APPENDIX E

TRAFFIC NOISE

Differences in the impacts associated with Phase 1 and the Full Buildout of the Build Alternatives are minor based on the size of the project footprint, purchased ROW, and traffic impacts. As such, there have been no changes to Appendix E between the Draft Environmental Impact Statement and the Final Environmental Impact Statement.

FINAL
BILLINGS BYPASS
NCPD 56(55), CN 4199
TRAFFIC NOISE IMPACT ASSESSMENT

Prepared for:

David Evans and Associates, Inc.
1331 17th Street, Suite 900
Denver, CO 80202

Completed by:

Big Sky Acoustics, LLC

March 23, 2012

TABLE OF CONTENTS

Section **Page**

APPENDICES

TABLE OF CONTENTS
(Continued)

TABLES

FIGURES

1.0 INTRODUCTION

Big Sky Acoustics, LLC (BSA) was tasked to conduct a Traffic Noise Impact Assessment for the Billings Bypass EIS project according to the U.S. Code of Federal Regulations Part 772 (23 CFR 772) *Procedures for Abatement of Highway Traffic Noise and Construction Noise*, and Montana Department of Transportation's (MDT's) *Traffic Noise Analysis and Abatement Policy* (MDT 2011). Potential noise impacts at noise-sensitive receptor locations due to vehicles traveling on the proposed alignments within the project limits were evaluated.

MDT is analyzing three alignment alternatives for an alternate principal arterial route that would extend approximately 3.5 miles between Interstate 90 (I-90) and Old Highway 312 northeast of Billings, Montana in Yellowstone County (**Figure 1**, attached). The three alternatives under consideration include:

- Mary Street Option 1 Alternative
- Mary Street Option 2 Alternative
- Five Mile Road Alternative

The Billings Bypass is proposed as a four-lane arterial with proposed speed limits of 45 to 50 mph. All three alternatives begin at the I-90 interchange with Johnson Lane and follow the same alignment north to the Yellowstone River. North of the river, the alternatives use different alignments, as described and shown in **Appendix A**. However, each alternative also includes improvements to the secondary corridors: Five Mile Road as a two-lane configuration (45 mph) for Mary Street Options 1 and 2; and Mary Street as a three-lane configuration (35 mph) for the Five Mile Road Alternative. The Five Mile Road Alternative has two connection options (A and B) with Old Highway 312 under consideration.

The project is located partially within the City of Billings limits, and the surrounding land use is mixed with rural agricultural, residential and industrial areas, including four gravel pit operations (**Figure 1**). Billings Bypass qualifies as a Type I project per 23 CFR 772 due to significant alignment shifts, roadway segments proposed over virgin ground, and the addition of traffic lanes. For the noise analysis, BSA evaluated traffic noise level impacts for the No-Build Alternative (i.e., not changing the existing roadway) and for the three Build Alternatives, at receptors located adjacent to the proposed roadways. The analysis extended beyond 500 feet from the proposed centerlines due to geometric conditions and traffic volumes. Per MDT, the project Present Year is 2010 and the Design Year is 2035.

2.0 TERMINOLOGY

Noise levels are quantified using units of decibels (dB). Noise levels can also be expressed as A-weighted decibels (dBA). Humans typically have reduced hearing sensitivity at low frequencies compared with their response at high frequencies, and the A-weighting of noise levels closely correlates to the frequency response of normal human hearing. By utilizing A-weighted noise levels in a study, a person's response to noise can be assessed. Decibels are logarithmic values, and cannot be combined using normal algebraic addition. For example, the combined noise level of two 50-dBA noise sources would be 53 dBA, not 100 dBA.

Traveling from a noise source to a receptor in an outdoor environment, noise levels decrease with increasing distance between the source and receptor. Traffic noise levels typically decrease between approximately 3 and 4.5 dBA every time the distance between the road and receptor is doubled depending on the characteristics of the source and the conditions over the path that the noise travels. The reduction in noise levels for either case can be increased if a solid barrier, such as a man-made wall, or natural topography is located between the source and receptor.

The ambient noise at a receptor location in a given environment is the all-encompassing sound associated with that environment, and is due to the combination of noise sources from many directions, near and far, including the noise source of interest. The background noise at a given location is due to any sources that are not associated with the noise source of interest.

For environmental noise studies, ambient noise levels and noise impact criteria are typically based on A-weighted equivalent noise levels, L_{eq}, during a certain time period. The equivalent noise level during a one-hour period is represented as L_{eq}(h) and is the metric used by FHWA and MDT for traffic noise studies. The equivalent noise level is defined as the steady state noise level that has the same acoustical energy as the actual, time-varying noise signal during the same time period. The L_{eq}(h) metric is useful for traffic noise studies because it uses a single number to describe the constantly fluctuating ambient noise levels at a receptor location during one hour of time.

3.0 ACTIVITY CATEGORIES AND NOISE ABATEMENT CRITERIA

23 CFR 772 outlines the procedures to determine if traffic noise impacts will occur for a project and when traffic noise abatement measures will be considered. The Federal Highway Administration (FHWA) and MDT identify traffic noise impacts according to Noise Abatement Criteria (NAC) for various land uses. Traffic noise impacts occur for roadway projects when the predicted L_{eq}(h) noise level at a receptor location in a project's Design Year "approaches or exceeds" the NAC values listed in **Table 3-1**, or when there is a "substantial noise increase" above existing ambient noise levels at a receptor. MDT defines "approach" as 1 dBA (i.e., 1 dBA less than the NAC value), and "substantial noise increase" as at least 13 dBA above the Present Year noise level.

For Activity Category B and C land uses, such as residences, churches, day care centers, hospitals, libraries, parks, playgrounds, schools, sports areas, etc., the exterior NAC is 67 dBA. Activity Category D land uses (e.g., churches, day care centers, hospitals, medical facilities, etc.) also have an interior NAC of 52 dBA, which is used when exterior abatement measures are not feasible and reasonable. For Activity Category E land uses, including hotels, offices, restaurants, etc., the exterior NAC is 72 dBA (**Table 3-1**). When traffic noise impacts are identified at noise-sensitive receptor locations, reasonable and feasible noise abatement measures need to be considered to reduce the traffic noise levels at the receptor.

For Activity Category G lands that have not been permitted for development (**Table 3-1**), the noise analysis determines where the Design Year L_{eq}(h) 60, 62 and 64 dBA traffic noise levels are predicted to occur. The analysis includes the setback distances from the proposed edge of the near travel lane out to the modeled 60, 62 and 64 dBA noise contour lines (**Section 7.0**).

Table 3-1: Noise Abatement Criteria

Activity Category	Activity Criteria[1] L_{eq}(h), dBA	Evaluation Location	Activity Description
A	57	Exterior	Lands on which serenity and quiet are of extraordinary significance and serve an important public need where the preservation of those qualities is essential if the area is to continue to serve its intended purpose.
B[2]	67	Exterior	Residential
C[2]	67	Exterior	Active sport areas, amphitheaters, auditoriums, campgrounds, cemeteries, day care centers, hospitals, libraries, medical facilities, parks, picnic areas, places of worship, playgrounds, public meeting rooms, public or nonprofit institutional structures, radio stations, recording studios, recreation areas, Section 4(f) sites, schools, television studios, trails, and trail crossings.
D	52	Interior	Auditoriums, day care centers, hospitals, libraries, medical facilities, places of worship, public meeting rooms, public or nonprofit institutional structures, radio studios, recording studios, schools, and television studios.
E[2]	72	Exterior	Hotels, motels, offices, restaurants/bars, and other developed lands, properties or activities not included in A-D, or F.
F	---	---	Agriculture, airports, bus yards, emergency services, industrial, logging, maintenance facilities, manufacturing, mining, rail yards, retail facilities, shipyards, utilities, (water resources, water treatment, electrical), and warehousing.
G	---	---	Undeveloped lands that are not permitted.

[1] The L_{eq}(h) Activity Criteria values are for impact determination only, and are not design standards for noise abatement measures. MDT defines "approach" as 1 dBA less than the NAC value, and "substantially exceed" as at least 13 dBA greater than the Present Year noise level.

[2] Includes undeveloped lands permitted for this Activity Category.

4.0 AFFECTED ENVIRONMENT

4.1 Ambient Noise Level Measurements

BSA completed seven noise level measurements in September 2007 and July 2011 to determine the existing ambient noise levels at representative receptor locations located along the proposed Billings Bypass alignments. Noise level measurements were conducted in general accordance with the American National Standard (ANSI) S12.18-1994, *Procedures for Outdoor Measurement of Sound Pressure Level* (ANSI 1994). The measurements were 20 to 30-minutes in duration, and the L_{eq}(h) for each one-hour period was calculated from the measurement data.

BSA conducted the ambient noise level measurements using either a CEL Instruments Model 593.C1 or a Larson Davis Model 831 Type I sound level meter with a preamplifier and 0.5-inch diameter microphone. The meters were calibrated using a CEL Instruments Model 284/2 Acoustical Calibrator prior to and checked after the measurements. The meters were set to "slow" response per FHWA requirements, and mounted on a tripod, such that the microphone and windscreen were approximately 5 feet above the ground surface. The measurement locations are depicted on **Figures 1 through 4** (attached), and **Table 4-1** summarizes the measured ambient $L_{eq}(h)$ noise levels.

Table 4-1: Outdoor Ambient Noise Level Measurements

Location	Date and Time (hours)	Description	Measured $L_{eq}(h)$[1] (dBA)	Dominant Noise Sources during Measurements	Build Alternative
1	7/13/11 1550 to 1610	Backyard at 3576 Summerfield Circle, Lot 140a.	40	Heavy equipment trucks in distance and Highway 312 traffic (faint). Other audible sources, including breeze in trees, birds, children playing at neighbors, and lawnmower in the distance, were brief.	Five Mile Road
2	7/13/11 1640 to 1700	Intersection of Mary Street with bike/pedestrian path. South of Lot 80.	56	Mary Street traffic. Other audible sources, including birds, dog barking in distance, breeze in trees, prop plane overhead and an ATV, were brief or intermittent.	Mary Street Option 1 Mary Street Option 2
3	7/14/11 1116 to 1146	North of I-90 on Johnson Lane, Lots 19b & 23.	57	Traffic on Johnson Lane and I-90. Other audible sources, including westbound onramp traffic, vehicles in/out of the gas station, insects and birds, were faint or intermittent.	Mary Street Option 1 Mary Street Option 2 Five Mile Road
4	7/14/11 1413 to 1433	Mary Street, east end of Lot 103b.	49	Traffic on Mary Street. Other audible sources, including birds, gravel pit crusher and backup alarms to northeast, and tractor to west, were faint or intermittent.	Mary Street Option 1 Mary Street Option 2
5	7/14/11 1449 to 1519	Flaming Creek cul-de-sac, Lot 115a.	43	Gravel pit crusher and backup alarms to northeast. Other audible sources, including birds, were intermittent.	Mary Street Option 2
6	9/20/07 1657 to 1717	Residence at end of Johnson Road, Lot 58.	50	Train whistle and gravel pit operations. Other audible sources including, aircraft, insects, and birds, were intermittent.	Mary Street Option 1 Mary Street Option 2 Five Mile Road
7	9/19/07 1605 to 1625	Residence at intersection Five Mile Road alignment and Hwy 312, Lot 156.	57	Hwy 312 traffic.	Five Mile Road

[1] The measured $L_{eq}(h)$ was calculated from the data collected during 20-or 30-minute measurement periods.

Temperature, relative humidity and wind speed were field-measured using a Radio Shack Model 63-867A Thermometer and Humidity Gauge, a R.A. Simerl Instruments Model BTC Series 994 Anemometer, and/or a Kestrel 3000 pocket meter. **Table 4-2** summarizes the atmospheric conditions during the noise level measurements.

Table 4-2: Atmospheric Conditions

Measurement Location	Date and Time (hours)	Temperature	Relative Humidity	Wind Speed and Direction
1	7/13/11 1550 to 1610	91 °F	37%	2 to 6 mph from the north
2	7/13/11 1640 to 1700	90 °F	35%	5 to 8 mph from the east
3	7/14/11 1116 to 1146	86 °F	47%	Calm
4	7/14/11 1413 to 1433	86 °F	47%	Calm
5	7/14/11 1449 to 1519	90 °F	40%	Calm to 3 mph from the east
6	9/20/07 1657 to 1717	65 °F	40%	Calm to 3 mph, variable
7	9/19/07 1605 to 1625	65 °F	50%	Calm to 8 mph from the southeast

4.2 Creating and Verifying the Traffic Noise Model

BSA predicted traffic noise levels at the receptors for the No-Build Alternative and the three Build Alternatives using the FHWA-approved Traffic Noise Model (TNM), Version 2.5 software program. TNM uses a three-dimensional coordinate system (x, y, and z) to define the location of the roadway, receptor locations and terrain elevations. The number and type of vehicles traveling on the roadway that were tallied during the measurements, the approximate speed of the traffic, the location of the centerlines of the driving lanes, the approximate ground elevations between the measurement locations and the roadway, and the measurement locations were entered into the model. Topographic elevations of the receptor locations, the roadway conditions, and the location of the proposed alternatives were based on the preliminary plan and cross-section drawings (DOWL HKM 2011).

The ambient noise level measurements taken by BSA (**Table 4-1**) were used to verify that the TNM model was reasonably accurate. **Table 4-3** lists the traffic data BSA counted during the field measurements at the four locations along existing roadways. The traffic data was used to compare the field-measured noise levels to the TNM-predicted traffic noise levels at the measurement locations. The difference between each field-measured $L_{eq}(h)$ level and the level predicted by the TNM model for the traffic conditions during each measurement period was 1 to 2 dBA. A difference of +/- 3 dBA between measured and predicted traffic noise levels indicates that a TNM model is reasonably accurate (FHWA 2010), and therefore, acceptable for traffic noise level predictions at the receptor locations.

Table 4-3: Measured Ambient vs. Predicted Noise Levels

Meas. Location	Date and Time (hours)	Distance and Direction from Centerline (feet)	Total Traffic Tallied During Measurement[1]	Measured $L_{eq}(h)^2$ (dBA)	Predicted $L_{eq}(h)$ by TNM Model (dBA)
2	7/13/11 1640 to 1700	62 feet south of Mary Street	Autos: 69	56	55
3	7/14/11 1116 to 1146	155 feet east of Johnson Lane	Autos: 39 HT: 16	57	56
4	7/14/11 1413 to 1433	98 feet south of Mary Street	Autos: 11	49	47
7	9/19/07 1605 to 1625	240 feet east of US 87	Autos: 615 MT: 15 HT: 15	57	57

Autos Automobiles – 2-axle, 4-wheel vehicles including pickup trucks
MT Medium trucks – 2-axle, 6-wheel vehicles, plus automobiles pulling trailers
HT Heavy trucks – 3 or more axles
1 Traffic tallied during the measurement periods was doubled or tripled to estimate 1-hour total traffic counts.
2 The measured Leq(h) was calculated from the data collected during 20-or 30-minute measurement periods.

4.3 Traffic Data Used for the Traffic Noise Predictions

The Present Year (2010) and Design Year (2035) traffic volumes used for the noise analysis were provided by Marvin and Associates (2011). The peak afternoon hour directional traffic data were used in the TNM model for each alternative, with 4% heavy truck traffic on the four-lane arterial segments. **Appendix B** includes the traffic data that was used for the noise level predictions.

4.4 Gravel Pit Noise Influence

As shown on **Figures 1 through 4**, several receptors are located near existing, active gravel pits, and the sounds from gravel pit operations influenced the noise levels at Measurement Locations 4, 5 and 6 (**Table 4-1**). Therefore, the gravel pit operations also influence the Present Year (2010) noise levels at nearby receptors, and the gravel pit noise levels were included in BSA's analysis (**Section 5.1**).

The total Present Year noise level at a receptor located near a gravel pit is due to the combination of traffic noise from existing roads and the noise of the gravel pit operations. For receptors located near gravel pits, **BSA** predicted traffic noise using TNM and gravel pit noise using Cadna-A Version 4.0 noise prediction software from DataKustik. Cadna-A uses algorithms from the International Organization for Standardization (ISO) Standard 9613-2, *Attenuation of Sound during Propagation Outdoors, Part 2: General Method of Calculation* (ISO 1996). This standard specifies the calculations to determine the reduction in noise levels due to the distance between the noise source and the receiver, the effect of the ground on the propagation of sound, and the effectiveness of natural barriers due to grade or man-made barriers. The dominant noise source in a gravel pit is a crusher. Based on previous work with gravel pits and mining operations, BSA used a crusher noise level of L_{eq} 66 dBA at 1,050 feet (BSA 2008) as the noise source of each gravel pit in the Cadna-A model.

5.0 ENVIRONMENTAL CONSEQUENCES

The purpose of the traffic noise level predictions is to determine if traffic noise impacts will occur at noise-sensitive receptor locations in the Design Year (2035). BSA identified noise-sensitive receptors using aerial photographs and site observations.

5.1 Results – No-Build vs. Build Alternatives

Predicted traffic noise levels for the No-Build Alternative and the three Build Alternatives are summarized in **Table 5-1**. Receptor locations are depicted on **Figures 2 through 4**. Activity Category B and C receptors include single-family residences (including groups of residences) and a church located along the Build Alternatives. BSA did not observe and additional Activity Category C receptors (e.g., parks, medical facilities, day care centers, schools, etc.) or Activity Category E receptors (e.g., hotels, offices, restaurants/bars, etc.) adjacent to the proposed alignments (**Table 3-1**).

Table 5-1: Predicted Traffic Noise Levels – L_{eq}(h) dBA

Receptor (Figures 2 through 4)	Description	No-Build Present Year[1] 2010	No-Build Design Year 2035	Mary Street Option 1 Design Year[2] 2035	Mary Street Option 1 Design Year increase over Present Year[3]	Mary Street Option 2 Design Year[2] 2035	Mary Street Option 2 Design Year increase over Present Year[3]	Five Mile Road Design Year[2] 2035	Five Mile Road Design Year increase over Present Year[3]
J1	Single-family residence	60	61	66	6	66	6	65	5
J2	Single-family residence	59	60	63	4	63	4	62	3
J3	Single-family residence	58	60	63	5	63	5	62	4
J4	Single-family residence	56	58	64	8	63	7	63	7
J5	Single-family residence	57	59	61	4	61	4	61	4
J6	Single-family residence	55	57	relocated	relocated	relocated	relocated	relocated	relocated
J7	Single-family residence	56	58	relocated	relocated	relocated	relocated	relocated	relocated
J8	Single-family residence	55	57	69	14	69	14	68	13
J9	Single-family residence	55	57	68	13	68	13	68	13
J10	Single-family residence	60	62	62	2	62	2	62	2
J11	Single-family residence	59	61	61	2	61	2	61	2
J12	Single-family residence	55	57	68	13	68	13	67	12
J13	Single-family residence	45	44	51	6	51	6	51	6
J14	Single-family residence	46	43	49	3	46	0	47	1
M1	Single-family residence	57	60	60	3	60	3	59	2
M2	4 Single-family residences	55	60	60	5	60	5	54	-1
M3	4 Single-family residences	55	60	61	6	61	6	61	6
M4	7 Single-family residences	54	60	62	8	62	8	61	7
M5	3 Single-family residences	54	60	62	8	62	8	61	7
M6	6 Single-family residences	54	59	62	8	62	8	61	7
M7	3 Single-family residences	54	59	61	7	61	7	61	7
M8	Heights Family Worship	49	55	59	10	59	10	57	8
M9	4 Single-family residences	51	57	62	11	62	11	61	10
M10	Single-family residence	51	57	61	10	61	10	61	10
M11	Single-family residence	50	55	60	11	60	10	59	9
M12	Single-family residence	51	57	61	10	61	10	61	10

Table 5-1: Predicted Traffic Noise Levels – L_{eq}(h) dBA

Receptor (Figures 2 through 4)	Description	No-Build Present Year[1] 2010	No-Build Design Year 2035	Mary Street Option 1 Design Year[2] 2035	Mary Street Option 1 Design Year increase over Present Year[3]	Mary Street Option 2 Design Year[2] 2035	Mary Street Option 2 Design Year increase over Present Year[3]	Five Mile Road Design Year[2] 2035	Five Mile Road Design Year increase over Present Year[3]
M13	Single-family residence	51	57	60	9	60	9	61	10
M14	Single-family residence	42	46	51	9	51	9	51	9
M15	Existing Bitterroot Heights Subdivision (First Filing) – 8 Single-family residences	39	42	47	8	47	8	44	5
M16	Single-family residence	51	54	57	6	57	6	58	7
M17	Single-family residence	51	54	59	8	59	8	58	7
M18	Single-family residence	42	43	62	20	61	19	50	8
M19	Single-family residence	51	54	61	10	61	10	59	8
M20	Single-family residence	52	55	62	10	62	10	60	8
M21	Single-family residence	52	55	68	16	68	16	61	9
M22	Single-family residence	51	53	60	9	60	9	58	7
M23	Single-family residence	51	54	60	9	60	9	58	7
M24	Single-family residence	50	53	60	10	59	9	58	8
M25	Single-family residence	51	54	60	9	59	8	59	8
M26	Single-family residence	52	55	60	8	60	8	60	8
M27	Single-family residence	52	54	60	8	60	8	60	8
M28	Single-family residence	49	52	58	9	57	8	57	8
M29	Single-family residence	44	39	47	3	47	3	42	-2
M30	Single-family residence	45	39	50	5	51	6	44	-1
M31	Single-family residence	45	39	51	6	52	7	44	-1
M32	Single-family residence	44	42	50	6	47	3	48	4
M33	Single-family residence	45	39	50	5	61	16	44	-1
M34	Single-family residence	45	39	55	10	69	24	48	3
M35	Single-family residence	45	41	61	16	48	3	46	1
M36	Single-family residence	45	39	52	7	44	-1	42	-3
M37	Single-family residence	52	44	55	3	52	0	57	5
M38	Single-family residence	50	39	51	1	48	-2	50	-1
M39	Single-family residence	55	44	55	0	53	-2	56	1
F1	Single-family residence	37	44	46	9	46	9	47	10
F2	Single-family residence	37	43	45	8	46	9	47	10
F3	Single-family residence	37	40	43	6	44	7	45	8
F4	Single-family residence	37	40	43	6	44	7	46	9
F5	Single-family residence	37	39	44	7	45	8	49	12
F6	Single-family residence	37	39	46	8	47	10	52	15
F7	Single-family residence	37	39	43	6	44	7	48	11
F8	Single-family residence	37	40	44	7	45	8	49	12
F9	Single-family residence	38	40	46	8	47	9	51	13
F10	Single-family residence	38	40	48	10	48	10	54	16
F11	Single-family residence	38	40	45	7	45	7	50	12
F12	Single-family residence	56	58	58	2	58	2	59	3
F13	Single-family residence	53	55	55	2	55	2	55	2
F14	Single-family residence	51	53	53	2	53	2	53	2

Shaded Indicates that the predicted traffic noise level meets or exceeds the traffic noise impact criteria (Section 3.0).

Relocated Indicates that the receptor may be relocated due to ROW acquisition for the Build Alternative indicated. Also exceeds the traffic noise impact criteria (Section 3.0).

1 Total Present Year = No Build Present Year noise level plus Gravel Pit Present Year noise level using logarithmic addition.

2 MDT defines "approach as 1 dBA less than NAC value (Table 3-1).

3 MDT defines "substantially exceed" as at least 13 dBA greater than Present Year noise level (Section 3.0).

For the noise-sensitive receptors located adjacent to the proposed Billings Bypass, no traffic noise impacts are predicted due to the No-Build Alternative in the Present Year (2010) or the Design Year (2035). However, as shown in **Table 5-1** traffic noise impacts are predicted for three Build Alternatives in the Design Year. These impacts are summarized in **Table 5-2**. The influence of the noise from the area gravel pit operations (**Figure 1**) is discussed in **Section 4.4**.

For the Mary Street Option 1 Alternative, traffic noise impacts are predicted at nine single-family residences, including two residences (J6 and J7) that may be relocated based on the current alignment (**Figure 2**). Of the seven remaining receptors, the predicted Design Year noise levels are either greater than the 66 dBA impact criterion for Activity Category B receptors (**Table 3-1**), or "substantially exceed" the Present Year noise levels (**Section 3.0**) by at least 13 dBA (**Table 5-1)**. Four receptors (J1, J8, J9, and J12) are located north of I-90 adjacent to Johnson Lane (**Figure 2**), and the predicted Design Year noise levels are 66 to 69 dBA. Three receptors (M18, M21 and M35) are located adjacent to Mary Street (**Figure 3**), and the noise levels are predicted to be 61 to 68 dBA (**Table 5-1**).

For the Mary Street Option 2 Alternative, traffic noise impacts are predicted at 10 single-family residences, including two residences (J6 and J7) that may be relocated based on the current alignment (**Figure 2**). Of the eight remaining receptors, six of the receptors (J1, J8, J9, J12, M18, and M21) are also impacted by Mary Street Option 1 Alternative, as described above. Receptors M33 and M34 are located adjacent to the proposed alignment on the eastern end of Mary Street (**Figure 3**), and the predicted Design Year noise levels are 61 and 69 dBA, respectively (**Table 5-1**).

For the Five Mile Road Alternative, traffic noise impacts are predicted at eight single-family residences, including two residences (J6 and J7) that may be relocated based on the current alignment (**Figure 2**). Of the six remaining receptors, three of the receptors (J8, J9 and J12) are also impacted by the Mary Street Option 1 and 2 Alternatives, as described above. (Receptor J1 is not impacted due to the reduced project traffic volume in the Design Year (**Appendix B**) for the Five Mile Road Alternative, compared to the Mary Street Option 1 and 2 alternatives.) Receptors F6, F9 and F10 are located east of the proposed Five Mile Road Alternative (**Figure 4**), and the predicted Design Year noise levels (51 to 54 dBA) (**Table 5-1**) "substantially exceed" the Present Year noise levels by at least 13 dBA (**Section 3.0**).

As discussed above, based on the current proposed alignment and right-of-way (ROW) acquisition, two single-family residences may be relocated. The possible relocations include Receptors J6 and J7, located north of I-90 and east of Johnson Lane (**Figure 2**), and these relocated receptors were counted as noise-impacted receptors. For all three Build Alternatives, the noise-impacted and relocated receptors are summarized in **Table 5-2**.

Table 5-2: Summary of Impacted and Relocated Receptors

Build Alternative	Number of Predicted Traffic Noise Impacted Receptors - Design Year (Table 5-1)	Number of Potentially Relocated Receptors
Mary Street Option 1	9	2
Mary Street Option 2	10	2
Five Mile Road	8	2

6.0 MITIGATION CONSIDERATIONS

When traffic noise impacts are predicted, possible abatement measures for the mitigation of street traffic noise need to be considered, and the measures are assessed to determine if they are feasible and reasonable (MDT 2011). Possible abatement measures include construction of noise barriers, modifying the proposed build alternatives, acquisition of real property, traffic management measures, or building modifications for Activity Category D public use or institutional structures. Barriers typically provide the highest level of noise reduction of these mitigation measures.

According to MDT's Noise Policy, to determine if a mitigation measure is feasible, the measure must provide a minimum 5-dBA reduction in noise levels at 75% of the impacted front row receptors, and must not cause safety hazards or maintenance, utility or access limitations. To determine if a mitigation measure is reasonable involves an examination of costs, public support, and whether a noise reduction design goal of 7 dBA can be achieved for 60% of the first row benefited receptors (MDT 2011).

6.1 Noise Barriers

A barrier is most effective when it is continuous and solid, and it blocks the direct line-of-sight between the roadway and a receptor. Barriers can be constructed using built up dirt to create a berm, using concrete, concrete block, other similar masonry materials, metal panels, or thick wood to create a wall, or a combination of a berm or Jersey barrier with a shorter wall on top. An earthen berm typically has a very large base for support and may also require additional ROW to accommodate construction. To be effective, the barrier wall must be continuous and solid with no gaps, holes or openings in it, including between the bottom edge of the barrier wall and the ground surface. Although it may be used for visual screening, vegetation is not effective barrier material since sound passes readily through it. In fact, it takes 200-feet deep stands of non-deciduous vegetation to achieve 4 to 5 dBA noise reduction (MDT 2011).

MDT uses a Cost-Effectiveness Index (CEI) to determine if a barrier is reasonable, and the CEI takes into consideration the noise reduction the barrier will provide and the number of benefited receptors. The CEI is calculated for each barrier. MDT currently uses a planning cost \$35/ft^2 for noise barriers, which includes wall and foundation construction, and a CEI that exceeds \$4,900 is not considered reasonable (MDT 2011).

Since barriers are not cost effective for isolated, individual receptors, such as Mary Street Receptors M18, M21, M33, M34 and M35 (**Figure 3**), BSA only considered traffic noise barrier walls as mitigation measures for groups of receptors that included impacts. Therefore, BSA calculated the CEI for Johnson Lane Receptors J1 to J12 (**Figure 2**) for all the Build Alternatives, and for Receptors F1 to F11 (**Figure 4**) for the Five Mile Road Alternative, to determine if barriers would be reasonable to eliminate the impacted receptors in these areas. BSA assumed that the barrier would be located on the ROW line near the receptors.

The barrier results are summarized in **Table 6-1**. As shown, the CEI values are well above MDT's $4,900 reasonableness criterion due to the small number of benefited receptors. Therefore, barriers would not be reasonable for traffic noise mitigation for the Billings Bypass Build Alternatives.

Table 6-1: Summary of Estimated CEI Values

Receptors	Build Alternative	Barrier Length	Barrier Height	Number of Benefited Receptors	Estimated CEI
J1 to J12	Mary Option 1 Mary Option 2 Five Mile Road	1,750 feet	10 feet	3	$24,598
			14 feet	4	$24,223
F1 to F11	Five Mile Road	3,100 feet	10 feet	3	$57,713
			14 feet	5	$46,311

Earthen berms can also be used for traffic noise mitigation. It is the understanding of BSA that during right-of-way negotiations, residents have asked for berms to be constructed as visual buffers to a roadway. If a berm is constructed to block the direct line of sight to a road, it will also reduce traffic noise. The impacted Johnson Lane and Mary Street receptors (**Table 5-1**) are located very close to the proposed roadways or at elevations above the proposed alignments due to the existing terrain. Therefore, sufficiently high berms could not be constructed due to limited space or lower elevation in these areas, and would be ineffective. However, berms could be used as a visual buffer and possibly as a traffic noise mitigation measure (if sufficient height can be achieved) for receptors along the Five Mile Road alignment (**Figure 4**), because the terrain is relatively flat.

6.2 Design Modifications

Shifting the horizontal and/or vertical alignments of the build alternatives to reduce traffic noise impacts can provide more distance between a roadway and a receptor, resulting in lower noise levels. BSA evaluated horizontal alignment shifts as a noise mitigation measure.

Shifting the alignment near the I90/Johnson Lane Interchange to eliminate the traffic noise impacts at Receptors J8, J9 and J12, and eliminate the relocated residences at Receptors J6 and J7 (**Figure 2**), would be feasible if the Build Alternative alignment was moved to the north side of the railroad tracks at Johnson Lane. A similar alignment, known as the Johnson Lane Option 2

Alternative, was evaluated in 2011 (BSA 2011), but was determined to be unreasonable and eliminated from further consideration.

For the Mary Street Option 1 and Mary Street Option 2 Alternatives, shifting the alignments to avoid impacted Receptors M18, M33, M34 and M35 (**Figure 3**) would move the roadway closer to other receptors, which may create new impacts, require the acquisition of additional ROW, or relocate additional receptors. Therefore, shifting the alignment of the Mary Street Option 1 and 2 Alternatives may not be feasible or reasonable.

For the Five Mile Road Alternative, shifting the alignment away from impacted receptors F6, F9 and F10 (**Figure 4**) may be feasible, provided that the centerline could be relocated approximately 350 to 400 feet west to eliminate the noise impacts. The proposed centerline is approximately 275 to 300 feet from the impacted receptors, and the relocating the centerline would more than double the distance between the roadway and the receptors.

6.3 Acquisition of Real Property

Acquisition of Real Property or interests therein (predominantly unimproved property) is evaluated as a noise mitigation measure to serve as a buffer zone to preempt development which would be adversely impacted by traffic noise (MDT 2011). Although this measure would not eliminate any of the impacts shown at existing receptors due to their proximity to the Build Alternative alignments, the acquisition of property could help avoid future traffic noise impacts for the Future Filings of the Bitterroot Heights Subdivision or other Activity Category G lands (**Table 3-1**, **Figure 3**, and **Section 7.0**). Additional right-of-way could be acquired in certain undeveloped areas to reduce traffic noise impacts, based on the setback distances shown in **Table 7-1**.

6.4 Traffic Management Measures

Traffic management measures include traffic control devices, signing for prohibition of certain vehicle types, time-use restrictions for certain vehicle types, modified speed limits, and exclusive lane designations (MDT 2011).

As shown in Appendix A, traffic control devices, including stop-controlled, signalized and roundabout intersections, are being considered for the three Build Alternatives. For this assessment, BSA assumed that the Build Alternatives included the traffic control devices shown on **Appendix A, Figures 1 through 3**, and that the traffic was free flowing (i.e., the bypass traffic did not stop) at the proposed speed limits (**Section 1.0**). However, the traffic control devices and locations will be refined for the final design of the Preferred Alternative, and the traffic noise predictions should be recalculated at that time (**Section 9.0**).

Restricting certain vehicle types, like heavy trucks, or limiting the time of day that certain vehicles may use the Billings Bypass are not reasonable mitigation measures. The purpose of the proposed project is to improve truck/commercial vehicle access and mobility in the eastern area of Billings, and to improve connectivity between I-90 and Old Highway 312 (**Appendix A**).

Modifying speed limits is a potential noise mitigation measure, if it does not hinder the function of the Bypass. Traffic noise levels are reduced by approximately 1 dBA for every 5 mph reduction in speed. However, speed limits are generally set by the Transportation Commission, and are usually reduced for safety concerns rather than noise impacts (MDT 2011).

For the Build Alternatives, the proposed speed limits for the four-lane sections are 45 to 50 mph. For the secondary corridors, Five Mile Road is proposed as a 45 mph two-lane configuration for Mary Street Options 1 and 2 Alternatives, and Mary Street is proposed as a 35 mph three-lane configuration for the Five Mile Road Alternative (**Section 1.0**). Based on the results shown in **Table 5-1**, reducing the speed limits by 5 to 10 mph would reduce the predicted noise levels by 1 to 2 dBA, eliminating one receptor (J1) of the nine impacts of the Mary Street Option 1 Alternative, and one of the 10 impacts of the Mary Street Option 2 Alternative. Reducing the speed limit by 10 mph (a 2 dBA reduction) would also eliminate two of the eight impacts for the Five Mile Road Alternative (Receptors J12 and F9). However, a 10 mph reduction in speed may hinder the functionality of the roadways.

Exclusive lane designations is a potential noise mitigation measure, but not reasonable for the Billings Bypass. Receptors are located on both sides of the proposed roadway alignments (**Figures 1-4**). Therefore, designating a truck lane in each direction, for example, would not change the predicted noise levels at the receptors.

7.0 COORDINATION WITH LOCAL OFFICIALS

Traffic noise can significantly affect the value and usefulness of property near roadways. Traffic noise at future areas of frequent residential outdoor use can be annoying, distracting and hinder communication. In March 2008, MDT published *Growing Neighborhoods in Growing Corridors: Land Use Planning for Traffic Noise* to provide guidance for avoiding traffic noise problems in the future. For example, if the L_{eq}(h) 60 dBA can be met at a building façade by planning a site accordingly, then the need for traffic noise control measures, such as barrier walls, earthen berms, building material modifications, etc., can be avoided in the future. For comparison, 60 dBA represents the typical exterior background noise levels of a large urban area and the background noise levels inside large busy offices.

The Bitterroot Heights Subdivision is located north of Mary Street and between Bitterroot Drive and Hawthorne Lane (**Figure 3**). The Bitterroot Heights Subdivision Master Plan was submitted to the City of Billings in 2004, and the First Filing residential section (Receptor M15) has been built on the northeastern section of the property. Eight Future Filing sections are shown on the Preliminary Plat, including three sections located adjacent to and north of Mary Street, but the Future Filings have not been submitted or permitted by the City (City of Billings 2012). The Future Filing sections of the Bitterroot Heights Subdivision is an area of potential development and is currently categorized as an Activity Category G receptor (**Table 3-1**).

To avoid future traffic noise impacts in any Activity Category G lands that have not been permitted for development, including Future Filings for the Bitterroot Heights Subdivision, BSA used the TNM model to determine the approximate distances to where the Design Year L_{eq}(h) 60, 62 and 64 dBA noise levels are predicted to occur. MDT considers the 60 dBA noise contour setback distance for rapid growth rate areas, and considers the 62 or 64 dBA noise contour setback distances for slower growth rate areas. **Table 7-1** lists the minimum setback distances for each roadway alternative and segment to help local officials evaluate future development for noise compatible use.

Table 7-1: Traffic Noise Level vs. Minimum Setback Distance

Build Alternative	Roadway Segment (Figure 1)	Distance to 60 dBA L_{eq}(h) Traffic Noise Level[1]	Distance to 62 dBA L_{eq}(h) Traffic Noise Level[2]	Distance to 64 dBA L_{eq}(h) Traffic Noise Level[2]
Mary Street Option 1	I-90 to Five Mile Road	375 feet	300 feet	225 feet
Mary Street Option 2				
Five Mile Road				
Mary Street Option 1	Mary Street (4-lane): Five Mile Road to Old Hwy 312	250 feet	180 feet	125 feet
Mary Street Option 2				
Mary Street Option 1	Five Mile Road (2-lane): Mary Street to Old Hwy 312	110 feet	75 feet	50 feet
Mary Street Option 2				
Five Mile Road	Five Mile Road (4-lane): Dover Road to Old Hwy 312	125 feet	90 feet	55 feet
Five Mile Road	Mary Street (3-lane): Five Mile Road to Old Hwy 312	100 feet	70 feet	45 feet

1 MDT considers the 60 dBA noise contour setback distance for rapid growth rate areas.
2 MDT considers the 62 or 64 dBA noise contour setback distances for slower growth rate areas.

Local officials should strongly encourage developers to incorporate noise-compatible development on their planned/proposed properties. Examples of noise-compatible development include providing greenbelts, open space, or parkland between the residents and the roadway. Garages, carports or storage sheds should front the roadway, rather than residences. If residential buildings must be located along the roadway, the homes should be designed so that less-sensitive rooms, such as kitchens, laundry rooms, utility rooms, and storage spaces, face the roadway rather than bedrooms and living rooms. Windows in the roadway-side of the building should be avoided. Strategies that incorporate noise-compatible development concepts are proactive and preventative in nature, and can avoid traffic noise impact problems in the future.

8.0 CONSTRUCTION NOISE

Road construction may cause localized, short-duration noise impacts, which may cause annoyance to people living in the area. For Type 1 projects, the noise study identifies land uses or activities that may be affected by construction noise, determines measures to minimize or eliminate adverse construction noise impacts, and incorporates needed abatement measures, if necessary.

During construction of the Billings Bypass project, the contractor should comply with all applicable regulations governing equipment source levels and the City of Billings Noise Ordinance. (Yellowstone County does not have specific noise regulations.) The Billings Municipal Code limits noise in residential districts to 55 dBA (8 a.m. to 8 p.m.) and 50 dBA (8 p.m. to 8 a.m.), and noise in industrial districts to 80 dBA (8 a.m. to 8 p.m.) and 75 dBA (8 p.m. to 8 a.m.). Construction noise is limited to the maximum permissible noise levels specified for industrial districts (BMC 2012).

In addition, contractors should consider use the following techniques to reduce construction noise impacts at the identified receptors:

1. Place stationary noise sources away from receptors.
2. Use portable noise barriers or use natural terrain to provide shielding.
3. Turn idling equipment off.
4. Drive equipment forward instead of backward; lift instead of drag materials; and avoid scraping or banging activities.
5. Avoid operating equipment in such a manner which may annoy, disturb, endangers the comfort, repose, health, peace or safety of any reasonable person of normal sensitivity (BMC 2012).
6. Use quieter equipment with properly sized and maintained mufflers, engine intake silencers, less obtrusive backup alarms, engine enclosures, noise blankets or rubber linings.

9.0 RECOMMENDATIONS

Based on the results of the Traffic Noise Impact Assessment, BSA developed recommendations so that the predicted traffic noise levels are accurately reflected in the Preferred Alternative. During the Final Design, implement the following:

- Update the Traffic Noise Impact Assessment to ensure the predicted traffic noise levels and any proposed traffic noise mitigation measures have been accurately updated and evaluated.

- Evaluate the effect of the selected traffic control devices at intersections, including signals, stop signs and roundabouts, on the predicted traffic noise levels.

- If the Five Mile Road Alternative is selected as the Preferred Alternative, determine if shifting the alignment away from impacted receptors F6, F9 and F10 (**Figure 4**) is feasible. Moving the centerline approximately 350 to 400 feet west will eliminate the predicted noise impacts.

- Evaluate if earthen berms could be used as a visual buffer and/or as a traffic noise mitigation measure for receptors along the Five Mile Road alignment, if selected as the Preferred Alternative. Additional right-of-way may be required to construct the berm.

- Evaluate the acquisition of real property during the right-of-way phase to help avoid traffic noise conflicts in the future on existing undeveloped lands, including the Future Filings of the Bitterroot Heights Subdivision (**Figure 3**). This could increase the right-of-way needed in undeveloped areas, and should be based on the setback distances shown in **Table 7-1**.

10.0 REFERENCES

American National Standard Institute (ANSI). 1994. Procedures for Outdoor Measurement of Sound Pressure Level. Designation: S12.18-1994. (Reaffirmed 1999).

Big Sky Acoustics (BSA). 2011. *Final Preliminary Traffic Noise Assessment of Existing Conditions.* October 18, 2011.

Big Sky Acoustics (BSA). 2008. *Helena Sand & Gravel Lake Helena Drive Gravel Pit Environmental Noise Study*. Prepared for Helena Sand & Gravel. February 29.

Billings Municipal Code (BMC). 2012. Chapter 17 – Noise.

City of Billings. 2012. Email transmission from Wyeth Friday, Planning Division Manager, regarding the Bitterroot Heights Subdivision. January 6, 2012.

DOWL HKM, Inc. 2011. Preliminary Design Plan and Cross Sections for the Billings Bypass. December 16, 2011.

Federal Highway Administration (FHWA). 2010. *Highway Traffic Noise: Analysis and Abatement Guidance.*

International Organization for Standardization (ISO). 1996. Attenuation of Sound During Propagation Outdoors, Part 2: General Method of Calculation. Designation: 9613-2.

Marvin & Associates. 2011. No-Build and Build Present Year (2010) and Design Year (2035) traffic projections for the Billings Bypass project. September 26, 2011

Montana Department of Transportation (MDT). 2011. *Traffic Noise Analysis and Abatement Policy.* April.

Montana Department of Transportation (MDT). 2008. *Growing Neighborhoods in Growing Corridors: Land Use Planning for Traffic Noise*.

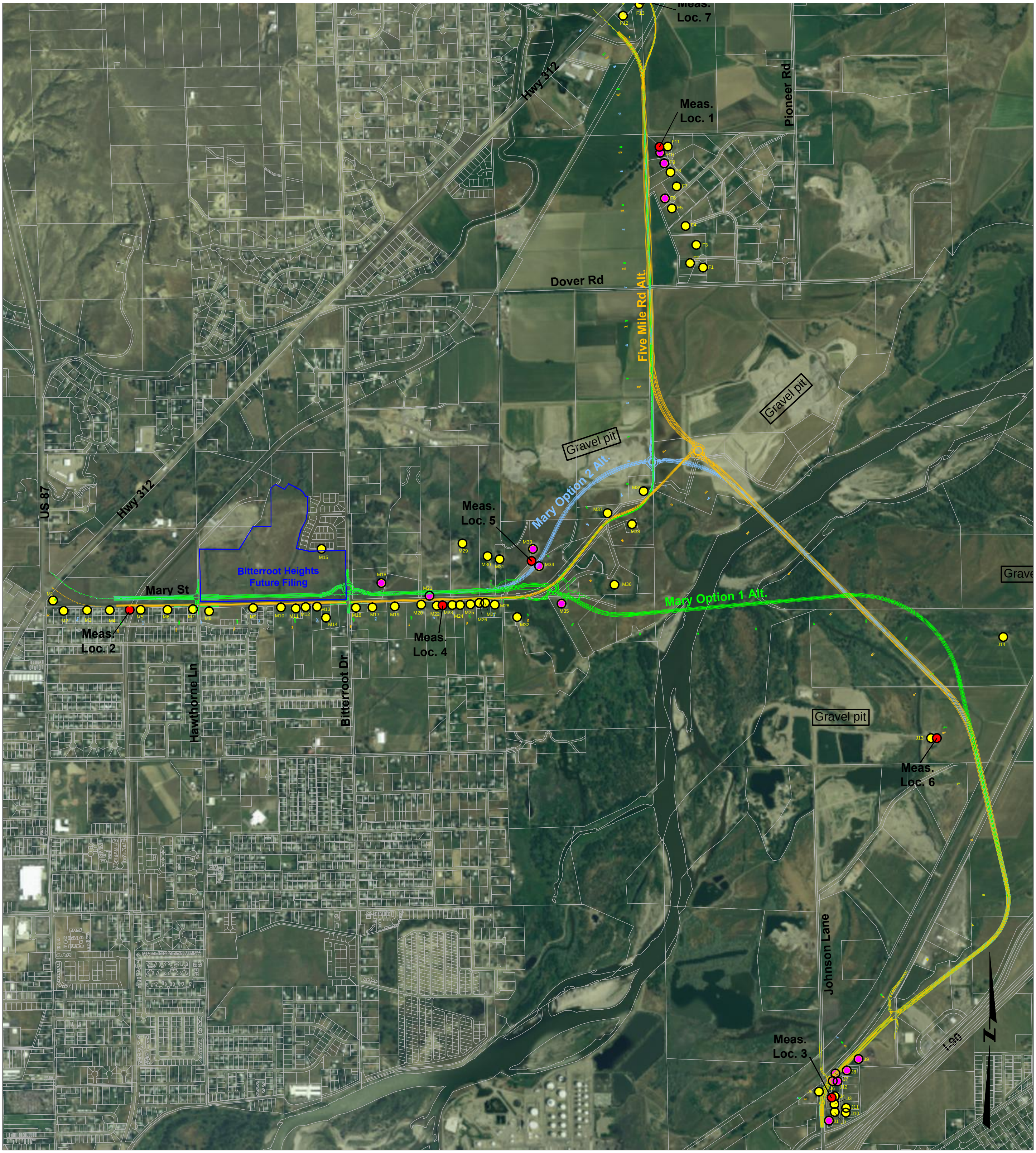
U.S. Code of Federal Regulations Part 772 (23 CFR 772). 2011. Procedures for Abatement of Street Traffic Noise and Construction Noise.

11.0 STANDARD OF CARE

To complete this report, BSA has endeavored to perform its work in a manner consistent with that degree of care and skill ordinarily exercised by members of the acoustical profession currently practicing under similar circumstances. BSA makes no warranty, either express or implied, as to the professional services it has rendered to complete this report.

For the completion of this report, BSA has used data provided by David Evans & Associates Inc., Marvin & Associates, DOWL HKM, Inc. and MDT in performing services, and is entitled to rely upon the accuracy and completeness thereof. Therefore, if the information (i.e., traffic data, location of the travel lanes, modification of Build Alternative alignments, etc.) and assumptions used to create this report change, then the noise study should be reevaluated.

FIGURES



- Receptor location
- Measurement location
- Impacted receptor location

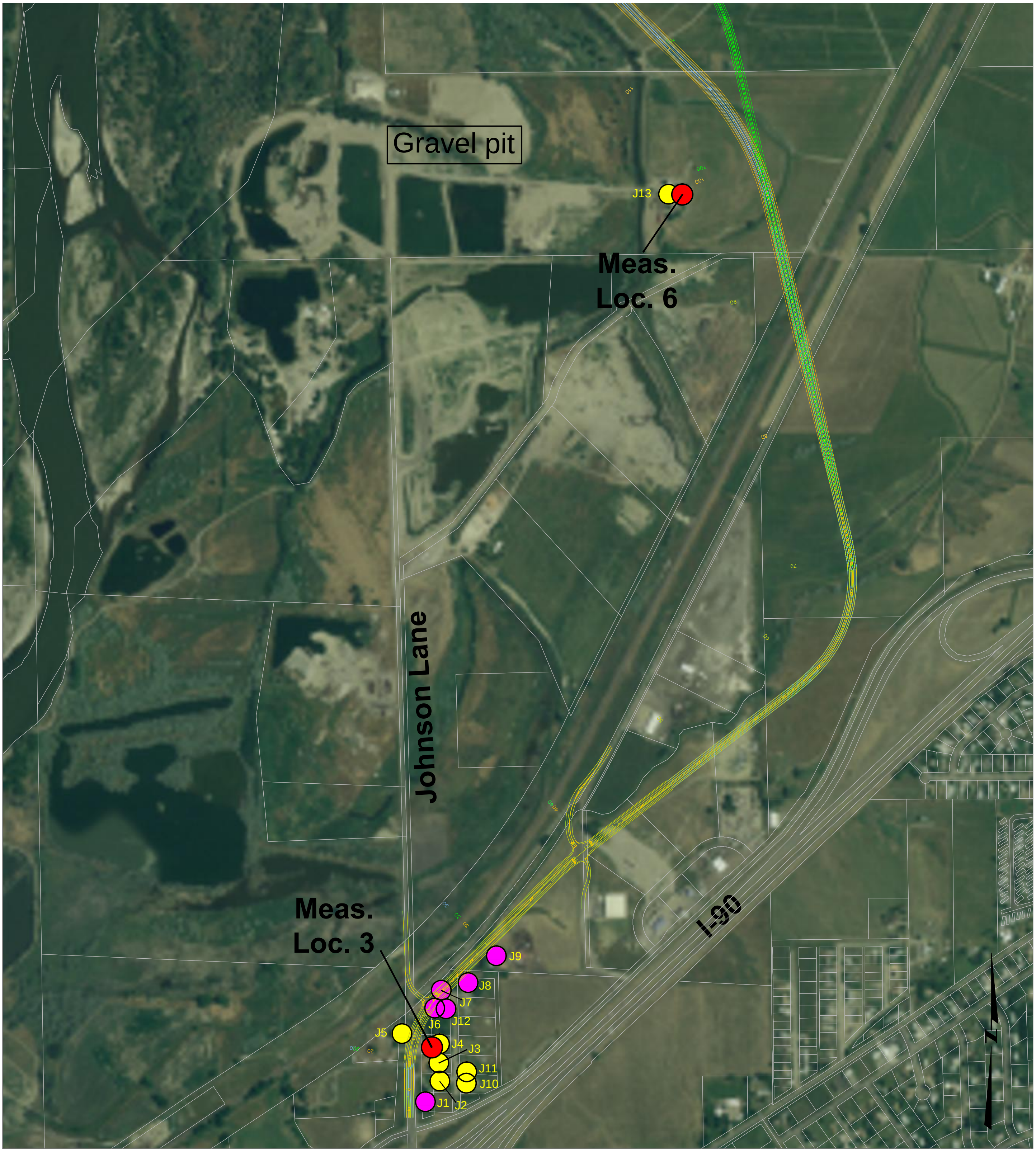
Big Sky Acoustics, LLC

FIGURE 1

RECEPTOR LOCATIONS, MEASUREMENT LOCATIONS & BUILD ALTERNATIVES: OVERVIEW

Billings Bypass Traffic Noise Impact Assessment

Scale: NTS



- Receptor location
- Impacted receptor location
- Measurement location

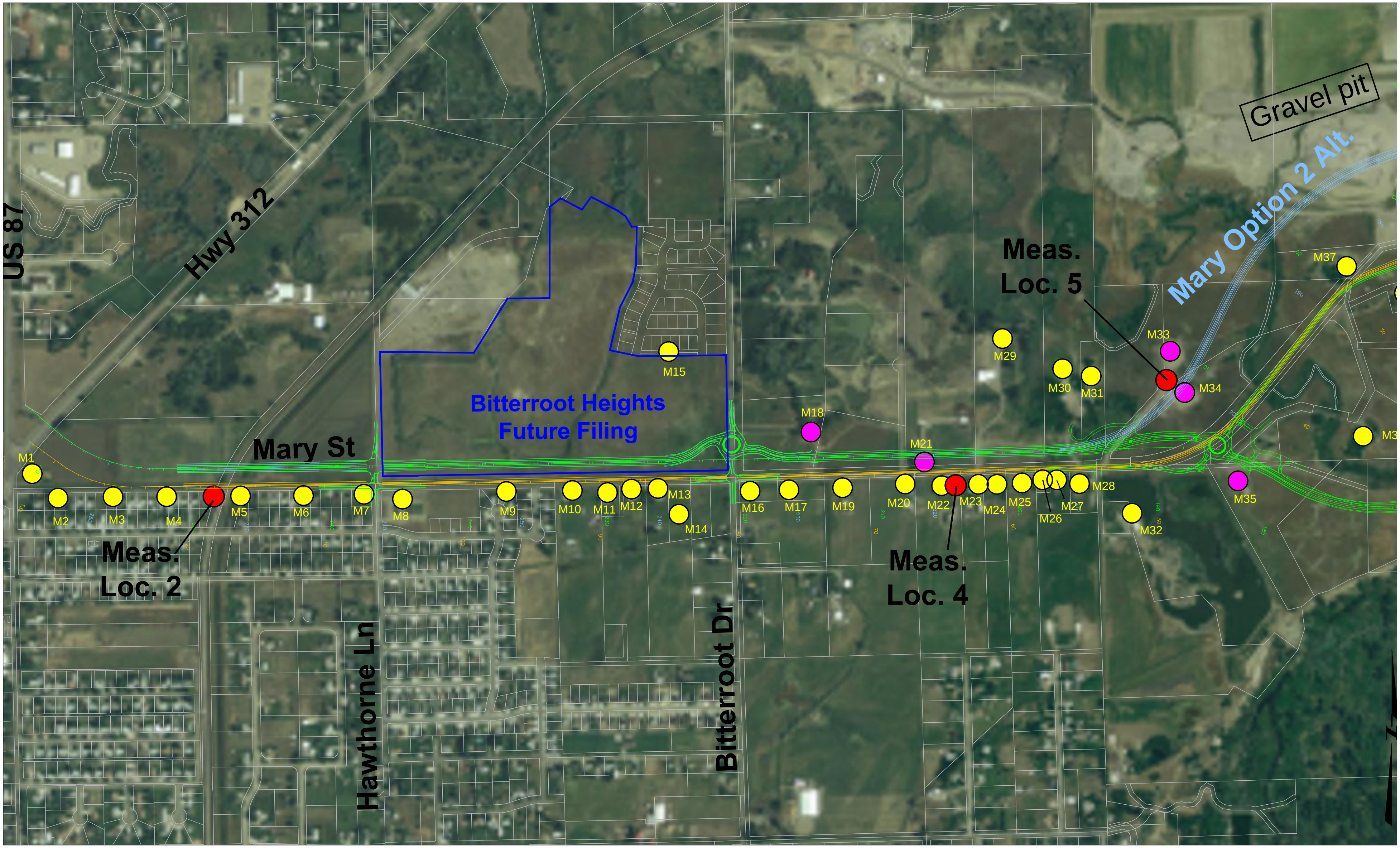
Big Sky Acoustics, LLC

FIGURE 2

RECEPTOR AND MEASUREMENT LOCATIONS: JOHNSON LANE

Billings Bypass Traffic Noise Impact Assessment

Scale: 1" = 1,000'



- Receptor location
- Impacted receptor location
- Measurement location

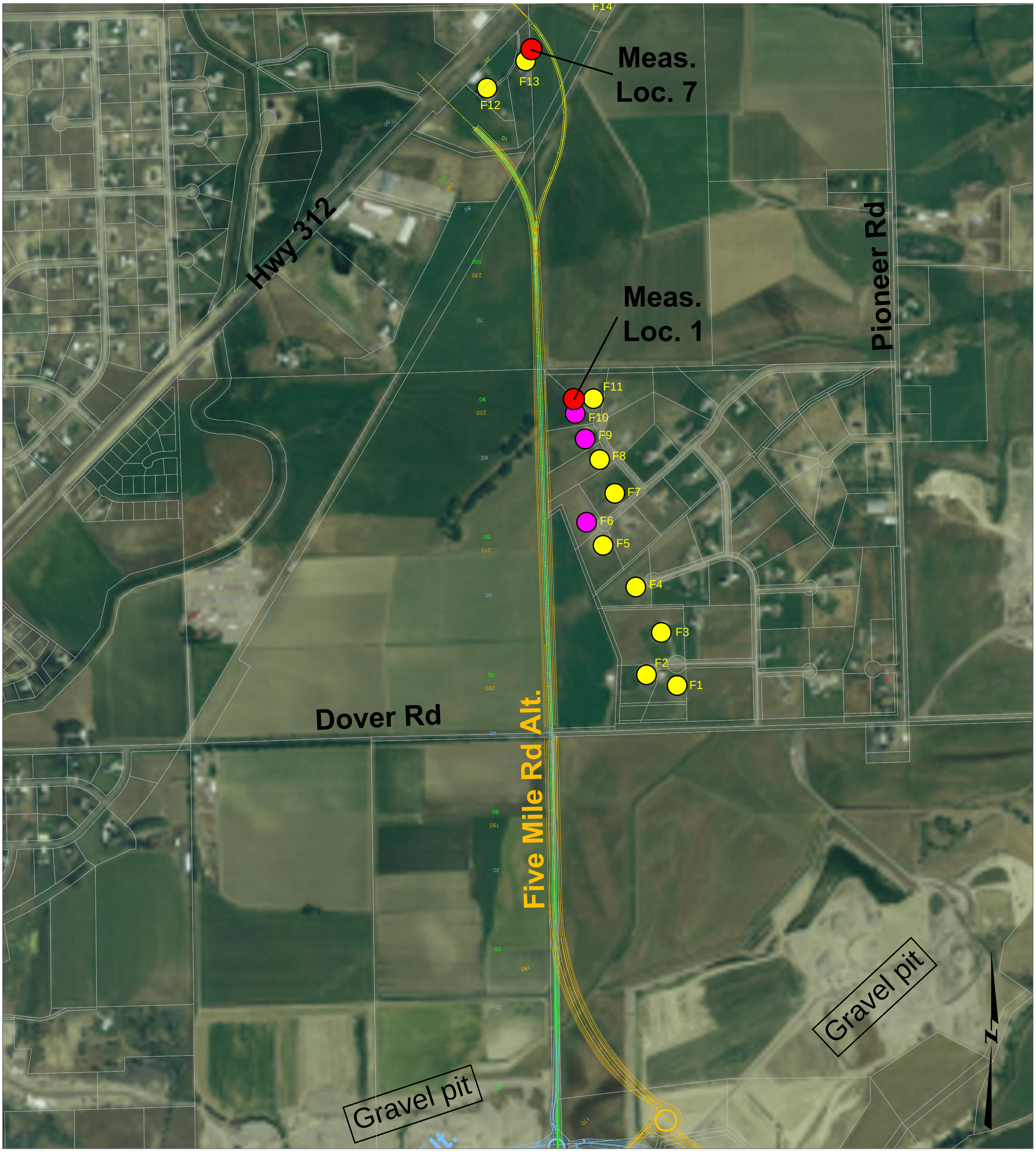
Big Sky Acoustics, LLC

FIGURE 3

RECEPTOR AND MEASUREMENT LOCATIONS: MARY STREET

Billings Bypass Traffic Noise Impact Assessment

Scale: 1" = 1,000'



- Receptor location
- Impacted receptor location
- Measurement location

Big Sky Acoustics, LLC

FIGURE 4

RECEPTOR AND MEASUREMENT LOCATIONS: FIVE MILE ROAD

Billings Bypass Traffic Noise Impact Assessment

Scale: 1" = 1,000'

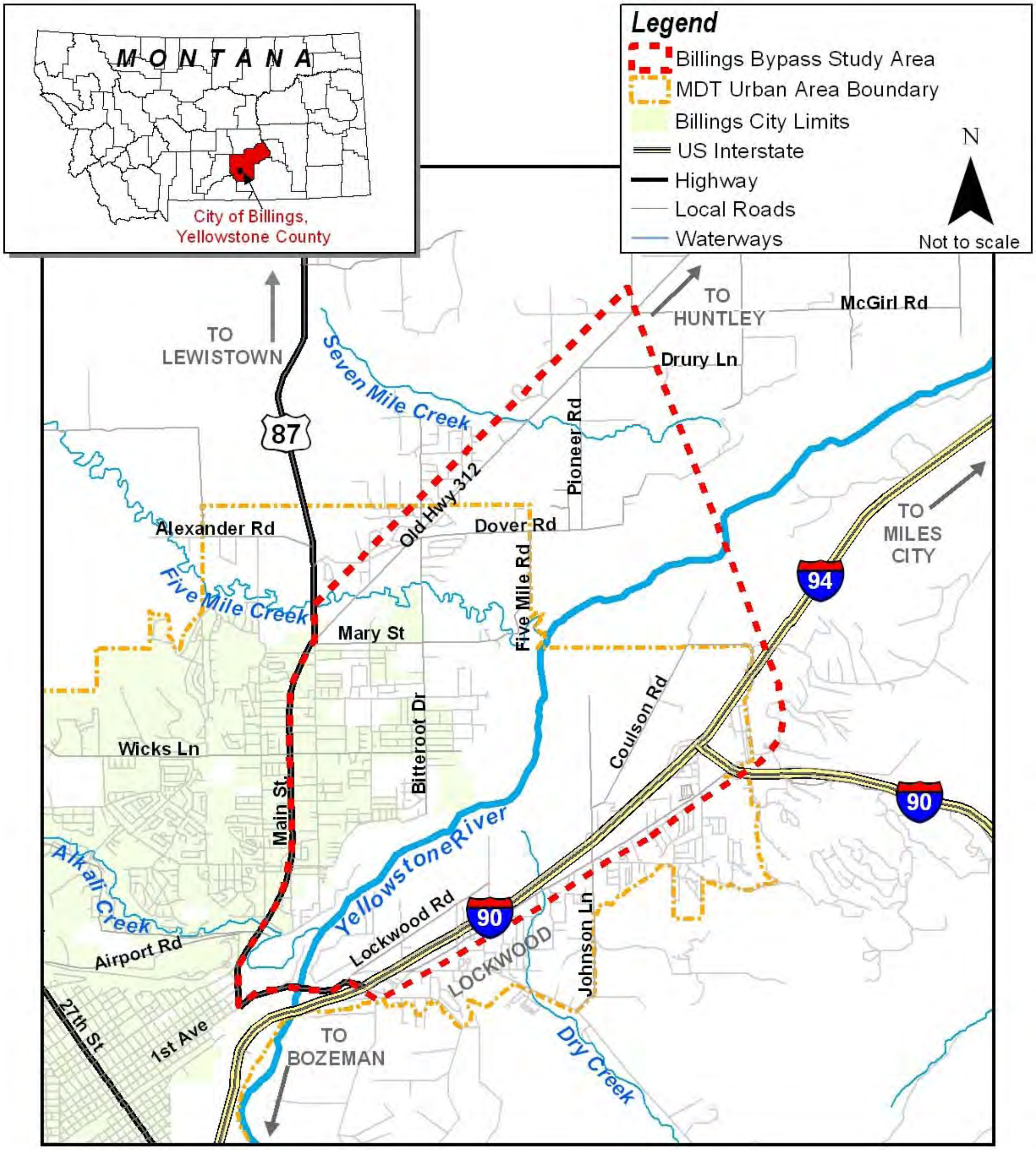
APPENDIX A
BUILD ALTERNATIVES

1.0 INTRODUCTION

The Montana Department of Transportation (MDT), in cooperation with the Federal Highway Administration (FHWA), intends to complete an Environmental Impact Statement (EIS) for the Billings Bypass project. The project is located in Yellowstone County partially within the City of Billings limits (see Figure 1). The project limits extend from Interstate 90 (I-90) to Old Highway 312 (Old Hwy 312), a distance of approximately 3.5 miles. The project is referred to as Billings Bypass, NCPD 56(55), CN 4199.

The purpose of the proposed project is to improve access and connectivity between I-90 and Old Highway 312 to improve mobility in the eastern area of Billings. Four primary transportation needs are identified below:

- Reduce physical barrier impacts to the transportation system
- Improve connectivity between Lockwood and Billings
- Improve mobility to and from Billings Heights
- Improve truck/commercial vehicle access to and through Billings


MONTANA
City of Billings,
Yellowstone County
Legend
Billings Bypass Study Area
MDT Urban Area Boundary
Billings City Limits
US Interstate
Highway
Local Roads
Waterways
N
Not to scale
TO LEWISTOWN
TO HUNTLEY
McGirl Rd
Drury Ln
Seven Mile Creek
87
Pioneer Rd
Old Hwy 312
Dover Rd
Alexander Rd
Five Mile Creek
Five Mile Rd
Mary St
TO MILES CITY
94
Wicks Ln
Bitteroot Dr
Coulson Rd
Main St
90
Yellowstone River
Alkali Creek
Lockwood Rd
LOCKWOOD
Johnson Ln
Airport Rd
27th St
1st Ave
TO BOZEMAN
Dry Creek

2.0 ALTERNATIVES CARRIED FORWARD

The proposed roadway would connect between two existing transportation corridors – the I-90/I94 corridor and Route X 56788 (Old Highway [Hwy] 312). Three alternatives are under consideration for the proposed roadway. The decision-making process undertaken through the EIS will lead to selection of one of these three alternatives, which are depicted in Figures 2, 3, and 4.

- Mary Street Option 1 Alternative
- Mary Street Option 2 Alternative
- Five Mile Road Alternative
- The project is proposed as a four-lane principal arterial designed to NHS standards. The typical section varies by alternative as explained below in Section 2.1.
- Each alternative begins at the I-90 interchange with Johnson Lane, which would be reconstructed as part of the project. Although the specific interchange design will not be defined in the EIS, five conceptual interchange options are explained in Section 2.2 and evaluated in this visual assessment. The other intersection improvements associated with each alternative are also explained in Section 2.2.
- Each alternative uses the same alignment between the Johnson Lane interchange and the Yellowstone River. North of the river, the alternatives use different alignments as shown in Figures 2, 3, and 4. The alternatives would also include improvements to secondary corridors to meet design objectives for operations and safety. These improvements are also identified in Figures 2, 3, and 4.

Figure 1: Mary Street Option 1 Alternative

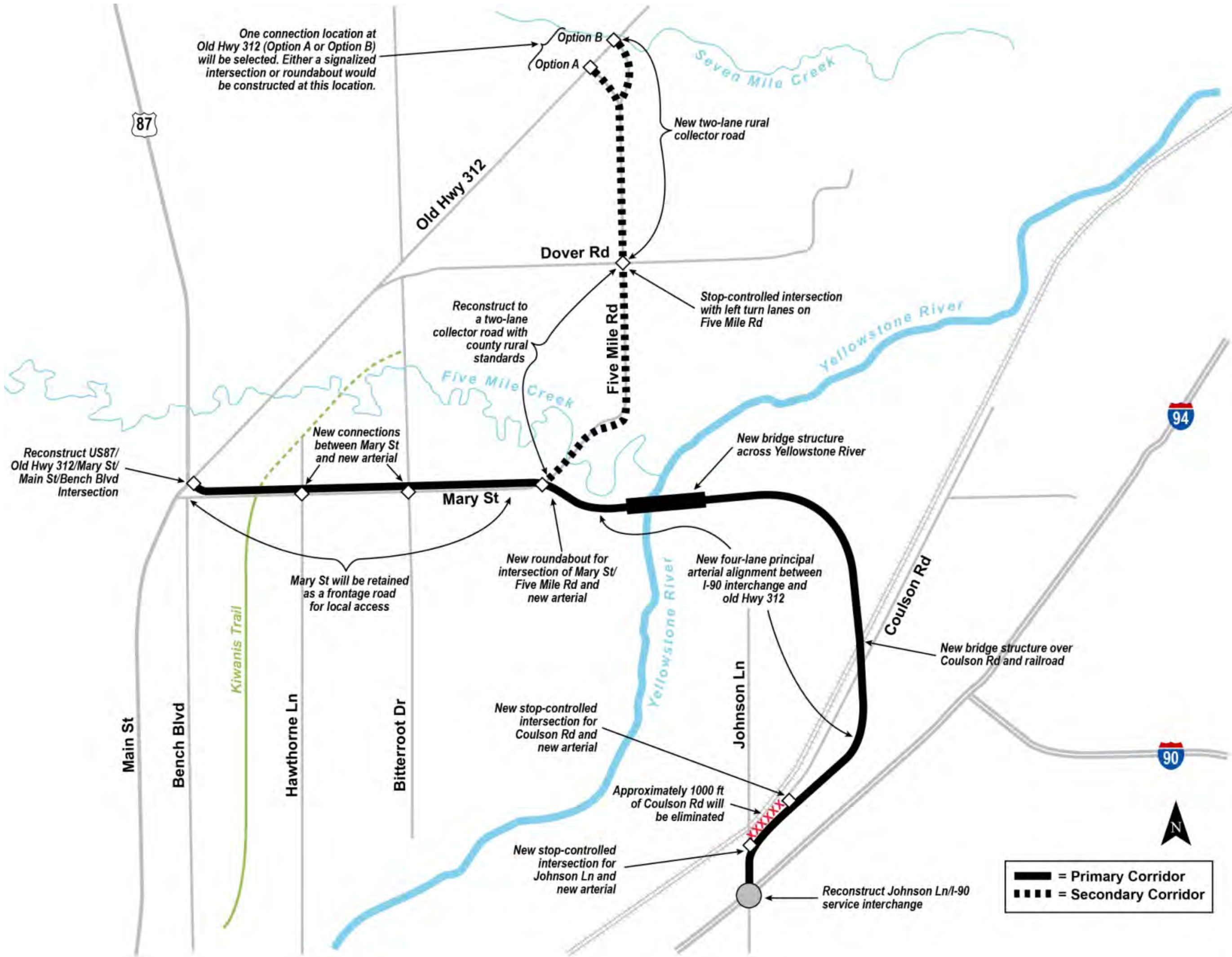


Figure 2: Mary Street Option 2 Alternative

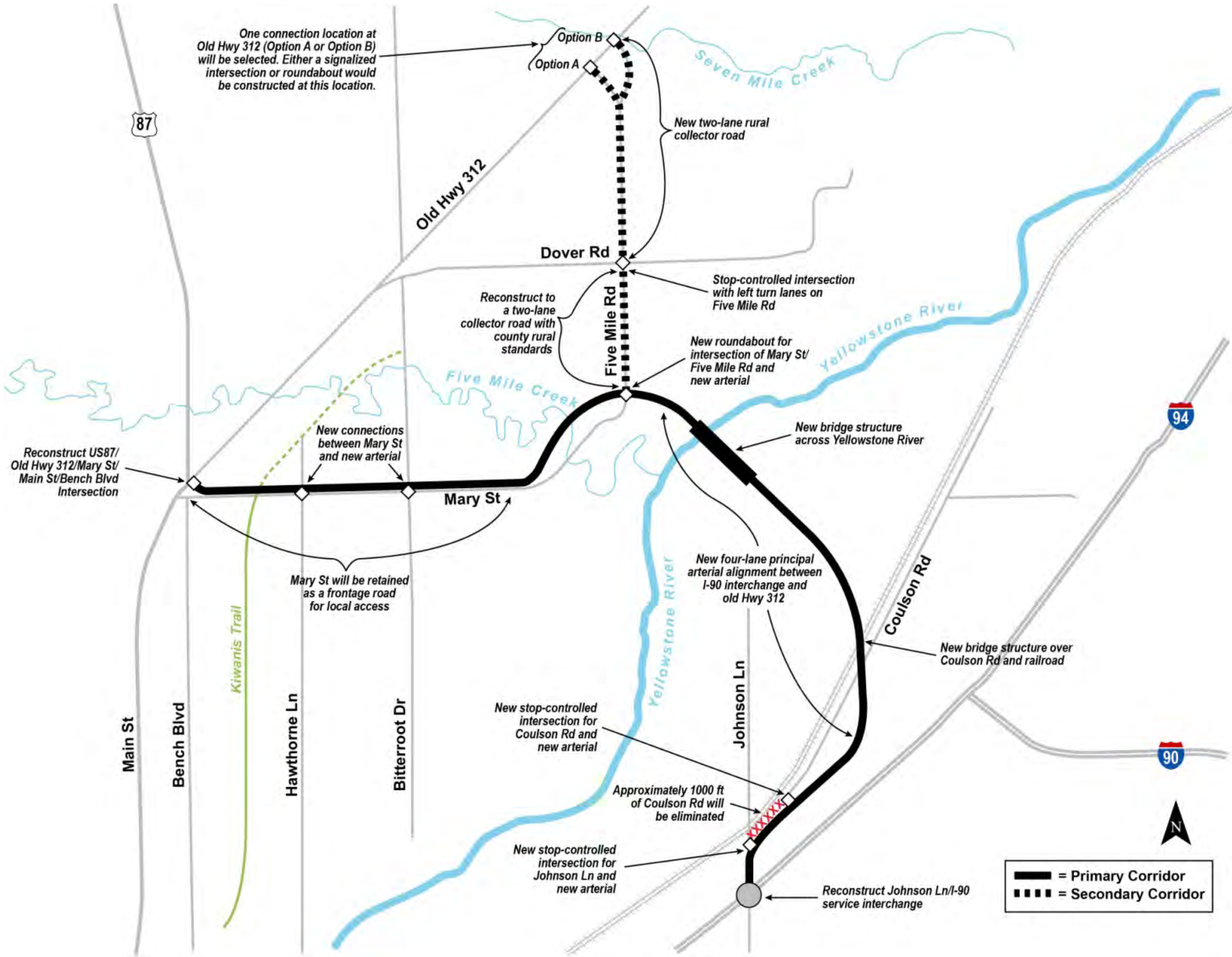
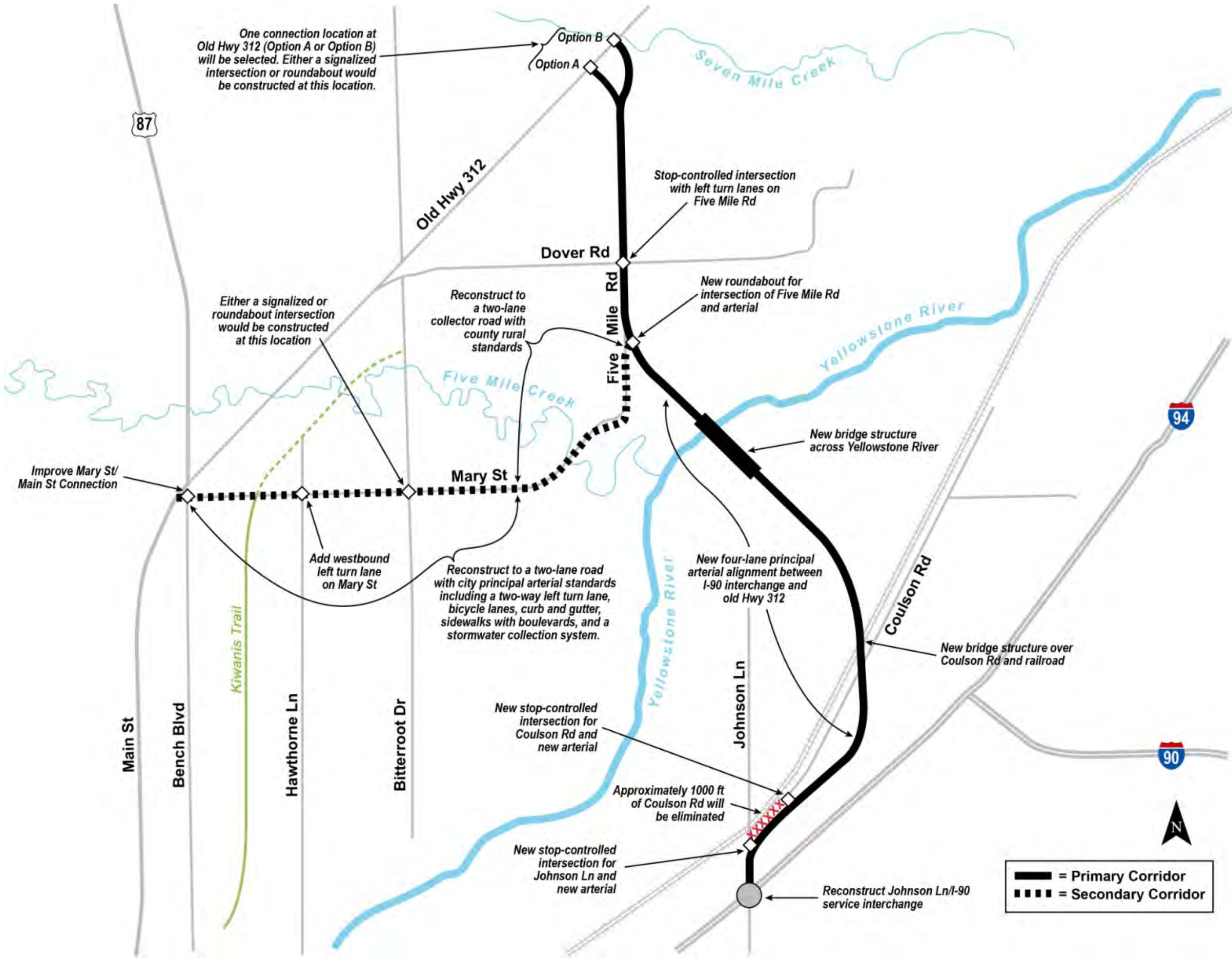


Figure 3: Five Mile Road Alternative



APPENDIX B
TRAFFIC DATA

Alternative System Link Traffic Volumes

Compiled 09-26-2011

	Link		Existing	Length	No-Build Alternative ADT		Mary Street Option 1 ADT		Mary Street Option 2 ADT		Five Mile Road Alt. ADT	
Route	From	To	ADT	Miles	Year 2015	Year 2035	Year 2015	Year 2035	Year 2015	Year 2035	Year 2015	Year 2035
Highway 312	US 87	Dover Road	10900	1.32	11500	16600	9800	13550	9800	13550	9800	13500
	Dover Road	Five Mile Road	8700	1.47	9100	11800	8900	10950	8900	10550	8900	10900
	Five Mile Road	S-522 Huntley	6500	6.16	6800	9100	7500	10,500	7900	10800	9100	10800
US 87 North	Highway 312	Independence Lane	5900	0.96	6200	13000	6200	13000	6200	13000	6200	13000
Main Street	1st Avenue N	4th/6th Avenues North	36100	0.32	37900	54000	31400	41350	31700	41850	32800	44350
	4th/6th Avenues North	Airport Road	49200	0.40	48700	62400	47400	52150	43700	52400	44900	54900
	Airport Road	Hilltop Road	42200	0.64	47100	60000	41900	49750	42100	50000	43300	52500
	Hilltop Road	Wicks Lane	35200	1.02	35600	49200	30800	39500	31200	39700	31700	42250
	Wicks Lane	US 87/312	19350	1.00	20000	31300	16000	28350	15900	28650	19900	27750
Bench Boulevard	US 87	Wicks Lane	2900	1.03	3200	5700	4000	5350	3900	4900	3900	5200
	Wicks Lane	Hilltop Road	4300	1.01	5500	8500	4400	6900	4300	7000	4200	7000
	Hilltop Road	Main Street	na	1.36	10200	14250	8900	11850	9100	12050	8950	12050
Bitteroot Drive	Dover Road	Mary Street	900	0.96	950	2500	950	2650	950	2650	950	2650
	Mary Street	Wicks Lane	1800	1.00	1900	3200	2150	4250	2200	4100	2300	4100
Mary Street	Bench Boulevard	Bitteroot Drive	1450	1.00	1500	4000	1250	3100	1250	3100	3100	9700
	Bitteroot Drive	5 Mile Road	500	1.15	550	1000	500	1000	500	1000	4350	8800
5 Mile Road	Mary Street	Dover Road	100	0.65	150	500	2800	4850	3250	5150	4350	8800
Dover Road	HWY 312	Bitteroot Drive	1600	0.08	1700	3800	1700	3900	1700	3900	1700	3900
	Bitteroot Drive	5 Mile Road	1000	1.00	1050	2400	1050	2300	1050	2300	1050	2300
Wicks Lane	Lake Elmo Road	Main Street	15500	0.24	16300	20100	16300	20250	16300	20250	16300	20250
	Main Street	Bench Boulevard	15300	0.24	15500	21900	15100	21600	15150	21550	15200	21550
	Bench Boulevard	Bitteroot Drive	4100	1.00	4400	6400	4000	6050	4000	6050	4000	6050
Hilltop Road	Lake Elmo Road	Main Street	8900	0.24	9300	10000	9300	10000	9300	10000	9300	10000
	Main Street	Bench Boulevard	6400	0.24	5000	7600	5000	7600	5000	7600	5000	7600
Johnson Lane	Old Hardin Road	Johnson Interchange	12500	0.17	13200	18800	13200	18800	13200	18800	13200	18800
	Johnson Interchange	Coulson Road	1400	0.29	1500	2100	10000	18000	10000	17700	8850	15100
US 87	Lockwood Interchange	Old Hardin Road	10900	0.58	11500	16400	11500	16400	11500	16400	11500	16400
	1st Avenue N/Main	Lockwood Interchange	28000	1.25	29400	42000	22900	29350	23200	29850	24300	32350
I-94	Huntley Interchange	Pinehill Interchange	7100	6.21	7400	10600	6400	9200	6000	8900	6000	8900
I-90	S. 27th St. Interchange	Lockwood Interchange	24900	2.76	26100	37400	24900	35550	25000	35700	25000	35800
	Lockwood Interchange	Johnson Ln Interchange	21800	1.27	22900	32700	19500	27550	19900	27950	20100	27100
	Johnson Ln Interchange	Pinehill Interchange	14100	2.45	14800	21200	13800	19800	13400	19500	13400	19500
Mary Street Option 1	Highway 312	Bitteroot Drive	0	0.97	0	0	2750	9400				
	Bitteroot Drive	Five Mile Road	0	0.65	0	0	2800	11550				
	Five Mile Road	Johnson Lane	0	3.08	0	0	8800	15900				
Mary Street Option 2	Highway 312	Bitteroot Drive	0	0.97	0	0			4400	9000		
	Bitteroot Drive	Five Mile Road	0	1.18	0	0			5500	10900		
	Five Mile Road	Johnson Lane	0	2.75	0	0			8750	15600		
Five Mile Road Align.	Highway 312	Dover Road	0	0.93	0	0					3150	4400
	Dover Road	Five Mile/Mary	100	0.45	150	500					3250	5200
	Five Mile/Mary	Johnson Lane	0	2.82	0	0					7600	13000

ADT = Average Daily Traffic Along Entire Link

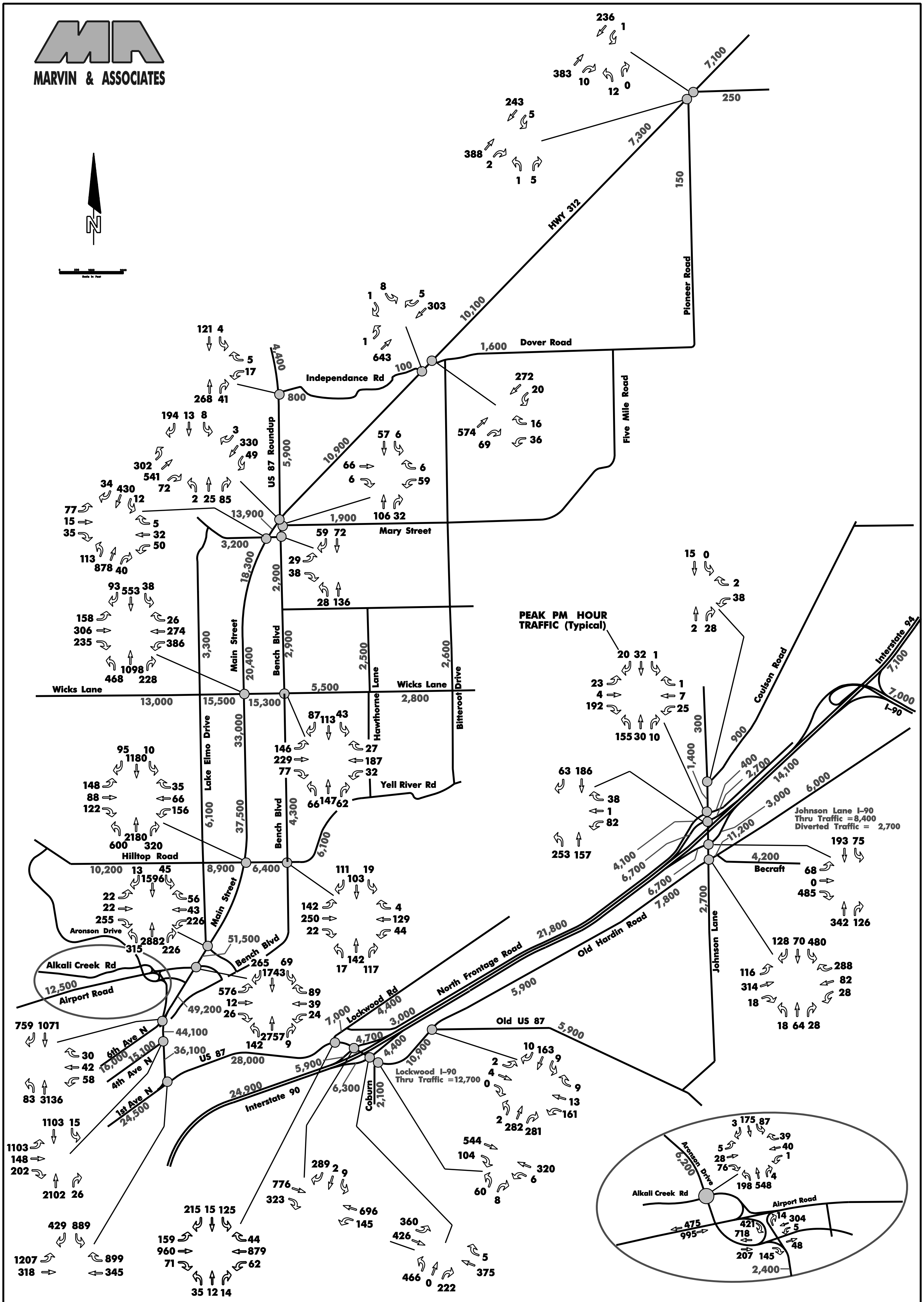
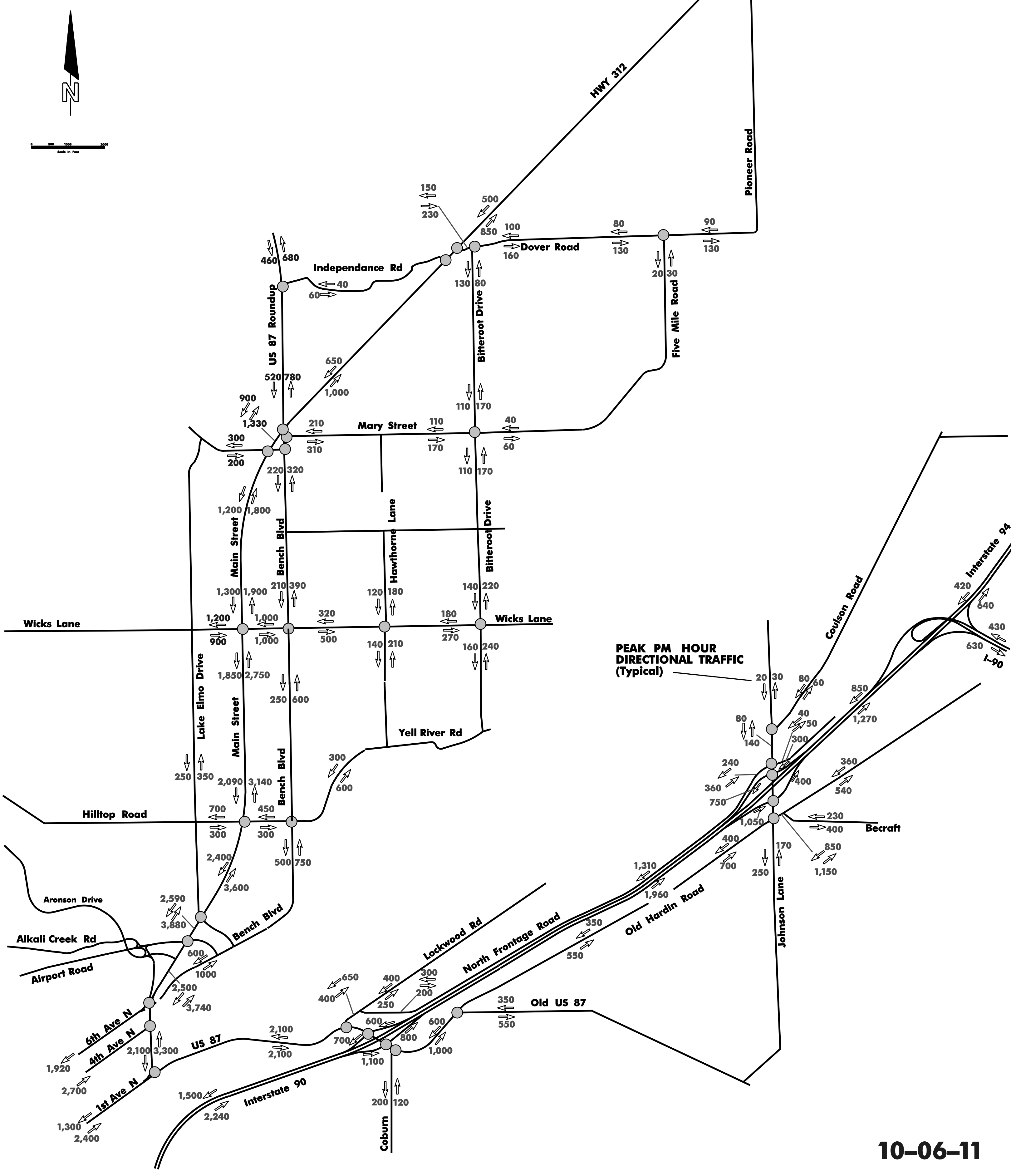


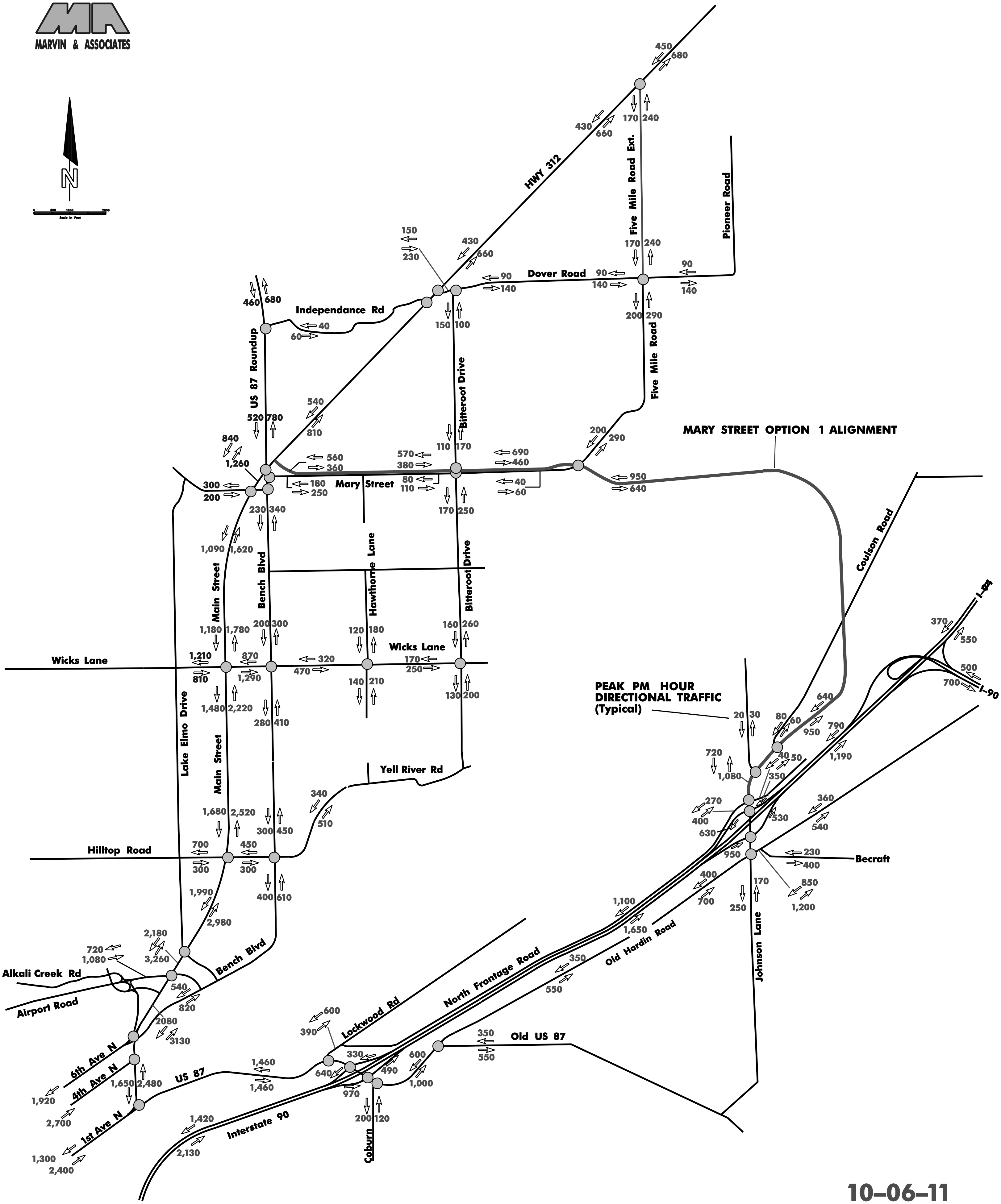
Figure 1. Existing (2010) Traffic Volumes on Impacted System

MARVIN & ASSOCIATES



10–06–11

Figure NB2. Year 2035 Design Hour Traffic Volumes on No–build System



10–06–11

Figure M3. Year 2035 Peak Hour Volumes – Mary Option 1

MARVIN & ASSOCIATES

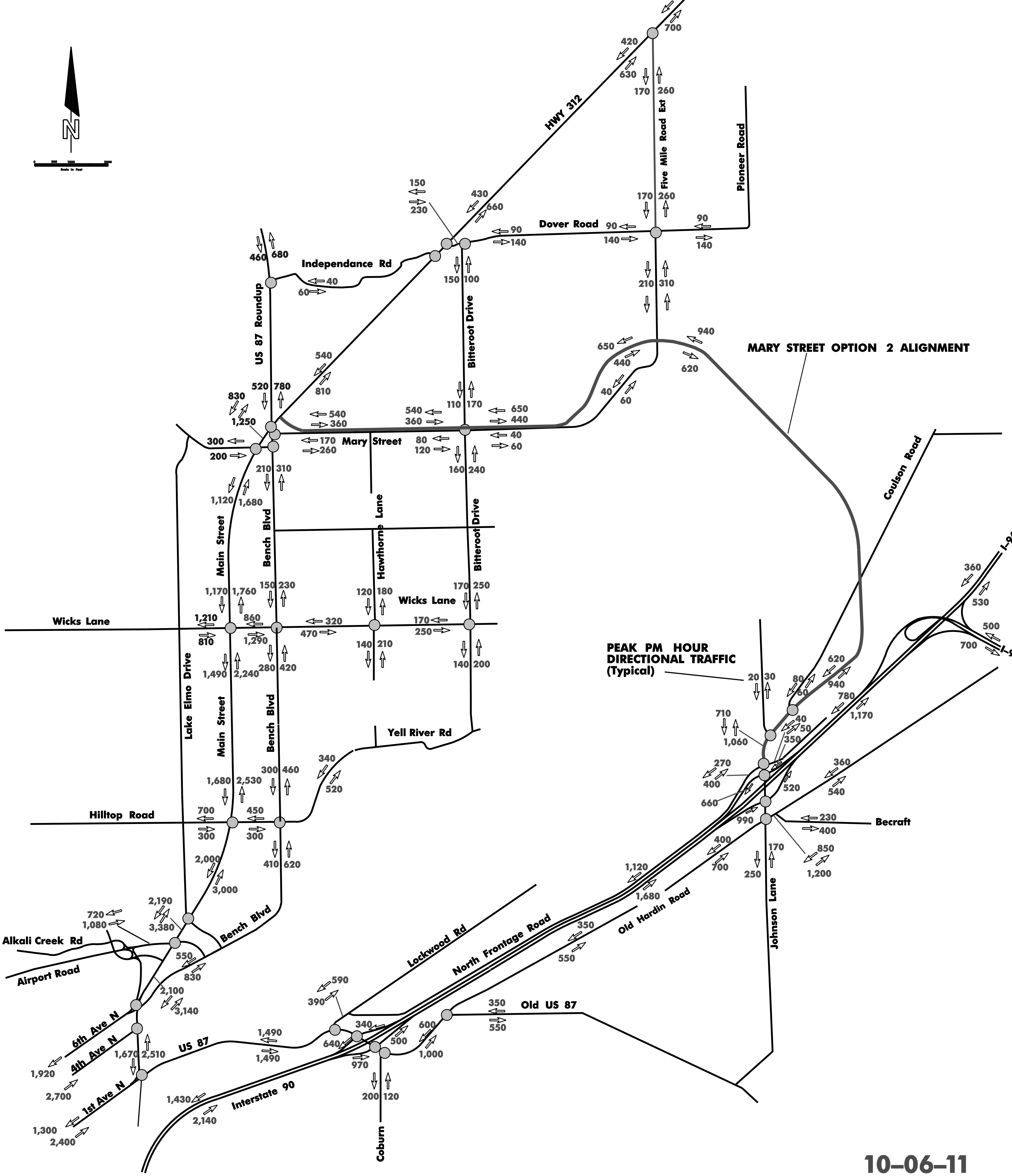


Figure M4. Year 2035 Peak Hour Volumes – Mary Option 2

MARVIN & ASSOCIATES

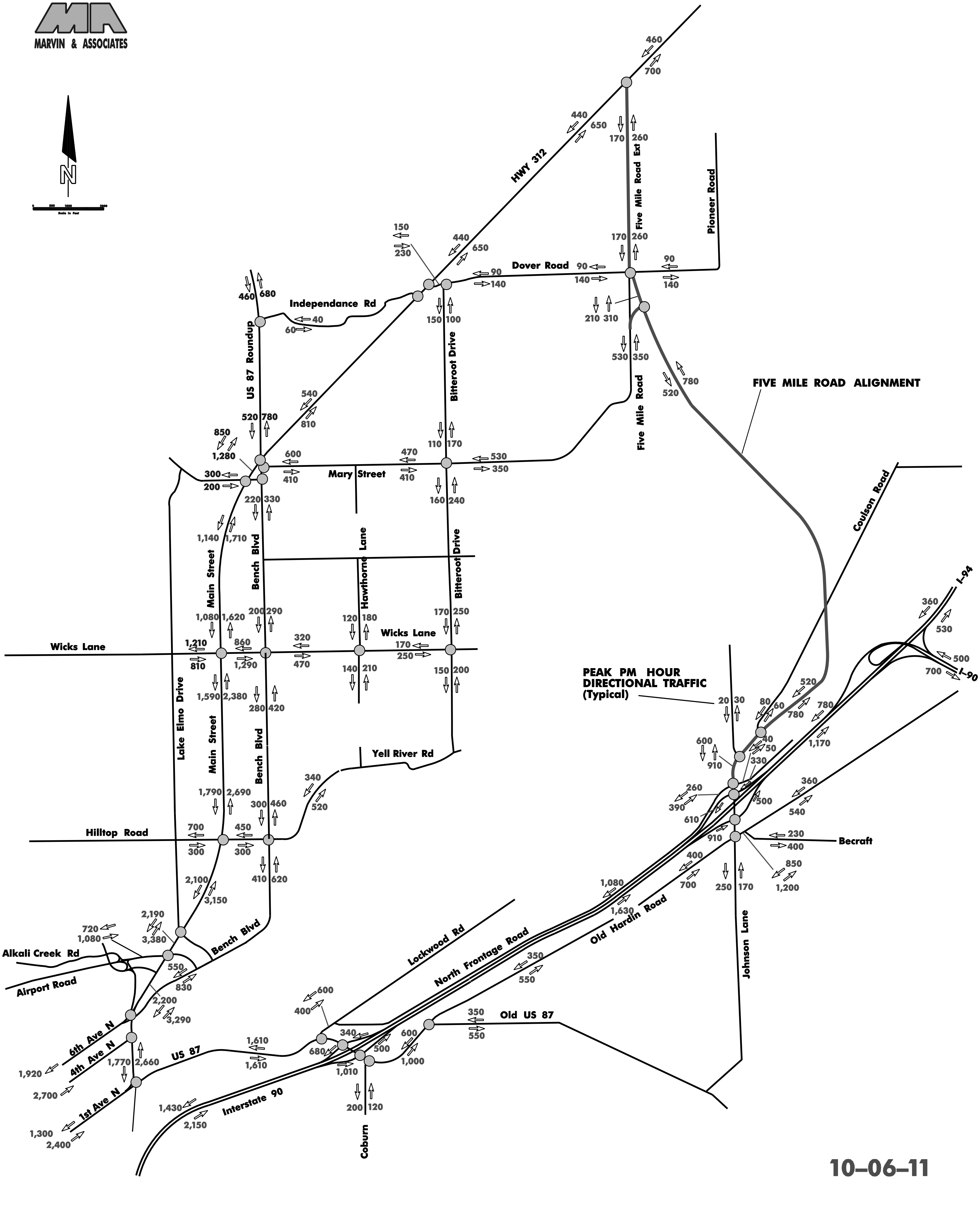


Figure FM2. Year 2035 Peak Hour Volumes – Five Mile Road Alternative