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Managing Water in the West

2005 BANK EROSION MONITORING REPORT

SAN ACACIA REACH OF THE RIO GRANDE, NM

Final Report

Department of the Interior
Bureau of Reclamation
Albuquerque Area Office

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Department of the Interior
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MISSION STATEMENTS

The mission of the Department of the Interior is to protect and provide access to our Nation's natural and cultural heritage and honor our trust responsibilities to Indian tribes and our commitments to island communities.

The mission of the Bureau of Reclamation is to manage, develop, and protect water and related resources in an environmentally and economically sound manner in the interest of the American public.

2005 BANK EROSION MONITORING
SAN ACACIA REACH

The 2005 spring runoff was a large runoff year, which set off a series of eroding banklines in the San Acacia, NM area (Figure 1). Although a meandering channel pattern recently emerged in this reach of the Rio Grande (Reclamation 2003), extensive amounts of bank erosion were absent until this year; several sets of alternating eroding banklines setup during the 2005 spring runoff (Figure 1). The purpose of this report is to document the extent of bank erosion in the San Acacia area, especially at the RM 111 River Maintenance Priority Site, and describe other observations found during the monitoring effort.

The San Acacia Reach is located approximately 120 river miles downstream from Cochiti dam (Figure 1), near Socorro, NM. Three existing Reclamation River Maintenance Priority Sites are found in this reach; these locations are where previously formed meandering bends threaten the western levee/LFCC system. Two levee setback projects are underway to reduce the potential for levee failure at these sites. While monitoring these Priority Sites during the 2005 runoff event, several other bends and bank erosion locations were observed (Figure 1).

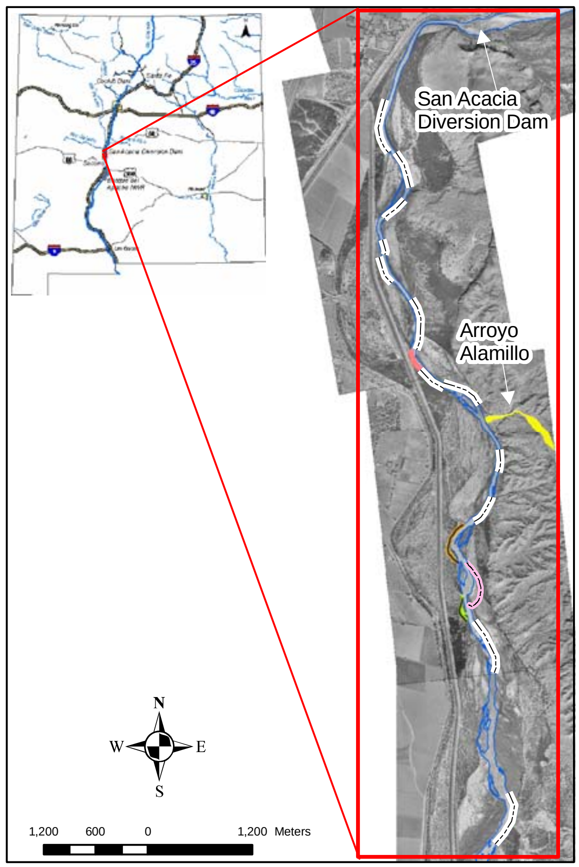

Figure 1: Location of the San Acacia Reach along the Rio Grande in New Mexico. The colored lines indicate banklines that have been mapped in detail. The white and black lines are banklines that were observed eroding during the 2005 runoff period.

2005 Runoff Data

The 2005 spring runoff on the Rio Grande began in early April and continued until late June (Figure 2). USGS discharge data from the Rio Grande at Otowi, NM gage (Otowi gage) is the river flow entering Cochiti Reservoir which peaked on May 28th at just over 9,000 cfs. Data from the Rio Grande at Cochiti, NM gage (Cochiti gage) shows the peak discharge release from Cochiti Dam occurred on June 2nd at about 6,500 cfs. The peak of the runoff for the Rio Grande at San Acacia, NM (San Acacia gage) occurred on May 25, 2005 with a flow of 7,800 cfs, but this peak was short-lived (less than 1 hour) and appears to have been a local storm event. The next highest peak flow, which correlates with the Cochiti dam release on June 2nd occurred on June 10th at the San Acacia gage, with a peak of 7,200 cfs.

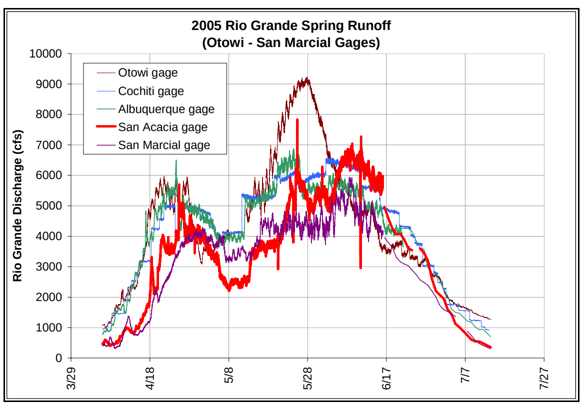

Figure 2: Hydrograph showing USGS daily gage data for April through mid-July 2005 on the Rio Grande.

Comparison of the 2005 runoff data with historical data shows that 2005 clearly had the largest runoff since 1995 (Figure 2 and Figure 3), however it is comparable to runoffs in the early 1990s. Between 1996 and 2004, only one spring runoff peaked greater than 4,000 cfs, and of the remaining years, only two peaked greater than 3,000 cfs; along with the decreased peak flow, the volume of water was significantly smaller (Figure 3). These low-flow years are coincident with the climatic drought conditions that have prevailed in the region since 1996. Prior to the drought, discharge data from the early 1990s shows that the spring runoffs consistently peaked 4,000-6,000 cfs (Figure 4); the volume of water in these years was relatively large compared to the low-flow years. Visual comparisons of the 2005 spring runoff data with the data from the early 1990s indicates that the 2005 spring runoff was similar to the early 1990 runoffs in both peak values and volume (Figure 4).

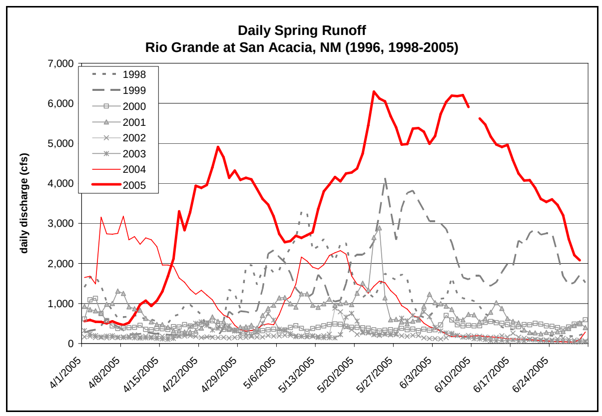

Figure 3: Rio Grande spring runoff data at the USGS San Acacia gage for April through June for 1996 and 1998-2005.

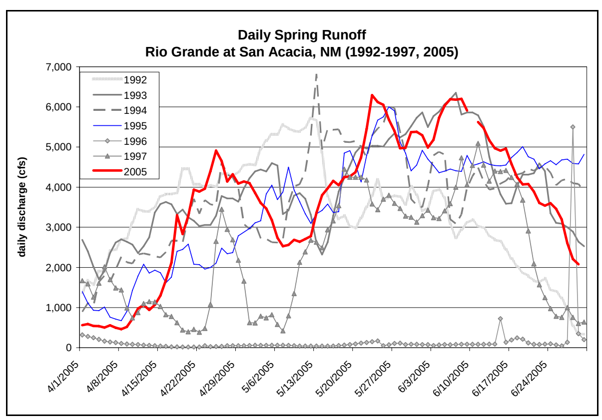

Figure 4: Rio Grande spring runoff data at the USGS San Acacia gage for April through June for 1992-1997 and 2005.

RM 111 and RM 110 Bend Migration Sites

Banklines at three locations migrated significantly in the San Acacia area (Figure 5): RM 111 River Maintenance Priority Site (RM 111 PS), RM 110 West Site and RM 110 East Site. The RM 111 PS and the RM 110 West Sites were visited regularly throughout the runoff event, and their banklines were mapped in detail several times, including after the runoff event was finished. As accessing the RM 110 East Site was not possible during the runoff event, this site was mapped in detail after runoff and only once (October 2005).

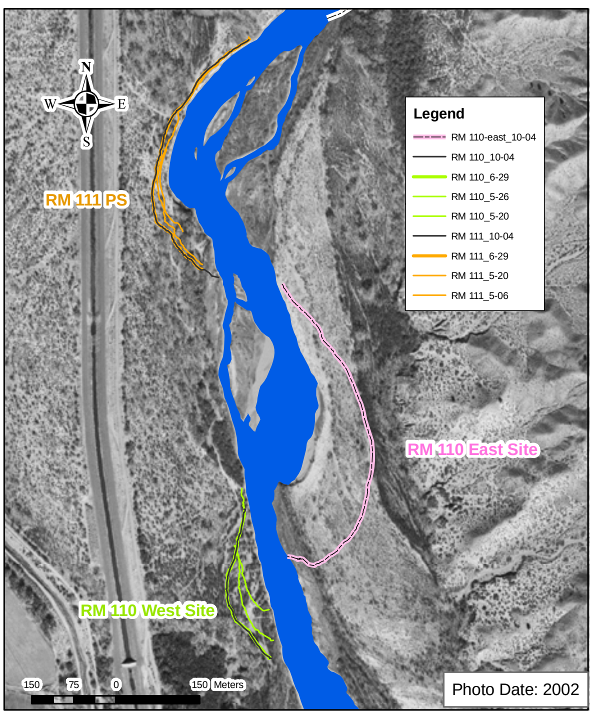

Figure 5: GPS mapped Rio Grande bankline locations at three migrating bends in the San Acacia Reach during Spring Runoff 2005; background is a geo-rectified 2002 aerial photograph.

Detailed bankline mapping was performed primarily with a sub-meter Global Positioning System (GPS) rover unit. These data were post-processed with real-time base station data to improve position accuracy. Numerous digital photographs were taken at each of the sites during the mapping session. Periodic photographs were also taken during monitoring flights (airplane flights with varying altitudes) which were used in conjunction with the GPS data to estimate ongoing erosion during the runoff. In addition to the GPS mapping, terrace height was confirmed throughout this area (Figure 6).

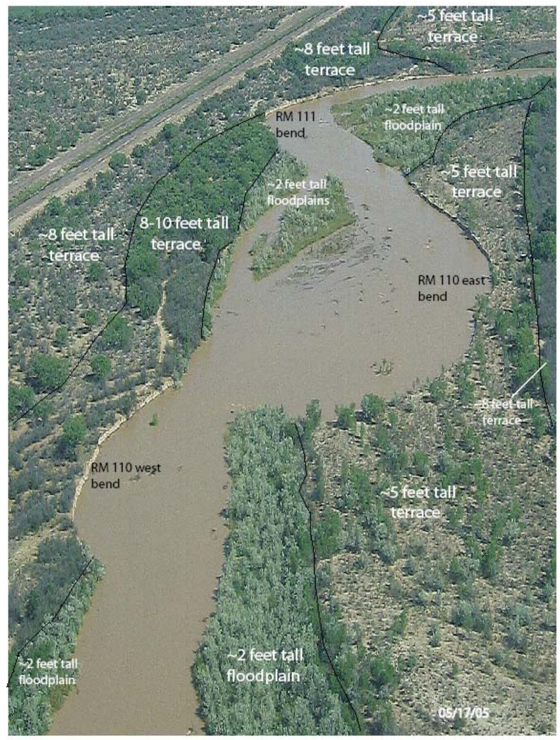

Figure 6: Outline of terraced surfaces and active floodplains between RM 111 and RM 110 on the Rio Grande in the San Acacia Reach; bank heights from the ordinary high water mark (Massong 2005b).

The two northern bends, RM 111 and RM 110 East were well established bends prior to 2005 and were being monitored, especially the bend at RM 111, as it is close to the levee toe and is one of Reclamation's River Maintenance Priority Sites (Massong 2005a). The bend at RM 110 West initially formed in early May 2005 and rapidly grew in size throughout the runoff event.

RM 111 Priority Site

Movement of the bankline at the San Acacia RM 111 River Maintenance Priority Site was ongoing throughout the 2005 spring runoff (Figure 7). A bankline survey on October 4, 2005 showed that no significant bankline erosion occurred after the June 30th survey (Figure 5). This bend generally migrated 60 meters at the bend apex in the downstream direction, while the downstream extent migrated about 110 meters downstream. The area of the bend increased by 25% in 2005 (Table 1). The bank material present at this site is a combination of spoils and historical Rio Grande floodplain and riverine sediments composed of sand and silt. The bank is 8-10 feet (Figure 6) and varies between a vertical exposure and a slight lay-back.

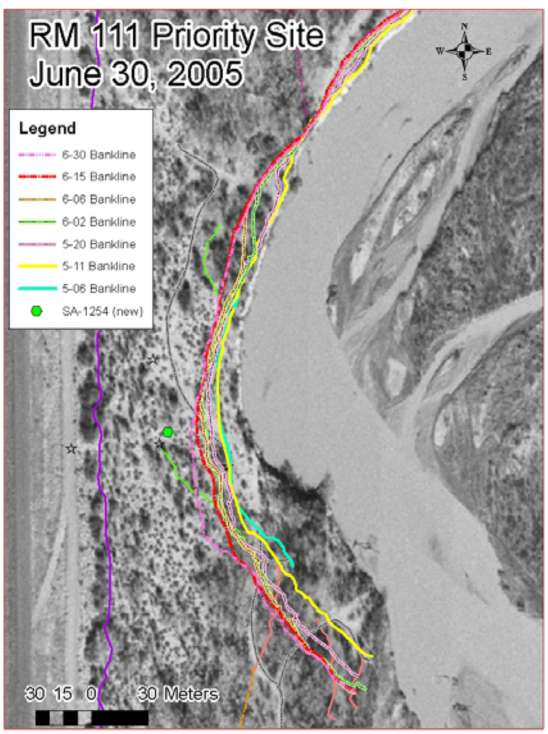

Figure 7: Bankline locations for the migrating bend at RM 111 from early May through the end of June 2005.

In mid-May, a smaller bend, within the migrating bend, formed immediately downstream from a relatively stable bank location (red circle on Figure 8). The stable bank location is anchored by a line of mature cottonwood trees that grew-up around an old fashion sediment retention line (similar to jetty jacks). As this small bend scoured out, the dominate direction of migration for the whole bend changed from predominately downstream to an almost perpendicular direction (west). During this phase, the bend apex shifted its location upstream.

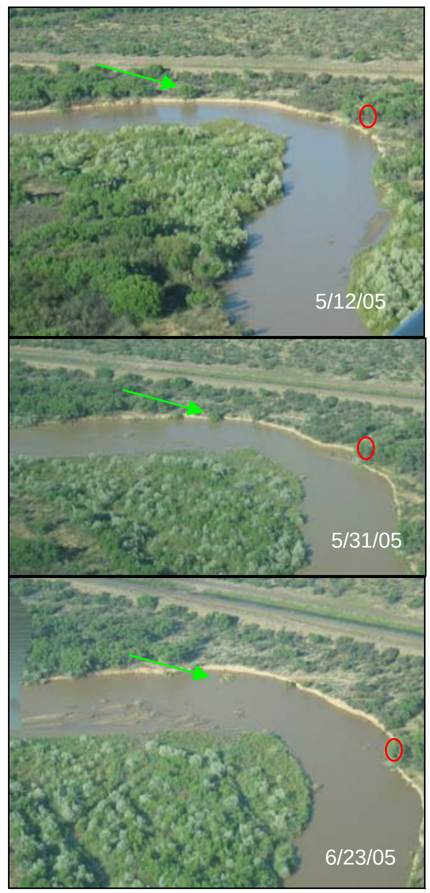

Figure 8. Bend migration at RM 111. Green arrow points at a mature cottonwood; the red circle is a relatively stable bank location with mature cottonwood trees.

Table 1: Summary of area of the RM 111 bend.

Year	Area of Bend	% increase
1996	17,800 m^2	--
1999	43,900 m^2	150%
2005	54,700 m^2	25%

RM 110 West Site

As stated earlier in this report, this bend initially formed in early May 2005, with the first detailed bankline data collected on May 20th, when it was determined that this bankline was rapidly retreating. The bankline location was mapped several times during runoff, and then two times after runoff ended. The initiation of this erosion is concurrent with the downstream migration of the RM110 East bend. The bank material present at this site is historical Rio Grande floodplain and riverine sediments composed of sand and silt. The bank is 8-10 feet higher than the current ordinary high flow (Figure 6) and forms a vertical bank.

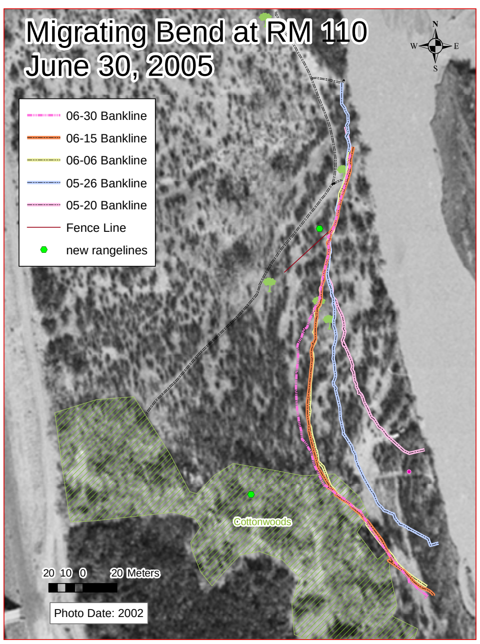

Figure 9: Bankline locations for the migrating bend at RM 110 from just after bank erosion began in late May through the end of June 2005.

The initial bend formed as a large scallop eroded into the bankline (Figure 10) in early May 2005. During this phase, the erosion was measurable in feet of bankline retreat per day. The vegetation on the terrace eroding at this time was composed of small patches of dense and sparse saltcedar; the saltcedar patches do not appear to hinder bend migration. The river continued to erode these sediments and vegetation through the end of May. In early June, the apex of the bend migrated into a stand of mature, relatively dense cottonwood trees; in response, the curvature of the bend tightened (Figure 10), and overall migration slowed. Since that time, the downstream migration of the bend appears stalled. However, bank sediments have continued to erode upstream of the cottonwood stand (Figure 9); as a result, the apex of the bend shifted upstream.

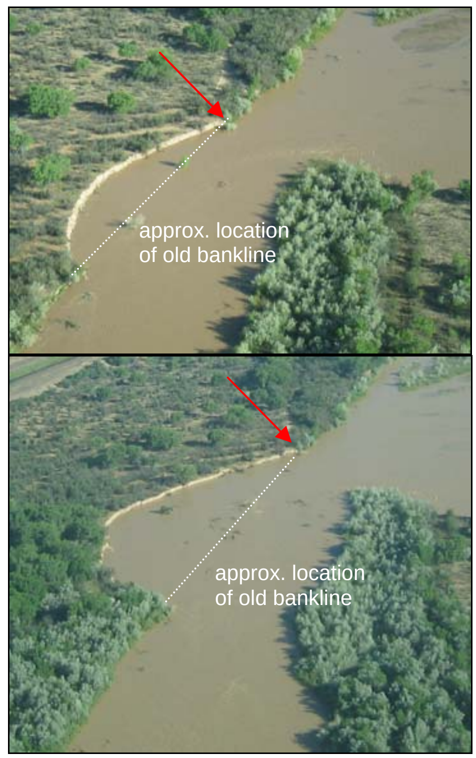

Figure 10: Aerial photos of RM 110 in early May 2005 (top photo) and early June 2005 (bottom photo). Note the location of the upstream end of the bend is stable (red arrow).

The current bankline at the bend apex is approximately 65 meters closer to the levee than it was prior to runoff. The length of the bankline increased as the bend developed and is currently about 50 meters longer than before the bend formed (Figure 10). The area of the current bend is approximately 12,400 m^2.

RM 110 East Site

This bend initially formed about 1996 and began migrating in the late 1990s; bend migration stalled by 2000 and began vegetating (Figure 11). During the 2005 runoff event, this bend began migrating rapidly downstream; by the end of the runoff event, the apex of the bend had moved approximately 160 meters in the downstream direction (Figure 5). The length of the bankline increased from about 420 meters to 660 meters, while the area of the bend more than doubled (Table 2).

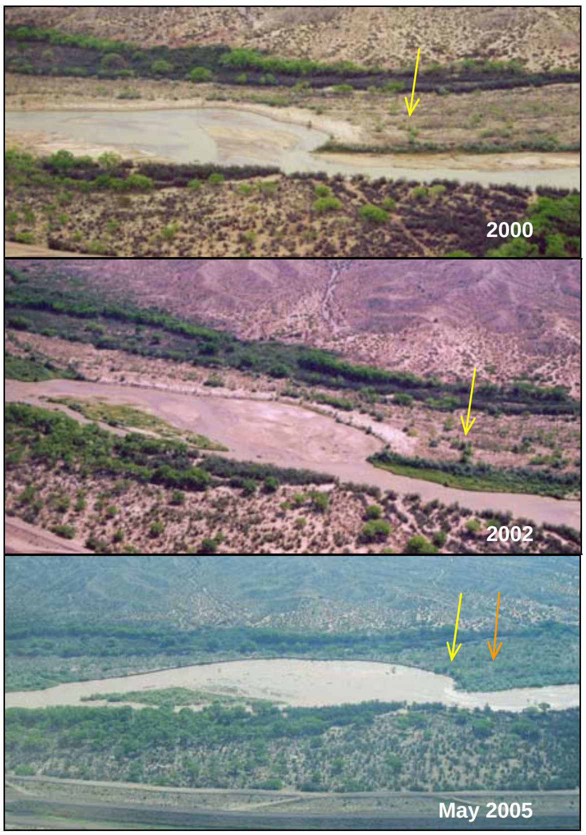

Figure 11: Aerial photos looking east towards the bend at RM 110 East (2000, 2002 and May 2005). The yellow arrow shows the location of a small stand of cottonwood trees in each of the photos. The orange arrow shows the approximate location of the bend apex/bankline in October 2005.

Unlike the bank material found at both the RM 111 bend and RM 110 West bend, this bank material was recently (within 20 years) deposited and abandoned riverine sediments. This loosely packed river sand (a.k.a., sugar sand, Figure 12) composes a 5 foot terrace (Figure 6). The vegetation on this terrace is sparse saltcedar, cottonwood, and the occasional Russian olive tree. Shrubs and cacti are also growing on the surface. The bank material appears to offer no resistance to the river erosion.

Table 2: Summary of area of the RM 110 East bend.

Year	Area of Bend	% increase
1996	1,200 m^2	--
1999	21,600 m^2	1,700%
2005	64,900 m^2	200%

Figure 12: Looking upstream along the bankline at the RM 110 East bend. Note the lay back of the bankline, as the sugar sand lacks the ability to form vertical banks.

Effect of Bank Height

In the San Acacia Reach a variety of bank heights exist (Massong 2005b) that range from about 2 feet to greater than 30 feet. Most of the tall banks eroding are between 8-12 feet tall and are vegetated with sporadic stands of dense, mature vegetation; many of the shorter banks that are eroding are active floodplains which contain dense stands of immature woody vegetation. Erosion processes differ based on bank height as the tall banks erode by an undercut-collapse process while the floodplains erode as the vegetation is mechanically ripped away by the flowing water.

For the purposes of this study, a high or tall bank is defined as those banks where the bank is taller than the roots of woody vegetation growing on top of the bank (Figure 14). Based on this definition, tall banks in the San Acacia Reach are 5 feet or taller. The short banks are active floodplains which were flooded during the 2005 spring runoff.

Erosion of Active Floodplains (short banks)

Erosion of the active floodplain surfaces were difficult to monitor during runoff, as inundation of the surface hides the erosion. In this area, these lower surfaces are recently deposited bars that currently act as a floodplain. They are heavily vegetated with a mixed stand of woody species: cottonwood, willow, Russian olive and saltcedar (Figure 13). The roots of the riparian vegetation extend throughout the bank and probably extend down to the low-flow water surface elevation.

These densely vegetated surfaces are relatively resistant to river erosion and often create a 'hook' at the downstream end of migrating bends (Figure 5 and Figure 11). As the 'hook' impeded the downstream migration of the RM 110 East bend, a scallop formed in the bankline immediately upstream of the 'hook' which moved the apex upstream and the thalweg closer to the bankline. This sequence of events appeared to be necessary to erode the sediments and vegetation on the floodplain. The upstream scalloping of the bank material is almost like a partial flanking of the resisting surface; a true flanking of the 'hook' would leave a isolated patch of relatively undisturbed bank material (an island) in the channel, which has not occurred at these sites.

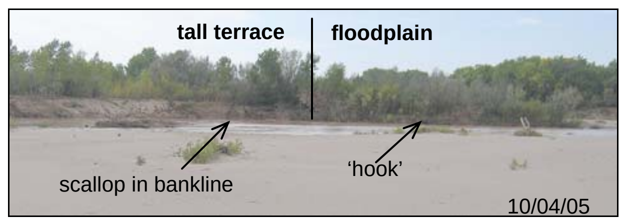

Figure 13: Looking downstream at the 'hook' in the RM 110 East bend: the bank height transitions from a tall bank to a short bank (floodplain).

Erosion of Terraces (Tall Banks)

Bank erosion for tall terraces occurs directly at the base of the terrace and was quite visible throughout runoff. The erosion process has two steps: first step is erosion at the water surface level creating an undercut (Figure 14). Since this type of erosion is selective (e.g., only eroding the fine sediment), it easily scours around deeper root that have minimal mass structures, such as saltcedar tap roots (Figure 15).

The second step of bank erosion for high banks is bank failure or collapse which occurs catastrophically as the undercut bank material falls in to the river channel (Figure 14). The amount of undercutting depends on the size of the root mass in the top layer of the bank (i.e., large cottonwood root mass creates a larger undercut bankline.

Figure 14: Undercut banks at RM 111, near San Acacia, NM on the Rio Grande, May 2005.

Vegetation on the tall banks consists primarily of saltcedar and mature cottonwood trees. The root masses from saltcedar do not appear to significantly hinder bank erosion, as the river easily erodes the bank sediment surrounding the saltcedar taproot (Figure 15). Conversely, the large, horizontal cottonwood root-masses provide enough bank support to create large undercut banks (Figure 16).

Figure 15: Bank erosion at RM 111, near San Acacia, NM on the Rio Grande, May 2005. Mature saltcedar poised on the eroding bankline, ready to fall into the Rio Grande.

Figure 16: Large undercut bank at RM 111 on May 20, 2005.

Woody debris accumulation during a bank migration event can both hinder and aid bankline erosion. The accumulation of in-channel debris along an eroding bankline can hinder bankline retreat (Figure 17) as the large trees re-direct the thalweg away from the bankline. In fact, at the RM 111 bend, the large cottonwood in the May 20th photo (Figure 17) took several weeks to fall into the river, and during that time, it noticeably hindered bend migration. However, after it fell, the river rapidly eroded the bankline next to the tree, with the tree appearing to aid the erosion by directing the thalweg into the bankline (Figure 17).

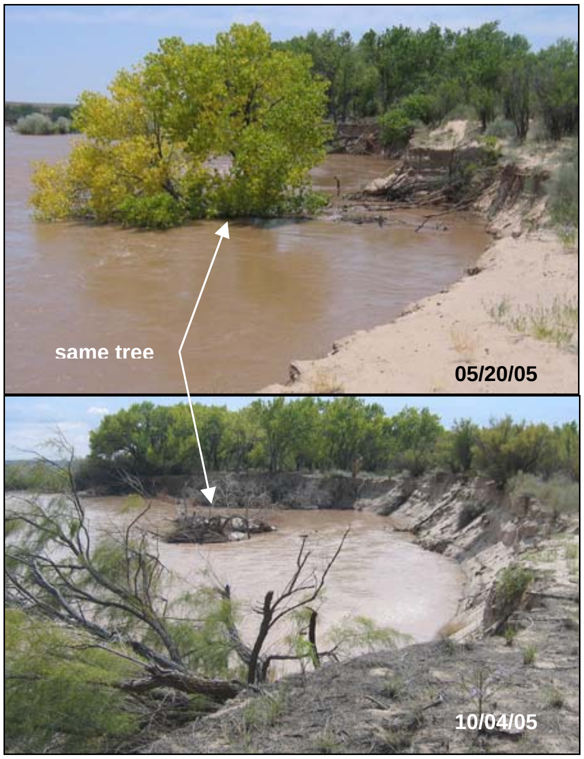

Figure 17: Bank erosion at RM 111, near San Acacia, NM on the Rio Grande. Note the extensive bankline retreat since this cottonwood fell into the Rio Grande.

Channel Widening versus Channel Migration

Bank erosion during the 2005 runoff event was rampant in the San Acacia area; a classic pattern of an alternating thalweg set-up during the runoff event, which caused alternating banklines to erode. This bank erosion and bend development can be easily divided into two types of bends: 1-erosion bends that are creating a wider channel, and 2-laterally migrating bends. Interestingly, the size of the bend does not appear to influence the type of bend developed, nor does the proximity of the thalweg to the bankline. Based almost solely on the location of bar development in relation to the erosion, each bend in the San Acacia area can be classified as either a 'widening' or migrating bend.

Erosion Widening the Channel

Large sections of bankline are eroding upstream of Arroyo Alamillo (Figure 1), however all of this erosion appears to be simply 'widening' of the river channel. The eroding banklines tend to have a relatively long length, while the bend has a low curvature. The most important characteristic of these types of bends is the lack of active point bar growth opposite the bank erosion (Figure 18). Without ongoing deposition on the inside of the bend, the full cross section of the channel stays relatively deep and active at even low flows. Also these banklines did not retreat significantly during the runoff event.

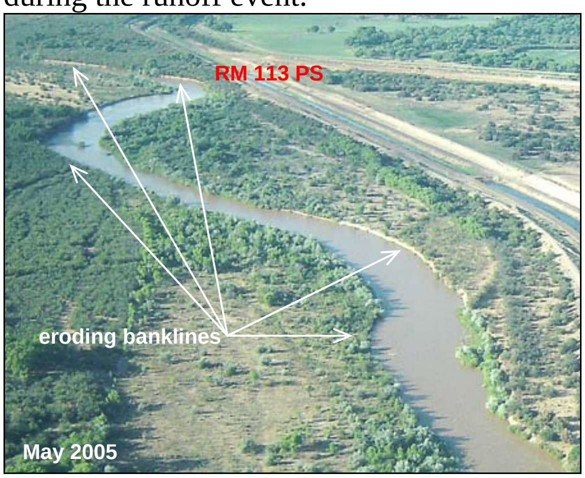

Figure 18: Aerial photograph of alternating eroding banklines along the Rio Grande between RM 114 (lower right) and RM 113 (upper left) in the San Acacia area.

Erosion Causing Lateral Migration

The three bends between RM 111 and RM 110 which were described earlier, are classic examples of migrating bends. Although these bends became quite large during 2005, they have a curvature that is relatively tight compared to the 'widening' bends found upstream of Arroyo Alamillo. Most distinctively, large point bars (Figure 19) were observed growing as the bankline retreated, in fact, these point bars emerged just after the runoff peak and remained emerged as water level decreased. The retreat of the bankline was not only significant, but large enough to warrant periodic mapping to determine rates of movement (Figure 5).

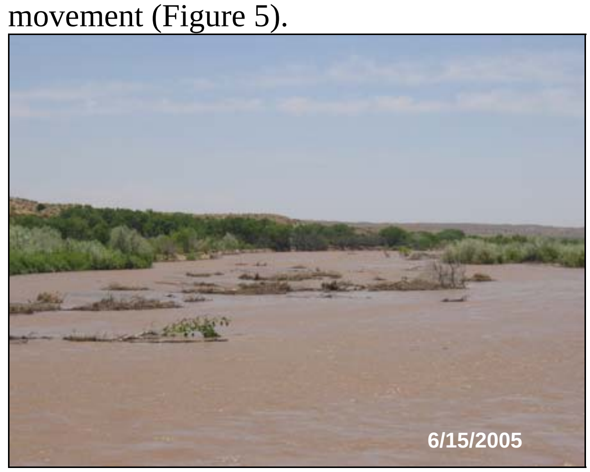

Figure 19: Point bar growth on east bank, opposite the eroding bankline at the RM 111 River Maintenance Priority Site.

Obviously, the migrating bends can easily move the river channel into and beyond the levee system that is present to the west; perhaps less obvious is that even the slower ‘widening’ bends are moving the location of the river’s edge and should also be routinely monitored, albeit with less rigor than the actively migrating bends. Further investigations are necessary to: 1-assess measurable characteristics that define each type of river bend, 2-create a model that defines the formation of the two types of bends, and 3-prepare a model that could predict whether the ‘widening’ bends will transform into migrating bends.

References:

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