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Rio Grande Water Surface Elevation Changes in the Los Lunas Reach

Middle Rio Grande Project, New Mexico
Interior Region 7: Upper Colorado Basin

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Water Surface Elevation Changes in the Los Lunas Area

Middle Rio Grande Project, New Mexico
Interior Region 7: Upper Colorado Basin

prepared by

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Cover Photo: NM-6 Bridge in Los Lunas. (Reclamation/Robert Padilla)

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Executive Summary

Over the last century, the Middle Rio Grande (MRG) has seen major changes to its hydrologic flow and sediment regimes, with significant changes to discharge magnitudes, as well as to sediment volumes and concentrations. For most of the MRG, there has been reduction in the peaks of both the snowmelt and rainfall-runoff flow events, and a reduction in the volume and concentration of sediment. These factors have resulted in substantial changes in hydraulic and geomorphic characteristics of the MRG. Several previous studies have documented the changes in the MRG, including the reach from Isleta to San Acacia. However, these studies have often averaged the data for the entire 53-mile Isleta to San Acacia reach, rather than focusing on a localized area (Klein et al., 2018a, 2018b). In this report we highlight the hydraulic and geomorphic changes that have occurred in the 20-mile Los Lunas subreach, defined herein as from Isleta Diversion Dam to the NM-309 bridge in Belen.

In the reach between Isleta and the Belen Bridge, the channel has experienced significant narrowing (via vegetation encroachment), particularly since 1990. This narrowing reduced the active channel area for flood flows. Flood flows are the flows that exceed the 2-year return flow for this reach. In the subreach between Los Lunas and Belen, some bed incision accompanied the channel narrowing, giving the flood flows more area before overbanking onto the floodplain. However, in the subreach between Isleta and Los Lunas, the channel bed has slightly aggraded since approximately 2000, further reducing the main channel area for flood flows. This decrease in channel area resulted in higher water surface elevations during flood flows. This has been confirmed with anecdotal accounts and field measurements that show that the flow rate at which the floodplain inundates is declining over time. At the Los Lunas Highway 6 bridge, the water surface elevation at 5,570 cfs in 2005 was 0.5 feet lower than the water surface elevation observed at 3,700 cfs in 2019.

These changes in flood-stage water surface elevations are particularly significant for the Los Lunas subreach, which is considered a semi-perched reach. It is considered semi-perched because the main channel banks are higher than the adjacent floodplain and higher than the toes of the riverside levees. When high flows overtop the banks, the water becomes trapped in the floodplain, unable to drain back to the river. Thus, there is a potential for poor water conveyance in this reach and a potential for saturated levees, increasing their risk of failure. This report will highlight the hydraulic and geomorphological changes that have happened over time and the resulting increased water surface elevations and overbank flooding during flood flows.

Introduction and Purpose

The Los Lunas subreach, herein defined as from Isleta Diversion Dam to the Belen Bridge, has experienced extensive overbank flooding during high flow years like 2017 and 2019. Anecdotal accounts state that the flow rate at which the floodplain inundates is declining over time. Excessive floodplain inundation can result in water losses to infiltration and evapotranspiration, and saturate and weaken the riverside spoil levees. In this particular subreach, the negative aspects of river overbanking are amplified by the fact that this reach's floodplain is often lower than the river's banks, meaning that overbanked flows often have no return path to the river.

With so much at stake, it is important to understand the extent of the river's geomorphic and hydraulic changes, and the most likely factors which contributed to these changes. Previous studies (Klein et al., 2018a & b) have analyzed the Isleta to San Acacia reach for geomorphic and hydraulic changes, but these studies often averaged the data for the entire reach and did not zoom in on for narrowly focused analysis of the Los Lunas subreach.

The purpose of this report is to provide geomorphic and hydraulic data and trends within just the Los Lunas subreach to better understand the causes and extent of the recent increases in water surface elevations.

Analysis Methods

Reclamation has an ongoing hydrographic data collection program on the Middle Rio Grande to provide information for monitoring conditions associated with the Rio Grande. The data collected data is used to build hydraulic models which can be useful for estimating additional information about the river's behavior. The following sections discuss Reclamation's data collection program and the hydraulic models used in the current Los Lunas analysis.

Data Collection Program

Reclamation's data collection program includes cross section surveys, longitudinal profiles, water surface elevations, floodplain topography, channel bathymetry, sediment transport data, and bed material data. The particular data programs that have informed this present analysis are described below.

Reclamation's cross section survey program has existed since the 1970s and spans from Velarde down to Caballo Reservoir. Field cross sections are collected as frequently as annually or as infrequently as a one-time survey. In the reach from Isleta to San Acacia Diversion Dam there are 107 cross sections that are regularly surveyed approximately every three years. It is worth noting that the cross sections are usually surveyed at low flows. Since the river's sand bed changes somewhat during high flows, this difference in cross section geometry can add inaccuracies when predicting water surface elevations at high flows.

In the 1960s, a set of lines known as the Aggradation/Degradation (Agg/Deg) lines were set up on the Rio Grande spanning from the Cochiti Diversion Dam to the headwaters of the Elephant Butte Reservoir. These lines are set at 500-f-oot spacing. Photogrammetry has been employed to collect elevation data on these Agg/Deg lines roughly every decade. Data collection efforts have occurred in 1962, 1972, 1985, 1992, and 2002 with the use of stereo models using aerial photography (Varyu, 2013; Klein et al., 2018b), while in 2012 Light Detection and Ranging (LiDAR) sensors were used.

Water surface elevations are collected during particularly high flow years to help understand the impact of water levels relative to the levee and floodplain elevations. Water surface elevations in this reach that were used in the current analysis were collected during the high flow years of 2005, 2017, and 2019.

Hydraulic Models

A discussion on the hydraulic models used in this present analysis is provided below to help the reader get a sense of the accuracy of the current analysis. It is worth noting that in general, one-dimensional (1D) hydraulic models have difficulty accurately predicting conditions in perched and semi-perched reaches such as Los Lunas (see section on Channel Perching for further discussion of this condition). If a hydraulic model's limitations resulted in excessive uncertainty in the results (based on professional judgement), then the data was not carried further into subsequent analyses nor presented in the results.

In 2016, a 1D steady state model was built in HEC-RAS from Isleta to San Acacia Diversion Dam by the Reclamation's Technical Services Division (TSD), Albuquerque Area Office. In this model, cross sections surveyed in 2014 and 2015 were used; these cross sections are at an average spacing of about 0.5 miles. The floodplain elevation data for this model was derived from a LiDAR and 4-band aerial photography data collected in 2012. Calibration of this model to approximate the channel roughness was completed for two flow sets: less than 5,000 cfs and greater than 5,000 cfs. For less than 5,000 cfs, water surface elevations for cross sections collected during the 2014 and 2015 survey period were used. However, for flows greater than 5,000 cfs, 2005 high flow event water surface elevations were used. This model is a useful tool for approximating recent hydraulic conditions when field data is missing, but also has some weaknesses. One weakness is that the large spatial distribution of the cross sections data used in this model may inaccurately represent the entire reach. Also, using 2005's water surface elevation data for calibration of the model could result in a half foot or more error of the water surface elevation due to significant narrowing in the channel between 2005 and 2015.

Additional 1D HEC-RAS steady state models were developed by Reclamation Technical Service Center (TSC) in Denver, Colorado for each of the photogrammetry/LiDAR collection years (apart from 1985 due to data inaccuracies) using the station/elevation data extracted along the Agg/Deg lines. Since the extracted data from the photogrammetry/LiDAR does not capture the underwater channel prism, TSC has developed an iterative program to approximate the underwater prism along the Agg/Deg lines that reflects the mean bed elevation at the time of data collection that are used in the HEC-RAS models. Although these models are useful for comparing changes over time, as shown in Figure 1 and Figure 2, changes over time are not completely accurate due to precision of data over time. Also bank heights were assigned differently in different years.

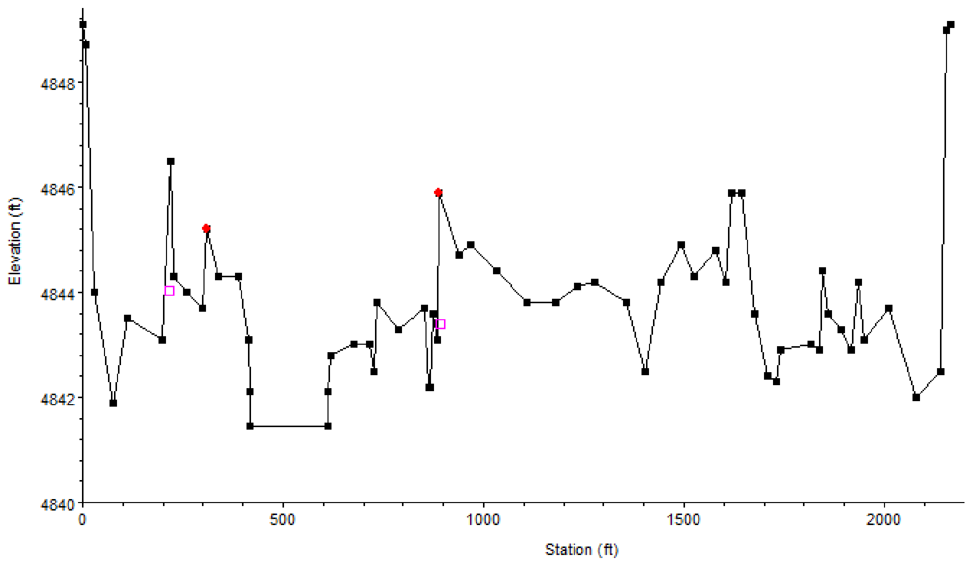

Figure 1: Agg/Deg cross section 756 for data collected in 2002

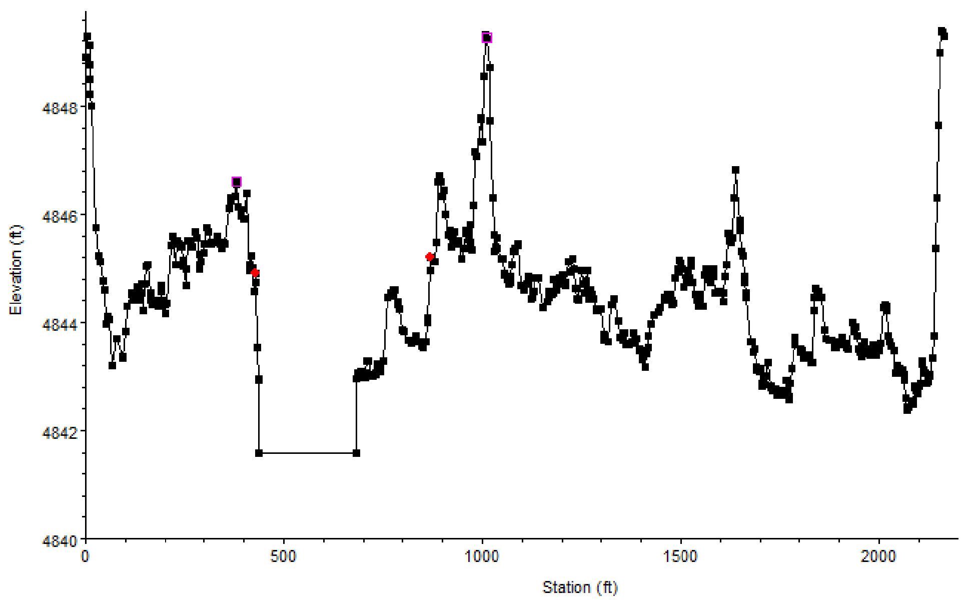

Figure 2: Agg/Deg cross section 756 for data collected in 2012

Regional Changes

The Middle Rio Grande has undergone significant changes over time in both climate change and in land and river management practices. The most significant change in river management practices was the construction of Cochiti Dam in the 1970s. The dam, along with a changing climate, greatly altered the hydrologic and sediment regimes of the MRG. Below we present the main regional changes that have been observed between Isleta and San Acacia Diversion Dams.

Hydrologic Changes

The Rio Grande river is usually driven by the spring snow-melt runoff which occurs during spring and early summer. However, there are also high, flashy peaks from rainfall-runoff during the fall mainly coming from the tributaries to the river (Klein et al., 2018a). Peaks of both the snow-melt and rainfall-runoff flow events have been curtailed in recent decades due to upstream reservoirs (MEI, 2002). Rainfall-runoff events primarily originating in unregulated watersheds like the Rio Puerco and Rio Salado are the exception and production of high peak discharges are still possible (Klein et al., 2018a).

Analysis of flows at USGS gaging stations 08330000 "Rio Grande at Albuquerque, NM" and 08332010 "Rio Grande Floodway near Bernardo, NM" for two time periods (1942–2001 and 2002–2014) shows that the average annual flow volume has been decreasing over time. Figure 3 shows that there is a 33% reduction in volume of flow between the two time periods at the Albuquerque gage and 45% reduction of flow between the two time periods at the Bernardo gage.

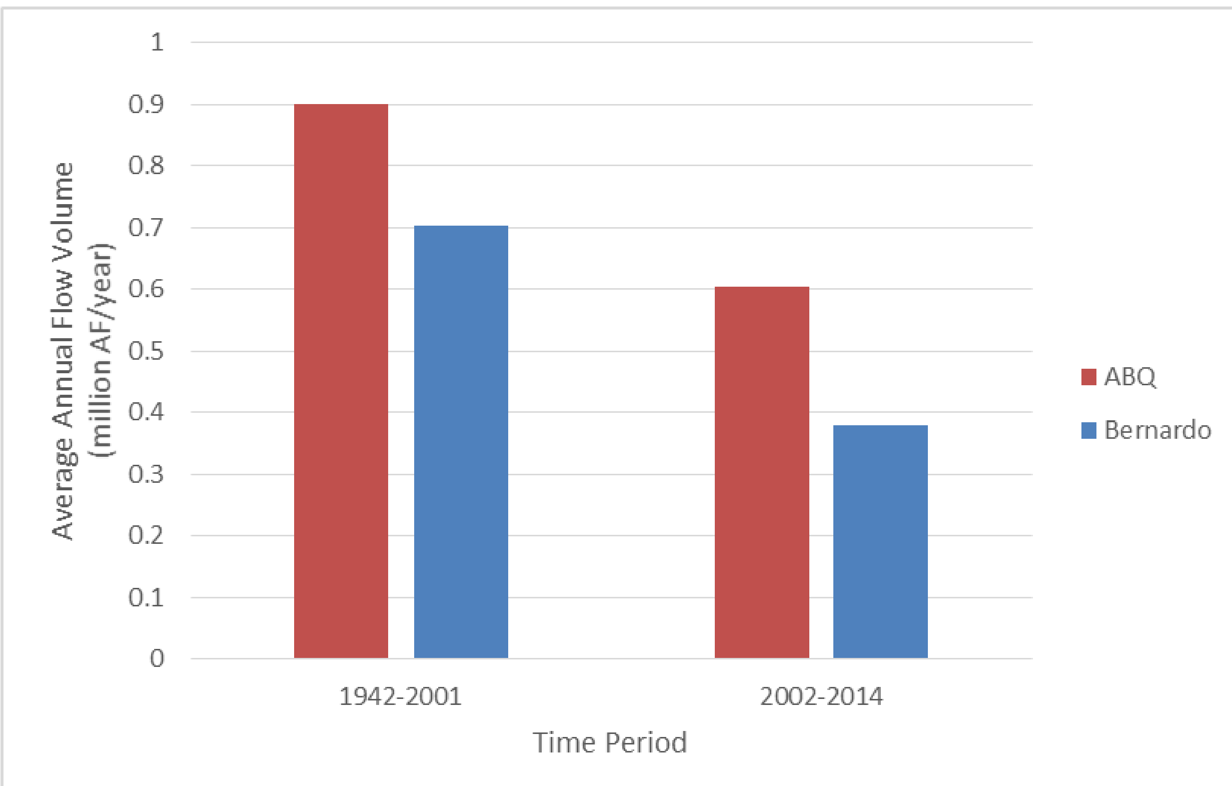

Figure 3: Average annual flow volumes at USGS gaging stations 08330000 and 08332010 for periods 1942-2001 and 2002-2014

The peak flows experienced in the reach are also decreasing over time. The 2-year flood at Bernardo for the time period between 1930 and 2008 is calculated to be 4,900 cfs (using Log-Pearson Type III analysis). Another similar analysis on the time period between 1993 and 2013 also at Bernardo gage shows the two-year flood to be 3,290 cfs. The 2-year flood is the peak flow for which there is a 50% probability of being equaled or exceeded in any given year. Decreases in peak flows can significantly alter the channel geometry. More information on the reach hydrology was presented by Klein et al. (2018a).

Sediment Changes

Using the USGS sediment data for Rio Grande at Albuquerque (USGS 08330000), Bernardo (USGS 08332000 and 08332010), and San Acacia (USGS 08354900), an analysis of volume of suspended sediment transported between 1970–1999 and 2000–2014 was done. Results indicate that there has been a decline over time in the average annual volume of suspended sediment at these gaging stations. At Albuquerque USGS gage there is a 37% decrease, at Bernardo USGS gage a 67% decrease, and at San Acacia USGS gage a 23% decrease between these two time periods.

It is worth noting that the sediment volume decreases between the Albuquerque gage and the Bernardo gage – the sediment is likely depositing within this reach. Also, the sediment volume increases significantly between the Bernardo gage and the San Acacia gage. This is likely due to addition of sediment from the Rio Puerco and Rio Salado. However, there is evidence of decrease in annual average values, consistent with the declining sediment volume from the Rio Puerco (Klein et al., 2018b). Figure 4 shows these results.

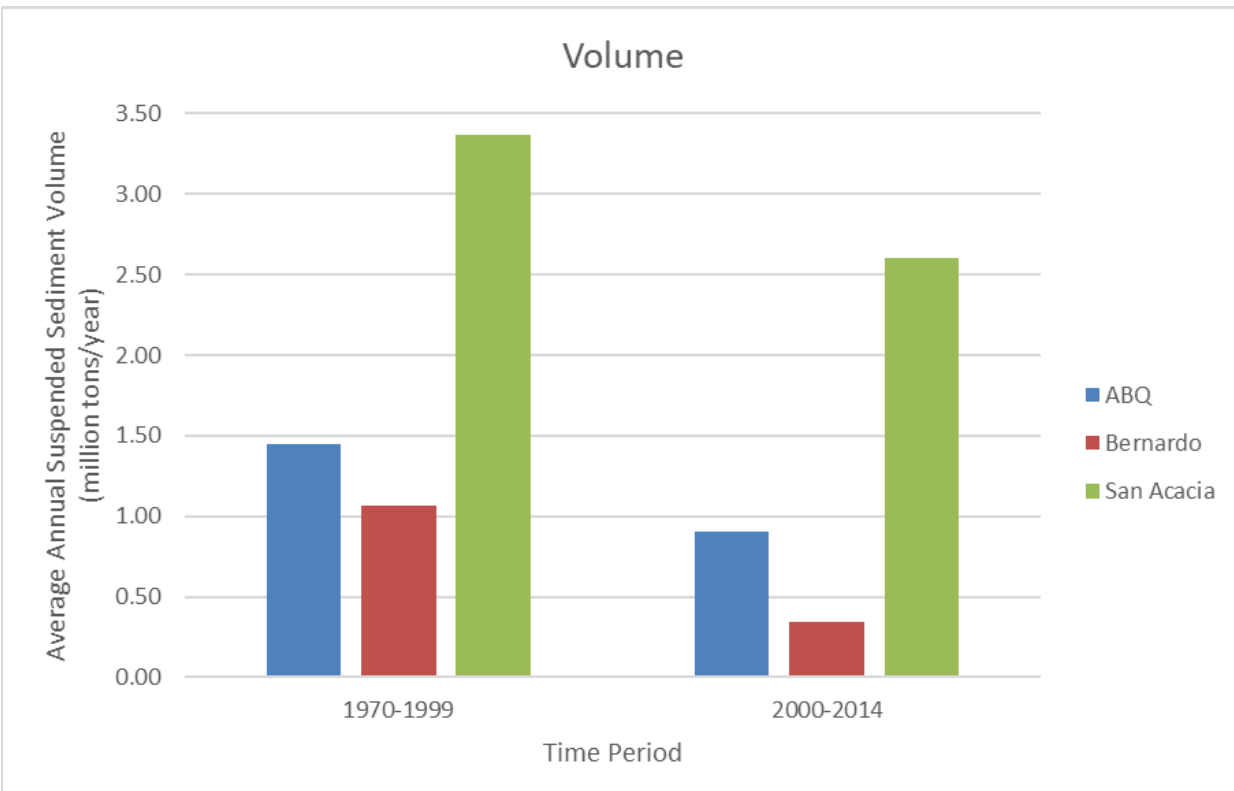

Figure 4: Average Annual Suspended Sediment Volume (million tons/year) for Albuquerque, Bernardo and San Acacia USGS gaging stations for periods 1970–1999 and 2000–2014

Further analysis of the annual suspended sediment volume and annual discharge for the same time periods reveals that the mean annul suspended sediment concentration has also decreased on the Rio Grande and Rio Puerco. At Albuquerque USGS gage there is a 11% decrease, at Bernardo USGS gage a 22% decrease, and at San Acacia USGS gage a 3% decrease in concentration between these two time periods. However, the decrease in concentration of suspended sediment is less than the decrease in volume of suspended sediment as shown in Figure 5.

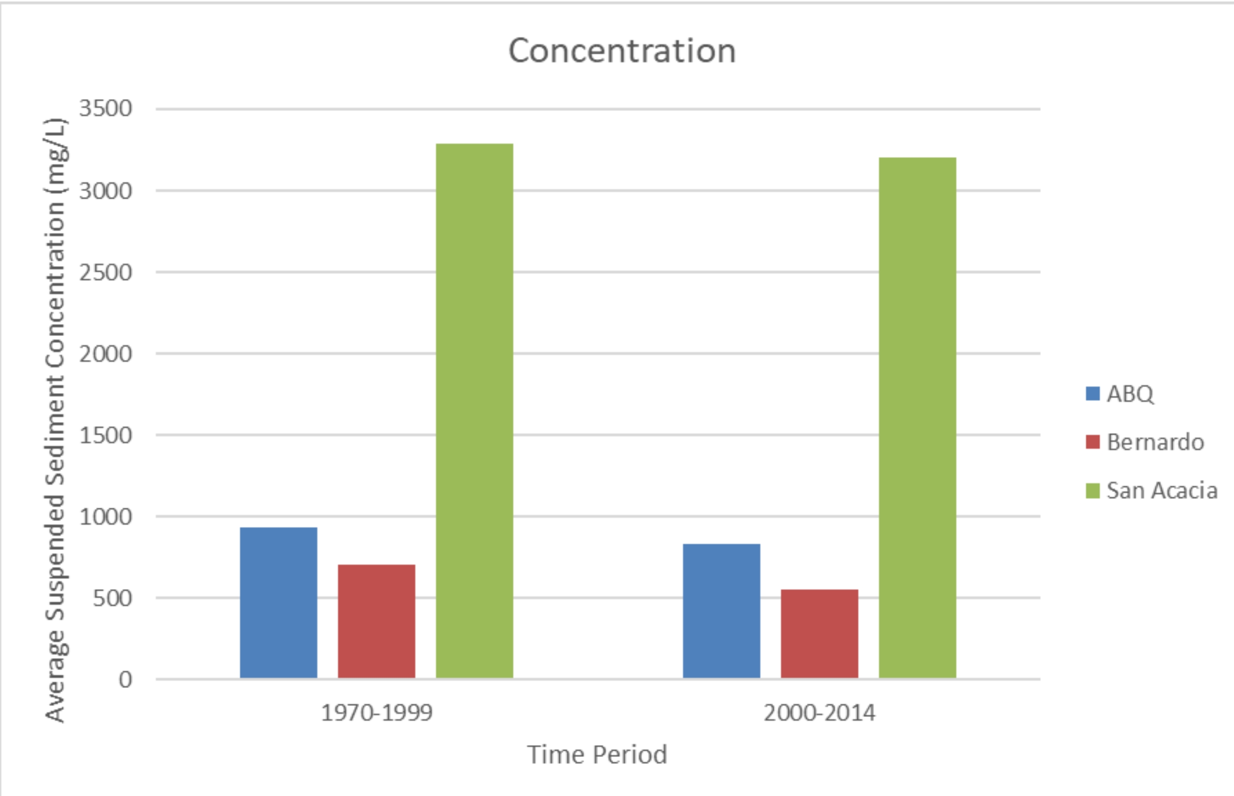

Figure 5: Average Suspended Sediment concentration (mg/l) for Albuquerque, Bernardo and San Acacia USGS gaging stations for periods 1970–1999 and 2000–2014

River Management Changes

In addition to Cochiti Dam's construction in the 1970s and its impact on sediment and water continuity, other more localized river management changes likely had an impact on the current trends and conditions in the MRG.

Previous to the 1990s, the Bureau of Reclamation annually mowed the river channel including the Los Lunas area to maintain a 550-foot channel width. In the mid-1990s this practice was discontinued due to endangered species concerns and economics.

Also, historically the Middle Rio Grande (MRG) frequently dried up during summer. In the late 1990s as a result of the Rio Grande silvery minnow (RGSM) being listed as an endangered species, supplemental flows were provided to the channel in the summer to prevent drying and to provide habitat for the RGSM. Along with sustaining localized RGSM populations in the reach, these supplemental flows are also irrigating the emergent bosque vegetation that would most likely desiccate during the historically dry summer conditions.

Los Lunas Geomorphic and Hydraulic Changes

The previously discussed regional hydrologic and sediment changes, as well as other river management changes, have had an impact on the character of the river over time. The following sections demonstrate how these changes affected the Los Lunas reach in planform, average channel width, average bed elevation, hydraulic depths and velocities, and water surface elevation.

Planform

Since the late 1940s, Rio Grande between Isleta and San Acacia has seen a transition to a narrower, slightly sinuous channel from a wide, braided channel (Klein at al., 2018a). The wide braided river was channelized in the 1960s, but the channel continued to have multiple, active, and open sand-bed channels, bars, and islands in 2002 as shown in Figure 6. The figure also shows that the sand-bedded features had partially vegetated by 2012 and had fully vegetated by 2017. According to the Massong model (Massong et al., 2010), M5 and M6 stages represent deeper and narrower river sections with channel bars that had once been active but due to lower flows developed vegetation and then became attached to the bank. Massong's planform model predicts that the reach between Isleta and Highway 309 will move towards more lateral migration, unless the river is transport-limited, in which case the reach will move towards sediment plugs and avulsion (Klein et al., 2018a).

Figure 6: Planform channel changes for Los Lunas NM-6 bridge area for 1935, 1962, 2012, and 2017

Channel Width

The average and range of active (non-vegetated) channel width has decreased since 1960s. Figure 7 shows results of width analysis for the reach between Isleta and Rio Puerco at the Agg/Deg lines for the years 1962, 1972, 1985, 1992, 2002, and 2012. For 2016, aerial imagery data was used. The maximum and minimum widths are also shown. The minimum width has remained nearly the same.

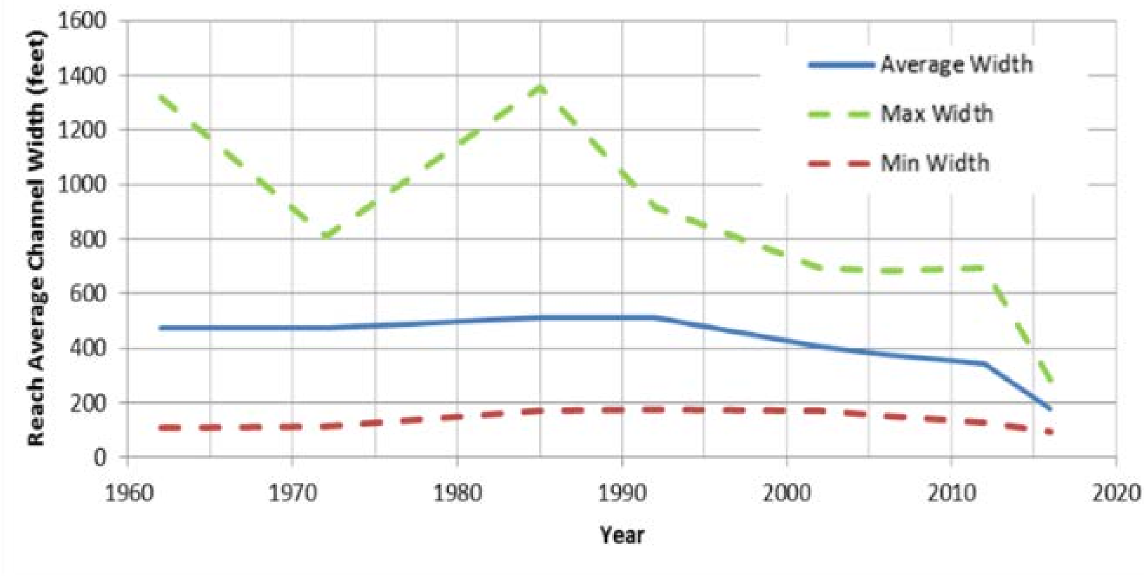

Figure 7: Reach Average Channel Width from Isleta to the confluence with the Rio Puerco

Figure 8 shows a closer look at the channel width changes by sub-reach between Isleta and NM-309 for different periods. There is more channel narrowing between NM-6 and NM-309 than there is between Isleta and NM-6 and especially between 1992–2002.

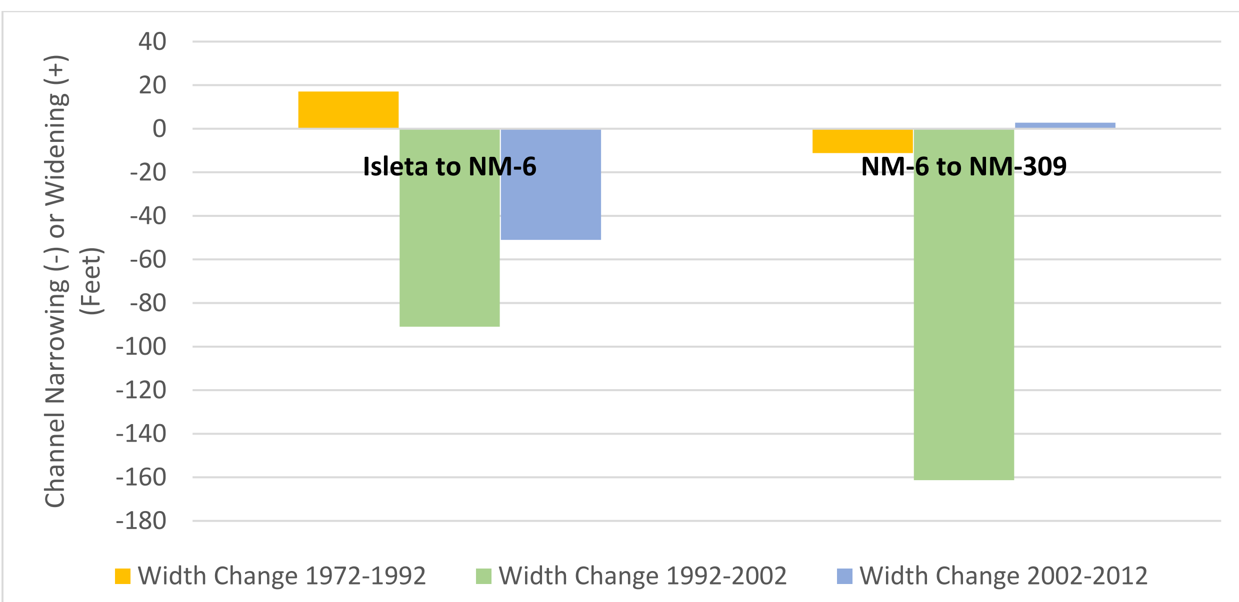

Figure 8: Channel width changes from 1972 to 2012 from Isleta to Belen

Figure 9 shows the typical narrowing pattern in this reach from Isleta to NM-309 with a typical cross section. The black topography line shows the wide sand bed in the 1990s, but by the late teens the colored lines show the channel has narrowed significantly with stable banks and a fluctuating bed.

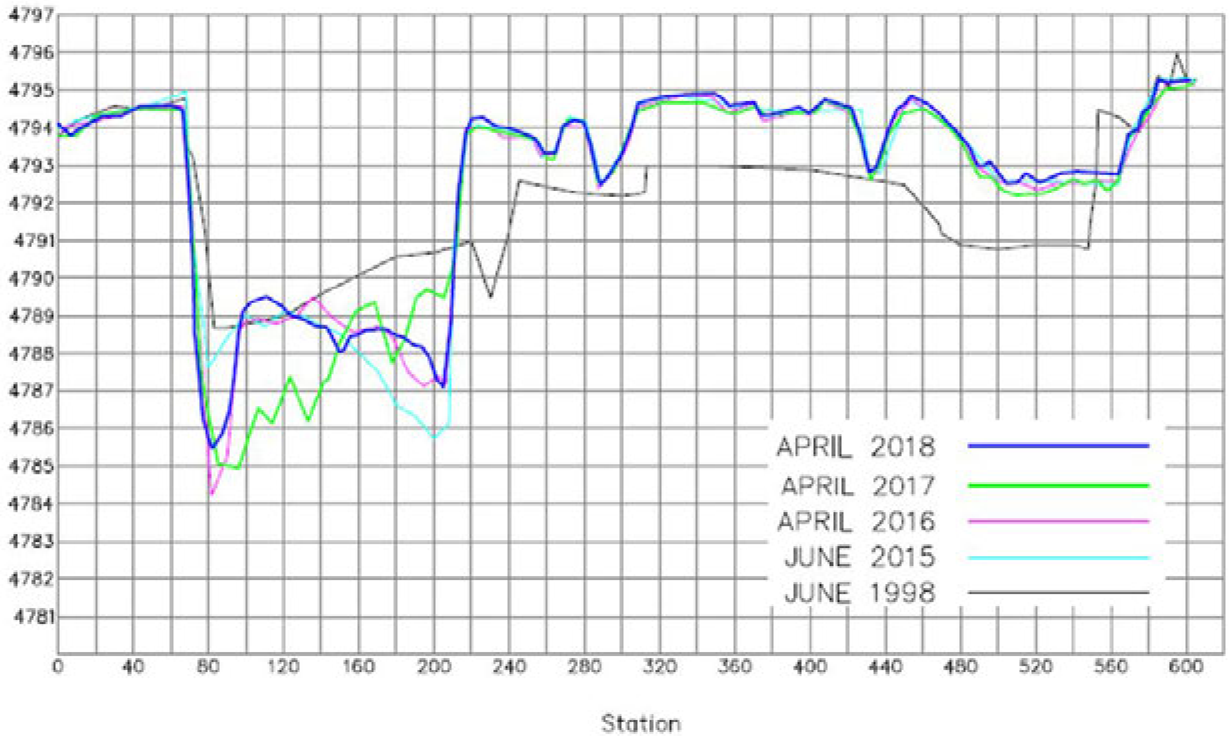

Figure 9: Typical cross section between San Isleta Diversion Dam and NM-309 bridge showing changes in channel width over time.

Average Bed Elevation

A longitudinal river profile of the mean channel bed elevations is a useful way to assess bed changes occurring longitudinally in a river (Klein et al., 2018a). The longitudinal river profiles for Los Lunas area are obtained from the Agg-Deg 1962–2012 studies. Since these Agg-Deg datasets are photogrammetrically obtained, they do not capture the underwater prism. However, Reclamation's TSC in Denver has developed an iterative process by which the active channel portion of the dataset is adjusted to obtain a best match for wetted channel widths as well as the mean bed elevations between the established aggradation-degradation lines. The mean bed elevations estimated for Los Lunas area from 1962 to 2012 are shown in Figure 10. The results indicate that the mean bed elevation in this area has relatively been stable over the years, with slight bed aggradations recently in the upstream half and slight degradations recently in the downstream half.

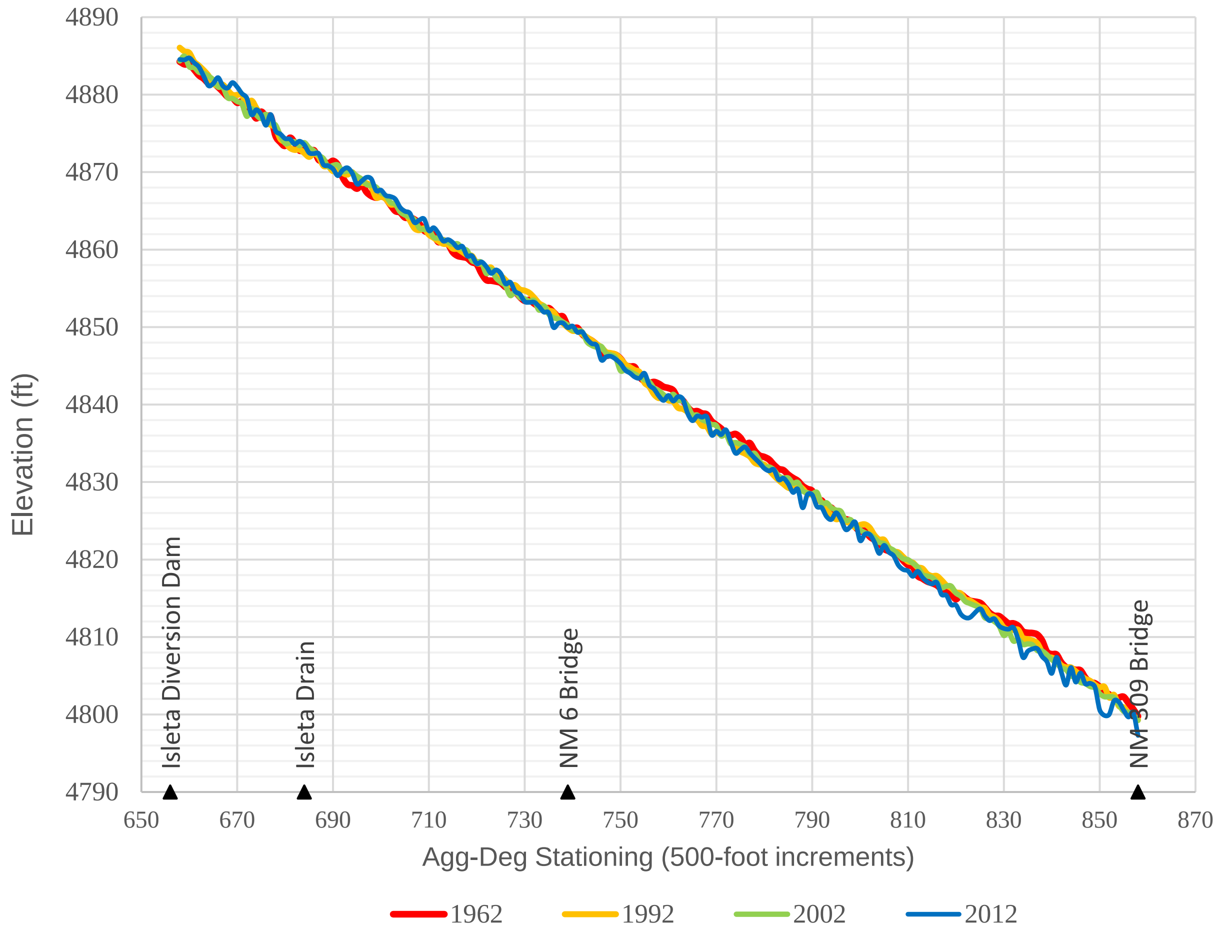

Figure 10: Average bed elevation for Isleta to Belen for 1962, 1992, 2002, and 2012

Hydraulic Depth and Velocity

Hydraulic information for the Los Lunas reach were extracted from a 1D HEC-RAS model developed using the Agg/Deg lines geometry data considering a discharge of 5,000 cfs. The Manning's n values used were based on values used by a Colorado State University study (Vensel et al., 2006) that evaluated channel changes on the Rio Grande between the Rio Puerco and San Acacia Diversion Dam.

A discharge value of 5,000 cfs was used to provide a consistent reference point between the years and to be like the previous Colorado State University Studies (Vensel et al., 2006). This discharge value is close to the 2-year regulated peak flow values calculated by Wright (2010) for the USGS gage at Bernardo (4,900 cfs) and is of a similar magnitude to the USGS gages at Albuquerque (4,000 cfs) and San Acacia (7,800 cfs) (Klein et al., 2018b).

Figure 11 shows the cross-section averaged hydraulic depth information extracted from the model runs within Isleta to NM-309 bridge in Belen. The hydraulic depth is calculated as the cross-sectional flow area divided by the water's top width (USACE, 2010) and is used as a surrogate for average flow depth. Between 1962 and 2002 the hydraulic depth between Isleta to NM-309 decreased about 0.3 feet at 5,000 cfs and increased around 0.9 feet at 5,000 cfs between 2002 and 2012 (Klein et al., 2018). The average channel width was found to be decreasing in this area thus the top width is decreasing at a faster rate than the average cross-sectional area at 5,000 cfs. The typical cross section shown in Figure 9 reflects this trend by showing channel narrowing and deepening.

Changes in the reach-averaged mean channel velocity are also shown in Figure 11. The mean channel velocity in the Isleta to NM-309 shows a slight reduction between 1962 and 2002. The mean channel velocity in this reach increases 0.75 feet per second at 5,000 cfs between 2002 and 2012, which is consistent with the trend of decreasing reach average cross sectional flow area satisfying continuity.

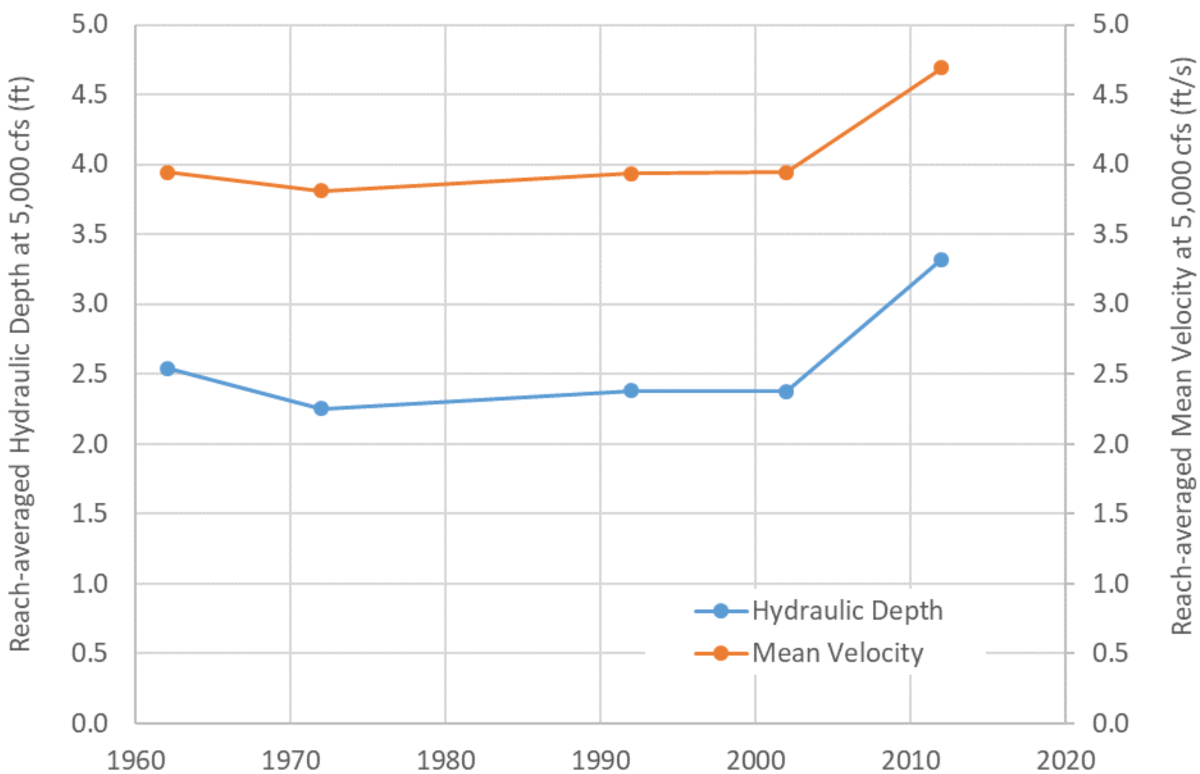

Figure 11: Modeled reach-averaged hydraulic depth (ft) and mean velocity (ft/sec) at 5,000 cfs for Isleta to Belen

Water Surface Elevation (WSE)

The geomorphic changes previously described have impacted how high water is in the channel for a given flow. The water surface elevation (WSE) at a few locations within the Los Lunas reach has been measured over time, and those measurements are shown in the section below. However, because the measurements were taken at different flow rates, they are difficult to compare. Thus, in addition to the field measurements shown below, the 5,000-cfs WSE modeling results are also provided.

Field-Measured Changes

The field measured WSE at different locations at Los Lunas and at Belen are shown in Figure 12 to Figure 15. Figure 12 shows the cross-section on the upstream side of NM-6 bridge (CO-738.1), Figure 13 shows the cross section on the downstream side of NM-6 bridge (CO-741), Figure 14 shows the cross section five miles north of NM-309 (RM 154.5/CO-806), and Figure 15 shows the cross section two miles north of NM-309 (RM 152/CO-833).

At Los Lunas as shown in Figure 12 and Figure 13 , the WSE is increasing over time. For example, the WSE for a discharge of 5,570 cfs which occurred in May 2005 is approximately equal to the WSE for a discharge of 3,170 cfs which occurred in May 2017. Also, the WSE for discharge of 3,700 cfs which occurred in July 2019 is approximately 0.5 feet above the WSE for discharge of 5,570 cfs in May 2005.

At Belen, higher discharges have higher WSEs as expected as shown in Figure 14 and Figure 15. For example, the WSE for discharge of 5,570 cfs in May 2005 is higher than the WSE for discharge of 4,540 cfs in 2019.

Therefore, effects of geomorphic changes along Isleta to Belen reach have a larger effect on water-surface elevation at Los Lunas than at Belen.

Table 1: Field measured WSEs within the Los Lunas subreach

Location	Rangeline	Year	Flow (cfs)*	WSE (ft)
NM-6 Bridge -Upstream Side	CO-738.1	2005	5,570	4852.56
		2017	3,330	4852.38
		2019 (May)	3,170	4852.52
		2019 (July)	3,700	4853.01
NM-6 Bridge – Downstream Side	CO-741	2005	5,570	4851.70
		2017	3,330	4851.74
		2019 (July)	3,700	4852.27
Five Miles North of NM-309 Bridge (Belen)	CO-806	2005	5,570	4823.83
		2019	4,540	4823.61
Two Miles North of NM-309 Bridge (Belen)	CO-833	2005	5,570	4813.20
		2019	3,170	4812.37

* As measured at the USGS Bosque Farms gage

Figure 12: Cross section immediately upstream of NM-6 bridge (CO-738.1)

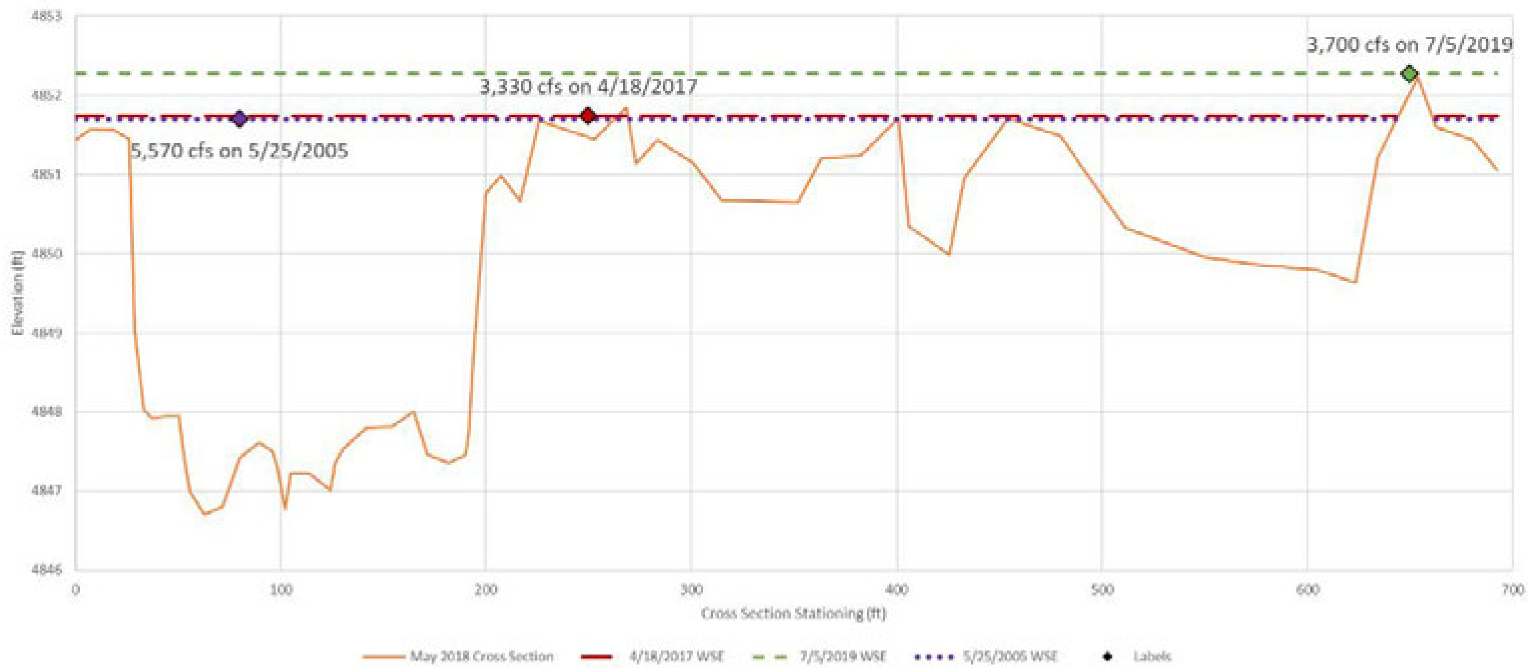

Figure 13: Cross section on the downstream side of NM-6 Bridge (CO-741)

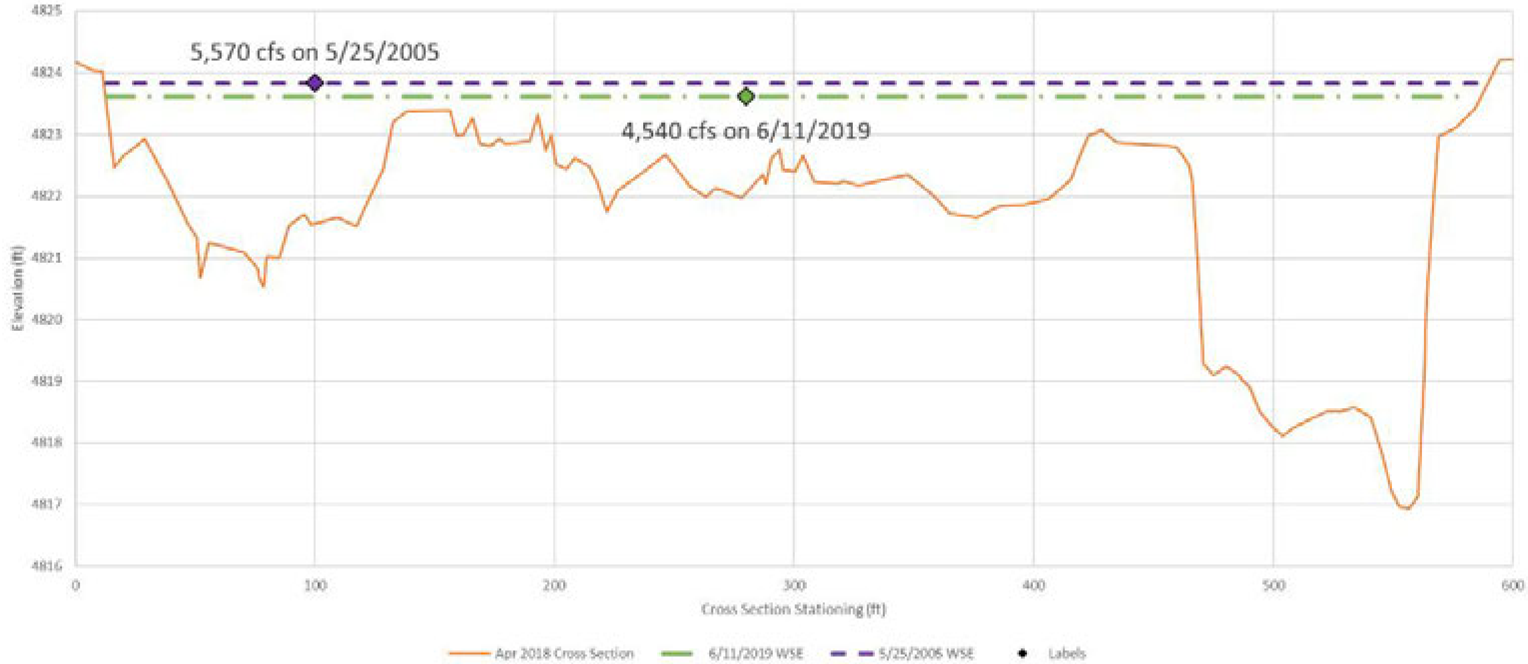

Figure 14: Cross section five miles North of NM-309 (RM 154.5 / CO-806)

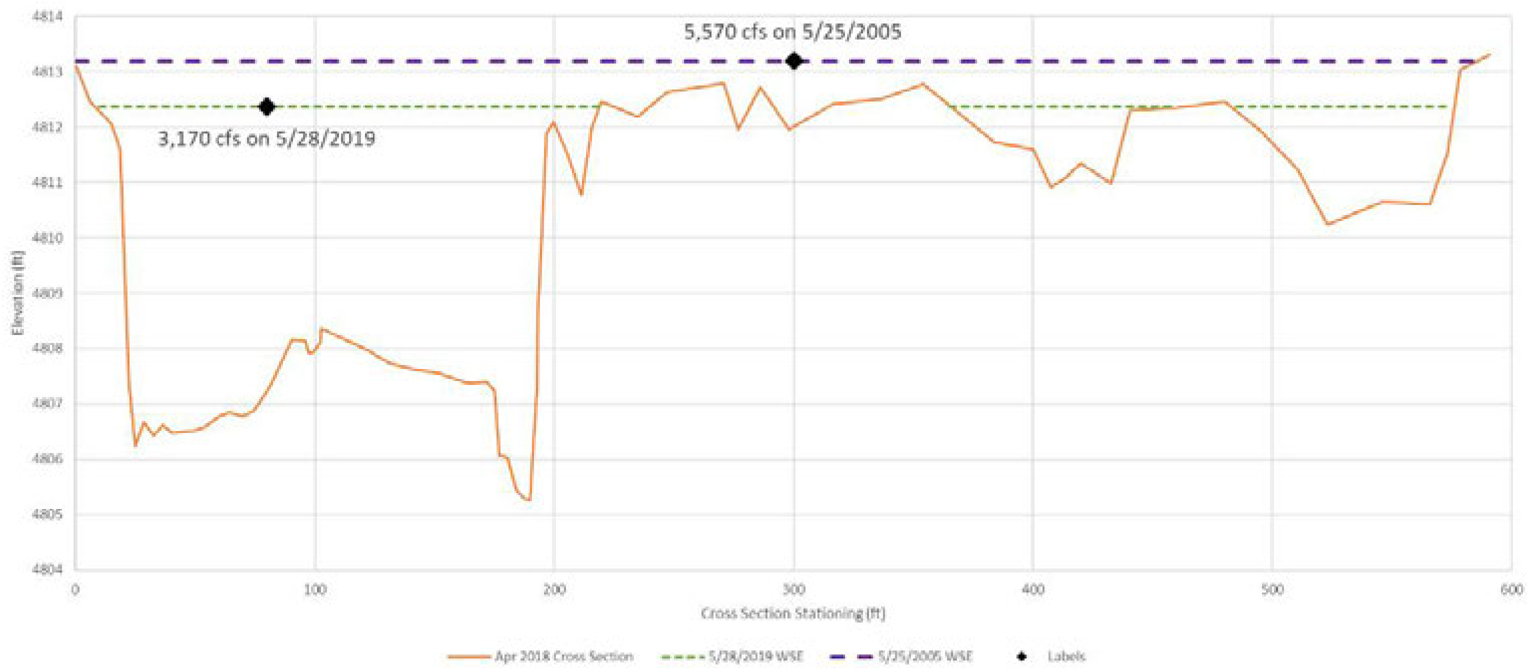

Figure 15: Cross section two miles North of NM-309 (RM 152 / CO-833)

Modeled Changes

Changes in water surface elevation (WSE) at 5,000 cfs were modeled using the Agg/Deg models. The results of this analysis are shown in Figure 16 and Figure 17 for Los Lunas area. From the historical models (using the Agg/Deg cross section lines) shown in Figure 16 and Figure 17, the WSE at 5,000 cfs has remained relatively stable, with slightly higher WSE raises in the Isleta to Los Lunas area in the 2012 model than in the Belen area.

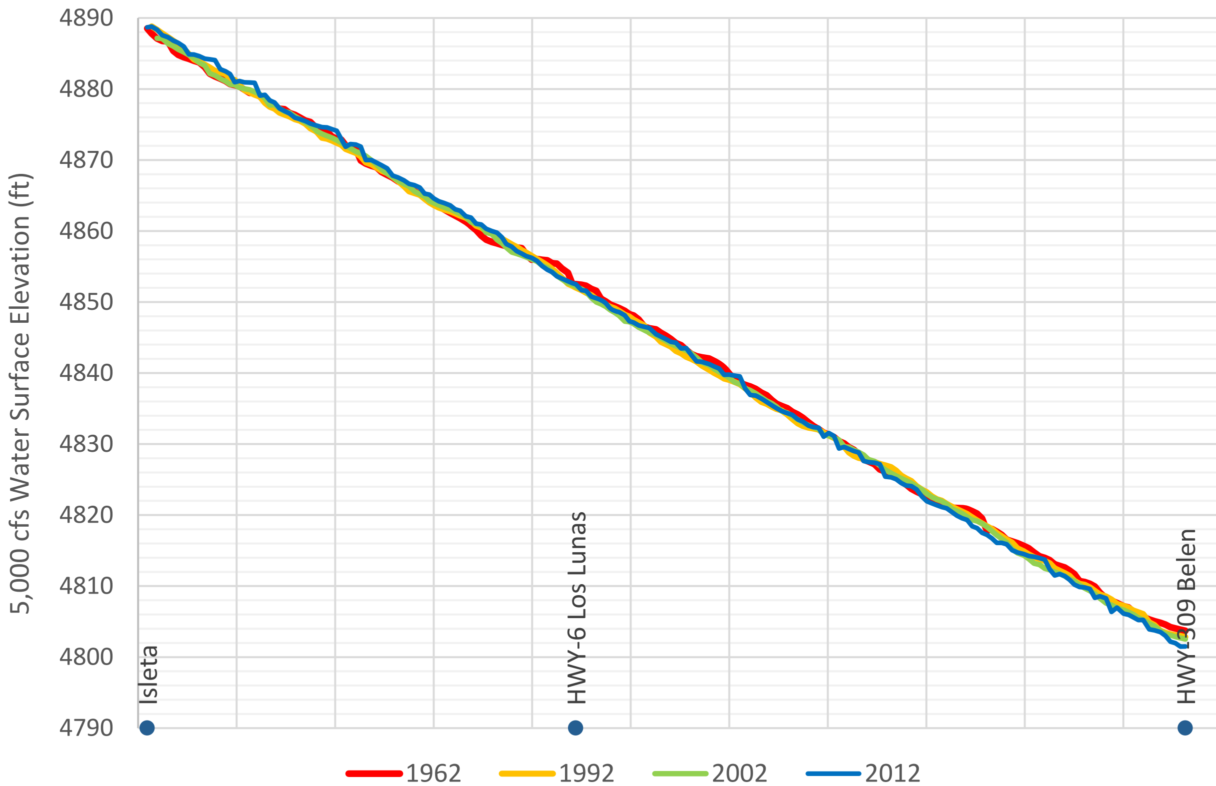

Figure 16: Historical WSE for discharge of 5,000 cfs (1962-2012)

Figure 17 shows the changes in average bed elevation over time and how that impacts the 5,000 cfs WSE. If the average bed elevation decreases, but the 5,000 cfs WSE does not decrease the same amount, it means that the channel has narrowed and/or roughened. Or, if the average bed elevation increases, but the 5,000 cfs WSE increases even more, that also means that the channel has narrowed and/or roughened. This is true in the Isleta to NM-6 subreach for both time periods, but only true for NM-6 to NM-309 for the 2002–2012 time period. In the most recent time period from 2002 to 2012, the Agg-Deg models show the 5,000-cfs WSE increased 0.5 feet from Isleta to NM-6, while the 5,000 cfs WSE decreased 0.2 feet from NM-6 to NM-309. It is likely that the 5,000-cfs WSE has further increased since 2012 between Isleta and NM-6.

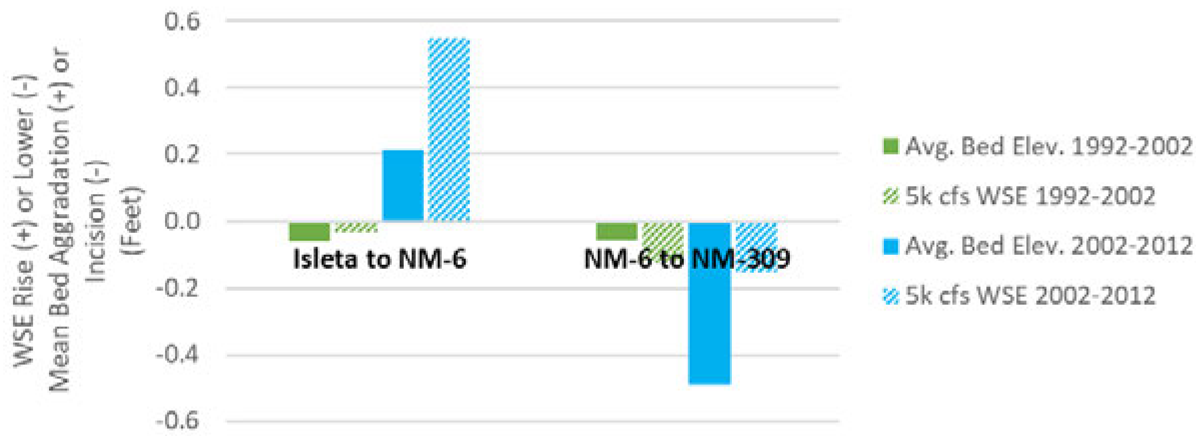

Figure 17: Change in average bed elevation and 5,000 cfs WSE for 1992–2002 and 2002–2012

Significance of WSE Changes in the Los Lunas Area

Changes in WSE over time can have bigger impacts on some reaches than others due to the geometry of the channel and floodplain. This is true of changes in the Los Lunas area. In this area, the channel banks are higher than the floodplain, and the area is considered a semi-perched reach. When high flows overtop the banks, the water becomes trapped in the floodplain, unable to drain back to the river. Thus, there is a potential for poor water conveyance in this reach and a potential for saturated levees, increasing their risk of failure. The following section more fully describes the unique topography of the Los Lunas area.

Channel Perching

To evaluate general trends in the floodplain surface, relative elevation maps (REMs) were created along the Rio Grande between Isleta and San Acacia Diversion Dams (Slaughter and Hubert, 2014; Olson et al., 2014; Coe, 2016). REMs are also known as height above river (HAR) rasters and show the elevation increases along a river corridor above a set of water surface elevations for a given flow rate (Klein et al, 2018a). In the Klein et al. (2018a) study, REMs were generated by subtracting the 500-cfs water surface elevation (500_WSE) for the reach created from 1D HE-RAS model from the 2012 bare earth LiDAR dataset topographical surface. REM was symbolized using 1-, 2-, 3-, 4-, and 5-foot plus elevations above the modeled water surface. The resulting REMs for the Los Lunas area are shown in Figure 18 and Figure 19. There are some areas where there was not adequate 2012 LiDAR coverage and therefore the REM could not be produced in that area.

As shown in Figure 18 and described in the Klein et al. (2018a) study, from Isleta Diversion Dam downstream to around Los Chavez, New Mexico (~River Mile 154, 2012 river mile demarcations are used herein) recently vegetated sand deposits within the historic channel form a lower terrace adjacent to the active channel. Outside of the historic channel the LiDAR dataset shows there is a higher terrace (2–3 feet higher than the lower terrace within the historic channel) that often is a linear strip that parallels the active channel. This is most likely a natural levee formation that has formed through sediment deposition at the edges of what was once the historical banks of the active channel. The vegetation present in these areas also helps trap sediments that settle out once the river flows go overbank. The formation of natural levees along the main channel banks is a common occurrence along river channels with high suspended sediment loads. In addition, natural levees tend to build up over time with finer deposits like silts and clays. The floodplain beyond these natural levees is about 1–3 feet lower than the natural levees. This creates a condition where the active channel is at or slightly higher than the floodplain just inside the levees. This creates a perched channel condition that could cause water to pool at the toes of the adjacent levee infrastructure and prevent overbanked flood flows from draining back to the main channel.

Between Los Chavez, New Mexico and Sabinal, New Mexico (~River Mile 135) the active channel continues to have an adjacent lower terrace formed by recently vegetated sand deposits within the historic channel. This lower terrace is bounded by a higher terrace (2 to 4+ feet higher than the lower terrace) that tends to extend to the levees bounding both sides of the floodplain. There are lower elevation surfaces (1 to 3 feet lower than the higher terrace) mixed within this higher terrace, such as on the river right upstream of the NM Highway 309 Bridge in Belen (~River Mile 151), river left at the aerial gas lines south of Belen (~River Mile 144), the river right across from the confluence with Abo Arroyo (~River Mile 140), and the river left around River Mile 138. These lower surfaces are often along the toe of the adjacent infrastructure, but not always, creating a patchwork of lower surfaces that often have linear extensions of the surface propagating from them. The latter are suggestive of a series of high flow channels, although these are not all interconnected.

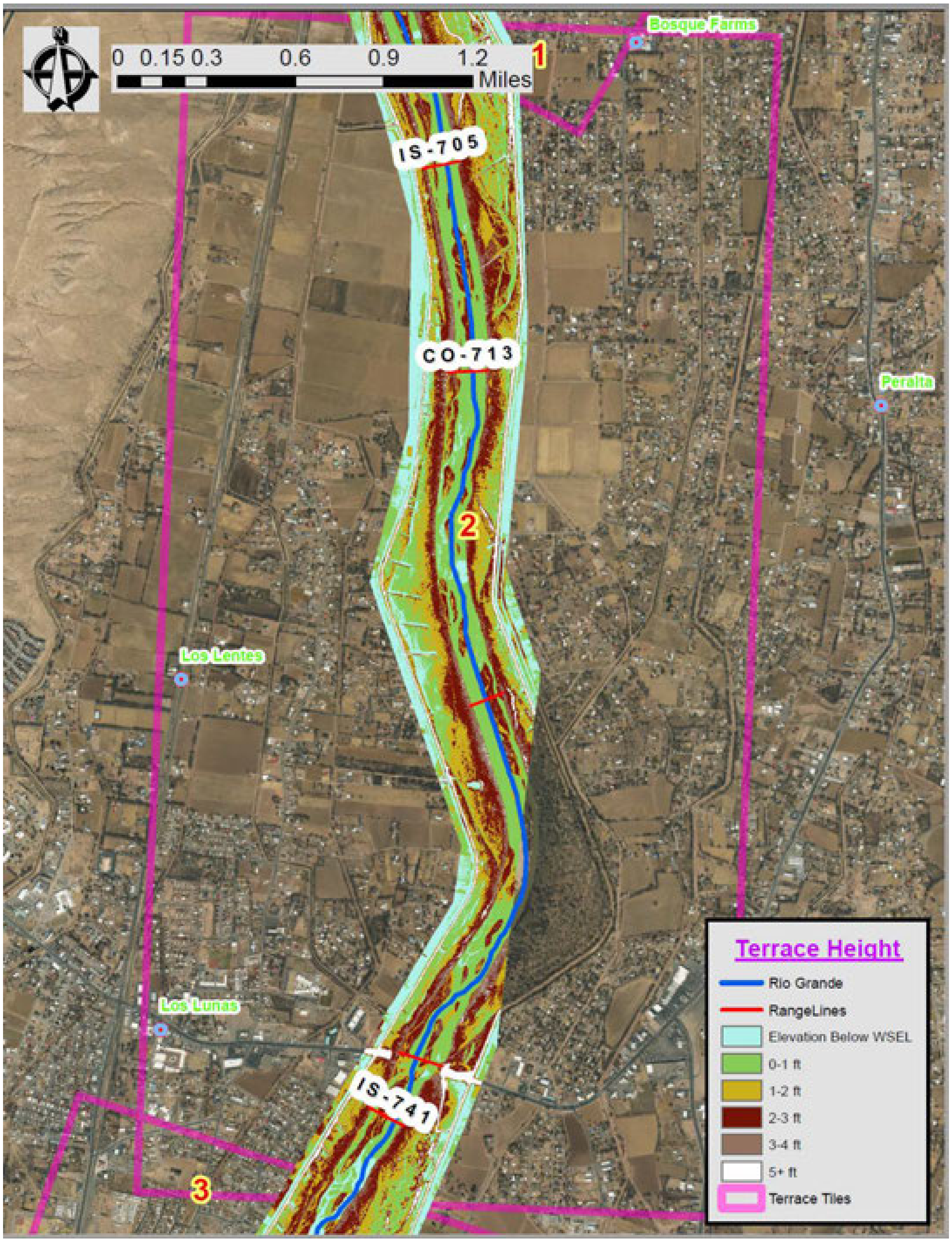

Figure 18: REM (or terrace heights above a 500 WSE) from Bosque farms to Los Lunas. LiDAR data was missing at the river bend downstream of CO-724, so this area was not analyzed

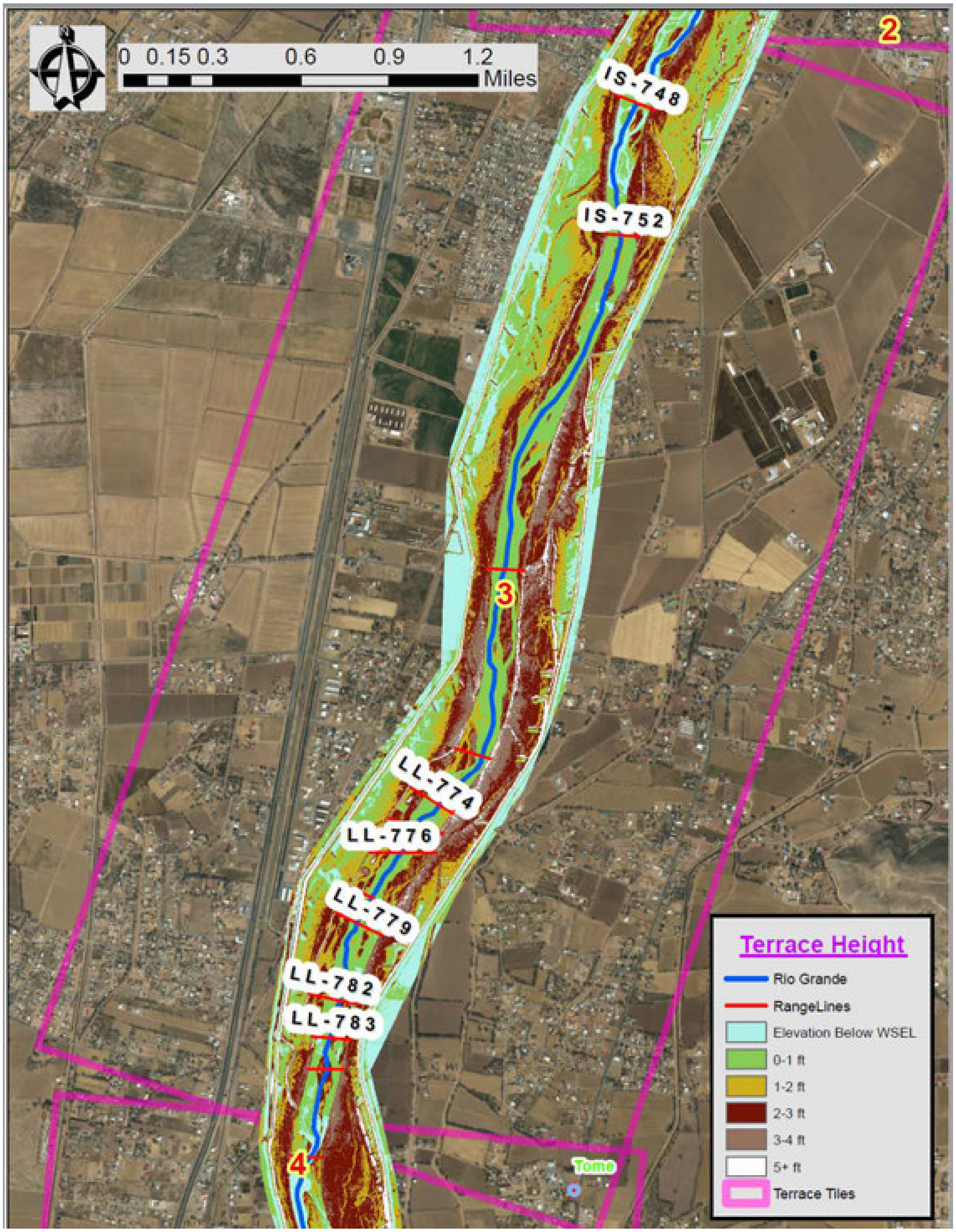

Figure 19: REM (or terrace above 500 WSE) from Valencia to Tome

A typical river cross section for the reach is provided in Figure 20 to further illustrate the semi-perched conditions typical of the Los Lunas area. The cross section shows that while the lowest part of the channel is below the floodplain, the banks are higher than the floodplain, including the levee toes.

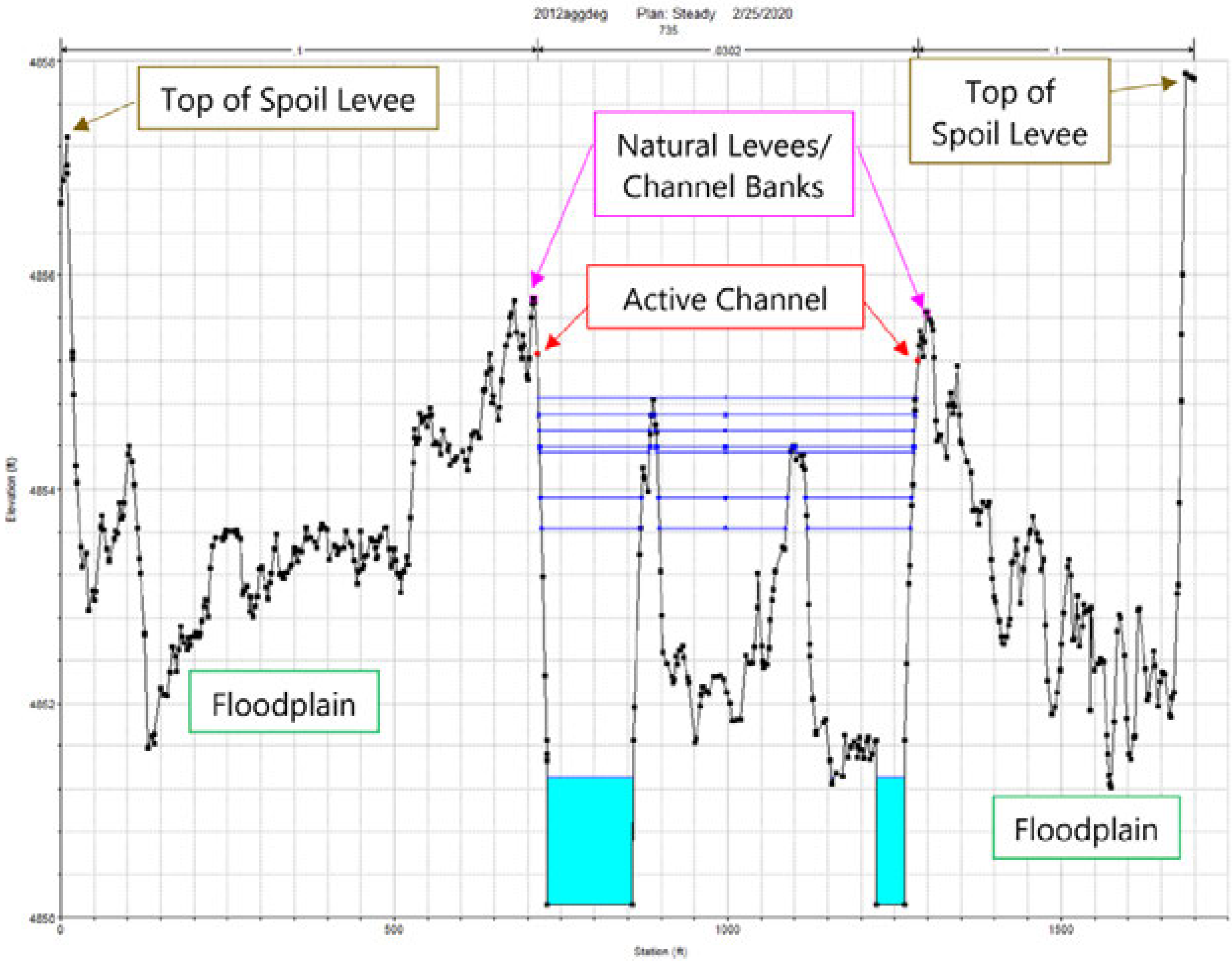

Figure 20: A semi-perched cross section typical of Isleta to Belen (Agg-Deg 735)

For such semi-perched cross sections, if flood water flows over the banks it may become trapped in the floodplain and may take a long time to flow back to the river channel or infiltrate into the floodplain after high flows.

Hydraulic Profiles

The hydraulic profiles for the 2014/2015 geometry model are shown in Figure 21 to Figure 24 for Isleta to Highway 309. These figures include profiles of the minimum channel elevation, water surface elevation at 5,000 cfs, right and left top of banks, and right and left toe of levees. The top of the levees was not shown in the figures, but it's worth noting that the 5,000-cfs WSE does not overtop the levees at any location. Due to intermittent perched channel conditions in this reach, the channel water may or may not be physically against the levees when the 5,000-cfs WSE is above the elevation of the levee toes. At this reach, the elevation of the 5,000 cfs water surface in the channel is always above levee toe (as high as 4 feet) (Klein et al., 2018b).

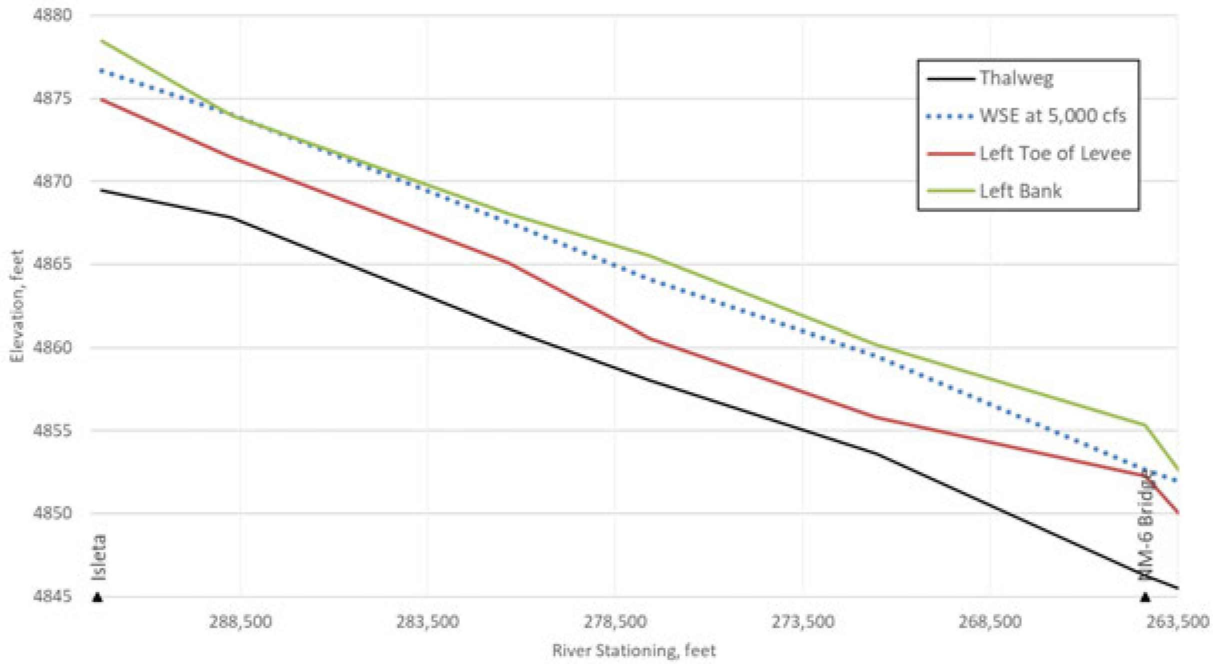

Figure 21: Hydraulic profile at 5,000 cfs using the 2014/2015 geometry for Isleta to NM-6 bridge

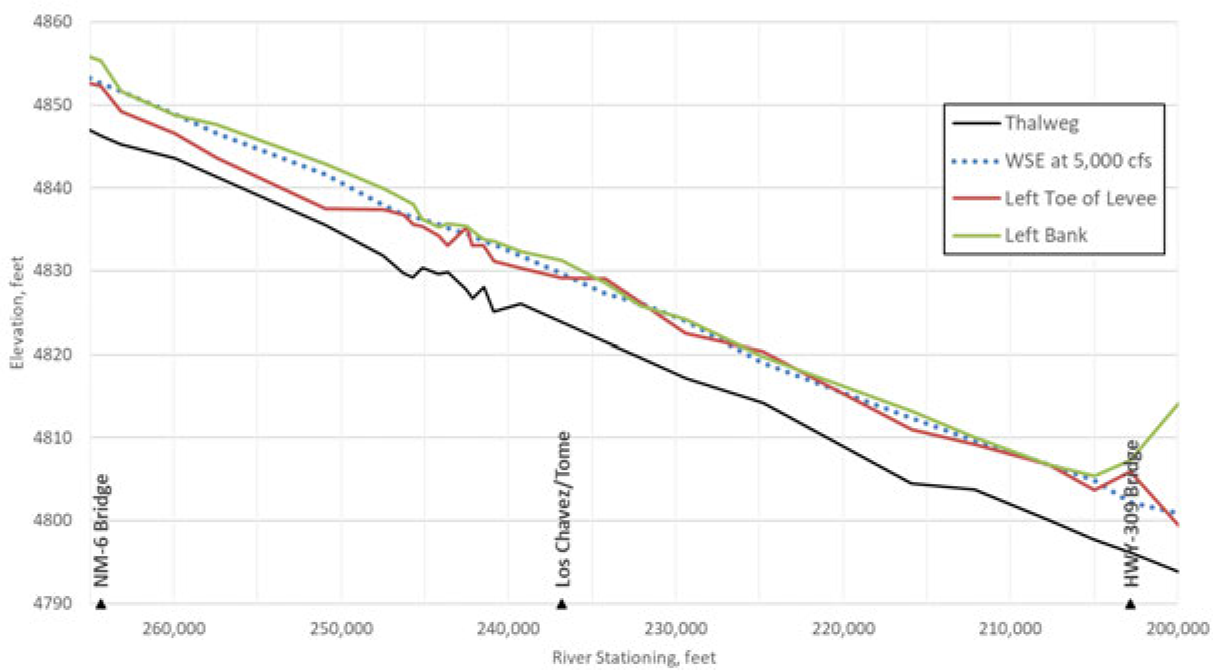

Figure 22: Hydraulic profile at 5,000 cfs using the 2014/2015 geometry for NM-6 bridge to HWY-309 bridge

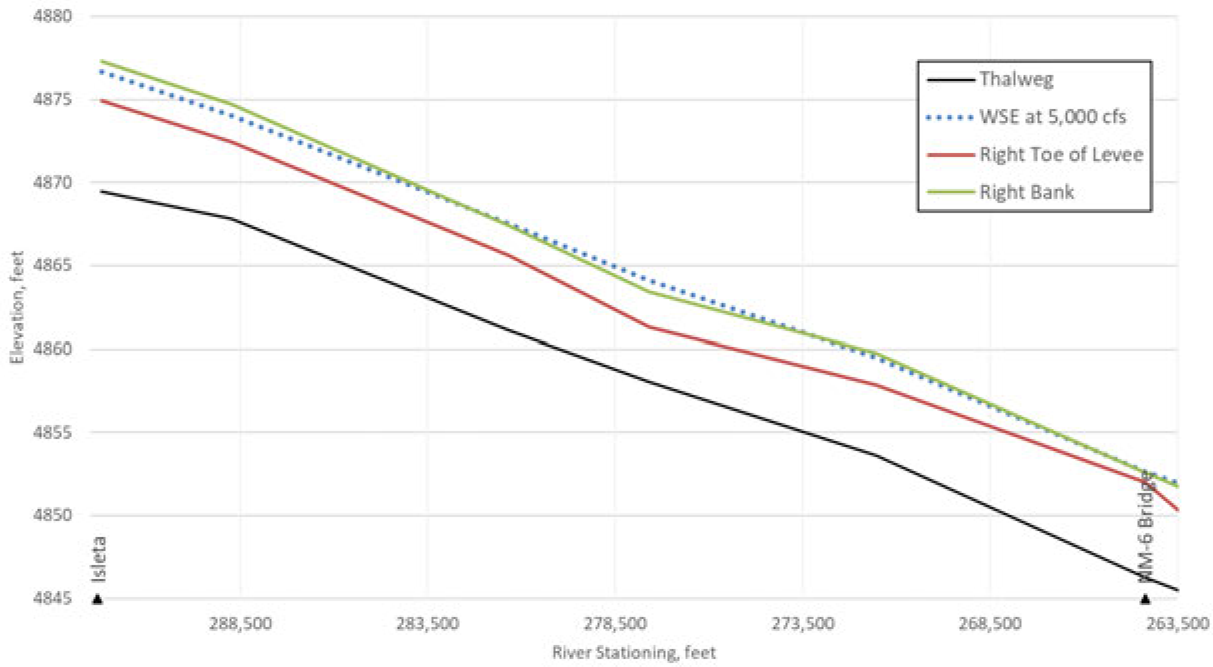

Figure 23: Hydraulic profile at 5,000 cfs using the 2014/2015 geometry for Isleta to NM-6 bridge

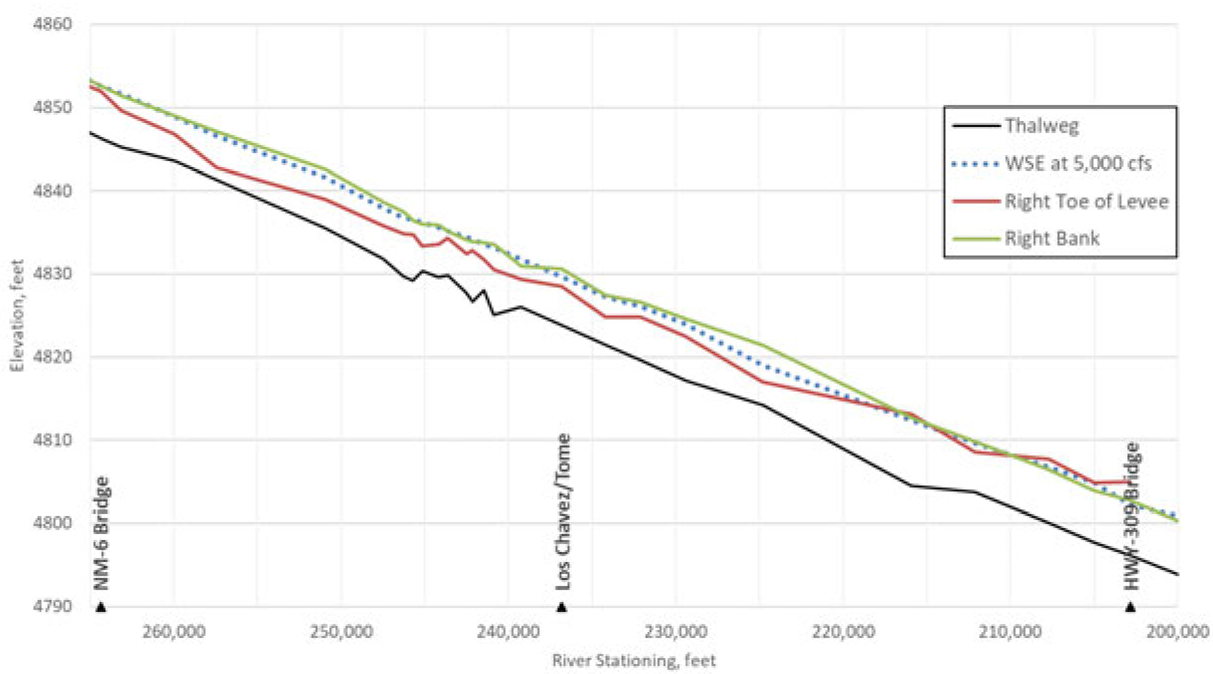

Figure 24: Hydraulic profile at 5,000 cfs using the 2014/2015 geometry for NM-6 bridge to HWY-309 bridge

Klein at al. (2018b) also analyzed the water surface elevations for varying flow rates in the Isleta to Rio Puerco reach. The study found that for the 2014/2015 channel geometry, banks (in this instance defined as high points next to the channel) are overtopped at an average of 4,600 cfs. The water surface is at the same elevation as the levee toes at an average flow of 3,100 cfs. Due to intermittent perched channel conditions, when the water surface is at the same elevation as the levee toes, the levee toes may or may not be wet.

Considering the unique impacts that flood flows have on the Los Lunas floodplain due to its unique semi-perched topography, the recent rise in WSE for a given flow warrants note and consideration for potential action.

Summary and Conclusions

The Middle Rio Grande (MRG) has undergone significant changes over time in climate change, hydrologic change, and in land and river management practices. The construction of upstream dams greatly altered the hydrologic and sediment regimes of the MRG. Since the construction of these dams, the average annual flow volume has been decreasing. There has also been a decline of average annual volume and concentration of suspended sediment.

These changes in hydrology and sediment concentration have resulted in significant geomorphic and hydraulic changes along the MRG. Since the late 1940s, the Rio Grande between Isleta and San Acacia has seen a transition to a narrower, slightly sinuous channel from a wide, braided channel. The average and range of active channel width has also significantly decreased since 1940s. An analysis of the river between Isleta and San Acacia shows that there is more channel narrowing between NM-6 and NM-309 than there is between Isleta and NM-6 and especially between 1992–2002. Field measurements at locations near Los Lunas show that WSEs are increasing over time. For example, at the NM-6 bridge, the July 2019 WSE for 3,700 cfs is approximately 0.5 feet above the May 2005 WSE for 5,570 cfs. Field measurements show that these WSE increases are not as pronounced closer to Belen. Hydraulic models also confirm that the 5,000-cfs WSE has increased over time.

In the Los Lunas area, the channel is considered semi-perched, which means that the main channel banks are higher than the adjoining floodplain. Relative Elevation Maps (REMs) and channel cross sections are available to demonstrate the semi-perched conditions within the Los Lunas areas. The extent of the semi-perched condition shown on REMs reveals the severity of the impact that rising WSEs during flood flows can have in this subreach. Overbanked flows become stranded in the floodplain and saturate the toes of the spoil levees. Since the overbanked flows are unable to drain back to the main channel, the levee toes remain saturated until infiltration and evaporation can remove the water.

In conclusion, the regional climate, hydrology, and anthropogenic changes have changed the nature of the river and its floodplain the Los Lunas subreach to the point where negative impacts are felt at progressively lower flows. These negative impacts are most significantly felt by those responsible for effective conveyance of interstate waters, and by those responsible for maintaining the riverside levees for the purpose of protecting adjacent urban and agricultural communities from flooding.

Reclamation Next Steps

Reclamation is currently engaged in a study of the Los Lunas area to better understand water conveyance and habitat in the floodplain. A 2-dimensional hydraulic model will attempt to quantify the amount of habitat created in the floodplain at various discharge rates. Also, the model will attempt to quantify when and where the channel first overbanks into the floodplain, quantify the volume of water that gets trapped in the floodplain, and quantify the percent of water flowing in the channel versus the floodplain.

Once these competing conditions of water conveyance and ecological habitat are better quantified, the information will be disseminated to interested parties, most particularly the New Mexico Interstate Stream Commission and the Middle Rio Grande Conservancy District. The information will be used to better inform decisions and partnerships for potential actions in the river channel and floodplain areas.

Also, Reclamation will use the Los Lunas study results to inform a Site Identification Report that is underway for the Isleta to San Acacia reach. This report will identify and make priority recommendations for potential maintenance construction sites aimed to improve downstream water and sediment delivery and ecological habitat within the Isleta to San Acacia reach.

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