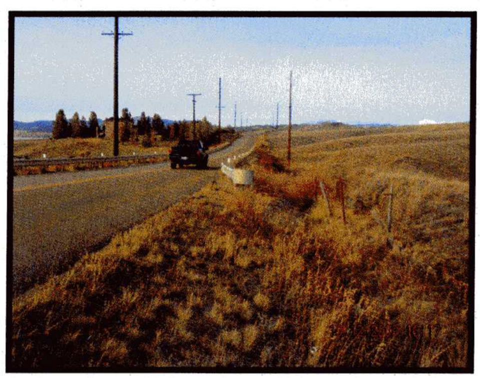
Lake Helena Drive – Preliminary Engineering Report

LEWIS & CLARK COUNTY

RPA PROJECT NO. 09503.000

Prepared For:

Lewis & Clark County
3402 Cooney Drive
Helena, MT 59602



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RPA

December, 2009

STATE OF MONTANA
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PURPOSE AND OBJECTIVES

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 road study segment is Lake Helena Drive. The study limits begin at the intersection of old US Highway 12 (E. Main Street) in East Helena, and extend northerly to its intersection with Lincoln Road East. The study segment is further described in the following section titled "Location & Description". Lake Helena Drive is considered a high-priority road by County staff to receive reconstructive improvements. The prioritization is in some part due to the impacts caused by traffic utilizing this Minor Collector highway. Lake Helena Drive serves as a primary connector for local traffic movement across the easterly Helena Valley with its intersections to U.S. Highway 12, Canyon Ferry Road (Montana Secondary Highway 430), York Road (Montana Secondary Highway 280), and Lincoln Road East (Montana Secondary Highway 453). In addition, when compared to other portions of the County, this area has experienced a substantial amount of residential subdivision construction in recent years. Development has added 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 March 5, 2009), Part H Streets and Roads, the County will also utilize this document to calculate the pro rata cost share of each new subdivision 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 phases.

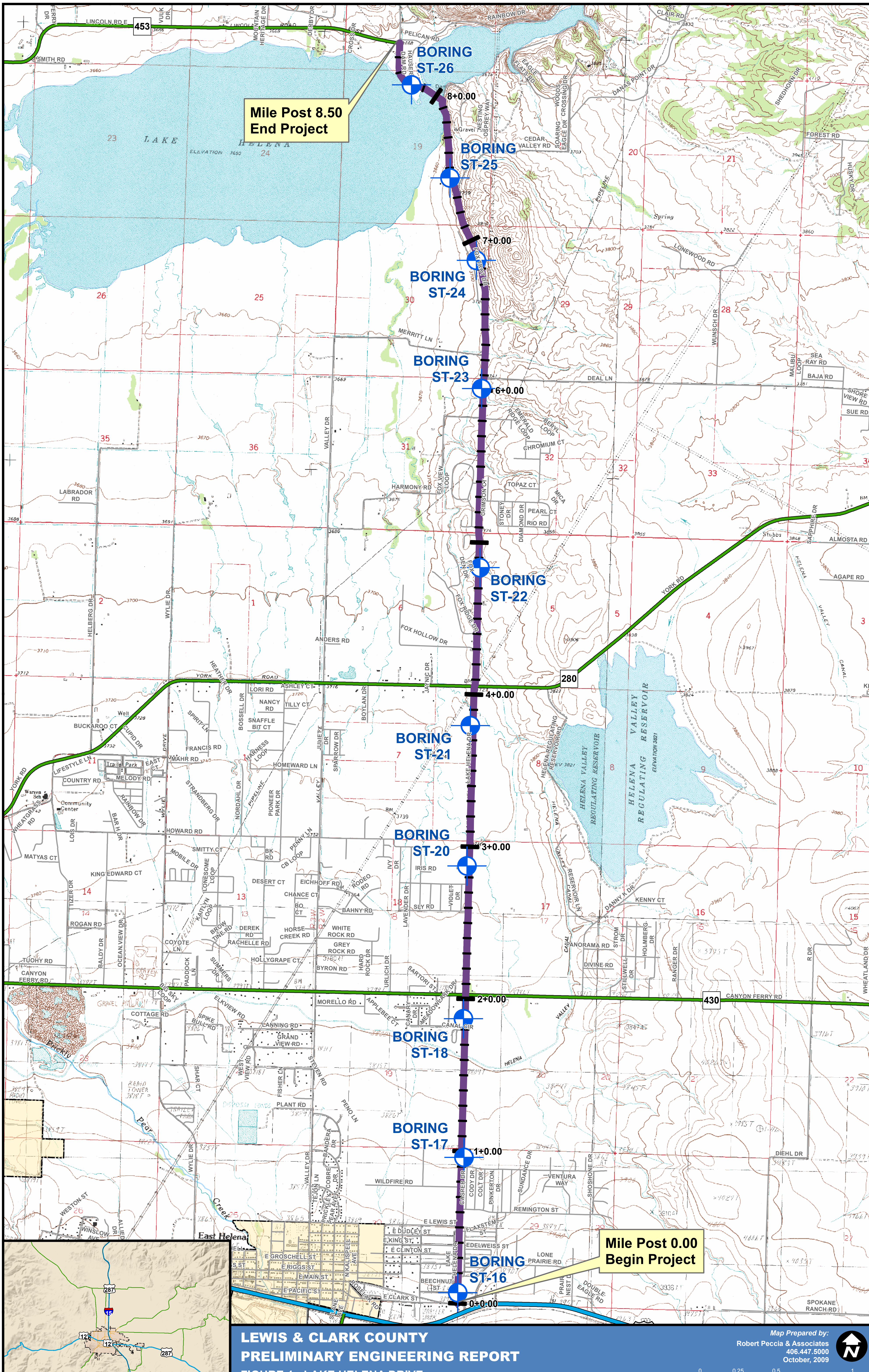
RPA has prepared this report with services rendered to meet or exceed those of the practicing consulting engineering industry under similar budget and time restraints. No warranty, expressed or implied, is made.

LOCATION & DESCRIPTION

Lake Helena Drive lies within the easterly portion of what is locally known as the Helena Valley. The study area begins at the intersection of old US Highway 12 (E. Main Street) in East Helena. This intersection is a few hundred feet away from E. Main Street's intersection with U.S. Highway 12. The project extends northerly for approximately 8.5 miles, terminating at its intersection with Lincoln Road East (Montana Secondary Highway 453). North of this intersection, the roadway continues and is locally known as Hauser Dam Road. Refer to the following project location map, **Figure 1**. For the purpose of this study, Milepost [MP] 0.00 is considered as Lake Helena Drive's intersection with E. Main Street of East Helena. The mileposts increase in a south to north direction. From Milepost 0.00, Lake Helena Drive continues due north along the section lines common to Sections 29 and 30, 19 and 20, 17 and 18, 7 and 8, and 5 and 6 in Township 10 North [T. 10 N.], Range 2 West [R. 2 W.]. The project continues into T. 11 N., R. 2 W., along the section lines common to Sections 31 and 32, and 29 and 30. The road alignment then begins to contour around the foothills east of Lake Helena before crossing the Lake Helena causeway at approximately MP 8.0. The project terminates at MP 8.5 within the southwest quarter of Section 18, T. 11 N., R. 2 W.

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 generally 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 Minor Collector. Based on the evaluation presented herein, we estimate the average overall base cost to reconstruct Lake Helena Drive to meet assigned design criteria to be approximately $1.0 million per mile. This cost estimate includes design engineering, right-of-way acquisition and other contingencies. Alternative add-ins such as installing a new sewer or water main, signals, turn lanes, or a new pedestrian/bicycle path would increase the cost. Refer to the cost summaries contained in the report for each applicable road segment.



LEWIS & CLARK COUNTY
PRELIMINARY ENGINEERING REPORT
FIGURE 1 - LAKE HELENA DRIVE

Map Prepared by:
Robert Peccia & Associates
406.447.5000
October, 2009

Design Controls and Criteria

METHODOLOGY TO DEVELOP REPORT

Field methods to obtain existing geometric information were used to expedite the process to meet the budget constraint and time period allocated in the scope of work. The work is indicative of the preliminary nature of this project's current status and level of design and development. Explicitly, formal survey work of setting control and then completing instrumental topographical survey was not completed. As such, CADD based design work has not been undertaken, except for some basic diagramming. Field reviews were completed in October 2009. For on site field reviews, most measurements were taken with a steel tape. Longer measurements were obtained using a wheel tape. For slope or grade estimates, a four-foot long digital smart level was used to record the information in degrees or percent format. This then was converted to approximate slope rates, such as horizontal:vertical (h:v) for describing existing road fill or cut slope rates as an example. For longer measurements, such as checking sight distances, a hand-held laser rangefinder was used. GIS information was used to minimize walking or windshield review time. An amount of certificates of survey and subdivision plats were referenced as a means to crosscheck information, but by no means was a full record research performed. The plan set of the County's 1995 reconstruction of Lake Helena Drive from York Road north to Deal Lane was also referenced to assist in this report's preparation.

REFERENCE STANDARDS

The reference standards used in this study are those specified by the Lewis and Clark County Subdivision Regulations. Specifically, in the Road Standards, referenced documents include 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.

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 approximately one-half of its length; from the beginning of the project, MP 0.0, northerly to approximately MP 4.05 at the intersection with York Road. In this location, the road grades slope south to north and are very moderate at about 1.0%. The area is semi-arid with few significant cross-draining structures. The road generally parallels the natural south to north/northwesterly drainage pattern of the valley in this location. North of York Road the terrain is characterized by intermittent east to west cross-drainage draws that drain into Lake Helena. As such, the road's vertical alignment becomes steeper, and rolls from positive to negative grades as the highway traverses the foothills beginning southeast of Lake

Helena. Except for the road approach to the causeway, the road experiences up to approximately 5.5% grades between crests and sags with lesser grades in between.

The area is a mix of irrigated and dry land agricultural tracts between parcels of developed suburban residential subdivisions. Lake Helena Drive is functionally classified by the County as a Minor Collector. This classification serves to collect a mix of traffic from abutting properties via local road approaches, or intersections of similar collector routes (e.g. York Road, Canyon Ferry Road and Lincoln Road), and distributes to other roads of equal or higher classification.

EXISTING RIGHT-OF-WAY

Recorded right-of-way documentation along Lake Helena Drive appears to be incomplete and its level of documentation is correlated to the level of development adjacent to the roadway. Due to the lack of historical roadway construction information, to ascertain the widths of the existing right-of-way, we reviewed a sample of certificates of survey and subdivision plats. Then, the documented width(s), if available, were compared to present GIS data.

From the beginning of the project, at MP 0.00 through the Eastgate I Subdivision (MP 0.50), the documented right-of-way width is 80 feet overall, with an additional 15 feet per side of utility easements. North of this, to about MP 0.9 fronting the Eastgate II Subdivision, the existing right-of-way is apparently 60 feet wide overall. An additional 30 feet on the east side of the road is reserved as a park and utilities easement created by the Eastgate II subdivision.

From approximately MP 1.0 to the Helena Valley Canal (MP 1.6), the single plat we reviewed showed no recorded road right-of-way easement for the east side of the road. However, a subdivision plat just north of the canal crossing depicts 60 feet of road easement (30 feet on each side of centerline), with an additional 90 feet of irrigation easement paralleling the right-of-way on the west side.

Between Canyon Ferry Road (MP 2.0) and York Road (MP 4.0), all development has been so far established to being on the west side of the highway; with the east side currently remaining as productive agricultural ground. The four subdivision plats reviewed in this location depicted 30 feet of road easement from the centerline west, or 60 feet overall in some cases where designated. A variable width irrigation easement parallels the west side of the road through Section 18, T. 10 N., R. 2. W. Its easement width is depicted as being between 50 feet and 80 feet.

North of York Road (MP 4.0) to where the road crosses the Lake Helena causeway at about MP 8.0, the apparent right-of-way is generally 60 feet wide overall, except for approximately the first mile to MP 5.0 in which GIS indicates it to be 100 feet (likely including parallel irrigation easements on the west side of the road). Within this segment, the County completed a Lake Helena Drive improvements project in 1995 from York Road north to Deal Lane (MP 6.08). The reconstruction project as we understand was designed to primarily fit within the right-of-way corridor established apparently by the right-of-way fencing. The plans show the fencing, but do not specify the existing highway easement width. Plan measurements between the east and west fences that parallel the road vary, but generally yields between 60 and 100+ feet in locations.

In the north half of Sections 29 and 30, and south half of Sections 19 and 20, T. 11 N., R. 2 W., (approximately MP 6.6 to MP 7.3) the county road experiences a curvilinear alignment as it traverses the hillsides above the southeast shoreline of Lake Helena. The subdivision plats reviewed in this location depict 60 foot overall road easement widths.

North of the Lake Helena causeway to the intersection with Lincoln Road has apparently 75 feet of right-of-way or less based on GIS. The GIS information showed variable widths, not necessary parallel to the road alignment. The certificates of survey reviewed in this area do not specify the existing road easement width in relation to the road.

The County standard minimum overall right-of-way width is 80 feet for a Minor Collector. Based on this, the existing right-of-way would need to be widened an additional 20 feet in locations where the right-of-way is currently 60 feet. Some locations may require more right-of-way depending on the overall width of construction, which truly dictates the necessary right-of-way limits. Estimating the required amount of new right-of-way for road reconstruction is discussed later in this report.

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 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.

In Appendix J, Table A of the Lewis and Clark County Subdivision Regulation Road Standards, the specified design speed applicable to Lake Helena Drive, being a Minor Collector, is 50 miles per hour (mph) for level terrain and 40 mph for rolling terrain. A copy of Table A is included in **Appendix C**. By comparison, **Exhibit 6-1** of the AASHTO Green Book is a table of suggested minimum design speeds for Rural Collectors. Copies of AASHTO exhibits referenced for design purposes are contained in **Appendix C**. For the segment of Lake Helena Drive south of York Road, with over 2000 vehicles per day, and the road being in level terrain, AASHTO’s minimum design speed is 60 mph, or 10 mph greater than the County standard. For the segment north of York Road, specifically north of Deal Lane, in rolling terrain AASHTO recommends a minimum 40 mph design speed. This is based on comparing the design year traffic north of Deal Lane to being less than 2,000 vehicles per day. For this road segment, the County’s standard meets AASHTO’s recommended design speed.

In the above paragraphs, design speed as a function of traffic volume and terrain was discussed. Another function of design speed is the highway’s vertical alignment in relation to the terrain.

Exhibit 6-4 of the Green Book specifies maximum suggested grades, in percent (%), for specified design speeds of Rural Collector highways. For the County specified 50 mph design speed (level terrain) a highway grade not to exceed 6% is recommended. For the County specified 40 mph design speed (rolling terrain) the maximum recommended grade is 8%. Except for the east approach to the Lake Helena causeway, there are no existing grades exceeding those recommended based on the terrain criteria.

The County has established different regulatory speed limits for different segments of road in this study area. The regulatory speeds are at, or less than the County standard design speeds, and are deemed appropriate by the County based on terrain, the road's surfacing condition, geometrics, and level of roadside development. The County has established the following regulatory speed limits:

- Old U.S. Highway 12 to Boundary Street (MP 0.0 to MP 0.9) = 35 mph except for school zone when children are present
- Boundary Street to Canyon Ferry Road (MP 0.9 to MP 2.0) = 45 mph
- Canyon Ferry Road to York Road (MP 2.0 to MP 4.0) = 50 mph
- York Road to Deal Lane – Paved Surfacing (MP 4.0 to MP 6.1) = 40 mph
- Deal Lane North to end of Gravel (MP 6.1 to MP 7.9) = 35 mph
- Lake Helena Drive Causeway (MP 7.9 to MP 8.1) = 15 mph
- Causeway to Lincoln Road (MP 8.1 to MP 8.5) = 25 mph

Table 1: Posted Regulatory Speeds vs. Design Speed Standards

			Design Speed (mph)		
Mile Post	Terrain	Regulatory Speed	County	AASHTO	Location
MP 0.0 to 0.9	Level	35 mph	50	60	Old Hwy 12 to Boundary St.
MP 0.9 to 2.0	Level	45 mph	50	60	Boundary St. to Canyon Ferry Rd.
MP 2.0 to 4.0	Level	50 mph	50	60	Canyon Ferry Rd. to York Rd.
MP 4.0 to 6.1	Rolling	40 mph	40	50	York Road to Deal Lane
MP 6.1 to 7.9	Rolling	35 mph	40	40	Deal Lane North to End of Gravel
MP 7.9 to 8.5	Level	25 mph/15 mph	50	50	Causeway to Lincoln Road

In summary, based on the above comparisons, we believe the County's standard design speeds are appropriate for this facility. The design speeds are at or slightly higher than the current regulatory speeds, which is indicative of improving conditions to those of highest practical to attain the desired degree of safety, mobility, and efficiency subject to environmental, economic and other social, political or aesthetic constraints.

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. 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, ATS completed traffic classification counts to help analyze the traffic mix. This then was used to complete a road surfacing evaluation as a part of this PER.

Lewis and Clark County also provided RPA with the historical traffic counts for Lake Helena Drive. The AADT counts date back 20 years to give a very good baseline of information to characterize traffic growth. The historic traffic counts as well as the 2009 ATS traffic classification counts that were completed specific for this project are shown in **Appendix A.**

For the segments in which year 2009 counts were available, RPA plotted the historic traffic counts to assess the annual growth rate. A linear trend line was established from the past 20-year historical counts and used to project out to a future 20-year evaluation period to year 2029. Based on the trend line, the yearly growth rate within the 20-year performance period is approximately 3.85% north of Canyon Ferry Road, and 3.09% north of Deal Lane. The estimated AADT for year 2029 is 3,759 vehicles per day north of Canyon Ferry Road, and 1,753 north of Deal Lane. Trend line graphs are also shown in **Appendix A**. The table below summarizes the historic and projected traffic based on the data contained in Appendix A.

Table 2: Average Annual Daily Traffic (AADT)

Lake Helena Drive		Average Annual Daily Traffic (AADT)		
Co. Road No.	Location	Year 2008	Year 2009	Design Year 2029
7A-70	S. of Canyon Ferry Rd.	2,546	Not Complete	~
7A-69	N. of Canyon Ferry Rd.	1,667	2,401	3,759
7A-68	S. of York Road	1,285	Not Complete	~
7A-67	N. of York Road	2,060	Not Complete	~
7A-66	S. of Deal Lane	860	Not Complete	~
7A-65	N. of Deal Lane	842	880	1,753

CRASH HISTORY

Crash data for Lake Helena Drive was requested from the MDT Safety Management Engineer on September 4, 2009. The data request included the intersections of Lake Helena Drive with the MDT on-system highways of York Road (Highway S-280) and Lincoln Road (Highway S-453). Crash history information was not requested at the intersection of Canyon Ferry Road (Highway S-430) due to the improvements being completed at that location by the MDT under the Canyon Ferry Road, STPS 430-1(6)1 project. The crash summary and detailed crash data was received on September 28, 2009.

There were forty reported crashes between January 2004 and December 2008 along Lake Helena Drive from Old U.S. Highway 12 north to Lincoln Road. A concentration of eleven crashes occurred along a stretch of road starting at the intersection with Old U.S. Highway 12 and extending north approximately one mile. The majority of the reported crashes in this location occur at the intersections with local residential roads. Another noted area of crash concentrations occurs between Merritt Lane (MP 6.2) and Lincoln Road (Project End). Twelve crashes occurred along this approximate two-mile stretch of Lake Helena Drive. Travel speeds on this segment of gravel road in excess of what the road conditions warrant are likely contributors to the crashes. With excess speed, an errant vehicle has less time to recover given the steepness and proximity of the non-traversable terrain immediately near the edge of traveled way.

Of the forty reported crashes along Lake Helena Drive, eight resulted in injuries, none of which resulted in fatalities. Twelve crashes occurred when the road conditions were icy, wet, snowy or slushy while twenty occurred at night. Approximately 18% of the reported crashes included alcohol as a contributing circumstance. Approximately 67% of the crashes involved single-vehicles. No pedestrians were involved in any of the reported crashes. Approximately one-half of the most harmful effects of the reported crashes were attributed to roadside features such as utility poles, fence, ditch, or embankments.

Four crashes were reported on York Road at the intersection with Lake Helena Drive during the five-year reporting period of 2004 – 2008. Three of the four crashes were non-junction related involving collisions with animals.

Seven crashes were reported on Lincoln Road at its intersection with Lake Helena Drive, three of which were non-junction related.

HORIZONTAL ALIGNMENT

Some of the largest impacts to terrain as a result of road reconstruction can be attributed to realigning the road. So as a part of this PER, an important aspect to review is whether or not substantial horizontal curve improvements are warranted. If curves are less than minimum standards, improvements should be consider to increase safety by reducing the sharpness of curves (making the radius larger to meet design speed criteria) which lessens the probability of vehicles "missing" the curve and running off of the road.

To the benefit of the project, the Lake Helena Drive horizontal road alignment is primarily straight (tangential) from the beginning of the project north to about MP 6.5, or void of curvature for about 75% of the project length. The one exception to being a relatively straight roadway in this segment is a set of reverse curves at about MP 5.1, near Country View Drive just north of the Fox Ridge golf course. The other approximate 25% of the project length, north of Deal Lane, is built in rolling terrain that utilizes some horizontal curves to traverse the hillsides south and east of Lake Helena. We reviewed the GIS derived road alignment, and the engineering drawings of the road improvements completed in 1995 between York Road and Deal Lane to determine whether or not the facility meets current minimum road curvature criteria.

The County's Road Standards contained in Appendix J of the Subdivision Regulations lists the minimum centerline curvature for a Minor Collector as 440 feet for rolling terrain. At MP 5.1, the reverse curve alignment contains 800-foot radius curves, and therefore exceeds minimum County criteria. North of Deal Lane there are eight horizontal curves within the gravel road section, of which the shortest-radius curve is at approximate MP 7.7 at the approach to the Lake Helena causeway. GIS reviewed data is inconclusive, but it appears that this curve is very close to meeting minimum curvature criteria.

Since the County road standards reference MDT and AASHTO criteria, we used both to help ensure and verify horizontal curvature guidance. For a Rural Collector road, the MDT does not use less than a 45 mph design speed (versus the County minimum 40 mph for rolling terrain). However, the MDT allowable minimum radius is 450 feet for a local road of the same design speed. The two agency's minimum horizontal curvature standards are relatively close for the given design speed.

AASHTO's horizontal curvature guidance is summarized in **Exhibit 3-15**, of which a copy is contained in **Appendix C**. For a 40 mph design speed, using a side friction factor of *f*=0.16 and a conservative maximum superelevation rate of e=8.0%, yields the minimum recommended radius of horizontal curvature of 444 feet, which is very close to the County's minimum standard.

In this rudimentary check, the horizontal curves north of Deal Lane appear to meet minimum curvature requirements, yet this will require verification with more accurate survey when further design is undertaken. The possible exception, as noted previously, is with the curve approaching the south end of the causeway at MP 7.7. The regulatory speed limit is set to 15 mph in advance to the approach at causeway as a safety precaution due to the proximity of fisherman to through traffic. It is our opinion that it is unlikely the speed limit will be increased near this fishing site. For this reason, and the steepness of the approaching terrain to the causeway, we anticipate that any road improvements in the causeway location would primarily be focused on upgrading the surfacing and roadside drainage and safety slopes, with little if any modifications to road curvature, especially attempting to meet 40 mph design speed criteria.

In summary, north of York Road, the existing road alignment appears to meet minimum county standards for horizontal curvature, subject to more accurate survey verification. Substantial impacts to improve the road alignment beyond minimum standards will not likely be required. Instead, impacts to the surroundings will more so be necessary to improve the safety of the road by widening the road and flattening roadside slopes. This is further discussed later in the report. As noted above, the crash history does justify road improvements, and the most appropriate corrections would best be served by improving the surfacing, and roadside traverseability for errant vehicles. However, when design of the roadway's reconstruction is undertaken, the designer's should strive to improve the alignment, and exceed minimum standards where conditions are favorable to do so.

VERTICAL ALIGNMENT

The County road regulations list their maximum allowable grades for Minor Collectors as 6% for level terrain and 8% for rolling terrain. **Exhibit 6-4** of the AASHTO Green Book, contained in

Appendix C for reference, identifies suggested maximum grades for Rural Collectors in specific terrain and design conditions. The County's maximum grade criteria matches that of AASHTO for the chosen design speeds of 50 mph for level terrain, and 40 mph rolling terrain.
The vertical alignment of Lake Helena Drive is generally level from the beginning of the project to York Road. It is for the most part set relatively equal to the south to north drainage characteristic of this area, at about a 1.0% grade.

North of York Road, the vertical alignment encounters rolling terrain. This is a result of the alignment crossing natural east to west gullies draining towards Lake Helena. The gullies are more predominant south of Deal Lane. This segment, between York Road and Deal Lane, had been reconstructed approximately 15 years ago by the County to improve the road for additional traffic in conjunction with locating the County's new landfill off of Deal Lane. The steepest grade in this reconstructed segment is 5.50%, which is within the County's maximum grade requirements.

The gravel-surfaced section of the road north of Deal Lane also exhibits a rolling profile, but it is not a pronounced as the terrain south of Deal Lane. And, since the maximum grades south of Deal Lane meet minimum criteria, we therefore believe that the road profile north of Deal Lane will require only minor improvements.

The one exception to meeting standards is the south approach grade that drops down to the Lake Helena causeway. This approach grade exceeds standards for a Minor Collector. The road grade can be improved upon, but unlikely come in to full compliance to established design criteria. As noted above, exception to design criteria should be considered in this location to maintain lower travel speeds to the benefit of the many recreationalists using this area.

SIGHT DISTANCE

Applicable to horizontal and vertical alignment geometric features is the design element of sight distance. The measure of a driver's sight distance is critical to safely avoid collisions with objects. This is measured by stopping sight distance in both horizontal and vertical planes. In addition, to promote efficiency of the highway facility relative to its functional classification, an amount of passing sight distance for drivers to enter the opposing lane to pass vehicles is desired.

As noted above, the roadway primarily lies on straight tangent sections for approximately the first 6.5 miles (approximately 75%) of its length. North of Deal Lane, the alignment exhibits horizontal curves, and these appear to be at or perhaps only slightly better than meeting minimum requirements. In terms of improving sight distance along horizontal curves, we believe that since the horizontal alignment will likely be close to the existing when reconstruction is undertaken, the best improvements will be realized as a result of road widening. This is further discussed later in the report regarding improvements to be made to the road's cross-sectional geometrics. In short, the sight distance along the inside of a horizontal curve that is otherwise limited due to a steep cut slope, will be improved as the road is widened to include shoulders. Adding shoulders to the road will effectively require the uphill side cut slopes to be further offset from the traveled way and will therefore increase the driver's line of site distance around the inside of the curve.

Stopping sight distance as applied to the vertical alignment of a roadway can be assessed by the rate of curvature, K, of each crest or sag vertical curve. **Exhibit 6-2** of the AASHTO Green Book, contained in **Appendix C**, lists the various criteria for both crest and sag vertical curves. Sight distance along the road in level terrain does not appear to be an issue since vertical curvature on the road grade is slight. In the rolling terrain, based on a design speed of 40 mph north of York Road, to achieve the minimum stopping sight distance of 305 feet, the minimum design K for a crest vertical curve is 44 and a sag vertical curve is 64. If the actual K for a crest or vertical curve exceeds these values, then the stopping sight distance as a driver passes over these curves is deemed acceptable.

The apparent worst-case crest and sag vertical curves in terms of sight distance, those with the lowest K, are between York Road and Deal Lane. This is a result of the deeper drainage gullies that the road traverses. However, the existing road in this location had been reconstructed about 15 years ago. As a result of this reconstruction, the grade line was improved and the K values of all crest and sag vertical curves are now at 70 or better. These exceed the minimum K criteria. Therefore, we do not envision any substantial improvements to be required to the present road grade and its associated sight distance except for the approach grade just south of the causeway.

STRUCTURES

The bridge spanning the Helena Valley Canal at approximately MP 1.6, north of Boundary Street, is a pre-cast modular Tri-deck type installation. The overall deck width is 30 feet. The structure's span is approximately 44 feet. The installation includes steel guardrail. The structure, abutments and guardrail appear to be in good condition having been installed approximately 10 years ago. The overall guardrail installation is about 1'-2" wide per side. Both guardrails reduce the clear width of the roadway to about 28 feet when crossing this structure. Due to the level terrain in this area, we expect both the horizontal alignment and vertical grades to match the existing structure when the road is reconstructed. In terms of meeting minimum road width requirements, AASHTO recommends that the clear width be equal to or greater than the approach traveled way width, wherever practical. For a bridge to remain in place with design traffic exceeding 2,000 vehicles per day, AASHTO further recommends a minimum 28-foot clear width as shown in **Exhibit 6-7**, as contained in **Appendix C**. The existing bridge meets AASHTO minimum width criteria to remain in place. However, AASHTO recommends meeting the new road approach width <u>if practical</u>, and the reconstructed road in this segment meets criteria to be built to an overall width of 32-feet wide (4 feet wider than the clear width of the bridge). The discussion on developing the new road typical sections follows in this report. Due to the apparent 4-foot difference in proposed road top-surface width vs. the bridge clear width, the County will need to ascertain the practicality and cost-benefit of widening the structure. One means of determining need, or practicality, is by reference to the crash history. In the five-year crash data obtained for this report there were no reported incidents in which the bridge has contributed to the circumstances of a crash.

EXISTING ROADWAY SURFACING

The following summarizes the road's existing surfacing condition as detailed in this report's pavement evaluation contained in **Appendix B**.

Project Beginning to Canyon Ferry Road

From MP 0.0 to MP 2.0, three soil borings along the road alignment were completed as a part of this study. The borings, identified as ST-16, ST-17 and ST-18 were completed approximately equal distance apart, and therefore separated by just less than 1 mile. The thickness of asphalt surfacing in place varies between samples from 3 inches to 7 1/2 inches. One of the three base course samples (33% of the segment) qualifies as poor material. One of the two base course samples obtained does not meet Lewis and Clark County gradation specifications for crushed top surfacing or select base course. With each boring, soil samples were also obtained of subgrade material directly below the aggregate base material. The subgrade soil consists of silty sand and clayey sand. Two-thirds of the subgrade samples have moisture contents being over optimum, and are considered wet. Due to the moisture content, these subgrades are considered to have a high probability of risk to becoming unstable during construction under heavy-tired construction equipment. To alleviate, subgrade stabilization will likely be required. Stabilization techniques could either consist of exposing and processing the subgrade to promote drying, or over-excavating and replacing with subbase material spread over a geosynthetic fabric.

Summary MP 0.0 to MP 2.0:

- The existing asphalt surfacing thickness meets or exceeds minimum County standards by ¾ inch or more;
- Existing base aggregate thickness is 1 1/2 to 8-inches less in thickness than the minimum County specifications;
- The thickest base course encountered is however of poor quality;
- 2/3 of the segment has a high probability of requiring subgrade stabilization treatment.

Canyon Ferry Road to York Road

Soil borings ST-20 and ST-21 were completed between Canyon Ferry Road and York Road, MP 2.0 to MP 4.0. The surfacing in this segment is understood to be shaped and rolled asphalt millings reclaimed from a MDT interstate milling project. The depth of millings sampled are 5 to 5 ¾ inches. The existing base course aggregate sampled qualifies as good in both samples, but is comparably thin to the County's specifications; being 1 ¾ to 4 ¾ inches thick. Subgrade samples encountered similar silty sand and clayey sand classifications of soil. One of the two subgrade samples was over optimum moisture by 4 – 8%. Due to the soil's classification and moisture content, the subgrade is considered moderate to high in probability of requiring stabilization during construction.

Summary MP 2.0 to MP 4.0:

- The existing asphalt surfacing is not Montana Public Works compliant in material makeup;

- The existing base thickness is good quality, but is over 4 to 7 inches less in thickness than minimum County specifications;
- The subgrade in this segment has moderate to high risk of requiring stabilization.

York Road to Deal Lane

This 2-mile segment from approximately MP 4.0 to MP 6.0 was reconstructed and rehabilitated by the County in conjunction with relocating the Scratchgravel District landfill to Deal Lane. Reconstruction plans are dated 1995. The road was reconstructed with a new surfacing section comprised of 3 inches of plant mix asphalt surfacing over 6 inches of crushed aggregate base course. Soil borings ST-22 and ST-23 were completed in this segment as a part of this PER to evaluate its surfacing makeup. The borings encountered 3 ½ to 3 ¾ inches of plant mix surfacing over 3 to 5 ¾ inches gravel base. The existing base course quality is considered to be good. One subgrade sample was also retrieved from each boring. The ST-22 sample consisted of clayey sand at or below optimum moisture. The moisture content resulted in a low probability of requiring subgrade stabilization during construction. ST-23 consisted of silty gravel near optimum moisture. This material is considered to have little risk of encountering subgrade stabilization issues.

Summary of MP 4.0 to MP 6.1:

- The existing base surfacing is good quality, albeit thin compared to minimum County standards for a Minor Collector;
- The road's subgrade quality has low risk of requiring further preparation other than standard shaping and compaction.

Deal Lane to Lake Helena Causeway

This segment of Lake Helena Drive is gravel surfaced, and extends from north of Deal Lane (MP 6.1 to MP 7.9). Of the two soil borings completed (ST-24 and ST-25), one had no distinguishable gravel surfacing and one had 3 inches. Both subgrade samples are classified as clayey sand with each being below optimum moisture content. The moisture content is favorable to expect no risk of subgrade failure.

Summary MP 6.1 to MP 7.9:

- Gravel surfaced road does not meet minimum County surfacing requirements for a Minor Collector;
- Present gravel surfacing encountered is negligible to about 3 inches deep according to samples taken;
- Subgrade conditions considered good

Lake Helena Causeway to Project End

The project is asphalt surfaced from the south approach to the causeway (approximately MP 7.9) to the project end at Lake Helena Drive's intersection with Lincoln Road (MP 8.5). One soil boring, ST-26, was completed in this segment at about MP 8.2. The boring encountered 1 ¾ inches of existing asphalt surfacing, and 6 ¼ inches of base gravel. The base gravel is considered to be good quality, however the subgrade material is of high risk to being unstable during construction. The silty sand subgrade has a moisture condition of over 5 – 10% above optimum, and likely will require stabilization by means of exposing and drying, or over-excavating and replacing with subbase spread over a geosynthetic fabric.

Summary MP 7.9 to MP 8.5:

- The existing surfacing section is 1 ¼ inches less, and the base aggregate course is 2 ¾ inches less than minimum County requirements for a Minor Collector;
- During reconstruction, the subgrade is at a high risk of becoming unstable under construction equipment traffic.

EXISTING ROADWAY TYPICAL SECTION

The following describes the primary features of each road segment's existing typical section characteristics; such as road width, cut and fill slope rates, depth of ditch, etc.

Project Beginning to Boundary Street (MP 0.0 to MP 0.9)

This segment of roadway exhibits the most urbanized characteristics, attributable to its proximity to East Helena. Within the Eastgate I subdivision, or about the project's first ½ mile, the existing road is approximately 34 feet wide. On each side of the road is a 2.5 feet wide sidewalk. This sidewalk delineates the edge of pavement (no curb), and is about 3 inches higher than the edge of pavement elevation. This was installed with the subdivision, and the lack of curb, coupled with the 3-inch lip between the edge of pavement and the concrete sidewalk effectively eliminated the need for curb laydowns at each driveway. The subdivision was approved in the late 1970's. As such, the sidewalk width does not meet modern-day Americans with Disabilities Act (ADA) site accessibility requirements for clear passage of disabled wheelchair users. The minimum County standard sidewalk width is 5 feet wide, and the sidewalk is to be offset from the curb at 5 feet, with 10 feet being desirable.

Storm water runoff in this location is primarily collected onto Lake Helena Drive from the intersecting local roads. There is no storm drainage system. The runoff instead continues as surface flow on both sides of the road, and flows northward along the lip of the sidewalks until it is collected and diverted into a roadside ditch that begins at the west side of Lake Helena Drive at East Lewis Street. This ditch on the west side of the road is the area's primary runoff conveyance feature north of East Lewis Street. It collects runoff from Eastgate I on the east and west side of Lake Helena Drive. The ditch on the east side of the road, beginning north of the Eastgate Elementary School is shallow and collects lesser runoff from Eastgate II.

Each public road intersection to Lake Helena Drive within the Eastgate I subdivision terminates with substandard approach radii. These are about 2.5 feet in radius. Lewis and Clark County road design criteria specify 25-foot minimum intersection curb return radii.

The existing road right-of-way in this segment is apparently 80 feet overall, with an additional 15 feet per side for utility easements. The existing road template including the existing sidewalks is at about 40 feet wide. The road profile is slightly lower than the surrounding terrain. The road template exhibits relatively flat cut slopes of about 10:1 to 20:1 (horizontal run : vertical rise) extending upward from the sidewalks to intersect the level terrain at the outer limits of the road right-of-way.

As previously noted, the regulatory speed limit in this section is 35 mph except near the Eastgate Elementary School, located on the east side of Lake Helena Drive south of Remington Street (MP 0.6).

Boundary Street to Canyon Ferry Road (MP 0.9 to MP 2.0)

Cross-sectional measurements of Lake Helena Drive between Boundary Street and Canyon Ferry Road were taken to include surfacing widths, cut and fill slope rates, ditch widths and depth of the roadside ditch. The overall paved top surface measured to be approximately 24 to 25 feet wide, with two 12-foot or greater travel lanes. The approaches to the bridge spanning the Helena Valley Canal at approximate MP 1.6 have been widened to about 28 feet overall, to match the traveled way width of the bridge. There are no distinguishable paved shoulders.

The roadside ditch foreslope on the west side of the road appeared to be flatter than that on the east side in the locations reviewed. The foreslope on the west side was measured to be between 3.5:1 to 4:1 (horizontal:vertical, i.e. 3.5 feet horizontal distance for each 1 foot vertical drop). The flatter roadside slopes on the west side are indicative of the drainage improvements completed by the County approximately 8 years ago to increase the capacity of the roadside ditch while installing multiple arch pipes under the road to dissipate runoff to the east side of the highway. On the east side, the ditch foreslopes generally had about a 3:1 slope rate.

Most roadside ditch depths in locations measured were about 3 1/2 feet deep on the west side, and lesser on the east side; at about 18 inches deep. In all cases, the ditch on the west side was somewhat trapezoidal in shape with a width of about 4 feet wide. The ditch running along the east side of the road is more v-shaped.

The ditch backslopes on the west side of the road are constructed to fit within the limited area defined between the overhead transmission line running along the right-of-way and the edge of road. The roadside ditch cut slopes on the east side were presumably constructed to fit within the assumed available right-of-way as defined by the fence line. At approximately 18 inches deep, the ditch on the east side is too shallow to install approach drains and still meet minimum cover requirements.

The existing roadway's physical characteristics between Boundary Street and Canyon Ferry Road are very consistent as shown in **Photo 1.** This is primarily due to the level terrain. The following **Figure 2** is a representation of the road segment as shown in Photo 1, and is based on the composite field measurements described above.

Photo 1: Looking north along the west roadside ditch between Boundary Street and Canyon Ferry Road. Note the overhead transmission lines dictate available room for roadside improvements.

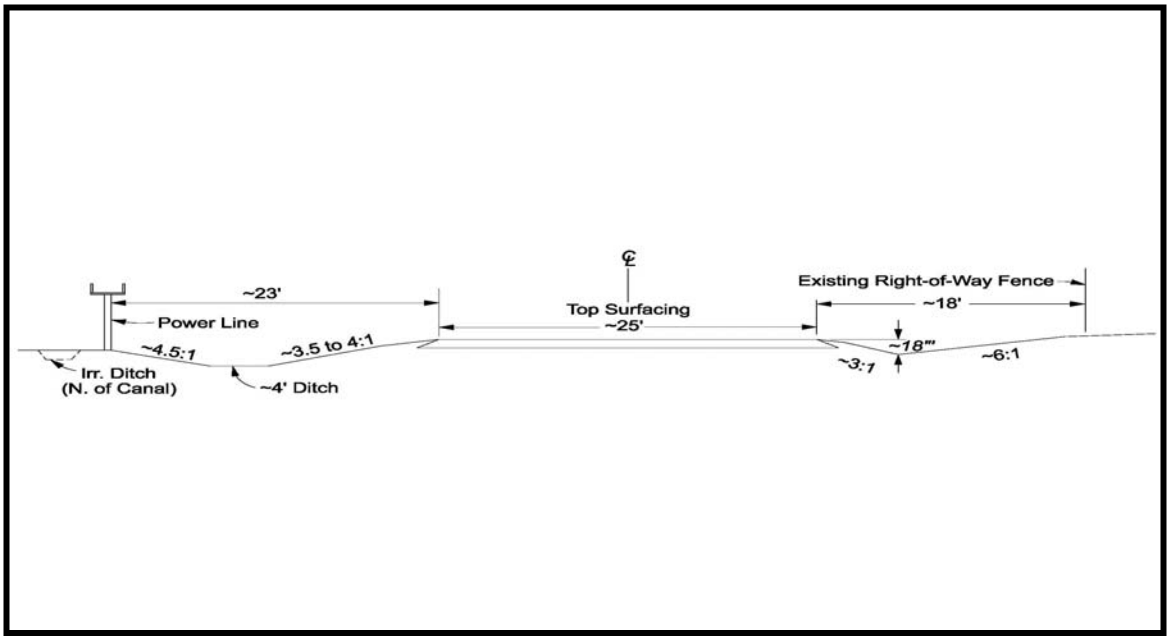


Figure 2: Existing Road Section Between Boundary St. and Canyon Ferry Road

Canyon Ferry Road to York Road (MP 2.0 to MP 4.0)

Photo 2: Looking north along Lake Helena Drive north of Canyon Ferry Road.

Lake Helena Drive between Canyon Ferry Road and York Road is very similar in aspects to the section south of Canyon Ferry Road. The primary exception is that both roadside ditches are very shallow, at about 18 inches deep. In this segment, the overhead transmission line and Helena Valley Irrigation Canal lateral running along the west side of the right-of-way are both a continuation of physical features that limit the opportunity for roadside improvements (unless each is relocated). The typical constraints and similarities of both segments are shown in **Photo 2** above, and **Figure 3**, below.

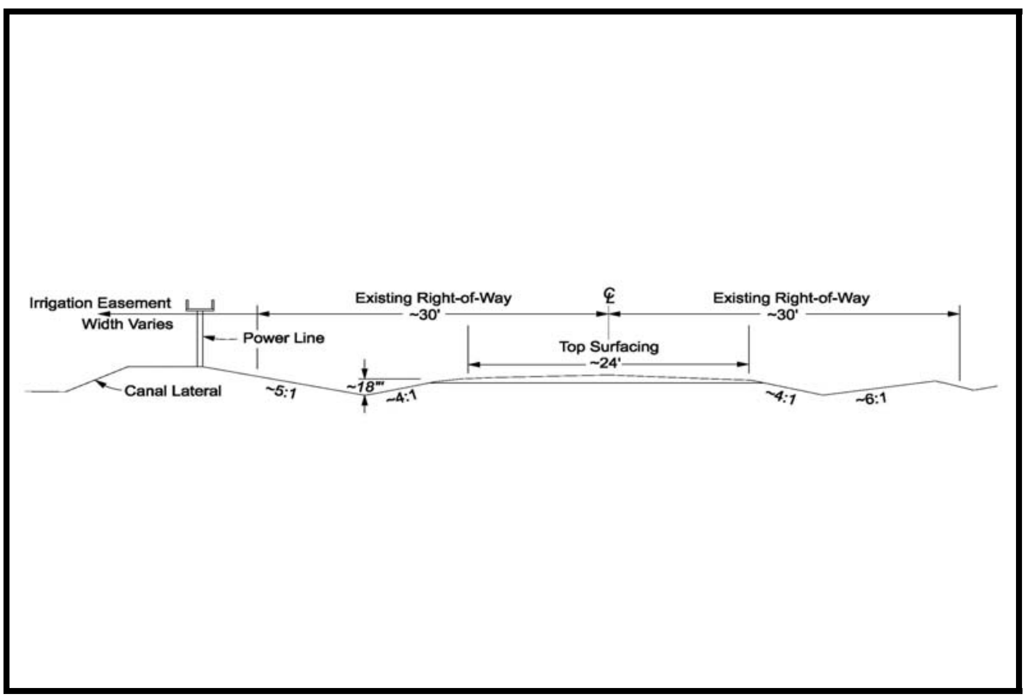


Figure 3: The Existing Section Between Canyon Ferry Road and York Road.

York Road to Deal Lane (MP 4.0 to MP 6.1)

Figure 4 below is a composite diagram showing the typical road width, ditches and cut and fill slopes of the road segment between York Road and Deal Lane. The upper figure represents a typical fill section traversing a drainage, while the lower figure represents a typical section with the profile cutting through the crest of a hill. This portion of Lake Helena Drive is the only segment to have received somewhat recent reconstructive improvements. The reconstruction was completed in 1995 and included new surfacing, adjustments to the vertical profile to improve sight distance, and roadside slope flattening. The efforts completed by the County were to rehabilitate the road in preparation of receiving additional traffic in conjunction of constructing a new solid waste depository adjacent to Deal Lane. With the limited budget reconstruction, the County completed the work to improve the road surfacing while providing roadside safety improvements. As such, grades were improved, but the resultant action required increasing cut depths at the crest of vertical curves, and similarly increasing fill heights to improve sight distance through sag vertical curves. To limit cost, all work was completed to fit the road within the existing right-of-way and limit utility impacts, primarily to the overhead transmission lines running parallel on both sides of the highway. Since improvements were completed to fit within the width constraints of right-of-way and utilities, the cut and fill slope rates adjacent to the travel way, are relatively steep at about a 2:1 in locations, and therefore do not meet current County or AASHTO standards for safety relative to the amount of traffic and travel speeds using the facility. However, where feasible, safety was further improved over its pre-existing condition by installing guardrail barriers in the fill sections.

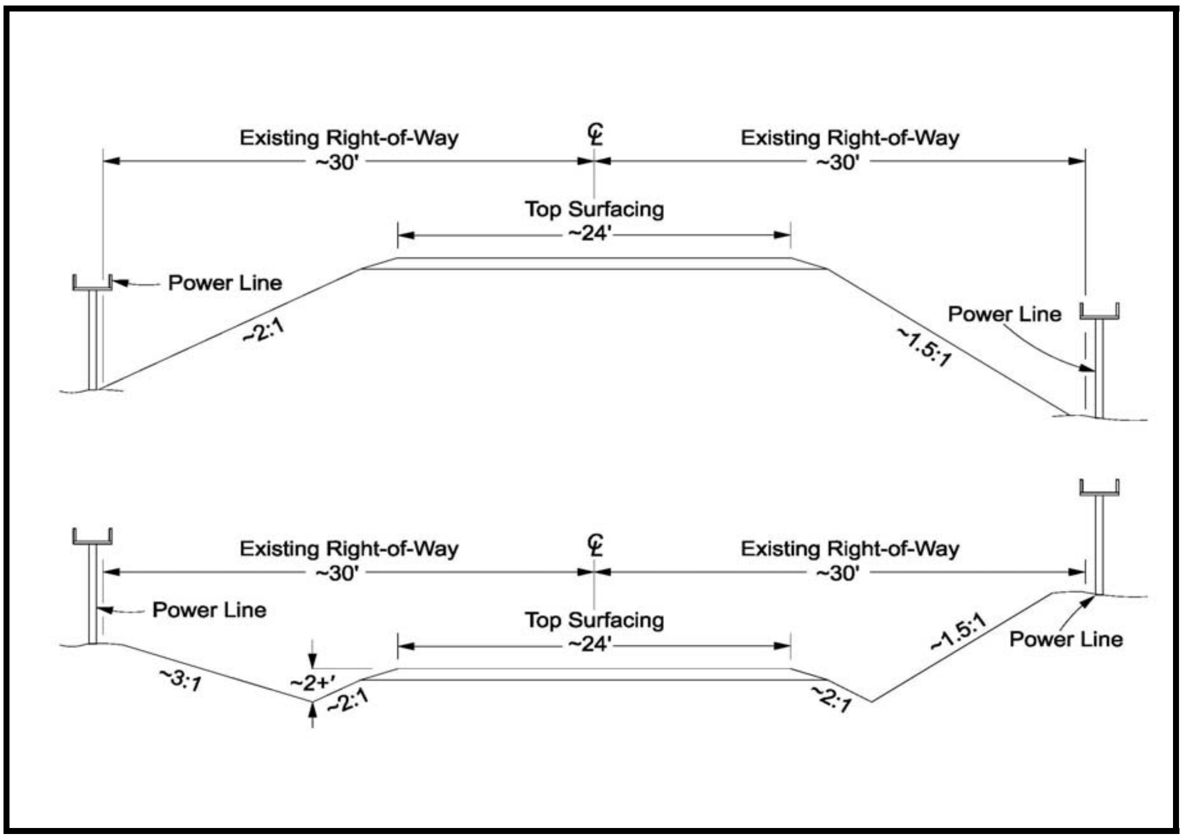


Figure 4: Representative Cut and Fill Sections of the Paved Section North of York Road

Photo 3: Photo of a cut section transitioning to a fill section through a drainage. Note the guardrail installed for safety. Roadside slopes are steepened to fit within utility and right-of-way limitations.

Deal Lane to Lake Helena Causeway (MP 6.1 to MP 7.9)

This road segment is the only portion of Lake Helena Drive that remains gravel surfaced. It experiences the least amount of daily traffic as compared to the other sections, at about 880 vehicles per day in its present state. Future travel prediction is that this segment will increase to over 1,700 vehicles per day within a 20-year period.

The gravel road is currently signed for a regulatory speed limit of 35 mph to account for the changing conditions that a driver can experience on a gravel road. The road for the most part is maintained to hold as wide as a surface width as attainable to fit within the hillside cut and fill slopes. However, in between surfacing blade and reshaping operations, the gravel surfacing displaces from the traveled way to the ditch or fill slopes. This creates what appears to be a wider road void of gravel surfacing. In its prime condition, the road is approximately 24 feet wide, with about 18-inch deep ditches. The cut slopes are generally characterized as steep at about 1.5:1. The cut slope is somewhat steeper in locations where the road traverses through exposed bedrock. Fill slopes are similarly steep compared to the County's current standards. The overall width of the road from the toe of fills to the top of cut sections is generally built to fit within the allowable right-of-way as shown in the **Figure 5** depiction, and it's accompanying representative **Photo 4**.

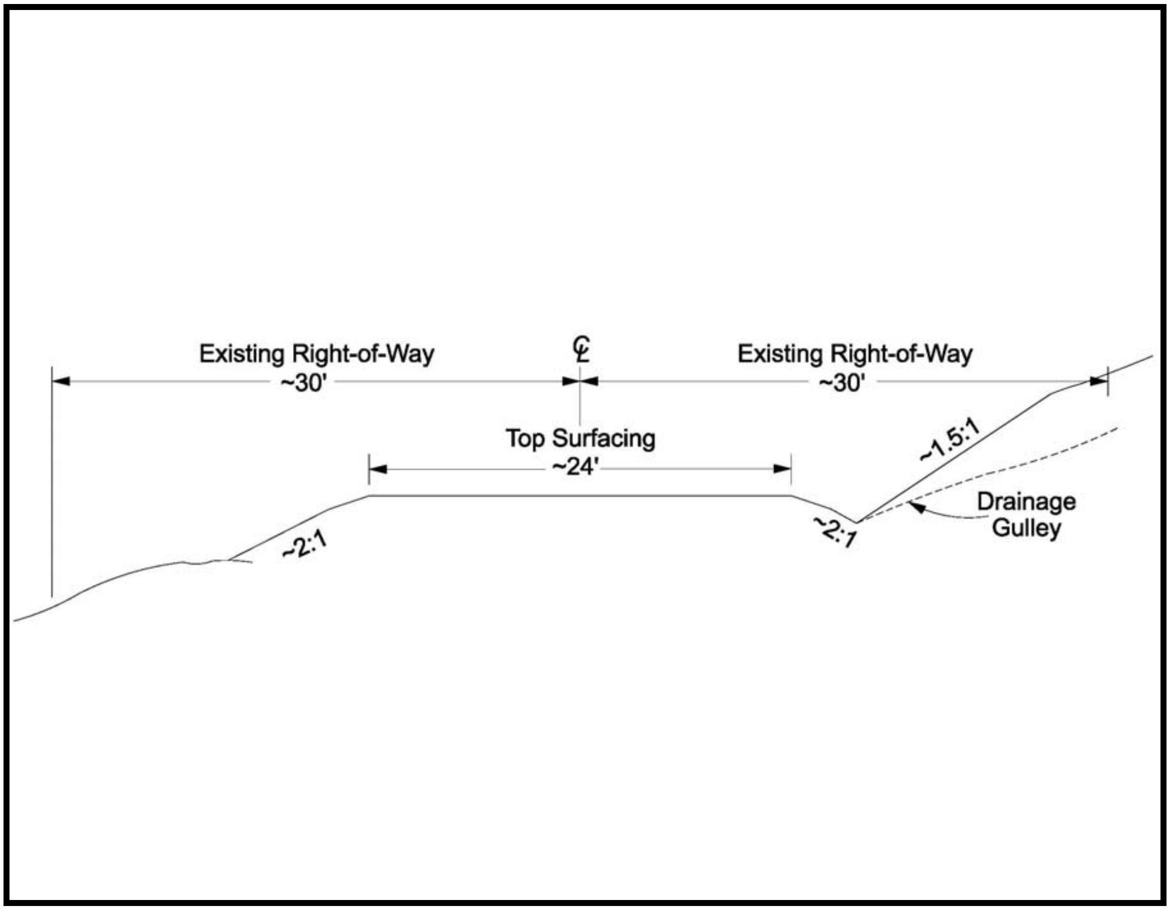


Figure 5: Typical Sectional Characteristics of the Gravel Road North of Deal Lane.

Photo 4: The width of the gravel road can vary depending on gravel displacement. Cut and fill slopes are steep relative to the proximity of the driver.

Lake Helena Causeway to Lincoln Road (MP 7.9 to MP 8.5)

The short segment of road from the causeway north to the intersection of Lincoln Road is deteriorated having been blade patched numerous times. However, this segment contains some desirable roadside geometrics. As shown below in **Photo 5**, this section of the project exhibits the flattest ditch slopes throughout the study area even though it has the lowest posted regulatory speed limit of the project at 25 mph. Given the flat roadside slopes and low travel speeds, this segment generally provides the best opportunity for an errant vehicle leaving the road to make a safe recovery. Although the ditch slope rates are favorable, the depth of the ditch would desirably be increased which would provide good cover depth over approach drains. However, there is little opportunity to do so due to the built up housing and Lake Helena limiting the potential to widen the right-of-way. As such, for the purpose of this study, given the very low operating speed and relatively good roadside recovery area, we believe the reconstructive effort in this segment would be focused on reconstructing the road surfacing, and not on the geometrics of the road.

Photo 5: The segment of road north of the causeway exhibits some desirable roadside geometrics.

PROPOSED ROADWAY TYPICAL SECTION

Preliminary Surfacing Design

For this study, ten soil borings were completed along the alignment to sample and evaluate the existing road's surfacing section and subgrade quality. The results of the sample testing were combined with projected traffic data to develop recommended pavement designs. Two surfacing designs were prepared. One design is for the segment north of York Road, and the other is for the segment south of that intersection. Both recommended surfacing designs are used within this study to estimate reconstruction impacts and costs. As such, the preliminary surfacing designs are developed to also meet or exceed the surfacing requirements of the Lewis and Clark County Road Regulations for this Minor Collector highway.

Based on the input parameters and the approach of analyzing the pavement design to be in accordance with the County Subdivision Regulations, the recommended reconstruction should have new pavement sections that meet or exceed the structural integrity of the following (refer to **Appendix B** for the full pavement design evaluation):

South of York Road

- 3" Thick (Compacted) New Asphalt Pavement
- 3" Thick (Compacted) Crushed Top Surfacing
- 6" Thick (Compacted) Select Base Course (3-Inch Minus Gradation)
- 5" Thick (Compacted) Subbase Course (3-Inch Minus Gradation)

17" Total Thickness

North of York Road

- 3" Thick (Compacted) New Asphalt Pavement
- 3" Thick (Compacted) Crushed Top Surfacing
- 6" Thick (Compacted) Select Base Course (3-Inch Minus Gradation)
- 6" Thick (Compacted) Subbase Course (3-Inch Minus Gradation)

18" Total Thickness

A comparison notes that there is very little difference in the two recommended surfacing sections even though the average daily traffic in the southern portion of the highway is about two to three times greater than that of the segment north of York Road. The predominant makeup of the daily traffic for each road section is passenger sized vehicles. In terms of surfacing design, these lighter vehicles provide limited impact. The primarily reason the design pavement sections are similar, is due to the similarities in heavy truck traffic. The southern portion of the road experiences its predominant heavy truck traffic due to a gravel pit operation. The segment north of York Road experiences heavy truck traffic from County haul trucks to and from the landfill. In both segments, the heavy truck traffic is the factor that creates the similarity in pavement sections.

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 affects 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 below. This shows the recommended clear zones based on the design speed and traffic volume parameters for each segment of Lake Helena Drive. The clear zones shown below are measured in feet from the edge of the traveled way.

Table 3: Roadside Clear Zone Requirements

		Forelslopes			Backslopes		
Design Speed	**Design AADT**	**6H:1V or Flatter**	**5H:1V to 4H:1V**	**3H:1V**	**3H:1V**	**5H:1V to 4H:1V**	**6H:1V or Flatter**
50 mph	1,500-6,000	16-18	20-26	**	12-14	14-16	16-18
40 mph	1,500-6,000	12-14	14-16	**	12-14	12-14	12-14

** Since recovery is less likely on the unshielded, traversable 3H:1V slopes, fixed objects should not be present in the vicinity of the toe of these slopes. Recovery of high-speed vehicles that encroach beyond the edge of the shoulder may be expected to occur beyond the toe of the slope. Determination of the width of the recovery area at the toe of the slope should take into consideration right-of-way availability, environmental concerns, economic factors, safety, needs and crash histories.

Pursuant to County standards, the 50 mph design speed is applicable to the portion of Lake Helena Drive traversing the level terrain south of York Road, and the 40 mph is representative to the highway traversing the rolling terrain north of York Road. Applying the minimum allowable foreslope rate of 4:1 as shown in Figure 3 of Appendix J of the County's Subdivision Regulations yields a 14-foot minimum clear zone along the roadside foreslope at a design speed of 40 mph. Similarly, at 50 mph, the minimum clear zone for a 4:1 roadside foreslope is 20 feet. For the purposes of this study, we are applying the minimum recommended design clear zones to develop the proposed road template. This minimum recommended clear zone will limit construction impacts, road reconstruction costs, and reduce right-of-way acquisition.

Surfacing Width

Figure 3 contained in Appendix J of Lewis and Clark County's Subdivision Regulations depicts the County's minimum standard road typical for a two-lane Minor Collector. Each travel lane is to be 12-feet wide. The shoulder width can vary between 2 feet and 4 feet, as measured between the edge of the travel lane to the edge of the surfacing. Since the County standard in itself does not give guidance on what applications to use the lesser or greater of the two shoulder widths, 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. Applicable to the portion of Lake Helena Drive south of York Road, for over 2,000 vehicles per day at a design speed of 50 mph, the recommended shoulder width is 8 feet. However, for Minor Collector highways the County has adopted 4 feet as the maximum required. Based on this, the recommended overall road surfacing width for reconstruction to accommodate two travel lanes and shoulders south of York Road is 32 feet; accounting for two 12-foot travel lanes and two 4-foot shoulders.

The design-year traffic volume north of York Road varies from between 1,500 to over 2,000 vehicles per day. In reference to **Exhibit 6-5**, at a design speed of 40 mph the overall recommended road surface width is 34 feet to 40 feet wide depending on the design traffic volume. For this PER, the design surfacing width north of York Road will be 32 feet which is 2 feet less than AASHTO's minimum recommendation. This then is the most attainable width in attempt to meet AASHTO guidance while not exceeding County criteria.

Design Typical Section

The following **Figures 6** and **7** display the recommended road design typical sections to reconstruct Lake Helena Drive north of the Eastgate subdivisions. Figure 6 is representative of Lake Helena Drive south of York Road, and Figure 7 is the road section north of York Road. Each typical section is based on the design methodology previously discussed in which the County Road Standards served as the basis supplemented by AASHTO guidance as needed. They are very similar with equal travel lane and shoulder widths. The most notable difference is the greater clear zone required for a 50 mph design speed as compared to a 40 mph design speed.

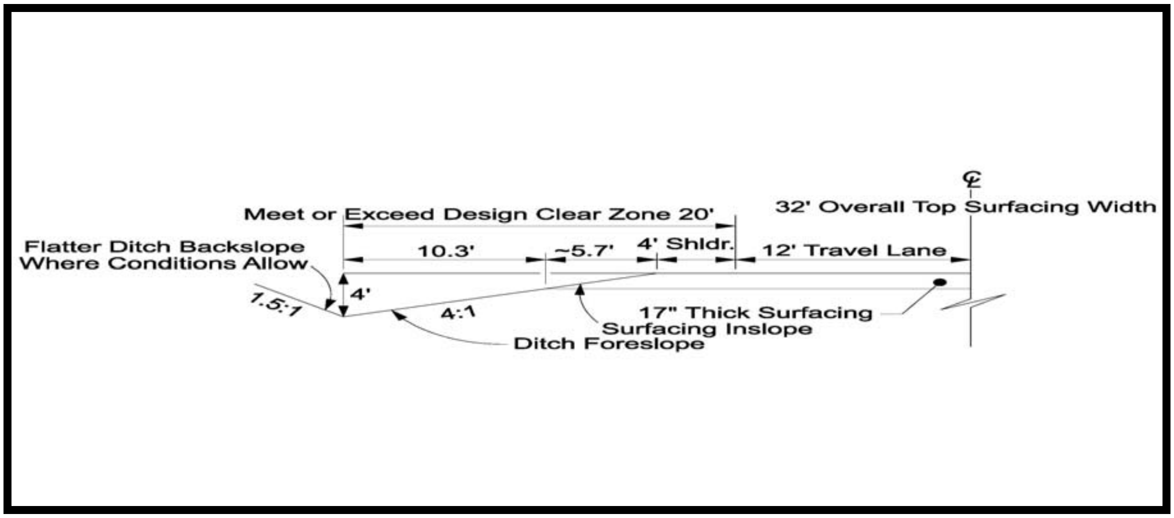


Figure 6: Proposed Road Template for Lake Helena Drive South of York Road

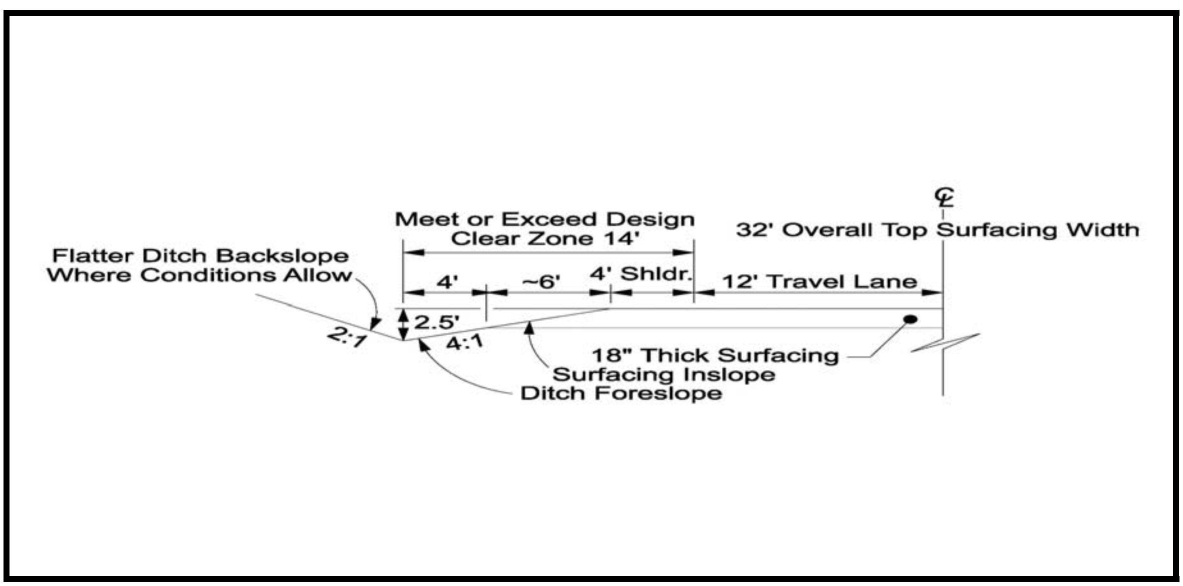


Figure 7: Proposed Road Template for Lake Helena Drive North of York Road.

Miscellaneous Grading, Cut and Fill Slopes

To estimate earthwork and miscellaneous other feature impacts to reconstruct the roadway, we applied the design typical sections, shown in Figures 6 and 7 over the existing road templates as shown in previous Figures 2 through 5. The superimposed design placed over the existing road yielded **Figure 8**, below. The estimate is based on the reconstruction closely following the existing horizontal and vertical alignments.

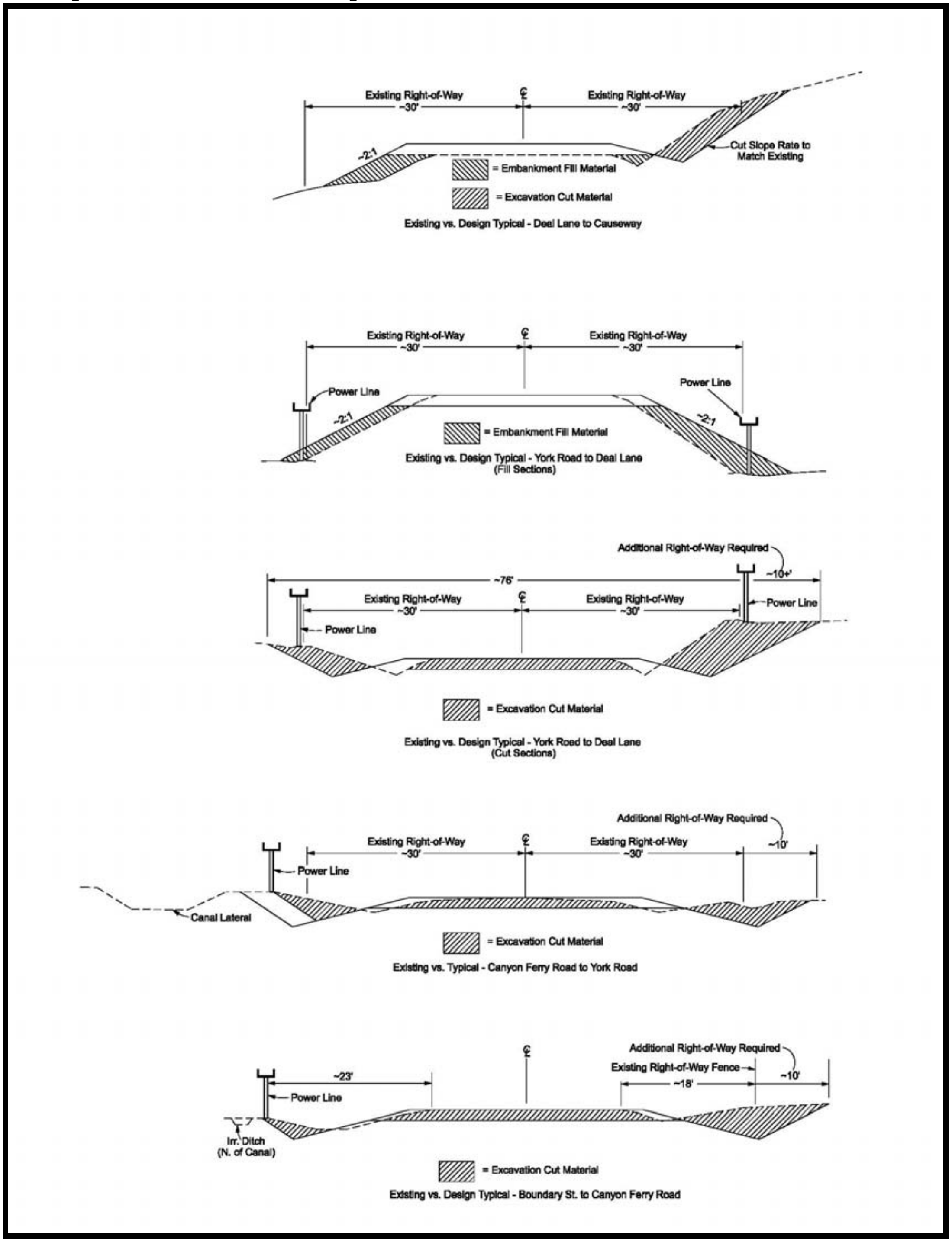


Figure 8: Estimated Cut/Fill Impacts to Reconstruct Lake Helena Drive

Figure 8 shows representative cut and fill impacts anticipated to reconstruct Lake Helena Drive from south (shown on the bottom) to north (shown at the top) to minimum standards.

As shown in the bottom, from Boundary Street to Canyon Ferry Road, the primary result will be lengthening the ditch foreslopes to implement a recovery area within the clear zone. Lengthening the slope will increase the ditch depth most predominantly on the east side of the highway. The overhead power transmission line along the westerly right-of-way was held as a feature control point to not be impacted. As can be seen, the west side ditch backslope will likely need warping and steepening to catch the top of the cut slope to the base of the power poles. We anticipate that the road widening will require about 10 feet minimum of additional right-of-way to accommodate the cut slopes, with an additional 5 feet from the top of cut to provide an impact free zone to relocate certain buried utilities. As noted in a previous section of this report, brief record research indicates that the existing right-of-way in this location is generally 60 feet. The County's minimum overall right-of-way width for a Minor Collector is 80 feet. Based on this preliminary assessment, we presume the overall 80 feet of right-of-way should be obtained.

The drawing second up from the bottom in **Figure 8** represents the anticipated impacts of reconstructing Lake Helena Drive from Canyon Ferry Road north to York Road. Similar to south of Canyon Ferry Road, this segment also has a overhead power transmission line running along the west side of the road. Just west of that is a Helena Valley Canal irrigation lateral. As shown, widening the road (to include shoulders) as well as developing the roadside ditch to provide a greater depth to install approach culverts would likely cut into the base of the power poles and canal berm. We therefore anticipate that the ditch backslopes will need to be steepened to limit impacts to the utilities and irrigation canal. The roadside impacts along the east side of this road segment are similar to that anticipated south of Canyon Ferry Road. The existing right-of-way in this segment is believed to be about 60 feet wide overall.

The road sections north of York Road to Deal Lane are depicted as the third and fourth drawings up from the bottom in **Figure 8**. The County had improved this segment with road widening to the point that any additional widening will likely impact property and utilities on both sides of the road. If re-constructed to include a 4-foot shoulder on each side, and flatten cut slopes we would expect the minimum impacts to be those as shown. The existing right-of-way in this portion of the project is believed to be a minimum 60 feet wide. We estimate construction will require all of the 80 feet of right-of-way specified as minimum for reconstructing a Minor Collector route.

The top-most drawing in **Figure 8** represents the gravel-surfaced section of Lake Helena Drive north of Deal Lane. The primary impacts will be a result of adding shoulders to the edge of the road and improving the ditch capacity and roadside safety by widening the ditch. As can be seen, it will require 2:1 fill slopes to minimize right-of-way acquisition on the downhill side of the road. Fill slopes of this rate should be considered for shielding with guardrail to provide safety for vehicles from potentially overturning. Desirably, the need for guardrail would be eliminated and the fill slopes would be flattened to 4:1 or better, as per the County design references. As shown in the diagram, flattening fill slopes and road widening into the uphill cut sections will require additional right-of-way.

At the beginning of the project through the Eastgate I subdivision we anticipate reconstruction to be primarily rebuilding the road surfacing (no widening), installing new curb and gutter to improve storm runoff capability, and removing and replacing the existing sidewalk to meet accessibility requirements. This work would not require substantial slope modifications, and therefore would likely fit within the existing right-of-way in that section.

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 warranted to confirm such items as slope stability, subgrade stabilization limits, final cut/fill slope rates, foundation settlement, and excavation/embankment shrink factors.

During the course of developing the pavement designs, the borings identified as ST-16, ST-17, ST-20, ST-21 and ST-26 encountered silty and clayey sand subgrade that was primarily over optimum moisture content. The geotechnical engineer evaluated these locations to have moderate to high risks of subgrade failure during construction. The preliminary indications therefore are that approximately 50% of the highway alignment can anticipate the need for some subgrade stabilization during the course of reconstruction. For the purpose of completing the road reconstruction cost estimate, we are including an increase in the subbase material by an additional 10-inches 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 B**.

PROPERTY VALUES

Previously in this report, we estimated the existing highway right-of-way widths based on records researched. The section of the report addresses how land valuations were estimated.

The predominant land use along this study segment is currently residential or irrigated agricultural. We presume the highest and best use of the current agricultural property is that to be developed into a residential subdivision.

To assign fully defendable and accountable costs to right-of-way impacts is outside the scope and budget of this document. To do so would require the preparation of multiple appraisals. By virtue of the amount of parcels adjoining this highway's right-of-way, the appraiser fee to complete this work could amount to over one hundred thousand dollars based on industry rates. Instead, to obtain a reasonable estimate of right-of-way acquisition costs, we contacted a local appraiser to complete a brief research of 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. However, most property along the corridor is predominantly yet undeveloped agricultural.

Based on the above, we assumed for this estimate that the cost to acquire land for right-of-way from a parcel to be about $32,000 per acre. To acquire the necessary right-of-way, the property must first be appraised. We estimate the appraiser fees for researching comparable sales history, preparing the property valuations, and obtaining title evidence will cost approximately $2,000 per parcel. An assigned land acquisition agent would then use the appraisals to negotiate and procure the necessary right-of-way. We assigned a cost of $1,500 per parcel for the fees that would be charged by a right-of-way acquisition agent. We used web-based information to estimate the number of properties impacted per segment of road. Overall, we project that 65 to 75 properties could be impacted during the course of reconstructing 8.5 miles of this road.

DRAINAGE & HYDRAULICS

Mainline Cross Drains

From the beginning of the project to York Road, MP 0.0 to 4.0, the existing road traverses level terrain following the direction of the south-to-north natural drainage patterns. As such, the primary hydraulic conveyance feature in the more urbanized area within the Eastgate subdivision, from MP 0.0 to MP 0.5, consists of sheet flow along the edge of the sidewalk. There is no curb and gutter or storm drain system in this location. The sidewalks end north of MP 0.5 and the runoff enters roadside ditches at this point. Flowing northerly, the County installed a cross-draining culvert at approximate MP 1.2, and double culverts nearer to the Helena Valley Canal at about MP 1.6. These three culverts are 42” x 28 ½” corrugated metal arch pipes; each about 56 feet in length. These drains divert the runoff approaching the canal to the east under the road to drain into the agricultural fields.

Photo 6: Double culverts installed just south of the Helena Valley Canal, MP 1.6.

Excess runoff that reaches the canal is diverted under the canal from the west roadside ditch by a small-diameter siphon. The runoff then flows northerly until crossing under Lake Helena Drive just south of its intersection with Canyon Ferry Road, at about MP 2.0. The cross-drains installed at this location were completed by the MDT as part of the Canyon Ferry Road reconstruction project. The double pipe installation consists of two 28 ½ " x 18" reinforced concrete pipe arches (RCPA's). It's unlikely that future Lake Helena Drive reconstruction will impact these two culverts due to the recent roundabout completed at this intersection by the MDT.

The runoff directed by the two RCPA's near the south side of the Lake Helena Drive/Canyon Ferry Road intersection is then directed easterly to flow along Canyon Ferry Road. At about 0.3 miles east of the intersection, the runoff is combined with runoff flowing northerly crossing under Canyon Ferry Road at this location. This drainage crossing proceeds in a northwesterly direction and is a floodway known as the Lake Helena Drive Branch of the Prickly Pear Creek floodplain.

There are few cross-drains under the road between Canyon Ferry Road and York Road (MP 2.0 to MP 4.0). Similarly, runoff picked up in this area is therefore conveyed primarily along the roadside, crossing under roads that intersect Lake Helena Drive by the means of small-diameter approach drains. As previously discussed, the roadside ditches in this segment are very shallow with issues of not having adequate cover between the top of the pipe and the approach surfacing. Widening the roadside ditch in this area will provide not only an improved clear recovery area for motorists, but will also increase the ditch depth to allow for improved installation of culverts. Culverts with adequate depth of cover will experience less structural damage from vehicles crossing over the culvert, and lessen crushing the ends of the pipes due to running over the inlets and outlets while turning in or out of approaches.

Photo 7: Shallow ditch with a crushed pipe.

The Lake Helena Drive Branch of the Prickly Pear Creek floodplain as conveyed east of the project under Canyon Ferry Road again crosses under Lake Helena Drive at about MP 3.1. The crossing appears to combine both irrigating water and runoff. The conveyance under Lake Helena Drive is by two 24-inch diameter corrugated metal pipes. It is likely that these are undersized to handle both flood and irrigation waters.

Lake Helena Drive between York Road and Deal Lane was improved by the County to include new surfacing, grade adjustments and road widening. The reconstruction included installing new culverts where the reconstruction impacts dictated. The most predominant drainage features in this area are the east-to-west draws that convey runoff from the top of the hill divides east of this location. The road reconstruction upsized the existing cross-drains by replacing small diameter pipes with larger 24-inch or 30-inch culverts. Where determined as being appropriate, existing pipes were left in place with extensions added to meet the needs of the new construction limits.

North of Deal Lane is characterized by similar east-to-west drainage draws, albeit not as wide as those south of Deal Lane. Due to the road cut into the hillside, there is very little difference in elevation between the bottom of the uphill ditch and the road surface. This provides little opportunity to install even minimum size cross-drains without experiencing pipe crushing due to loading, or inlet silting as a result of the gravel road surfacing being dissipated into the ditch. Widening and increasing the depth of the roadside ditch will improve all matters. There are approximately four major drainage gullies in this area and an abundance of lesser draws. We presume that the major drainages would require at least 24-inch diameter pipe installations, and the lesser draws and terrain breaks would require 18-inch relief pipes.

As previously discussed, we assume that the segment of road between the Lake Helena causeway and Lincoln Road would require very little drainage upgrading. Most reconstructive improvements would likely be focused on improving the road surfacing. Expectations are that approach culverts in this location will be lengthened as necessary.

For estimating the length of new replacement cross-drains, we used the typical road section dimensions as shown previously in this report.

Approach Culverts

As noted above, 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 GIS. 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.

Drainage Summary

The tables below summarize hydraulic conveyance features by road segment within the study area. 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 unuseable condition for many pipes observed in the field. As previously discussed, we did not observe culverts being installed in some drainages or draws that cross the highway. This observation was primarily in the gravel road segment north of Deal Lane. It is plausible that some pipe inlets or outlets were crushed or partially hidden from view at the time due to a build up of sediment.

Due to the scope of this report, the majority of notable crossings were inspected, but a substantial amount of review was also "windshield." For this reason, we have included a nominal quantity of new pipe to provide a more reasonable cost estimate than otherwise assuming no pipes will be needed in questionable locations.

Table 4: Culvert Drains – East Lewis Street to Canyon Ferry Road (MP 0.5 to MP 2.0)

Approximate Milepost	Diameter or Span	Rise	Est. Length	Remarks
1.2	42"	28-1/2"	64'	Replace Existing Corrugated Metal Arch Pipe
1.6	42"	28-1/2"	2 x 64'	Replace Two Existing CMPA's
Varies	15"	~	56' Ea.	Install New Approach Pipes. Estimated # of Approaches = 7

Table 5: Culvert Drains – Canyon Ferry Road to York Road (MP 2.0 to 4.0)

Approximate Milepost	Diameter or Span	Rise	Est. Length	Remarks

3.1	36”	~	2 x 64’	Replace Existing 24” with 36” drains at Floodway Crossing
3.9	24"	~	64’	Irrigation
Varies	15”	~	56' Ea.	Install New Approach Pipes. Estimated # of Approaches and Field Access = 12

Table 6: Culvert Drains – York Road to Deal Lane (MP 4.0 to 6.1)

Approximate Milepost	Diameter or Span	Rise	Est. Length	Remarks
4.0	24”	~	70’	Replace Existing
4.1	24"	~	70’	Replace Existing
4.3	24”	~	70’	Replace Existing
4.4	24”	~	2 x 70’	Replace Two Existing
4.8	30”	~	75’	Replace Existing
5.5	30”	~	75’	Replace Existing
5.7	15”	~	70’	Replace Existing
5.9	24”	~	70’	Replace Existing
Varies	15”	~	56’ Ea.	Install New Approach Pipes. Estimated # of Approaches and Field Access = 16

Table 7: Culvert Drains – Deal Lane to Lake Helena Causeway (MP 6.1 to 7.9)

Approximate Milepost	Diameter or Span	Rise	Est. Length	Remarks
6.2	24”	~	65’	Drainage Crossing
6.5	24"	~	65’	Drainage Crossing
6.9	24”	~	65’	Drainage Crossing
7.7	24”	~	65’	Drainage Crossing
Varies	15”	~	6 x 60’	Misc. Terrain Relief Pipes
Varies	15”	~	56’ ea.	Install New Approach Pipes. Estimated # of Approaches and Field Access = 12

PEDESTRIAN AND BICYCLE FACILITIES

Except for the sidewalk in the more urbanized area near East Helena, there are 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.

AUXILIARY TURN LANES

The existing highway is a two-lane facility with no auxiliary lanes for left or right turns. The scope of this work does not include completing definitive turn lane warrant studies at key intersections. However, when the highway design is initiated, it can be reasonably ascertained that one or more turn lanes may be warranted. Therefore for the benefit of this study, we have included an estimated cost to construct a left-turn lane serving an approach in a non-signalized intersection. The discussion on traffic control signals follows this section. Turn lanes should be considered at each signalized intersection.

We based the estimated turn lane geometrics for a left-turn lane on the guidelines presented by MDT in their Traffic Engineering Manual. We assume that the shoulder widths in the location of a turn lane will be maintained at 4-feet wide. Using 40 mph design speed criteria, the lane shift bay taper rate will be 40:1 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 320 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 480 feet of total length for lane shift tapers entering and exiting the left turn area, and 320 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 800 feet.

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. Therefore, an estimated cost to install signal hardware has been included.

Reconstruction Cost Estimate

The following tables summarize the estimated cost to reconstruct Lake Helena Drive within the segments:

- Old U.S. Highway 12 to East Lewis Street (MP 0.0 to MP 0.5)
- East Lewis Street to Canyon Ferry Road (MP 0.5 to MP 2.0)
- Canyon Ferry Road to York Road (MP 2.0 to MP 4.0)
- York Road to Deal Lane (MP 4.0 to MP 6.1)
- Deal Lane North to end of Gravel (MP 6.1 to MP 7.9)
- Lake Helena Causeway to Lincoln Road (MP 8.1 to MP 8.5)

Following the tables is a summary of how some of the numbers of units shown in the table were estimated. The units were then multiplied by the average unit cost. To arrive at an average unit cost, we reviewed the bid history of four highway projects currently under construction in the Helena Valley. These projects ranged from full highway reconstructions to spot safety improvement projects. It should be noted that the County could similarly improve Lake Helena Drive by either several smaller spot improvements projects, or larger-length reconstructions.

Old U.S. Highway 12 to East Lewis Street (MP 0.0 to MP 0.5)

Major Work Feature	Unit	Unit Cost	# of Units	Total Cost
Survey - Staking and Grade Control	LS	$15,000.00	1	$15,000
Topsoil - Salvage and Place	CY	$4.05	700	$2,835
Excavation - Unclassified	CY	$5.50	6950	$38,225
MPDES Permit Fees	LS	$900.00	1	$900
Crushed Top Surfacing (3-inch Depth)	CY	$25.41	960	$24,394
Select & Subbase Course (11-inch Depth)	CY	$12.00	4107	$49,284
Aggregate Treatment (Prime)	SQ YDS	$0.41	9974	$4,089
Chip Seal Cover	SQ YDS	$0.69	9387	$6,477
Plant Mix Asphalt Paving	Ton	$81.38	1633	$132,894
Emulsified Asphalt Seal (CRS-2P)	Ton	$647.86	16.0	$10,366
Traffic Gravel	CY	$19.03	717	$13,644
Remove/Reset Signs	Each	$184.30	15	$2,765
Interim Striping - Yellow Paint	Gal	$34.18	10	$342
Final Striping - Yellow Paint	Gal	$34.18	10	$342
Interim Striping - White Paint	Gal	$34.30	18	$617
Final Striping - White Paint	Gal	$34.30	18	$617
Remove Existing Sidewalk	SY	$8.50	1349	$11,467
New Sidewalk	SY	$45.00	2933	$131,985
New Concrete Curb & Gutter	LF	$12.00	5544	$66,528
Seeding	Acre	$294.16	0.3	$88
Fertilize Seed	Acre	$120.84	0.3	$36

Condition Seedbed Surface	Acre	$221.51	0.3	$66
Geotextile - Subgrade Stabilization	SY	$1.50	4693	$7,040
Subgrade Stabilization Gravel (10 – inch Depth)	CY	$8.00	1304	$10,432
Subexcavation	CY	$5.50	1304	$7,172
Subtotal - Construction	**$537,605**			
Preliminary, Final Engineering, Geotechnical & Survey	8% of Construction			$43,008
Construction QA/QC	4% of Construction			$21,504
Contractor Mobilization	5% of Construction			$26,880
Contingency	10% of Construction			$53,761
Traffic Control During Construction	8% of Construction			$43,008
Right-of-Way Appraisals by Agent	LS			$0
Right-of-Way Acquisition by Agent	LS			$0
Purchase Right-of-Way – No New Expected	Acre	$32,000	0.0	$0
Total Est. Road Reconstruction Cost (2009)	**$725,766**			
Alternate – Add One Traffic Signal	**Each**	**$68,000**		**$68,000**
Alternate – Add Sanitary Sewer Main	**Per Mile**	**$211,200**	**x 0.5 Mi**	**$105,600**
Alternate – Add Water Main	**Per Mile**	**$396,000**	**x 0.5 Mi**	**$198,000**
Alternate – Add Bicycle/Ped. Path Reconstruction	**Per Mile**	**$77,825**	**x 0.5 Mi**	**$38,913**

LS = Lump Sum, CY = Cubic Yard, SQ YDS = Square Yards, GAL = Gallon, LF = Linear Feet

East Lewis Street to Canyon Ferry Road (MP 0.5 to MP 2.0)

Major Work Feature	Unit	Unit Cost	# of Units	Total Cost
Survey - Staking and Grade Control	LS	$22,500.00	1	$22,500
Topsoil - Salvage and Place	CY	$4.05	3700	$14,985
Excavation - Unclassified	CY	$5.50	37110	$204,105
MPDES Permit Fees	LS	$900.00	1	$900
Temporary Erosion Control - LS	LS	$2,000.00	1	$2,000
Crushed Top Surfacing (3-inch Depth)	CY	$25.41	2695	$68,480
Select & Subbase Course (11-inch Depth)	CY	$12.00	12320	$147,840
Aggregate Treatment (Prime)	SQ YDS	$0.41	29921	$12,268
Chip Seal Cover	SQ YDS	$0.69	28160	$19,430
Plant Mix Asphalt Paving	Ton	$81.38	4898	$398,599
Emulsified Asphalt Seal (CRS-2P)	Ton	$647.86	47.9	$31,032
Traffic Gravel	CY	$19.03	2151	$40,934
Remove/Reset Signs	Each	$184.30	8	$1,474

Interim Striping - Yellow Paint	Gal	$34.18	27	$923
Final Striping - Yellow Paint	Gal	$34.18	27	$923
Interim Striping - White Paint	Gal	$34.30	55	$1,886
Final Striping - White Paint	Gal	$34.30	55	$1,886
Remove Existing Culverts	LF	$12.27	584	$7,166
Approach/Relief Drain Pipe – 15 Inch Diam.	LF	$33.00	392	$12,936
Drainage Pipe - 42” x 28-1/2”	LF	$95.00	192	$18,240
Farm Fence - Type Type 5M	LF	$2.25	7920	$17,820
Fence Panels	Each	$145.92	16	$2,335
Remove Existing Fence	LF	$0.49	7920	$3,881
Seeding	Acre	$294.16	6.0	$1,765
Fertilize Seed	Acre	$120.84	6.0	$725
Condition Seedbed Surface	Acre	$221.51	6.0	$1,329
Geotextile - Subgrade Stabilization	SY	$1.50	10340	$15,510
Subgrade Stabilization Gravel (10 – inch Depth)	CY	$8.00	2872	$22,976
Subexcavation	CY	$5.50	2872	$15,796
Subtotal - Construction	**$1,090,644**			
Preliminary, Final Engineering, Geotechnical & Survey	8% of Construction			$87,252
Construction QA/QC	4% of Construction			$43,626
Contractor Mobilization	5% of Construction			$54,532
Contingency	10% of Construction			$109,064
Traffic Control During Construction	8% of Construction			$87,252
Right-of-Way Appraisals by Agent	LS			$20,000
Right-of-Way Acquisition by Agent	LS			$15,000
Purchase Right-of-Way	Acre	$32,000	3.6	$115,200
Total Est. Road Reconstruction Cost (2009)	**$1,622,570**			
Est. Total Road Cost Per Mile	**Miles**	**$1,622,570**	**/ 1.5 Mi =**	**$1,081,713**
Alternate – Add One Traffic Signal	**Each**	**$68,000**		**$68,000**
Alternate – Add One Turn Lane	**Each**	**$75,000**		**$75,000**
Alternate – Add Sanitary Sewer Main	**Per Mile**	**$211,200**	**x 1.5 Mi**	**$316,800**
Alternate – Add Water Main	**Per Mile**	**$396,000**	**x 1.5 Mi**	**$594,000**
Alternate – Add Bicycle/Ped. Path Reconstruction	**Per Mile**	**$77,825**	**x 1.5 Mi**	**$116,738**

LS = Lump Sum, CY = Cubic Yard, SQ YDS = Square Yards, GAL = Gallon, LF = Linear Feet

Canyon Ferry Road to York Road (MP 2.0 to MP 4.0)

Major Work Feature	Unit	Unit Cost	# of Units	Total Cost
Survey - Staking and Grade Control	LS	$30,000.00	1	$30,000
Topsoil - Salvage and Place	CY	$4.05	4950	$20,048
Excavation - Unclassified	CY	$5.50	49480	$272,140
MPDES Permit Fees	LS	$900.00	1	$900
Temporary Erosion Control - LS	LS	$2,000.00	1	$2,000
Crushed Top Surfacing (3-inch Depth)	CY	$25.41	3593	$91,298
Select & Subbase Course (11-inch Depth)	CY	$12.00	16427	$197,124
Aggregate Treatment (Prime)	SQ YDS	$0.41	39894	$16,357
Chip Seal Cover	SQ YDS	$0.69	37546	$25,907
Plant Mix Asphalt Paving	Ton	$81.38	6531	$531,493
Emulsified Asphalt Seal (CRS-2P)	Ton	$647.86	63.8	$41,333
Traffic Gravel	CY	$19.03	2868	$54,578
Remove/Reset Signs	Each	$184.30	6	$1,106
Interim Striping - Yellow Paint	Gal	$34.18	36	$1,230
Final Striping - Yellow Paint	Gal	$34.18	36	$1,230
Interim Striping - White Paint	Gal	$34.30	73	$2,504
Final Striping - White Paint	Gal	$34.30	73	$2,504
Remove Existing Culverts	LF	$12.27	864	$10,601
Approach/Relief Drain Pipe - 15 Inch Diam.	LF	$33.00	672	$22,176
Drainage Pipe -36 Inch Diam	LF	$96.79	128	$12,389
Drainage Pipe - 24 Inch Diam	LF	$50.00	64	$3,200
Farm Fence - Type Type 5M	LF	$2.25	10560	$23,760
Fence Panels	Each	$145.92	21	$3,064
Remove Existing Fence	LF	$0.49	10560	$5,174
Seeding	Acre	$294.16	8.0	$2,353
Fertilize Seed	Acre	$120.84	8.0	$967
Condition Seedbed Surface	Acre	$221.51	8.0	$1,772
Geotextile - Subgrade Stabilization	SY	$1.50	13787	$20,681
Subgrade Stabilization Gravel (10 – inch Depth)	CY	$8.00	3829	$30,632
Subexcavation	CY	$5.50	3829	$21,060
Subtotal - Construction	**$1,449,581**			
Preliminary, Final Engineering, Geotechnical & Survey	8% of Construction			$115,966
Construction QA/QC	4% of Construction			$57,983
Contractor Mobilization	5% of Construction			$72,479
Contingency	10% of Construction			$144,958
Traffic Control During Construction	8% of Construction			$115,966

Right-of-Way Appraisals by Agent	LS			$8,000
Right-of-Way Acquisition by Agent	LS			$6,000
Purchase Right-of-Way	Acre	$32,000	4.8	$153,600
Total Est. Road Reconstruction Cost (2009)	**$2,124,533**			
Est. Total Road Cost Per Mile	**Miles**	**$2,124,533**	**/ 2.0 Mi =**	**$1,062,267**
Alternate – Add One Traffic Signal	**Each**	**$68,000**		**$68,000**
Alternate – Add One Turn Lane	**Each**	**$75,000**		**$75,000**
Alternate – Add Sanitary Sewer Main	**Per Mile**	**$211,200**	**x 2.0 Mi**	**$422,400**
Alternate – Add Water Main	**Per Mile**	**$396,000**	**x 2.0 Mi**	**$792,000**
Alternate – Add Bicycle/Ped. Path Reconstruction	**Per Mile**	**$77,825**	**x 2.0 Mi**	**$155,650**

LS = Lump Sum, CY = Cubic Yard, SQ YDS = Square Yards, GAL = Gallon, LF = Linear Feet

York Road to Deal Lane (MP 4.0 to MP 6.1)

Major Work Feature	Unit	Unit Cost	# of Units	Total Cost
Survey - Staking and Grade Control	LS	$31,500.00	1	$31,500
Topsoil - Salvage and Place	CY	$4.05	4540	$18,387
Excavation - Unclassified	CY	$5.50	45338	$249,359
MPDES Permit Fees	LS	$900.00	1	$900
Temporary Erosion Control - LS	LS	$3,000.00	1	$3,000
Crushed Top Surfacing (3-inch Depth)	CY	$25.41	3773	$95,872
Select & Subbase Course (12-inch Depth)	CY	$12.00	17248	$206,976
Aggregate Treatment (Prime)	SQ YDS	$0.41	41889	$17,175
Chip Seal Cover	SQ YDS	$0.69	39423	$27,202
Plant Mix Asphalt Paving	Ton	$81.38	6858	$558,104
Emulsified Asphalt Seal (CRS-2P)	Ton	$647.86	67.0	$43,407
Traffic Gravel	CY	$19.03	3011	$57,299
Remove/Reset Signs	Each	$184.30	6	$1,106
Interim Striping - Yellow Paint	Gal	$34.18	38	$1,299
Final Striping - Yellow Paint	Gal	$34.18	38	$1,299
Interim Striping - White Paint	Gal	$34.30	77	$2,641
Final Striping - White Paint	Gal	$34.30	77	$2,641
Remove Existing Culverts	LF	$12.27	1536	$18,847
Approach/Relief Drain Pipe - 15 Inch Diam.	LF	$33.00	966	$31,878
Drainage Pipe - 30 Inch Diam	LF	$62.87	150	$9,431
Drainage Pipe - 24 Inch Diam	LF	$50.00	420	$21,000
Farm Fence - Type Type 5M	LF	$2.25	11088	$24,948

Fence Panels	Each	$145.92	23	$3,356
Remove Existing Fence	LF	$0.49	11088	$5,433
Guardrail	LF	$19.77	2600	$51,402
Guardrail Terminal Section	Each	$2,804.91	6	$16,829
Seeding	Acre	$294.16	8.4	$2,471
Fertilize Seed	Acre	$120.84	8.4	$1,015
Condition Seedbed Surface	Acre	$221.51	8.4	$1,861
Geotextile - Subgrade Stabilization	SY	$1.50	3447	$5,171
Subgrade Stabilization Gravel (10 – inch Depth)	CY	$8.00	1914	$15,312
Subexcavation	CY	$5.50	1914	$10,527
Subtotal - Construction	**$1,537,648**			
Preliminary, Final Engineering, Geotechnical & Survey	8% of Construction			$123,012
Construction QA/QC	4% of Construction			$61,506
Contractor Mobilization	5% of Construction			$76,882
Contingency	10% of Construction			$153,765
Traffic Control During Construction	8% of Construction			$123,012
Right-of-Way Appraisals by Agent	LS			$66,000
Right-of-Way Acquisition by Agent	LS			$49,500
Purchase Right-of-Way	Acre	$32,000	5.1	$163,200
Total Est. Road Reconstruction Cost (2009)	**$2,354,525**			
Est. Total Road Cost Per Mile	**Miles**	**$2,354,525**	**/ 2.1 Mi =**	**$1,121,202**
Alternate – Add One Traffic Signal	**Each**	**$68,000**		**$68,000**
Alternate – Add One Turn Lane	**Each**	**$75,000**		**$75,000**
Alternate – Add Sanitary Sewer Main	**Per Mile**	**$211,200**	**X 2.1 Mi**	**$443,520**
Alternate – Add Water Main	**Per Mile**	**$396,000**	**X 2.1 Mi**	**$831,600**
Alternate – Add Bicycle/Ped. Path Reconstruction	**Per Mile**	**$77,825**	**X 2.1 Mi**	**$163,433**

LS = Lump Sum, CY = Cubic Yard, SQ YDS = Square Yards, GAL = Gallon, LF = Linear Feet

Deal Lane to Lake Helena Causeway (MP 6.1 to MP 7.9)

Major Work Feature	Unit	Unit Cost	# of Units	Total Cost
Survey - Staking and Grade Control	LS	$27,000.00	1	$27,000
Topsoil - Salvage and Place	CY	$4.05	2025	$8,201
Excavation - Unclassified	CY	$5.50	20250	$111,375
MPDES Permit Fees	LS	$900.00	1	$900
Temporary Erosion Control - LS	LS	$3,000.00	1	$3,000

Crushed Top Surfacing (3-inch Depth)	CY	$25.41	3234	$82,176
Select & Subbase Course (12-inch Depth)	CY	$12.00	14784	$177,408
Aggregate Treatment (Prime)	SQ YDS	$0.41	35905	$14,721
Chip Seal Cover	SQ YDS	$0.69	33791	$23,316
Plant Mix Asphalt Paving	Ton	$81.38	5879	$478,433
Emulsified Asphalt Seal (CRS-2P)	Ton	$647.86	57.4	$37,187
Traffic Gravel	CY	$19.03	2581	$49,116
Remove/Reset Signs	Each	$184.30	6	$1,106
Interim Striping - Yellow Paint	Gal	$34.18	33	$1,128
Final Striping - Yellow Paint	Gal	$34.18	33	$1,128
Interim Striping - White Paint	Gal	$34.30	66	$2,264
Final Striping - White Paint	Gal	$34.30	66	$2,264
Remove Existing Culverts	LF	$12.27	932	$11,436
Approach/Relief Drain Pipe - 15 Inch Diam.	LF	$33.00	1032	$34,056
Drainage Pipe - 24 Inch Diam	LF	$50.00	260	$13,000
Farm Fence - Type Type 5M	LF	$2.25	15206	$34,214
Fence Panels	Each	$145.92	30	$4,378
Remove Existing Fence	LF	$0.49	5069	$2,484
Guardrail	LF	$19.77	2230	$44,087
Guardrail Terminal Section	Each	$2,804.91	6	$16,829
Seeding	Acre	$294.16	7.2	$2,118
Fertilize Seed	Acre	$120.84	7.2	$870
Condition Seedbed Surface	Acre	$221.51	7.2	$1,595
Geotextile - Subgrade Stabilization	SY	$1.50	1,125	$1,688
Subgrade Stabilization Gravel (10 – inch Depth)	CY	$8.00	500	$4,000
Subexcavation	CY	$5.50	500	$2,750
Subtotal - Construction	**$1,194,228**			
Preliminary, Final Engineering, Geotechnical & Survey	8% of Construction			$95,538
Construction QA/QC	4% of Construction			$47,769
Contractor Mobilization	5% of Construction			$59,711
Contingency	10% of Construction			$119,423
Traffic Control During Construction	8% of Construction			$95,538
Right-of-Way Appraisals by Agent	LS			$54,000
Right-of-Way Acquisition by Agent	LS			$40,500
Purchase Right-of-Way	Acre	$32,000	4.4	$140,800
Total Est. Road Reconstruction Cost (2009)	**$1,847,507**			
Est. Total Road Cost Per Mile	**Miles**	**$1,847,507**	**/ 1.8 Mi =**	**$1,026,393**

Alternate – Add One Traffic Signal	**Each**	**$68,000**		**$68,000**
Alternate – Add One Turn Lane	**Each**	**$75,000**		**$75,000**
Alternate – Add Sanitary Sewer Main	**Per Mile**	**$211,200**	**x 1.8 Mi**	**$380,160**
Alternate – Add Water Main	**Per Mile**	**$396,000**	**x 1.8 Mi**	**$712,800**
Alternate – Add Bicycle/Ped. Path Reconstruction	**Per Mile**	**$77,825**	**x 1.8 Mi**	**$140,085**

LS = Lump Sum, CY = Cubic Yard, SQ YDS = Square Yards, GAL = Gallon, LF = Linear Feet

Lake Helena Causeway to Lincoln Road (MP 8.1 to MP 8.5)

Major Work Feature	Unit	Unit Cost	# of Units	Total Cost
Survey - Staking and Grade Control	LS	$5,000.00	1	$5,000
Topsoil - Salvage and Place	CY	$4.05	300	$1,215
Excavation - Unclassified	CY	$5.50	3000	$16,500
MPDES Permit Fees	LS	$900.00	1	$900
Temporary Erosion Control - LS	LS	$500.00	1	$500
Crushed Top Surfacing (3-inch Depth)	CY	$25.41	720	$18,295
Select and Subbase Course (12-inch Depth)	CY	$12.00	3285	$39,420
Aggregate Treatment (Prime)	SQ YDS	$0.41	7979	$3,271
Chip Seal Cover	SQ YDS	$0.69	7509	$5,181
Plant Mix Asphalt Paving	Ton	$81.38	1306	$106,282
Emulsified Asphalt Seal (CRS-2P)	Ton	$647.86	12.8	$8,293
Traffic Gravel	CY	$19.03	574	$10,923
Remove/Reset Signs	Each	$184.30	4	$737
Interim Striping - Yellow Paint	Gal	$34.18	8	$273
Final Striping - Yellow Paint	Gal	$34.18	8	$273
Interim Striping - White Paint	Gal	$34.30	15	$515
Final Striping - White Paint	Gal	$34.30	15	$515
Approach Drain Pipe Extension - 15 Inch Diam.	LF	$33.00	100	$3,300
Seeding	Acre	$294.16	0.2	$59
Fertilize Seed	Acre	$120.84	0.2	$24
Condition Seedbed Surface	Acre	$221.51	0.2	$44
Geotextile - Subgrade Stabilization	SY	$1.50	5515	$8,273
Subgrade Stabilization Gravel (10 – inch Depth)	CY	$8.00	1532	$12,256
Subexcavation	CY	$5.50	1532	$8,426
Subtotal - Construction	**$250,475**			
Preliminary, Final Engineering, Geotechnical & Survey	8% of Construction			$20,038
Construction QA/QC	4% of Construction			$10,019

Contractor Mobilization	5% of Construction			$12,524
Contingency	10% of Construction			$25,048
Traffic Control During Construction	8% of Construction			$20,038
Right-of-Way Appraisals by Agent	LS			$0
Right-of-Way Acquisition by Agent	LS			$0
Purchase Right-of-Way – No New Expected	Acre	$32,000	0.0	$0
Total Est. Road Reconstruction Cost (2009)	**$338,142**			
Alternate – Add One Traffic Signal	**Each**	**$68,000**		**$68,000**
Alternate – Add One Turn Lane	**Each**	**$75,000**		**$75,000**
Alternate – Add Sanitary Sewer Main	**Per Mile**	**$211,200**	**x 0.4 Mi**	**$84,480**
Alternate – Add Water Main	**Per Mile**	**$396,000**	**x 0.4 Mi**	**$158,400**
Alternate – Add Bicycle/Ped. Path Reconstruction	**Per Mile**	**$77,825**	**x 0.4 Mi**	**$31,130**

ESTIMATING PROCEDURE

Grading

- The Excavation – Unclassified quantity is estimated from **Figure 8** 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. A percentage of this was increased to factor in additional excavation for miscellaneous other features, such as re-building road approaches, excavating for culvert installations, etc.

- Where applicable the Borrow for Embankment quantity is similarly estimated from Figure 8. A 20% shrink factor was first applied to the quantity estimated to complete the roadway widening. This quantity is then deducted from the excavation quantity to arrive at an estimated borrow quantity.

- Topsoil Salvage and Placing is calculated based on a percentage of the road excavation quantity.

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 6 and 7**.

- 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.

Drainage

- The summarized length of approach pipe lengths is estimated based on the number approaches and their assumed cross-sectional characteristics such as slope rate and depth of cover. Approach top widths are estimated as being an average of 24 feet. The amount of access approaches intersecting the roadway in each applicable segment is based on GIS aerial photographs and limited windshield survey. The approach pipes would be 15-inch diameter at minimum to meet the County's requirements for a Minor Collector. A quantity of 24-inch diameter cross drains is included in the estimate. This quantity is to serve as highway relief pipes for minor terrain breaks, such as small cross-draining gullies and draws in localized drainage basins, or for those locations were no other pipe was observed but terrain reasonably dictates. Other major drainage features are listed as observed in the field. Their new installation lengths are estimated based on the dimensions generated from the proposed road templates.

Fencing

- For this project, we assume most right-of-way acquisition will occur on the east side of the road only from the project beginning to York Road, and on both sides of the highway north of that location. This then would preserve the majority of the overhead utilities along the right-of-way where possible. To re-fence the right-of-way, we assume using a typical 5-strand barbwire fence with metal posts.

Guardrail

- The estimated need for guardrail north of Deal Lane is based on the deeper fill slope embankments observed during field reviews at drainage crossings. We also utilized the estimated quantities contained in the road improvements project completed north of York Road to Deal Lane.

Roadside Revegetation

- Quantifying seeding, fertilizer and seedbed conditioning is based on sectional measurements taken from the finished slopes shown in **Figure 8**.

Subgrade Stabilization

- The preliminary pavement designs included with this report identifies some areas as having poor quality subgrade material. We included an amount of stabilization gravel to be placed over a geotextile fabric based on the recommendations contained in the pavement design. Similarly, we estimated the amount of geotextile needed on a range of digouts based on the subgrade widths derived from **Figures 6 and 7**.

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.

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.

Right-of-Way

- To estimate appraisal costs for right-of-way acquisition, we applied a $2,000 per parcel fee for an assumed 65 parcels. A similar approach is taken to estimate fees for an agent to prepare closing documents, negotiate the right-of-way and file documents for record.

- The existing right-of-way width appears to generally be 60 feet wide for most of the project. This is based on a cursory check of a limited amount of subdivision plats along Lake Helena Drive. Pursuant to **Figure 8**, we assume a minimum of an additional 15 feet of right-of-way will be needed to reconstruct the road. As such, the County will likely require that the minimum standard for Minor Collectors (80 feet of overall right-of-way width) be maintained. The additional 20 feet of needed right-of-way is then applied for the length of the project between Boundary Street and the Lake Helena Causeway to develop a per acre need per section of road.

- $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. 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.

Miscellaneous

- The estimate includes a per mile cost to install an 8” water main and an 8” 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

Traffic Counts for Lake Helena Drive

1989 → 2006

	cv06	7A-46	Applegate Drive	North of Valley View	238	1) 218	240	308	323	315	285	322	346	345	387	NCT	NCT	414	491	NCT	NCT	498	709	432
	cv05	7A-47	Applegate Drive	South of Brookings Rd.	459	1) 391	454	449	442	449	429	476	523	500	554	NCT	NCT	658	737	NCT	NCT	1,195	991	716
	cv04	7A-48	Applegate Drive	North of Lincoln Rd.	NCT	1) 449	619	464	479	450	NCT	501	598	581	633	NCT	NCT	782	897	NCT	NCT	922	MDT	850
	cv03	7A-49	Applegate Drive	South of Lincoln Rd.	NCT	1) 614	726	562	788	770	NCT	766	944	841	705	NCT	NCT	758	1,049	NCT	NCT	1,019	MDT	
	cv02	7A-50	Applegate Drive	North of John G. Mine Rd.	NCT	1) 300	299	357	335	323	NCT	609	759	729	731	NCT	NCT	977	982	NCT	NCT	920	831	800
	cv01	7A-51	Applegate Drive	South of John G. Mine Rd.	NCT	1) 241	283	240	245	304	NCT	1) 459	479	460	440	NCT	NCT	539	562	NCT	NCT	660	520	565
	cv31	7A-52	Lincoln Road	East of Applegate Dr.	NCT	1) 1,659	1,531	1,763	1,249	2,094	NCT	2,437	2,404	2,682	2,542	NCT	NCT	2,849	NCT	NCT	NCT	3,693	MDT	
	cv68	7A-53	Green Meadow Drive	North of Lincoln Rd.	NCT	NCT	NCT	528	483	533	614	726	788	941	756	NCT	NCT	840	877	NCT	NCT	854	MDT	900
	cv30	7A-54	Lincoln Road	West of Applegate Dr.	NCT	1) 1,217	1,281	1,312	1,492	1,600	NCT	1,680	1,777	1,994	1,954	NCT	NCT	1,990	NCT	NCT	NCT	2,496	MDT	2,690
	cv21	7A-55	John G. Mine Road	East of Applegate Dr.	NCT	1) 227	311	282	316	288	NCT	1) 843	452	557	648	NCT	NCT	686	799	NCT	NCT	901	861	847
	cv104	7A-56	Lone Mountain Dr.	North of Lincoln Rd.											92	NCT	NCT	137	204	NCT	NCT	314	MDT	
	cv20	7A-57	John G. Mine Road	West of Applegate Dr.	NCT	1) 230	?) 70	202	219	177	NCT	322	412	400	461	NCT	NCT	447	570	NCT	NCT	554	512	571
	cv64	7A-58	John G. Mine Road	East of Green Meadow Dr.	NCT	NCT	NCT	283	261	254	NCT	350	421	397	353	NCT	NCT	444	516	NCT	NCT	536	548	619
	cv66	7A-59	John G. Mine Road	West of Green Meadow Dr.	NCT	NCT	NCT	NCT	NCT	170	183	272	318	291	152	NCT	NCT	218	174	NCT	NCT	226	253	215
	cv74	7A-60	Norris Road	East of Green Meadow Dr.	NCT	NCT	NCT	354	318	330	NCT	413	428	552	487	NCT	NCT	500	645	NCT	NCT	525	483	601
	cv75	7A-61	Masonic Home Road	East of Frontage Rd.	NCT	NCT	NCT	357	354	388	386	480	502	378	478	NCT	NCT	578	575	NCT	NCT	561	644	575
	cv84	7A-62	Timber Trail Drive	West of Hauser Dam Rd.	NCT	NCT	NCT	NCT	NCT	L) 219	73	103	150	184	202	NCT	NCT	182	190	NCT	NCT	166	202	217
	cv59	7A-63	Hauser Dam Road	North of Lincoln Rd. East	NCT	NCT	115	385	412	567	318	403	515	512	534	NCT	NCT	668	621	NCT	NCT	702	•858	677
	cv29	7A-64	Hauser Dam Road	South of Lincoln Rd. East	NCT	214	188	378	227	427	328	1) 347	448	486	490	NCT	NCT	609	713	NCT	NCT	884	774	788
	cv28	7A-65	Lake Helena Drive	North of Deal Ln.	176	298	290	332	306	358	255	299	424	362	583	NCT	NCT	735	804	NCT	NCT	986	938	842
7A-65 →	cv27	7A-66	Lake Helena Drive	South of Deal Ln.	191	223	206	247	259	318	278	345	446	419	525	NCT	NCT	761	873	NCT	NCT	974	989	860
	cv26	7A-67	Lake Helena Drive	North of York Rd.	183	NCT	342	328	487	597	620	654	1,125	975	969	NCT	NCT	1,354	2,025	NCT	NCT	2,091	1960	2,060
	cv25	7A-68	Lake Helena Drive	South of York Rd.	NCT	114	333	192	223	250	201	253	328	220	444	NCT	NCT	722	1,250	NCT	NCT	1,243	1,188	1,285
7A-69 →	cv24	7A-69	Lake Helena Drive	North of Canyon Ferry Rd.	NCT	1) 163	376	221	254	255	247	271	279	379	502	NCT	NCT	771	983	NCT	NCT	1,619	1513	1,667
	cv23	7A-70	Lake Helena Drive	South of Canyon Ferry Rd.	NCT	1) 398	1,109	691	772	936	741	863	994	1,020	1,113	NCT	NCT	1,918	2,900	NCT	NCT	2,690	2574	2,546
	cv13	7A-71	Deal Road	East of Lake Helena Dr.	68	?) 118	NCT	140	125	160	162	180	247	187	353	NCT	NCT	313	405	NCT	NCT	411	393	290
	cv14	7A-72	Deal Road	1.2 mi. West of York Rd.	81	NCT	95	113	115	L) 126	138	103	112	79	119	NCT	NCT	150	181	NCT	NCT	272	210	166
	cv85	7A-73	Hart Drive	East of York Rd.	NCT	NCT	NCT	NCT	NCT	182	244	238	251	236	281	NCT	NCT	241	259	NCT	NCT	298	287	250
	cv87	7A-74	Keir Drive	North of Keir Rd.	NCT	NCT	NCT	NCT	NCT	278	345	315	283	302	384	NCT	NCT	431	422	NCT	NCT	335	169	133
	cv88	7A-75	Hart Drive	North of Canyon Ferry Rd.	NCT	NCT	NCT	NCT	NCT	L) 42	48	47	84	80	63	NCT	NCT	69	108	NCT	NCT	90	115	92
	cv12	7A-76	Canyon Ferry Road	East of Lake Helena Dr.	NCT	1) 1,119	1,170	1,735	1,767	2,000	2,058	1,974	1,769	1,817	2,245	NCT	NCT	2,171	NCT	NCT	NCT	2,714	2804	2,651
	cv76	7A-77	Glass Drive	North of Lincoln Rd.	NCT	NCT	NCT	395	427	485	468	488	544	588	590	NCT	NCT	533	612	NCT	NCT	604	604	619
	cv63	7A-78	Montana Avenue	North of Lincoln Rd.	NCT	NCT	1,268	1,457	1,498	1,650	1,821	2,038	2,380	2,693	2,635	NCT	NCT	3,331	3,406	NCT	NCT	3,910	MDT	4,020
	cv67	7A-79	Lincoln Road	East of Montana Ave.	NCT	NCT	1) 1,820	3,005	3,137	3,183	3,366	3,774	4,789	4,332	4,093	NCT	NCT	4,513	-	NCT	NCT	5,991	MDT	-
	cv11	7A-80	Canyon Ferry Road	West of Lake Helena Dr.	NCT	1) 1,573	1,951	2023	2,102	2,379	2,471	2,329	2,348	2,251	2,807	NCT	NCT	2,974	NCT	NCT	NCT	3,518	3502	3,813
	cv50	7A-81	York Road	West of Lake Helena Dr.	889	1,001	1,099	1,399	1,092	1,529	1,551	1) 1,872	1,712	1,858	1,843	NCT	NCT	2,088	NCT	NCT	NCT	3,413	2420	1,924
	cv22	7A-82	Lake Helena Drive	North of Old US 12	NCT	1) 2,323	3,682	2,273	2,376	2,890	3,499	3,872	3,715	4,138	4,341	NCT	NCT	3,881	5,911	NCT	NCT	2,617	4394	3,898
	cv32	7A-83	Old US 12	West of Lake Helena Dr.	NCT	1) 887	2,221	1,142	1,237	1,424	1,678	1,286	1,738	1,619	2,088	NCT	NCT	2,756	2,675	NCT	NCT	2,584	2399	2,076
	cv33	7A-84	Old US 12	East of Lake Helena Dr.	NCT	1) 1,021	1,777	85	83	L) 105	136	2,835	2,536	2,972	3,053	NCT	NCT	2,549	3,235	NCT	NCT	3,281	3024	2,476
	cv100	7A-85	Remington St.	East of Lake Helena Dr.											1,388	NCT	NCT	1,424	NCT	NCT	NCT	1,237	1232	1,337
	cv106	7A-86	Boundary St.	East of Lake Helena Dr.											832	NCT	NCT	931	NCT	NCT	NCT	1,070	1089	1,151
	cv80	7A-87	Spokane Creek Road	South of Matt Staff Rd.	NCT	NCT	NCT	NCT	310	547	841	1) 653	719	810	996	NCT	NCT	774	1,137	NCT	NCT	1,022	MDT	1,170
	cv92	7B-38	Franklin Mine Rd.	East of Head Dr.							313	333	335	312	289	NCT	NCT	457	422	NCT	NCT	471	341	359
	cv91	7B-39	Head Dr.	North of Franklin Mine Rd.							328	366	416	356	308	NCT	NCT	459	414	NCT	NCT	372	363	326
	cv19	7B-40	Head Drive	North of Country Club Ave.	W) 324	1) 335	1) 425	339	403	286	307	355	444	377	350	NCT	NCT	370	393	NCT	NCT	429	DEL.	DELETED
	cv90	7B-41	Head Dr.	South of Franklin Mine Rd.							260	336	312	262	237	NCT	NCT	372	340	NCT	NCT	378	360	333
	cv07	7B-42	Birdseye Road	North of Barret Rd.	1,094	1) 1,160	726	1,200	1,396	1,364	1,517	1,396	1,332	1,426	1,406	NCT	NCT	1,456	1,736	NCT	NCT	1,515	1564	1,475
	cv16	7B-43	Franklin Mine Road	West of Green Meadow Dr.	W) 1,216	1) 785	803	249	1,226	1,116	689	837	816	800	903	NCT	NCT	871	891	NCT	NCT	986	826	813
	cv57	7B-44	[redacted]	[redacted]	[redacted]	[redacted]	[redacted]	[redacted]	[redacted]	[redacted]	[redacted]	[redacted]	[redacted]	[redacted]	[redacted]	[redacted]	[redacted]	[redacted]	[redacted]	[redacted]	[redacted]	[redacted]	[redacted]	[redacted]
	cv56	7B-45	[redacted]	[redacted]	[redacted]	[redacted]	[redacted]	[redacted]	[redacted]	[redacted]	[redacted]	[redacted]	[redacted]	[redacted]	[redacted]	[redacted]	[redacted]	[redacted]	[redacted]	[redacted]	[redacted]	[redacted]	[redacted]	[redacted]
	cv52	7B-46	Forestvale Road	East of Green Meadow Dr.	NCT	396	549	370	457	498	423	494	522	511	615	NCT	NCT	586	610	NCT	NCT	531	478	452
	cv53	7B-47	Forestvale Road	West of McHugh Dr.	NCT	419	528	NCT	537	512	618	569	557	634	639	NCT	NCT	572	727	NCT	NCT	654	613	1,475
	cv54	7B-48	Forestvale Road	East of McHugh Dr.	NCT	503	600	NCT	599	658	727	643	667	698	634	NCT	NCT	836	752	NCT	NCT	766	690	597
	cv55	7B-49	Forestvale Road	West of Montana Ave.	NCT	769	NCT	946	900	881	1,108	1,002	1,047	1,043	1,066	NCT	NCT	1,105	1,013	NCT	NCT	1,007	1010	858
	cv95	7B-50	Frontage Dr.	North of Sierra Rd.											524	NCT	NCT	594	618	NCT	NCT	799	627	572

Tom, I looked at the traffic data sheets and those numbers are not ADT values for the roads. Here are the numbers that you
should be using for the AADT values on these roads. Note that these values are the ADT numbers collected in the filed factor by the MDT annual count factors to create AADT volumes (0.85 for August counts). Give me a call if you have any questions.

7A-65 = 880
7A-69 = 2401
7A-78 = 4396
7B-02 = 1170
7B-42 = 1773

Bob Abelin, P.E.
Abelin Traffic Services
406-459-1443

Basic Axle Class Summary: 7A-65 CLASS

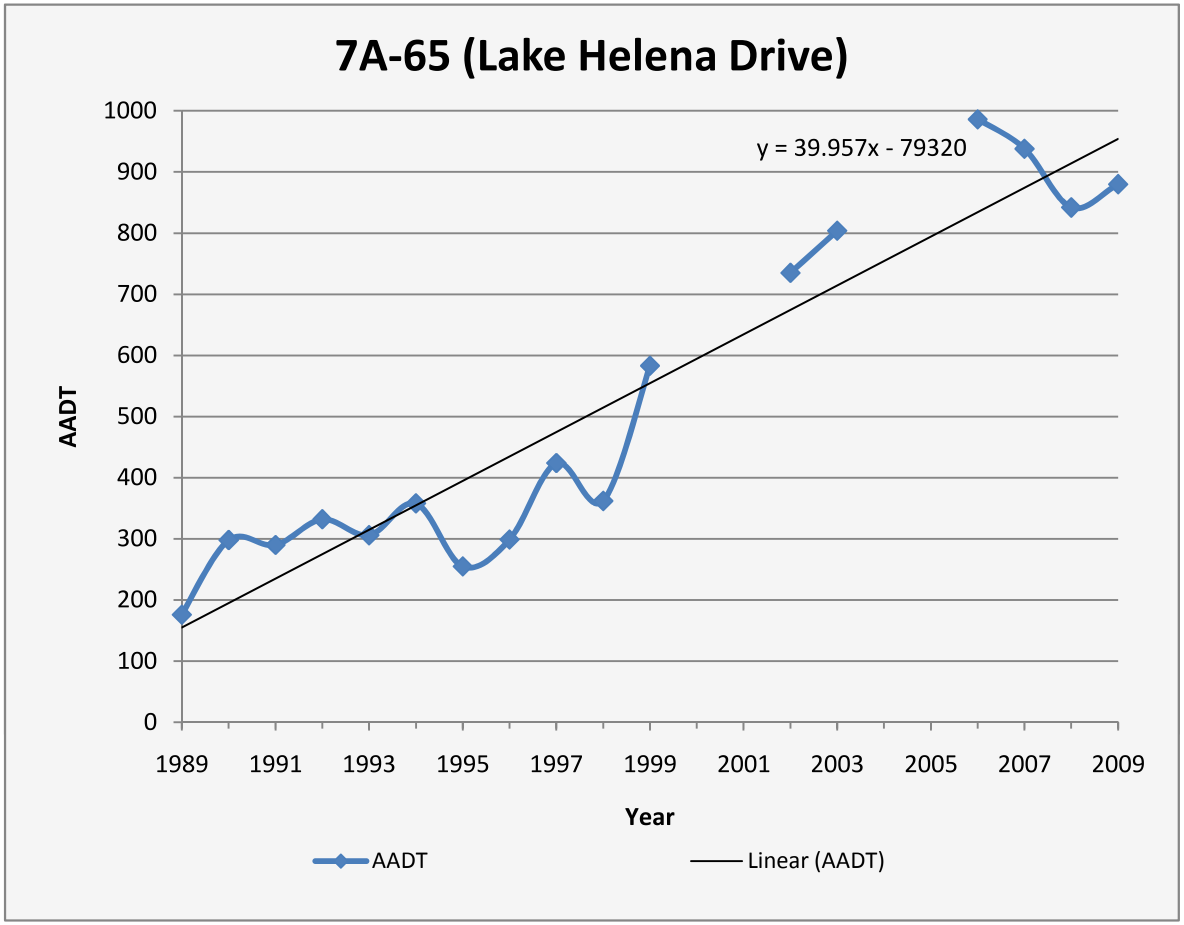
(DEFAULTB) Description	Lane	#1 Cycle	#2 Cars	#3 2A-4T	#4 Buses	#5 2A-SU	#6 3A-SU	#7 4A-SU	#8 4A-ST	#9 5A-ST	#10 6A-ST	#11 5A-MT	#12 6A-MT	#13 Other	Total
TOTAL COUNT :	#1.	12	413	441	0	10	6	1	20	5	12	4	0	5	929
	#3.	14	453	443	0	8	10	1	20	3	8	9	1	1	971
		26	866	884	0	18	16	2	40	8	20	13	1	6	1900
Percents :	#1.	1%	44%	47%	0%	1%	1%	0%	2%	1%	1%	0%	0%	1%	49%
	#3.	1%	47%	46%	0%	1%	1%	0%	2%	0%	1%	1%	0%	0%	51%
		1%	46%	47%	0%	1%	1%	0%	2%	0%	1%	1%	0%	0%	
Average :	#1.	0	9	10	0	0	0	0	0	0	0	0	0	0	19
	#3.	0	10	10	0	0	0	0	0	0	0	0	0	0	20
		0	19	20	0	0	0	0	0	0	0	0	0	0	39
Days & ADT :	#1.	1.9	484												
	#3.	1.9	506												
		1.9	991												

Basic Axle Class Summary: 7A-69

(DEFAULTB) Description	Lane	#1 Cycle	#2 Cars	#3 2A-4T	#4 Buses	#5 2A-SU	#6 3A-SU	#7 4A-SU	#8 4A-ST	#9 5A-ST	#10 6A-ST	#11 5A-MT	#12 6A-MT	#13 Other	Total
TOTAL COUNT :	#1.	8	456	270	0	6	3	0	11	1	0	0	0	0	755
	#2.	36	1188	792	1	6	19	4	25	1	3	3	1	3	2082
		44	1644	1062	1	12	22	4	36	2	3	3	1	3	2837
Percents :	#1.	1%	60%	36%	0%	1%	0%	0%	1%	0%	0%	0%	0%	0%	27%
	#2.	2%	57%	38%	0%	0%	1%	0%	1%	0%	0%	0%	0%	0%	73%
		2%	58%	37%	0%	0%	1%	0%	1%	0%	0%	0%	0%	0%	
Average :	#1.	0	10	6	0	0	0	0	0	0	0	0	0	0	16
	#2.	1	26	17	0	0	0	0	1	0	0	0	0	0	45
		1	36	23	0	0	0	0	1	0	0	0	0	0	61
Days & ADT :	#1.	1.9	393												
	#2.	1.9	1086												
		1.9	1480												

7A-65 (Lake Helena Drive - North of Deal Lane)

Year	AADT
1989	176
1990	298
1991	290
1992	332
1993	306
1994	358
1995	255
1996	299
1997	424
1998	362
1999	583
2000	
2001	
2002	735
2003	804
2004	
2005	
2006	986
2007	938
2008	842
2009	880
2029	**1753**

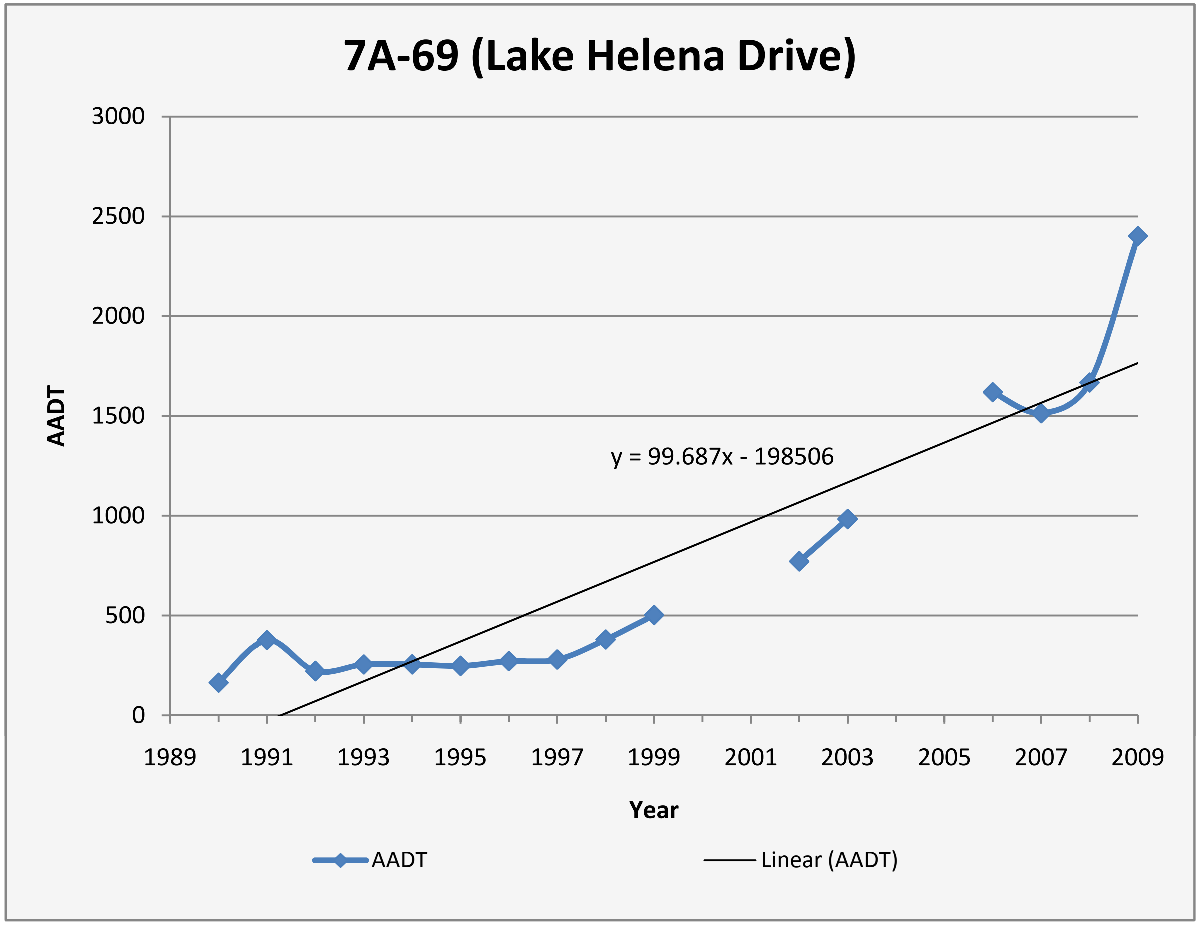


2009	954
2029	1753
Yearly Growth Rate	**3.09%**

7A-69 (Lake Helena Drive - North of Canyon Ferry Road)

Year	AADT
1989	
1990	163
1991	376
1992	221
1993	254
1994	255
1995	247
1996	271
1997	279
1998	379
1999	502
2000	
2001	
2002	771
2003	983
2004	
2005	
2006	1619
2007	1513
2008	1667
2009	2401
2029	**3759**

2009	1765
2029	3759
Yearly Growth Rate	**3.85%**



Appendix B

PAVEMENT DESIGN FOR LAKE HELENA DRIVE

October 5, 2009 Project 09-2560B

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

Dear Tom:

Re: Pavement Evaluation, Lake Helena 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 (RPA) and Lewis and Clark County to complete initial preliminary engineering analysis for a future reconstruction of a portion of Lake Helena Drive. The pavement evaluation was performed in general accordance with our Subconsultant Agreement dated June 11, 2009.

Project Information

It is our understanding Lake Helena Drive from about East Helena north to Lincoln Road East 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, in conjunction with other preliminary engineering work, is from East Helena extending northward for 8 1/2 miles. The Lake Helena Drive roadway limits considered for this pavement evaluation are shown on the attached Boring Location Sketch. The existing road surfacing varies; is either paved, recycled millings, or gravel surfacing. The gravel surfacing portion is from just north of Deal Lane to the Lake Helena Causeway.

At this time, the engineering evaluation along Lake Helena Drive is based on a total reconstruction need with a new pavement section to bring the road into compliance of meeting or exceeding the minimum road standards in accordance with the Lewis and Clark Subdivision Regulations dated September 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. This pavement evaluation is being prepared to supplement the preliminary engineering analysis.

Field Procedures

On July 7, 2009, Borings ST-16 through ST-26 were performed along the 8 1/2-mile alignment being considered for reconstruction. Therefore, the borings were located generally at or slightly under 1 mile apart. Boring locations were selected by our personnel and staked in the field by RPA personnel. The borings generally alternated between the northbound and southbound lanes. The locations of Borings ST-16 through ST-26 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 surfacing materials 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. Representative samples will remain in our office for a period of 60 days to be available for your examination.

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 borings was existing asphalt or gravel surfacing underlain by gravel base course over clayey sand and silty sand subgrades. Table 1 below summarizes the existing surfacing and subgrade conditions encountered at the borings. We wish to point out that Boring ST-19 was not performed.

Table 1. Summary of Boring Conditions – Lake Helena Drive

Boring	ST-16	ST-17	ST-18	ST-20	ST-21	ST-22	ST-23	ST-24	ST-25	ST-26
Existing Asphalt Surface	3¾"	7½"	3"	5"	5¾"	3¾"	3½"	---	---	1¾"
Existing Gravel Surfacing	---	---	---	---	---	---	---	None	3"	---
Existing Base Thickness	7½"	1"(1)	3½"	1¾"(1)	4¾"	5¾"	3"	---	---	6¼"
Existing Base Quality	Poor	Good	Good	Good	Good	Good	Good	---	---	Good
Subgrade	SC	SM	SC	SC	SM	SC	GM	SC	SC	SM
BPF	10, 8	7	22, 12	14, 5	10, 5	18, 14	21	22, 14	37, 17	10, 5
Moisture Condition	Over 2 – 4%	Over 2 – 5%	Near	Near	Over 4 – 8%	Below to Near	Near	Below	Below	Over 5 – 10%
Risk of Subgrade Failure	High	High	Low	Moderate	High	Low	None	None	None	High

SC = Clayey Sand
SM = Silty Sand
GM = Silty Gravel

General Statistical Summary

Existing Base Course: Note 1. Base is too thin to salvage.
1 of 8 borings (13%) encountered POOR quality base course
7 of 8 borings (87%) encountered GOOD quality base course

Subgrade Conditions: 4 of 10 borings (40%) have HIGH risk to become unstable during construction
1 of 10 borings (10%) have MODERATE risk to become unstable during construction.
2 of 10 borings (20%) have LOW risk to become unstable during construction
3 of 10 borings (30%) encountered relatively stable subgrades.

Existing Asphalt Surfacing. As indicated in Table 1 above, eight of ten borings encountered existing asphalt surfacing to depths ranging from 1 3/4 to 7 1/2 inches, but was primarily 3 to 3 3/4 inches thick. The asphalt surfacing along the alignment is either conventional plant mix asphalt pavement or rolled/reshaped asphalt millings. Beneath the existing asphalt surfacing, the borings generally encountered good quality base course, which was 1 to 7 1/2 inches thick. Penetration tests were performed in the base course directly beneath the asphalt surface while drilling. In general, penetration resistances in the base course typically ranged from 2 to 9 blows for 6 inches of penetration, indicating it was very loose to medium dense.

Gravel Surfacing. Borings ST-24 and ST-25 were performed in the gravel surfaced portion of Lake Helena Drive near Lake Helena. Boring ST-24 did not encounter any noticeable gravel surfacing, while 3 inches was present at Boring ST-25.

Subgrade. Beneath the existing base course, the borings primarily encountered clayey sand, clayey sand with gravel, and silty sand subgrades. Silty gravel subgrade was encountered in Boring ST-23. Penetration resistances typically ranged from 5 to 37 BPF, but primarily ranged from 5 to 22 BPF. These values indicated the clayey sand and silty sand subgrade were primarily loose to medium dense.

Moisture content tests were performed on all of the penetration test samples from the borings. The moisture contents are indicated on the boring logs and were either compared to the optimum moisture content determined by our standard Proctor (described below) or typical optimum moisture contents for these types of soils. Based on these moisture content tests, the subgrade conditions beneath existing pavement were mostly over optimum moisture content and would be considered wet. Subgrade conditions at Borings ST-24 and ST-25, in the gravel surfacing portion, were below optimum moisture content, indicating they were moist.

Groundwater. Groundwater was not encountered in any of the borings to their termination depth of 5 1/2 feet at the time of our fieldwork. We wish to point out that clay subgrades were encountered by the borings. Several days may be required for groundwater levels to develop and stabilize in these types of clay soils. This is especially true for Boring ST-26 performed near Lake Helena. Surface water can also become trapped on top of these clay soils (perched groundwater), and then be encountered during construction.

Laboratory Tests

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

Table 2. Summary of Laboratory Tests

Sample	Atterberg Limits			P_{200} (%)	Standard Proctor		CBR Value
	LL	PL	PI		MDD	OMC	
Base Course, ST-16	Nonplastic			14.6	---	---	---
ST-18	Nonplastic			9.1	---	---	---
Composite Subgrade, ST-16 and ST-18	28	15	13	20.1	133.2	8.5	17.9
Composite Subgrade, ST-20 and ST-22	33	13	20	18.8	115.8	10.1	5.4
Composite Subgrade, ST-24 and ST-25	22	14	8	29.9	134.6	7.1	30.0

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

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 sample from Boring ST-18 tested meets the specifications, while the base sample from Boring ST-16 does not.

Standard Proctors (ASTM D 698) and California bearing ratio (CBR) tests were performed on three clayey sand subgrade samples indicated above. CBR values varied relatively significantly, ranging from 5.4 to 30.0.

Pavement Analysis and Recommendations

Available Information. RPA provided us with the traffic information indicated on the attached graphs for Roadways 7A-69, which represents south of York Road, and 7A-65, which represents north of York Road. A linear relationship was used to estimate the increase in Average Annual Daily Traffic (AADT) over a 20-year period. Abelin Traffic Services (ATS) performed the various traffic counts on this and numerous other Lewis and Clark County roads as part of the County's annual traffic count program. The 2009 traffic count summaries for these roads are attached. These summaries show the relative percentages and daily traffic of the 13 standard classes of vehicles using the road. These traffic counts, however, do not reflect the increase in truck traffic associated with Helena Sand and Gravel's new pit located west of Lake Helena Drive and south of Canyon Ferry Road.

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

Table 3. Summary of Pavement Design Assumptions and Analysis

	Lake Helena Drive	
Parameter:	**North of York Road**	**South of York Road**
Road Classification	Minor Collector	Minor Collector
2009 AADT	954	1,765
2029 AADT	1,753	3,759
Estimated Annual Growth	3.09%	3.85%
Performance Period	20 Years	20 Years
Initial Serviceability	4.2	4.2
Terminal Serviceability	2.5	2.5
Reliability	85	85
Number of Lanes in Design Direction	1	1
Percent All Trucks in Design Lane	50	50
Percent Trucks in Design Direction	100	100
18-kip ESALs	157,725	135,454

As can be seen above, we calculated the design ESAL of 157,725 for north of York Road and 135,454 for south of York Road, even though the AADT is much higher for the south portion. The justification is in the ATS report, where the north portion has a much higher percentage of truck traffic, which has a significant impact on ESALs. For our calculations, vehicle/truck factors were used for the 13 classes of vehicles counted in the ATS traffic classification count. These vehicle/truck factors were obtained from the *washington.edu* website, and the table is attached.

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

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

As previously indicated in Table 2, CBR values of 5.4, 17.9, and 30.0 were determined for subgrade samples along this roadway. When considering the variability, it is our opinion a design CBR of one standard deviation below the mean should be used. This results in a CBR of 5.5, which results in an M_r equal to 8,300.

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

Section Materials	**Lake Helena Drive**	
	North of York Road	**South of York Road**
Asphalt Pavement	3"	3"
Crushed Top Surfacing	3"	3"
Select Base Course*	6"	6"
Subbase Course*	6"	5"
Total	**18"**	**17"**

*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 and Subbase Course.

Constructability.

General. A common problem in roadway construction is encountering unstable subgrades. Unstable subgrades are those subgrade soils that are excessively wet and soft, and cannot support heavy rubber-tired construction equipment as well as cannot be compacted to specification. They commonly occur beneath existing paved 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.

The risk of subgrade failure during construction at each boring is indicated in Table 1. We considered 50 percent of the entire alignment to have a moderate to high risk of subgrade failure during construction.

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

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

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

Item	Alternative 1	Alternative 2
Asphalt Pavement	3"	3"
Crushed Top Surfacing	3"	3"
Select Base and/or Subbase	20"	23"
Geosynthetic	Tensar BX 1300 over 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 Lake Helena 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 the Robert Peccia & Associates to use in conjunction with the preliminary road reconstruction analysis being completed by them for the County. In the absence of our written approval, we make no representation and assume no responsibility to other parties regarding this report. The data, analyses and recommendations may not be appropriate for other structures or purposes. We recommend parties contemplating other alignments or purposes contact us.

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

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

Sincerely,

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

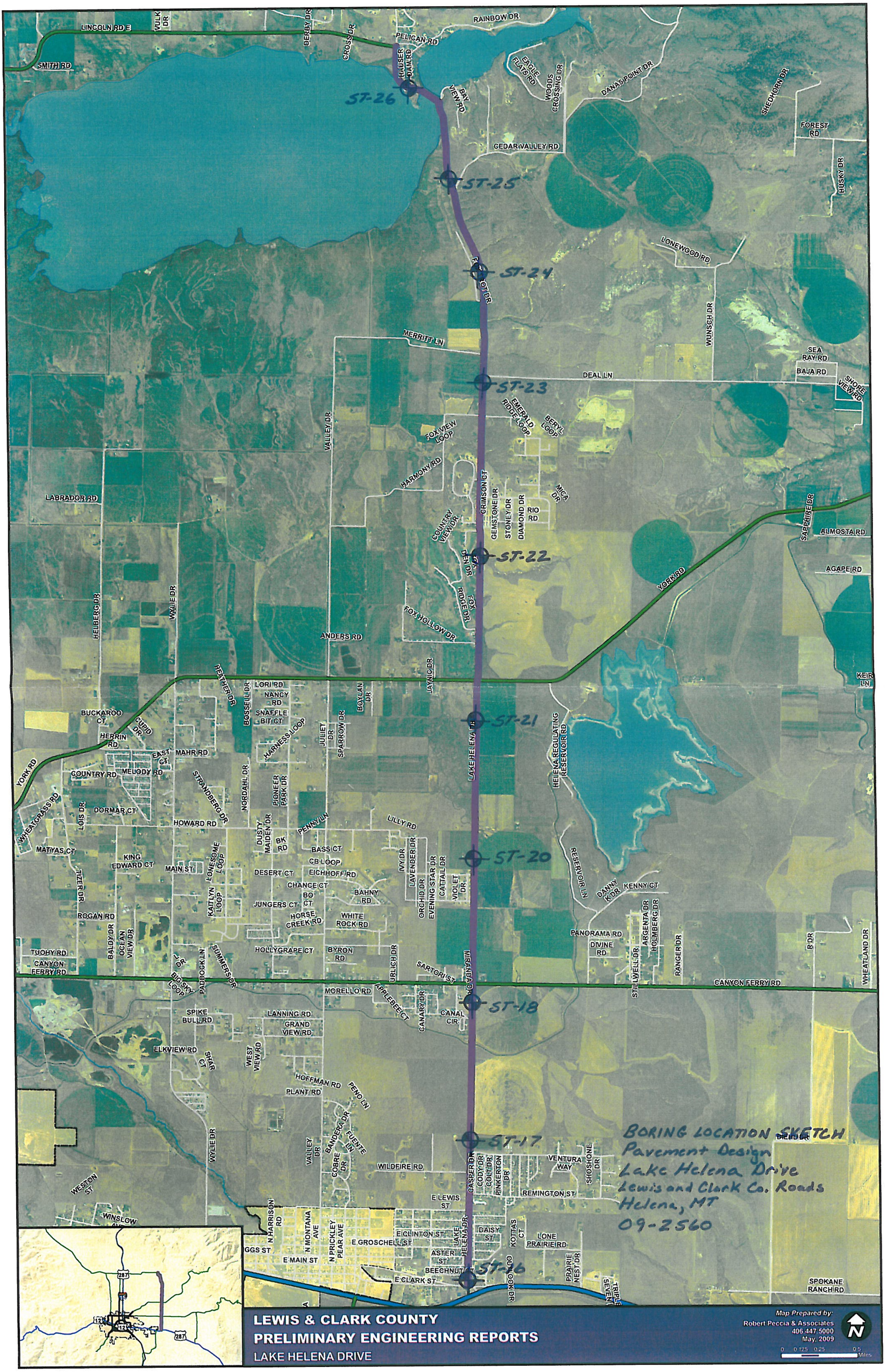
MONTANA
GREGORY T. STAFFILENO
No. 10798 P.E.
REGISTERED PROFESSIONAL ENGINEER

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

Brett M. Warren, EI
Reviewing Engineer

gts/bmw:khr

Attachments:
Boring Location Sketch
Descriptive Terminology
Log of Boring Sheets ST-16 through ST-18, and ST-20 through ST-26
Laboratory Tests
Laboratory Test of Aggregate
Pavement Analysis:
    North of York Road (5 sheets)
    South of York Road (5 sheets)
Washington DOT Vehicle/Truck Factors


LINCOLN RD E
SMITH RD
PELICAN RD
RAINBOW DR
HAUSER DAM RD
CROSS DR
BERRY DR
EAGLE FLATS RD
WOODS CROSSING DR
DANAS POINT DR
SHEDHORN DR
BAY VIEW DR
FOREST RD
CEDAR VALLEY RD
HUSKY DR
ST-26
ST-25
ST-24
ST-23
ST-22
ST-21
ST-20
ST-18
ST-17
ST-16
LONEWOOD RD
WUNSCH DR
MERRITT LN
DEAL LN
SEA RAY RD
BAJA RD
SHORE VIEW RD
VALLEY DR
FOX VIEW LOOP
EMERALD RIDGE LOOP
BERYL LOOP
HARMONY RD
CRIMSON CT
GEMSTONE DR
STONEY DR
DIAMOND DR
RIO RD
MICA DR
LABRADOR RD
COUNTRY VIEW DR
SAPPHIRE DR
ALMOSTA RD
AGAPE RD
YORK RD
FOX RIDGE DR
FOX HOLLOW DR
HELBERG DR
WYLIE DR
ANDERS RD
KEIR LN
FEATHER DR
LORI RD
NANCY RD
SNAFFLE BIT CT
BOSSELL DR
BOYLAN DR
JAYNIC DR
BUCKAROO CT
CUPID DR
HERRIN RD
EAST CT
MAHR RD
HARNESS LOOP
JULIET DR
SPARROW DR
LAKE HELENA DR
HELENA REGULATING RESERVOIR RD
COUNTRY RD
MELODY RD
STRANDBERG DR
NORDAHL DR
PIONEER PARK DR
WHEATGRASS RD
LOIS DR
DORMAR CT
HOWARD RD
PENNY LN
LILLY RD
MATYAS CT
KING EDWARD CT
MAIN ST
LONESOME LOOP
DUSTY MAIDEN DR
BK RD
BASS CT
CB LOOP
EICHHOFF RD
IVY DR
LAVENDER DR
EVENING STAR DR
CATTAIL DR
VIOLET DR
RESERVOIR LN
DESERT CT
CHANCE CT
BAHNY RD
DANNY K DR
KENNY CT
TIZER DR
KAITLYN LOOP
JUNGERS CT
BO CT
ORCHID DR
ROGAN RD
HORSE CREEK RD
WHITE ROCK RD
PANORAMA RD
ARGENTA DR
HOLMBERG DR
BALDY DR
OCEAN VIEW DR
DIVINE RD
TUOHY RD
HOLLYGRAPE CT
BYRON RD
URLICH DR
MIRANDA DR
STILLWELL DR
RANGER DR
B DR
WHEATLAND DR
CANYON FERRY RD
PADDOCK LN
SUMMERS DR
SARTORI ST
BIG SKY LOOP
MORELLO RD
APPLEBEE CT
GANARY DR
CANAL CIR
SPIKE BULL RD
LANNING RD
GRAND VIEW RD
ELKVIEW RD
SHAR CT
WEST VIEW RD
HOFFMAN RD
PLANT RD
PENO LN
BANDERA DR
FUENTE LN
VALLEY DR
COBRE DR
WILDFIRE RD
CASPER DR
CODY DR
COLT DR
PINKERTON DR
VENTURA WAY
SHOSHONE DR
REMINGTON ST
WESTON ST
WINSLOW
N HARRISON RD
N MONTANA AVE
N PRICKLEY PEAR AVE
E LEWIS ST
E CLINTON ST
E GROSCHELL ST
DAISY ST
KOTTAS CT
LONE PRAIRIE RD
ASTER ST
BEECHNUT ST
E MAIN ST
E CLARK ST
COOK DR
PRAIRIE NEST DR
SPOKANE RANCH RD
BORING LOCATION SKETCH
Pavement Design
Lake Helena Drive
Lewis and Clark Co. Roads
Helena, MT
09-2560
LEWIS & CLARK COUNTY
PRELIMINARY ENGINEERING REPORTS
LAKE HELENA DRIVE
Map Prepared by:
Robert Peccia & Associates
406.447.5000
May, 2009
N
0 0.125 0.25 0.5 Miles

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	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] $C_U = D_{50} / D_{10}$
$C_C = (D_{30})^2 / (D_{10} \times D_{50})$
[F] If soil contains ≥ 15% sand, add "with sand" to group name.
[G] If fines classify as CL-ML, use dual symbol GC-GM or SC-SM.
[H] If fines are organic, add "with organic fines" to group name.
[I] If soil contains ≥ 15% gravel, add "with gravel" to group name.
[J] If Atterberg limits plot in hatched area, soil is a CL-ML, silty clay.
[K] If soil contains 15 to 29% plus No. 200, add "with sand" or "with gravel", whichever is predominant.
[L] If soil contains ≥ 30% plus No. 200 predominantly sand, add "sandy" to group name.
[M] If soil contains ≥ 30% plus No. 200 predominantly gravel, add "gravelly" to group name.
[N] PI ≥ 4 and plots on or above "A" line.
[O] PI < 4 or plots below "A" line.
[P] PI plots on or above "A" line.
[Q] PI plots below "A" line.

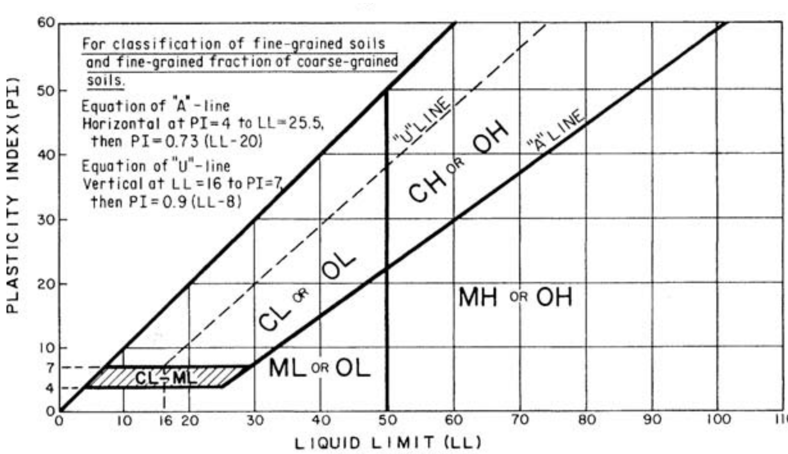


FIG. 4 Plasticity Chart

Laboratory Tests

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

Particle Size Identification

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

Relative Density of Cohesionless Soils

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

Consistency of Cohesive Soils

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

Moisture Content (MC) Description

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

Drilling Notes

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

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

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

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

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

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LOG OF BORING

PROJECT: 09-2560 **PAVEMENT DESIGN** Lewis and Clark County Roads Helena, Montana	BORING: **ST-16** LOCATION: Lake Helena Drive, see attached sketch.

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

Elev.	Depth 0.0	Symbol	Description of Materials	BPF	WL	MC (%)	Remarks
	0.3		FILL: 3 3/4" of Asphalt Pavement.				
	0.9		FILL: 7 1/2" of Silty Sand with Gravel Base Course.				Base course bag sample: MC=5.2% P_{200}=14.6%
		SC	CLAYEY SAND with GRAVEL, fine- to coarse-grained, low plasticity, brown, moist to wet, medium. (Alluvium)	3/4/5		12.2	
							Composite subgrade bag sample ST-16 and ST-18: LL=28, PL=15, PI=13 P_{200}=20.1%
	3.5			4/4/4		10.6	
	5.5	SM	SILTY SAND, fine- to coarse-grained, trace Gravel, brown, moist to wet, loose. (Alluvium)	3/3/4		13.0	Jar sample: LL=25, PL=15, PI=10 P_{200}=38.9%
			END OF BORING Water not observed with 4' of hollow-stem auger in the ground. Water not observed to dry cave-in depth of 1 1/2' immediately after withdrawal of auger.				

BORING BPF WL MC 2560.GPJ LAGNNN06.GDT 10/2/09

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LOG OF BORING

PROJECT: 09-2560 **PAVEMENT DESIGN** Lewis and Clark County Roads Helena, Montana	BORING: **ST-17** LOCATION: Lake Helena Drive, see attached sketch.

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

Elev.	Depth 0.0	Symbol	Description of Materials	BPF	WL	MC (%)	Remarks
	0.0–0.6		FILL: 7 1/2" of Asphalt Pavement.				
	0.6–0.7		FILL: 1" of Gravel Base.				
	0.7–2.5	SM	SILTY SAND, fine- to coarse-grained, brown, moist, loose. (Alluvium)	3/4/3		13.1	
	2.5–4.8	GP	POORLY GRADED GRAVEL with SAND, fine- to coarse-grained, brown, rather dry, dense to very dense. (Alluvium)	4/16/30		2.1	
				36/50-3"		0.6	
	4.8		END OF BORING				

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

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

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LOG OF BORING

PROJECT: 09-2560 **PAVEMENT DESIGN** Lewis and Clark County Roads Helena, Montana		BORING: **ST-18** LOCATION: Lake Helena Drive, see attached sketch.	
DRILLED BY: C. Larsen	METHOD: 3 1/4" HSA, Automatic	DATE: 7/7/09	SCALE: 1" = 1'

Elev.	Depth 0.0	Symbol	Description of Materials	BPF	WL	MC (%)	Remarks
			FILL: 3" of Asphalt Pavement.				
	0.3		FILL: 3 1/2" of Well Graded Gravel with Silt and Sand Base.				
	0.5	SC	CLAYEY SAND with GRAVEL, fine- to coarse-grained, low plasticity, brown, moist to rather dry, medium dense. (Alluvium)	9/13/9		7.9	Base course bag sample: MC=5.3% P_{200}=9.1% Composite subgrade bag sample ST-16 and ST-18: LL=28, PL=15, PI=13 P_{200}=20.1%
				6/6/10		10.2	
				19/33/27		1.8	
	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.				

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LOG OF BORING

PROJECT: 09-2560 **PAVEMENT DESIGN** Lewis and Clark County Roads Helena, Montana	BORING: **ST-20** LOCATION: Lake Helena Drive, see attached sketch.

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

Elev.	Depth 0.0	Symbol	Description of Materials	BPF	WL	MC (%)	Remarks
			FILL: 5" of Asphalt Pavement.				
	0.5		FILL: 1 3/4" of Gravel Base.				
	0.6	SC	CLAYEY SAND, fine- to coarse-grained, low plasticity, trace Gravel, brown, moist, medium dense. (Alluvium)	5/9/8		9.0	Composite subgrade sample ST-20 and ST-22: LL=33, PL=13, PI=20 P_{200}=18.8%
	2.5	SM	SILTY SAND, fine- to coarse-grained, brown, wet to moist, very loose to dense. (Alluvium)	3/2/3		15.7	
				14/20/30		2.5	
	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 1/2' immediately after withdrawal of auger.				

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LOG OF BORING

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

BORING: **ST-21**
LOCATION:
Lake Helena Drive, see attached sketch.

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

Elev.	Depth	Symbol	Description of Materials	BPF	WL	MC (%)	Remarks
	0.0		FILL: 5 3/4" of Asphalt Pavement.				
	0.5		FILL: 4 3/4" of Gravel Base.				
	0.9	SM	SILTY SAND, fine-grained, trace Clay, brown, wet, loose. (Alluvium)	8/5/5 3/2/2		17.5 34.2	
	3.0	CL	SANDY LEAN CLAY, low plasticity, brown, wet, rather soft. (Alluvium)				
	4.5	SM	SILTY SAND, fine-grained, brown, rather dry, loose. (Alluvium)	3/5/3		4.7	
	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 1/2' immediately after withdrawal of auger.				

BORING BPF WL MC 2560.GPJ LAGNNN06.GDT 10/2/09

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LOG OF BORING

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

BORING: **ST-22**

LOCATION: Lake Helena Drive, see attached sketch.

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

Elev.	Depth	Symbol	Description of Materials	BPF	WL	MC (%)	Remarks
	0.0		FILL: 3 3/4" of Asphalt Pavement.				
	0.3		FILL: 5 3/4" of Gravel Base.				
	0.9	SC	CLAYEY SAND, fine- to coarse-grained, low plasticity, trace lenses of Lean Clay, brown, moist, medium dense. (Alluvium)	7/9/9		5.7	Composite subgrade bag sample ST-20 and ST-22: LL=33, PL=13, PI=20 P_{200}=18.8%
				6/8/6		11.2	
	3.5	CL	SANDY LEAN CLAY, low plasticity, brown, moist, rather stiff. (Alluvium)	3/6/6		8.9	
	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 1/2' immediately after withdrawal of auger.				

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LOG OF BORING

PROJECT: 09-2560 **PAVEMENT DESIGN** Lewis and Clark County Roads Helena, Montana	BORING: **ST-23** LOCATION: Lake Helena Drive, see attached sketch.

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

Elev.	Depth 0.0	Symbol	Description of Materials	BPF	WL	MC (%)	Remarks
	0.3		FILL: 3 1/2" of Asphalt Pavement.				
	0.5		FILL: 3" of Gravel Base.				
	1.5	GM	SILTY GRAVEL, fine- to coarse-grained, light brown, moist, medium dense. (Alluvium)	2/12/9		7.6	
	5.5	SM	SILTY SAND, fine-grained, brown, moist, loose to medium dense. (Alluvium)	6/8/8		6.8	
				3/3/4		10.21	

END OF BORING

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

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

BORING BPF WL MC 2560.GPJ LAGNNN06.GDT 10/2/09

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LOG OF BORING

PROJECT: 09-2560 **PAVEMENT DESIGN** Lewis and Clark County Roads Helena, Montana	BORING: **ST-24** LOCATION: Lake Helena Drive, see attached sketch.

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

Elev.	Depth 0.0	Symbol	Description of Materials	BPF	WL	MC (%)	Remarks
		SC	CLAYEY SAND with GRAVEL, fine- to coarse-grained, low plasticity, light brown, moist, medium dense to dense. (Alluvium)				Note: No asphalt pavement encountered.
				11/20/12		4.2	Composite subgrade bag sample ST-24 and ST-25: LL=22, PL=14, PI=8 P_{200}=29.9%
				7/8/6		5.9	
				3/7/5		5.7	
	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 10/2/09

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LOG OF BORING

PROJECT: 09-2560 **PAVEMENT DESIGN** Lewis and Clark County Roads Helena, Montana	BORING: **ST-25** LOCATION: Lake Helena Drive, see attached sketch.

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

Elev.	Depth 0.0	Symbol	Description of Materials	BPF	WL	MC (%)	Remarks
	0.3		FILL: 3" Gravel Surfacing.				
		SC	CLAYEY SAND with GRAVEL, fine- to coarse-grained, low plasticity, light brown, wet, loose to dense. (Alluvium)	15/22/15		4.6	Composite subgrade bag sample ST-24 and ST-25: LL=22, PL=14, PI=8 P_{200}=29.9%
				12/10/7		3.3	
	5.5			4/4/5		8.4	
			END OF BORING Water not observed with 4' of hollow-stem auger in the ground. Water not observed to dry cave-in depth of 1 1/2' immediately after withdrawal of auger.				

BORING BPF WL MC 2560.GPJ LAGNNN06.GDT 10/2/09

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LOG OF BORING

PROJECT: 09-2560 **PAVEMENT DESIGN** Lewis and Clark County Roads Helena, Montana	BORING: **ST-26** LOCATION: Lake Helena Drive, see attached sketch.

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

Elev.	Depth	Symbol	Description of Materials	BPF	WL	MC (%)	Remarks
	0.0						
	0.1		FILL: 1 3/4" of Asphalt Pavement.				
	0.7		FILL: 6 1/4" of Gravel Base.				
		SM	SILTY SAND, fine-grained, trace Gravel, intermixed layers of Silty Sand and Sandy Lean Clay, brown, wet, loose to very loose. (Alluvium)	9/5/5		24.9	
				3/3/2		16.9	
				1/1/2		27.9	
	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 1/2' immediately after withdrawal of auger.				

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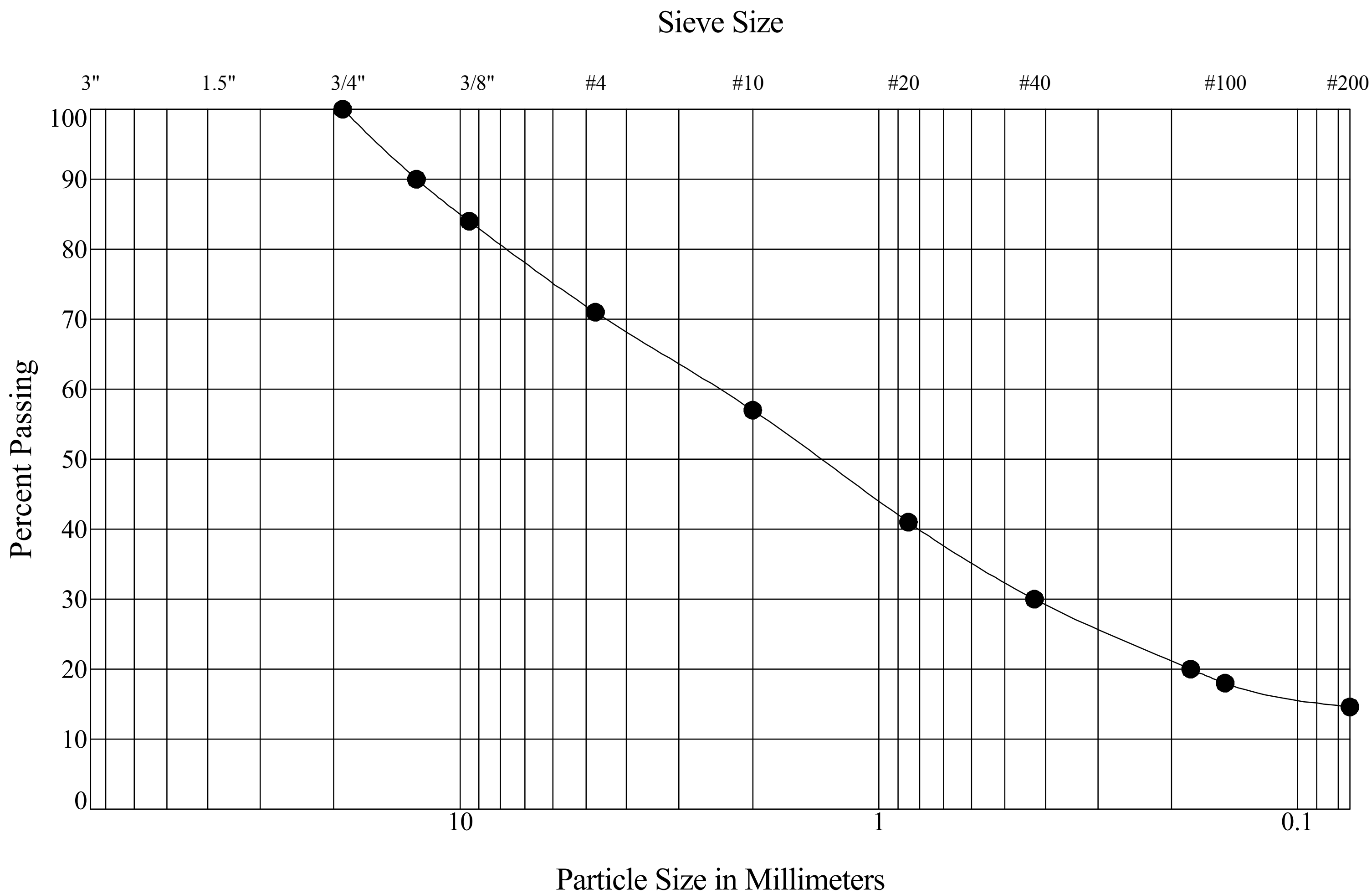
LOG OF BORING

PROJECT: 09-2560 **PAVEMENT DESIGN** Lewis and Clark County Roads Helena, Montana	BORING: **ST-26** LOCATION: Lake Helena Drive, see attached sketch.

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

Elev.	Depth	Symbol	Description of Materials	BPF	WL	MC (%)	Remarks
	0.0						
	0.1		FILL: 1 3/4" of Asphalt Pavement.				
	0.7		FILL: 6 1/4" of Gravel Base.				
		SM	SILTY SAND, fine-grained, trace Gravel, intermixed layers of Silty Sand and Sandy Lean Clay, brown, wet, loose to very loose. (Alluvium)	9/5/5		24.9	
				3/3/2		16.9	
				1/1/2		27.9	
	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 1/2' immediately after withdrawal of auger.				

BORING BPF WL MC 2560.GPJ LAGNNN06.GDT 10/2/09



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	84	71	57	41	30	20	18	14.6

Boring No.: ST-16 Date Received: 07/15/2009
Sample No.: ---
Depth: Base Course

Percent Gravel: 29.0
Percent Sand: 56.4
Percent Silt + Clay: 14.6
ASTM Group Name: SILTY SAND with GRAVEL

Liquid Limit:	NP
Plastic Limit:	NP
Plasticity Index:	NP
Classification:	SM
Moisture Content:	5.2%

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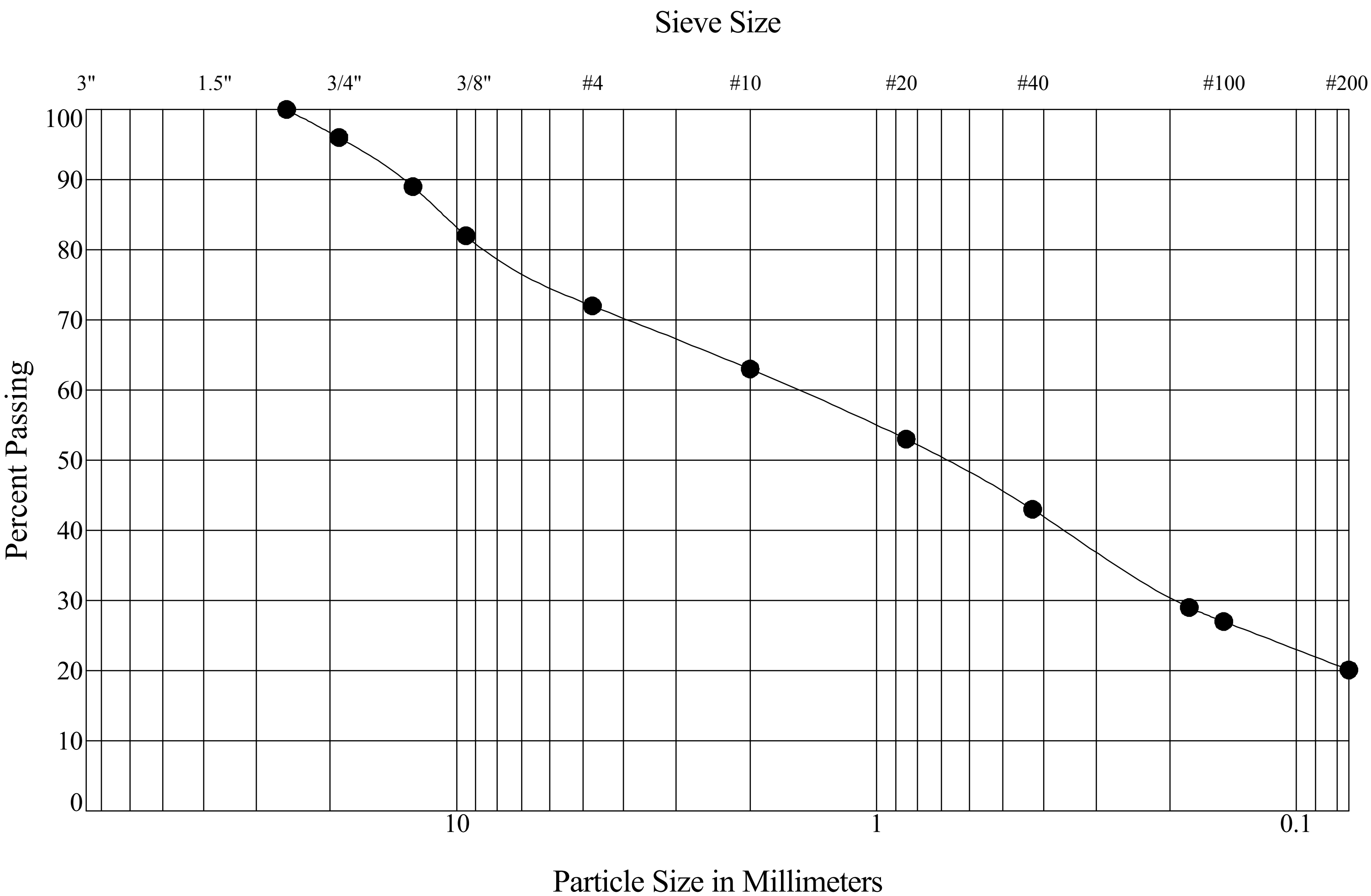
Sieve Analysis

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

10/2/09



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
		96	82	72	63	53	43	29	27	20.1

Boring No.: ST-16 and ST-18 Date Received: 07/15/2009
Sample No.: P-8
Depth: Subgrade

Percent Gravel: 28.0
Percent Sand: 51.9
Percent Silt + Clay: 20.1
ASTM Group Name: CLAYEY SAND with GRAVEL

Liquid Limit:	28
Plastic Limit:	15
Plasticity Index:	13
Classification:	SC
Moisture Content:	

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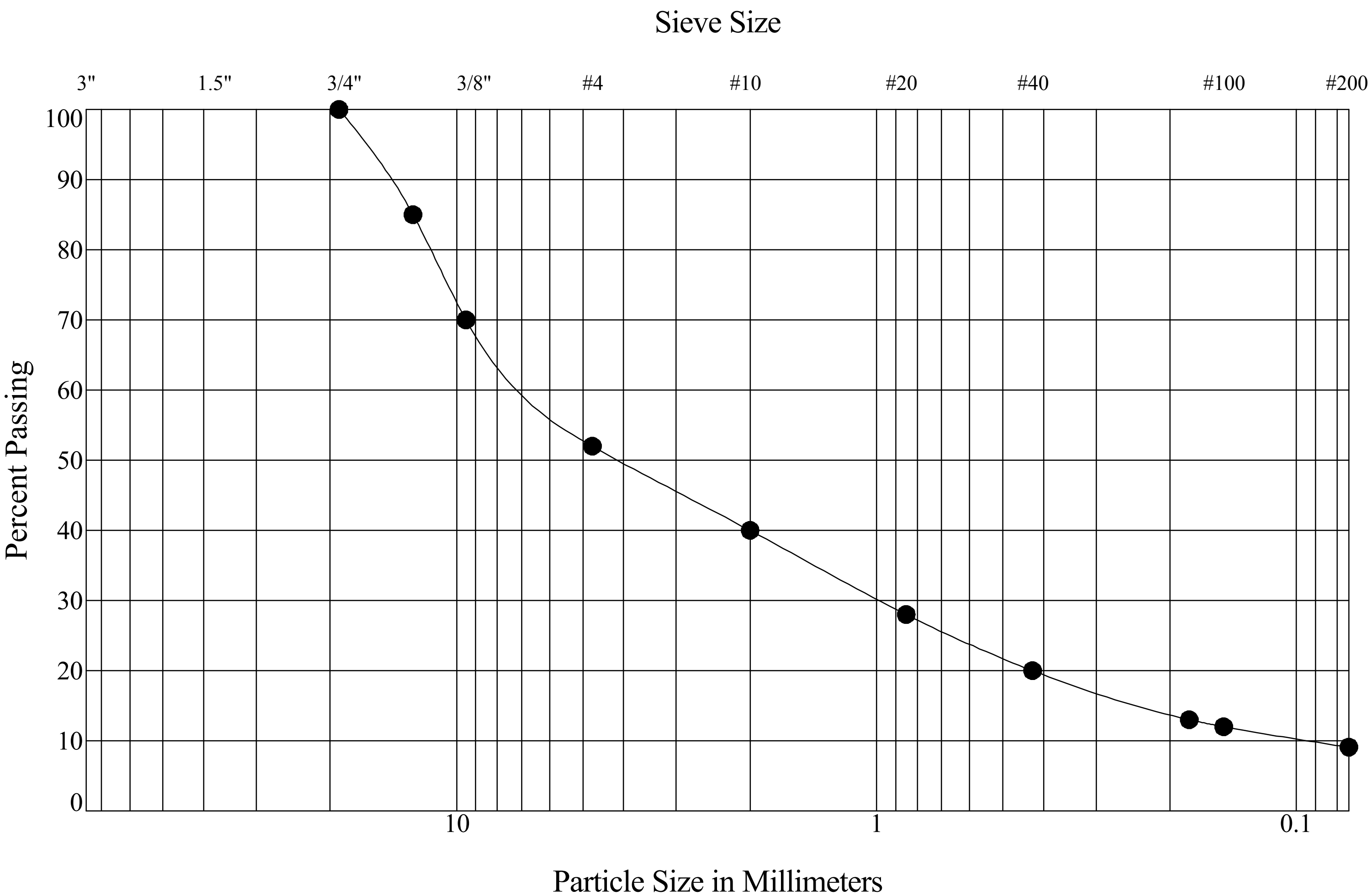
Sieve Analysis
Project Number: 09-2560
Lewis and Clark County Roads
Helena, Montana

10/2/09



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	70	52	40	28	20	13	12	9.1

Boring No.: ST-18 Date Received: 07/15/2009
Sample No.: ---
Depth: Base Course

Liquid Limit:	NP
Plastic Limit:	NP
Plasticity Index:	NP
Classification:	GW-GM
Moisture Content:	3.3%

Percent Gravel: 48.0
Percent Sand: 42.9
Percent Silt + Clay: 9.1
ASTM Group Name: WELL-GRADED GRAVEL with SILT and SAND

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Sieve Analysis
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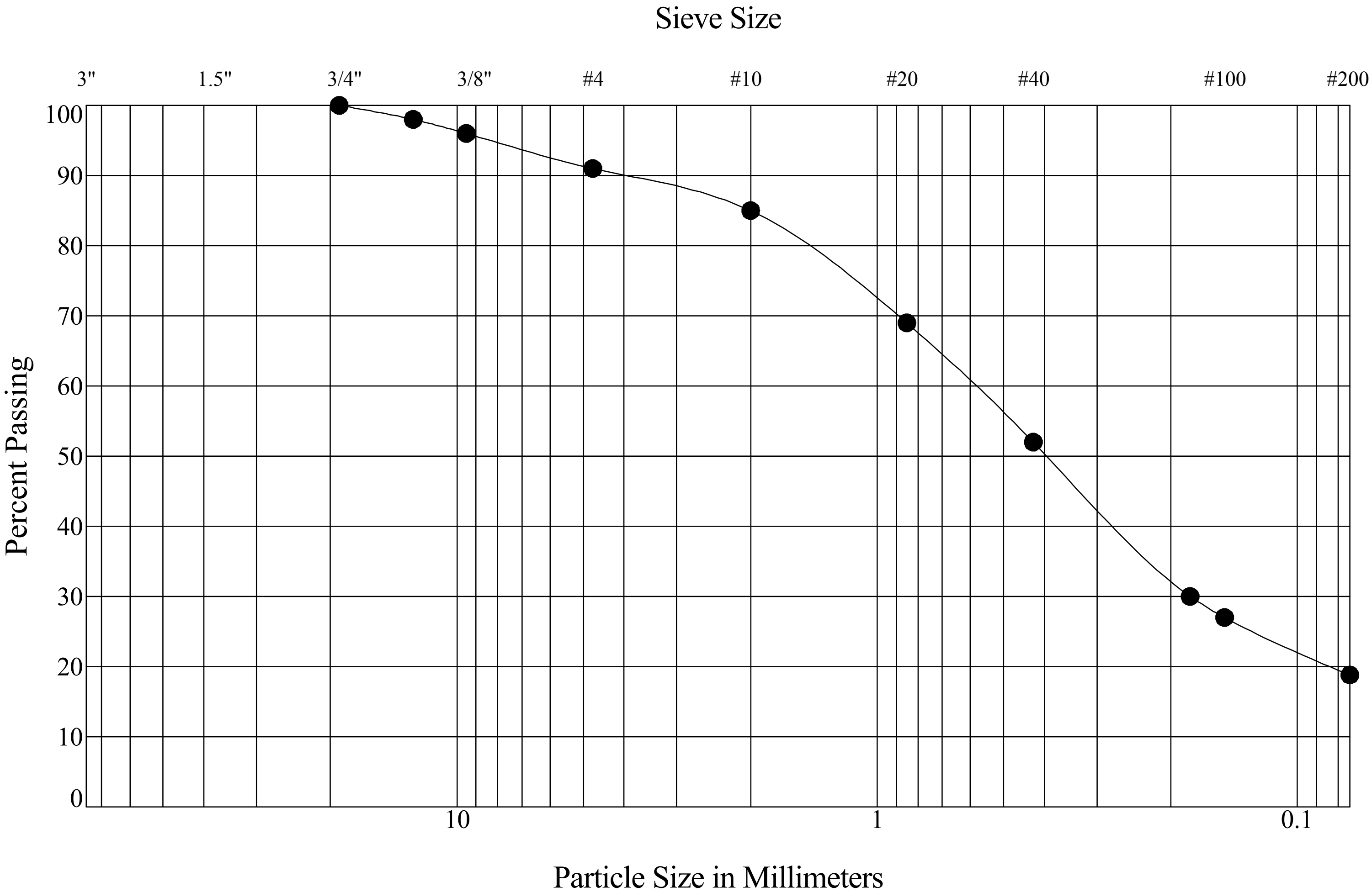
Helena, Montana

10/2/09



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	96	91	85	69	52	30	27	18.8

Boring No.: ST-20 and ST-22 Date Received: 07/15/2009
Sample No.: P-9
Depth: Subgrade

Percent Gravel: 9.0
Percent Sand: 72.2
Percent Silt + Clay: 18.8
ASTM Group Name: CLAYEY SAND

Liquid Limit:	33
Plastic Limit:	13
Plasticity Index:	20
Classification:	SC
Moisture Content:	

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Sieve Analysis
Project Number: 09-2560
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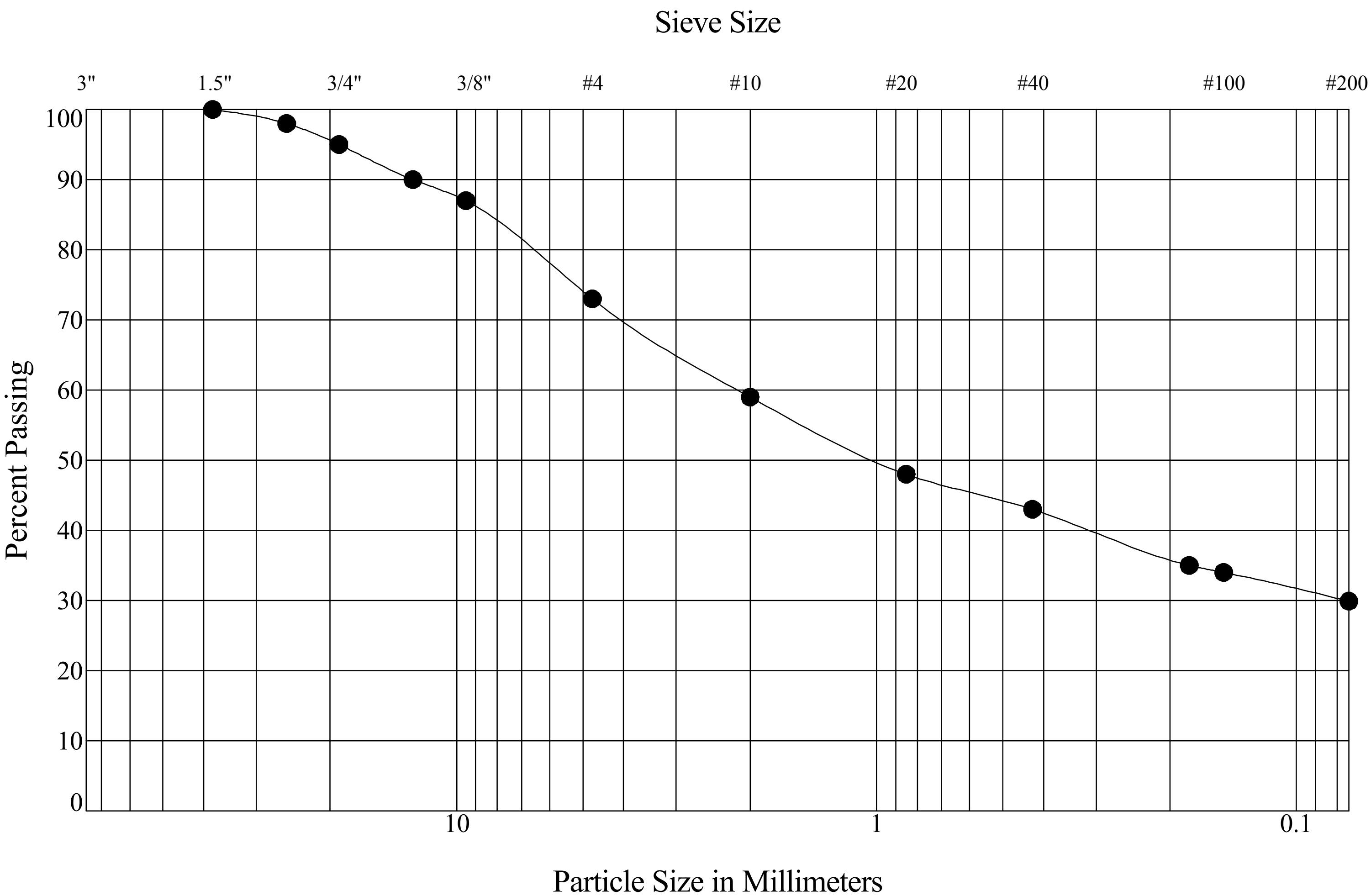
Helena, Montana

10/2/09



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	95	87	73	59	48	43	35	34	29.9

Boring No.: ST-24 and ST-25 Date Received: 07/15/2009
Sample No.: P-10
Depth: Subgrade

Liquid Limit:	22
Plastic Limit:	14
Plasticity Index:	8
Classification:	SC
Moisture Content:	

Percent Gravel: 27.0
Percent Sand: 43.1
Percent Silt + Clay: 29.9
ASTM Group Name: CLAYEY SAND with GRAVEL

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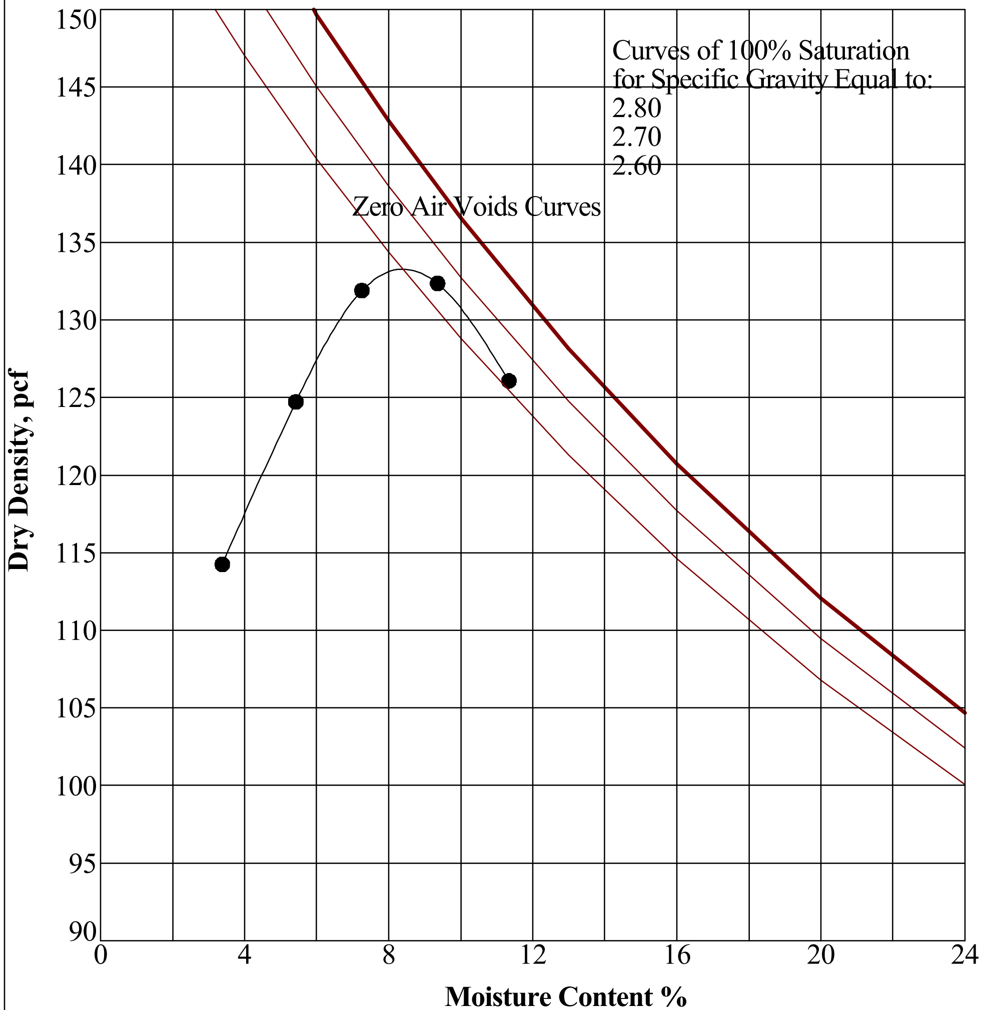
Helena, Montana

10/2/09



ASTM D 698 Method C

Maximum Dry Density, pcf	Optimum Moisture Content %
133.2	**8.5**

Rammer Type: Mechanical
Preparation Method: Moist

Soil Description (Visual-Manual)

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

Sieve Size	% Retained
1 1/2"	0
3/4"	4
3/8"	18
#4	28

Sample No:	---
Lab Sample No:	P-8
Date Sampled:	07/07/2009
Sampled By:	Drill Crew
Date Received:	07/15/2009
Sampled From:	ST-16 and ST-18 Lake Helena Drive
Depth:	Subgrade
Performed by:	MBK/SKG
Date Performed:	08/03/2009

Comments

Remarks

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

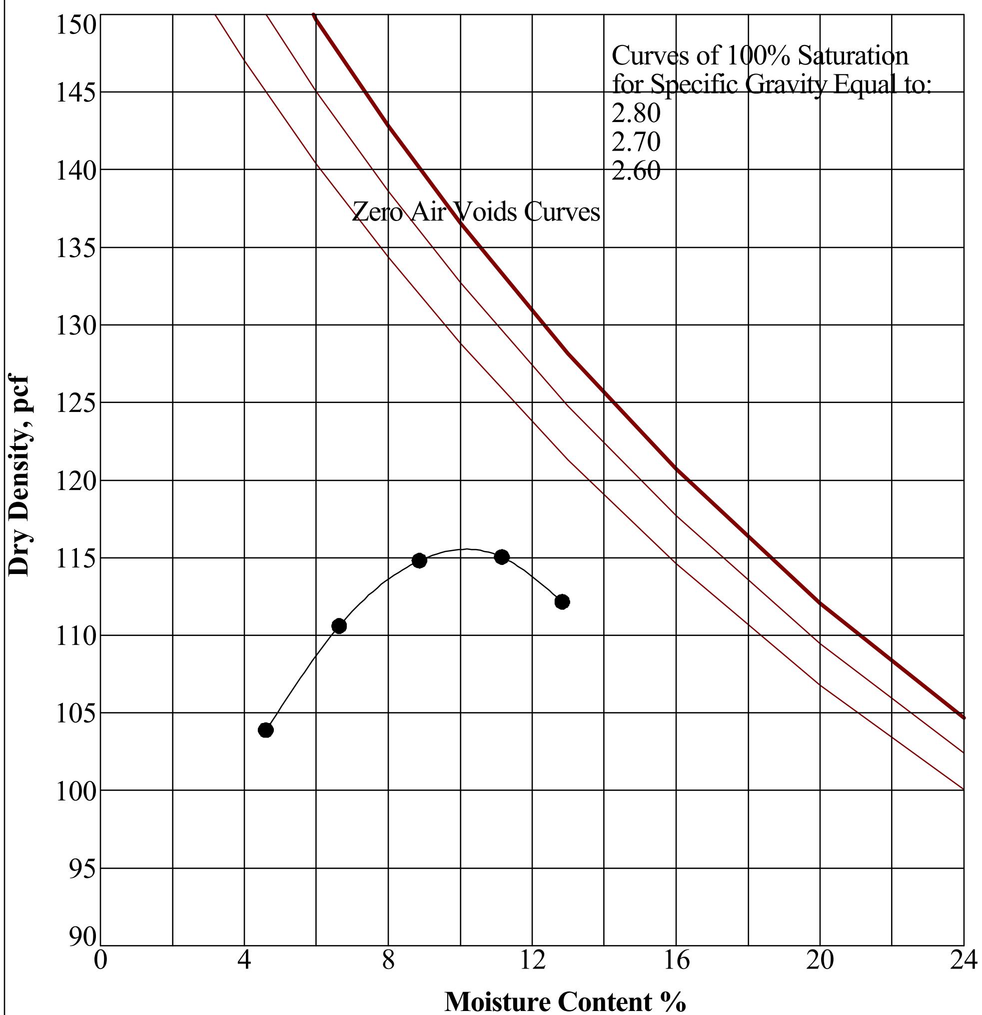
Laboratory Compaction Characteristics of Soil (Proctor)

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

PROCTOR

P-8

10/2/09



ASTM D 698 Method C

Maximum Dry Density, pcf	Optimum Moisture Content %
115.8	**10.1**

Rammer Type: Mechanical
Preparation Method: Moist

Soil Description (Visual-Manual)

CLAYEY SAND, fine- to coarse-grained, low plasticity, trace Gravel, brown, moist.

Sieve Size	% Retained
1 1/2"	0
3/4"	0
3/8"	4
#4	9

Sample No:	---
Lab Sample No:	P-9
Date Sampled:	07/07/2009
Sampled By:	Drill Crew
Date Received:	07/15/2009
Sampled From:	ST-20 and ST-22 Lake Helena Drive
Depth:	Subgrade
Performed by:	MBK/SKG
Date Performed:	08/03/2009

Comments

Remarks

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

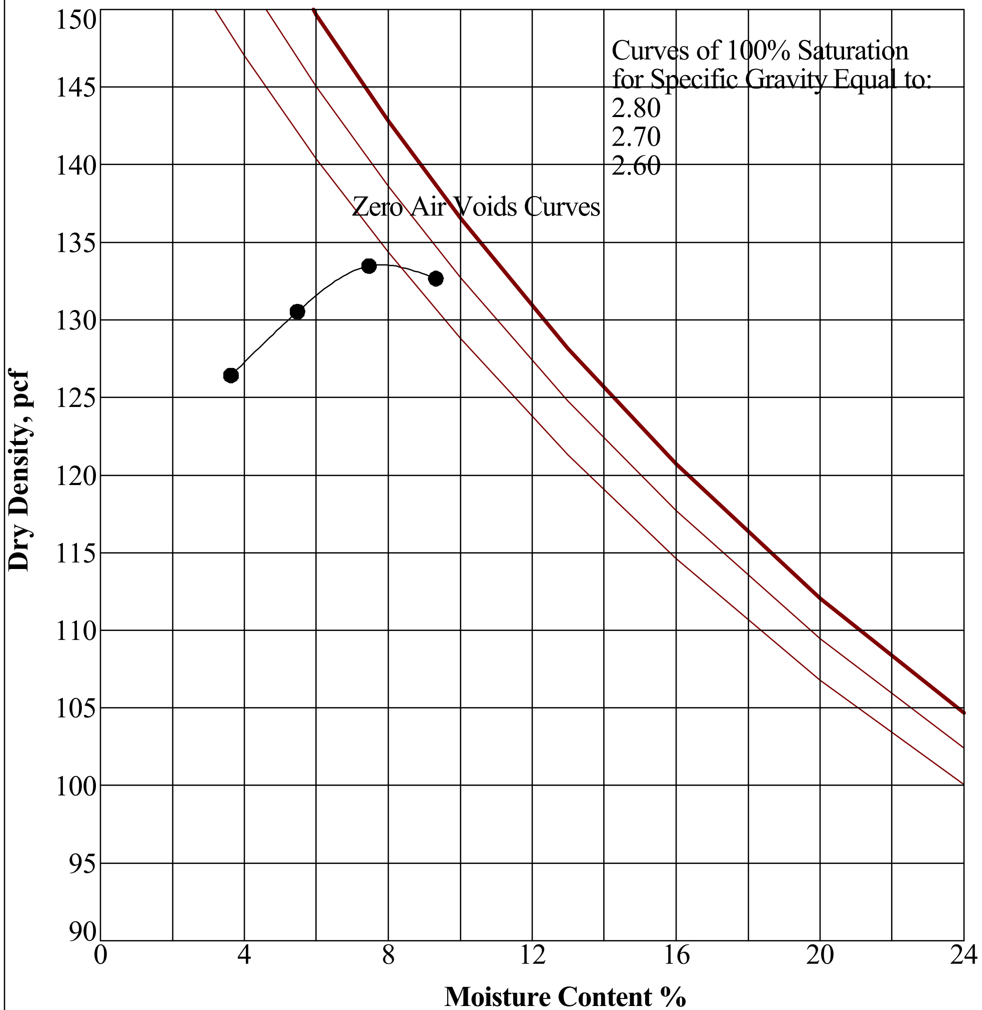
Laboratory Compaction Characteristics of Soil (Proctor)

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

PROCTOR

P-9

10/2/09



ASTM D 4718 Oversize Correction

Maximum Dry Density, pcf	***Optimum Moisture Content %***
134.6	***7.1***

ASTM C 127

Coarse Specific Gravity = 2.46
Absorption = 2.0%

Fine Portion

ASTM D 698 Method C with Correction

Maximum Dry Density, pcf	Optimum Moisture Content %
133.6	7.4

Rammer Type: Mechanical

Preparation Method: Moist

Soil Description (Visual-Manual)

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

Sieve Size	**% Retained**
1 1/2"	0
3/4"	5.3
3/8"	13
#4	27

Sample No:	---
Lab Sample No:	P-10
Date Sampled:	07/07/2009
Sampled By:	Drill Crew
Date Received:	07/15/2009
Sampled From:	ST-24 and ST-25 Lake Helena Drive
Depth:	Subgrade
Performed by:	MBK/SKG
Date Performed:	08/06/2009

Comments

Additional Remarks

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

Laboratory Compaction Characteristics of Soil (Proctor)

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

PROCTOR

P-10

10/2/09

California Bearing Ratio Test

(ASTM D 1883 /AASHTO T 193)

Project: 09-2560 Lewis and Clark County Roads
Lake Helena Drive

Date: 10/02/09

Boring: ST-24 and ST-25 **Sample:** P-10 **Depth:** Subgrade

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

Maximum Dry Density: 133.6 pcf Procedure: ASTM D 698 Method C

Initial			**Final**		
Wt. Specimen + Tare Wet	559.1	gms	Wt. Specimen + Tare Wet	1219.8	gms
Wt. Specimen + Tare Dry	527.9	gms	Wt. Specimen + Tare Dry	1124.8	gms
Wt. Tare	146.7	gms	Wt. Tare	270.5	gms
Moisture Content	8.2%		Moisture Content	11.1%	

Initial Wt. 4650.9 gms Diameter 6.00 in Initial Ht. 4.58 in

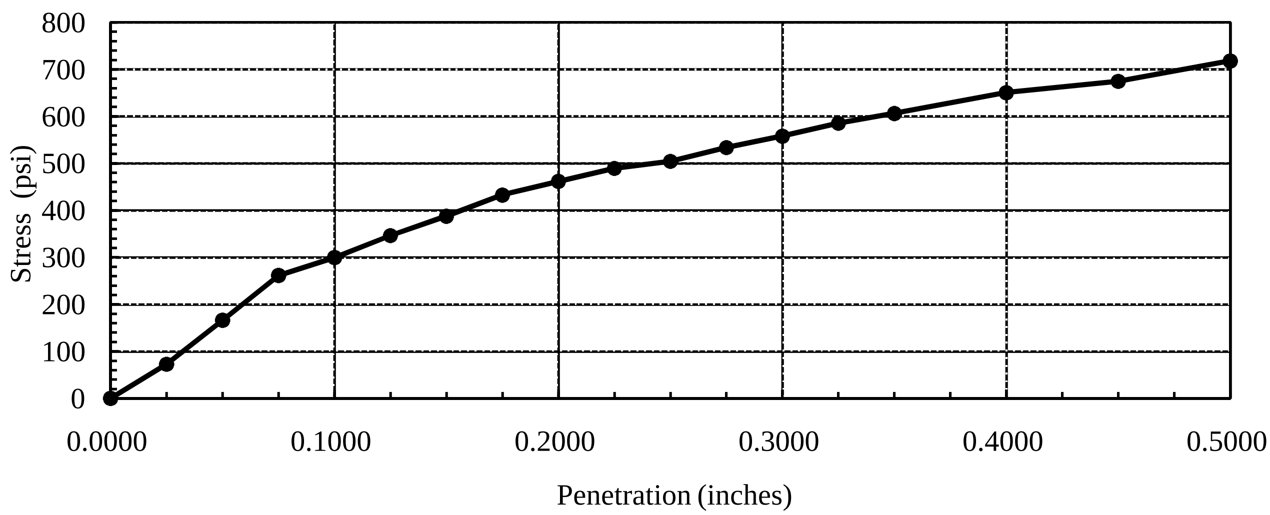
Initial Dry Unit Wt. 126.5 pcf Initial Relative Compaction 94.7%
Final Dry Unit Wt. 126.4 pcf Final Relative Compaction 94.6%

Swell Test

Surcharge Weight 22.5 lbs Surcharge Pressure 133.4 psf
Initial Dial Rdg. 0.5000 Final Dial Rdg. 0.5015 Swell 0.0%

CBR Test

Surcharge Weight 22.5 lbs Surcharge Pressure 128.1 psf
CBR @ 0.1 in. **30.0** CBR @ 0.2 in **30.8**



California Bearing Ratio Test

(ASTM D 1883 /AASHTO T 193)

Project: 09-2560 Lewis and Clark County Roads
Lake Helena Drive

Date: 10/02/09

Boring: ST-16 and ST-18 **Sample:** P-8 **Depth:** Subgrade

Sample Description: Clayey Sand with Gravel, fine- to coarse-grained, low plasticity, brown, moist.
(Remolded to 95% relative compaction.)
(Sample was submersed in water and allowed to saturate for 96.5 hours.)

Maximum Dry Density: 133.2 pcf Procedure: ASTM D 698 Method C

Initial			**Final**		
Wt. Specimen + Tare Wet	595.3	gms	Wt. Specimen + Tare Wet	996.6	gms
Wt. Specimen + Tare Dry	562.5	gms	Wt. Specimen + Tare Dry	925.4	gms
Wt. Tare	186.7	gms	Wt. Tare	281.9	gms
Moisture Content	8.7%		Moisture Content	11.1%	

Initial Wt. 4679.4 gms Diameter 6.00 in Initial Ht. 4.58 in

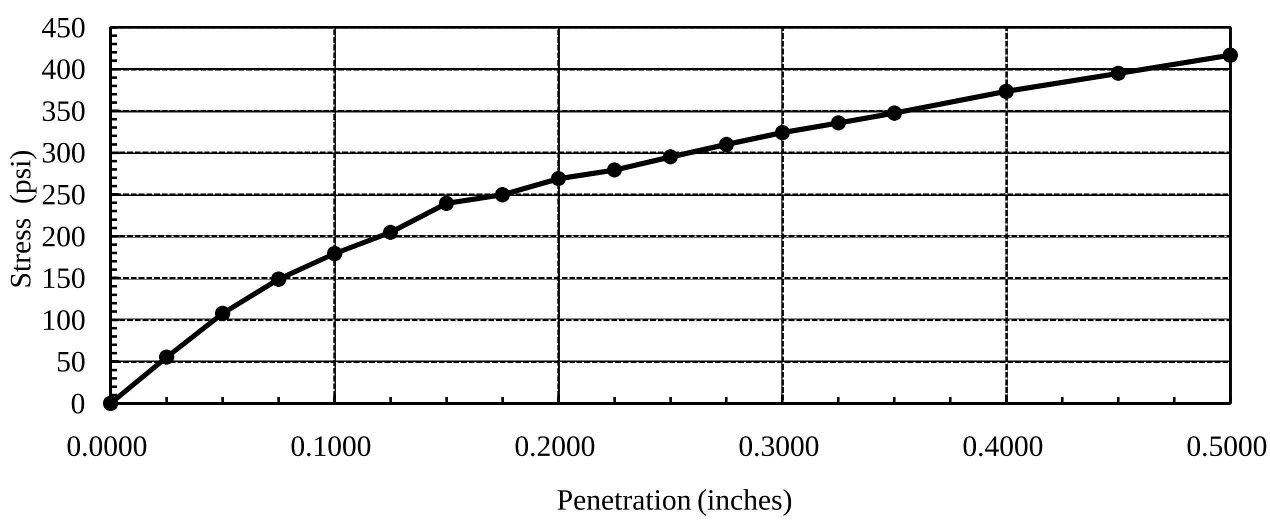
Initial Dry Unit Wt. 126.6 pcf Initial Relative Compaction 95.1%
Final Dry Unit Wt. 126.5 pcf Final Relative Compaction 95.0%

Swell Test

Surcharge Weight 22.5 lbs Surcharge Pressure 133.4 psf
Initial Dial Rdg. 0.5000 Final Dial Rdg. 0.5025 Swell 0.1%

CBR Test

Surcharge Weight 22.5 lbs Surcharge Pressure 128.1 psf
CBR @ 0.1 in. **17.9** CBR @ 0.2 in **17.9**



California Bearing Ratio Test

(ASTM D 1883 /AASHTO T 193)

Project: 09-2560 Lewis and Clark County Roads
Lake Helena Drive

Date: 10/02/09

Boring: ST-20 and ST-22 **Sample:** P-9 **Depth:** Subgrade

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

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

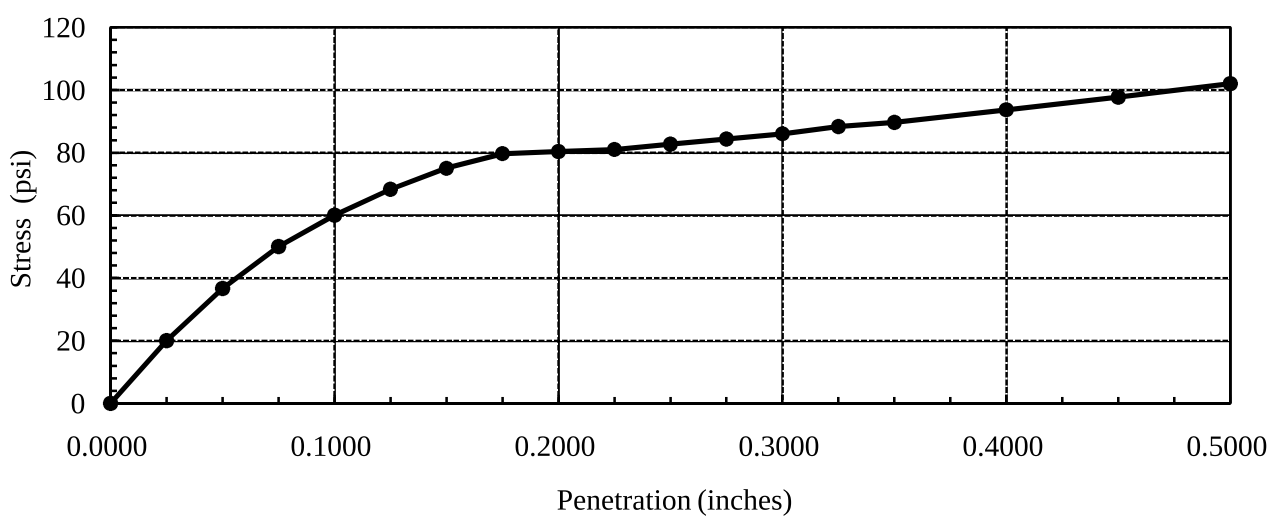
Initial			**Final**		
Wt. Specimen + Tare Wet	438.4	gms	Wt. Specimen + Tare Wet	1321.8	gms
Wt. Specimen + Tare Dry	408.8	gms	Wt. Specimen + Tare Dry	1202.1	gms
Wt. Tare	147.2	gms	Wt. Tare	298.1	gms
Moisture Content	11.3%		Moisture Content	13.2%	

Initial Wt. 4165.4 gms Diameter 6.00 in Initial Ht. 4.58 in

Initial Dry Unit Wt. 110.1 pcf Initial Relative Compaction 95.1%
Final Dry Unit Wt. 109.6 pcf Final Relative Compaction 94.7%

Swell Test
Surcharge Weight 22.5 lbs Surcharge Pressure 133.4 psf
Initial Dial Rdg. 0.5000 Final Dial Rdg. 0.5191 Swell 0.4%

CBR Test
Surcharge Weight 22.5 lbs Surcharge Pressure 128.1 psf
CBR @ 0.1 in. **6.0** CBR @ 0.2 in **5.4**



Laboratory Test of Aggregate

Date: October 2, 2009

Project: **09-2560 Pavement Evaluation**
Lake Helena 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-16 Base Course**	**ST-18 Base Course**	**Crushed Top Surfacing**	**Select Base Course**
1 1/2"	---	---	---	100
3/4"	100	100	100	---
1/2"	90	85	---	---
No. 4	71*	52	40 – 70	25 – 60
No. 10	57*	40	25 – 55	---
No. 40	30	20	---	---
No. 100	18	12	---	---
No. 200	14.6*	9.1	2 – 10	2 – 12

Remarks: *Do not meet specifications.

BILLINGS
2611 Gabel Road
P.O. Box 80190
Billings, MT 59108-0190
P 406.652.3930
F 406.652.3944

skgeotechnical.com

MISSOULA
4041 Whippoorwill Drive
P.O. Box 16123
Missoula, MT 59808-6123
P 406.721.3391
F 406.721.6233

Basic Axle Class Summary: 7A-65 CLASS

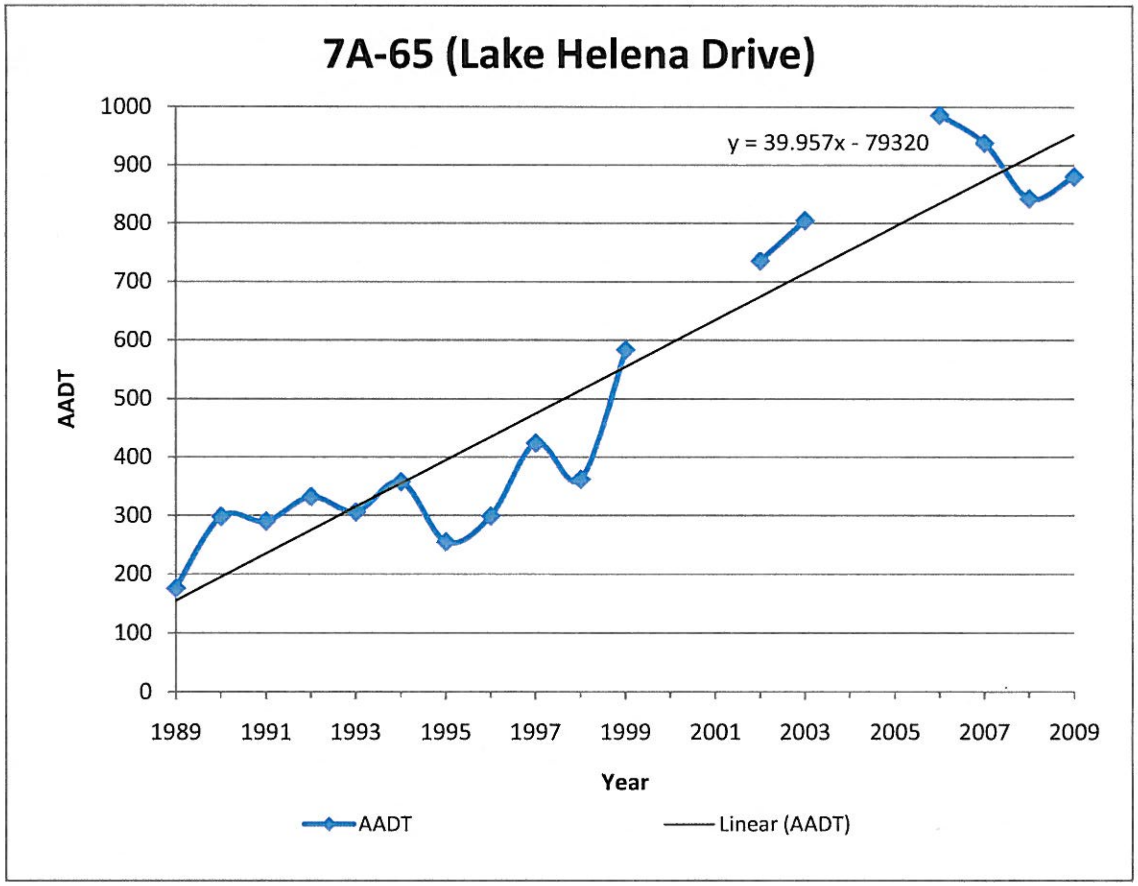
(DEFAULTB) Description	Lane	#1 Cycle	#2 Cars	#3 2A-4T	#4 Buses	#5 2A-SU	#6 3A-SU	#7 4A-SU	#8 4A-ST	#9 5A-ST	#10 6A-ST	#11 5A-MT	#12 6A-MT	#13 Other	Total
TOTAL COUNT :	#1.	12	413	441	0	10	6	1	20	5	12	4	0	5	929
	#3.	14	453	443	0	8	10	1	20	3	8	9	1	1	971
		26	866	884	0	18	16	2	40	8	20	13	1	6	1900
Percents :	#1.	1%	44%	47%	0%	1%	1%	0%	2%	1%	1%	0%	0%	1%	49%
	#3.	1%	47%	46%	0%	1%	1%	0%	2%	0%	1%	1%	0%	0%	51%
		1%	46%	47%	0%	1%	1%	0%	2%	0%	1%	1%	0%	0%	
Average :	#1.	0	9	10	0	0	0	0	0	0	0	0	0	0	19
	#3.	0	10	10	0	0	0	0	0	0	0	0	0	0	20
		0	19	20	0	0	0	0	0	0	0	0	0	0	39
Days & ADT :	#1.	1.9	484												
	#3.	1.9	506												
		1.9	991												

N. of York Rd.

7A-65 (Lake Helena Drive - North of Deal Lane)

Year	AADT
1989	176
1990	298
1991	290
1992	332
1993	306
1994	358
1995	255
1996	299
1997	424
1998	362
1999	583
2000	
2001	
2002	735
2003	804
2004	
2005	
2006	986
2007	938
2008	842
2009	880
2029	**1753**

2009	954
2029	1753
Yearly Growth Rate	**3.09%**



DARWin(tm) - Pavement Design

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N. of York Rd.

Flexible Structural Design Module

Project Description
Lake Helena Drive, North of Deal Lane, Lewis and Clark County, Helena, Montana

Flexible Structural Design Module Data

18-kip ESALs Over Initial Performance Period:	157,725
Initial Serviceability:	4.2
Terminal Serviceability:	2.5
Reliability Level (%):	85
Overall Standard Deviation:	.45
Roadbed Soil Resilient Modulus (PSI):	8,300
Stage Construction:	1
Calculated Structural Number:	2.36

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):	6.00
Calculated Layer SN:	.38
Total Thickness (in):	18.00
Total Calculated SN:	2.41

Rigorous ESAL Calculation

Initial Performance Period (years):	20
Initial Two-Way Daily Traffic (ADT):	954
Number of Lanes In Design Direction:	1
Percent of All Trucks In Design Lane (%):	50
Percent Trucks In Design Direction (%):	100
Growth:	Simple

N. of York Rd

Class: 1
% of ADT: 1.36
Annual % Growth: 3.09
Average Initial Truck Factor (ESALs/truck): .0001
Annual % Growth in Truck Factor: 0
Accumulated 18K ESALs over Performance Period: 6

Class: 2
% of ADT: 46.23
Annual % Growth: 3.09
Average Initial Truck Factor (ESALs/truck): .0003
Annual % Growth in Truck Factor: 0
Accumulated 18K ESALs over Performance Period: 625

Class: 3
% of ADT: 46.52
Annual % Growth: 3.09
Average Initial Truck Factor (ESALs/truck): .004
Annual % Growth in Truck Factor: 0
Accumulated 18K ESALs over Performance Period: 8,387

Class: 4
% of ADT: 0
Annual % Growth: 3.09
Average Initial Truck Factor (ESALs/truck): .57
Annual % Growth in Truck Factor: 0
Accumulated 18K ESALs over Performance Period: 0

Class: 5
% of ADT: .94
Annual % Growth: 3.09
Average Initial Truck Factor (ESALs/truck): .26
Annual % Growth in Truck Factor: 0
Accumulated 18K ESALs over Performance Period: 11,016

Class: 6
% of ADT: .84
Annual % Growth: 3.09
Average Initial Truck Factor (ESALs/truck): .42
Annual % Growth in Truck Factor: 0
Accumulated 18K ESALs over Performance Period: 15,902

Class: 7
% of ADT: .1
Annual % Growth: 3.09
Average Initial Truck Factor (ESALs/truck): .42
Annual % Growth in Truck Factor: 0
Accumulated 18K ESALs over Performance Period: 1,893

Class: 8
% of ADT: 2.1
Annual % Growth: 3.09
Average Initial Truck Factor (ESALs/truck): .3
Annual % Growth in Truck Factor: 0
Accumulated 18K ESALs over Performance Period: 28,396

Class: 9
% of ADT: .42
Annual % Growth: 3.09
Average Initial Truck Factor (ESALs/truck): 1.2
Annual % Growth in Truck Factor: 0
Accumulated 18K ESALs over Performance Period: 22,717

Class: 10
% of ADT: 1.05
Annual % Growth: 3.09
Average Initial Truck Factor (ESALs/truck): .93
Annual % Growth in Truck Factor: 0
Accumulated 18K ESALs over Performance Period: 44,014

N. of York Rd.

Class: 11
% of ADT: .08
Annual % Growth: 3.09
Average Initial Truck Factor (ESALs/truck): .82
Annual % Growth in Truck Factor: 0
Accumulated 18K ESALs over Performance Period: 2,957

Class: 12
% of ADT: .05
Annual % Growth: 3.09
Average Initial Truck Factor (ESALs/truck): 1.06
Annual % Growth in Truck Factor: 0
Accumulated 18K ESALs over Performance Period: 2,389

Class: 13
% of ADT: .31
Annual % Growth: 3.09
Average Initial Truck Factor (ESALs/truck): 1.39
Annual % Growth in Truck Factor: 0
Accumulated 18K ESALs over Performance Period: 19,422

Total % of ADT (should be 100): 100.00
Cumulative Esals for all Classes: 157,725

Lake Helena Drive, N. of Canyon Ferry Rd (Representative of S. of York Rd)

Basic Axle Class Summary: 7A-69

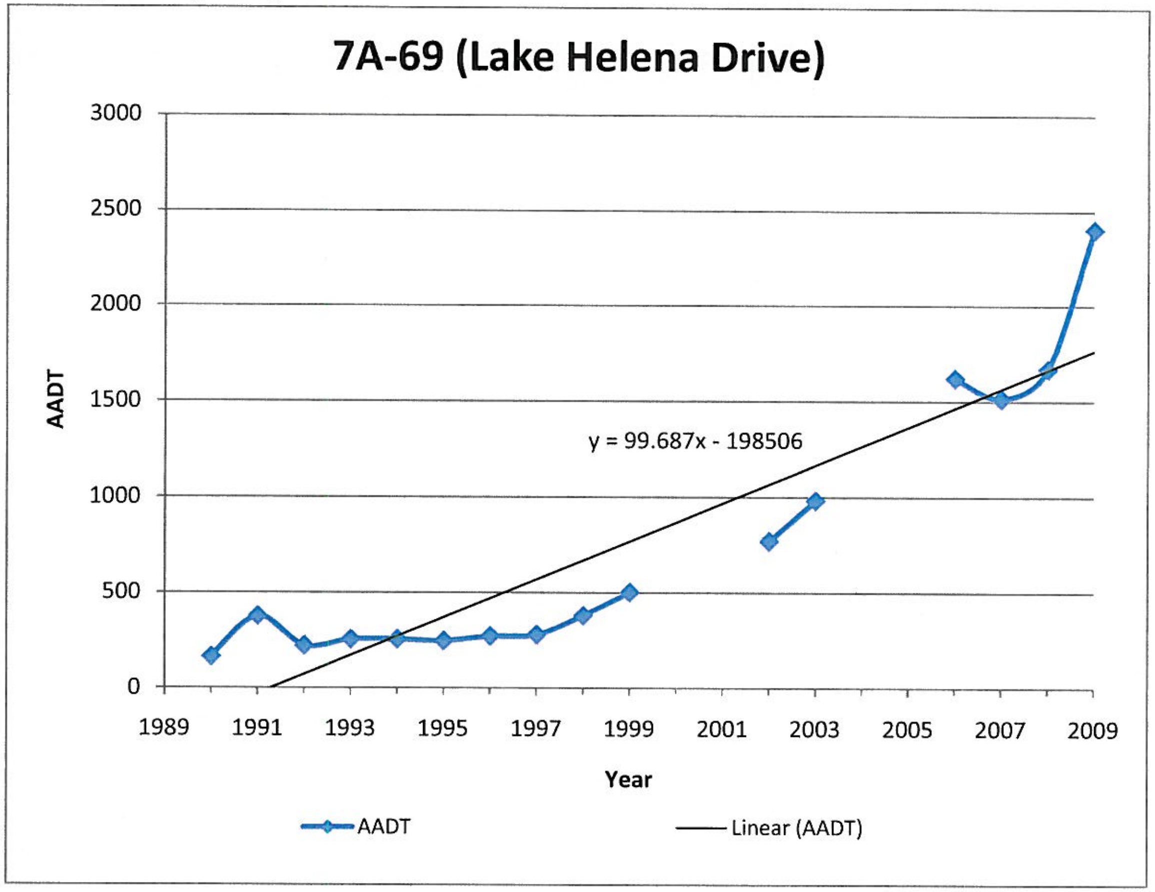
(DEFAULTB) Description	Lane	#1 Cycle	#2 Cars	#3 2A-4T	#4 Buses	#5 2A-SU	#6 3A-SU	#7 4A-SU	#8 4A-ST	#9 5A-ST	#10 6A-ST	#11 5A-MT	#12 6A-MT	#13 Other	Total
TOTAL COUNT :	#1.	8	456	270	0	6	3	0	11	1	0	0	0	0	755
	#2.	36	1188	792	1	6	19	4	25	1	3	3	1	3	2082
		44	1644	1062	1	12	22	4	36	2	3	3	1	3	2837
Percents :	#1.	1%	60%	36%	0%	1%	0%	0%	1%	0%	0%	0%	0%	0%	27%
	#2.	2%	57%	38%	0%	0%	1%	0%	1%	0%	0%	0%	0%	0%	73%
		2%	58%	37%	0%	0%	1%	0%	1%	0%	0%	0%	0%	0%	
Average :	#1.	0	10	6	0	0	0	0	0	0	0	0	0	0	16
	#2.	1	26	17	0	0	0	0	1	0	0	0	0	0	45
		1	36	23	0	0	0	0	1	0	0	0	0	0	61
Days & ADT :	#1.	1.9	393												
	#2.	1.9	1086												
		1.9	1480												

S. of York Rd

7A-69 (Lake Helena Drive - North of Canyon Ferry Road)

Year	AADT
1989	
1990	163
1991	376
1992	221
1993	254
1994	255
1995	247
1996	271
1997	279
1998	379
1999	502
2000	
2001	
2002	771
2003	983
2004	
2005	
2006	1619
2007	1513
2008	1667
2009	2401
2029	**3759**

2009	1765
2029	3759
Yearly Growth Rate	**3.85%**



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DARWin(tm) - Pavement Design

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Flexible Structural Design Module

Representative of S. of York Rd.

Project Description
Lake Helena Drive, North of Canyon Ferry Road, Lewis and Clark County, Helena, Montana

Flexible Structural Design Module Data
18-kip ESALs Over Initial Performance Period: 135,454
Initial Serviceability: 4.2
Terminal Serviceability: 2.5
Reliability Level (%): 85
Overall Standard Deviation: .45
Roadbed Soil Resilient Modulus (PSI): 8,300
Stage Construction: 1

Calculated Structural Number: 2.30

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): 5.00
Calculated Layer SN: .32

Total Thickness (in): 17.00
Total Calculated SN: 2.35

Rigorous ESAL Calculation
Initial Performance Period (years): 20
Initial Two-Way Daily Traffic (ADT): 1,765
Number of Lanes In Design Direction: 1
Percent of All Trucks In Design Lane (%): 50
Percent Trucks In Design Direction (%): 100
Growth: Simple

S. of York Rd

Class: 1
% of ADT: 1.55
Annual % Growth: 3.85
Average Initial Truck Factor (ESALs/truck): .0001
Annual % Growth in Truck Factor: 0
Accumulated 18K ESALs over Performance Period: 14

Class: 2
% of ADT: 57.93
Annual % Growth: 3.85
Average Initial Truck Factor (ESALs/truck): .0003
Annual % Growth in Truck Factor: 0
Accumulated 18K ESALs over Performance Period: 1,530

Class: 3
% of ADT: 37.43
Annual % Growth: 3.85
Average Initial Truck Factor (ESALs/truck): .004
Annual % Growth in Truck Factor: 0
Accumulated 18K ESALs over Performance Period: 13,182

Class: 4
% of ADT: .04
Annual % Growth: 3.85
Average Initial Truck Factor (ESALs/truck): .57
Annual % Growth in Truck Factor: 0
Accumulated 18K ESALs over Performance Period: 2,007

Class: 5
% of ADT: .42
Annual % Growth: 3.85
Average Initial Truck Factor (ESALs/truck): .26
Annual % Growth in Truck Factor: 0
Accumulated 18K ESALs over Performance Period: 9,615

Class: 6
% of ADT: .78
Annual % Growth: 3.85
Average Initial Truck Factor (ESALs/truck): .42
Annual % Growth in Truck Factor: 0
Accumulated 18K ESALs over Performance Period: 28,844

Class: 7
% of ADT: .14
Annual % Growth: 3.85
Average Initial Truck Factor (ESALs/truck): .42
Annual % Growth in Truck Factor: 0
Accumulated 18K ESALs over Performance Period: 5,177

Class: 8
% of ADT: 1.27
Annual % Growth: 3.85
Average Initial Truck Factor (ESALs/truck): .3
Annual % Growth in Truck Factor: 0
Accumulated 18K ESALs over Performance Period: 33,545

Class: 9
% of ADT: .07
Annual % Growth: 3.85
Average Initial Truck Factor (ESALs/truck): 1.2
Annual % Growth in Truck Factor: 0
Accumulated 18K ESALs over Performance Period: 7,396

Class: 10
% of ADT: .11
Annual % Growth: 3.85
Average Initial Truck Factor (ESALs/truck): .93
Annual % Growth in Truck Factor: 0
Accumulated 18K ESALs over Performance Period: 9,007

S. of York Rd.

Class: 11
% of ADT: .11
Annual % Growth: 3.85
Average Initial Truck Factor (ESALs/truck): .82
Annual % Growth in Truck Factor: 0
Accumulated 18K ESALs over Performance Period: 7,942

Class: 12
% of ADT: .04
Annual % Growth: 3.85
Average Initial Truck Factor (ESALs/truck): 1.06
Annual % Growth in Truck Factor: 0
Accumulated 18K ESALs over Performance Period: 3,733

Class: 13
% of ADT: .11
Annual % Growth: 3.85
Average Initial Truck Factor (ESALs/truck): 1.39
Annual % Growth in Truck Factor: 0
Accumulated 18K ESALs over Performance Period: 13,462

Total % of ADT (should be 100): 100.00
Cumulative Esals for all Classes: 135,454

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

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

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

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

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

Figure 4: FHWA Class 5

Figure 5: FHWA Class 8

Figure 6: FHWA Class 11

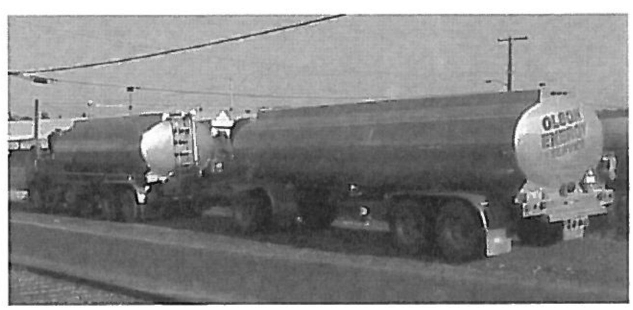

Figure 7: FHWA Class 10

Appendix C

Design Reference Exhibits

TABLE A
COUNTY ROAD DESIGN CRITERIA

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

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

Exhibit 3-2. Stopping Sight Distance on Grades

Decision Sight Distance

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

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

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

METRIC

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

US Customary

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

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

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

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

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

Exhibit 6-1. Minimum Design Speeds for Rural Collectors

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

Design speed (km/h)	Minimum width of traveled way (m) for specified design volume (veh/day)[a]			
	under 400	400 to 1500	1500 to 2000	over 2000
30	6.0[b]	6.0	6.6	7.2
40	6.0[b]	6.0	6.6	7.2
50	6.0[b]	6.0	6.6	7.2
60	6.0[b]	6.6	6.6	7.2
70	6.0	6.6	6.6	7.2
80	6.0	6.6	6.6	7.2
90	6.6	6.6	7.2	7.2
100	6.6	6.6	7.2	7.2
	Width of shoulder on each side of road (m)			
All speeds	0.6	1.5[c]	1.8	2.4

US Customary

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
20	20[b]	20	22	24
25	20[b]	20	22	24
30	20[b]	20	22	24
35	20[b]	22	22	24
40	20[b]	22	22	24
45	20	22	22	24
50	20	22	22	24
55	22	22	24	24
60	22	22	24	24
	Width of shoulder on each side of road (ft)			
All speeds	2.0	5.0[c]	6.0	8.0

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

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

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

See text for roadside barrier and offtracking considerations.

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

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

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

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

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

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

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

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

Vertical Clearance

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

Horizontal Clearance to Obstructions

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

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

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