RECLAMATION

Managing Water in the West

San Acacia River Mile 111 Priority Site

Bend Migration Assessment
Final Report

U.S. Department of the Interior
Bureau of Reclamation

March 2005

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by

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Upper Colorado Region
Albuquerque Area Office
Environment Division
Albuquerque, New Mexico

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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.

Introduction

South of the San Acacia diversion dam (5.2 miles), the Rio Grande channel is migrating southwest, which is causing rapid erosion of the west channel bank. The migration is nearing the levee (Figure 1) and has created the potential to jeopardize levee integrity. This site is listed by the Bureau of Reclamation-Albuquerque Area Office as a River Maintenance Priority Site: San Acacia Priority Site at RM 111 (RM 111). The rate and direction of bend migration is evaluated in this analysis to address river maintenance needs at the RM 111 Priority Site: Reclamation is pursuing a levee setback project at this location. This bend evaluation is intended to assist in estimating the project life for the levee setback. The assessment is based primarily on comparing river locations on current and historical aerial photographs with a Geographic Information System (ArcMap 8.2).

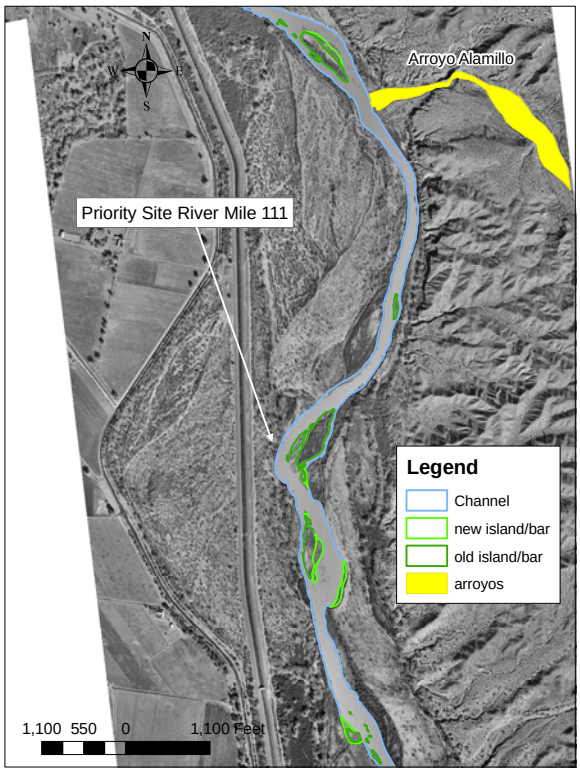

Figure 1: Recent aerial photograph (2001) of the priority site at RM 111.

Bend Evolution

Bankline evolution of the RM 111 bend was assessed using Reclamation historical aerial photographs and digitized bankline data. Seven sets/years of aerial photographs were used in the assessment: 1949, 1972, 1988, 1992, 1996, 1999, and 2001. The 1988, 1996 and 1999 photographs were scanned, geo-referenced, and had bankline shapefiles created by Tyler Smith (Reclamation-Technical Services Division, Albuquerque Area Office). The 1949, 1972 and 1992 photographs were scanned and geo-referenced by Jan Oliver at Reclamation, Technical Services Center-GIS and Remote Sensing Group, Denver, CO; Oliver also created bankline shapefiles for these photosets as well as the 2001 photos. The 2001 photographs were prepared digitally. Two aspects of the bend were assessed with the photo data: the general shape of the bend, and location of its apex. The bend apex is defined in Smith and Massong (2004).

The evolution of the bend at RM 111 is divided into two phases: 1-bend initiation and pattern development (1985-1996) and 2-initiation of lateral migration (1996-present). The RM 111 bend first appeared in the 1985 digitized data as a slight undulation in the bankline (Figure 2). The bend became slightly more distinct in the 1988 photos but its apex had not migrated significantly. By 1992, the bend was still a small and shallow undulation in the bankline, but it had developed a rounded curvature. Another small bend formed 1988-1992, immediately upstream of the RM 111 bend. Although these two bends were still distinct undulations in the 1996 bankline, they became somewhat connected as the entire bankline began to migrate westward. The apex of this new, large bend was slightly upstream and westward of the original RM 111 bend found in 1992. Along with this bend evolution, a medial bar had developed in the right-center of the 1996 active channel. The development of the island indicates a significant shifting of the thalweg both in location and likely an increase in depth. The change in thalweg characteristics are consistent with the braided-to-meandering transition/evolution that has been documented upstream in this reach of the Rio Grande (Reclamation 2003) and farther upstream near Albuquerque, NM (Massong 2004). The transitioned channels usually have a relatively deep thalweg which easily erodes bank material and laterally migrate.

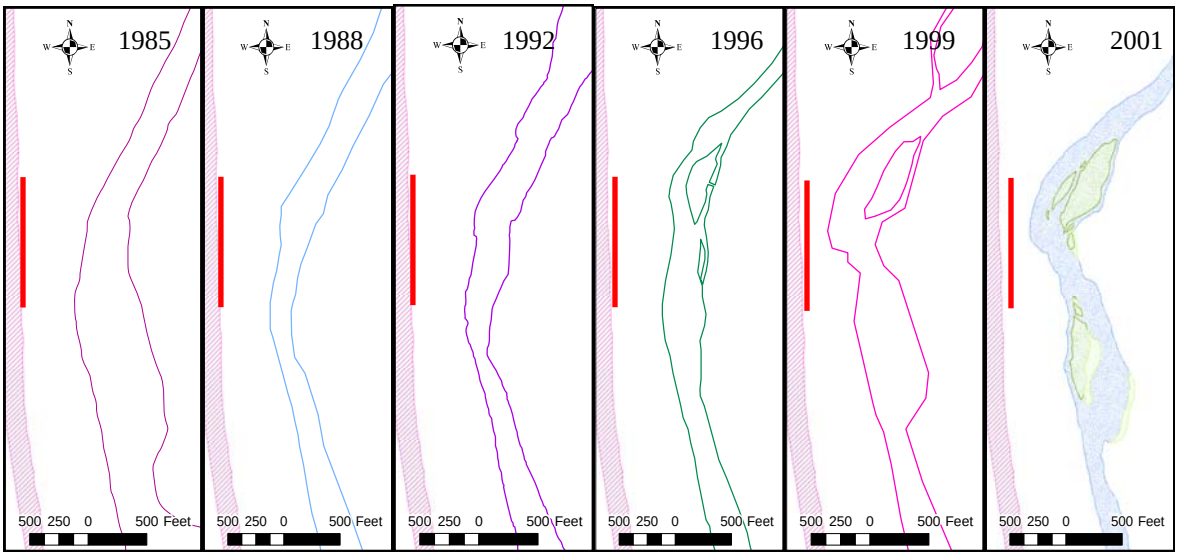

Figure 2: River channel and bank outlines at RM 111 from 1985 (left) to 2001 (right) displaying the development of the RM 111 bend (upstream bend) and the bend that has developed immediately downstream of the project area. The pink striped polygon on the west side of each inset figure is the current levee location. The red line identifies the present location of potential levee erosion.

Between 1996-1999, the bend began to migrate laterally (Figure 2), rounding its bankline and completely engulfing the two smaller bends found in the 1996 photos. In conjunction with migration of the west bank, the medial bar immediately upstream grew westward. The older sections of this bar became vegetated and now appear stable (cover photo); significant vegetation growth occurred 1996-1999. No bend migration occurred between 1999 and 2001; however, the downstream end of the bend appears to have been eroded. The lack of bend migration in this time frame is likely due to relatively lower spring flows in the 1999-2001 period (Appendix A, Reclamation 2003). Although no migration occurred 1999-2001, the medial bar continued to grow creating a smaller wetted channel width. This decrease in channel width enhanced the single thalweg that was already present: the thalweg appeared to become more prominent along the west bank and likely deepened. Although these recent changes appear minor, they appear to be preparing the bend to continue the migration trend once larger flows return.

Migration Analysis and Rates

The migration characteristics of two meander bends were assessed: 1-the priority site bend, RM 111 (Figure 3); and the bend immediately downstream (Appendix B). As discussed earlier, the bend located at RM 111 initially migrated upstream while it was forming, but then moved rapidly downstream and towards the west levee after it had established its form. Between 1996 and 2001, this bend migrated at an average rate of 90 feet/year (Table 1), with all the migration occurring between 1996 an 1999. Between 1999 and 2001, the migration stalled, however field observations in March 2004 indicate that migration has resumed.

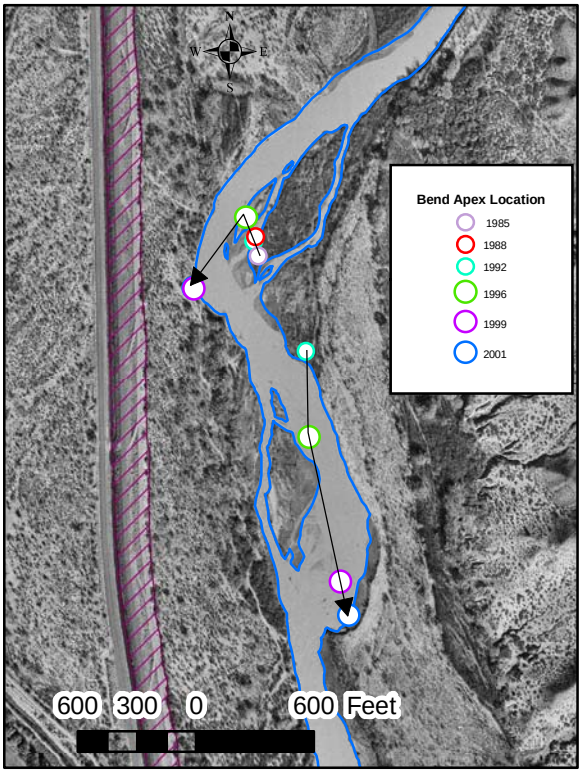

Figure 3: History of apex locations of two bends: bend at RM 111 and the bend immediately downstream. Photo date: 2001.

Table 1: Summary of bend migration at the RM 111 priority site.

Time Period	Distance (ft)	Direction (°)	Rate of Migration
1985-1992	80	345 (west of north)	10 ft/yr
1992-1996	125	345 (west of north)	30 ft/yr
1996-2001	450	225 (south of west)	90 ft/yr

Future Erosion Rates and Bend Locations

Estimating the exact rate of future migration of the bend at RM 111 is difficult as the bank composition is complex. The bank material at the RM 111 bend contains sediments from a series of historic channels and islands (Figure 4). The oldest bank material at the RM 111 bend is that of the 1918 island (Figure 5) located immediately downstream of the current bend apex; based on field observations, the height of this surface is approximately 10-12 feet above the current channel bed. Between 1918 and 1935, the two 1918 islands became connected and the boundaries were rounded by the river. The eastern edge of the 1935 island was either eroded directly by the river or was mechanically altered as part of the channel re-alignment between 1935 and 1949, either way, the current west bank of the Rio Grande stabilized by 1949 and has shifted little since that time. The island remnants present in the 2001 photos (Figure 4-the uncolored patches left of center in the figure) were those originally mapped in 1918 and hence are likely older than 100 years. The dominant vegetation on these surfaces are mature cottonwoods, grasses, small bushes and the occasional juniper found in the understory. Interestingly, few saltcedar and Russian Olive trees are present. The surface associated with the active 1935 channel is now a terrace with a height of approximately 8 feet (Reclamation 2003).

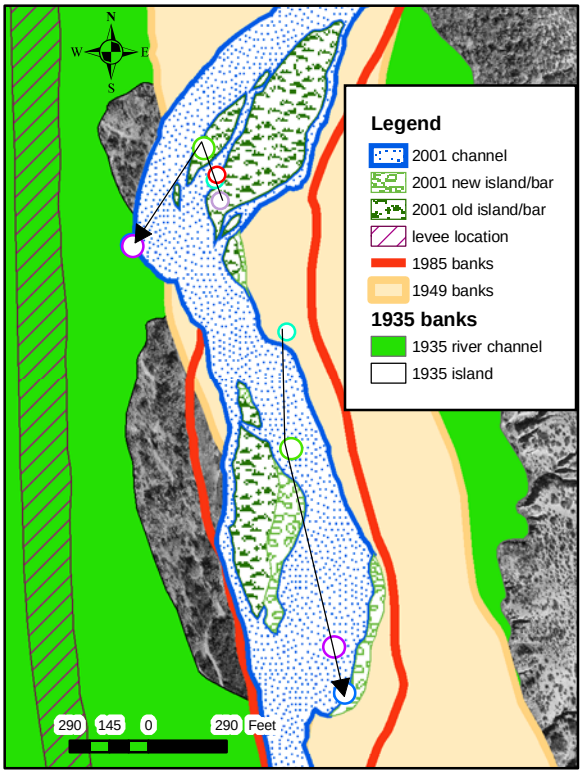

Figure 4: The current channel location overlain on the historical channels (1935-1949).

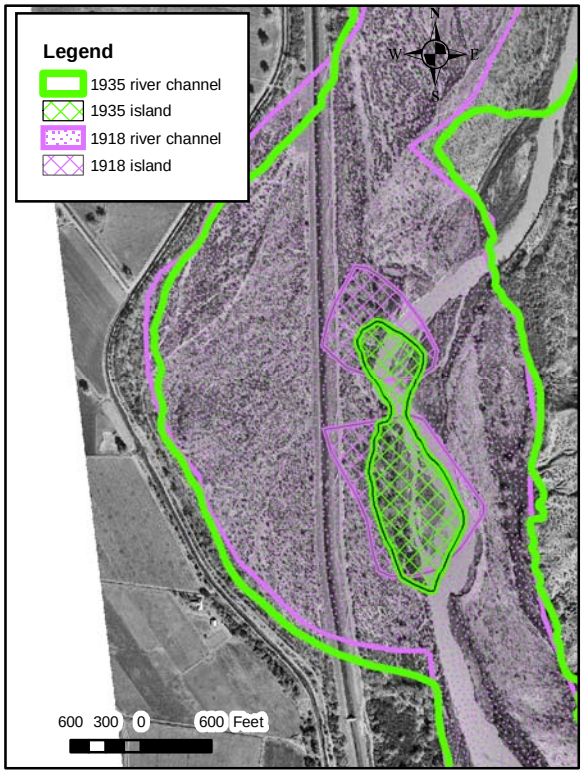

Figure 5: The location of the Rio Grande in 1918 and 1935 at RM 111. Note the large island present in the middle of the bends in 1918 and 1935.

The current channel location overlain on the historical channels (1935-1949) show the vegetated island present in 1918 was partially eroded by the Rio Grande in 1949 photos, and that the current channel is actively eroding the northern section of the old island. If the bend continues to migrate in it current direction, it will continue to intersect the old island at the downstream end of the bend. Also, since the current channel can not flank the old island, as the 1935 surface is 8 feet higher than the current channel and can not be flooded, the current channel must completely erode the old island to reach the proposed new levee location.

The future migration of the bend at RM 111 was estimated using the current migration direction with a combination of two migration rates at this bend: current migration rate of 90 feet/year for the first 10 years; and the RM 114 migration rate of 40 ft/yr (Smith and Massong 2004) for after the first 10 years. The current migration rate of 90 feet/year was applied for the first 10 years of movement; however, after the first 10 years, the resistant island material is presumed to slow the total migration rates. In the RM 114 assessment, several bends were assessed which had longer migration histories than the RM 111 bend; ~40 feet/year appeared to be representative of migrations of those bends. As those bends are migrating through similar sediments as the 1935 surface at RM 111, they are likely representative of the long term potential at this site. With an average rate of 40 feet/year, the RM 111 bend could reach the 1935 bankline in approximately 50 years (Figure 6). However, the new levee location will be on the inside of the old 1935 bend, thus reducing the bend radius by approximately 450 feet at the estimated bend apex location (Figure 6). As a consequence, the RM 111 bend is projected to reach the new levee alignment in approximately 30 years.

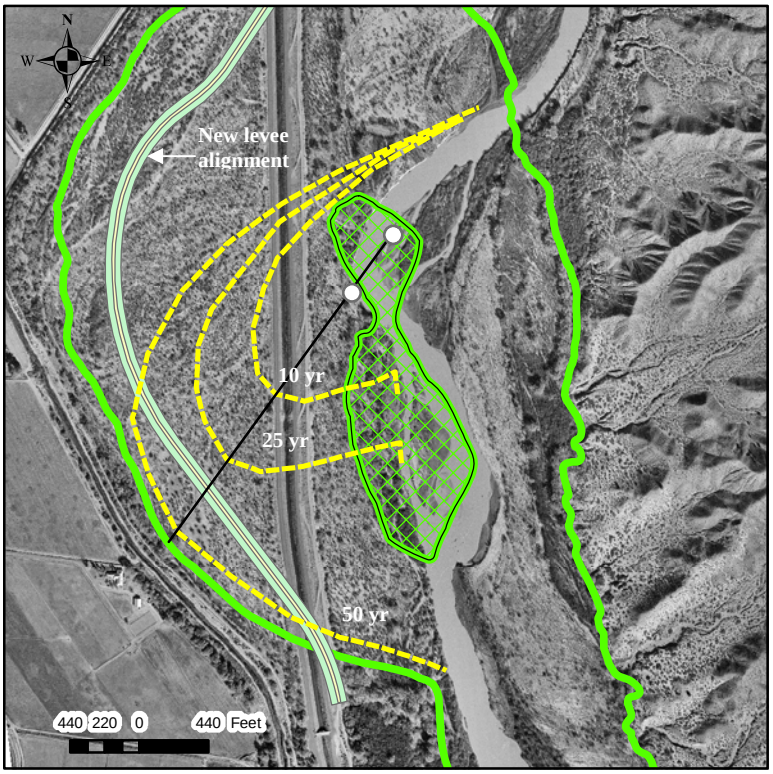

Figure 6: Estimated bend location at Priority Site RM 111 at 10 years, 25 years and 50 years with an overlay of the estimated new levee alignment position. Background photo date is 2001; 1935 channel location in green; 1935 island in green hatch. Estimated new levee alignment provided by Tyler Smith-Reclamation, AAO.

Since the erosion rates of the old 1918 island are unknown, the projected rates of bend migration are relatively poor. Re-assessment of future migration rates at about 15 years should be performed to assess the reasonableness of using the 40 feet/year migration rate. Also, significant peak flows in this reach could also reduce the certainty of these estimates, as large events can rapidly erode sand composed bank material such as those found in the 1935 terrace at RM 111.

Literature Cited

Bureau of Reclamation, 2003, Geomorphic Assessment of the Rio Grande, San Acacia Reach, June 2003, Technical Report, Upper Colorado Region, Albuquerque Area Office, Albuquerque NM, 78 p.

Massong, T. M., 2004, Geomorphology Summary, Rio Grande-Bernalillo Bridge Reach, September 2004, unpublished Technical Report (final draft), Bureau of Reclamation, Albuquerque, NM, 17+ p.

Smith T. and Massong, T., 2004, San Acacia River Mile 114 and 113 Priority Sites, Bend Migration Estimates, August 2004, unpublished Technical Report (draft), Bureau of Reclamation, Albuquerque, NM.

Appendix A

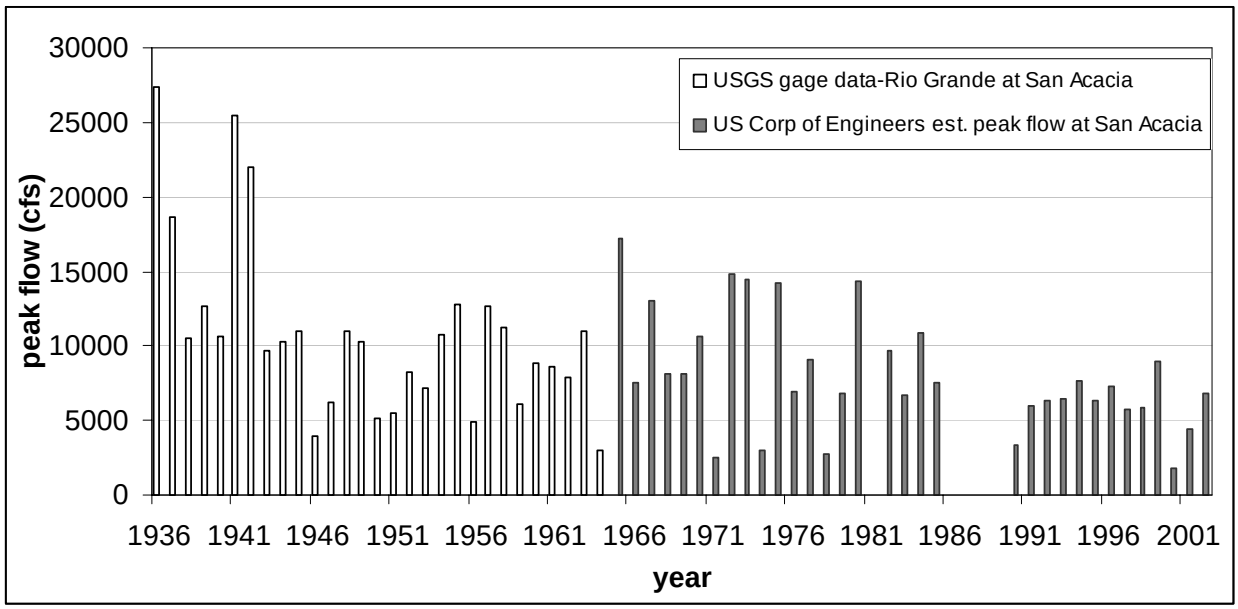

Figure A-1: Summary of peak flow data for the Rio Grande at San Acacia.

Appendix B
Description of the Bend downstream of RM 111

The bend immediately downstream of RM 111 developed between 1992 and 1996 and since that time has migrated and grown (Figure B-1). Between 1996 and 1999, this bend experienced its most rapid migration at 250 feet/year (Figure B-2, Table B-1), before slowing to a rate of 60 feet/year (1999-2001). Similarly to the RM 111 bend, this bend also migrated 2001-2004 based on visual inspections in March 2004 (Figure B-1).

Figure B-1: Photos of the bend immediately downstream from the San Acacia Priority Site RM 111. The top photo (2000) looks toward the east bank. The bottom photo (2004) looks toward the west bank and levee. Notice that the island/bar at the top right of the 2004 photo has fairly new vegetation growth with just the beginnings of woody vegetation (the mint-green vegetation is Russian Olive). The bar is present in the 2000 photo, however not vegetated. Also note that the bend did erode the outside of the bend

between the two photo dates; however the opposing angle makes measurements impossible.

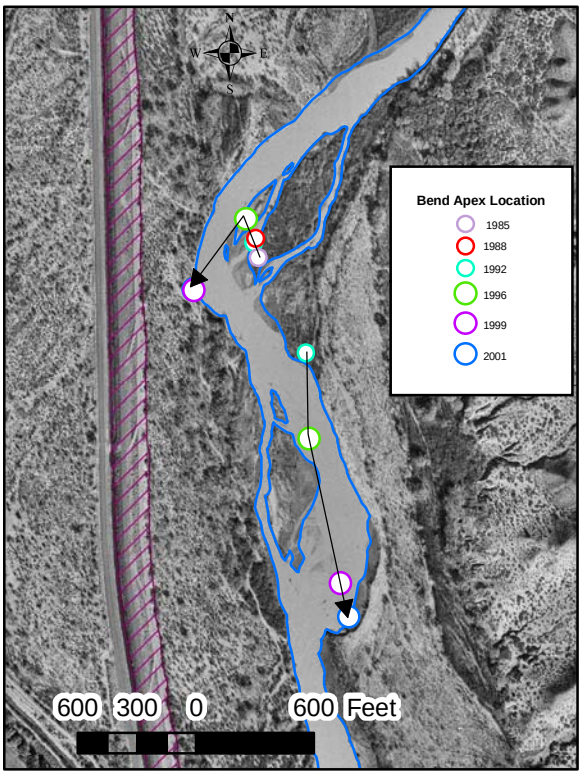

Figure B-2: History of apex locations of two bends: bend at RM 111 and the bend immediately downstream. Photo date: 2001.

Table B-1: Summary of bend migration for the meander bend downstream from RM 111 bend.

Time Period	Distance (ft)	Direction (°)	Rate of Migration
1992-1996	440	180 (south)	110 ft/yr
1996-1999	760	170 (east of south)	250 ft/yr
1999-2001	185	170 (east of south)	60 ft/yr

The bank material at the bend downstream of RM 111 is relatively uncomplicated as it is predominantly riverine sediments deposited in the 1980s; the bank height is estimated at 4-6 feet (Reclamation 2003). The Rio Grande had a relatively large channel width in 1985 with a western boundary similar to that present today, while the eastern bank extended well beyond the current location of the channel (Figure B-3). Between 1985 and 1988, the channel re-aligned and narrowed in this section of the reach; as a consequence of this change, the 1988 channel was significantly narrower with most of the eastern portion of the channel abandoned. This section of abandoned channel is now the eastern bankline; it is composed predominantly of loose sand (a.k.a., sugar sand) that is easily eroded by the river. The erosion occurring at this site is mostly parallel to the current active channel, hence the dominant change in the Rio Grande due to this bend migration is active channel widening. Also, the large bend migration rates occurring at this downstream bend are likely higher than would be expected at RM 111 since the

bank material eroding at RM 111 is more cohesive and the bend direction is not parallel to the current active channel. However, the rates of migration at this downstream bend are considered the maximum rates to be expected in this reach of river.

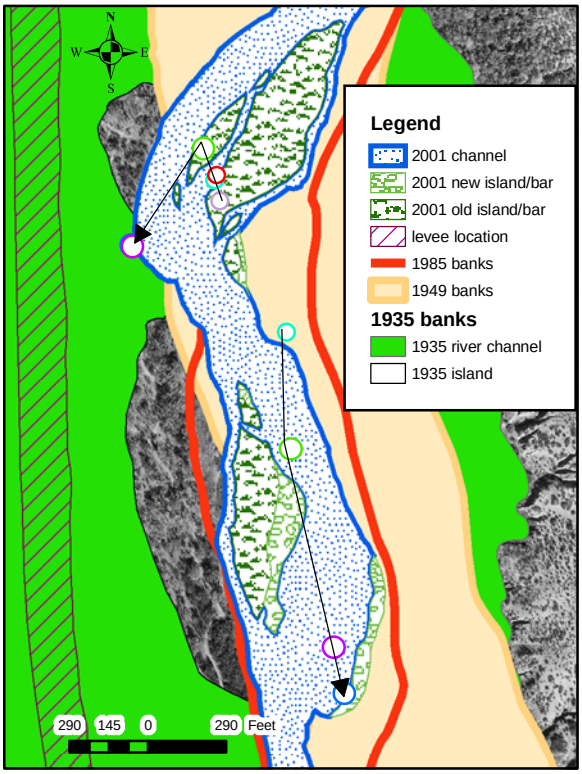

Figure B-3: The current channel location overlain on the historical channels (1935-1949).