NEW MEXICO ABANDONED MINE LAND PROGRAM

FINAL DRAINAGE REPORT

ALLISON, NEW MEXICO

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DRAFT REPORT

PROJECT NO.: LT2043298.01

DATE: AUGUST 2020

WSP

2019 GALISTEO ST., SUITE M-1
SANTA FE, NEW MEXICO
505.395.2190

WSP.COM

Our ref.: LT2043298.01

AUGUST 18, 2020

Meghan J. McDonald, PE
New Mexico Abandoned Mine Land Program
Mining & Minerals Division
1220 South Saint Francis Drive, Santa Fe, NM 87505

Dear Ms. McDonald,

Transmitted herein is the Allison Drainage Assessment and Report. The report incorporates the comments provided by AML on July 17, 2020 on draft report submitted on July 7, 2020 . The AML Program tasked WSP to prepare a drainage assessment of Allison Project, located in McKinley County, New Mexico, under SHARE No. 19-521-0620-0163 as Task Order No. 1. The enclosed document details the findings of WSP's drainage analysis and recommendations of Allison.

The purpose of this report is to assess the current drainage conditions in the community of Allison, and provide recommendations to mitigate drainage issues on the project site. This report provides conceptual designs to control and/or redirect stormwater from areas prone to ground subsidence and reduce sedimentation within the community. The information and analysis present in this report is based on survey data and other best available data the time of preparation.

Any questions or requests for additional information should be directed to myself via email.

Kind Regards,

Jennifer Hyre

Jennifer

Encl. Final Drainage Report

QUALITY MANAGEMENT

ISSUE/REVISION	FIRST ISSUE	REVISION 1	REVISION 2	REVISION 3
Remarks	Draft Report	Final Report		
Date	07/07/2020	08/18/2020		
Prepared by	Govinda Karki, PE	Govinda Karki		
Signature				
Checked by	Farshad Omidvaran, PE	Farshad Omidvaran, PE		
Signature				
Authorized by	Richard Rotto, PE	Jennifer Hyre		
Signature				
Project number	LT2043298.01	LT2043298.01		
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File reference	Task Order 1	Task Order 1		

SIGNATURES

PREPARED BY

Govinda Karki, PE
Drainage Engineer

REVIEWED BY

Farshad Omidvaran, PE,
Drainage Project Manager

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PRODUCTION TEAM

MINING & MINERALS DIVISION

AML Program	Megan J. McDonald, PE

WSP

Project Manager	Jennifer Hyre
Senior Drainage Engineer	Farshad Omidvaran, PE
Drainage Engineer	Govinda Karki, PE

SUBCONSULTANT

Precision Survey, Inc.	Larry Medrano, PS

TABLES

FIGURES

1 GENERAL PROJECT INFORMATION

1.1 DESCRIPTION AND PURPOSE

The unincorporated town of Allison, New Mexico (**Figure 1**) is routinely affected by legacy subsurface coal mining. Subsidence was first observed in the 1980's. Subsidence features in the form of sinkholes and ground cracks have developed in the community above the abandoned mine workings of the historic Allison Mine. Deteriorating underground workings, lack of an effective stormwater conveyance system, and landowner alterations to the landscape continue to aggravate sinkhole development near residences and businesses in the town of Allison.

Under the As-Needed Professional Ecological Engineering and Landscape Architectural Services PSA, SHARE No. 19-521-0620-0163, the Abandoned Mine Land (AML) Program requested that WSP perform a drainage assessment for the Allison Project, referenced as Task Order 1, located in Allison, McKinley County, New Mexico.

The objective of Task Order 1 is to provide the AML Program a detailed solution to the drainage issues near the historic Allison Mine. Currently, there are subsidence issues caused by legacy mining and made worse by the lack of a proper conveyance system for stormwater and ephemeral flows. This report provides a detailed assessment of the current drainage conditions at Allison and proposes stable and effective alternatives for stormwater conveyance.

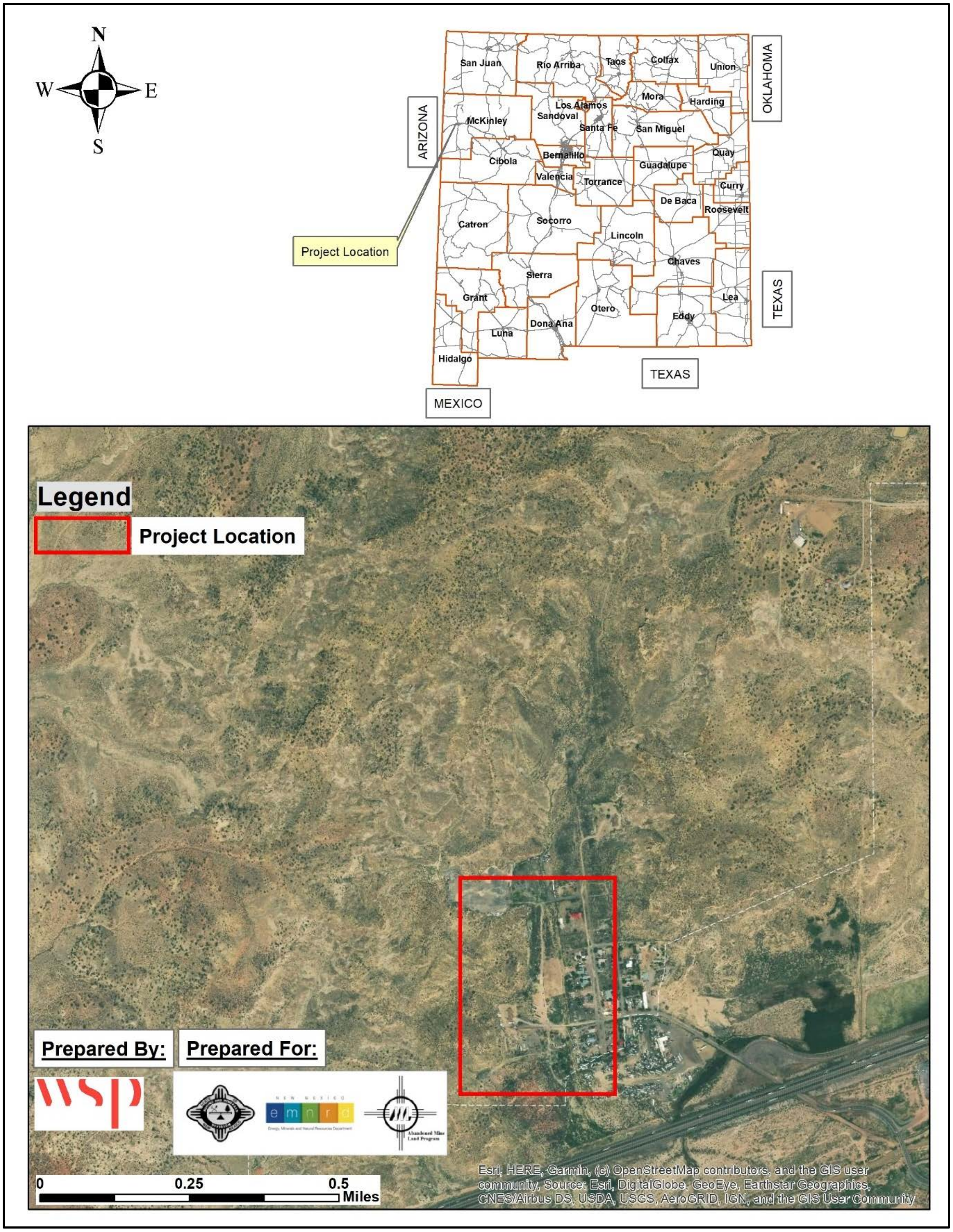


Figure 1 - Vicinity Map for Allison, New Mexico

1.2 BACKGROUND, KICK-OFF MEETING AND FIELD OBSERVATION

The Allison Mine was first established in 1894 as the Mulholland-Casa and Diamond-Allison Mine (**Figure 2**). In its infancy, the mine employed approximately 12 laborers and 2-4 top-men directing the day-to-day operations. The mine produced an estimated 3,100 tons of coal in the first five years of operation. At its pinnacle, in 1918, the mine employed 300 men and produced 240,000 tons of coal annually.

Figure 2 - Image of Allison Mine, 1916 (Library of Congress)

Figure 3 - Image of Allison Coal Camp, 1916 (Library of Congress)

The community of Allison was established in the late 1800's, not long after the establishment of the Allison Mine complex (**Figure 3**). The town provided housing and a centralized community for the miners working in mines just west of Gallup, NM. At its peak, the coal camp was home to more than 600 residents including families, single men and service providers. Community services provided in Allison included a company store, a one-room schoolhouse, a two-bed hospital, and a company-man constable. The Diamond Coal Company, a conglomerate in control of the Allison Mine, refused to allow theaters, cafes, bars, or other social establishments, preferring to maintain a sober atmosphere. Laborers lived in two to three-room houses consisting of one or two bedrooms and a large kitchen. Outdoor plumbing was provided in the form of individual outhouses and an outdoor faucet at every third house. Allison owned its own power plant and provided electricity throughout the housing development. Each family residence contained enough land to garden and raise barnyard animals. Although most residents have since relocated since the closure of the mine in 1940, the community of Allison has endured.

The first known account of subsidence in Allison occurred in the 1980’s when the AML Program received reports of ground settling and foundation cracks throughout the townsite. At the time, it was assumed that surface settling was in some way correlated to the abandoned mine workings found underneath the townsite. After meeting with residents and conducting field reconnaissance, the AML Program determined the area deserved further exploration and worked in concert with Stewart Brothers Drilling, a drilling company, to investigate the subsurface conditions. Stewart Brothers performed speculative drilling in 1985 and 1986. Based on their findings, Eby Mine Services and their subcontractor Badger Drilling performed additional exploratory drilling followed by injection grouting in 1987 to stabilize the subsidence.

Since the 1987 stabilization efforts, the AML Program completed two additional emergency construction projects from 2015 to 2018 to abate hazardous conditions caused by open subsidence features.

In 2015, the AML Program was notified that a sinkhole approximately 40’x20’x30’ (Length x Width x Depth) developed within a drainage channel on private property (Figure 4). The sinkhole quickly advanced and had grown to 90’x45’x30’(Length x Width x Depth) in a matter of weeks. AML contracted Alan Kuhn Associates to investigate subsurface conditions of the subsidence and its margins, and profile the conditions underground (Figure 5).

Figure 4 - Photo of Initial Sinkhole, 2015 (NM AML Program)

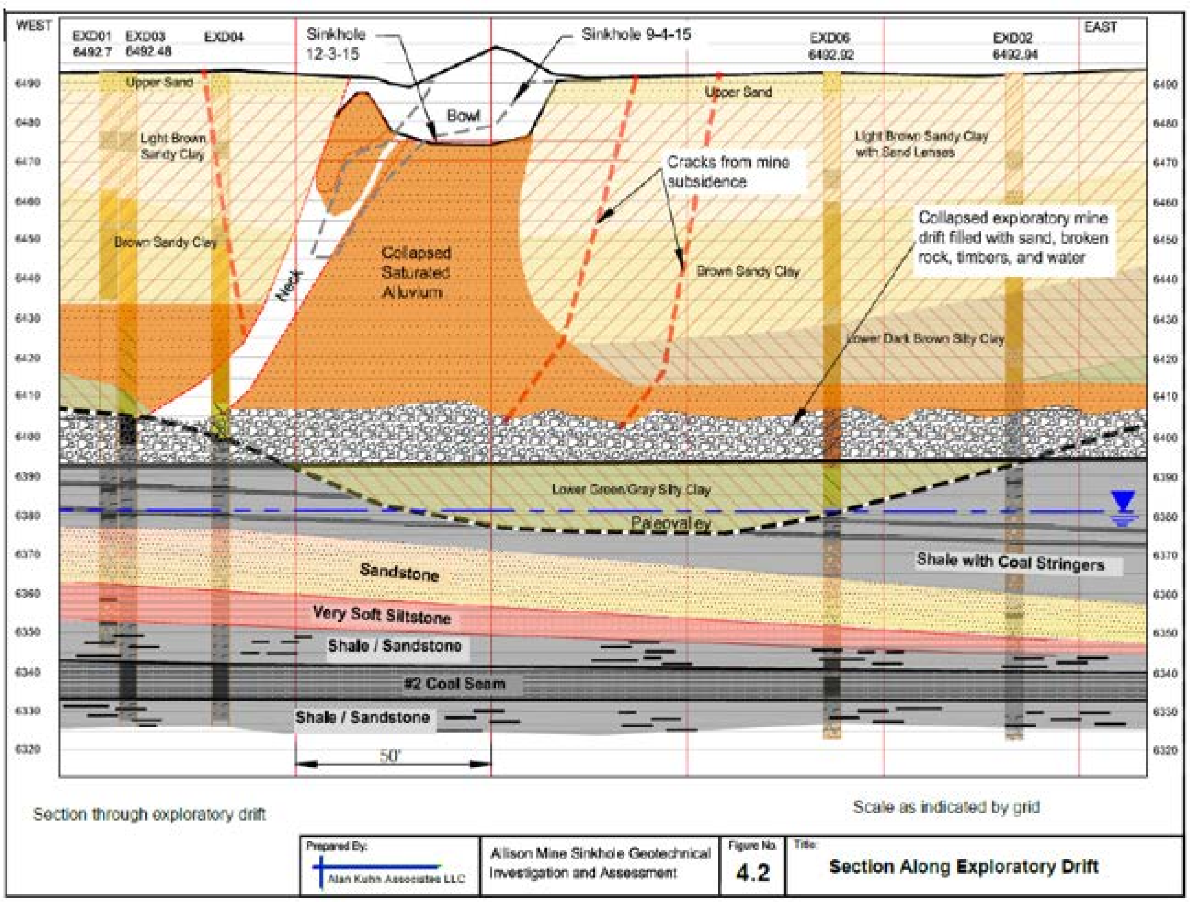


Figure 5 - Subsurface Profile by Alan Kuhn Associates (NM AML Program, Alan Kuhn)

To impede the development of future sinkholes, AML filled the subsidence and tension cracks and rerouted surface water away from the sinkhole.

The AML Program ultimately determined the subsidence was likely caused by failing underground mine workings, surface tension crack development, and infiltration of water through the tension cracks to the subsurface voids. AML also believed that the development of the sinkholes was exacerbated by an earthen dam ('fill pad") built by a landowner upstream.

A second sinkhole developed near the first 2015 sinkhole. Newly developed surface tension cracks merged with the tension cracks recorded during the first event and destabilized the area. Fearing a threat to the health and safety of the residents of Allison, AML entered into an emergency contract with Golder Associates Inc. to perform a geotechnical investigation and provide recommendations to fill the sinkhole and stabilize the surrounding landscape.

Geotechnical investigations performed under the direction of the AML Program concluded that stormwater-related erosion contributed to the formation and widening of sinkholes at the Allison site. The AML Program's contractor drilled and injected grout into underground mine workings to construct a bulkhead, then into the subsurface, in a grid pattern, to help stiffen and shore-up the alluvial soils and prevent further degradation. Contractors also dug out the tension cracks and filled them with compacted, native soil. The approximately 2-acre construction footprint, including a 100' length of the drainage channel, was restored and reseeded. The stabilization project was completed in June of 2018; there has been no recorded migration of the sinkhole since then.

Presently, the community continues to have concerns regarding the integrity of the underground mine workings. The New Mexico Abandoned Mine Land Program is charged with safeguarding abandoned mine lands in New Mexico and has contracted with WSP to find a drainage solution that limits further subsidence by improving stormwater conveyance and reducing infiltration.

A project kick-off meeting was held on June 19th, 2019 at the AML offices. A preliminary site visit was conducted on June 24th, 2019. Members of the Project Team included representatives from the AML Program, Golder and Associates Inc. (Golder), and WSP.

The project kick-off meeting provided an opportunity to introduce members of the project team, familiarize them with the project background and provide an overview of the current site conditions. AML discussed the historical room and pillar coal mining methods, the location of the subsurface workings (**Figure 6**), subsequent impacts to the community, and AML's previous work at the site.

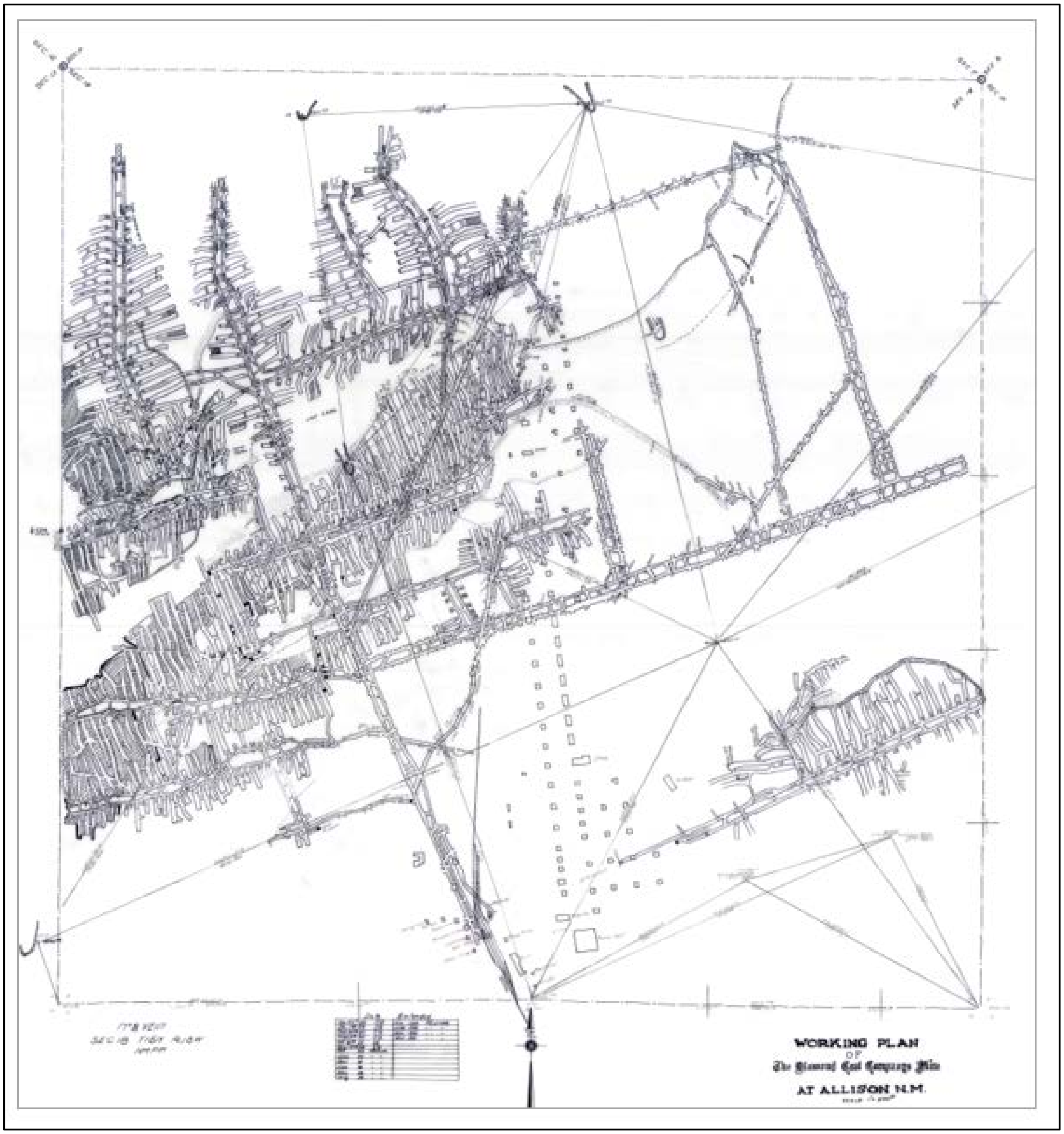


Figure 6 - Image of Allison Mine Working Plan (Map) Circa 1924 (NM AML Program)

The preliminary field visit, led by Meghan McDonald and Joe Vinson of the AML Program, included a tour of the project site. The tour consisted of walking in and around the townsite to assess how the current drainage patterns have been affected by landowner intervention, and how the drainage affects downstream residents. The Project Team initially explored the site of the “Phase III Emergency Project” and discussed key elements of the previous work to stabilize the sinkholes. The team then evaluated the current drainage pattern and walked the existing channel downstream of the Phase III Emergency Project down to the NMDOT right-of-way fence.

Thereafter, the Project Team walked to the site of the upstream “Fill Pad Area” and observed sections of the upstream drainage channel. Upon returning from the upstream areas, the team toured town including Coronado Blvd, Cortez Road, and Acoma Street.

The project footprint is mostly found on private property. Evidence that landowner activities have altered the historic alignment of the drainage channel was seen both upstream and downstream of the Phase III Emergency Project area (**Figure 7**) “.

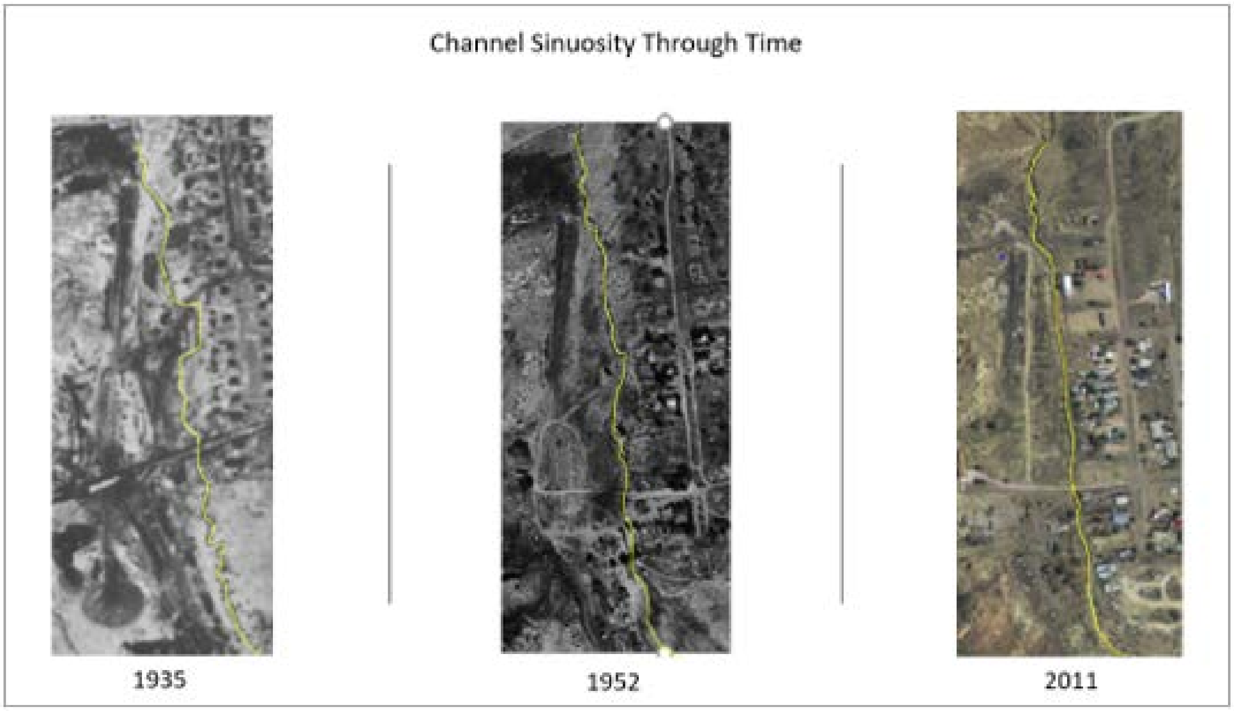


Figure 7 - Image of Landowner Effects on Channel Sinuosity Through Time

Changes to the upstream section included a new “Fill Pad Area” above town that appears to be a landfill made from construction debris and channel armoring in the drainage channel below the Fill Pad Area made from concrete fragments purposefully placed along the channel banks. WSP and AML inspected the Fill Pad Area, built by a landowner, that is suspected of exacerbating downstream flooding and erosion. The “Fill Pad Area” appears to include a landfill of construction debris from a road project (concrete slab remnants, rebar, asphalt millings and/or base course material). The AML team members believe the “Fill Pad Area” was constructed sometime in 2012. The landfill disrupts, and likely slows, the historic flows through Allison.

The downstream section of the drainage channel has been realigned by the expanding operations at Speedway Towing near I-40.

AML also pointed out culverts and other infrastructure that are blocked or partially blocked and no longer convey stormwater as intended.

Golder was able to identify and point out landmarks and features of the historic mines that surround and undermine the project area. WSP toured remediated subsidence areas, observed some of the old bore holes and injection sites (for grouting subsurface cracks), historic wells, and safeguarded mine entrances. Meeting Minutes of the kick-off meeting and field visit are attached in **APPENDIX C.**

1.3 AS-BUILTS AND PLANS

Historic documents, photos and aerials provided by AML were reviewed as a part of the drainage study. Some of the relevant documents are attached in **APPENDIX C** and **D**.

1.4 DRAINAGE DESIGN CRITERIA

Drainage design criteria in Section 200 of New Mexico Department of Transportation's (NMDOT) Drainage Design Manual has been followed for design of the drainage structures included herein. The 24-hour duration storm was used for all hydrologic analyses. The 50-year and 100-year storm frequencies were used for the design flood and check flood, respectively for the drainage channel, while the 10-year and 25-year storm frequencies were used for design of roadside ditches and drop inlets. **Table 1,** excerpted from Table 203-1, Table 204-1, and Table 204-2 of the Drainage Manual, summarizes the applicable criteria for this project.

Table 1 - Criteria for Drainage Structures for Local Roads

	Design Flood	**Check Flood**
Main Drainage Channel and Drainage Structures	50- Year	100-Year
Existing and New Culverts	25- Year	50-Year
Roadside Ditches, Inlets, and Curb Drop Inlets	10- Year	25-Year

1.5 FEMA FLOODPLAINS

A FIRMette map, created from the digital Flood Insurance Rate Map (FIRM) prepared by Federal Emergency Management Agency (FEMA), is shown in **Figure 8**. FIRM 35031C1520E, dated February 17, 2010, designates the project area lies within a Zone X. The Zone X on the FIRM is an area of minimal flood hazard, which has a moderate to low risk of flooding. Zone X is the area determined to be outside the 500-year flood. Code of Federal Regulation CFR 44 is not applicable for any developmental changes within the project area.

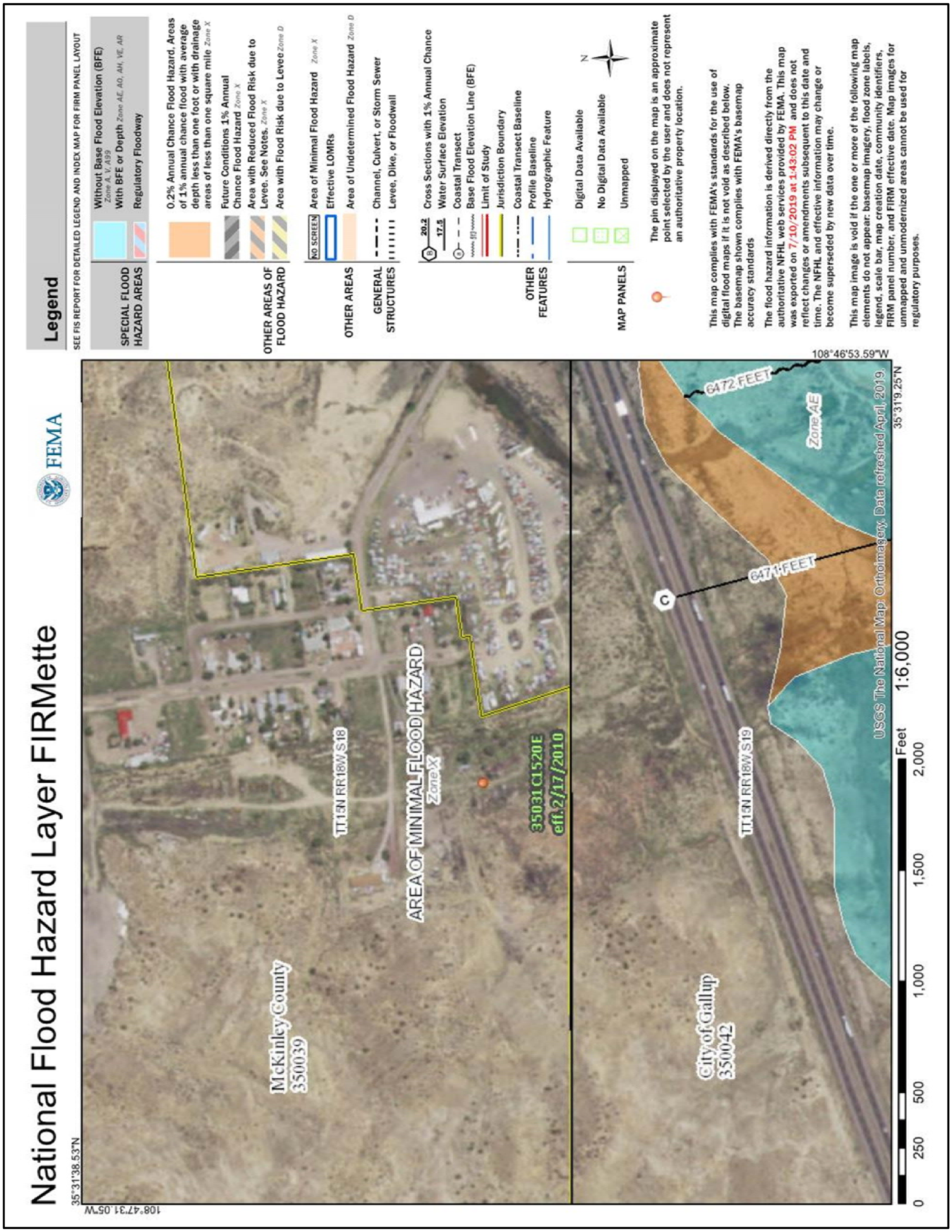


Figure 8 - FIRMette Map from FIRM 35031C1520E for Project Location

2 HYDROLOGIC ANALYSIS

2.1 DRAINAGE BASIN DELINEATION

The Watershed Modeling System (WMS 10.1) software program was used to delineate drainage areas for several points of interest using the topographic survey surface. The survey was performed in July 2019 by Precision Surveys, Inc. with photogrammetry and aerial mapping provided by AeroTech Mapping. Basin areas extending beyond the limits of the survey were supplemented with publicly available 10-meter USGS digital elevation model (DEM) data. A basin is delineated using a selected point of interest to more accurately estimate the peak flow at individual points of interest along a flow path. An overview of the full basin map is shown in **Figure 9** with more detailed drainage basin delineations using the detailed survey data provided in **Figure 10** and **Figure 11**.

2.2 STORM DRAINAGE SYSTEM AND DESCRIPTION

Drainage is conveyed through the study area from three separate paths: offsite drainage from coal basin via basin SB-15; offsite drainage from the Allison drainage channel that passes through town via basins SB-1 thru SB-6; and local street drainage via SB-7 thru SB-14. The local street drainage through the town of Allison has an existing storm drainage system consisting of roadside ditches and driveway culverts; however, the ditches and culverts have silted in over time. The runoff from all tributary drainage basins ultimately discharges into the existing 12-6' x 5' concrete box culvert (CBC) at I-40. The existing channel conveys runoff from upstream sub-basins and no stormwater from the town flows into the existing channel or into the sinkhole in the project study area. As a part of drainage study, the hydraulic capacity of the existing driveway turnout drainage structures was analyzed. Recommendations to replace or maintain existing infrastructure are based on field observations and hydraulic modeling.

2.3 BASIN CONDITION

Unnamed arroyos in the study area are ephemeral streams with an alluvial channel that flows north to south and crosses under I-40 at Milepost 18.5. Contributing area at I-40 is about 4 square miles. The average annual precipitation for the basin is 11.54 inches. The study area consists mostly of semi-arid lands with a partial cover of shrubs and some grasses.

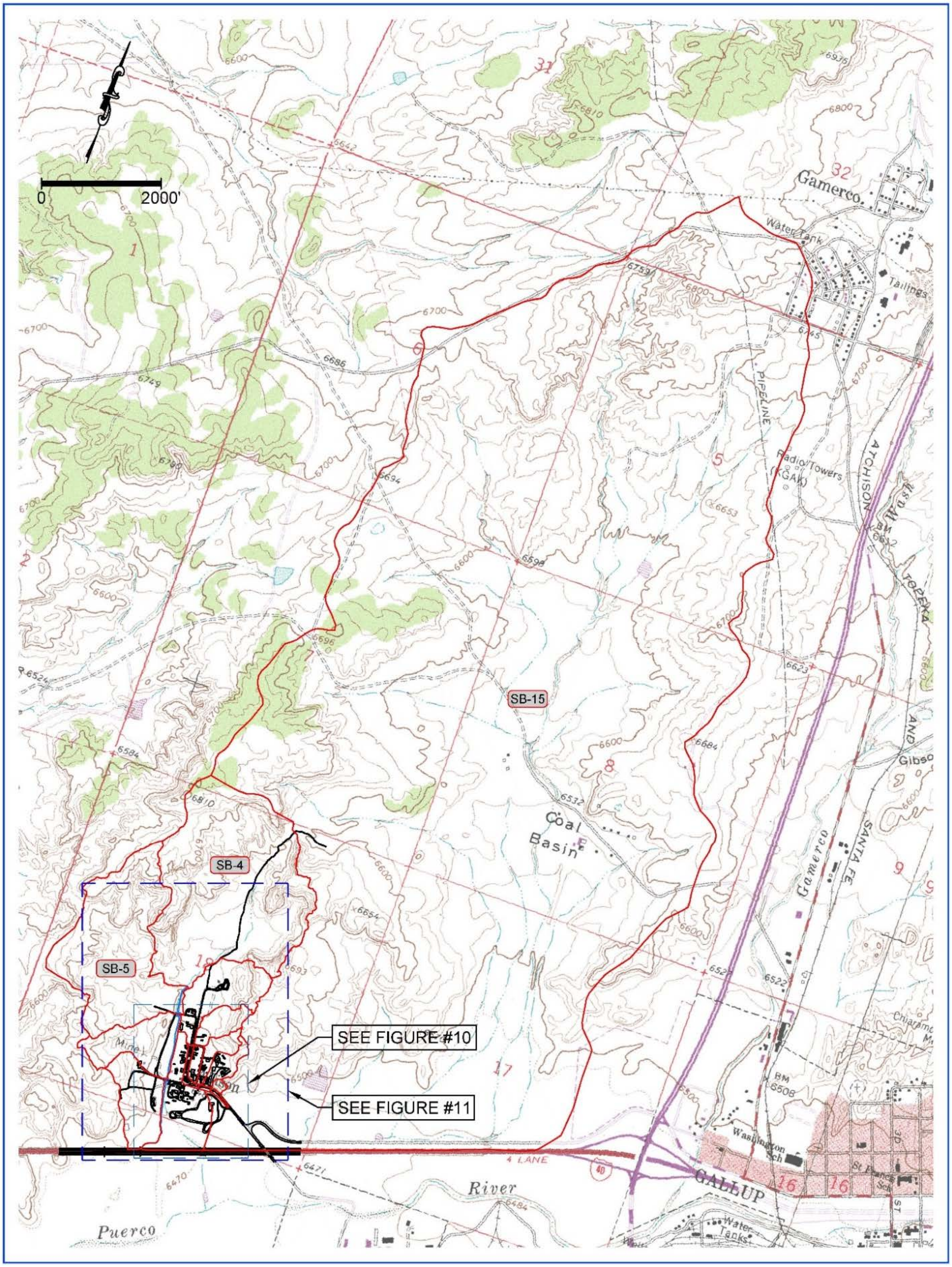


Figure 9 - Drainage Basin Map-1

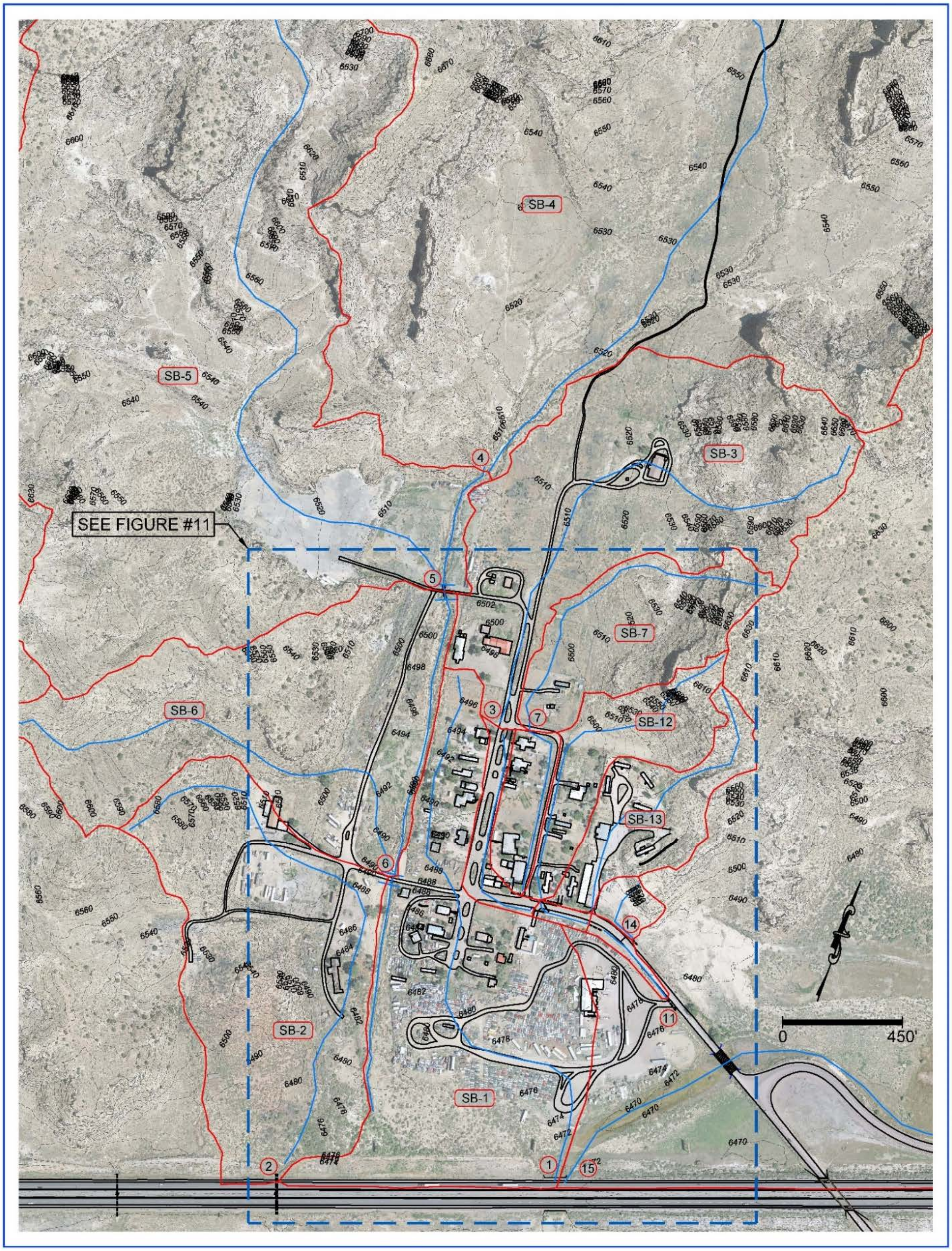


Figure 10 - Drainage Basin Map-2

Figure 11 - Drainage Basin Map-3

2.4 PREVIOUS DRAINAGE STUDIES

Construction of NMDOT project No. I-40-1(19)18 was completed in 1964. A hydrological analysis was conducted for the culverts crossing the project limits. An as-built was provided by the NMDOT, however, the study does not include any hydrological analysis for the channel within the AML project area. A portion of the 1964 as-built is shown in **Appendix D**.

In 2018, as requested by NMDOT, WSP performed a hydrological analysis and prepared an opinion report regarding the impact of the sinkhole development on the existing major drainage crossings under I-40. The result showed that the existing culverts within the NMDOT right-of-way do not impose any risk and are adequately sized to convey the anticipated design flows. However, the study also found that cross drainage structures at Acoma Street and the pipe culvert at the upper limit of the AML site were undersized.

2.5 HYDROLOGIC ANALYSIS METHODS

The NMDOT Drainage Design Manual (2018 Edition), sub-section 401.2, dictates the hydrologic analysis method used for all NMDOT projects; the same drainage design criteria and methodology has been adapted for this study. The NRCS Unit Hydrograph Method was used for hydrologic analysis to estimate peak flow in all basins.

2.6 RAINFALL DATA AND DISTRIBUTIONS

Historical rainfall data was obtained from the "Precipitation-Frequency Atlas of the United States" NOAA Atlas 14, Volume 1, Version 5. Rainfall depth for the study area is summarized in **Table 2.**

Table 2 –NOAA Rainfall Depth-Uncorrected

Depth - Duration - Frequency (DDF) Table (inches)							
Time / Frequency	2-year	5-year	10-year	25-year	50-year	100-year	500-year
5-min	0.236	0.318	0.383	0.474	0.546	0.624	0.823
15-min	0.446	0.601	0.723	0.894	1.030	1.180	1.550
60-min	0.743	1.000	1.200	1.490	1.720	1.960	2.590
2-hr	0.864	1.150	1.380	1.720	2.000	2.300	3.090
3-hr	0.933	1.220	1.460	1.790	2.070	2.370	3.180
6-hr	1.080	1.370	1.610	1.960	2.240	2.540	3.300
12-hr	1.240	1.550	1.800	2.150	2.430	2.710	3.470
24-hr	1.340	1.700	2.000	2.420	2.750	3.090	3.960

2.7 SOIL DATA, LAND USE, AND RUNOFF CURVE NUMBERS

Soil information used for this study was obtained from the U.S. Department of Agriculture (USDA) Natural Resources Conservation Service (NRCS) Soil Survey Geographic database (SSURGO). Land use data were found from the United States Geological Survey (USGS) and runoff was quantified with a soil parameter derived by the Soil Conservation Service (SCS) called the Curve Number (CN). Weighted curve numbers were developed for each drainage sub-basin based on the ground cover and hydrological soil group types found within each area. A weighted CN using the soil and land use maps was determined for each sub-basin and is shown in **Appendix A**.

The CN is an established method for determining storm runoff over an area based on land use and hydrologic soil group. Hydrologic Soil Groups (HSG's) are determined by SSURGO based on type and infiltration characteristics of a soil. HSG A has the highest infiltration rate and the lowest runoff potential while HSG D has the lowest infiltration rate and highest runoff potential. The SSURGO database shows that soils within the study area are classified as HSG C and D. **Figure 12** shows the distribution of HSG's within the watershed.

The land use/land cover within the watershed is characterized as rural arid land at lower elevations with a mixture of grass and low growing brushes and mostly bare land at higher elevations. **Figure 13** shows the land use map of the watershed as defined by USGS.

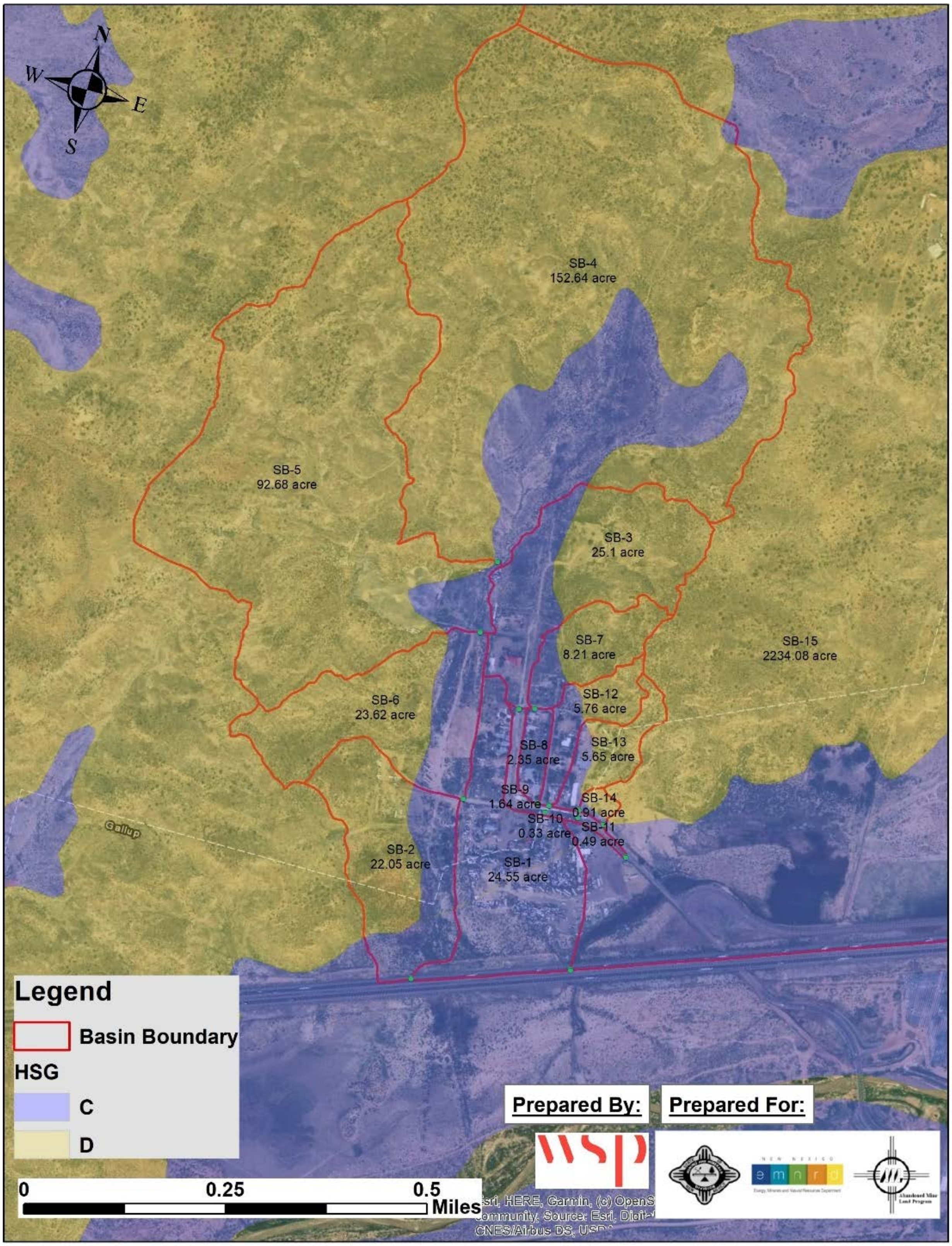


Figure 12 - Soil Map

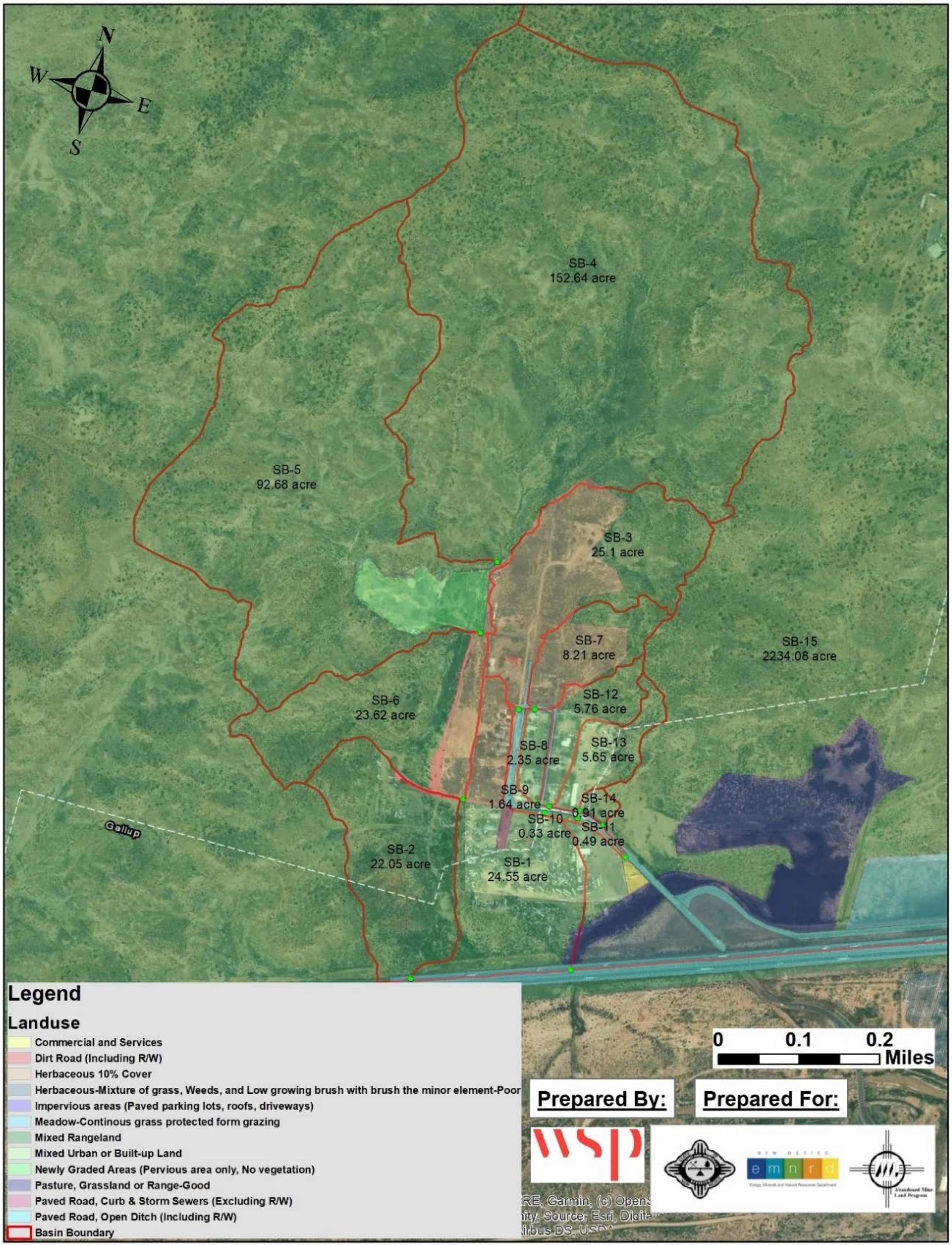


Figure 13 - Land Use Map

2.8 TIME OF CONCENTRATION AND LAG TIME

Time of Concentration (Tc) was estimated as outlined in the NMDOT Drainage Design Manual, Subsection 402.9. The Upland Method was utilized to estimate travel times for sheet flow and shallow concentrated flow conditions for the upper reaches of each sub-basin. For the analysis, overland flow was assumed for the first 300', and then shallow concentrated flow from the end of overland flow to the beginning of the blue flow line on the USGS quadrangle topographic map. The Kirpich Equation was used to calculate travel time for gullying or channel segment of watercourse (blue line). A minimum allowable Tc of 10 minutes was utilized per the NMDOT Standard. **Table 3** shows the calculated Tc for each sub-basin.

Table 3- Time of Concentration

Basin	FLOW	FLOW	ELEV. 1	LEN. 1	ELEV. 2	LEN. 2	ELEV. 3	LEN. 3	ELEV. 4	Tc 1	Tc 2	Tc 3	TOTAL Tc
ID (SB)	TYPE 1	TYPE 2	(ft.)	(ft.)	(ft.)	(ft.)	(ft.)	(ft.)	(ft.)	(hrs.)	(hrs.)	(hrs.)	(hrs.)
SB-1	SG	GW	6497	300	6492	1975	6471	-	-	0.09	0.33	-	0.42
SB-2	SG	GW	6594	300	6556	1891	6471	-	-	0.03	0.15	-	0.19
SB-3	SG	GW	6653	300	6619	1838	6494	-	-	0.04	0.12	-	0.17
SB-4	SG	GW	6804	300	6770	3859	6506	-	-	0.04	0.25	-	0.29
SB-5	SG	GW	6714	217	6635	3008	6498	-	-	0.01	0.24	-	0.25
SB-6	SG	GW	6629	300	6592	1612	6487	-	-	0.03	0.11	-	0.17
SB-7	SG	GW	6648	300	6543	1024	6494	-	-	0.02	0.08	-	0.17
SB-8	SG	GW	6494	300	6489	360	6486	-	-	0.09	0.07	-	0.17
SB-9	SG	GW	6493	300	6490	497	6485	-	-	0.12	0.09	-	0.21
SB-10	SG	GW	6486	300	6482	-	-	-	-	0.10	-	-	0.17
SB-11	SG	GW	6482	300	6478	-	-	-	-	0.10		-	0.17
SB-12	SG	GW	6629	300	6554	1058	6486	-	-	0.02	0.07	-	0.17
SB-13	SG	GW	6613	300	6561	872	6484	-	-	0.03	0.05	-	0.17
SB-14	SG	GW	6529	300	6482	-	-	-	-	0.03	-	-	0.17
SB-15	SG	GW	6843	300	6832	1202	6721	20977	6471	0.06	0.07	1.52	1.65

2.9 CHANNEL ROUTING

Watershed routing was utilized for multiple sub-basins to determine the combined flow rate at a point of interest along the conveyance system. The Muskingum-Cunge routing method was used to route the flow through the connecting reaches. This routing method considers the length, cross section shape, average slope, and average Manning's roughness coefficient for each reach. Cross sections were estimated by tracing watercourse widths from the project survey if within the survey limits and using Google Earth if beyond the survey limits.

2.10 PEAK DISCHARGE COMPUTATIONS

The HEC-HMS hydrologic model was used to estimate peak flow using the NRCS unit hydrograph method without considering additional abstraction and evaporation losses within the watershed. The basins for HEC-HMS are shown in **Figure 14**. The peak discharges estimated by NRCS unit hydrograph for each basin are shown in

Table 4. Detailed HEC-HMS output is shown in **Appendix B**. Discharge at the point of interest, as identified and shown in the drainage basin map, is also shown in **Table 5** with their combined basins.

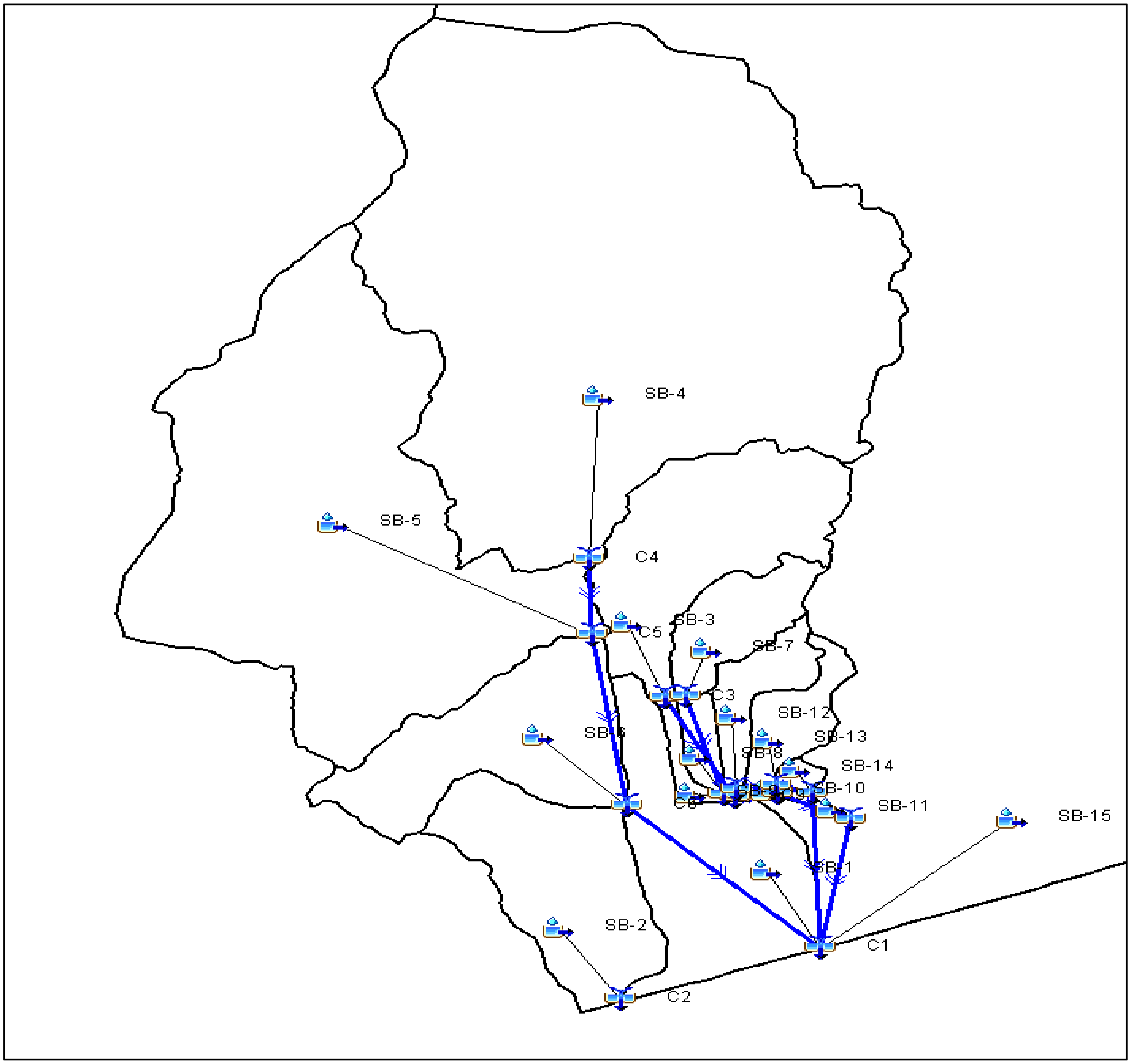


Figure 14 - Basin Model for HEC-HMS

Table 4 - Estimated Peak Flow from Sub basins

Drainage Basins	Basin Properties					NCRS Unit Hydrograph				
	D.A.	Soil Type				Curve	Q 100	Q 50	Q 25	Q 10
	(ac.)	%A	Number	(cfs)	%D	Number	(cfs)	(cfs)	(cfs)	(cfs)
SB-1	24.55	0	0	100	0	82.8	31.5	12.9	19.5	82.8
SB-2	22.05	0	0	62	38	74.5	24.1	6.2	12.1	74.5
SB-3	25.10	0	0	40	60	84.7	53.0	22.6	33.5	84.7
SB-4	152.64	0	0	31	69	75.8	148.2	41.3	76.9	75.8
SB-5	92.68	0	0	36	64	78.2	119.4	38.7	66.2	78.2
SB-6	23.62	0	0	32	68	78.0	33.1	10.7	18.4	78.0
SB-7	8.21	0	0	35	65	86.2	18.6	8.3	12.0	86.2
SB-8	2.35	0	0	100	0	91.0	6.8	3.5	4.7	91.0
SB-9	1.64	0	0	100	0	91.9	3.6	1.8	2.5	91.9
SB-10	0.33	0	0	100	0	91.5	0.9	0.5	0.7	91.5
SB-11	0.49	0	0	100	0	91.5	1.5	0.8	1.0	91.5
SB-12	5.76	0	0	48	52	84.1	11.8	4.9	7.4	84.1
SB-13	5.65	0	0	25	75	83.8	11.3	4.7	7.0	83.8
SB-14	0.91	0	0	50	50	73.5	0.9	0.2	0.4	73.5
SB-15	2234.1	0	0	55	45	74.5	794.0	226.7	412.5	74.5

Table 5- Estimated Peak Flow at Selected Locations

Outlet Point per Figure 6	Contributing Basins	Drainage Area	Q_{100}	Q_{50}	Q_{25}	Q_{10}
		(acre)	(cfs)	(cfs)	(cfs)	(cfs)
1	Outlet-6 and SB-1 (CBC at I-40)	2578	889.6	664.3	467.9	260.6
2	SB-2 (CMP at I-40)	22.1	24.1	17.7	12.1	6.2
3	SB-3	25.1	53.0	42.7	33.5	22.6
4	SB-4	152.6	148.2	110.1	76.9	41.3
5	SB-4 and SB-5	245.3	246.0	183.1	128.3	72.9
6	SB-4, SB-5, and SB-6	268.9	285.5	221.6	163.1	95.8
7	SB-7	8.2	18.6	15.2	12.0	8.3
8	SB-7 and SB-8	10.6	22.0	17.9	14.2	9.9
9	SB-3 and SB-9	26.7	45.9	36.6	29.5	21.1
10	SB-9, and SB-10	27.0	46.6	38.7	31.3	22.4
11	SB-9, SB-10, SB-11	27.6	51.4	42.6	34.4	24.3
12	SB-7, SB-8, and SB-12	16.3	22.0	18.1	14.4	10.0
13	SB-7, SB-8, SB-12 & SB-13	22.0	31.0	24.9	19.2	13.0
14	SB-7, SB-8, SB-12, SB-13, & SB-14	22.9	31.4	25.7	20.5	14.0
15	Outlet-6, SB-1, Outlet 14, Outlet-11, and SB-15 (CBC at I-40)	2578	889.6	664.3	467.9	260.6

3 HYDRAULIC ANALYSIS AND RECOMMENDATION FOR IMPROVED DRAINAGE

The proposed recommendations for improvements are based on the hydrologic and hydraulic analyses for the study area and take into consideration the findings of the AML Program geotechnical investigation conducted by Golder and Associates (Golder). The proposed improvement areas include the (1) Northwest Fill Pad Area, (2) Drainage Channel, (3) Residential and Commercial Area and the (4) Interstate 40 Area. The Drainage Channel consists of three reaches (upper, middle, and lower) separated by an upper and lower culvert. After consultation with AML and Golder, the project team decided the lowest risk of subsidence was the existing alignment of the drainage channel as the Phase III Emergency Project repaired the sink hole and pressure grouted portions of the surrounding area.

WSP also ranked all four areas of drainage improvement considering geotechnical findings provided by the Golder and surface drainage issue as follows:

1. Drainage channel
2. Northwest Fill Pad Area
3. Commercial and Residential Area
4. Interstate 40 Area

Drainage channel is considered as most needed improvement as the surface water needs to be conveyed through adequate channel and cross drainage structures to avoid seepage. The channel and culvert is designed to carry 100- year storm. If this improvement is not completed, surface water continued to infiltrate and seepage through the area.

Northwest fill Pad Area is considered as second most needed improvement as the flow from northwest needs to be conveyed away from the site to avoid any detention and subsurface flow through the fill pad area. If this improvement is not completed, seepage flow might continue through the fill pad area and might be concerning for sinkhole area.

Commercial and Residential Area is considered as part of drainage improvement in town to improve road drainage system and to avoid surface flow going into the drainage channel. This improvement is suggested as part of roadway drainage improvement which will be helpful to address concern on drainage channel.

The improvements to Interstate 40 area are part of a regular operational and maintenance to ensure that the flows from the upstream are not attenuated and can freely discharge under I-40.

3.1 NORTHWEST FILL PAD AREA

The Northwest Fill Pad Area appears to be a manmade graded and flattened landfill built in 2012 comprised of construction debris. The Fill Pad Area is made of asphalt millings and/or base course material. At the upstream edge of the Fill Pad Area a “dam” made out of construction debris extends across the valley floor. **Figure 15** depicts the flat Fill Pad with the debris “dam” visible in the background. The debris dam, shown in **Figure 16**, is made of large fragments of broken up concrete and large fragments of broken up asphalt pavement. The material is assumed to have been dumped loosely in place as it has large voids between adjacent fragments. Due to the lose placement of the debris with no filler material to seal the voids, storm runoff can directly enter the material that makes up the Fill Pad Area.

Figure 17 shows the drainage channel from the upper valley disappearing into the “dam”. After storm water enter the debris dam, it continues as subsurface flow through the Fill Pad Area. Surface waters entering the Fill Pad Area as subsurface flows are assumed to contribute to the subsidence issues of Allison. Two alternatives, described below, were developed to convey the surface waters through the Fill Pad Area without allowing the waters to percolate into the subsurface soils.

Figure 15 - Fill Pad Area Walking Towards the "Dam"

Figure 16 - Fill Pad Area "Dam" as Viewed from Upstream

Figure 17 – Upstream Channel Entering the Base of the Fill Pad Area "Dam"

Figure 18 – Historical Channel Alignment (Source: Google Earth 10/23/2011)

Figure 19 – Fill Pad Area (Source: Google Earth 10/29/2012)

Figure 18 depicts the historical drainage channel alignment prior to the construction of the Fill Pad Area. **Figure 19** shows the Fill Pad Area after construction. The perimeter of the Fill Pad Area is shown as a yellow boundary in both figures for comparison purposes.

Alternative No. I: Open Channel with Guide Bank

Alternative No. 1 attempts to restore the alignment and grade of the historical drainage channel through the Fill Pad Area. A trapezoidal open channel (8' bottom width, 3' minimum depth with 2.5:1 side slopes) is recommended on north east side of the fill pad to convey flow coming from the upstream valley above the debris dam. The open channel would extend from above the fill pad down to the main drainage channel downstream. The channel should be lined with a geosynthetic clay liner to prevent infiltration, 6" of protective bedding material and a 12" layer of Class B Riprap (6-inch minimum dimension). The membrane liner would help impede vegetation growth and any subsequent slowing of water. The purpose of the riprap is to minimize erosion of the channel bottom. However, compacted earthen lining might be considered to reduce the cost of lining. A guide bank with a geosynthetic clay liner is recommended just upstream of the fill pad area to direct or funnel the flow into the open channel. Two concrete rundowns below the fill pad, at two steep drops along the proposed open channel, are needed to tie into the main channel below.

A schematic of proposed alternative is shown in **Figure 20**Error! Reference source not found.. Hydraulic analysis for the channel is also shown in **Appendix B**. **Table 6**Error! Reference source not found. and **Table 7** identify characteristics of the Alternative including pros and cons, design life and rough order of magnitude costs. A conceptual cost estimate for the alternatives are provided in **Appendix E**.

Table 6 – Fill Pad Area Alternative No. 1 Pros and Cons

Pros	Cons
• Lower cost than Alternative No. 2 • Minimal maintenance • Reestablishes historic alignment • Prevents infiltration	• Limits land use of Fill Pad Area

Table 7 – Fill Pad Area Alternative No. 1 Design Life and Estimated Costs

Design Life	Cost (Rough Order-of-Magnitude)
• 50-75 years for channel with periodic cleaning	$293,850 (Details are included in Appendix E)

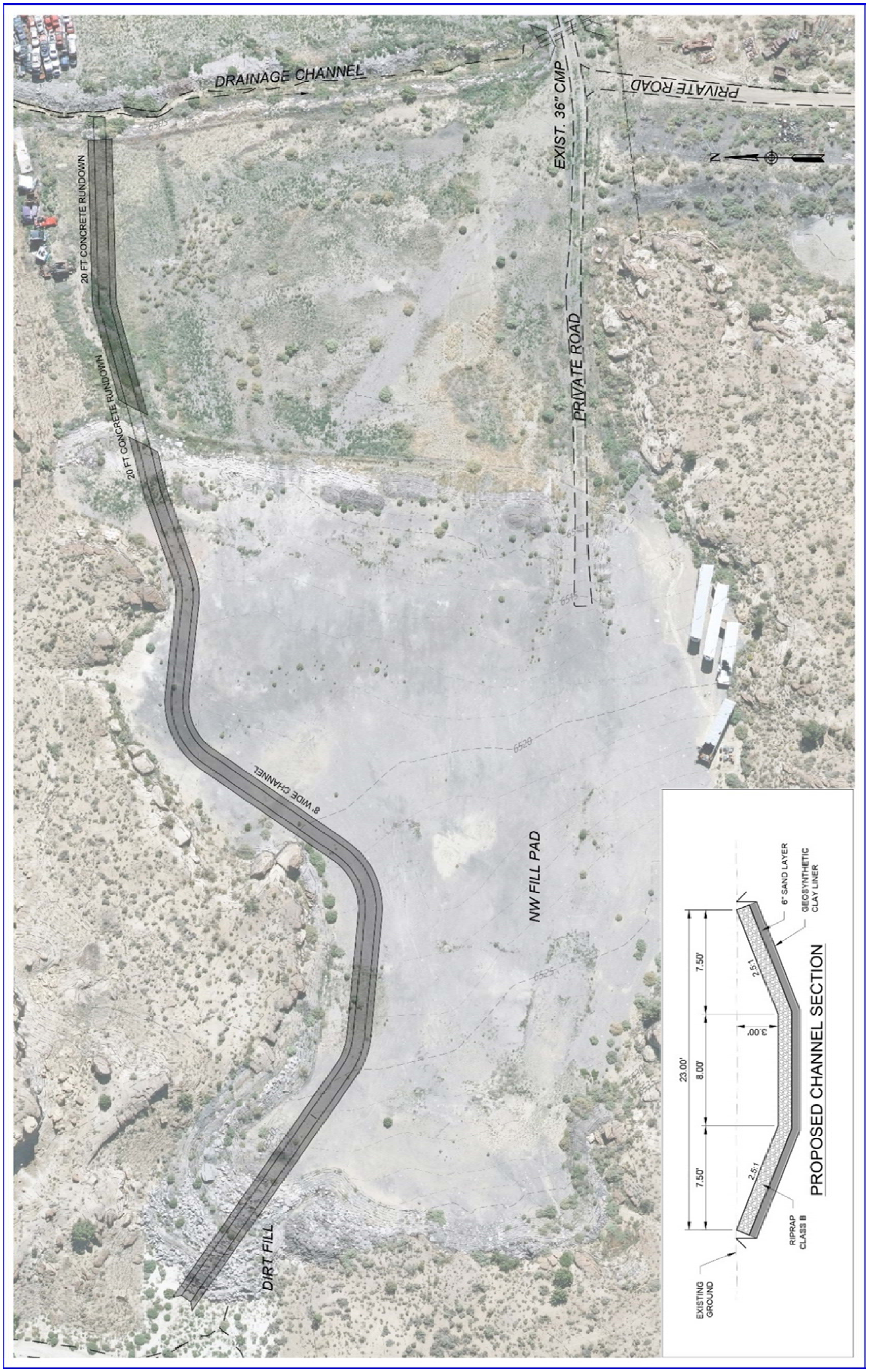


Figure 20 - North Fill Pad Area Alternative No. 1

Alternative II: Storm Drain Pipe with Guide Bank

In lieu of the open channel alternative described above, Alternative No. 2 utilizes a 1,000 ft. storm drain pipe through the fill pad area to convey flows to the main drainage channel downstream. A 48-inch diameter storm drain pipe is sufficient to convey the flows to the drainage channel. The benefit of Alternative No. 2 is that it does not limit the use of the property as much as Alternative No. 1.

Storm drain pipe requires manholes for inspection and maintenance every 300 to 500 ft. The manholes would need to remain accessible at all times so the property owners would not be permitted to cover the manholes. This alignment would require a minimum of three (3) manholes for access and maintenance.

Upstream of the fill pad area, the stormwater shall be direct to an improved drop inlet with a guide bank.

Table 8 and **Table 9** identifies characteristics of the Alternative including pros and cons, design life and rough order of magnitude costs. A schematic of proposed alternative is shown in Error! Reference source not found..

Table 8 – Fill Pad Area Alternative No. 2 Pros and Cons

Pros	Cons
• Maximizes land use of Fill Pad Area • Prevents infiltration	• Higher cost than Alternative No. 1 • Requires routine cleaning and maintenance

Table 9 - Fill Pad Area Alternative No. 2 Design Life and Estimated Costs

Design Life	Cost (Rough Order-of-Magnitude)
• 50-75 years for channel with routine inspection and cleaning	$504,500 (Details are included in Appendix E)

Due to the maintenance issues in long term, WSP's preferers alternative -1 Northwest field Pad area improvement.

Figure 21 - North Fill Pad Area Alternative No. 2

3.2 DRAINAGE CHANNEL

During the preliminary drainage investigation, two alignments below Hopi Street were conceptualized for the main drainage channel, namely the existing channel alignment and a new alignment west of the existing channel. The two conceptual alignments were presented to the AML Program geotechnical consultant, who evaluated the risk hazard of each alternative. The alignments are briefly described in the geotechnical consultant's report entitled the "Preliminary Undermining Hazard Report" for Allison, New Mexico. The geotechnical consultant concluded that the western alignment has a higher risk hazard potential as it "will pass over more extensive workings" while the existing alignment "is likely to overlie fewer workings, and has some previous mitigation."

Based on the topographic data, hydraulic analysis, and the AML Program geotechnical consultant's assessment of sinkhole subsidence hazard potential, the project team recommends the drainage channel be maintained in the current location. Although the current channel alignment passes through the known subsidence area, the historic sinkhole has been stabilized by injection grouting with extensive removal and replacement of the upper portion of the soil strata. As suggested by the geotechnical consultant, sinkhole development is a risk in Allison, and rerouting drainage through new areas may increase the risk of future subsidence.

To minimize the risk of future subsidence, surface water should be conveyed through the project site as expeditiously as possible to minimize infiltration. Furthermore, the geotechnical consultant recommends "a flexible liner to reduce the potential for infiltration and subsurface erosion (piping) into underlying workings."

However, the channel should be designed to an appropriate geometry to accommodate and convey stormwater safely. The designed storm event for the channel is assumed to be 100-year storm. The channel should be lined to impede vegetation growth, prevent abrupt changes in discharge velocities and avoid seepage into the underground workings. The liner would keep the channel bottom free of impediments to flow. The proposed liner can be synthetic or natural but should be flexible to accommodate future settling. Lining the channel with a flexible cover can allow the channel bottom to respond to differential settlement and takes into consideration the dynamic nature of a stream.

For the hydraulic analysis, the drainage channel was divided into three reaches (upper, middle and lower) separated by two culverts. The hydraulic analysis of each reach was performed using HEC-RAS (version 5.0.7) to determine water surface elevation (WSE) in the channel, hydraulic capacity of channel and other hydraulic parameters such as velocity and depth of flow. A trapezoidal channel (12' bottom, 4' minimum depth, with 2.5:1 side slopes) is recommended for all reaches. A schematic of the proposed channel improvement and typical cross section is shown in **Figure 22**. All associated HEC-RAS results are provided in Appendix B. The proposed channel depth 30 ft upstream of the lower culvert is increased to 5 ft to account for the back-water effect of the culvert.

Two culverts, one located between the upper and middle reaches and the second, located between the middle and lower reaches, are needed to safely convey stormwater beneath the two roads. The designed storm event for the culvert is assumed to be 100-year storm.

HEC-RAS (Version 5.0.7) was used to perform the hydraulic analysis of the culverts and main channel conveyance system. Peak flow estimated by Unit Hydrograph Method was used for hydraulic analysis. The 50-year design flood and 100-year check flood were used for design of channel and culverts in accordance with the NMDOT drainage criteria. **Table 10** summarizes the design flowrates and structure recommendations along the drainage channel.

Table 10 - Recommendations for Drainage Structures Along the Drainage Channel

Outlet Point	Contributing Basins	D.A. (acre)	Q_2 (cfs)	Q_{25} (cfs)	Q_{50} (cfs)	Q_{100} (cfs)	Existing Structure	Proposed Structure
1	Outlet-6 and SB-1	2578	53.5	467.9	664.3	889.6	16-6'x5' CBC	Same
2	SB-2	22.05	0.8	12.1	17.7	24.1	1-30" CMP and 1-30" RCP	Same
4	SB-4	152.64	7.0	76.9	110.1	148.2	Existing Channel	New Channel
5	SB-4 and SB-5	245.32	15.0	128.3	183.1	246.0	1-36" CMP and 1-48" CMP *	New 12’x4’ CBC
6	SB-4, SB-5, and SB-6	268.94	17.2	163.1	221.6	285.5	1-48" CMP *	New 12’x4’ CBC
See **Figures 9 to 11** for the location of the outlet point and associated drainage basins * 2018 NMDOT Drainage study found cross drainage structures at these locations are undersized. Proposed improvement will convey the 100-year storm.								

Two structure alternatives are proposed for the two culverts. The preferred alternative for the two culverts is a single barrel 12’ x 4’ CBC with concrete headwalls and wingwalls. NMDOT Standard Drawings 511-60 and 511-67 provide the standard design and construction details of the CBC alternative. The advantages of a concrete box culvert are that the structure is very durable and does not require any cover on top of the road. Vehicles can drive directly atop the culvert. The disadvantages of the CBC structure is the duration of construction and the costs. The proposed culverts and channel improvements would carry a 100-year flood. The proposed schematic and culvert is shown in **Appendix E** and the associated hydraulic analysis results are shown in **Appendix B**.

Table 11 and **Table 12** summarize the pros and cons, design life, and estimated costs of concrete box culvert alternative.

Table 11 – Pros and Cons of the Concrete Box Culvert (CBC) Alternative

Pros	Cons
• Durable • Low profile (No minimum cover) • Rigid frame structure	• Higher cost than aluminum alternative • Construction duration (one or more months)

Table 12 - Design Life and Estimated Costs of the Concrete Box Culvert (CBC) Alternative

Design Life	Cost (Rough Order-of-Magnitude)
• 75 years for channel with maintenance	$1,572,700 (Details are included in Appendix E)

In lieu of a CBC structure, an alternate drainage structure is an 11'-11" span x 3'-7" rise aluminum box culvert manufactured by CONTECH (Structure Number 16). Aluminum headwalls and wingwalls are available. However, as an enhancement, concrete headwalls and wingwalls can be used in lieu of aluminum headwalls and wingwalls. The advantages of aluminum box culverts are that they can be assembled offline and erected in place in a single day. The disadvantages are that aluminum box culverts are flexible structures and can warp due to unbalanced or impact loading and that they require a minimum cover of 1.5' of soil and pavement. They are also easily damaged by vehicles. The proposed schematic and culvert is shown in **Appendix E** and the associated hydraulic analysis results are shown in **Appendix B**. **Table 13** and **Table 14** summarize the pros and cons, design life, and estimated costs of aluminum box culvert alternative.

Table 13 – Pros and Cons of the Aluminum Box Culvert (ALBC) Alternative

Pros	Cons
• More economical than concrete • Easy installation (one day)	• Flexible structure / warping / nondurable • Requires 1.5 ft of soil and pavement cover • Easily damaged by vehicles • Requires engineered backfill

Table 14 - Design Life and Estimated Costs of the Aluminum Box Culvert (ALBC) Alternative

Design Life	Cost (Rough Order-of-Magnitude)
• 50 to 75 years if not damaged	$1,525,400 (Details are included in Appendix E)

For the lower reach of the drainage channel, the proposed alignment maximizes the use of property for private or commercial purposes. The same size channel is continued up to the inlet of the existing I-40 CBC as shown in **Figure 22**. The same upstream channel slope is maintained in the lower reach to carry the design flow.

Because of the durability and low cover availability in the field, WSP's preferers alternative -1 for drainage channel improvement.

Figure 22 - Drainage Channel Schematic Drainage Plan

3.3 COMMERCIAL AND RESIDENTIAL AREA

The drainage basin contributing to runoff entering the commercial and residential areas are shown in **Figure 9**, **Figure 10**, and **Figure 11**. Basins SB-3 contributes runoff to De Vargas Road. Basins SB-3 and SB-9 contributes runoff to N. Coronado Blvd. Basin SB-7 conveys runoff to Zuni Street. Basins SB-7, SB-8, and SB-12 contribute runoff to Cortez Road. In addition to the above drainage basins, SB-10, SB-11, SB-13, and SB-14 contribute runoff to Alison Road.

Surface drainage through the commercial and residential areas is conveyed through a series of roadside ditches and culverts eventually reaching Allison Road. The drainage criteria for roadside ditches shown in **Table 1** specifies a 10-year design flood and 25-year check flood. **Table 15** summarizes the design flowrates for the drainage basins contributing runoff to the commercial and residential area.

Proposed ditch cross sections to convey the design flood are shown in **Figure 23**. Ditches should be lined with a geosynthetic clay liner (GCL), which will be covered with soil. No GCL will be left exposed. Details will be provided in final design. No armoring or Riprap is recommended on the ditches. A 3' deep bar ditch is recommended along De Vargas Road, N. Coronado Blvd. and Allison Road, with single 30" diameter driveway culverts. Along Zuni Street and Cortez Road, 2.5' deep bar ditches are proposed with 24" diameter driveway culverts. Culverts were evaluated assuming up to 6" of embedment below the ditch flowline. A minimum of 12" of cover should be provided over all culverts. Consideration should be given to the reconstruction of the roadway surfacing in order to better control surface drainage and the roadway cross slope. An asphalt pavement section is recommended.

Table 16 provides an evaluation summary of proposed new culvert locations. **Table 17** provides an evaluation of existing culvert locations. **Table 18** and **Table 19** summarize the pros and cons, design life, and estimated costs of aluminum box culvert alternative

A schematic drainage plan for the commercial and residential area is provided in **Figure 23**.

Table 15 – Design Flowrates for Commercial and Residential Areas

Outlet Point	Contributing Drainage Basins	D.A. (acre)	Q_{25} (cfs)	Q_{10} (cfs)
7	SB-7	8.21	12.0	8.3
8	SB-7 and SB-8	10.56	14.2	9.9
9	SB-3 and SB-9	26.74	29.5	21.1
10	SB-9, and SB-10	27.07	31.3	9.2
11	SB-9, SB-10, SB-11	27.56	34.4	9.5
12	SB-7, SB-8, and SB-12	16.32	14.4	4.0
13	SB-7, SB-8, and SB-12 & 13	21.97	19.2	5.1
14	SB-7, SB-8, and SB-12, 13, 14	22.88	20.5	5.6

Table 16 – New Culvert Evaluation Summary for Commercial and Residential Areas

Culvert No.	Contributing Drainage Basins	D.A. (acre)	Q_{25} (cfs)	Q_{10} (cfs)	Existing Structure	Recommended Structure
CP-1	SB-3	25.1	33.5	22.6	None	1'-30" CP
CP-2	SB-3	25.1	33.5	22.6	None	1'-30" CP
CP-3	SB-3	25.1	33.5	22.6	None	1'-30" CP
CP-4	SB-3	25.1	33.5	22.6	None	1'-30" CP
CP-5	SB-3	25.1	33.5	22.6	None	1'-30" CP
CP-6	SB-3	25.1	33.5	22.6	None	1'-30" CP
CP-8	SB-3, SB-9	26.74	29.5	21.1	None	1'-30" CP
CP-9	SB-3, SB-9	26.74	29.5	21.1	None	1'-30" CP
CP-10	SB-3, SB-9	26.74	29.5	21.1	None	1'-30" CP
CP-11	SB-3, SB-9	26.74	29.5	21.1	None	1'-30" CP
CP-12	SB-3, SB-9	26.74	29.5	21.1	None	1'-30" CP
CP-13	SB-3, SB-9	26.74	29.5	21.1	None	1'-30" CP
CP-14	SB-3, SB-9	26.74	29.5	21.1	None	1'-30" CP
CP-7	SB-7	8.2	12.0	8.3	None	1'-30" CP
CP-15	SB-7, SB-8	10.6	14.2	9.9	None	1'-30" CP
CP-16	SB-1, SB-3, SB-9	26.74	29.5	21.1	None	1'-30" CP
Note: See **Figure 23** for culvert pipe locations						

Table 17 – Existing Culvert Evaluation Summary for Commercial and Residential Areas

Culvert No.	Contributing Drainage Basins	D.A. (acre)	Q_{25} (cfs)	Q_{10} (cfs)	Existing Structure	Recommended Structure
CD-1	SB-12	5.76	7.4	4.9	1'-18" CMP	1'-24" CMP
CD-2	SB-7 and SB-8	10.56	14.2	9.9	1'-14" CMP	1'-24" CMP
CD-3	SB-12	5.76	7.4	4.9	1'-18" CMP	1'-24" CMP
CD-4	SB-12	5.76	7.4	4.9	1'-10" CMP	1'-24" CMP
CD-5	SB-7 and SB-8	10.56	14.2	9.9	1'-12" CMP	1'-24" CMP
CD-6	SB-12	5.76	7.4	4.9	1'-18" CMP	1'-24" CMP
CD-7	SB-7 and SB-8	10.56	14.2	9.9	1'-12" CMP	1'-24" CMP
CD-8	SB-12	5.76	7.4	4.9	1'-18" CMP	1'-24" CMP
CD-9	SB-7 and SB-8	10.56	14.2	9.9	1'-12" CMP	1'-24" CMP
CD-10	SB-7 and SB-8	10.56	14.2	9.9	1'-18" CMP	1'-30" CMP
CD-11	SB-3 and SB-9	26.7	29.5	21.1	1'-18" CMP	1'-30" CMP
CD-12	SB-7, SB-8, SB-12	16.3	14.4	10.0	1'-18" CMP	1'-30" CMP
CD-13	SB-7, SB-8, SB-12 & 13	22.0	19.2	13.0	Unknown	1'-30" CMP
CD-14	SB-9, SB-10	27.0	31.3	22.4	1'-18" CMP	1'-30" CMP
CD-15	SB-7, SB-8, SB-12, 13 & 14	22.9	20.5	14.0	1'-24" CMP	1'-30" CMP
CD-16	SB-9, SB-10, SB-11	27.6	34.4	24.3	1'-30" CMP	1'-30" CMP
Note: See **Figure 23** for culvert pipe locations						

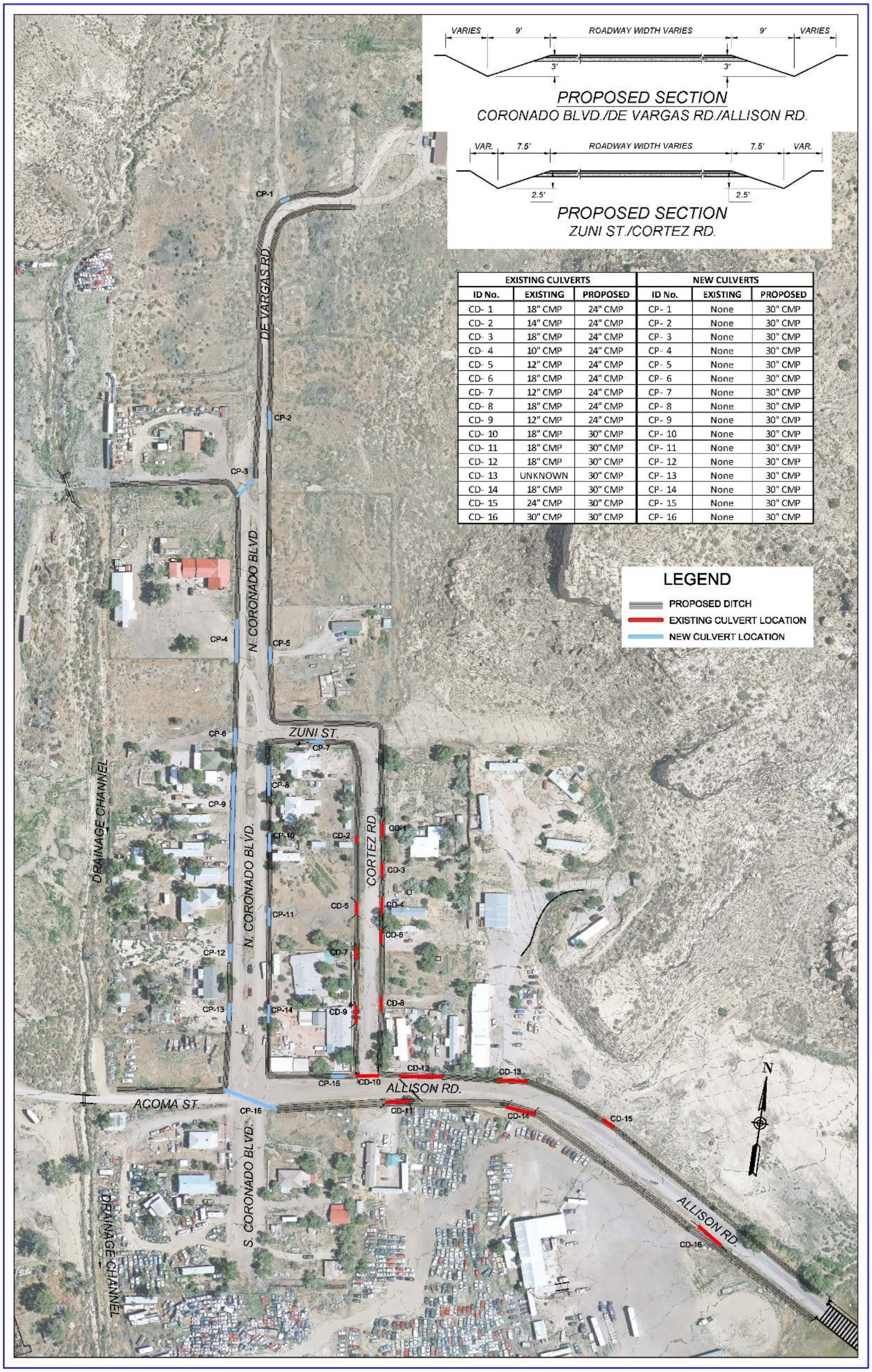
Table 18 – Pros and Cons of the Improvement

Pros	Cons
• Prevents scattered drainage flow and going into the drainage channel • Improved road drainage system	• High project cost

Table 19 – Design Life and Estimated Costs of the Improvement

Design Life	Cost (Rough Order-of-Magnitude)
• 30 to 50 years if not damaged	$510,800 (Details are included in Appendix E)

WSP prefers improvement of road drainage system, which should include removal and replacement existing turnout culvert and installing new culverts as proposed. However, if the improvement is carried out in phases due to funding constrains, this improvement could be done in last phase after main channel and northwest fill pad area improvement.



EXISTING CULVERTS			NEW CULVERTS		
ID No.	EXISTING	PROPOSED	ID No.	EXISTING	PROPOSED
CD- 1	18" CMP	24" CMP	CP- 1	None	30" CMP
CD- 2	14" CMP	24" CMP	CP- 2	None	30" CMP
CD- 3	18" CMP	24" CMP	CP- 3	None	30" CMP
CD- 4	10" CMP	24" CMP	CP- 4	None	30" CMP
CD- 5	12" CMP	24" CMP	CP- 5	None	30" CMP
CD- 6	18" CMP	24" CMP	CP- 6	None	30" CMP
CD- 7	12" CMP	24" CMP	CP- 7	None	30" CMP
CD- 8	18" CMP	24" CMP	CP- 8	None	30" CMP
CD- 9	12" CMP	24" CMP	CP- 9	None	30" CMP
CD- 10	18" CMP	30" CMP	CP- 10	None	30" CMP
CD- 11	18" CMP	30" CMP	CP- 11	None	30" CMP
CD- 12	18" CMP	30" CMP	CP- 12	None	30" CMP
CD- 13	UNKNOWN	30" CMP	CP- 13	None	30" CMP
CD- 14	18" CMP	30" CMP	CP- 14	None	30" CMP
CD- 15	24" CMP	30" CMP	CP- 15	None	30" CMP
CD- 16	30" CMP	30" CMP	CP- 16	None	30" CMP

Figure 23 – Commercial and Residential Schematic Drainage Plan

3.4 INTERSTATE 40 AREA

The hydraulic analysis of NMDOT drainage structures (Allison Road and I-40) were evaluated and found that they adequately sized to convey the design and check flood. These structures appear to be sound and hydraulically functional; however, cleaning of the inlet and outlet is required for both structures to remove the deposited silt at the bottom of the structures. Cleaning the structures should include grading the outlets to drain with a positive slope all the way to the Rio Puerco. The bridge inspection report for BR #6729, attached in **Appendix D**, suggests cleaning and tree removal (**Table 20**). WSP suggests that the analysis and the recommendations in this report be coordinated with the NMDOT Drainage Design Bureau to ensure that the proposed improvements will not adversely impact their facilities.

Table 20 - Bridge Inspection Report Data

Bridge Inspection Report (2016)							
Bridge No.	Size	Culvert Rating	Scour Rating	Waterway Adequacy	Channel Rating	Channel and Channel Protection	Recommendations
6729	6 ft x 5 ft x 124 ft (3-unit 4 box each CBC)	(62) 6 Deterioration	(113) 8 Stable Above Footing	(71) 8 Equal Desirable	(61) 7 Minor Damage	Bridge is on a small intermittent stream with grassy, brush, flat, indistinct banks & channel. Good alignment. No scour, 2 ft – 3 ft of silt, minor debris. No channel protection needed. Tree at barrels 5-6 at inlet and barrels 4-6 at outlet.	Short Term: Patrol: Remove vegetation and silt from structure.
8712	6 ft x 5 ft x 34 ft (4-unit 4 box each CBC)	(62) 7 Minor Deterioration	(113) 8 Stable Above Footing	(71) 8 Equal Desirable	(61) 7 Minor Damage	Small intermittent stream with low indistinct banks and flat grassy bottom. Good alignment. 18-inch silt and minor debris. Northern Barrels have tumble weeds. Fence across channel downstream. Heavy vegetation in channel. Ponded water upstream and downstream.	Short Term: Remove vegetation and debris from boxes (Verify if environmental clearance is needed, may be wetlands).

Drainage channel improvements in Allison should direct offsite flows towards the 12-6’ x 5’ CBC culvert. As shown on as-built plans, the 10-ft. high east-west dike located within NMDOT right-of-way between Station 1014+25 and Station 1022+50 (PN I-040-1 (19) 18) and the 10-ft. high north-south dike atop the old railroad grade should be reestablished and maintained to direct flows to the 12-6 ’x 5’ CBC and away from the 2-30” culverts.

3.5 PROPERTY OWNER CONSIDERATIONS

The AML Program should be aware that the above recommended improvements will require landowner approval. The northwest fill pad area is currently maintained by a landowner with the intention of operating a salvage yard atop the pad. The proposed alternatives would require approval from the landowner and the sacrifice of some acreage in order to implement the above design. In order to monitor and maintain infrastructure associated with the drainage channel, WSP also recommends the appropriate jurisdictional agency (McKinley County) acquire drainage easements for the drainage infrastructure within Allison. An easement would allow access to the channel should there be a need for maintenance in the future. There are at least two main property owners that the AML would have to enter into agreements with; property boundaries, with the two impacted properties highlighted, are shown in **Appendix E**.

3.6 AREA OF POTENTIAL DISTURBANCE

The AML Program requested a conceptual footprint of the proposed drainage improvements for the Allison Project to be used for planning improvements. **Figure 24** graphically depicts the conceptual footprint. The final footprint shall be established through preliminarily and final design and is recommended to occur after appraisal and acquisition of appropriate drainage easements. Consideration should be made of potential staging areas for the contractor and any other aspects of the proposed work, after consideration of all disciplines. Shapefiles of the conceptual area of disturbance are available upon request.

Figure 24 – Area of Potential Disturbance

4 CONCLUSIONS

Geotechnical investigations performed under the direction of the AML Program concluded that stormwater-related erosion contributed to the formation and widening of sinkholes at the AML project site in Allison, NM. The purpose of the above drainage assessment is to provide the AML Program a detailed solution to the drainage issues near the historic Allison Mine.

Based on the findings of this report and data provided by the geotechnical consultant, WSP has determined that a successful stormwater management strategy must provide an efficient and comprehensive delivery of ephemeral flows to properly sized and fully functioning infrastructure within the drainage basin. Improper drainage and infiltration of water create opportunities for future subsidence events. WSP contends that if the drainage is improved (by creating an efficient conveyance system) and infiltration is limited, the risk of subsidence will be drastically reduced.

WSP ranked all four areas of drainage improvement considering geotechnical findings provided by the Golder and surface drainage issue as follows:

- Drainage channel
- Northwest Fill Pad Area
- Commercial and Residential Area
- Interstate 40 Area

WSP recommends that an open channel be reestablished through the northeast corner of the fill pad. Prior to the placement of the fill pad, stormwater from the upstream basin coalesced at this point and joined the main drainage channel further downstream. A trapezoidal channel with rock rundowns to accommodate elevation drops, would help move the water and prevent it from infiltrating through the fill pad. The main drainage channel should be reshaped and graded to ensure there is enough slope to keep the water moving. The main drainage channel would also the natural grade and tie into the CBC at I-40, ultimately draining into the Rio Puerco.

It is recommended to line the channel, in its entirety, with an impermeable membrane. A liner will reduce friction and maintain the velocities needed to prevent water ponding, help deter the growth of vegetation and prevent water from seeping into underground workings. The channel should be regraded to ensure there is adequate slope to keep the water moving. The channel geometry should be reconstructed to accommodate large storm events, to prevent flooding of adjacent properties. All culverts, roadside ditches, and other infrastructure should be periodically monitored and maintained when necessary.

The drainage through the current residential area is adequately sized and is designed to move water efficiently. However, many of the roadside ditches have filled with sediment and the culverts have been partially plugged. Reestablishing roadside ditches and cleaning the adjoining culverts will restore the proper conveyance of water and will reduce flooding or pooling during storm events.

The NMDOT structures are suitable. It is recommended they be cleaned to maintain flows and limit further sedimentation. Existing dikes within the NMDOT right-of-way and along the historical railroad bed should be reestablished.

Key Takeaways:

Keep the water moving; there should be no retention or detention of water.

- **Northwest Fill Pad Area**: Open channel rather than piped conduit is the preferred alternative for mitigating the effects of the fill pad; the open channel is less costly and requires the least amount of maintenance. The suggested location of the open channel is the historic channel and would reestablish the preferred path for storm flows.
- **Drainage Channel:** In consultation with the AML Program and the Geotechnical team, the current channel alignment is the best option; all other locations for the channel realignment were deemed infeasible due to subsurface mine workings, terrain/topography, and/or, lack of information. An impervious channel lining should be used to prevent infiltration of water to avoid further subsidence.
- **Two culverts**: will help convey flow in the channel under the roads that cross the drainage channel currently. The culverts will help convey large flows under the road and reduce potential for overtopping during significant storm events.
- **Interstate 40:** All drainage structures were deemed adequate. Culverts should be cleaned and periodically maintained. Vegetation should be managed to allow unobstructed flow of water. The dikes should be reestablished.
- **NMDOT**: should be consulted to discuss maintenance roles and responsibilities to ensure conveyance of storm flows.
- **Commercial and Residential Areas:** roadside ditches must be re-established, and culverts require cleaning.
- **County and residents**: should be consulted to discuss maintenance roles and responsibilities in order to maintain clean and operable drainage facilities.
- **Drainage easements**: should be obtained prior to any work and should provide enough width to provide an access road to maintain drainage features.

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HEC-RAS

APPENDIX A

NOAA POINT PRECIPITATION

WEIGHTED CURVE NUMBER

NOAA Atlas 14, Volume 1, Version 5
Location name: Gallup, New Mexico, USA*
Latitude: 35.5252°, Longitude: -108.7865°
Elevation: 6492.1 ft**
* source: ESRI Maps
** source: USGS

POINT PRECIPITATION FREQUENCY ESTIMATES

Sanja Perica, Sarah Dietz, Sarah Heim, Lillian Hiner, Kazungu Maitaria, Deborah Martin, Sandra Pavlovic, Ishani Roy, Carl Trypaluk, Dale Unruh, Fenglin Yan, Michael Yekta, Tan Zhao, Geoffrey Bonnin, Daniel Brewer, Li-Chuan Chen, Tye Parzybok, John Yarchoan

NOAA, National Weather Service, Silver Spring, Maryland

PF_tabular | PF_graphical | Maps_&_aerials

PF tabular

PDS-based point precipitation frequency estimates with 90% confidence intervals (in inches)[1]

Duration	Average recurrence interval (years)									
	1	2	5	10	25	50	100	200	500	1000
5-min	0.183 (0.157-0.216)	0.236 (0.202-0.278)	0.318 (0.271-0.375)	0.383 (0.324-0.449)	0.474 (0.398-0.557)	0.546 (0.456-0.640)	0.624 (0.517-0.733)	0.707 (0.580-0.831)	0.823 (0.666-0.972)	0.920 (0.735-1.09)
10-min	0.278 (0.239-0.329)	0.360 (0.308-0.424)	0.484 (0.413-0.570)	0.583 (0.494-0.684)	0.722 (0.607-0.847)	0.831 (0.695-0.975)	0.950 (0.787-1.12)	1.08 (0.883-1.26)	1.25 (1.01-1.48)	1.40 (1.12-1.66)
15-min	0.345 (0.296-0.408)	0.446 (0.382-0.525)	0.601 (0.512-0.707)	0.723 (0.613-0.848)	0.894 (0.753-1.05)	1.03 (0.862-1.21)	1.18 (0.976-1.38)	1.33 (1.10-1.57)	1.55 (1.26-1.83)	1.74 (1.39-2.06)
30-min	0.465 (0.398-0.549)	0.600 (0.514-0.707)	0.809 (0.689-0.952)	0.973 (0.825-1.14)	1.21 (1.01-1.42)	1.39 (1.16-1.63)	1.59 (1.31-1.86)	1.80 (1.47-2.11)	2.09 (1.69-2.47)	2.34 (1.87-2.77)
60-min	0.575 (0.493-0.680)	0.743 (0.636-0.875)	1.00 (0.853-1.18)	1.20 (1.02-1.41)	1.49 (1.25-1.75)	1.72 (1.44-2.02)	1.96 (1.63-2.31)	2.22 (1.83-2.61)	2.59 (2.09-3.06)	2.89 (2.31-3.43)
2-hr	0.676 (0.577-0.795)	0.864 (0.743-1.02)	1.15 (0.980-1.35)	1.38 (1.18-1.63)	1.72 (1.45-2.02)	2.00 (1.67-2.34)	2.30 (1.90-2.69)	2.62 (2.15-3.07)	3.09 (2.49-3.62)	3.48 (2.76-4.09)
3-hr	0.735 (0.637-0.857)	0.933 (0.807-1.09)	1.22 (1.05-1.42)	1.46 (1.25-1.69)	1.79 (1.53-2.08)	2.07 (1.75-2.40)	2.37 (1.99-2.75)	2.70 (2.24-3.14)	3.18 (2.58-3.69)	3.57 (2.86-4.16)
6-hr	0.859 (0.757-0.984)	1.08 (0.951-1.24)	1.37 (1.20-1.57)	1.61 (1.41-1.84)	1.96 (1.70-2.24)	2.24 (1.93-2.55)	2.54 (2.17-2.89)	2.86 (2.42-3.25)	3.30 (2.75-3.77)	3.68 (3.04-4.22)
12-hr	0.987 (0.876-1.12)	1.24 (1.10-1.40)	1.55 (1.37-1.76)	1.80 (1.59-2.04)	2.15 (1.89-2.43)	2.43 (2.12-2.74)	2.71 (2.35-3.06)	3.02 (2.60-3.42)	3.47 (2.94-3.93)	3.85 (3.23-4.38)
24-hr	1.06 (0.940-1.20)	1.34 (1.18-1.51)	1.70 (1.50-1.92)	2.00 (1.76-2.24)	2.42 (2.12-2.70)	2.75 (2.40-3.07)	3.09 (2.69-3.46)	3.45 (2.98-3.87)	3.96 (3.39-4.43)	4.36 (3.70-4.89)
2-day	1.17 (1.05-1.30)	1.47 (1.32-1.63)	1.85 (1.66-2.06)	2.16 (1.93-2.40)	2.58 (2.30-2.87)	2.91 (2.58-3.24)	3.26 (2.88-3.63)	3.61 (3.17-4.02)	4.10 (3.57-4.57)	4.48 (3.87-5.00)
3-day	1.27 (1.15-1.41)	1.59 (1.44-1.76)	2.01 (1.81-2.22)	2.33 (2.10-2.58)	2.78 (2.49-3.07)	3.13 (2.80-3.45)	3.49 (3.11-3.85)	3.85 (3.42-4.26)	4.35 (3.83-4.82)	4.74 (4.15-5.25)
4-day	1.37 (1.24-1.51)	1.72 (1.56-1.89)	2.16 (1.96-2.38)	2.51 (2.27-2.76)	2.97 (2.69-3.27)	3.34 (3.01-3.67)	3.71 (3.34-4.08)	4.09 (3.66-4.49)	4.60 (4.09-5.06)	4.99 (4.42-5.49)
7-day	1.62 (1.49-1.78)	2.03 (1.86-2.23)	2.55 (2.34-2.79)	2.94 (2.70-3.21)	3.47 (3.17-3.79)	3.88 (3.54-4.24)	4.30 (3.90-4.70)	4.72 (4.26-5.16)	5.27 (4.71-5.78)	5.69 (5.06-6.25)
10-day	1.82 (1.67-1.98)	2.28 (2.10-2.49)	2.85 (2.62-3.10)	3.28 (3.01-3.57)	3.85 (3.53-4.18)	4.28 (3.91-4.65)	4.71 (4.29-5.12)	5.14 (4.66-5.59)	5.70 (5.13-6.21)	6.11 (5.49-6.67)
20-day	2.40 (2.20-2.64)	3.01 (2.75-3.30)	3.75 (3.43-4.12)	4.33 (3.95-4.74)	5.10 (4.64-5.57)	5.68 (5.16-6.20)	6.26 (5.66-6.85)	6.84 (6.15-7.49)	7.61 (6.80-8.34)	8.18 (7.27-8.99)
30-day	2.94 (2.69-3.23)	3.68 (3.37-4.04)	4.58 (4.18-5.01)	5.26 (4.79-5.76)	6.14 (5.59-6.73)	6.80 (6.16-7.44)	7.45 (6.73-8.15)	8.09 (7.28-8.86)	8.91 (7.97-9.80)	9.53 (8.47-10.5)
45-day	3.62 (3.32-3.95)	4.55 (4.17-4.95)	5.64 (5.17-6.14)	6.46 (5.90-7.01)	7.50 (6.83-8.14)	8.27 (7.51-8.98)	9.01 (8.17-9.80)	9.74 (8.81-10.6)	10.7 (9.60-11.6)	11.3 (10.1-12.4)
60-day	4.16 (3.80-4.54)	5.21 (4.77-5.70)	6.43 (5.87-7.03)	7.33 (6.68-8.00)	8.46 (7.70-9.23)	9.29 (8.46-10.1)	10.1 (9.17-11.0)	10.9 (9.84-11.8)	11.8 (10.7-12.9)	12.5 (11.3-13.7)

[1] Precipitation frequency (PF) estimates in this table are based on frequency analysis of partial duration series (PDS).

Numbers in parenthesis are PF estimates at lower and upper bounds of the 90% confidence interval. The probability that precipitation frequency estimates (for a given duration and average recurrence interval) will be greater than the upper bound (or less than the lower bound) is 5%. Estimates at upper bounds are not checked against probable maximum precipitation (PMP) estimates and may be higher than currently valid PMP values.

Please refer to NOAA Atlas 14 document for more information.

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PF graphical

Weighted Curve Number

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Runoff Curve Number Report

(Generated by WMS)

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Thu Sep 05 08:48:50 2019

Runoff Curve Number Report for Basin SB-5

HSG	Land Use Description	CN	Area	Product
			acres	CN x A
D	Mixed Rangeland	77	85.703	6599.101
D	Newly graded areas (previous area only, no veg	94	3.374	317.167
C	Newly graded areas (previous area only, no veg	91	3.374	307.045
C	Herbaceous 100% Cover	88	0.225	19.795

CN (Weighted) = Total Product \ Total Area

==

78.1553

Runoff Curve Number Report for Basin SB-4

HSG	Land Use Description	CN	Area	Product
			acres	CN x A
D	Mixed Rangeland	77	123.673	9522.835
C	Mixed Rangeland	70	28.300	1980.999
C	Herbaceous 107over	88	0.669	58.828

CN (Weighted) = Total Product \ Total Area

==

75.7504

Runoff Curve Number Report for Basin SB-11

HSG	Land Use Description	CN	Area	Product
			acres	CN x A
C	Mixed Urban or Built-up Land	91	0.246	22.398
C	Paved Road; open ditch (including r/w)	92	0.246	22.644

CN (Weighted) = Total Product \ Total Area

==

91.5

Runoff Curve Number Report for Basin SB-10

HSG	Land Use Description	CN	Area	Product
			acres	CN x A
C	Paved Road; open ditch (including r/w)	92	0.163	15.025
C	Mixed Urban or Built-up Land	91	0.163	14.862

CN (Weighted) = Total Product \ Total Area

==

91.5

Runoff Curve Number Report for Basin SB-7

HSG	Land Use Description	CN	Area acres	Product CN x A
C	Herbaceous 10¥over	88	1.998	175.830
D	Herbaceous 10Gover	92	3.552	326.795
D	Mixed Rangeland	77	2.664	205.135

CN (Weighted) = Total Product \ Total Area

==

86.1622

Runoff Curve Number Report for Basin SB-2

HSG	Land Use Description	CN	Area acres	Product CN x A
D	Mixed Rangeland	77	13.553	1043.600
C	Mixed Rangeland	70	8.270	578.884
C	Paved Road; open ditch (including r/w)	92	0.230	21.134

CN (Weighted) = Total Product \ Total Area

==

74.5313

Runoff Curve Number Report for Basin SB-8

HSG	Land Use Description	CN	Area	Product
			acres	CN x A
C	Mixed Urban or Built-up Land	91	2.351	213.930

CN (Weighted) = Total Product \ Total Area

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91

Runoff Curve Number Report for Basin SB-1

HSG	Land Use Description	CN	Area	Product
			acres	CN x A
C	Herbaceous 10Õover	88	3.741	329.215
C	Dirt Road; (including r/w)	87	0.468	40.684
C	Mixed Urban or Built-up Land	91	10.288	936.205
C	Mixed Rangeland	70	9.119	638.322
C	Paved Road; open ditch (including r/w)	92	0.701	64.534
C	Paved Road; curbs & storm sewers (excluding r/	98	0.234	22.914

CN (Weighted) = Total Product \ Total Area

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82.7619

Runoff Curve Number Report for Basin SB-6

HSG	Land Use Description	CN	Area	Product
			acres	CN x A
D	Mixed Rangeland	77	15.974	1230.014
C	Mixed Rangeland	70	3.375	236.238
C	Herbaceous 10çover	88	4.050	356.382
C	Dirt Road; (including r/w)	87	0.225	19.574

CN (Weighted) = Total Product \ Total Area

==

77.981

Runoff Curve Number Report for Basin SB-15

HSG	Land Use Description	CN	Area	Product
			acres	CN x A
D	Mixed Rangeland	77	969.011	74613.811
C	Mixed Rangeland	70	1096.441	76750.858
C	Mixed Urban or Built-up Land	91	13.283	1208.787
C	Pasture, grassland, or range-Good	74	22.964	1699.371
C	Herbaceous-mixture of grass, weeds, and low ..	87	11.482	998.954
C	Paved Road; open ditch (including r/w)	92	11.933	1097.792
C	Commercial and Services	94	0.450	42.327
D	Pasture,grassland,or range-Good	80	2.702	216.136
C	Meadow-continous grass, protedted from grazing	71	18.011	1278.806
C	Impervious areas(paved parking lots, roofs, dr	98	51.783	5074.697
D	Mixed Urban or Built-up Land	93	36.023	3350.111

CN (Weighted) = Total Product \ Total Area

==

74.4519

Runoff Curve Number Report for Basin SB-9

HSG	Land Use Description	CN	Area	Product
			acres	CN x A
C	Mixed Urban or Built-up Land	91	0.206	18.708
C	Paved Road; open ditch (including r/w)	92	1.439	132.398

CN (Weighted) = Total Product \ Total Area

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91.875

Runoff Curve Number Report for Basin SB-3

HSG	Land Use Description	CN	Area	Product
			acres	CN x A
C	Herbaceous 10¥over	88	9.951	875.662
D	Herbaceous 10over	92	5.428	499.344
C	Paved Road; open ditch (including r/w)	92	0.226	20.806
D	Mixed Rangeland	77	9.498	731.377

CN (Weighted) = Total Product \ Total Area

==

84.7387

Runoff Curve Number Report for Basin SB-14

HSG	Land Use Description	CN	Area	Product
			acres	CN x A
D	Mixed Rangeland	77	0.454	34.981
C	Mixed Rangeland	70	0.454	31.801

CN (Weighted) = Total Product \ Total Area

==

73.5

Runoff Curve Number Report for Basin SB-12

HSG	Land Use Description	CN	Area	Product
			acres	CN x A
C	Herbaceous 10...over	88	0.250	22.011
C	Paved Road; open ditch (including r/w)	92	0.500	46.024
C	Mixed Rangeland	70	0.250	17.509
C	Mixed Urban or Built-up Land	91	1.751	159.333
D	Mixed Rangeland	77	2.501	192.600
D	Mixed Urban or Built-up Land	93	0.500	46.524

CN (Weighted) = Total Product \ Total Area

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84.1304

Runoff Curve Number Report for Basin SB-13

HSG	Land Use Description	CN	Area acres	Product CN x A
C	Mixed Urban or Built-up Land	91	1.412	128.526
D	Mixed Urban or Built-up Land	93	1.177	109.459
D	Mixed Rangeland	77	3.060	235.630

CN (Weighted) = Total Product \ Total Area

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83.8333

APPENDIX B

HEC-HMS RESULTS

HYDRAULIC ANALYSIS RESULTS

Project: AML Simulation Run: 2-Year

Start of Run: 26Aug2019, 12:00 Basin Model: WMS Watershed
End of Run: 27Aug2019, 12:00 Meteorologic Model: 2-Year
Compute Time: 06Jul2020, 09:06:13 Control Specifications: WMS Control Info

Hydrologic Element	Drainage Area (MI2)	Peak Discharge (CFS)	Time of Peak	Volume (AC-FT)
SB-1	0.04	4.2	26Aug2019, 18:30	0.5
SB-2	0.03	0.8	26Aug2019, 18:30	0.2
SB-3	0.04	8.1	26Aug2019, 18:15	0.7
SB-4	0.24	7.0	26Aug2019, 18:30	1.4
SB-5	0.14	7.5	26Aug2019, 18:15	1.2
SB-6	0.04	2.0	26Aug2019, 18:15	0.3
SB-7	0.01	3.2	26Aug2019, 18:15	0.2
SB-8	0.00	1.6	26Aug2019, 18:15	0.1
SB-9	0.00	0.9	26Aug2019, 18:15	0.1
SB-10	0.00	0.2	26Aug2019, 18:15	0.0
SB-11	0.00	0.4	26Aug2019, 18:15	0.0
SB-12	0.01	1.7	26Aug2019, 18:15	0.1
SB-13	0.01	1.6	26Aug2019, 18:15	0.1
SB-14	0.00	0.0	26Aug2019, 18:30	0.0
SB-15	3.49	39.5	26Aug2019, 19:30	16.2
C1	4.03	53.5	26Aug2019, 18:45	21.0
C2	0.03	0.8	26Aug2019, 18:30	0.2
C3	0.04	8.1	26Aug2019, 18:15	0.7
C4	0.24	7.0	26Aug2019, 18:30	1.4
C5	0.38	15.0	26Aug2019, 18:30	2.5
C6	0.42	17.2	26Aug2019, 18:30	2.8
C7	0.01	3.2	26Aug2019, 18:15	0.2
C8	0.02	3.9	26Aug2019, 18:30	0.4
C9	0.04	8.8	26Aug2019, 18:30	0.8
C10	0.04	9.2	26Aug2019, 18:30	0.8
C11	0.04	9.5	26Aug2019, 18:30	0.8
C12	0.03	4.0	26Aug2019, 18:30	0.5

Page 1

Hydrologic Element	Drainage Area (MI2)	Peak Discharge (CFS)	Time of Peak	Volume (AC-FT)
C13	0.03	5.1	26Aug2019, 18:30	0.6
C14	0.04	5.6	26Aug2019, 18:30	0.7
RT3	0.04	8.0	26Aug2019, 18:30	0.7
RT4	0.24	7.9	26Aug2019, 18:30	1.4
RT5	0.38	15.4	26Aug2019, 18:30	2.5
RT6	0.42	18.6	26Aug2019, 18:45	2.8
RT7	0.01	3.1	26Aug2019, 18:30	0.3
RT8	0.02	3.0	26Aug2019, 18:30	0.4
RT9	0.04	9.0	26Aug2019, 18:30	0.8
RT10	0.04	9.3	26Aug2019, 18:30	0.8
RT11	0.04	9.5	26Aug2019, 18:45	0.8
RT12	0.03	4.2	26Aug2019, 18:30	0.5
RT13	0.03	5.6	26Aug2019, 18:30	0.7
RT14	0.04	6.1	26Aug2019, 18:45	0.7

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Project: AML   Simulation Run: 10-Year

Start of Run: 26Aug2019, 12:00   Basin Model: WMS Watershed
End of Run: 27Aug2019, 12:00   Meteorologic Model: 10-Year
Compute Time: 06Jul2020, 09:06:12   Control Specifications: WMS Control Info

Hydrologic Element	Drainage Area (MI2)	Peak Discharge (CFS)	Time of Peak	Volume (AC-FT)
SB-1	0.04	12.9	26Aug2019, 18:30	1.3
SB-2	0.03	6.2	26Aug2019, 18:15	0.6
SB-3	0.04	22.6	26Aug2019, 18:15	1.5
SB-4	0.24	41.3	26Aug2019, 18:15	4.6
SB-5	0.14	38.7	26Aug2019, 18:15	3.4
SB-6	0.04	10.7	26Aug2019, 18:15	0.9
SB-7	0.01	8.3	26Aug2019, 18:15	0.5
SB-8	0.00	3.5	26Aug2019, 18:15	0.2
SB-9	0.00	1.8	26Aug2019, 18:15	0.2
SB-10	0.00	0.5	26Aug2019, 18:15	0.0
SB-11	0.00	0.8	26Aug2019, 18:15	0.0
SB-12	0.01	4.9	26Aug2019, 18:15	0.3
SB-13	0.01	4.7	26Aug2019, 18:15	0.3
SB-14	0.00	0.2	26Aug2019, 18:15	0.0
SB-15	3.49	226.7	26Aug2019, 19:15	59.3
C1	4.03	260.6	26Aug2019, 19:15	72.8
C2	0.03	6.2	26Aug2019, 18:15	0.6
C3	0.04	22.6	26Aug2019, 18:15	1.5
C4	0.24	41.3	26Aug2019, 18:15	4.6
C5	0.38	72.9	26Aug2019, 18:30	8.1
C6	0.42	95.8	26Aug2019, 18:30	8.9
C7	0.01	8.3	26Aug2019, 18:15	0.5
C8	0.02	9.9	26Aug2019, 18:15	0.8
C9	0.04	21.1	26Aug2019, 18:30	1.7
C10	0.04	22.4	26Aug2019, 18:30	1.7
C11	0.04	24.3	26Aug2019, 18:30	1.8
C12	0.03	10.0	26Aug2019, 18:30	1.1

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Hydrologic Element	Drainage Area (MI2)	Peak Discharge (CFS)	Time of Peak	Volume (AC-FT)
C13	0.03	13.0	26Aug2019, 18:15	1.4
C14	0.04	14.0	26Aug2019, 18:30	1.4
RT3	0.04	19.4	26Aug2019, 18:30	1.5
RT4	0.24	45.2	26Aug2019, 18:30	4.6
RT5	0.38	89.2	26Aug2019, 18:30	8.1
RT6	0.42	90.6	26Aug2019, 18:30	9.0
RT7	0.01	6.8	26Aug2019, 18:30	0.6
RT8	0.02	7.4	26Aug2019, 18:30	0.8
RT9	0.04	22.1	26Aug2019, 18:30	1.7
RT10	0.04	24.0	26Aug2019, 18:30	1.7
RT11	0.04	21.0	26Aug2019, 18:30	1.8
RT12	0.03	10.2	26Aug2019, 18:30	1.1
RT13	0.03	13.8	26Aug2019, 18:30	1.4
RT14	0.04	15.2	26Aug2019, 18:45	1.5

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Project: AML   Simulation Run: 25-Year

Start of Run: 26Aug2019, 12:00   Basin Model: WMS Watershed
End of Run: 27Aug2019, 12:00   Meteorologic Model: 25-Year
Compute Time: 06Jul2020, 09:06:14   Control Specifications: WMS Control Info

Hydrologic Element	Drainage Area (MI2)	Peak Discharge (CFS)	Time of Peak	Volume (AC-FT)
SB-1	0.04	19.5	26Aug2019, 18:30	1.9
SB-2	0.03	12.1	26Aug2019, 18:15	1.0
SB-3	0.04	33.5	26Aug2019, 18:15	2.1
SB-4	0.24	76.9	26Aug2019, 18:15	7.3
SB-5	0.14	66.2	26Aug2019, 18:15	5.3
SB-6	0.04	18.4	26Aug2019, 18:15	1.3
SB-7	0.01	12.0	26Aug2019, 18:15	0.8
SB-8	0.00	4.7	26Aug2019, 18:15	0.3
SB-9	0.00	2.5	26Aug2019, 18:15	0.2
SB-10	0.00	0.7	26Aug2019, 18:15	0.0
SB-11	0.00	1.0	26Aug2019, 18:15	0.1
SB-12	0.01	7.4	26Aug2019, 18:15	0.5
SB-13	0.01	7.0	26Aug2019, 18:15	0.5
SB-14	0.00	0.4	26Aug2019, 18:15	0.0
SB-15	3.49	412.5	26Aug2019, 19:15	96.2
C1	4.03	467.9	26Aug2019, 19:15	116.4
C2	0.03	12.1	26Aug2019, 18:15	1.0
C3	0.04	33.5	26Aug2019, 18:15	2.1
C4	0.24	76.9	26Aug2019, 18:15	7.3
C5	0.38	128.3	26Aug2019, 18:15	12.6
C6	0.42	163.1	26Aug2019, 18:30	13.9
C7	0.01	12.0	26Aug2019, 18:15	0.8
C8	0.02	14.2	26Aug2019, 18:15	1.1
C9	0.04	29.5	26Aug2019, 18:30	2.3
C10	0.04	31.3	26Aug2019, 18:30	2.4
C11	0.04	34.4	26Aug2019, 18:30	2.4
C12	0.03	14.4	26Aug2019, 18:30	1.5

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Hydrologic Element	Drainage Area (MI2)	Peak Discharge (CFS)	Time of Peak	Volume (AC-FT)
C13	0.03	19.2	26Aug2019, 18:15	2.0
C14	0.04	20.5	26Aug2019, 18:30	2.0
RT3	0.04	27.3	26Aug2019, 18:30	2.1
RT4	0.24	77.9	26Aug2019, 18:30	7.4
RT5	0.38	152.4	26Aug2019, 18:30	12.6
RT6	0.42	166.6	26Aug2019, 18:30	14.0
RT7	0.01	9.5	26Aug2019, 18:30	0.8
RT8	0.02	10.5	26Aug2019, 18:30	1.0
RT9	0.04	31.0	26Aug2019, 18:30	2.3
RT10	0.04	33.9	26Aug2019, 18:30	2.4
RT11	0.04	33.8	26Aug2019, 18:30	2.4
RT12	0.03	15.0	26Aug2019, 18:30	1.5
RT13	0.03	20.2	26Aug2019, 18:30	2.0
RT14	0.04	20.8	26Aug2019, 18:30	2.0

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Project: AML Simulation Run: 50-Year

Start of Run: 26Aug2019, 12:00 Basin Model: WMS Watershed
End of Run: 27Aug2019, 12:00 Meteorologic Model: 50-Year
Compute Time: 06Jul2020, 09:06:15 Control Specifications:WMS Control Info

Hydrologic Element	Drainage Area (MI2)	Peak Discharge (CFS)	Time of Peak	Volume (IN)
SB-1	0.0384	25.3	26Aug2019, 18:30	1.14
SB-2	0.0345	17.7	26Aug2019, 18:15	0.71
SB-3	0.0392	42.7	26Aug2019, 18:15	1.27
SB-4	0.2385	110.1	26Aug2019, 18:15	0.77
SB-5	0.1448	91.2	26Aug2019, 18:15	0.89
SB-6	0.0369	25.3	26Aug2019, 18:15	0.88
SB-7	0.0128	15.2	26Aug2019, 18:15	1.37
SB-8	0.0037	5.7	26Aug2019, 18:15	1.73
SB-9	0.0026	3.0	26Aug2019, 18:15	1.81
SB-10	0.0005	0.8	26Aug2019, 18:15	1.78
SB-11	0.0008	1.3	26Aug2019, 18:15	1.78
SB-12	0.0090	9.5	26Aug2019, 18:15	1.23
SB-13	0.0088	9.1	26Aug2019, 18:15	1.21
SB-14	0.0014	0.7	26Aug2019, 18:15	0.66
SB-15	3.4908	589.9	26Aug2019, 19:15	0.69
C1	4.0282	664.3	26Aug2019, 19:15	0.72
C2	0.0345	17.7	26Aug2019, 18:15	0.71
C3	0.0392	42.7	26Aug2019, 18:15	1.27
C4	0.2385	110.1	26Aug2019, 18:15	0.77
C5	0.3833	183.1	26Aug2019, 18:15	0.81
C6	0.4202	221.6	26Aug2019, 18:30	0.82
C7	0.0128	15.2	26Aug2019, 18:15	1.37
C8	0.0165	17.9	26Aug2019, 18:15	1.45
C9	0.0418	36.6	26Aug2019, 18:15	1.30
C10	0.0423	38.7	26Aug2019, 18:30	1.31
C11	0.0431	42.6	26Aug2019, 18:30	1.32
C12	0.0255	18.1	26Aug2019, 18:30	1.37

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Hydrologic Element	Drainage Area (MI2)	Peak Discharge (CFS)	Time of Peak	Volume (IN)
C13	0.0343	24.9	26Aug2019, 18:15	1.33
C14	0.0357	25.7	26Aug2019, 18:30	1.30
RT3	0.0392	33.8	26Aug2019, 18:30	1.27
RT4	0.2385	106.6	26Aug2019, 18:30	0.77
RT5	0.3833	207.4	26Aug2019, 18:30	0.81
RT6	0.4202	235.2	26Aug2019, 18:30	0.82
RT7	0.0128	12.2	26Aug2019, 18:15	1.36
RT8	0.0165	13.2	26Aug2019, 18:30	1.44
RT9	0.0418	38.3	26Aug2019, 18:30	1.30
RT10	0.0423	42.0	26Aug2019, 18:30	1.31
RT11	0.0431	44.4	26Aug2019, 18:30	1.32
RT12	0.0255	18.9	26Aug2019, 18:30	1.37
RT13	0.0343	25.3	26Aug2019, 18:30	1.33
RT14	0.0357	28.2	26Aug2019, 18:30	1.30

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Project: AML Simulation Run: 100-Year

Start of Run: 26Aug2019, 12:00 Basin Model: WMS Watershed
End of Run: 27Aug2019, 12:00 Meteorologic Model: 100-Year
Compute Time: 06Jul2020, 09:06:12 Control Specifications: WMS Control Info

Hydrologic Element	Drainage Area (MI2)	Peak Discharge (CFS)	Time of Peak	Volume (AC-FT)
SB-1	0.04	31.5	26Aug2019, 18:30	2.9
SB-2	0.03	24.1	26Aug2019, 18:15	1.7
SB-3	0.04	53.0	26Aug2019, 18:15	3.2
SB-4	0.24	148.2	26Aug2019, 18:15	12.4
SB-5	0.14	119.4	26Aug2019, 18:15	8.6
SB-6	0.04	33.1	26Aug2019, 18:15	2.2
SB-7	0.01	18.6	26Aug2019, 18:15	1.1
SB-8	0.00	6.8	26Aug2019, 18:15	0.4
SB-9	0.00	3.6	26Aug2019, 18:15	0.3
SB-10	0.00	0.9	26Aug2019, 18:15	0.1
SB-11	0.00	1.5	26Aug2019, 18:15	0.1
SB-12	0.01	11.8	26Aug2019, 18:15	0.7
SB-13	0.01	11.3	26Aug2019, 18:15	0.7
SB-14	0.00	0.9	26Aug2019, 18:15	0.1
SB-15	3.49	794.0	26Aug2019, 19:15	165.7
C1	4.03	889.6	26Aug2019, 19:15	198.3
C2	0.03	24.1	26Aug2019, 18:15	1.7
C3	0.04	53.0	26Aug2019, 18:15	3.2
C4	0.24	148.2	26Aug2019, 18:15	12.4
C5	0.38	246.0	26Aug2019, 18:15	21.0
C6	0.42	285.5	26Aug2019, 18:30	23.2
C7	0.01	18.6	26Aug2019, 18:15	1.1
C8	0.02	22.0	26Aug2019, 18:15	1.5
C9	0.04	45.9	26Aug2019, 18:15	3.5
C10	0.04	46.6	26Aug2019, 18:30	3.6
C11	0.04	51.4	26Aug2019, 18:30	3.7
C12	0.03	22.0	26Aug2019, 18:30	2.2

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Hydrologic Element	Drainage Area (MI2)	Peak Discharge (CFS)	Time of Peak	Volume (AC-FT)
C13	0.03	31.0	26Aug2019, 18:15	2.9
C14	0.04	31.4	26Aug2019, 18:30	3.0
RT3	0.04	42.4	26Aug2019, 18:15	3.2
RT4	0.24	138.1	26Aug2019, 18:30	12.4
RT5	0.38	267.5	26Aug2019, 18:30	21.0
RT6	0.42	310.7	26Aug2019, 18:30	23.1
RT7	0.01	15.2	26Aug2019, 18:15	1.1
RT8	0.02	16.1	26Aug2019, 18:30	1.5
RT9	0.04	46.2	26Aug2019, 18:30	3.5
RT10	0.04	50.7	26Aug2019, 18:30	3.6
RT11	0.04	55.3	26Aug2019, 18:30	3.7
RT12	0.03	23.0	26Aug2019, 18:30	2.2
RT13	0.03	30.8	26Aug2019, 18:30	2.9
RT14	0.04	35.9	26Aug2019, 18:30	3.0

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MANNING'S EQUATION for OPEN CHANNEL FLOW

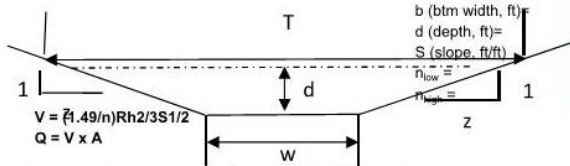
Project:	AML		Location:	Allison Road,Gallup,NM	
Calculated By:	GK	Date:	12/18/2019	50- Year Flow (cfs)	53.0
Checked By:	PE	Date:	12/19/2019	100- Year Flow (cfs)	73.0

Mannings Formula

Q = (1.486/n)ARh2/3S1/2

R = A/P
A = cross sectional area
P= wetted perimeter
S = slope of channel
n = Manning's roughness coefficient

V = (1.49/n)Rh2/3S1/2
Q = V x A



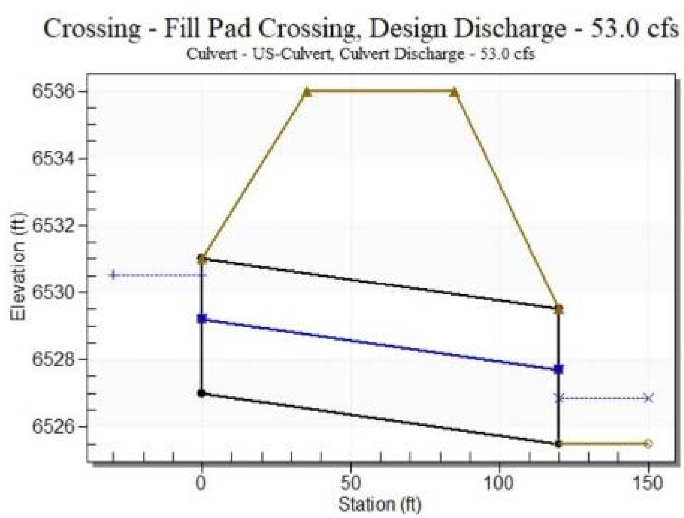
INPUT

z (sideslope)=	3
z (sideslope)=	3
b (btm width, ft)=	8.00
d (depth, ft)=	1.50
S (slope, ft/ft)	0.015
n_{low} =	0.020
n_{high} =	0.016

Calculated Parameters				Low N		High N	
Depth, ft	Area, sf	Wetted Perimeter, ft	Hydraulic Radius, ft	Velocity, fps	Flow, cfs	Velocity, fps	Flow, cfs
1.5	18.75	17.49	1.07	9.53	178.74	11.92	223.43

T =	17.00
Dm =	1.10

Water Surface Profile Plot for Culvert: US-Culvert



Site Data - US-Culvert

Site Data Option: Culvert Invert Data
Inlet Station: 0.00 ft
Inlet Elevation: 6527.00 ft
Outlet Station: 120.00 ft
Outlet Elevation: 6525.50 ft
Number of Barrels: 1

Culvert Data Summary - US-Culvert

Barrel Shape: Circular
Barrel Diameter: 4.00 ft
Barrel Material: Concrete
Embedment: 0.00 in
Barrel Manning's n: 0.0240
Culvert Type: Straight
Inlet Configuration: Square Edge with Headwall
Inlet Depression: None

HEC-RAS Result for Main Channel with Proposed (12’x4’) CBC

Reach	River Sta	Profile	Q Total	Min Ch El	W.S. Elev	Crit W.S.	E.G. Elev	E.G. Slope	Vel Chnl	Flow Area		Top Width	Froude # Chl
			(cfs)	(ft)	(ft)	(ft)	(ft)	(ft/ft)	(ft/s)	(sq ft)		(ft)	
HEC-Check	1777.34	50-Year	183.10	6497.00	6500.21	6498.79	6500.38	0.002051	3.33	55.02		22.34	0.37
HEC-Check	1777.34	100-Year	246.00	6497.00	6500.93	6499.14	6501.11	0.001733	3.41	72.16		24.69	0.35
HEC-Check	1757		Culvert										
HEC-Check	1739.36	50-Year	183.10	6496.24	6498.05	6498.05	6498.84	0.017117	7.12	25.70		16.40	1.00
HEC-Check	1739.36	100-Year	246.00	6496.24	6498.41	6498.41	6499.34	0.016561	7.74	31.77		17.28	1.01
HEC-Check	1676	50-Year	183.10	6494.56	6496.91		6497.21	0.005155	4.35	42.08		23.77	0.58
HEC-Check	1676	100-Year	246.00	6494.56	6497.31		6497.66	0.005178	4.74	51.86		25.74	0.59
HEC-Check	1513.93	50-Year	183.10	6493.72	6496.04		6496.34	0.005484	4.45	41.17		23.57	0.59
HEC-Check	1513.93	100-Year	246.00	6493.72	6496.39		6496.77	0.005787	4.94	49.84		25.34	0.62
HEC-Check	1371.77	50-Year	183.10	6492.68	6494.41	6494.38	6495.06	0.016042	6.49	28.23		20.65	0.98
HEC-Check	1371.77	100-Year	246.00	6492.68	6494.77	6494.70	6495.50	0.014533	6.84	35.94		22.44	0.95
HEC-Check	1243.8	50-Year	183.10	6491.25	6493.66		6493.94	0.004712	4.21	43.44		24.05	0.55
HEC-Check	1243.8	100-Year	246.00	6491.25	6494.04	6493.27	6494.38	0.004877	4.64	52.98		25.96	0.57
HEC-Check	1091.84	50-Year	183.10	6490.30	6492.02	6492.02	6492.68	0.016241	6.51	28.11		20.71	0.98
HEC-Check	1091.84	100-Year	246.00	6490.30	6492.35	6492.35	6493.11	0.015542	7.01	35.10		24.47	0.98
HEC-Check	882.09	50-Year	183.10	6488.14	6490.70	6489.86	6490.93	0.003784	3.90	46.97		58.93	0.50
HEC-Check	882.09	100-Year	246.00	6488.14	6491.33	6490.19	6491.56	0.002910	3.86	63.79		90.62	0.45
HEC-Check	652.2	50-Year	221.60	6486.63	6490.31	6488.55	6490.43	0.001359	2.84	77.92		55.97	0.31
HEC-Check	652.2	100-Year	285.50	6486.63	6491.04	6488.86	6491.16	0.001096	2.82	101.36		61.30	0.29
HEC-Check	630		Culvert										
HEC-Check	611.44	50-Year	221.60	6486.34	6488.84		6489.21	0.006150	4.92	45.03		24.07	0.63
HEC-Check	611.44	100-Year	285.50	6486.34	6489.19		6489.62	0.006224	5.31	54.07		28.02	0.65
HEC-Check	511.88	50-Year	221.60	6485.65	6488.11	6487.56	6488.48	0.008861	4.94	44.88		99.50	0.64
HEC-Check	511.88	100-Year	285.50	6485.65	6488.46	6487.88	6488.89	0.008736	5.30	53.84		104.04	0.65
HEC-Check	304.11	50-Year	221.60	6484.09	6486.55	6486.01	6486.94	0.006362	4.96	44.72		45.96	0.64
HEC-Check	304.11	100-Year	285.50	6484.09	6486.90	6486.33	6487.34	0.006422	5.35	53.41		49.65	0.66
HEC-Check	125.09	50-Year	221.60	6482.80	6484.98	6484.72	6485.51	0.010012	5.82	38.08		39.56	0.80
HEC-Check	125.09	100-Year	285.50	6482.80	6485.30	6485.04	6485.91	0.010012	6.26	45.58		42.03	0.81

HEC-RAS Result for Main Channel with Proposed (11’ 11”’x3’7”’) Type 16 Aluminum Box Culvert (ALBC)

Reach	River Sta	Profile	Q Total	Min Ch El	W.S. Elev	Crit W.S.	E.G. Elev	E.G. Slope	Vel Chnl	Flow Area	Top Width	Froude # Chl
			(cfs)	(ft)	(ft)	(ft)	(ft)	(ft/ft)	(ft/s)	(sq ft)	(ft)	
HEC-Check	1777.34	50-Year	183.10	6497.00	6500.22	6498.79	6500.39	0.002007	3.30	55.44	22.40	0.37
HEC-Check	1777.34	100-Year	246.00	6497.00	6500.96	6499.14	6501.13	0.001697	3.38	72.70	24.76	0.35
HEC-Check	1757		Culvert									
HEC-Check	1739.36	50-Year	183.10	6496.24	6497.84	6498.04	6498.89	0.026206	8.22	22.28	15.89	1.22
HEC-Check	1739.36	100-Year	246.00	6496.24	6498.19	6498.41	6499.39	0.023809	8.76	28.08	16.75	1.19
HEC-Check	1676	50-Year	183.10	6494.56	6496.91	6496.26	6497.21	0.005155	4.35	42.08	23.77	0.58
HEC-Check	1676	100-Year	246.00	6494.56	6497.31	6496.59	6497.66	0.005178	4.74	51.86	25.74	0.59
HEC-Check	1513.93	50-Year	183.10	6493.72	6496.04		6496.34	0.005484	4.45	41.17	23.57	0.59
HEC-Check	1513.93	100-Year	246.00	6493.72	6496.39		6496.77	0.005787	4.94	49.84	25.34	0.62
HEC-Check	1371.77	50-Year	183.10	6492.68	6494.41	6494.38	6495.06	0.016042	6.49	28.23	20.65	0.98
HEC-Check	1371.77	100-Year	246.00	6492.68	6494.77	6494.70	6495.50	0.014533	6.84	35.94	22.44	0.95
HEC-Check	1243.8	50-Year	183.10	6491.25	6493.66		6493.94	0.004708	4.21	43.46	24.05	0.55
HEC-Check	1243.8	100-Year	246.00	6491.25	6494.04	6493.28	6494.38	0.004877	4.64	52.98	25.96	0.57
HEC-Check	1091.84	50-Year	183.10	6490.30	6492.02	6492.02	6492.68	0.016241	6.51	28.11	20.71	0.98
HEC-Check	1091.84	100-Year	246.00	6490.30	6492.35	6492.35	6493.11	0.015542	7.01	35.10	24.47	0.98
HEC-Check	882.09	50-Year	183.10	6488.14	6490.70	6489.86	6490.93	0.003767	3.89	47.04	59.06	0.50
HEC-Check	882.09	100-Year	246.00	6488.14	6491.31	6490.19	6491.55	0.002982	3.89	63.23	89.81	0.46
HEC-Check	652.2	50-Year	221.60	6486.63	6490.29	6488.55	6490.42	0.001440	2.93	75.68	55.48	0.32
HEC-Check	652.2	100-Year	285.50	6486.63	6490.99	6488.87	6491.12	0.001193	2.93	97.45	60.93	0.30
HEC-Check	630		Culvert									
HEC-Check	611.44	50-Year	221.60	6486.34	6488.84	6488.26	6489.21	0.006009	4.86	45.64	24.50	0.63
HEC-Check	611.44	100-Year	285.50	6486.34	6489.19	6488.57	6489.62	0.006068	5.24	54.51	28.82	0.64
HEC-Check	511.88	50-Year	221.60	6485.65	6488.11	6487.56	6488.48	0.008861	4.94	44.88	99.50	0.64
HEC-Check	511.88	100-Year	285.50	6485.65	6488.46	6487.88	6488.89	0.008736	5.30	53.84	104.04	0.65
HEC-Check	304.11	50-Year	221.60	6484.09	6486.55	6486.01	6486.93	0.006377	4.96	44.68	45.94	0.64
HEC-Check	304.11	100-Year	285.50	6484.09	6486.90	6486.33	6487.34	0.006418	5.34	53.42	49.65	0.66
HEC-Check	125.09	50-Year	221.60	6482.80	6484.98	6484.72	6485.51	0.010012	5.82	38.08	39.56	0.80
HEC-Check	125.09	100-Year	285.50	6482.80	6485.30	6485.04	6485.91	0.010012	6.26	45.58	42.03	0.81

HEC-RAS Result (100-Year) for Upper Proposed Culvert (12'x4') CBC

Plan: MODI HEC-Test HEC-Check RS: 1757 Culv Group: Culvert #1 Profile: 100-Year

Q Culv Group (cfs)	246.00	Culv Full Len (ft)	
# Barrels	1	Culv Vel US (ft/s)	8.70
Q Barrel (cfs)	246.00	Culv Vel DS (ft/s)	11.00
E.G. US. (ft)	6501.12	Culv Inv El Up (ft)	6497.00
W.S. US. (ft)	6500.93	Culv Inv El Dn (ft)	6496.24
E.G. DS (ft)	6499.34	Culv Frctn Ls (ft)	0.55
W.S. DS (ft)	6498.41	Culv Exit Loss (ft)	0.64
Delta EG (ft)	1.78	Culv Entr Loss (ft)	0.59
Delta WS (ft)	2.52	Q Weir (cfs)	
E.G. IC (ft)	6500.74	Weir Sta Lft (ft)	
E.G. OC (ft)	6501.12	Weir Sta Rgt (ft)	
Culvert Control	Outlet	Weir Submerg	
Culv WS Inlet (ft)	6499.36	Weir Max Depth (ft)	
Culv WS Outlet (ft)	6498.10	Weir Avg Depth (ft)	
Culv Nml Depth (ft)	1.77	Weir Flow Area (sq ft)	
Culv Crt Depth (ft)	2.36	Min El Weir Flow (ft)	6503.51

HEC-RAS Result (100-Year) for Lower Proposed Culvert (12'x4') CBC

Plan: MODI HEC-Test HEC-Check RS: 630 Culv Group: Culvert #1 Profile: 100-Year

Q Culv Group (cfs)	285.50	Culv Full Len (ft)	
# Barrels	1	Culv Vel US (ft/s)	8.99
Q Barrel (cfs)	285.50	Culv Vel DS (ft/s)	8.36
E.G. US. (ft)	6491.16	Culv Inv El Up (ft)	6486.63
W.S. US. (ft)	6491.04	Culv Inv El Dn (ft)	6486.34
E.G. DS (ft)	6489.62	Culv Frctn Ls (ft)	0.26
W.S. DS (ft)	6489.19	Culv Exit Loss (ft)	0.65
Delta EG (ft)	1.54	Culv Entr Loss (ft)	0.63
Delta WS (ft)	1.85	Q Weir (cfs)	
E.G. IC (ft)	6490.82	Weir Sta Lft (ft)	
E.G. OC (ft)	6491.16	Weir Sta Rgt (ft)	
Culvert Control	Outlet	Weir Submerg	
Culv WS Inlet (ft)	6489.28	Weir Max Depth (ft)	
Culv WS Outlet (ft)	6489.19	Weir Avg Depth (ft)	
Culv Nml Depth (ft)	2.65	Weir Flow Area (sq ft)	
Culv Crt Depth (ft)	2.60	Min El Weir Flow (ft)	6492.21

HEC-RAS Result for Upper Proposed Culvert (11'11"x3' 7") ALBC

Plan: METAL HEC-Test HEC-Check RS: 1757 Culv Group: Culvert #1 Profile: 100-Year

Q Culv Group (cfs)	246.00	Culv Full Len (ft)	
# Barrels	1	Culv Vel US (ft/s)	8.73
Q Barrel (cfs)	246.00	Culv Vel DS (ft/s)	10.62
E.G. US. (ft)	6501.14	Culv Inv El Up (ft)	6497.00
W.S. US. (ft)	6500.96	Culv Inv El Dn (ft)	6496.24
E.G. DS (ft)	6499.34	Culv Frctn Ls (ft)	0.61
W.S. DS (ft)	6498.41	Culv Exit Loss (ft)	0.60
Delta EG (ft)	1.80	Culv Entr Loss (ft)	0.59
Delta WS (ft)	2.54	Q Weir (cfs)	
E.G. IC (ft)	6500.77	Weir Sta Lft (ft)	
E.G. OC (ft)	6501.14	Weir Sta Rgt (ft)	
Culvert Control	Outlet	Weir Submerg	
Culv WS Inlet (ft)	6499.37	Weir Max Depth (ft)	
Culv WS Outlet (ft)	6498.18	Weir Avg Depth (ft)	
Culv Nml Depth (ft)	1.89	Weir Flow Area (sq ft)	
Culv Crt Depth (ft)	2.37	Min El Weir Flow (ft)	6503.51

HEC-RAS Result for Lower Proposed Culvert (11'11"x3' 7") ALBC

Plan: METAL HEC-Test HEC-Check RS: 630 Culv Group: Culvert #1 Profile: 100-Year

Q Culv Group (cfs)	285.50	Culv Full Len (ft)	
# Barrels	1	Culv Vel US (ft/s)	8.32
Q Barrel (cfs)	285.50	Culv Vel DS (ft/s)	8.41
E.G. US. (ft)	6491.12	Culv Inv El Up (ft)	6486.63
W.S. US. (ft)	6490.99	Culv Inv El Dn (ft)	6486.34
E.G. DS (ft)	6489.62	Culv Frctn Ls (ft)	0.30
W.S. DS (ft)	6489.19	Culv Exit Loss (ft)	0.67
Delta EG (ft)	1.51	Culv Entr Loss (ft)	0.54
Delta WS (ft)	1.80	Q Weir (cfs)	
E.G. IC (ft)	6490.89	Weir Sta Lft (ft)	
E.G. OC (ft)	6491.12	Weir Sta Rgt (ft)	
Culvert Control	Outlet	Weir Submerg	
Culv WS Inlet (ft)	6489.51	Weir Max Depth (ft)	
Culv WS Outlet (ft)	6489.19	Weir Avg Depth (ft)	
Culv Nml Depth (ft)	2.88	Weir Flow Area (sq ft)	
Culv Crt Depth (ft)	2.61	Min El Weir Flow (ft)	6492.01

APPENDIX C

HISTORICAL DOCUMENTS

MEETING MINUTES

Meeting Minutes

Kick off Meeting

PROJECT NAME	Task Order 1: Drainage Assessment, Allison, McKinley County, NM
PROJECT NUMBER	2043298.01.01
DATE	19 June 201919 June 2019
TIME	9:30 am
VENUE	Office of the Secretary Conference Room, NM AML Program
SUBJECT	Project Kick-off Meeting
CLIENT	NM AML Program
PRESENT	<u>AML</u> • Meghan McDonald, PE • Mike Tompson, PE • Steven Needles • Yeny Maestas • Joe Vinson <u>WSP</u> • Richard Rotto, PE • Parviz Eftekhari, PE • Zoe Isaacson <u>Golder Associates</u> • Emily Clark • John Purcell

Meeting Agenda:

- Introductions
- Project Purpose/Objectives
- Project Background
- Drainage and Geotechnical Objectives
- Known Issues
- Consultant Scope Review
- Deliverable Discussion

Representatives from the New Mexico AML Program (AML), Golder and Associates (Golder), and WSP met on 06/19/2019 to discuss the assigned drainage assessment and geotechnical investigation of the community of Allison, NM. Allison sits upon a historic subsurface coal mine and has been the focus of a multi-phased effort by the AML Program to safeguard the mines and retard the development of sinkholes and further subsidence.

The primary purpose of the project kick-off meeting was to introduce members of the project team, and to familiarize them with the project background and current site conditions. AML discussed the historical room and pillar coal mine, the location of the subsurface workings, subsequent impacts to the community and previous work at the site. There have been three major phases of work:

1980's: AML worked in concert with the company Stuart Brothers to address foundation and surface settlement in Allison. They were contacted because residents began reporting structural damage to houses and signs of subsidence and assumed it was correlated to the abandoned mine workings. Stuart Brothers performed exploratory drilling in 1985-1986. Eby Mine Services and their subcontractor Badger Drilling performed additional exploratory drilling followed by injection grouting in 1987.

2015 Phase I: AML was notified that a sinkhole approximately 40'x20'x30' appeared within a drainage channel on a private property in Allison. After storm events, the sinkhole would grow, and by the time AML was able to get shovel to ground, the sinkhole had grown to 90'x45'x30'. AML contracted Alan Kuhn Associates to investigate the subsurface conditions of the sinkhole and margins, and profile the conditions underground. AML filled the sinkhole and tension cracks, and rerouted surface water away from the sinkhole footprint. AML believes this subsidence was caused by failing underground mine workings, surface tension crack development, and infiltration of water through the tension cracks to the subsurface mine openings.

2016 Phase II: A second sinkhole developed near the first sinkhole they filled in 2015. Surface tension cracks were spreading and merging with the tension cracks recorded during the first event. A calf was found in a small hole, and the AML felt the need for an emergency safeguarding project was urgent. AML partnered with Golder to perform a geotechnical investigation and recommendations; AML's contractor drilled and injected grout into underground mine workings to construct a bulkhead, and into the subsurface in a grid pattern to help stiffen and shore-up the alluvial soils and prevent further degradation. Contractors also dug out the tension cracks and second sinkhole and filled them with compacted, native soil. The approximately 2-acre construction footprint, including 100' of channel length, was restored and seeded. The grouting was completed in June of 2018; there has been no recorded migration of the sinkhole to date.

AML outlined the scope of work for Task Order 1 for both WSP and Golder.

WSP has been tasked with a drainage assessment and to provide recommendations to the program on improving stormwater management to stunt further development of sinkholes and subsidence. To do this, AML aims to divert stormwater away from known areas as well as potential areas of subsidence, however, the entire area is prone to flooding. Potential areas of subsidence will be identified by Golder per their Task Order 1 scope of work, and through AML, will provide avoidance areas/ boundary shapefiles. There are also cultural resources that should be avoided.

AML recognizes that the subsurface mine workings are vast, and the elimination of all risk isn't possible; the directive is to reduce or minimize risk. Therefore, AML will provide a map showing an area to focus efforts.

WSP's drainage assessment should include photo documentation, historical stormwater diversion locations, current conveyances, and how NMDOT's proposed I-40 Allison Interchange work will affect drainages and current surface conditions. WSP is to research NMDOT plans for future work on I-40; all correspondence with NMDOT must include or be approved by AML.

As part of the deliverable package, AML would like WSP to provide “cutsheets” showing various typical means and methods to address the drainage issues; they would like “tools to fill their toolbox”. The cutsheets should include:

- Management goals/objectives
- Applications
- Benefits/limitations
- Maintenance requirements
- Cost and design life
- Design details, including approximate site location and map
- Example case study
- Site photos and sketches

The cutsheets will be used as an education and outreach tool for the community to get public input to both satisfy NEPA requirements and gain public buy-in.

Access and field visits will be coordinated through Joe Vinson and the AML team. WSP should call AML in advance of plans to visit the project area so they can alert the property owners.

AML will setup an FTP site for document sharing; they will let consultants know when it is up and running.

AML provided both Golder and WSP with the slideshow presentation, GIS data, historical records, results from previous phases of work and other pertinent information on a flash drive.

Next meeting

Field Visit - Monday, June 24th, Allison, New Mexico. 11:30 AM

Field Visit/Meeting:

PROJECT NAME	Task Order 1: Drainage Assessment, Allison, McKinley County, NM
PROJECT NUMBER	2043298.01.02
DATE	24 June 201924 June 2019
TIME	11:30 am
VENUE	Allison, McKinley County, NM
SUBJECT	Allison Field Visit
CLIENT	NMMMD AML Program
PRESENT	<u>AML</u> • Meghan McDonald, PE • Joe Vinson <u>WSP</u> • Richard Rotto, PE • Zoe Isaacson • Parviz Eftekhari, PE • Govinda Karki, PE <u>Golder Associates</u> • Emily Clark • John Purcell • Jeff Clark

Meeting Agenda:

- Introductions
- Site Tour:
  - Previous AML work locations
  - Landowner disturbances and problem areas
  - Current drainage patterns
  - Focus areas for future work

Members of the Project Team including representatives from the New Mexico AML Program (AML), Golder Associates (Golder), and WSP met on 06/24/2019, in Allison, NM to visit the project area of the assigned drainage assessment and geotechnical investigation of the community of Allison, NM. The Team, led by Meghan McDonald of the AML program, toured the site and was made aware of specific problem areas and locations of past work.

The Team initially toured the site of the “Phase III Emergency Project” then followed the drainage channel downstream (south) to the NMDOT right-of-way fence. The Team then walked to the site of the upstream “Fill Pad Area” and observed sections of the upstream drainage channel. Upon returning from the upstream areas, the Team toured through portions of Coronado Blvd, Cortez Road, and Acoma Street.

The project footprint is mostly found on private property. Evidence that some landowner activities had altered the historic drainage of the drainage channel was seen both upstream and downstream of the Emergency Project.

The downstream section included expanded operations at Speedway Towing near I-40. The upstream section included manmade debris placed along the banks of the upstream channel.

WSP and AML inspected a large debris dam and “Fill Pad Area”, built by a landowner, that is suspected of exacerbating downstream flooding and erosion. The “Fill Pad Area” appears to include a landfill of construction material from a road project (concrete slab remnants, rebar, asphalt millings and/or base course material). The AML team members suggest the fill activity occurred around 2012. The landfill disrupts and likely slows the historic flows through Allison. AML also pointed out culverts and other infrastructure that are blocked or partially blocked and no longer convey stormwater as intended.

Having worked on the project site previously, the Golder team was able to identify landmarks and features of the historic mines that surround and undermine the project area. WSP was able to see remediated areas of subsidence areas, old bore holes and injection sites (for grouting subsurface cracks), historic wells, and safeguarded mine entrances. The Team observed small surface disturbances, such as potholes with subsidence potential.

The tour consisted of walking on private property to assess how the current drainage patterns has been affected by landowner intervention, and how it in-turn affects downstream residents. The tour lasted approximately 4 hours in total.

Next meeting

Item c) Field Reconnaissance – WSP plans to reconnoiter the area in more detail once aerial surveys are completed.

Management/Coordination Meeting:

PROJECT NAME	Task Order 1: Drainage Assessment, Allison, McKinley County, NM
PROJECT NUMBER	2043298.01.01
DATE	03 December 201903 December 2019
TIME	10:00 am
VENUE	Conference Room, NM AML Program
SUBJECT	Status Update
CLIENT	NM AML Program
PRESENT	AML • Meghan McDonald, PE • Mike Tompson, PE • Erin Taylor • Rick Wessle WSP • Richard Rotto, PE • Parviz Eftekhari, PE • Zoe Isaacson Golder Associates • Emily Clark • Jeff Clark

Meeting Agenda:

- Introductions
- Golder Status Update
- WSP Update
- Public Meeting
- Next Steps

Representatives from the New Mexico AML Program (AML), Golder and Associates (Golder), and WSP met on 12/03/2019 to discuss the assigned drainage assessment and geotechnical investigation of the community of Allison, NM.

First, Golder shared findings from a field investigation and risk hazard assessment. Golder conducted a field survey to identify surface features, associated with past mining, that together with land use classifications, present low to high risk to public health and or infrastructure. By evaluating hazards (sinkholes or surface anomalies) and the consequence of failure (infrastructure settling), Golder was able to assign a risk value to each anomaly.

To determine the level of hazard associated with a discrete feature, Golder used historic mine maps to tie the surface anomaly to subsurface mine workings. Surface features on undermined areas were assigned the greatest hazard. The hazard ranking also included depth of overburden and rock quality to assess the likelihood of a void reaching the surface. Consequence, the other factor in the risk assessment was solely based on land use. Parcels with housing were assigned the highest value and were thus at greatest consequence should there be a failure. Based on the risk analysis, Golder has been able to identify areas that need further investigation and or mitigation.

WSP then presented a status update on the drainage assessment and discussed design alternatives for the drainage in and around the community. However, based on Golder's findings and much discussion, it was determined that the preferred alternative is in fact, the current channel alignment. The area to the west of the drainage channel is undermined and has little rock or overburden to prevent sinkhole development. To the east, there are a diverse group of private landowners that may not allow the client to build, and maintain access to, the new drainage infrastructure. The east side of the drainage channel is also buffered by an earthen berm that should remain place and free of encroachment by any improvements to the drainage channel.

There are, however, two areas to the north and south of the current drainage channel that may need to be addressed and improved. There is a contributing drainage channel to the north and northwest of the “fill pad area” that may need some realignment and or channel improvements, as well as in the south to connect the mainstem to the CBC to the east. Further analyses are needed to determine the level of effort required to implement and maintain a functioning system.

Next Steps:

The AML Program is looking to submit their NEPA documents by the end of January/ beginning of February. As such, WSP should be able to deliver a basic footprint or plan view of the expected drainage channel and improvements. Typical cross sections and disturbance area (including an access road along the western flank, actual channel, and buffer from the earthen burn along the eastern flank) should be included. AML needs this information to properly plan for the expected impacts to cultural resources within the project APE.

Golder will continue to conduct their geotechnical investigation; should WSP need any additional testing, such as, soil sampling percolation rates, etc., they are to let AML and Golder know so they can include it in their scope.

Next meeting

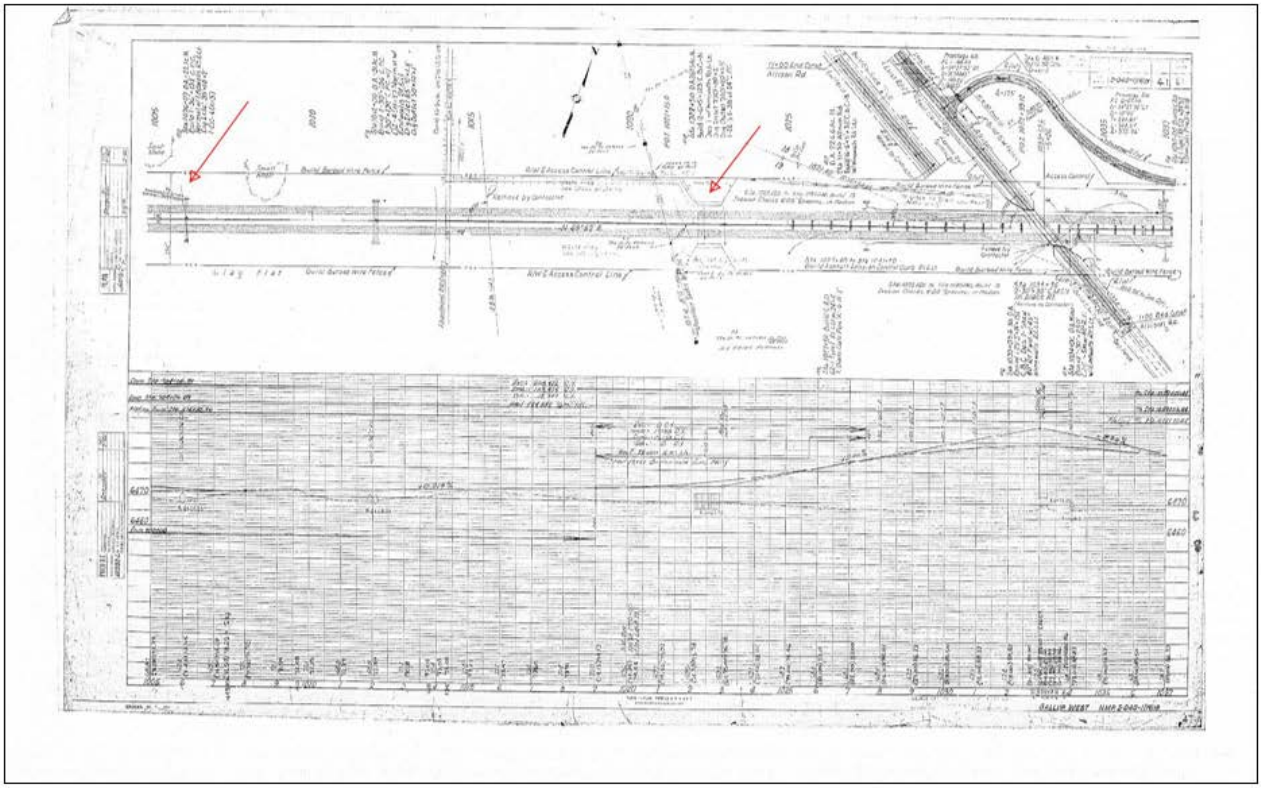
TBD

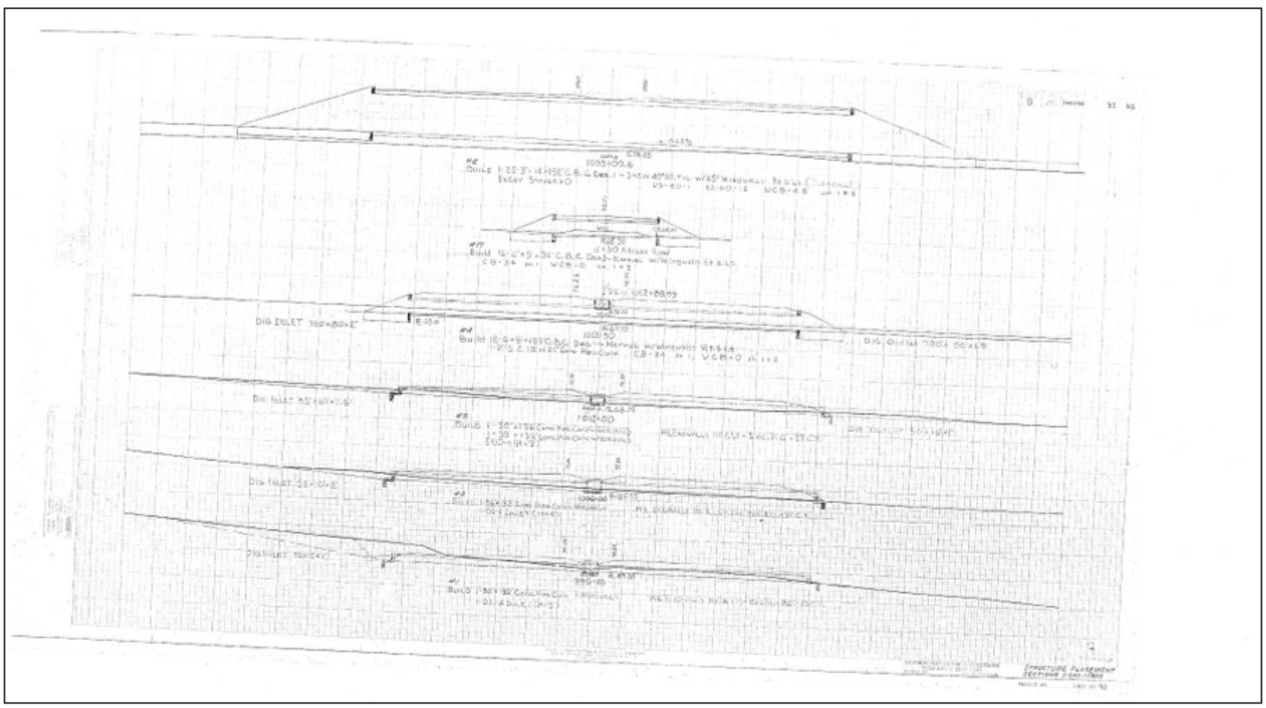
APPENDIX D

NMDOT AS BUILT PLANS

NMDOT BRIDGE INPECTION REPORT

NMDOT RESEARCH





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Project Bridge Color Template

Bridge_Number: 06729

Proj_Doc_Date: 2/11/2016

PROJ_DOC_DESC: ACTIVE

Proj_Control_Number:

Project_Number:

Document Type: INSPECTION REPORTS

X PB1 X

NMDOT

Bridge Inspection Report

000000000006729
Facility Carried(7): I-40 EBL/WBL
Mile Post(11): 19.42 mi (31.25 km)
Team Leader: DEMETRIO TRUJILLO
Inspection Date: 02/11/2016

New Mexico DEPARTMENT OF TRANSPORTATION

IDENTIFICATION

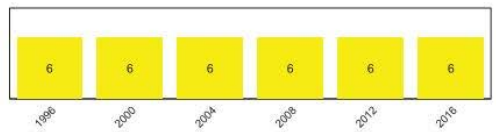
NBI Number:	000000000006729	**County (3):**	31 McKINLEY	**Custodian (21):**	State Highway Ager
Location (9):	1.35 MI W OF US-491	**Health Index:**	90.34	**Year Built (27):**	1966
SHD District (2):	District 6	**SR:**	78.20	**Year Recon (106):**	
Type of Service On (42A):	1 Highway	**SD/FO:**	ND	**Historical (37):**	5 Not eligible for NRHP
Feature Intersected (6):	UNNAMED WATERWAY	**Latitude (16):**	35.52		
Type of Service Under(42B)	5 Waterway	**Longitude (17):**	-108.78		
Placecode (4):	Gallup	**Owner (22):**	State Highway Agency		

BRIDGE NOTES

Patrol 46-58, McKinley County: 3 units of 4 boxes each 6 ft X 5 ft X 124 ft CBC Design I. 2.6 ft of fill cover. No work noted since the last inspection of 2/20/2012. ...

CULVERT GEOMETRY

Deck Area:	6,723.61
O. to O. Width (52):	0.00
Curb / Sidewalk Width L (50A):	0.00
Curb / Sidewalk Width R (50B):	0.00
Median (33):	2 Closed Med w/o Barrier
Width Curb to Curb (51):	0.00
# of Main Spans (45):	12
Main Material (43 A):	2 Concrete Continuous
Main Design (43 B):	19 Culvert
Max Span Length (48):	5.91
Structure Length (49):	80.05
NBIS Length (112):	Long Enough
Skew (34):	0
Structure Flared (35):	0 No flare
Approach Alignment (72):	8 Equal Desirable Crit



CULVERT CONDITION

Culvert Rating (62):	6 Deterioration
Bridge Rail (36A):	1 Meets Standards
Transition (36B):	1 Meets Standards
Approach Rail (36C):	1 Meets Standards
Approach Rail Ends (36D):	1 Meets Standards
Approach Roadway Width (32):(w/ shoulders)	83.99
Structure Evaluation (67):	6 Equal Min Criteria
Scour Rating (113):	8 Stable Above Footing
Waterway Adequacy (71):	8 Equal Desirable
Channel Rating (61):	7 Minor Damage

Team Leader		Reviewed By	
Signature and Date	DEMETRIO TRUJILLO 02/11/2016	***Signature and Date***	

Bridge Inspection Report

000000000006729

Facility Carried(7): I-40 EBL/WBL
Mile Post(11): 19.42 mi (31.25 km)
Team Leader: DEMETRIO TRUJILLO
Inspection Date: 02/11/2016

INSPECTION

Date of Inspection (90): 2/11/2016
Frequency (91): 48
Next Inspection: 2/11/2020
Crew Hours: 0.00
Snooper Hours: 0.00

Inspection Type	Freq (92)	Last Insp (93)	Next Insp
Element	48	2/20/2012	2/11/2020
Fracture Critical (A)		1/1/1901	1/1/1901
Underwater (B)		1/1/1901	1/1/1901
Special Insp (C)		1/1/1901	1/1/1901

LOAD RATING AND POSTING

Posting Status (41): A Open, no restriction
Posting % (70): 5 At/Above Legal Loads
Design Load (31): 5 MS 18 (HS 20)

Opr Method (63): 1 LF Load Factor
Opr Rating (64): HS30.7
Inv Method (65): 1 LF Load Factor
Inv Rating (66): HS19.8

Posting Loads Operating
NM-2 Axle:
NM-3A Axle:
NM-5A Axle:

ROADWAY

LOCATION

Kind of Hwy (5B): 1 Interstate Hwy
Lanes Under (28B): 0.00
Milepost (11): 19.42 mi (31.25 km)
Route Posted Speed: 65
Lanes On (28A): 4
Direction of Traffic (102): 2 2-way traffic
Detour Length (19): 1.24 mi (2.00 km)

CLEARANCES

Horizontal (47): 40.03
Horiz Ref (55A): N Feature not hwy or RR
Min Lat Left (56): 0.00
Underclearance (69): N Not applicable (NBI)
Min Lat Right (55B): 0.00
Minimum Lateral Underclearance R (55): 0.00
Minimum Lateral Underclearance L (56): 0.00
Minimum Vertical Clearance Minus: 0
Minimum Vertical Clearance Plus: 0

CLASSIFICATION

Funct Class (26): 01 Rural Interstate
NHS (104): 1 On the NHS
Defense Hwy (100): 1 On Interstate STRAHNET
ADT (29): 21,496 Cars/Day
Pct Trucks (109): 0.00%
ADT Year (30): 2018
Future ADT (114): 31,942.00
Year Of Future ADT (115): 2038

CRITICAL FINDINGS SUMMARY

Critical Findings: No
Date Found:
Date Updated:

New Mexico DEPARTMENT OF TRANSPORTATION

Bridge Inspection Report

000000000006729
Facility Carried(7): I-40 EBL/WBL
Mile Post(11): 19.42 mi (31.25 km)
Team Leader: DEMETRIO TRUJILLO
Inspection Date: 02/11/2016

NMDOT MISC. DATA

Old Bridge Number:		Known Utilities:	
Stay In Place Forms:		Stay In Place Form Type:	
Overlay Thickness:		Culvert Fill Depth:	2.00

SIP Notes:

Approach Roadway Condition:

Approach pavement is OGFC in good condition. Shoulders are in good condition with longitudinal cracks. Embankment is backfilled with millings in good condition. No bridge signing.

Channel & Channel Protection:

Bridge is on a small intermittent stream with grassy, brush, flat, indistinct banks & channel. Good alignment. No scour, 2 ft - 3 ft of silt, minor debris. No channel protection needed. Tree at barrels 5-6 at inlet and barrels 4-6 at outlet.

Recommendations:

Date 2016-02-11- Present: D.Trujillo, P.Salazar; Clear, Light Breeze, 43 deg. RECOMMENDATIONS: Short Term: Patrol: Remove vegetation and silt from structure. Repair damaged guardrail on WBL. Long Term: Bridge Crew, Put epoxy injection on parapets. Repair spalls on wingwalls.

Directions:

Bridge Inspection Report

000000000006729

Facility Carried(7): I-40 EBL/WBL
Mile Post(11): 19.42 mi (31.25 km)
Team Leader: DEMETRIO TRUJILLO
Inspection Date: 02/11/2016

New Mexico DEPARTMENT OF TRANSPORTATION

ELEMENT CONDITION SUMMARY

Elm/Env	Description	Total Qty	% in 1	Qty. St. 1	% in 2	Qty. St. 2	% in 3	Qty. St. 3	% in 4	Qty. St. 4
241/2	Re Conc Culvert	1,499.34	71%	1,059.71	29%	439.63	0%	0.00	0%	0.00
7369/2	Wingwalls	13.12	0%	0.00	100%	13.12	0%	0.00	0%	0.00
7371/2	Guardrail	1,000.66	95%	950.66	5%	50.00	0%	0.00	0%	0.00
7374/2	Parapets	164.04	40%	65.62	48%	78.74	12%	19.69	0%	0.00

ELEMENT NOTES

ELEM/ENV	ELEMENT NAME	QUANTITY	UNITS	QTY ST 1	QTY ST 2	QTY ST 3	QTY ST 4
241/2	*Re Conc Culvert*	*1,499.34*	*ft*	*1,059.71*	*439.63*	*0.00*	*0.00*

Top slab: Minor to medium transverse cracks & short longitudinal cracks both with rusty leach. A few small spalls & areas of light scale. Water seeps thru slab and at corners. 2 ft - 3 ft of silt. Walls: Preformed joint filler is sagging & leaking. Hairline to minor vertical, horizontal, & random cracks, some with leaching. Minor diagonal cracks near outlet. Scattered honeycomb, patch with delam. SW end of barrel #1 random cracks with rusty leaching.

ELEM/ENV	ELEMENT NAME	QUANTITY	UNITS	QTY ST 1	QTY ST 2	QTY ST 3	QTY ST 4
7369/2	*Wingwalls*	*13.12*	*(LF)*	*0.00*	*13.12*	*0.00*	*0.00*

Small impact spalls. Minor separation cracks, minor horizontal, vertical & diagonal cracks. Cracks parallel to top with delam. Spall @ NW corner with exposed rebar. Delamination on SW corner.

ELEM/ENV	ELEMENT NAME	QUANTITY	UNITS	QTY ST 1	QTY ST 2	QTY ST 3	QTY ST 4
7371/2	*Guardrail*	*1,000.66*	*(LF)*	*950.66*	*50.00*	*0.00*	*0.00*

Thrie beam & W beam on square wood posts, Type C anchors & continuous with Type A turn downs. 50 ft guardrail damaged and 6 posts broke WBL departure.

ELEM/ENV	ELEMENT NAME	QUANTITY	UNITS	QTY ST 1	QTY ST 2	QTY ST 3	QTY ST 4
7374/2	*Parapets*	*164.04*	*(LF)*	*65.62*	*78.74*	*19.69*	*0.00*

Hairline to minor vertical, horizontal & random cracks some delam. Minor scale, traces of rusty leach, some rusty chairs, small gouges & scrapes. Horizontal cracks more prominent on south side.

INSPECTION NOTES

The NMDOT is responsible for developing a four-year Statewide Transportation Improvement Program (STIP) that is cooperatively and/or consultatively planned, comprehensive in scope through the innovative use of Federal and State resources, fiscally constrained and attempts to address the multimodal transportation needs of New Mexico's transportation customers (NMDOT, 2018). The State's four-year transportation preservation and capital improvement program identifies multi-modal transportation projects that use Federal, State Bond, State priority, State Capital Outlay and local government transportation funds. It includes projects of regional significance (projects with high public interest or air quality impacts) and projects in the National Parks, National Forests and Indian Reservations (NMDOT STIP webpage).

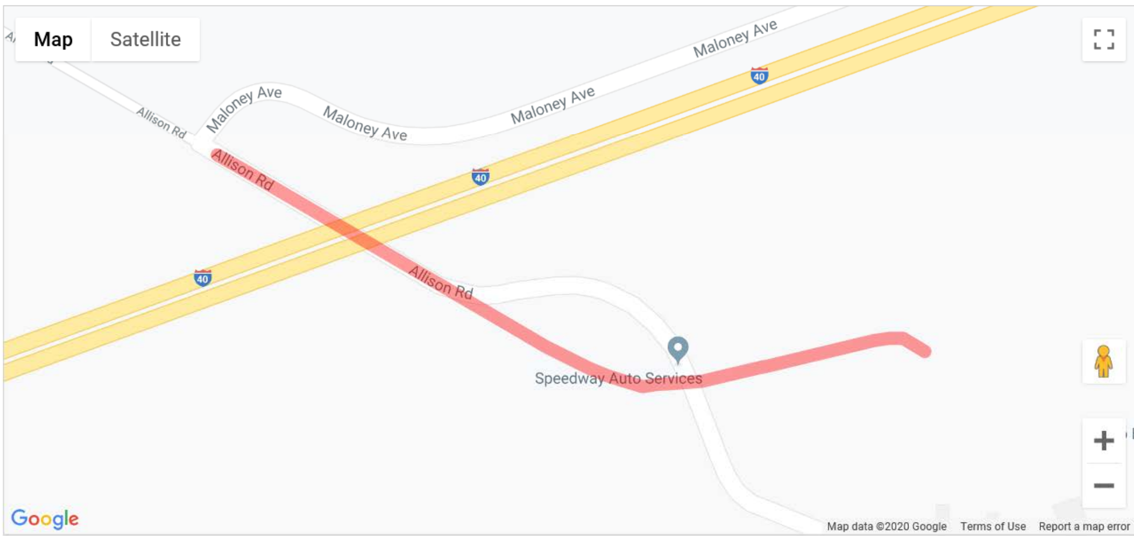
In total, there were six projects of concern included in the project outlook provided by the NMDOT STIP (Table 10). Of the six potential projects listed, only one is considered, at this time, to impact on the drainage plan developed for the community of Allison. WSP contacted Mr. Kazim of District 6 on January 10th, 2020, via email, to discuss the NMDOT's projected project outlook and pinpoint any work that may conflict with, or conceivably enhance, the drainage recommendations provided in this report. Specifically, WSP is aware of the Allison Corridor I-40 Overpass, Maloney and Acoma Connection (Control Number 6100210) NMDOT project to extend Allison Road over I-40. This project is adjacent to the CBC waterway at the southern end of the AML project site and may offer an opportunity address issues that would otherwise be too costly. As per STIP, it appears that the project will not be constructed within the town. Beginning of Project (BOP) start at just west of intersection of Maloney Acoma and Allison Road and WSP doesn't expect construction through the town.

Table 9- NMDOT STIP Data

NMDOT STIP: McKinely County						
Control #	REGION	COUNTY	LEAD AGENCY	PROJECT TITLE	PROJECT TYPE	PRODUCTION YEAR
6100970	D6	McKinley	NM DOT	Carbon Coal Intersection-INFORMATIONAL	Road - Major Preservation (6)	2022
6101060	D6	McKinley	NM DOT	I-40 WEST OF GALLUP.-INFORMATIONAL	Road - Major Rehabilitation (6)	
9900741	D6	McKinley	NM DOT	I-40	PE Oncall (18)	
6100210	D6	McKinley	NM DOT	ALLISON CORRIDOR - I-40 OVERPASS, MALONEY AND ACOMA CONNECTION, GALLUP-INFORMATIONAL **	Road - New Construction (1)	2025
6100111	D6	McKinley	NM DOT	ALLISON CORRIDOR IN GALLUP, NM.-INFORMATIONAL	ROW Acquisition (16)	
6100610	D6	McKinley	NM DOT	BNSF/NM 118 OVERPASS GALLUP, NM. ALLISON CORRIDOR-INFORMATIONAL	Road - New Construction (1)	

Control #	6100210	*Region/TIP*	D6 20-00	*Local ID*		*Total Cost*	$5,937,072
Lead Agency	NM Dot	*Contact*	Andrew Gallegos	*District*	6	*County*	Mckinley
Project Type	Road - New Construction (1)	*Air Quality*		*TCM*		*Construction*	2025 Start
Title	ALLISON CORRIDOR - I-40 OVERPASS, MALONEY AND ACOMA CONNECTION, GALLUP-INFORMATIONAL						
Limits	ALLISON ROAD from Milepost .7 to Milepost 2 (1.3 mile)						
Description	NEW CONSTRUCTION.						
Production Date		*Letting Date*					

Phase	Fund Source	Prior FFY	FFY2020	FFY2021	FFY2022	FFY2023	Future FFY	Total
CON	NAT HWY PERF PROG	-	-	-	-	-	$3,234,638	$3,234,638
CON	ROAD FUND	-	-	-	-	-	$877,042	$877,042
CON	STP FLEX	-	-	-	-	-	$713,530	$713,530
CON	STP OFF-SYS BRIDGES_NC	-	-	-	-	-	$185,359	$185,359
CON	STP URBAN - 5K TO 200K	-	-	-	-	-	$926,503	$926,503
	Total Construction	-	-	-	-	-	$5,937,072	$5,937,072
	Total Programmed	-	-	-	-	-	**$5,937,072**	**$5,937,072**
	Total Programmed (incl. ACCP)	-	-	-	-	-	**$5,937,072**	**$5,937,072**



Location of Allison Road Overpass

APPENDIX E

COST ESTIMATES

PROPERTY BOUNDARY

Allison Drainage Improvements
Conceptual Estimate of Construction Costs
Northwest Fill Pad Area - Alternative 1
Open Channel with Guide Bank

SUMMARY OF QUANTITIES

				ROADWAY		DRAINAGE		CONSTRUCTION ENGINEERING		CONSTRUCTION SIGNING		PERMANENT SIGNING		PROJECT TOTAL	
ITEM #	DESCRIPTION	UNIT	UNIT PRICE	ESTIMATE	AMOUNT	ESTIMATE	AMOUNT	ESTIMATE	AMOUNT	ESTIMATE	AMOUNT	ESTIMATE	AMOUNT	ESTIMATE	AMOUNT
201000	CLEARING AND GRUBBING	LS	$ -				$ 5,000.00							LS	$ 5,000.00
203000	UNCLASSIFIED EXCAVATION	C.Y.	$ 18.00		$ -	1660	$ 29,880.00		$ -		$ -		$ -	1660	$ 29,880.00
203100	BORROW*	C.Y.	$ 20.00			435	$ 8,700.00								$ 8,700.00
206100	SELECT BACKFILL MATERIAL**	C.Y.	$ 135.00		$ -	220	$ 29,700.00		$ -		$ -		$ -	220	$ 29,700.00
602010	RIPRAP CLASS B***	C.Y.	$ 175.00		$ -	435	$ 76,125.00		$ -		$ -		$ -	435	$ 76,125.00
603051	CLEAN WATER ACT COMPLIANCE WORK PLAN	LS	$ -			LS	$ 7,500.00							LS	$ 7,500.00
603221	CHECK DAM TYPE II	L.F.	$ 42.00		$ -	64	$ 2,688.00		$ -		$ -		$ -	64	$ 2,688.00
609706	CONCRETE LAYDOWN CURB 6"	LF	$ 32.00		$ -	60	$ 1,920.00		$ -		$ -		$ -	60	$ 1,920.00
621000	MOBILIZATION	LS	$ -			LS	$ 18,000.00							LS	$ 18,000.00
801000	CONSTRUCTION STAKING BY THE CONTRACTOR	LS	$ -			LS	$ 5,000.00	LS						LS	$ 5,000.00
802000	POST CONSTRUCTION PLANS	LS	$ -			LS	$ 5,000.00	LS						LS	$ 5,000.00
	** Sand Fill ** Clay Liner*				$ -		$ 189,513.00		$ -		$ -		$ -		$ 189,513.00
	*** Alternative of Riprap might be compacted earthen line channel to reduce th cost of lining				0%		100%		0%		0%		0%		100%
	RIGHT-OF-WAY ACQUISITION	S.F.	$ 3.00		$ -		$ -		$ -		$ -		$ -	0	$ -
	UTILITY RELOCATION (OVERHEAD ELEC. & TEL. ONLY)	L.F.	$ 15.00		$ -		$ -		$ -		$ -		$ -	0	$ -
	DESIGN SERVICES (8% FEE)	L.S.	$ 1.00	0	$ -		$ -		$ -		$ -		$ -	0	$ -
	CONSTRUCTION MANAGEMENT & INSPECTION (12% FEE)	L.S.	$ 1.00	0	$ -	22740	$ 22,740.00		$ -		$ -		$ -	22740	$ 22,740.00

Sub-Total	$ 212,253.00
Contingency	30.000%
NMGRT	8.4375%
Estimated Total	**$ 293,837.75**

1

Sub-Total	$ 212,253.00
Contingency	30.000%
NMGRT	8.4375%
Estimated Total	**$ 293,837.75**

DRAINAGE ESTIMATED COST RANGE**		
LOWER	EXPECTED ACCURACY	HIGHER
$249,762	15% TO 30%	$381,989

TOTAL ESTIMATED COST RANGE**		
LOWER	EXPECTED ACCURACY	HIGHER
$249,762	15% TO 30%	$381,989

Allison Drainage Improvements
Conceptual Estimate of Construction Costs
Northwest Fill Pad Area - Alternative 2
Storm Drain Pipe with Guide Bank

SUMMARY OF QUANTITIES

				ROADWAY		DRAINAGE		CONSTRUCTION ENGINEERING		CONSTRUCTION SIGNING		PERMANENT SIGNING		PROJECT TOTAL	
ITEM #	DESCRIPTION	UNIT	UNIT PRICE	ESTIMATE	AMOUNT	ESTIMATE	AMOUNT	ESTIMATE	AMOUNT	ESTIMATE	AMOUNT	ESTIMATE	AMOUNT	ESTIMATE	AMOUNT
201000	CLEARING AND GRUBBING	LS	$ 10,000.00			LS	$ 5,000.00							LS	$ 5,000.00
203000	UNCLASSIFIED EXCAVATION	C.Y.	$ 18.00		$ -	880	$ 15,840.00		$ -		$ -		$ -	880	$ 15,840.00
210003	MAJOR STRUCTURE BACKFILL	C.Y.	$ 65.00		$ -	420	$ 27,300.00		$ -		$ -		$ -	420	$ 27,300.00
570048	48" STORM DRAIN CULVERT PIPE	L.F.	$ 175.00		$ -	990	$ 173,250.00		$ -		$ -		$ -	990	$ 173,250.00
570049	48" STORM DRAIN CULVERT PIPE END SECTION	EACH	$ 1,500.00		$ -	1	$ 1,500.00		$ -		$ -		$ -	1	$ 1,500.00
623404	DR. IN. 4'X4' (TY.1) H=4'-1"TO 6'-0	EACH	$ 9,000.00		$ -	1	$ 9,000.00		$ -		$ -		$ -	1	$ 9,000.00
662072	MANHOLE TY E-6' DIA. OVER 6' TO 10' DEPTH	EACH	$ 17,000.00		$ -	3	$ 51,000.00		$ -		$ -		$ -	3	$ 51,000.00
603051	CLEAN WATER ACT COMPLIANCE WORK PLAN	LS	$ -			LS	$ 7,500.00							LS	$ 7,500.00
609706	CONCRETE LAYDOWN CURB 6"	LF	$ 32.00			20	$ 7,500.00								$ 7,500.00
621000	MOBILIZATION	LS	$ -	LS			$ 25,000.00							LS	$ 25,000.00
801000	CONSTRUCTION STAKING BY THE CONTRACTOR	LS					$ 2,500.00	LS						LS	$ 2,500.00
802000	POST CONSTRUCTION PLANS	LS						LS						LS	$ -
					$ -		$ 325,390.00		$ -		$ -		$ -		$ 325,390.00
					0%		100%		0%		0%		0%		100%
	RIGHT-OF-WAY ACQUISITION	S.F.	$ 3.00		$ -		$ -		$ -		$ -		$ -	0	$ -
	UTILITY RELOCATION (OVERHEAD ELEC. & TEL. ONLY)	L.F.	$ 15.00		$ -		$ -		$ -		$ -		$ -	0	$ -
	DESIGN SERVICES (8% FEE)	L.S.	$ 1.00	0	$ -		$ -		$ -		$ -		$ -	0	$ -
	CONSTRUCTION MANAGEMENT & INSPECTION (12% FEE)	L.S.	$ 1.00	0	$ -	39050	$ 39,050.00		$ -		$ -		$ -	39050	$ 39,050.00

Sub-Total	$ 364,440.00
Contingency	30.000%
NMGRT	8.4375%
Estimated Total	**$ 504,521.63**

1

Sub-Total	$ 364,440.00
Contingency	30.000%
NMGRT	8.4375%
Estimated Total	**$ 504,521.63**

DRAINAGE ESTIMATED COST RANGE**		
LOWER	EXPECTED ACCURACY	HIGHER
$428,843	15% TO 30%	$655,878

TOTAL ESTIMATED COST RANGE**		
LOWER	EXPECTED ACCURACY	HIGHER
$428,843	15% TO 30%	$655,878

Allison Drainage Improvements
Conceptual Estimate of Construction Costs
Main Drainage Channel - Alternative 1
Concrete Box Culvert

SUMMARY OF QUANTITIES

ITEM #	DESCRIPTION	UNIT	UNIT PRICE	ROADWAY ESTIMATE	ROADWAY AMOUNT	DRAINAGE ESTIMATE	DRAINAGE AMOUNT	CONSTRUCTION ENGINEERING ESTIMATE	CONSTRUCTION ENGINEERING AMOUNT	CONSTRUCTION SIGNING ESTIMATE	CONSTRUCTION SIGNING AMOUNT	PERMANENT SIGNING ESTIMATE	PERMANENT SIGNING AMOUNT	PROJECT TOTAL ESTIMATE	PROJECT TOTAL AMOUNT
201000	CLEARING AND GRUBBING	LS	$ -			LS	$ 5,000.00							LS	$ 5,000.00
203000	UNCLASSIFIED EXCAVATION	C.Y.	$ 18.00		$ -	7500	$ 135,000.00		$ -		$ -		$ -	7500	$ 135,000.00
203100	BORROW*	C.Y.	$ 20.00		$ -	1310	$ 26,200.00		$ -		$ -		$ -	1310	$ 26,200.00
206100	SELECT BACKFILL MATERIAL**		$ 135.00		$ -	660	$ 89,100.00								$ 89,100.00
511030	STRUCTURAL CONCRETE, CLASS AA	C.Y.	$ 800.00		$ -	70	$ 56,000.00		$ -		$ -		$ -	70	$ 56,000.00
540060	REINFORCING BARS GRADE 60	LB	$ 1.50		$ -	18000	$ 27,000.00		$ -		$ -		$ -	18000	$ 27,000.00
602010	RIPRAP CLASS B	C.Y.	$ 175.00		$ -	3500	$ 612,500.00		$ -		$ -		$ -	3500	$ 612,500.00
603051	CLEAN WATER ACT COMPLIANCE WORK PLAN	LS			$ -	LS	$ 7,500.00							LS	$ 7,500.00
621000	MOBILIZATION	LS	$ -			LS	$ 50,000.00							LS	$ 50,000.00
801000	CONSTRUCTION STAKING BY THE CONTRACTOR	LS				LS	$ 3,000.00	LS						LS	$ 3,000.00
802000	POST CONSTRUCTION PLANS	LS				LS	$ 3,000.00	LS						LS	$ 3,000.00
	*Sand Fill ** Clay Liner*				$ -		$ 1,014,300.00		$ -		$ -		$ -		$ 1,014,300.00
					0%		100%		0%		0%		0%		100%
	RIGHT-OF-WAY ACQUISITION	S.F.	$ 3.00		$ -		$ -		$ -		$ -		$ -	0	$ -
	UTILITY RELOCATION (OVERHEAD ELEC. & TEL. ONLY)	L.F.	$ 15.00		$ -		$ -		$ -		$ -		$ -	0	$ -
	DESIGN SERVICES (8% FEE)	L.S.	$ 1.00	0	$ -		$ -		$ -		$ -		$ -	0	$ -
	CONSTRUCTION MANAGEMENT & INSPECTION (12% FEE)	L.S.	$ 1.00	0	$ -	121720	$ 121,720.00		$ -		$ -		$ -	121720	$ 121,720.00

Sub-Total	$ 1,136,020.00
Contingency	30.000%
NMGRT	8.4375%
Estimated Total	**$ 1,572,677.69**

1

Sub-Total	$ 1,136,020.00
Contingency	30.000%
NMGRT	8.4375%
Estimated Total	**$ 1,572,677.69**

DRAINAGE ESTIMATED COST RANGE**		
LOWER	EXPECTED ACCURACY	HIGHER
$1,336,776	15% TO 30%	$2,044,481

TOTAL ESTIMATED COST RANGE**		
LOWER	EXPECTED ACCURACY	HIGHER
$1,336,776	15% TO 30%	$2,044,481

Allison Drainage Improvements
Conceptual Estimate of Construction Costs
Main Drainage Channel - Alternative 2
Aluminum Box Culvert

SUMMARY OF QUANTITIES

ITEM #	DESCRIPTION	UNIT	UNIT PRICE	ROADWAY ESTIMATE	ROADWAY AMOUNT	DRAINAGE ESTIMATE	DRAINAGE AMOUNT	CONSTRUCTION ENGINEERING ESTIMATE	CONSTRUCTION ENGINEERING AMOUNT	CONSTRUCTION SIGNING ESTIMATE	CONSTRUCTION SIGNING AMOUNT	PERMANENT SIGNING ESTIMATE	PERMANENT SIGNING AMOUNT	PROJECT TOTAL ESTIMATE	PROJECT TOTAL AMOUNT
201000	CLEARING AND GRUBBING	LS	$ -			LS	$ 5,000.00							LS	$ 5,000.00
203000	UNCLASSIFIED EXCAVATION	C.Y.	$ 18.00		$ -	7500	$ 135,000.00		$ -		$ -		$ -	7500	$ 135,000.00
203100	BORROW*	C.Y.	$ 20.00		$ -	1310	$ 26,200.00		$ -		$ -		$ -	1310	$ 26,200.00
206100	SELECT BACKFILL MATERIAL**		$ 135.00		$ -	660	$ 89,100.00								$ 89,100.00
571576	11'11"S X 3'7"R METAL BOX CULVERT	LF	$ 1,050.00		$ -	50	$ 52,500.00		$ -		$ -		$ -	50	$ 52,500.00
602010	RIPRAP CLASS B	C.Y.	$ 175.00		$ -	3500	$ 612,500.00		$ -		$ -		$ -	3500	$ 612,500.00
603051	CLEAN WATER ACT COMPLIANCE WORK PLAN	LS			$ -	LS	$ 7,500.00							LS	$ 7,500.00
621000	MOBILIZATION	LS	$ -			LS	$ 50,000.00							LS	$ 50,000.00
801000	CONSTRUCTION STAKING BY THE CONTRACTOR	LS				LS	$ 3,000.00	LS						LS	$ 3,000.00
802000	POST CONSTRUCTION PLANS	LS				LS	$ 3,000.00	LS						LS	$ 3,000.00
	*Sand Fill ** Clay Liner*				$ -		$ 983,800.00		$ -		$ -		$ -		$ 983,800.00
					0%		100%		0%		0%		0%		100%
	RIGHT-OF-WAY ACQUISITION	S.F.	$ 3.00		$ -		$ -		$ -		$ -		$ -	0	$ -
	UTILITY RELOCATION (OVERHEAD ELEC. & TEL. ONLY)	L.F.	$ 15.00		$ -		$ -		$ -		$ -		$ -	0	$ -
	DESIGN SERVICES (8% FEE)	L.S.	$ 1.00	0	$ -		$ -		$ -		$ -		$ -	0	$ -
	CONSTRUCTION MANAGEMENT & INSPECTION (12% FEE)	L.S.	$ 1.00	0	$ -	118060	$ 118,060.00		$ -		$ -		$ -	118060	$ 118,060.00

Sub-Total	$ 1,101,860.00
Contingency	30%
NMGRT	8.4375%
Estimated Total	**$ 1,525,387.44**

1

Sub-Total	$ 1,101,860.00
Contingency	30.000%
NMGRT	8.4375%
Estimated Total	**$ 1,525,387.44**

DRAINAGE ESTIMATED COST RANGE**		
LOWER	EXPECTED ACCURACY	HIGHER
$1,296,579	15% TO 30%	$1,983,004

TOTAL ESTIMATED COST RANGE**		
LOWER	EXPECTED ACCURACY	HIGHER
$1,296,579	15% TO 30%	$1,983,004

Allison Drainage Improvements
Conceptual Estimate of Construction Costs
Commercial and Residential Area
Roadway Drainage Improvement

SUMMARY OF QUANTITIES

				ROADWAY		DRAINAGE		CONSTRUCTION ENGINEERING		CONSTRUCTION SIGNING		PERMANENT SIGNING		PROJECT TOTAL	
ITEM #	DESCRIPTION	UNIT	UNIT PRICE	ESTIMATE	AMOUNT	ESTIMATE	AMOUNT	ESTIMATE	AMOUNT	ESTIMATE	AMOUNT	ESTIMATE	AMOUNT	ESTIMATE	AMOUNT
201000	CLEARING AND GRUBBING	LS	$ -			LS	$ 5,000.00							LS	$ 5,000.00
203000	UNCLASSIFIED EXCAVATION	C.Y.	$ 18.00		$ -	1500	$ 27,000.00		$ -		$ -		$ -	1500	$ 27,000.00
570024	24" CULVERT PIPE	L.F.	$ 110.00		$ -	204	$ 22,440.00								$ 22,440.00
570025	24" CULVERT PIPE END SECTION	EACH	$ 1,150.00		$ -	18	$ 20,700.00								$ 20,700.00
570030	30" CULVERT PIPE	L.F.	$ 120.00		$ -	1103	$ 132,360.00								$ 132,360.00
570031	30" CULVERT PIPE END SECTION	EACH	$ 1,170.00		$ -	44	$ 51,480.00								$ 51,480.00
603051	CLEAN WATER ACT COMPLIANCE WORK PLAN	LS			$ -	LS	$ 7,500.00							LS	$ 7,500.00
621000	MOBILIZATION	LS	$ -			LS	$ 35,000.00							LS	$ 35,000.00
801000	CONSTRUCTION STAKING BY THE CONTRACTOR	LS				LS	$ 3,000.00	LS						LS	$ 3,000.00
802000	POST CONSTRUCTION PLANS	LS				LS	$ 3,000.00	LS						LS	$ 3,000.00
	* Sand Fill				$ -		$ 307,480.00		$ -		$ -		$ -		$ 307,480.00
					0%		100%		0%		0%		0%		100%
	RIGHT-OF-WAY ACQUISITION	S.F.	$ 3.00		$ -		$ -		$ -		$ -		$ -	0	$ -
	UTILITY RELOCATION (OVERHEAD ELEC. & TEL. ONLY)	L.F.	$ 15.00		$ -		$ -		$ -		$ -		$ -	0	$ -
	DESIGN SERVICES (8% FEE)	L.S.	$ 1.00	0	$ -	24600	$ 24,600.00		$ -		$ -		$ -	24600	$ 24,600.00
	CONSTRUCTION MANAGEMENT & INSPECTION (12% FEE)	L.S.	$ 1.00	0	$ -	36900	$ 36,900.00		$ -		$ -		$ -	36900	$ 36,900.00

Sub-Total	$ 368,980.00
Contingency	30.000%
NMGRT	8.4375%
Estimated Total	**$ 510,806.69**

1

Sub-Total	$ 368,980.00
Contingency	30.000%
NMGRT	8.4375%
Estimated Total	**$ 510,806.69**

DRAINAGE ESTIMATED COST RANGE**		
LOWER	EXPECTED ACCURACY	HIGHER
$434,186	15% TO 30%	$664,049

TOTAL ESTIMATED COST RANGE**		
LOWER	EXPECTED ACCURACY	HIGHER
$434,186	15% TO 30%	$664,049

PROPERTY BOUNDARY MAP

Effected Property	
Name of Property Owner	Parcel Number
Brandon Roy	R301463
David Steadman	R301464
Nany Olguin	R057991
Gallup Land Partners, LLC	R300831

APPENDIX F

SITE VISIT PHOTOS

Existing Channel at the Phase III Emergency Project

Culvert at Acoma Street (Looking Upstream)

Channel Below Acoma Street (Looking Downstream)

Ground Holes North of Acoma Street

Drainage Channel Upstream Culvert

Upstream Channel with Rubble Armoring

Graded Channel D/S of Acoma Street

Bottom of CBC at I-40