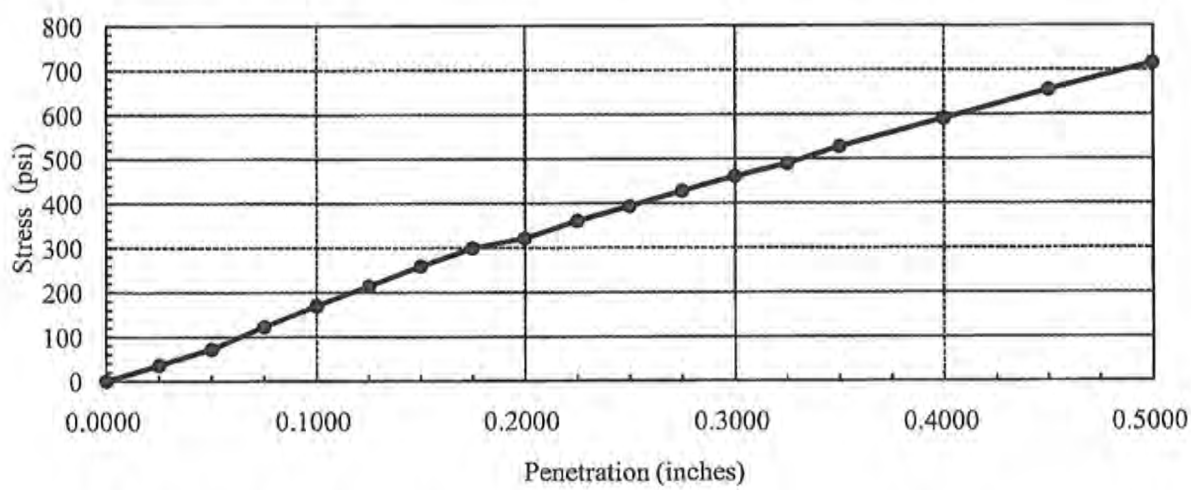
Initial			Final		
Wt. Specimen + Tare Wet	653.1	gms	Wt. Specimen + Tare Wet	1746.9	gms
Wt. Specimen + Tare Dry	605.5	gms	Wt. Specimen + Tare Dry	1630.9	gms
Wt. Tare	147.4	gms	Wt. Tare	293.8	gms
Moisture Content	10.4%		Moisture Content	8.7%	

Initial Wt. 4862.2 gms Diameter 6.00 in Initial Ht. 4.58 in

Initial Dry Unit Wt. 129.6 pcf Initial Relative Compaction 93.0%
Final Dry Unit Wt. 129.6 pcf Final Relative Compaction 93.0%

Swell Test
Surcharge Weight 22.5 lbs Surcharge Pressure 133.4 psf
Initial Dial Rdg. 0.5000 Final Dial Rdg. 0.5000 Swell 0.0%

CBR Test
Surcharge Weight 22.5 lbs Surcharge Pressure 128.1 psf
CBR @ 0.1 in. **17.0** CBR @ 0.2 in **21.4**



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California Bearing Ratio Test

(ASTM D 1883 /AASHTO T 193)

Project: 09-2560 Lewis and Clark County Roads
Wylie Drive

Date: 10/12/09

Boring: ST-11 **Sample:** P-5 **Depth:** Subgrade

Sample Description: Poorly Graded Sand with Silt and Gravel, fine- to coarse-grained, brown, moist.
(Remolded to 95% relative compaction.)
(Sample was submersed in water and allowed to saturate for 96.0 hours.)

Maximum Dry Density: 137.8 pcf Procedure: ASTM D 698 Method C

Initial			**Final**		
Wt. Specimen + Tare Wet	464.3	gms	Wt. Specimen + Tare Wet	1207.3	gms
Wt. Specimen + Tare Dry	443.6	gms	Wt. Specimen + Tare Dry	1132.2	gms
Wt. Tare	122.5	gms	Wt. Tare	241.6	gms
Moisture Content	6.4%		Moisture Content	8.4%	

Initial Wt. 4738.6 gms Diameter 6.00 in Initial Ht. 4.58 in

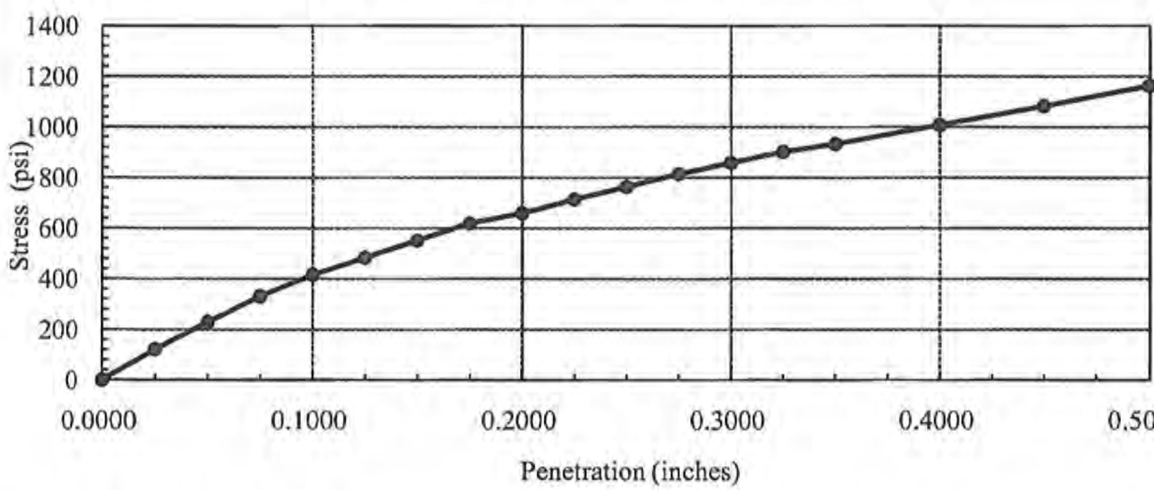
Initial Dry Unit Wt. 131.0 pcf Initial Relative Compaction 95.0%
Final Dry Unit Wt. 131.0 pcf Final Relative Compaction 95.0%

Swell Test

Surcharge Weight 22.5 lbs Surcharge Pressure 133.4 psf
Initial Dial Rdg. 0.5000 Final Dial Rdg. 0.5000 Swell 0.0%

CBR Test

Surcharge Weight 22.5 lbs Surcharge Pressure 128.1 psf
CBR @ 0.1 in. **41.6** CBR @ 0.2 in **43.9**



Laboratory Test of Aggregate

Date: October 13, 2009

Project: **09-2560 Pavement Evaluation**
Wylie 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:

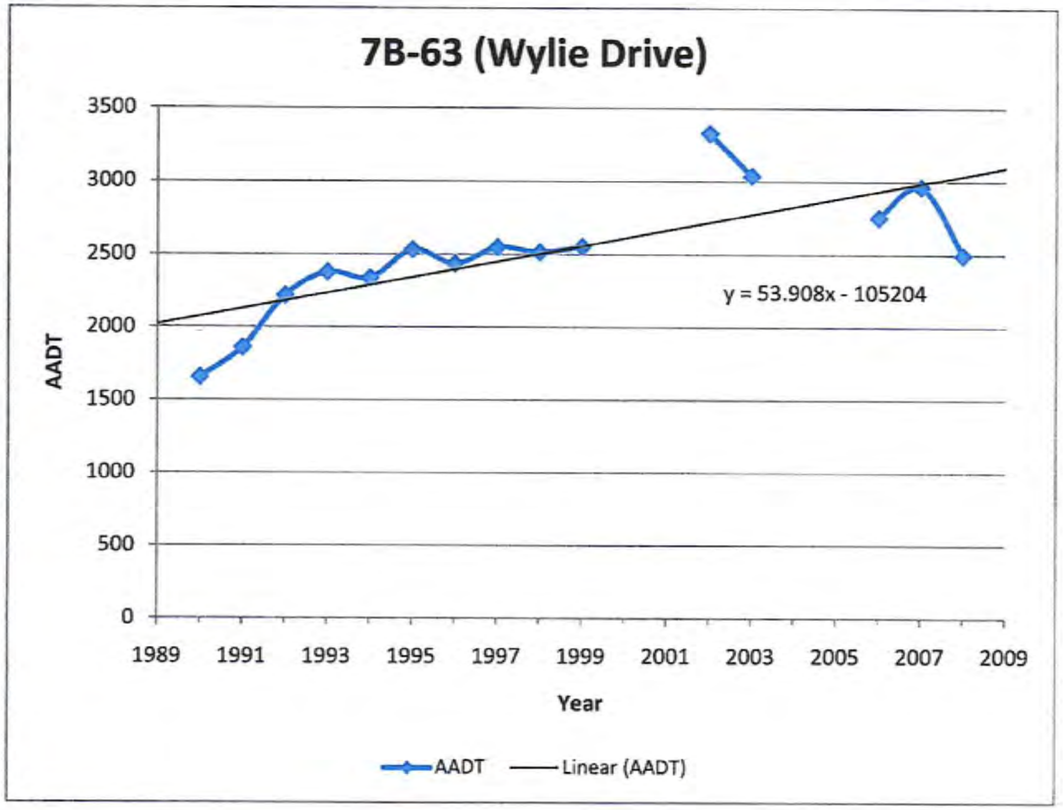
Gradation (ASTM C 136)

			12/18/2007 Lewis and Clark Subdivision	
Sieve Size	**ST-10 Base Course**	**ST-11 Base Course**	**Crushed Top Surfacing**	**Select Base Course**
1 1/2"	---	100	---	100
3/4"	100	95	100	---
1/2"	92	79	---	---
No. 4	69*	50	40 – 70	25 – 60
No. 10	54	39	25 – 55	---
No. 40	20	17	---	---
No. 100	10	9	---	---
No. 200	7.4	6.4	2 – 10	2 – 12

Remarks: *Do not meet specifications.

7B-63 (Wylie Drive - North of Canyon Ferry Road)

Year	AADT
1989	
1990	1653
1991	1856
1992	2216
1993	2376
1994	2337
1995	2532
1996	2435
1997	2549
1998	2515
1999	2553
2000	
2001	
2002	3333
2003	3038
2004	
2005	
2006	2752
2007	2964
2008	2496
2009	
2029	**4175**



2009	3097
2029	4175
Yearly Growth Rate	1.50%

==

DARWin(tm) - Pavement Design

A Proprietary AASHTOWARE(tm)
Computer Software Product

Flexible Structural Design Module

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

Flexible Structural Design Module Data
18-kip ESALs Over Initial Performance Period: 426,483
Initial Serviceability: 4.2
Terminal Serviceability: 2.5
Reliability Level (%): 90
Overall Standard Deviation: .45
Roadbed Soil Resilient Modulus (PSI): 18,500
Stage Construction: 1

Calculated Structural Number: 2.13

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): 2.00
Calculated Layer SN: .13

Total Thickness (in): 14.00
Total Calculated SN: 2.16

Simple ESAL Calculation
Initial Performance Period (years): 20
Initial Two-Way Daily Traffic (ADT): 3,097
% Heavy Trucks (of ADT) FHWA Class 5 or Greater: 3.3
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 (%): 1.5
Growth: Simple

Total Calculated Cumulative Esals: 426,483

Appendix D

Cost Estimates

Wylie Drive Reconstruction Cost Estimate

Major Work Feature	Unit	Unit Cost	Number of Units: Typical A	Typical B	Typical C	Total	Total Cost
Survey - Staking and Grade Control	MI	$15,000.00	0.65	0.85	0.50	2.00	$30,000
Topsoil - Salvage and Place	CY	$4.05	636	1,621	880	3,136	$12,702
Excavation - Unclassified	CY	$5.50	7,997	14,436	4,514	26,947	$148,210
MPDES Permit Fees	LS	$900.00	1	1	1	3	$2,700
Temporary Erosion Control - LS	LS	$4,000.00	1	1	1	3	$12,000
Select Base Course	CY	$12.00	3,188	4,350	2,559	10,097	$121,162
Crushed Top Course	CY	$25.41	1,327	2,061	1,199	4,586	$116,540
Aggregate Treatment (Prime)	SY	$0.41	12,622	17,044	10,026	39,693	$16,274
Asphalt Tack Coat	SY	$0.10	12,416	16,501	9,706	38,623	$3,862
Chip Seal & Cover	SY	$2.00	12,203	15,957	9,387	37,547	$75,093
Plant Mix Asphalt Paving	Ton	$81.38	2,243	3,223	1,883	7,348	$598,014
Curb and Gutter - Conc	LF	$15.50	3,432	0	0	3,432	$53,196
RCP Irr 24" Class 3	LF	$44.58	3,432	0	0	3,432	$152,999
Inlet Drop - Type 4	Each	$1,784.58	17	0	0	17	$30,623
Reset Mailbox	Each	$200.83	13	30	17	60	$12,050
Traffic Gravel	CY	$19.03	932	1,219	717	2,868	$54,578
Remove/Reset Signs	Each	$184.30	2	2	4	8	$1,474
Interim Striping - Yellow Paint	Gal	$34.18	27	36	21	84	$2,888
Final Striping - Yellow Paint	Gal	$34.18	27	36	21	84	$2,888
Interim Striping - White Paint	Gal	$34.30	27	36	21	84	$2,898
Final Striping - White Paint	Gal	$34.30	27	36	21	84	$2,898
Remove Existing Culverts	LF	$12.27	728	1,680	1,032	3,440	$42,209
Approach/Relief Drain Pipe - 18/24 In.Dia.	LF	$50.17	728	1,680	952	3,360	$168,571
Drainage Pipe 60 Inch Dia.	LF	$196.33	0	0	80	80	$15,706
Farm Fence - Type Type 5M	LF	$2.25	6,864	8,976	5,280	21,120	$47,520
Fence Panel	Each	$145.92	21	27	16	64	$9,339
Seeding	Acre	$294.16	3.78	4.95	2.91	11.64	$3,423
Fertilize Seed	Acre	$120.84	3.78	4.95	2.91	11.64	$1,406
Condition Seedbed Surface	Acre	$221.51	3.78	4.95	2.91	11.64	$2,578
Geotextile - Subgrade Stabilization	SY	$1.50	3,241	3,989	2,347	9,577	$14,366
Subgrade Stabilization Gravel (12 - inch Depth)	CY	$8.00	1,080	1,330	782	3,192	$25,540
Subexcavation	CY	$5.50	1,080	1,330	782	3,192	$17,558
Subtotal - Construction	**$/Segment**		**$693,581**	**$701,631**	**$406,052**		**$1,801,264**
Final Engineering, Geotec. & Survey	LS	8.00%	$55,486	$56,130	$32,484		$144,101
Construction QA/QC	LS	4.00%	$27,743	$28,065	$16,242		$72,051
Contractor Mobilization	LS	5.00%	$34,679	$35,082	$20,303		$90,063
Contingency	LS	10.00%	$69,358	$70,163	$40,605		$180,126
Traffic Control During Construction	LS	8.00%	$55,486	$56,130	$32,484		$144,101
Right-of-Way Appraisals by Agent	Each	$2,000.00	11	29	0	40	$80,000
Right-of-Way Acquisition by Agent	Each	$1,500.00	11	29	0	40	$60,000
Purchase Right-of-Way	Acre	$32,000.00	0.79	2.06	0.00	2.85	$91,152
Total Estimated Cost (2011)	**$/Segment**		**$ 1,000,047**	**$ 1,114,641**	**$ 548,171**		**$2,662,858**

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

Additional Alternate Costs

Major Work Feature	Unit	Unit Cost	Number of Units: Typical #1	Typical #2	Typical #3	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	0.65	0.85	0.50	2.00	$422,400
Water Main	MI	$396,000.00	0.65	0.85	0.50	2.00	$792,000
Bicycle/Ped. Path Reconstruction	MI	$77,825.00	0.65	0.85	0.50	2.00	$155,650