6. Analysis of Effects of Proposed Actions

The discussion of effects in this document is divided into several sections. The first section is general in nature and attempts to broadly define the effects of river maintenance (sections 6.1 and 6.2) large scale, reach basis. The effects of implementing river maintenance strategies on a reach level are discussed in section 6.1. The implementation of river maintenance strategies (see section 3.2) within a reach is designed to address observed trends resulting from underlying physical processes. The general geomorphic effects of implementing the six river maintenance strategies are described in section 6.1.1 and in the Strategy Effects Attachment, with additional reach implementation geomorphic details provided in section 6.1.2. The biological effects on the silvery minnow and the flycatcher are described in section 6.1.3 based on the known channel dynamics (observed geomorphic channel trends) and the anticipated channel responses to strategy implementation. The anticipated channel responses and conditions may change if the observed geomorphic trends adjust in the future.

River maintenance sites, within the context of this BA, may be implemented as individual sites within the context of a reach-based river maintenance strategy or as a priority site project. These two types of activities may use the same river maintenance methods (section 3.3) and implementation techniques (section 3.6.4.5). They also both rely on a variety of river maintenance support activities (section 3.6.4). The implementation of individual river maintenance site projects have localized effects on geomorphology, endangered species, and habitat conditions. The localized geomorphic effects of river maintenance methods are described in section 6.2. Biological effects for both silvery minnow and flycatchers are estimated based on the amount and distribution of work that has been performed historically or as predicted by the river maintenance Proposed Action. These effects are analyzed throughout section 6.2. Currently, the only recognized Pecos sunflower population within the defined river maintenance action area is on the Rhodes property south of Arroyo de las Cañas. Reclamation will work with the Service to avoid impact to the sunflower populations on any river maintenance activities that would affect the Pecos sunflower population.

Section 6.3 describes the biological and geomorphic effects from operation and maintenance of Project drains and the LFCC. Pecos sunflower effects are analyzed in conjunction with the Project drain near La Joya State Wildlife Area (section 6.3.2.3), since there are currently no known Pecos sunflower populations within the flood plain of the Rio Grande.

MRGCD MRG maintenance proposed actions are analyzed within section 6.4. A summary of all MRG biological effects is provided in section 6.5.

6.1 River Maintenance Strategy Effects on Geomorphology

Strategies define reach-scale management approaches to meet the river maintenance goals (see section 3.2). Strategies were assessed by geomorphic suitability for a reach. More information on the identification of the most likely strategies by reach and the rationale for why strategies are listed as unsuitable in a reach can be found in the Middle Rio Grande River Maintenance Program Comprehensive Plan and Guide (Reclamation 2012a). Only strategies that were determined to be suitable are described in this document. The following general (section 6.1.1) and reach by reach (section 6.1.2) sections describe the effects of suitable river maintenance strategies given the current geomorphic reach trends. Estimated effects on silvery minnow and flycatcher habitat due to implementation of these strategies are outlined in table 34 (later in this chapter). It should be noted that future geomorphic trends of the river could change, and the selection of suitable strategies could be different.

General strategy effects on the geomorphology are described based on the expected outcome of the change in the balance between sediment transport capacity and sediment supply within a reach after implementation. Where the probable magnitude of an effect is known, it is stated. The balance between sediment transport capacity and sediment supply affects channel processes and strongly influences geomorphic changes and conditions. An imbalance between sediment transport capacity and sediment supply is the key cause of most channel and flood plain adjustments. These are evinced in the river through changes in trends. Complementary strategies are those that create similar changes, relative to the balance between sediment transport capacity and sediment supply and could be used to address the same trends. Complementary strategies are also strategies that more likely are to be used in combination. Effects of multiple strategy combinations are not described explicitly, but the use of combinations from complementary strategies generally would produce the same described effects.

Reaches where sediment transport capacity is generally less than sediment supply are the reaches between Arroyo de las Cañas and the Full Pool Elephant Butte Reservoir Level. For these reaches, changes and corresponding strategies that bring sediment transport capacity closer to sediment supply include the following:[2]

- Increase sediment transport capacity – Reconstruct/Maintain Channel Capacity

[2] Promote Elevation Stability is an applicable strategy for aggrading reaches; however, the actual implementation would be through the complementary strategies of Reconstruct/Maintain Channel Capacity, Increase Available Area to the River, Manage Sediment, and/or Promote Alignment Stability.

- Reduce sediment supply – Manage Sediment
- Allow channel realignment to lower bed elevation – Increase Available Area to the River, Promote Alignment Stability
- Initiate channel realignment to lower elevation – Reconstruct/Maintain Channel Capacity
- Levee strengthening/raising to allow realignment – Reconstruct/Maintain Channel Capacity

Reaches where sediment transport capacity is generally greater than sediment supply are the reaches between Velarde and Otowi Bridge and those between Cochiti Dam and Arroyo de las Cañas. For these reaches, changes and corresponding strategies that bring sediment transport capacity closer to sediment supply include the following:

- Increase length of channel – Promote Alignment Stability, Increase Available Area to the River
- Limit bank erosion – Promote Alignment Stability
- Add sediment supply – Manage Sediment
- Reduce sediment transport capacity of high flows – Rehabilitate Channel and Flood Plain
- Reduce or control future channel bed lowering – Promote Elevation Stability

Additional information may be needed to better define a future specific project and its effects based upon its planned methods, changes in reach trends, and necessary monitoring or adaptive management. As needed, additional details tiered off this programmatic river maintenance BA would be developed and coordinated with the Service.

6.1.1 General River Maintenance Geomorphic Effects

The geomorphic effects of implementing river maintenance strategies (section 3.2 provides a description of the strategies) are estimated through an analysis of the expected physical changes in a reach as a result of strategy implementation. While the effects are described qualitatively, several tools were developed and used to aid in understanding the observed river trends and the strategy implementation effects on these trends on a reach by reach basis. These tools include mobile and fixed bed modeling (Varyu et al. 2011), meander belt analysis (Varyu et al. 2011), and the MRG planform evolution model (Massong et al.

2010). Results from these tools helped provide a qualitative understanding of the existing conditions and expected trajectory of reach adjustments without maintenance. The results also provided a means to assign and evaluate the effects of strategy implementation through a comparison of modeled physical results, such as:

- Bed elevation changes
- Flood plain inundation changes
- Bed material size changes
- Channel length changes
- Lateral mobility and its relationship with existing lateral constraints
- Sediment load changes
- Geomorphic planform changes

For the reaches between Cochiti Dam and the Full Pool Elephant Butte Reservoir Level; the modeling and analysis tool results (Varyu et al. 2011; Reclamation, 2012a) were coupled with professional judgment and individual reach geomorphology to provide a qualitative description of the reach implementation effects of river maintenance strategies. This description relies on the different methods that will be used to implement reach based strategies (see River Maintenance Methods Attachment for a description of localized methods associated with a strategy and a description of those methods and their general effects). The general method effects are combined with strategy characteristics to create a general description of the effects. These general effects are then refined to reach specific effects (see section 6.1.2). Professional judgment and an understanding of reach trends were used to provide a qualitative description of the geomorphic effects of river maintenance strategies for the 10 reaches (see figure 1 for a map of the reach designations).

The Strategy Effects Attachment provides a list, by strategy, of the general reach trends addressed (not in order of importance), the effects of implementing each strategy in a reach, additional potential complementary strategies that address the same trends, and effects of strategy implementation in downstream and upstream reaches. Strategies address observed geomorphic trends through four primary actions: stopping, reducing, reversing, and making it a non-issue. The first three are straightforward actions related to the strategy effect on the trend, given the current understanding on the MRG. The last one allows the trend to continue, while reducing the need for river maintenance. The Strategy Effects Attachment provides a further separation of strategy implementation and ensuing effects by the relationship between sediment transport capacity and sediment supply, since the outcomes are different if the sediment transport capacity is greater than or less than the sediment supply. If a strategy only lists one condition, such as sediment transport capacity less than sediment supply for Reconstruct and Maintain Channel Capacity, then it can be assumed that this strategy is not applicable to the other condition—in this case, sediment transport capacity greater than sediment supply. These are general reach effects; so there may be uncertainty in the magnitude of physical effect. Where the probable magnitude of physical effect is known, it is so stated.

6.1.2 Most Likely Geomorphic Strategy Effects by Reach

Strategies that address geomorphic trends and, thus, the most likely to be implemented, have been identified in the Proposed Action by reach (section 3.2.8). Where potential future geomorphic trends influence the effect of strategy implementation, they are included in each reach effects description. These potential future trends are identified through analysis of patterns of historical changes, results from Varyu et al. (2011), the planform evolution model (Massong et al. 2010), and professional judgment. Where the probable magnitude of an effect is known, it is stated. Where the magnitude of effect is uncertain, more information is needed to estimate it; and this would be developed, tiered off this programmatic river maintenance BA and coordinated with the Service.

Some general strategy effects are included in each reach strategy effects discussion where they are of much more significance than other general effects. It is possible that future geomorphic trends of the river could change so that additional strategies would become suitable for a reach or the converse. The 10 reaches are identified and shown graphically in section 2.1. Estimated effects on silvery minnow and flycatcher habitat due to implementation of these strategies in each reach are outlined in tables 33 and 34 (shown later in this document).

6.1.2.1 Velarde to Rio Chama – RM 285 to 272

6.1.2.1.2 Trends

This reach has been influenced by historical activity and past variability in the sediment and hydrology, resulting in a flood plain that is absent or disconnected from the main channel. Historical conditions and current hydrological inputs upstream and sediment inputs from tributaries located within this reach have contributed to the following trends currently observed in this reach.

- Channel narrowing
- Vegetation encroachment
- Bank erosion
- Coarsening of bed material
- Increased channel uniformity

6.1.2.1.2 Promote Elevation Stability

This strategy is not suitable because there is a low potential for new degradation.

6.1.2.1.3 Promote Alignment Stability

Reach Effects.—In general, this strategy addresses the trend of bank erosion through stabilizing the banks and preventing additional bank erosion that would harm or endanger public infrastructure, such as roads, irrigation facilities, houses, etc. The narrowness of this reach and the proximity of infrastructure likely would result in using a more direct and permanent bank protection method. Field observations show bank erosion opposite some new tributary deposits in the main channel. The general effects of this method implemented on a reach scale, for the sediment transport capacity greater than sediment supply case, are described in table 1 of the Strategy Effects Attachment. However, in this reach, the contribution of sediment from bank erosion is relatively low due to low rates of bend migration. Therefore, a decrease in sediment supply is not expected to have significant effects. This strategy likely would keep the current conditions for sinuosity and overbanking wetted area. Within this reach, there are numerous diversion dams that provide vertical stabilization through their effect on the river bed elevation. These diversion dams, to some extent, also help provide local alignment stability as, typically, bank protection is provided in close vicinity to the dams, upstream and downstream, to prevent flanking.

Upstream and Downstream Effects.—The general upstream and downstream effects are listed in table 1 of the Strategy Effects Attachment for the sediment transport capacity greater than sediment supply case. The sediment supply for the Rio Chama to Otowi Bridge Reach may decrease slightly, but effects are expected to be minimal. For the reach north of Velarde, it is not expected that there would be significant upstream effects.

6.1.2.1.4 Reconstruct and Maintain Channel Capacity

This strategy is not suitable because a reach-wide loss of channel capacity is not expected.

6.1.2.1.5 Increase Available Area to the River

Reach Effects.—In general, this strategy addresses channel narrowing, increased bank height, and bank erosion. The effects of this strategy would be to increase the degrees of freedom on the channel, as described in table 4 of the Strategy Effects Attachment, for the sediment transport capacity greater than sediment supply case. This allows for the possibility to increase the sinuosity and the overbanking wetted area by allowing the channel to migrate and create new depositional features. This channel evolution also may create the opportunity to decrease high-flow energy that may have the effect of decreasing the bed material size.

Upstream and Downstream Effects.—Implementing this strategy will provide additional area for future river migration but will not immediately affect current downstream or upstream reach trends. The general upstream and downstream effects are listed in table 4 of the Strategy Effects Attachment for the sediment transport capacity greater than sediment supply case. The Rio Chama to Otowi Bridge Reach has an existing sediment transport capacity greater than sediment supply, so the Rio Chama to Otowi Bridge Reach effects of adding sediment are expected to be minimal. If the bank material is fine enough, this strategy may deliver increased sediment load to the Cochiti Reservoir pool and have an impact on its serviceable life. Over time as the channel evolves nearer to dynamic equilibrium, downstream sediment supply from lateral migration will decrease. It is expected that the reduced sediment supply in the long term would have minimal effect on channel trends in the Rio Chama to Otowi Bridge Reach. The reach north of Velarde is outside the MRG Project area and is strongly influenced by geologic controls. Actions in the Velarde to Rio Chama Reach are expected to have minimal upstream effects for the reach north of Velarde. Near the upstream boundary on the Velarde to Rio Chama Reach is the Los Chico and La Canova Diversion Dam that effects bed elevation and river location and further limits effects upon the reach north of Velarde.

6.1.2.1.6 Rehabilitate Channel and Flood Plain

Reach Effects.—In general, this strategy addresses channel narrowing, vegetation encroachment, and bank erosion. This strategy would increase the overbanking wetted area and may increase the channel sinuosity. This strategy also would have the general effects as described in table 5 of the Strategy Effects Attachment for the sediment transport capacity greater than sediment supply case. This strategy also may increase the braiding within the reach; however, sediment loads are relatively small, so this effect is expected to be minimal. In the long term, this strategy may reduce the high-flow sediment transport capacity.

Upstream and Downstream Effects.—Implementing this strategy has the general upstream and downstream effects as described in table 5 of the Strategy Effects Attachment for the sediment transport capacity greater than sediment supply case. The Rio Chama to Otowi Bridge Reach has an existing transport capacity greater than supply, so the downstream reach effects of the addition of sediment are expected to be minimal. If the bank material is fine enough, this strategy may deliver increased sediment load to the Cochiti Reservoir pool, although the increase to the sediment supply is expected to be small and would be expected to have only a minimal impact on the reservoir pool’s serviceable life. Some methods also may induce sediment deposition, thereby decreasing downstream sediment supply. In comparison to downstream reaches, the sediment load in the Velarde to Rio Chama Reach is small, so this effect on the Rio Chama to Otowi Bridge Reach is expected to be minimal. It is expected that the reduced sediment supply in the long term would have minimal effect on channel trends in the Rio Chama to Otowi Bridge Reach. The upstream reach effects, for the reach north of Velarde, are expected to be minimal as described in table 5 of the Strategy Effects Attachment for the sediment transport capacity greater than sediment supply case.

6.1.2.1.7 Manage Sediment

This strategy is not suitable because there is no reach-wide imbalance in sediment transport capacity and sediment supply.

6.1.2.2 Rio Chama to Otowi Bridge – RM 272 to 257.6

6.1.2.2.1 Trends

This reach has been influenced by historical activity and past variability in the sediment and hydrology, resulting in the abandonment of a once relatively large flood plain. Historical conditions and current hydrological inputs upstream and sediment inputs from tributaries located within this reach have contributed to the following trends currently observed in this reach:

- Channel narrowing
- Vegetation encroachment
- Bank erosion
- Coarsening of bed material
- Increased channel uniformity

6.1.2.2.2 Promote Elevation Stability

Reach Effects.—In general, this strategy addresses the trends of increased bank height, incision or channel bed degradation, and coarsening of bed material. The general effects of this method implemented on a reach scale are described in table 1 of the Strategy Effects Attachment for the sediment transport capacity greater than sediment supply case. This strategy is expected to maintain the status quo for overbanking wetted area and sinuosity, although there is the possibility, depending on how the strategy is implemented, to increase the overbanking wetted area. The additional overbanking wetted area likely would be small since the expected maximum increase in bed elevation through implementing this strategy is 1–2 feet. In local areas where the bed elevation is below riparian vegetation root zone, additional bank erosion could occur. This strategy would help stabilize the bed in the reach and also may provide additional bank stability.

Upstream and Downstream Effects.—The general upstream and downstream effects are as described in table 1 of the Strategy Effects Attachment for the sediment transport capacity greater than sediment supply case. This strategy may decrease the amount of sediment available for the river to transport through the White Rock Canyon Reach. This reach has considerable geological controls, and effects from this strategy in the White Rock Canyon Reach are expected to be minimal. For the Velarde to Rio Chama Reach, this strategy may temporarily lower the sediment transport capacity. The bed through the Velarde to Rio Chama Reach may rise slightly, especially on the southern end of the downstream reach, with a minimal change expected in channel morphology and flood plain connectivity. The effects of implementing this strategy in the Rio Chama to Otowi Bridge Reach also may have the effect of a short-term bed material fining in the Velarde to Rio Chama Reach.

6.1.2.2.3 Promote Alignment Stability

Reach Effects.—In general, this strategy addresses the trend of bank erosion through stabilizing the banks and preventing additional bank erosion that would harm or endanger public infrastructure, such as roads, irrigation facilities, recreational facilities, houses, etc. The general effects of this method implemented on a reach scale are described in table 2 of the Strategy Effects Attachment for the sediment transport capacity greater than sediment supply case. However in this reach, due to low rates of lateral migration, the contribution of sediment from bank erosion is relatively low. Therefore, a decrease in sediment supply from bank erosion is not expected to have significant reach geomorphic effects. This strategy likely would keep the status quo for sinuosity and overbanking wetted area.

Upstream and Downstream Effects.—The general upstream and downstream effects are as described in table 1 of the Strategy Effects Attachment for the sediment transport capacity greater than sediment supply case. The sediment supply to the White Rock Canyon Reach may decrease slightly, but effects are expected to be minimal due to the extent of geological controls in the downstream reach. The downstream reach also feeds into the Cochiti Reservoir pool, so implementing this strategy in the Rio Chama to Otowi Bridge Reach may help to lengthen the reservoir life. It is not expected that there would be significant effects in the Velarde to Rio Chama Reach.

6.1.2.2.4 Reconstruct and Maintain Channel Capacity

This strategy is not suitable because a significant loss of channel capacity is not expected.

6.1.2.2.5 Increase Available Area to the River

Reach Effects.—In general, this strategy addresses channel narrowing, bank erosion, and increased channel uniformity. The effects of this strategy would be to increase the degrees of freedom on the channel, as described in table 4 of the Strategy Effects Attachment for the sediment transport capacity greater than sediment supply case. This allows for the possibility to increase the sinuosity and the overbanking wetted area by allowing the channel to migrate and create new depositional features. This channel evolution also may create the opportunity to decrease high-flow energy that may have the effect of decreasing the bed material size.

Upstream and Downstream Effects.—Implementing this strategy will provide additional area for future river migration but will not immediately affect current downstream or upstream reach trends. The general upstream and downstream effects are as described in table 4 of the Strategy Effects Attachment for the sediment transport capacity greater than sediment supply case. This strategy may increase the sediment supply to the White Rock Canyon Reach as the channel lengthens. Over time and as the channel evolves nearer to dynamic equilibrium, the White Rock Canyon Reach sediment supply from lateral migration will decrease. The White Rock Canyon Reach has significant geological controls, so minimal changes are expected in the local channel morphology or flood plain connectivity. If the bank material is fine enough, this strategy may deliver a small increase in sediment load to the Cochiti Reservoir pool and would be expected to have only a minimal impact on the reservoir pool's serviceable life. In the Velarde to Rio Chama Reach, there is the potential for this strategy to decrease the channel sediment transport capacity and/or reduce bed material size. However, this potential change is expected to have minimal effect on the channel morphology and flood plain connectivity.

6.1.2.2.6 Rehabilitate Channel and Flood Plain

Reach Effects.—In general, this strategy addresses channel narrowing, vegetation encroachment, bank erosion, and increased channel uniformity. This strategy would increase the overbanking wetted area and may increase the channel sinuosity. This strategy also would have the general effects as described in table 5 of the Strategy Effects Attachment for the sediment transport capacity greater than sediment supply case. This strategy may increase the braiding within the reach. In the long term, this strategy may reduce the high-flow sediment transport capacity, but the effect may diminish as sediment deposits in the overbank area and the high-flow channel becomes narrower.

Upstream and Downstream Effects.—Implementing this strategy has the general upstream and downstream effects as described in table 5 of the Strategy Effects Attachment for the sediment transport capacity greater than sediment supply case. The White Rock Canyon Reach has significant geological controls, so the downstream reach effects of the addition of sediment are expected to be minimal. The White Rock Canyon Reach geology has a controlling effect on the bed elevation and river location of this reach. If the bank material is fine enough, this strategy may deliver increased sediment load to the Cochiti Reservoir pool, although the increase to the sediment supply is expected to be small and would be expected to have only a minimal impact on the reservoir pool's serviceable life. Some methods also may induce sediment deposition, thereby decreasing the White Rock Canyon Reach sediment supply. In comparison to downstream reaches, the sediment load in the Rio Chama to Otowi Bridge Reach is small, so the effect in the White Rock Canyon Reach is expected to be minimal. In the Velarde to Rio Chama Reach, the potential exists for this strategy to decrease the channel sediment transport capacity and/or reduce the bed material size; however, the effect upon channel morphology and flood plain connectivity is expected to be minimal.

6.1.2.2.7 Manage Sediment

This strategy is not suitable because there is not a reach-wide imbalance in sediment transport capacity and sediment supply.

6.1.2.3 Cochiti Dam to Angostura Diversion Dam – RM 232.6 to 209.7

6.1.2.3.1 Trends

This reach is strongly influenced by the storage of the upstream sediment load in Cochiti Reservoir and coarse bed material sizes that have retarded incision. Bed material sediment load primarily is supplied from ephemeral tributaries and bank erosion. These sand and gravel sediments are mobilized at higher flows and deposit downstream on active mid-channel and bank-attached bars. The historical flood plain is hydrologically disconnected from the river because of reduced flow peaks and channel bed lowering. Cochiti Dam will continue to reduce sediment supply and high-flow peaks in this reach. Channel evolution due to the closure of Cochiti Dam has largely already occurred, and the following trends likely are to continue but potentially at a slower rate than other reaches of the Middle Rio Grande:

- Channel narrowing
- Vegetation encroachment
- Bank erosion
- Coarsening of bed material
- Increased channel uniformity

6.1.2.3.2 Promote Elevation Stability

Reach Effects.—The general effects of this method implemented on a reach scale are as described in table 1 of the Strategy Effects Attachment for the sediment transport capacity greater than sediment supply case. This strategy addresses the trends of incision or channel bed degradation, increased bank height, and coarsening of bed material. This strategy indirectly addresses bank erosion where a potential exists for the degradation to continue below the riparian root zone. Some additional channel incision and bed degradation is possible in this reach. This reach has well defined riffles that would become the boundary of sediment deposition above the structure. Sinuosity would remain the same as prior to implementation. Bed material size downstream from these structures is not expected to change. Sand and fine gravel sizes from ephemeral tributaries could initially deposit upstream, but this effect is expected to be temporary.

Effects on Upstream and Downstream Reaches.—The general upstream and downstream effects are described in table 1 of the Strategy Effects Attachment for the sediment transport capacity greater than sediment supply case. The upstream reach is White Rock Canyon, and Cochiti Dam prevents any upstream effects from occurring. Sediment delivery to downstream reaches would remain about the same as pre-implementation. Bed material size would not be affected downstream from this reach.

6.1.2.3.3 Promote Alignment Stability

Reach Effects.—In general, Promote Alignment Stability addresses the trend of bank erosion through stabilizing the banks where riverside infrastructure is threatened. The general effects of this method implemented on a reach scale are as described in table 2 of the Strategy Effects Attachment for the sediment transport capacity greater than sediment supply case. The width of the flood plain bounded by infrastructure in this reach is relatively narrow in some locations (Varyu et al. 2011), increasing the number of potential sites where this strategy could be implemented. The amount of sediment available from bank erosion would be reduced, with potential local bed coarsening. Where split channels exist, the effect of locally increasing the velocity and depth should affect the channel where implemented, while the other channel would not be influenced. Within the reach, upstream alignment stability can help downstream infrastructure by reducing the approach angle, influencing the channel alignment.

Effects on Upstream and Downstream Reaches.—The general upstream and downstream effects are described in table 2 of the Strategy Effects Attachment for the sediment transport capacity greater than sediment supply case. Strategies implemented in this reach do not impact upstream reaches since the reach is bounded on the north by Cochiti Dam. Angostura Diversion Dam confines the lateral location of this reach’s downstream boundary. Reduced bank erosion could cause a relatively small decrease in sediment supply to the Angostura Diversion Dam to Isleta Diversion Dam Reach.

6.1.2.3.4 Reconstruct and Maintain Channel Capacity

This strategy is not suitable because a significant loss of channel capacity is not expected.

6.1.2.3.5 Increase Available Area to the River

Reach Effects.—This strategy addresses the trends of channel narrowing, coarsening of bed material, bank erosion, and increased channel uniformity. The general effects of this method implemented on a reach scale area as described in table 4 of the Strategy Effects Attachment for the sediment transport capacity greater than sediment supply case. Lateral confinement is significant in this reach (Varyu et al. 2011), and providing an opportunity for the river to migrate across a larger portion of its historical flood plain would allow current geomorphology processes to continue. The small amount of channel lengthening and sinuosity increase would reduce or eliminate the potential for additional bed degradation. The size of active mid-channel and bank-attached bars throughout this reach likely would increase creating more depositional surfaces that are hydrologically connected.

Effects on Upstream and Downstream Reaches.—The general upstream and downstream effects are described in table 4 of the Strategy Effects Attachment for the sediment transport capacity greater than sediment supply case. Strategies implemented in this reach does not impact upstream reaches since the reach is bounded on the north by Cochiti Dam. The downstream reach boundary is Angostura Diversion Dam that controls the bed elevation and river location. A small increase in channel length may result in a lower amount of sediment being supplied to the Angostura Diversion Dam to Isleta Diversion Dam Reach downstream when the slope decreases and the size of mid-channel and bank-attached bars increases.

6.1.2.3.6 Rehabilitate Channel and Flood Plain

Reach Effects.—This strategy addresses channel narrowing, vegetation encroachment, coarsening of bed material, and increased channel uniformity. The general effects of this method implemented on a reach scale are as described in table 5 of the Strategy Effects Attachment for the sediment transport capacity greater than sediment supply case. Excavation of the channel banks to establish a lower elevation flood plain decreases the flow required to go over bank, and increases high-flow channel width. High-flow sediment transport rates would be reduced. Vegetation re-growth would occur in the excavated flood plain and on the channel margins. Due to the relatively low suspended sediment load from ephemeral tributaries and bank erosion, inundating flows will have a lower tendency to deposit sediment in the excavated flood plain than in reaches with greater load.

Effects on Upstream and Downstream Reaches.—The general upstream and downstream effects are described in table 5 of the Strategy Effects Attachment for the sediment transport capacity greater than sediment supply case. Strategies implemented in this reach do not impact upstream reaches since the reach is bounded on the north by Cochiti Dam. Angostura Diversion Dam exercises influence on the bed elevation and river location at the downstream reach boundary. The reduction in high-flow sediment transport capacity and overbank sediment deposition could result in a lower sediment supply to the Angostura Diversion Dam to Isleta Diversion Dam Reach. This could result in bed lowering downstream from existing grade control structures resulting in decreased flood plain connectivity and a narrower, deeper channel. These effects are expected to be small because the Jemez River supplies sediment to the Rio Grande about 1.5 miles downstream from the diversion dam, and the sediment supply in this reach is relatively smaller than downstream reaches.

6.1.2.3.7 Manage Sediment

This strategy is not suitable because modeling results show both aggradation and degradation within the reach.

6.1.2.4 Angostura Diversion Dam to Isleta Diversion Dam – RM 209.7 to 169.3

6.1.2.4.1 Trends

The storage of sediment and reduced high-flow peaks as a result of Cochiti Reservoir continue to affect this reach. Sediment is supplied to the reach by the Jemez River and other tributaries. Operational changes to increase sediment pass through at Jemez Canyon Dam will reduce the imbalance in sediment transport capacity and load, but the effects are not well known at this time. The reach is also affected by the formation of mid-channel and bank-attached bars that are becoming stabilized with vegetation. Three subreaches have been evolving as identified in the geomorphology baseline section 5.5.2.4. The upstream subreach largely has become a fairly narrow, single thread, gravel-dominated channel. The central subreach is a transition reach in which the percentage of gravel in the bed is increasing, and the downstream subreach is still sand dominated. In each of the three subreaches, the following reach-wide trends are present:

- Channel narrowing
- Vegetation encroachment
- Increased bank height
- Incision or channel bed degradation
- Bank erosion
- Coarsening of bed material
- Increased channel uniformity

The way in which each strategy affects these reach-wide trends can vary between subreaches.

6.1.2.4.2 Promote Elevation Stability

Reach Effects.—This strategy addresses the trends of incision or channel bed degradation, increased bank height, and coarsening of bed material. This strategy also may indirectly influence bank erosion where there is potential for the degradation to continue below the riparian root zone. The general effects of this method implemented on a reach scale are described in table 1 of the Strategy Effects Attachment for the sediment transport capacity greater than sediment supply case. When the river bed is raised about 1–2 feet, the water surface elevation is increased upstream to the next riffle or higher bed elevation location, promoting greater flood plain connectivity. In the downstream subreach (Bridge Street Bridge to Isleta Diversion Dam), there likely will be greater potential for increased flood plain connectivity when compared to the gravel-dominated bed reach that has already experienced some channel incision and degradation. Upstream of the structures in the sand-dominated bed subreach, sediment deposition would potentially occur faster than in the gravel bed dominated subreach because sand sizes are mobilized at lower discharges than gravel bed sizes. Sediment deposition upstream of the structures could become vegetated on the channel margins without sufficient flows to periodically mobilize sediment deposits, requiring maintenance/adaptive management to maintain channel hydraulic capacity. Sinuosity would remain the same as prior to implementation. The Albuquerque-Bernalillo County Water Authority low-head inflatable dam exerts a bed level controlling effect within this reach.

Effects on Upstream and Downstream Reaches.—The general upstream and downstream effects are described in table 1 of the Strategy Effects Attachment for the sediment transport capacity greater than sediment supply case. Sediment delivery to downstream reaches would remain about the same as pre-implementation. There may be a temporary short period of time where the sediment supply is slightly reduced as the upstream river bed establishes its post implementation elevation. However, this is likely a small amount of the total annual sediment load. The bed material size in the downstream reach is expected to remain the same. Bed elevations are controlled at the upstream and downstream reach boundaries by Angostura Diversion Dam and Isleta Diversion Dam, respectively.

6.1.2.4.3 Promote Alignment Stability

Reach Effects.—In general, Promote Alignment Stability addresses the trend of bank erosion, through stabilizing the banks where the laterally constraining infrastructure is threatened. The general effects of this method implemented on a reach scale are described in table 2 of the Strategy Effects Attachment for the sediment transport capacity greater than sediment supply case. This strategy is most applicable currently in the gravel-dominated bed subreach that has already experienced more bed degradation and lateral migration than the transition and sand-dominated bed subreaches. Should the bed material coarsen and/or incision and lateral migration occur in the future in the transition and sand-dominated bed subreaches, this strategy is likely to become more applicable. This is especially true since a significant amount of the calculated potential future meandering channel length is outside the current lateral constraints (Varyu et al. 2011). After implementation, the amount of sediment available from bank erosion potentially would be reduced, leading to local bed coarsening. Due to sediment inflow from the Jemez River and the numerous ephemeral tributaries, the reduction of sediment supply from bank erosion may be relatively small. Sinuosity would increase as the channel lengthens until lateral migration threatens the integrity of riverside infrastructure.

Effects on Upstream and Downstream Reaches.—The general upstream and downstream effects are described in table 2 of the Strategy Effects Attachment for the sediment transport capacity greater than sediment supply case. The bed elevation and river location upstream of this reach are strongly influenced by Angostura Diversion Dam; thus, any effects upon the bed elevation as a result of potential channel lengthening from lateral migration will not affect the upstream reach. Isleta Diversion Dam exerts a controlling effect upon the bed elevation and river location at the downstream boundary of this reach. There could be a small reduction in the portion of the total sediment supply derived bank erosion. However, given the number of tributaries, including the Jemez River, providing sediment supply, this effect is expected to be small.

6.1.2.4.4 Reconstruct and Maintain Channel Capacity

This strategy is not suitable because a significant loss of safe channel hydraulic capacity is not expected.

6.1.2.4.5 Increase Available Area to the River

This strategy is not suitable because urban development makes implementation so expensive as to be unfeasible.

6.1.2.4.6 Rehabilitate Channel and Flood Plain

Reach Effects.—This strategy addresses channel narrowing, vegetation encroachment, increased bank height, incision or channel bed degradation, coarsening of bed material, and increased channel uniformity. The general effects of this method implemented on a reach scale are described in table 5 of the Strategy Effects Attachment for the sediment transport capacity greater than sediment supply case. The reduced tendency for future bed coarsening would have the greatest effect on the sand-dominated bed subreach and should reduce or eliminate the tendency to develop a gravel dominated bed. Vegetation re-growth would occur in the excavated flood plain and on the channel margins. Inundating flows will likely deposit sediment in the vegetated overbank at a higher rate than in the Cochiti Dam to Angostura Diversion Dam subreach, due to the higher sediment load from tributaries.

Effects on Upstream and Downstream Reaches.—The general upstream and downstream effects are described in table 5 of the Strategy Effects Attachment for the sediment transport capacity greater than sediment supply case. The bed elevation and river location upstream of this reach are strongly influenced by Angostura Diversion Dam; thus, any effects upon the implementation reach will not affect the upstream reach. Reduction in high-flow sediment transport capacity and increased overbank sediment deposition could result in a lower amount of sediment being supplied to the Isleta Diversion Dam to Rio Puerco Reach. This effect is more pronounced during higher overbank flow peaks with longer durations and could result in downstream bed lowering, decreased flood plain connectivity, and a narrower, deeper channel.

6.1.2.4.7 Manage Sediment

Reach Effects.—The increased bank height, incision or bed degradation, coarsening of bed material, and increased channel uniformity trends are addressed by this strategy. The general effects of managing sediment in this reach consist of those due to increasing sand size sediment supply, as described in table 6 of the

Strategy Effects Attachment for the sediment transport capacity greater than sediment supply case. The potential for future bank erosion caused by bed degradation below the root zone would be reduced. Depositional bars and islands may form downstream from augmentation sites. The potential change in bed material size would be greatest in the gravel dominated bed reach where the sand size portion of the bed material gradation would increase.

Effects on Upstream and Downstream Reaches.—The general upstream and downstream effects of sediment augmentation are described in table 6 of the Strategy Effects Attachment for the sediment transport capacity greater than sediment supply case. The bed elevation and river location upstream of this reach are strongly influenced by Angostura Diversion Dam; thus, any effects upon the implementation reach will not affect the upstream reach. Deposition of bars and islands will likely occur in the Isleta Diversion Dam to Rio Puerco Reach unless the increased sediment supply can be transported through this reach. The bed elevation at Isleta Diversion Dam would be expected to remain the same. There is potential for additional sediment deposition upstream of the dam.

6.1.2.5 Isleta Diversion Dam to Rio Puerco – RM 169.3 to 127

6.1.2.5.1 Trends

Historically, the bed and alignment have been relatively stable except near the Rio Puerco. This reach is influenced by island and bar vegetation growth that has stabilized these once transient features, thereby narrowing the channel and encouraging new deposition along the bank. Current trends occurring in this reach are the following:

- Channel narrowing
- Vegetation encroachment
- Increased bank height
- Coarsening of bed material
- Increased channel uniformity

Continuation of these trends may cause additional trends to develop in the future:

- Incision or channel bed degradation
- Bank erosion

6.1.2.5.2 Promote Elevation Stability

Reach Effects.—This strategy addresses the trends of increased bank height and coarsening of bed material. This strategy can address increased bank height but only in the case where it is due to degradation. Since it is very possible that bed degradation and incision will become a future trend, similar to other reaches of the Middle Rio Grande that have narrowed, this strategy has been identified as suitable. The general effects of this method implemented on a reach scale are described in table 1 of the Strategy Effects Attachment for the sediment transport capacity greater than sediment supply case. Channel narrowing as a result of future channel incision would be reduced or slowed by bed elevation control. When the river bed is raised about 1–2 feet, the water surface elevation is increased upstream to the next riffle or high point in the bed, promoting greater flood plain connectivity and increased depth and velocity variability at high flows. Sediment deposition upstream of the structures could become vegetated on the channel margins without sufficient flows to periodically mobilize sediment deposits, requiring maintenance/adaptive management to maintain channel capacity. Sinuosity would remain the same as prior to implementation.

Effects on Upstream and Downstream Reaches.—The general upstream and downstream effects are as described in table 1 of the Strategy Effects Attachment for the sediment transport capacity greater than sediment supply case. Sediment delivery to Rio Puerco to San Acacia Diversion Dam Reach would remain about the same as pre-implementation. Bed material size would not be affected downstream from the structures. The upstream bed elevation is controlled by Isleta Diversion Dam and would not change with this strategy.

6.1.2.5.3 Promote Alignment Stability

This strategy is not suitable because analysis results show the meander belt is expected to continue to fit between constraints.

6.1.2.5.4 Reconstruct and Maintain Channel Capacity

Reach Effects—This strategy addresses trends of channel narrowing and vegetation encroachment. The trend of increase bank height due to sediment deposition could potentially reduce high-flow floodway capacity. The general effects of this method implemented on a reach scale are described in table 3 of the Strategy Effects Attachment for the sediment transport capacity less than sediment supply case. Where increased bank height has cut off side channels and backwaters, these may be reconnected. Vegetation encroachment could continue on the channel margins without sufficiently high flows to mobilize bed sediments after channel reconstruction. Potential bank erosion due to bed degradation and channel narrowing likely would decrease. No change in sinuosity is likely. The bed elevation may increase, and bed size may decrease due to reduced peak flow channel velocity and depth.

Effects on Upstream and Downstream Reaches.—The general upstream and downstream effects are as described in table 3 of the Strategy Effects Attachment for the sediment transport capacity less than sediment supply case. The upstream bed elevation and river location are influenced by Isleta Diversion Dam. Reduction in high-flow sediment transport capacity could result in lower downstream sediment supply. This could result in bed lowering, decreased flood plain connectivity, and a narrower, deeper channel in the Rio Puerco to San Acacia Diversion Dam Reach. The potential amount of these changes is not known.

6.1.2.5.5 Increase Available Area to the River

Reach Effects.—This strategy addresses the trends of channel narrowing, coarsening of bed material and increased channel uniformity. The general effects of this method implemented on a reach scale are described in table 4 of the Strategy Effects Attachment for the sediment transport capacity greater than sediment supply case. Allowing the river more space for lateral erosion and bar deposition could result in the formation of a larger flood plain with increases in overall flood plain connectivity and increased channel width. Bed degradation tendencies would be reduced or eliminated as the channel lengthens. Potential for bank erosion increases with the development of migrating channel bends; however, there would be more space to accommodate that migration.

Effects on Upstream and Downstream Reaches.—The general upstream and downstream effects are described in table 4 of the Strategy Effects Attachment for the sediment transport capacity greater than sediment supply case. Relocating riverside infrastructure will provide additional area for future river migration but will not immediately effect current reach trends. If channel lengthening occurs, there would be a reduced tendency for upstream bed lowering. The upstream sediment supply/transport capacity relationship would remain about the same; thus, channel width and flood plain connectivity would be essentially unchanged. The sediment supply to the Rio Puerco to San Acacia Diversion Dam Reach could be reduced if channel lengthening reduces degradation potential. The potential amount of this reduction is an unknown at this time.

6.1.2.5.6 Rehabilitate Channel and Flood Plain

Reach Effects.—This strategy addresses channel narrowing, vegetation encroachment, increased bank height, coarsening of bed material, and increased channel uniformity. The general effects of this method implemented on a reach scale are described in table 5 of the Strategy Effects Attachment for the sediment transport capacity greater than sediment supply case. Excavation of the channel banks to establish a lower elevation flood plain decreases the flow required to go over bank, and leads to increased high flow channel width. High flow sediment transport rates would be reduced, lowering the likelihood of future bed degradation and the tendency for the bed to coarsen. Vegetation re-growth would occur in the excavated flood plain, and on the channel margins. Inundating flows will likely deposit sediment in the vegetated overbank.

Effects on Upstream and Downstream Reaches.—The general upstream and downstream effects are as described in table 5 of the Strategy Effects Attachment for the sediment transport capacity greater than sediment supply case. The potential for continued upstream bed degradation would be reduced. Reduction in high-flow sediment transport capacity and overbank sediment deposition could result in a lower downstream sediment supply. This could result in bed lowering, decreased flood plain connectivity, and a narrower, deeper channel in the Rio Puerco to San Acacia Diversion Dam Reach. The potential amount of these changes is not known.

6.1.2.5.7 Manage Sediment

Reach Effects.—Increased bank height, coarsening of bed material, and increased channel uniformity are trends addressed by this strategy. The general effects of managing sediment in this reach consist of those due to increasing sediment supply are described in table 6 of the Strategy Effects Attachment for the sediment transport capacity greater than sediment supply case. The potential for future bank erosion caused by bed degradation below the root zone would be reduced. Downstream from augmentation sites, bars and islands may form due to sediment deposition.

Effects on Upstream and Downstream Reaches.—The general upstream and downstream effects of sediment augmentation are described in table 6 of the Strategy Effects Attachment for the sediment transport capacity greater than sediment supply case. No additional trends are expected in addition to these general upstream and downstream effects.

6.1.2.6 Rio Puerco to San Acacia Diversion Dam – RM 127 to 116.2

6.1.2.6.1 Trends

The uncontrolled, large, ephemeral tributaries of the Rio Puerco and Rio Salado strongly influence this reach through both peak flows and sediment load. The historically high load from the Rio Puerco has significantly decreased because that channel has evolved. Recent MRG evolution includes the development of small inset flood plains. Located between the tributary confluences is Sevilletta bend ,which is a 2½-mile-long geologic constriction in the center of the reach. Above the bend, the channel is narrowing with vegetation encroachment. The Rio Salado enters immediately below Sevilletta bend. It contributes sediment that is coarser than the Rio Grande, and the Rio Salado delta tends to act as a grade control. From here downstream to San Acacia Diversion Dam, the channel is currently moving laterally and degrading. The delta deposits upstream of the diversion dam have become heavily vegetated and confine the channel north against the Drain Unit 7 Levee. The current reach trends are:

- Channel narrowing
- Vegetation encroachment
- Increased bank height
- Incision or channel bed degradation – local
- Coarsening of bed material
- Increased channel uniformity

6.1.2.6.2 Promote Elevation Stability

Reach Effects and Effects on Upstream and Downstream Reaches.—As modeling results (Varyu et al. 2011) show, this reach is expected to mildly aggrade, so this strategy is suitable but would be implemented by methods falling primarily under the other strategies suitable for this reach—Reconstruct and Maintain Channel Capacity and Manage Sediment.

6.1.2.6.3 Promote Alignment Stability

Reach Effects.—For much of the reach, there appears to be adequate space for lateral migration at the 2006 channel widths. Of note is that channel narrowing could set in motion a geomorphic shift toward channel migration and the Drain Unit 7 extension and other infrastructure may be threatened as the channel position changes. The trend of bank erosion that threatens infrastructure is addressed through armoring the bank line or deflecting the main flow path away from the area of concern. Effects are described in table 2 of the Strategy Effects Attachment for the sediment transport capacity greater than sediment supply case. Modeling results (Varyu et al. 2011) don't show channel lengthening at the 2006 widths, but narrowing could change the stable slope to a condition where channel migration becomes an active process. Sinuosity could then increase because there is space available for lateral migration. Bed material could continue to coarsen as the supply of fines from bank erosion is reduced.

Effects on Upstream and Downstream Reaches.—The general upstream and downstream effects are described in table 2 of the Strategy Effects Attachment for the sediment transport capacity greater than sediment supply case. The downstream reach boundary is San Acacia Diversion Dam that controls bed elevation and puts boundaries on the lateral location of the river. There could be a relatively small decrease in sediment supplied to the San Acacia Diversion Dam to Arroyo de las Cañas Reach because of reduced bank erosion. Isleta Diversion Dam to Rio Puerco Reach effects are expected to be small.

6.1.2.6.4 Reconstruct and Maintain Channel Capacity

This strategy is not suitable because a significant loss of channel capacity is not expected.

6.1.2.6.5 Increase Available Area to the River

Reach Effects.—The trends of channel narrowing increased bank height, incision or channel bed degradation, coarsening of bed material, and increased channel uniformity are addressed by setting aside space for the channel to evolve. The general effects of this strategy in this reach are described in table 4 of the Strategy Effects Attachment for the sediment transport capacity greater than sediment supply case. Land use outside the infrastructure constraints is agricultural or wildlife refuges and the AT&SF Railroad. Altering land use in agricultural or wildlife areas may be more implementable than changing the railroad alignment. Potential for bank erosion increases with the development of migrating channel bends; however, there would be more space to accommodate that migration. There is uncertainty on how significant the process of migration will become in this reach.

Effects on Upstream and Downstream Reaches.—The general upstream and downstream effects are described in table 4 of the Strategy Effects Attachment for the sediment transport capacity greater than sediment supply case. The downstream reach boundary is San Acacia Diversion Dam that controls the bed elevation and puts bounds on river location. A longer channel could result in lower sediment supply to the San Acacia Diversion Dam to Arroyo de las Cañas Reach when the slope decreases and the size of mid-channel and bank-attached bars increases; but modeling results (Varyu 2011) show that the channel is not expected to lengthen at the 2006 channel widths. Isleta Diversion Dam to Rio Puerco Reach effects are expected to be small.

6.1.2.6.6 Rehabilitate Channel and Flood Plain

Reach Effects.—The trends of channel narrowing, vegetation encroachment, increased bank height, incision or channel bed degradation, coarsening of bed material, and increased channel uniformity are addressed by decreasing high-flow energy through lowering the bank height that increases flow area at lower discharges. New riparian vegetation will grow, and then sediment deposition is expected in the lowered overbank areas. The effects listed in table 5 of the Strategy Effects Attachment for the sediment transport capacity greater than sediment supply case would apply, but specific effects will depend on the type of implementation.

Effects on Upstream and Downstream Reaches.—The general upstream and downstream effects are described in table 5 of the Strategy Effects Attachment for the sediment transport capacity greater than sediment supply case. San Acacia Diversion Dam controls bed elevation and puts bounds on river location at the downstream reach boundary. Reduction in high-flow sediment transport capacity and overbank sediment deposition could result in a lower downstream sediment supply. This could then result in bed lowering, decreased flood plain connectivity, and a narrower, deeper channel in the San Acacia Diversion Dam to Arroyo de las Cañas Reach. The effect is not expected to be large.

6.1.2.6.7 Manage Sediment

This strategy is not suitable because modeling showed only a mild reach-wide imbalance in sediment transport capacity and sediment supply.

6.1.2.7 San Acacia Diversion Dam to Arroyo de las Cañas – RM 116.2 to 95

6.1.2.7.1 Trends

This reach is influenced by a large reduction in finer grain sizes from the Rio Puerco, but the Salado contributes coarser grain sizes. Additional influences include channel incision, formation of abandoned terraces, and width reduction.

San Acacia Diversion Dam prevents upstream migration of channel bed degradation. Many of the ephemeral tributaries junctions now act effectively as grade controls as described in the geomorphology baseline section 5.5.2.7. Current trends in this reach are the following:

- Vegetation encroachment
- Increased bank height
- Incision or bed degradation
- Bank erosion
- Coarsening of bed material
- Increased channel uniformity

Near San Acacia Diversion Dam, the amount of bed material coarsening and channel degradation is the greatest, decreasing in the downstream direction. From Escondida to Arroyo de las Cañas, the bed is predominantly sand with intermittent gravel deposits. Several smaller tributaries have been reconnected, increasing sediment supply within the reach.

6.1.2.7.2 Promote Elevation Stability

Reach Effects.—This strategy addresses the trends of increased bank height, incision or channel bed degradation, and coarsening of bed material. This strategy also may address bank erosion where there is potential for the degradation to continue below the riparian root zone. This strategy addresses increased bank height from the condition of channel bed degradation. The general effects of this method implemented on a reach scale are described in table 1 of the Strategy Effects Attachment for the sediment transport capacity greater than sediment supply case. This reach has natural grade controls from ephemeral tributary sediment deposits that could become the boundary of the relatively small amount of sediment deposition upstream of each structure. Channel narrowing as a result of future channel incision would be reduced or slowed by bed elevation control. Sediment deposition upstream of the structures likely would occur more quickly where the bed material load is largely sand sized. The upstream sediment deposits could become vegetated on the channel margins without sufficient flows to periodically mobilize sediment deposits, requiring maintenance/adaptive management to maintain channel capacity. Sinuosity would remain the same as prior to implementation. The lateral location of the river is fixed for most methods. Bed material size is not expected to change.

Effects on Upstream and Downstream Reaches.—The general upstream and downstream effects are described in table 1 of the Strategy Effects Attachment for the sediment transport capacity greater than sediment supply case. The upstream bed elevation is controlled by San Acacia Diversion Dam and would not change. Sediment delivery to the Arroyo de las Cañas to San Antonio Bridge Reach would remain about the same as pre-implementation. Bed material size would not be affected downstream from this reach. Bed elevation in the Arroyo de las Cañas to San Antonio Bridge is not likely to be affected by this strategy because sediment supply is not likely to change.

6.1.2.7.3 Promote Alignment Stability

Reach Effects.—This strategy addresses the trend of bank erosion by stabilizing banks where infrastructure is threatened by river bank migration. The general effects of this method implemented on a reach scale are described in table 2 of the Strategy Effects Attachment for the sediment transport capacity greater than sediment supply case. Sinuosity would increase as the channel lengthens until lateral migration threatens riverside infrastructure. Additional lateral migration would likely allow the river to increase the size of its inset flood plain. If the bed material size continues to coarsen in the downstream portion of this reach, and lateral migration were to occur in the future, this strategy will become more applicable.

Effects on Upstream and Downstream Reaches.—The general upstream and downstream effects are described in table 2 of the Strategy Effects Attachment for the sediment transport capacity greater than sediment supply case. The bed elevation and river location at the upstream boundary of this reach are controlled by San Acacia Diversion Dam, thus any potential changes in bed elevation as a result of channel lengthening from lateral migration will not affect the upstream reach. The bed elevation in the Arroyo de las Cañas to San Antonio Bridge Reach is not likely to be influenced by a small reduction in sediment supplied by bank erosion because Arroyo de las Cañas appears to be acting as a grade control. The downstream lateral location could be influenced by the alignment of this strategy.

6.1.2.7.4 Reconstruct and Maintain Channel Capacity

This strategy is not suitable because a significant loss of channel capacity is not expected.

6.1.2.7.5 Increase Available Area to the River

Reach Effects.—This strategy addresses the trends of channel narrowing, increased bank height, incision or bed degradation, coarsening of bed material, bank erosion, and increased channel uniformity. The general effects of this method implemented on a reach scale, are described in table 4 of the Strategy Effects Attachment for the sediment transport capacity greater than sediment supply case. Allowing the river more space for lateral erosion and bar deposition could result in the formation of a larger inset flood plain, increasing overall flood plain connectivity and channel width. Bed degradation tendencies would be reduced or eliminated as the channel lengthens, except where controlled by ephemeral tributary sediment deposits.

Effects on Upstream and Downstream Reaches.—The general upstream and downstream effects are described in table 4 of the Strategy Effects Attachment for the sediment transport capacity greater than sediment supply case. Relocating riverside infrastructure will provide additional area for future river migration. The presence of San Acacia Diversion Dam prevents any upstream reach channel changes. The downstream channel bed elevation most likely will not be affected due to Arroyo de las Cañas deposits in the river appearing to act as a grade control, even if the downstream sediment supply decreased. Sediment supply to the Arroyo de las Cañas to San Antonio Bridge Reach is likely to decrease because channel lengthening reduces degradation potential and sediment could be stored on forming point bars. Downstream sediment supply could be reduced if channel lengthening reduces degradation potential. The downstream reach has a sediment depositional trend, so this effect would potentially reduce the rate of aggradation.

6.1.2.7.6 Rehabilitate Channel and Flood Plain

Reach Effects.—This strategy addresses channel narrowing, vegetation encroachment, increased bank height, incision or channel bed degradation, bank erosion, coarsening of bed material, and increased channel uniformity. The general effects of this method implemented on a reach scale for the transport capacity greater than supply case are described in table 5 of the Strategy Effects Attachment for the sediment transport capacity greater than sediment supply case. Excavation of the channel banks to establish a lower elevation flood plain, in the abandoned river terraces, decreases the flow required to go over bank and leads to increased high-flow channel width. High-flow sediment transport rates would be reduced, lowering the likelihood of future bed degradation and the tendency for the bed to coarsen. Vegetation regrowth would occur in the excavated flood plain and on the channel margins. Inundating flows likely will deposit sediment in the vegetated overbank since there can be significant amounts of sediment in suspension particularly during Rio Puerco and Rio Salado flow events.

Effects on Upstream and Downstream Reaches.—The general upstream and downstream effects are described in table 5 of the Strategy Effects Attachment for the sediment transport capacity greater than sediment supply case. Upstream bed elevation is controlled by San Acacia Diversion Dam and would not be affected by this strategy. Reduction in high-flow sediment transport capacity and overbank sediment deposition could result in a lower sediment supply to the Arroyo de las Cañas to San Antonio Bridge Reach. This could result in slowing the aggradational trend in the downstream Arroyo de las Cañas Reach. It is not likely that this strategy would alter the downstream lateral channel location.

6.1.2.7.7 Manage Sediment

Reach Effects.—The increased bank height incision or bed degradation, coarsening of bed material and increased channel uniformity trends are addressed by this strategy. The general effects of managing sediment in this reach consist of those due to increasing sediment supply, as described in table 6 of the Strategy Effects Attachment for the sediment transport capacity greater than sediment supply case. The potential for future bank erosion caused by bed degradation below the root zone would be reduced. Sediment deposition likely could occur on inset flood plain features, decreasing the frequency of inundation, downstream from augmentation sites.

Effects on Upstream and Downstream Reaches.—The general upstream and downstream effects of sediment augmentation are described in table 6 of the Strategy Effects Attachment for the sediment transport capacity greater than sediment supply case. Sediment augmentation would have no effect upon the upstream bed elevation or channel location controlled by San Acacia Diversion Dam. It is likely that this strategy would increase sediment supply to the Arroyo de las Cañas to San Antonio Bridge, potentially exacerbating the aggradational trend. The amount of potential sediment supply is an unknown.

6.1.2.8 Arroyo de las Cañas to San Antonio Bridge – RM 95 to 87.1

6.1.2.8.1 Trends

This reach has experienced less change in bed elevation and average channel width since channelization than most other reaches of the MRG. Recent trends, which appear to be declining in effect, include:

- Channel narrowing
- Vegetation encroachment

Aggradation is extending into this reach, but on a smaller in scale than historically documented in the San Antonio Bridge to River Mile 78 and River Mile 78 to River Mile 60 Reaches. Recent arroyo reconnections and aggradation in the San Antonio to River Mile 78 Reach contribute to these trends:

- Aggradation
- Increased channel uniformity

Sediment storage in the channel is key to the recent trends observed in this reach. Strategies that address the channel filling (related to both narrowing and aggradation) would be appropriate, but the recent narrowing could increase sediment transport, move more sediment through the reach, and, thus, change the aggradation-related trends in this reach, potentially increasing bend migration.

6.1.2.8.2 Promote Elevation Stability

Reach Effects and Effects on Upstream and Downstream Reaches.—As recent observations and modeling results (Varyu et al. 2011) show, this reach is expected to aggrade, so this strategy is suitable but would be implemented by methods falling primarily under the other strategies suitable for this reach—Reconstruct and Maintain Channel Capacity and the Manage Sediment.

6.1.2.8.3 Promote Alignment Stability

This strategy is not suitable because modeling shows a low potential for lateral migration.

6.1.2.8.4 Reconstruct and Maintain Channel Capacity

Reach Effects.—The current reach trends of channel narrowing, vegetation encroachment, and aggradation are addressed by directly removing sediment from the channel, increasing sediment transport capacity through confining high flows, or reducing impacts from channel realignment through levee strengthening/ raising. Since the excess incoming sediment supply is not modified and sediment transport capacity is not likely to exceed previous levels, sediment excavation could require continued maintenance. The effects as described in table 3 of the Strategy Effects Attachment because the sediment transport capacity less than sediment supply case would apply in this reach. Bed material is expected to remain sand-dominated except in the upstream riffles. Sinuosity is not expected to change much, but the wetted area of the overbank at high flows is expected to decrease and discharge needed to go over bank increases, at least temporarily.

Effects on Upstream and Downstream Reaches.—The general upstream and downstream effects are described in table 3 of the Strategy Effects Attachment for the sediment transport capacity less than sediment supply case. Downstream effects include increased water and sediment delivery to the San Antonio Bridge to River Mile 78 Reach. Significant coarsening of bed material in the downstream reach is not expected. Arroyo de las Cañas deposits in the channel, at the upstream end of this reach**,** appear to be controlling degradation at current peak flows, but aggradation and bed material fining extending into the San Acacia Diversion Dam to Arroyo de las Cañas Reach is possible. The likelihood and magnitude of this effect is unknown at this time.

6.1.2.8.5 Increase Available Area to the River

This strategy is not suitable because modeling shows a low potential for lateral migration.

6.1.2.8.6 Rehabilitate Channel and Flood Plain

This strategy is not suitable because of historically stable bed and modeling show aggradation.

6.1.2.8.7 Manage Sediment

Reach Effects.—The reach trends of aggradation and increased channel uniformity can be addressed by this strategy. The general effects of this method implemented on a reach scale are described in table 6 of the Strategy Effects Attachment for the sediment transport capacity less than sediment supply case. Implementation would consist of reducing sediment supply. The reduction in sediment supply would reduce flooding and water losses.

Effects on Upstream and Downstream Reaches.—The general upstream and downstream effects are described in table 6 of the Strategy Effects Attachment for the sediment transport capacity less than sediment supply case. Reducing sediment supply in this reach should reduce the effects of sediment supply being greater than transport capacity in the upper portion of the San Antonio Bridge to River Mile 78 Reach. A reduction in aggradation in this reach might reduce aggradation in the San Acacia Diversion Dam to Arroyo de las Cañas Reach upstream.

6.1.2.9 San Antonio Bridge to River Mile 78 – RM 87.1 to 78

6.1.2.9.1 Trends

This reach is influenced by the pool elevation of Elephant Butte Reservoir. Under the current water and sediment loads, the pool is quite low and not expected to rise far in the near term. This base level lowering has led to the following current trends in the lower portion of the reach that are anticipated to be temporary (Makar and AuBuchon, 2012). :

- Increased bank height
- Incision or channel bed degradation
- Bank erosion
- Coarsening of bed material – minor

Three trends currently are observed that may or may not reverse when water and sediment loads increase and the pool fills:

- Channel narrowing
- Vegetation encroachment
- Increased channel uniformity

Under historically more frequent conditions, there is an excess of sediment supply as compared to transport capacity and long-term trends of:

- Aggradation
- Channel plugging with sediment
- Perched channel conditions

The dependence on pool elevation makes conditions of this reach variable in the long term. Given the wide variation in trends and the need to preserve peak flow channel capacity, valley drainage, and capacity in Elephant Butte Reservoir, strategies that address the long-term aggradation trends are appropriate for this reach and have been addressed herein.

6.1.2.9.2 Promote Elevation Stability

Reach Effects and Effects on Upstream and Downstream Reaches.—As this is a long-term aggrading reach, this strategy is suitable but would be implemented by methods falling under the other strategies suitable for this reach—Reconstruct and Maintain Channel Capacity, the Increase Available Area to the River, and the Manage Sediment.

6.1.2.9.3 Promote Alignment Stability

This strategy is not suitable because the reach over the long term is aggrading, and only localized lateral migration is expected.

6.1.2.9.4 Reconstruct and Maintain Channel Capacity

Reach Effects.—This strategy addresses the trends of channel narrowing, vegetation encroachment, aggradation, channel plugging with sediment, and perched channel conditions by directly removing sediment from the channel, increasing transport capacity through confining high flows, or reducing levee impacts from channel realignment. Since the excess incoming sediment load is not modified and transport capacity likely will not exceed previous levels, sediment excavation likely will require continued maintenance. The effects are described in table 3 of the Strategy Effects Attachment for the sediment transport capacity less than sediment supply case. Bed material is expected to remain sand. Sinuosity is not expected to change much, but wetted area of the overbank at high flows is expected to decrease and discharge needed to go over bank increase, at least temporarily.

Effects on Upstream and Downstream Reaches.—The general upstream and downstream effects are described in table 3 of the Strategy Effects Attachment for the sediment transport capacity less than sediment supply case. Downstream effects include increased water and sediment delivery to the River Mile 78 to Full Pool Elephant Butte Reservoir Level Reach and potentially to Elephant Butte Reservoir increasing the rate of storage capacity loss. Significant coarsening of the bed material in the River Mile 78 to Full Pool Elephant Butte Reservoir Level Reach is not expected. It is possible the Arroyo de las Cañas to San Antonio Bridge Reach aggradation could be reduced as channel filling in this reach is reduced.

6.1.2.9.5 Increase Available Area to the River

Reach Effects.—This strategy addresses the trends of channel narrowing, increased bank height, incision or channel bed degradation, bank erosion, coarsening of bed material, increased channel uniformity, aggradation, channel plugging with sediment, and perched channel conditions through allowing natural channel processes to cause channel evolution. The trends of aggradation, channel plugging with sediment, and perched channel conditions are addressed through allowing space for channel relocation to lower bed elevations. The general effects of this method implemented on a reach scale are described in table 4 of the

Strategy Effects Attachment for the sediment transport capacity less than sediment supply case. The majority of the surrounding land in this reach is federally owned. Sinuosity, wetted area, and discharge needed to go over bank are not expected to change significantly. However, it is possible that after natural channel realignment, the new channel bed elevation within the reach could be lowered far enough so that upstream effects could include channel degradation with higher flows required to go over bank and lowered water tables. This effect may be temporary unless the strategy is extended into the River Mile 78 to Full Pool Elephant Butte Reservoir Level Reach. Water delivery may be reduced until a continuous competent channel is formed. The magnitude of this effect is dependent on the increase in wetted area.

Effects on Upstream and Downstream Reaches.—The general upstream and downstream effects are described in table 4 of the Strategy Effects Attachment for the sediment transport capacity less than sediment supply case. It is possible that water delivery to the River Mile 78 to Full Pool Elephant Butte Reservoir Level Reach may be reduced, but the effect is expected to be small. Significant changes in the River Mile 78 to Full Pool Elephant Butte Reservoir Level Reach bed material size or sediment load are not expected. It is possible that effects due to lowered bed elevation, as discussed under reach effects, could extend into the Arroyo de las Cañas to San Antonio Bridge Reach. The extent and magnitude of the effect is dependent on the change in bed elevation.

6.1.2.9.6 Rehabilitate Channel and Flood Plain

This strategy is not suitable because the reach over the long term is aggrading.

6.1.2.9.7 Manage Sediment

Reach Effects.—The general effects of this method implemented on a reach scale are described in table 6 of the Strategy Effects Attachment for the sediment transport capacity less than sediment supply case. The trends of aggradation, channel plugging with sediment, perched channel conditions, and increased channel uniformity are addressed through storage of excess sediment supply in basins or by channel relocation to a lower elevation alignment. In either case, the sediment load transported and/or the perched condition where the elevation of the channel bed is higher than the flood plain should be reduced. Channel relocation would allow sediment storage in low lying areas, but maintenance may be required to sustain a continuous channel downstream in the new alignment. Sinuosity, local ground water table, wetted area, and discharge needed to go over bank are dependent on locations selected for implementation.

Effects on Upstream and Downstream Reaches.—The general upstream and downstream effects are described in table 6 of the Strategy Effects Attachment for the sediment transport capacity less than sediment supply case. It is possible that water delivery downstream may be reduced, but the effect is expected to be small and may be temporary depending upon the method used. Sediment load to the

River Mile 78 to Full Pool Elephant Butte Reservoir Level Reach would, of course, be reduced; and it is possible that the effect may extend to Elephant Butte Reservoir. Significant coarsening in the River Mile 78 to Full Pool Elephant Butte Reservoir Level Reach is not expected. Sediment deposition in low areas may temporarily reduce Arroyo de las Cañas to San Antonio Bridge Reach aggradation.

6.1.2.10 River Mile 78 to Full Pool Elephant Butte Reservoir Level – River Mile 78 to Elephant Butte Full Pool Reservoir Level

6.1.2.10.1 Trends

This reach is strongly influenced by the pool elevation of Elephant Butte Reservoir. Historically an aggrading and perched reach, the channel has degraded significantly. This is primarily due to the base level lowering effect of recent pool elevations. Under the current water and sediment loads, the pool is quite low and not expected to rise far in the near term. This base level lowering has led to the following current trends that are anticipated to be temporary:

- Increased bank height
- Incision or channel bed degradation
- Bank erosion
- Coarsening of bed material
- Increased channel uniformity

Two trends are currently observed that may or may not reverse when water and sediment loads increase and the pool fills:

- Channel narrowing
- Vegetation encroachment

Under historically more frequent conditions, there is an excess of sediment supply as compared to transport capacity and long-term trends of:

- Aggradation
- Channel plugging with sediment
- Perched channel conditions

The dependence on pool elevation makes conditions of this reach highly variable in the long term. Given the wide variation in trends and the need to preserve peak flow channel capacity, valley drainage and capacity in Elephant Butte Reservoir, strategies that address the long-term aggradation trends are appropriate for this reach. Loss of a continuous channel to the reservoir in this reach can impair water delivery.

6.1.2.10.2 Promote Elevation Stability

Reach Effects and Effects on Upstream and Downstream Reaches.—As this is a long-term aggrading reach, this strategy is suitable but would be implemented by methods falling under the other strategies suitable for this reach—Reconstruct and Maintain Channel Capacity, Increase Available Area to the River, and Manage Sediment.

6.1.2.10.3 Promote Alignment Stability

This strategy is not suitable because the reach over the long term is aggrading, and only localized lateral migration is expected.

6.1.2.10.4 Reconstruct and Maintain Channel Capacity

Reach Effects.—This strategy addresses the trends of channel narrowing, vegetation encroachment, aggradation, channel plugging with sediment, and perched channel conditions by removing sediment from the channel. Sediment transport capacity is increased by confining high flows that can increase flow capacity within the levee system. Building on the discussion in the trends section above, the duration of the effects of increasing the sediment transport capacity through partial or complete channel reconstruction (see table 4 of the Strategy Effects Attachment for the sediment transport capacity less than sediment supply case) are likely to be shorter than in other reaches if the base level control of pool elevation rises and longer if it remains low. A continued need for maintenance is expected if this strategy is implemented. Partial reconstruction via a pilot channel through sediment plugs can restore channel capacity. Confining over bank flows can increase local transport capacity and may prevent plug formation. Levee raising and strengthening can reduce concerns of levee failure during plugs and high-flow events. Little change is expected in sinuosity or the discharge required to go over bank and the resulting wetted area.

Effects on Upstream and Downstream Reaches.—The general upstream and downstream effects are described in table 3 of the Strategy Effects Attachment for the sediment transport capacity less than sediment supply case. Downstream effects include increased water and sediment delivery to Elephant Butte Reservoir resulting in an increased rate of reservoir capacity loss. The downstream bed material size is likely to increase if the pool remains low but is expected to remain in sand sizes. The San Antonio Bridge to River Mile 78 Reach effects could be channel degradation and longer duration of increased channel capacity, again dependent on Elephant Butte pool elevation. Higher flows required to go over bank and lowered water tables may accompany the degradation.

6.1.2.10.5 Increase Available Area to the River

Reach Effects.—This strategy addresses the trends of channel narrowing, increased bank height, incision or channel bed degradation, bank erosion, coarsening of bed material, and increased channel uniformity through allowing natural channel processes to cause channel evolution and increased length. The trends of aggradation, channel plugging with sediment, and perched channel conditions are addressed by allowing space for channel relocation. The San Marcial Railroad Bridge locally limits application of this strategy; but since the majority of the surrounding land is federally owned, implementation could be easier than in other reaches. There appears to be enough land available to realize the effects listed in table 4 of the Strategy Effects Attachment for the sediment transport capacity less than sediment supply case. Wetted area of high flows would increase when channel filling resumes. Sinuosity could increase if the pool remains low and the channel migrates. The discharge needed to go over bank is not expected to change until the pool elevation comes up; and, then, the discharge needed to spill out of the channel will decrease.

Effects on Upstream and Downstream Reaches.—The general upstream and downstream effects are described in table 4 of the Strategy Effects Attachment for the sediment transport capacity less than sediment supply case. The increased area available for overbank deposition could reduce the sediment load reaching Elephant Butte Reservoir, extending its useful capacity life. The bed material size downstream is expected to remain about the same. The San Antonio Bridge to River Mile 78 Reach aggradation, which has historically occurred over the long term, is expected to be reduced (at least temporarily) because there would be more area for future sediment deposition.

6.1.2.10.6 Rehabilitate Channel and Flood Plain

This strategy is not suitable because the reach over the long term is aggrading.

6.1.2.10.7 Manage Sediment

Reach Effects.—The effects of managing sediment on a reach basis consist of those due to reducing sediment supply as described in table 6 of the Strategy Effects Attachment for the sediment transport capacity less than sediment supply case. The trends of aggradation, channel plugging with sediment, perched channel conditions, and increased channel uniformity are addressed through storage of excess sediment supply. Federal land ownership of the majority of surrounding land means there is space available for constructed or natural basins. Wide variations in topography mean that using existing low spots is possible, minimizing implementation. If the deepest of the low spots are selected for implementation, higher discharges will be required for flows to go over bank, at least temporarily. Sinuosity will be a function of the locations selected for implementation.

Effects on Upstream and Downstream Reaches.—The general upstream and downstream effects are described in table 6 of the Strategy Effects Attachment for the sediment transport capacity less than sediment supply case. The increased sediment deposition will reduce the sediment load reaching Elephant Butte Reservoir, extending its useful capacity life. Bed material size downstream from the deposition basins is expected to coarsen but remain in sand sizes. The downstream channel bed is likely to degrade because of basin sediment storage within this reach. The San Antonio Bridge to River Mile 78 Reach aggradation, which has historically occurred over the long term, is expected to be reduced (at least temporarily) because there would be more space for future sediment deposition in this reach. The channel bed upstream may aggrade in the future depending upon the rate basins fill with sediment and how often they are relocated. Channel lowering may occur in upstream reaches if the elevation difference between the current channel bed and the new alignment through the basins is great enough.

6.**1.3 Most Likely** Biological Effects of River Maintenance Strategies **on Silvery Minnows and Flycatchers by Reach**

Tables 33 and 34 display the general reach by reach analysis of effects to silvery minnows, flycatchers, and their associated habitats from changes expected by implementing actions to achieve river maintenance strategies identified in the Proposed Action (section 3.2.8). The effects are general in nature and evaluate whether the river maintenance strategy would indicate a positive or negative outcome for the reach. Where the probable magnitude of an effect is known, it is analyzed. As needed, additional details of the effects, tiered off this programmatic river maintenance BA, would be developed and coordinated with the Service. The effects of these strategies on critical habitat of silvery minnow and flycatchers would be variable depending on the design and location of the project. Most types of projects are expected to have a temporary adverse effect to critical habitat through disturbance to the water quality or riparian vegetation. Long-term indirect effects may be adverse or beneficial.

6.2 River Maintenance Project Site Effects

The long-term geomorphic effects on the river and species habitat of a river maintenance site project are local in nature. There are short-term impacts for each of these method types that are related to the size of the impact area, the location or the project, implementation techniques and duration. The estimated effects are described by method in section 6.2.1. Effects from river maintenance support activities and unanticipated and interim work are described in sections 6.2.2 and 6.2.3. Effects predictions of specific acreages of impacts are analyzed in section 6.2.4.

6.2.1 Effects of River Maintenance Methods

River maintenance methods, and their expected local geomorphic effects, are described in the River Maintenance Methods Attachment. A summary of predicted species and habitat changes are outlined in table 35. These changes are dependent on project location and scope. Project specific analysis for river maintenance will be completed for all proposed projects and tiered off this

Table 33. Predicted Effects to Silvery Minnow Habitat from River Maintenance Strategies in Various Reaches

	Promote Elevation Stability	Promote Alignment Stability	Reconstruct/ Maintain Channel Capacity	Increase Available Area to the River	Rehabilitate Channel and Flood Plain	Manage Sediment
Velarde to Rio Chama		No effects to silvery minnow or silvery minnow critical habitat.		No effects to silvery minnow or silvery minnow critical habitat.	No effects to silvery minnow or silvery minnow critical habitat.	
Rio Chama to Otowi Bridge	No effects to silvery minnow or silvery minnow critical habitat.	No effects to silvery minnow or silvery minnow critical habitat.		No effects to silvery minnow or silvery minnow critical habitat.	No effects to silvery minnow or silvery minnow critical habitat.	
Cochiti Dam to Angostura Diversion Dam	The current distribution of silvery minnow and habitat within the Cochiti Dam to Angostura Diversion Dam Reach is unknown. Though current conditions are not favorable to silvery minnow, any activity to promote elevation stability should maintain current conditions. The proposed action will not change current conditions. Channel spanning features to promote elevation stability would be constructed to facilitate movement of silvery minnow.	The current distribution of silvery minnow and habitat within the Cochiti Dam to Angostura Diversion Dam Reach is unknown. Methods to promote alignment stability may reduce the rivers potential to maintain habitat complexity.		Implementing projects to increase the channel area are likely to have a positive impact on habitat diversity for silvery minnow by increasing sinuosity and hydrologically connected surfaces. Downstream effects are minimized by Angostura Diversion Dam.	Implementation of methods intended to reconnect the flood plain at lower discharge levels are likely to have positive effects on silvery minnow habitat by creating high productivity larval fish habitats that are inundated more often than existing conditions. There is the possibility that silvery minnow may become entrained on the flood plain when inundation subsides, which may result in take.	

Table 33. Predicted Effects to Silvery Minnow Habitat from River Maintenance Strategies in Various Reaches

	Promote Elevation Stability	Promote Alignment Stability	Reconstruct/ Maintain Channel Capacity	Increase Available Area to the River	Rehabilitate Channel and Flood Plain	Manage Sediment
Angostura Diversion Dam to Isleta Diversion Dam	This reach is currently occupied by silvery minnow. Any activity to promote elevation stability should maintain or improve current conditions for silvery minnow. Channel spanning features to promote elevation stability would be constructed to facilitate movement of silvery minnow.	This reach is currently occupied by silvery minnow. Strategies to promote alignment stability may reduce habitat complexity.			Methods to rehabilitate the channel and flood plain are generally designed to help the river function more naturally and benefit silvery minnow. There is the possibility that silvery minnow may become entrained on the flood plain when inundation subsides, which may result in take.	Likely would maintain current conditions within the reach.
Isleta Diversion Dam to Rio Puerco	This reach is currently occupied by silvery minnow. Any activity to promote elevation stability should maintain or improve current conditions for silvery minnow. Channel spanning features to promote elevation stability would be constructed to facilitate movement of silvery minnow.		Depending on the method used, long term effects may be positive or negative. Methods that decrease complexity are negative, strategies that allow for reconnection of abandoned side channels and backwaters would be positive.	Implementing projects to increase the channel area are likely to have a positive impact on habitat diversity for silvery minnow by increasing sinuosity and hydrologically connected surfaces.	Methods to rehabilitate the channel and flood plain are generally designed to help the river function more naturally and benefit silvery minnow. There is the possibility that silvery minnow may become entrained on the flood plain when inundation subsides, which may result in take.	Likely would maintain current conditions within the reach. Depositional bars and islands may form downstream of augmentation sites. This may increase habitat complexity for silvery minnow.

Table 33. Predicted Effects to Silvery Minnow Habitat from River Maintenance Strategies in Various Reaches

	Promote Elevation Stability	Promote Alignment Stability	Reconstruct/ Maintain Channel Capacity	Increase Available Area to the River	Rehabilitate Channel and Flood Plain	Manage Sediment
Rio Puerco to San Acacia Diversion Dam	This reach is currently occupied by silvery minnow. Any activity to promote elevation stability should maintain or improve current conditions for silvery minnow. Channel spanning features to promote elevation stability would be constructed to facilitate movement of silvery minnow	This reach is currently occupied by silvery minnow. Strategies to promote alignment stability may reduce habitat complexity.		Implementing projects to increase the channel area are likely to have a positive impact on habitat diversity for silvery minnow by increasing sinuosity and hydrologically connected surfaces.	Methods to rehabilitate the channel and flood plain are generally designed to help the river function more naturally and benefit silvery minnow. There is the possibility that silvery minnow may become entrained on the flood plain when inundation subsides that may result in take.	
San Acacia Diversion Dam to Arroyo de las Cañas	This reach is currently occupied by silvery minnow. Any activity to promote elevation stability should maintain or improve current conditions for silvery minnow. Channel spanning features to promote elevation stability would be constructed to facilitate movement of silvery minnow	This reach is currently occupied by silvery minnow. Strategies to promote alignment stability may reduce habitat complexity.		Implementing projects to increase the channel area are likely to have a positive impact on habitat diversity for silvery minnow by increasing sinuosity and hydrologically connected surfaces.	Strategies to rehabilitate the channel and flood plain are generally designed to help the river function more naturally and benefit silvery minnow. There is the possibility that silvery minnow may become entrained on the flood plain when inundation subsides that may result in take.	Likely would maintain current conditions within the reach.
Arroyo de las Cañas to San Antonio Bridge	Suitable strategy, likely to be implemented by methods falling under the other strategies identified for this reach.		Overbank area is expected to decrease temporarily.			Likely would maintain current conditions within the reach.

Table 33. Predicted Effects to Silvery Minnow Habitat from River Maintenance Strategies in Various Reaches

	Promote Elevation Stability	Promote Alignment Stability	Reconstruct/ Maintain Channel Capacity	Increase Available Area to the River	Rehabilitate Channel and Flood Plain	Manage Sediment
San Antonio Bridge to River Mile 78	Suitable strategy, likely to be implemented by methods falling under the other strategies identified for this reach.		Overbank area is expected to decrease. Increased water and sediment delivery to lower reaches may change likelihood of drying in those reaches.	Implementing projects to increase the channel area are likely to have a positive impact on habitat diversity for silvery minnow by allowing avulsions to occur, increasing hydrologically connected surfaces.		Likely would maintain current conditions within the reach.
River Mile 78 to Full Pool Elephant Butte Reservoir Level	Suitable strategy, likely to be implemented by methods falling under the other strategies identified for this reach.		Overbank area is expected to decrease temporarily.	Implementing projects to increase the channel area are likely to have a positive impact on habitat diversity for silvery minnow by increasing sinuosity and hydrologically connected surfaces.		Likely would maintain current conditions within the reach. May cause less aggradation in upstream reaches

Table 34. Predicted Effects to Flycatcher Habitat from River Maintenance Strategies in Various Reaches

	Promote Elevation Stability	Promote Alignment Stability	Reconstruct/ Maintain Channel Capacity	Increase Available Area to the River	Rehabilitate Channel and Flood Plain	Manage Sediment
Velarde to Rio Chama		This reach has minimal flycatcher territories and suitable habitat. This strategy decreases the erosion and deposition ability of the river, from lateral erosion, in turn decreasing the opportunity for a variety of successional stages needed for flycatcher habitat. However, deposition and erosion processes may still continue on bars and islands.		This reach has minimal flycatcher territories and suitable habitat. Positive impacts to flycatcher habitat with this strategy and habitat availability in this reach likely would increase with the added area the river could potentially meander.	This reach has minimal flycatcher territories and suitable habitat. This strategy would increase overbank wetted area and may increase the channel sinuosity. Minimal effects are expected upstream of and downstream from this reach. Flycatcher habitat may improve.	
Rio Chama to Otowi Bridge	Minimal flycatcher territories and suitable habitat in this reach. No impact on flycatcher. If anything, positive, as it would not let further incision occur in this reach.	Minimal flycatcher territories and suitable habitat in this reach. Alignment stability decreases erosion and deposition for regenerating flycatcher habitat from lateral erosion. However, deposition and erosion processes may still continue on bars and islands.		Minimal flycatcher territories and suitable habitat in this reach. Allowing the river to meander over a greater flood plain could create new and younger age classes of vegetation for flycatcher through erosion and deposition of sediments. Flycatcher habitat could improve with a meandering river.	Minimal flycatcher territories and suitable habitat in this reach. This strategy could have a positive impact on flycatcher habitat from the increased likelihood of overbank flooding and greater sinuosity.	

Table 34. Predicted Effects to Flycatcher Habitat from River Maintenance Strategies in Various Reaches

	Promote Elevation Stability	Promote Alignment Stability	Reconstruct/ Maintain Channel Capacity	Increase Available Area to the River	Rehabilitate Channel and Flood Plain	Manage Sediment
Cochiti Dam to Angostura Diversion Dam	This reach does not have flycatchers or flycatcher suitable habitat. Stabilizing the bed elevation would at least prevent further degradation of flycatcher habitat in this reach.	This reach does not have flycatchers or flycatcher suitable habitat. Reduced ability for erosion and deposition from lateral erosion needed for flycatcher habitat. However, deposition and erosion processes may still continue locally on bars and islands.		This reach does not have flycatchers or flycatcher suitable habitat. Allowing the river to meander over a greater flood plain could create new and younger age classes of vegetation for flycatcher through erosion and deposition of sediments.	This reach does not have flycatchers or flycatcher suitable habitat. Flycatcher habitat within this reach would not be affected as there really is none, or the potential for habitat creation would be slightly improved.	
Angostura Diversion Dam to Isleta Diversion Dam	Minimal flycatcher territories and suitable habitat. Current suitable habitat becoming over mature and declining in value for flycatchers. Preventing channel incision would help prevent further decrease in flycatcher habitat.	Minimal flycatcher territories and suitable habitat. Current suitable habitat becoming over mature and declining in value for flycatchers. No significant change to flycatcher habitat would occur.			Minimal flycatcher territories and suitable habitat. Current suitable habitat becoming over mature and declining in value for flycatchers. Flycatcher habitat within this reach would not be affected or would be slightly improved with an increased likelihood of flooding.	Minimal flycatcher territories and suitable habitat. Current suitable habitat becoming over mature and declining in value for flycatchers. Sediment management may build desirable point bar habitat for fly-catcher. However, the patch size may not be large enough for flycatcher. This reach has a low sediment supply and increasing the sediment supply could create islands and increased shoreline habitats.

Table 34. Predicted Effects to Flycatcher Habitat from River Maintenance Strategies in Various Reaches

	Promote Elevation Stability	Promote Alignment Stability	Reconstruct/ Maintain Channel Capacity	Increase Available Area to the River	Rehabilitate Channel and Flood Plain	Manage Sediment
Isleta Diversion Dam to Rio Puerco	Promoting elevation stability in this reach likely would not have a great impact on flycatcher habitat as there is not much currently present. However, this strategy would prevent future channel incision in this reach.		Minimal flycatcher habitat or territories within this reach. Overall, this strategy would not change flycatcher habitat significantly from existing conditions. If management activities are taken that allows bed elevation increases and reconnection of side channels and backwaters, benefits to flycatcher habitat would occur.	Minimal flycatcher territories and suitable habitat in this reach. Current suitable habitat becoming over mature and declining in value for flycatchers. Impacts to flycatcher habitat from this strategy could be positive if the river were to migrate to occupy the newly available area.	Minimal flycatcher territories and suitable habitat in this reach. Flycatcher habitat may benefit from increasing overbank flooding.	Minimal flycatcher territories and suitable habitat in this reach. Impacts for flycatcher depend on the type of sediment management.
Rio Puerco to San Acacia Diversion Dam	No impact on flycatcher. If anything, positive as it would not let further incision occur in this reach and allow a continuation of overbank flooding.	This reach has historically had populations of flycatchers and suitable habitat. This strategy decreases the river's abilities for erosion and deposition from lateral migration and, thus, decreases regenerating flycatcher habitat.		Allowing the river to meander over a greater flood plain could create new and younger age classes of vegetation through erosion and deposition, potentially improving and regenerating flycatcher habitat.	This reach has had localized populations of flycatchers and areas of suitable habitat. Habitat for flycatcher in this reach likely would be improved by this strategy by providing increased overbank flooding.	

Table 34. Predicted Effects to Flycatcher Habitat from River Maintenance Strategies in Various Reaches

	Promote Elevation Stability	Promote Alignment Stability	Reconstruct/ Maintain Channel Capacity	Increase Available Area to the River	Rehabilitate Channel and Flood Plain	Manage Sediment
San Acacia Diversion Dam to Arroyo de las Cañas	No impact on flycatcher as there are very few areas with suitable habitat or historic flycatcher territories. If anything, positive as it would not let further incision occur in this reach.	The river's ability for erosion and deposition would decrease, decreasing the potential for creating flycatcher habitat.		By increasing the space available for river movement, the potential for suitable conditions for seed establishment and creation of new flycatcher habitat would increase.	This strategy could have a positive impact on future potential flycatcher habitat from the increased likelihood of overbank flooding. Minimal areas of suitable or occupied habitat exist presently within this reach.	This reach likely would require the addition of sediment which would allow for some aggradation that would be beneficial for any potential flycatcher habitat creation in the future.
Arroyo de las Cañas to San Antonio Bridge	This strategy within this reach would involve stabilizing a rising bed, which would be achieved primarily through the Reconstruct/ Maintain Channel Capacity and Manage Sediment Strategies.		Overall, this strategy would not change the minimal flycatcher habitat existing currently within this reach. This reach currently has an aggrading channel and attached side channels; main-taining that trend would increase the possibility of flycatcher habitat creation. However, the maintenance of channel capacity in this reach may cause a reduction in potential overbank flooding and may reduce the possibility in habitat creation.			This strategy would not change flycatcher habitat significantly from existing conditions as there are minimal areas of suitable habitat or historic territories within this reach. However, the reduction in sediment in this reach may cause a reduction in potential overbank flooding and may reduce the possibility in habitat creation.

Table 34. Predicted Effects to Flycatcher Habitat from River Maintenance Strategies in Various Reaches

	Promote Elevation Stability	Promote Alignment Stability	Reconstruct/ Maintain Channel Capacity	Increase Available Area to the River	Rehabilitate Channel and Flood Plain	Manage Sediment
San Antonio Bridge to River Mile 78	This strategy within this reach would involve stabilizing a rising bed, which would be achieved primarily through the Reconstruct/ Maintain Channel Capacity, Increase Available Area to the River, and Manage Sediment Strategies.		There is a large population of flycatchers and an abundance of suitable habitat within this reach. Flycatcher impacts will depend on site locations and need site assessments.	This strategy would be beneficial to the abundance of currently existing flycatcher habitat by allowing the river to aggrade and potentially move into a larger flood plain, expanding habitat in the future.		Impacts would be site-specific for the large flycatcher population, but decreasing aggradation and the potential for occurrence of sediment plugs would negatively impact existing and developing flycatcher habitat.
River Mile 78 to Full Pool Elephant Butte Reservoir Level	No impact on the moderate amount of flycatcher habitat and territories mainly located in the northern extent of this reach. This strategy within this reach would involve stabilizing a rising bed, which would be achieved primarily through the Reconstruct/ Maintain Channel Capacity, Increase Available Area to the River, and Manage Sediment Strategies.		Removing sediment and preventing overbank flooding would be a detriment to flycatcher habitat. In instances where the channel would be relocated, if done so with a minimal bank height and an opportunity for overbank flooding, creation of flycatcher habitat may be possible.	Generally positive for flycatcher but needs to be accompanied by sediment management that promotes aggradation and the formation of potentially suitable flycatcher habitat, particularly in the severely degraded downstream portion of this reach. In areas where the bed degradation is currently below the root zone, the collapse of the bank may allow the formation of potentially suitable flycatcher habitat within the channel to occur.		Sediment augmentation may improve current flycatcher habitat in downstream portions of this reach, but settling basins would have the opposite effect. This strategy is very site-specific and depends on the Elephant Butte Reservoir level, and the incoming sediment supply in some areas the basin may create habitat, but require higher flows to allow for overbank flooding in other areas.

Table 35. Predicted Endangered Species, Geomorphic and Habitat Effects for River Maintenance Methods Proposed on the MRG

Method	Endangered Species Effects	Geomorphic Effects	Habitat Effects
Infrastructure relocation or setback	Generally out of flood plain; can be positive for silvery minnow habitat by allowing sinuosity and habitat diversity. Generally positive for flycatcher habitat by allowing for a wider as opposed to deeper river system. A greater likelihood of overbank flooding.	Can encourage current geomorphic processes to continue, such as bend migration, and the creation of new flood plain and riparian areas. Opportunity to connect to historical channels and oxbows. For incised channels, may provide an opportunity to establish new inset flood plain and riparian zone. Bank erosion should also result in deposition of sediment downstream and potentially establish bars and low surfaces. Bend migration can erode banks causing riparian vegetation to fall into the channel.	Bend migration river movement creates broader flood plain and more favorable riparian zone habitat. Inset flood plain increases overbank flooding and riparian zones which creates variable depth and velocity habitat types including potential spring runoff silvery minnow nursery habitat. The lateral and down valley migration of the river provides more opportunity for successional age classes of potentially native vegetation for flycatcher habitat. Longer meander bends may establish greater pool depth and eroding banks providing additional complexity.
CHANNEL MODIFICATION			
Complete Channel Reconstruction and Maintenance	Depends on project design and scope. Generally negative for silvery minnow habitat due to decrease in low velocity habitats. Projects may be designed to have less impact on silvery minnow habitat. Generally negative for flycatchers if channel decreases potential for overbank flooding and/or acts as a drain, decreasing ground water level that could cause stress for vegetation and eventually encourage exotic encroachment.	Increased sediment transport through a delta or reconstructed channel. Decreases upstream channel aggradation. Can lead to channel bed lowering upstream of the project site, and low-flow alternate bars can form within the excavated channel. Relatively uniform width, depth, and velocity. Reduces braiding and split delta channels. Can lower the ground water table, and reduce the size of river bars. If medial and alternate bars are not removed as part of ongoing maintenance, then the amount of shallower, lower velocity areas should increase.	Can have more uniform width, depth, and velocity. Limited amount of low or no velocity habitat; low amount of cover. Reduces braiding and distributary channels and, thus, provides less opportunity for riparian growth. Lowers ground water table and reduces the size of river bars. If medial and alternate bars are not removed as part of ongoing maintenance, then the amount of smaller depth and velocity habitat increases.
Channel Relocation Using Pilot Channels or Pilot Cuts	Depends on project design and scope. Projects may be designed to improve silvery minnow habitat or may decrease habitat diversity by creating a monotypic channel for water conveyance. Projects may be designed to improve flycatcher habitat or may decrease habitat suitability if channel takes too long to widen and incision and lowering of the water table occurs.	Lengthening can bring sediment transport capacity more in balance with sediment supply in supply-limited reaches. Re-establishes meanders, increases channel stability, and initiates new areas of bank erosion and deposition. Can provide overbank flooding and can create connected flood plain/ wetted areas.	Depending on project design and scope, can provide overbank flooding and establish new areas of riparian vegetation. Can increase the complexity of habitat by creating connected flood plain/wetted areas for silvery minnow egg entrainment and larval development.

Table 35. Predicted Endangered Species, Geomorphic and Habitat Effects for River Maintenance Methods Proposed on the MRG

Method	Endangered Species Effects	Geomorphic Effects	Habitat Effects
Island and Bank Clearing and Destabilization	Generally positive for silvery minnow, reduces flow needed to inundate overbank habitat. Projects may be designed to improve flycatcher habitat or may decrease habitat suitability if channel takes too long to widen and incision and lowering of the water table occurs.	Promotes a wider channel with greater flood plain connectivity, and better transport capacity/supply balance. New sediment balance may be temporary unless increased supply is maintained. Reduces further degradation of the channel and lowering of the water table. learing and destabilization would result in the lowering and/or loss of islands and bars, but sediments from destabilized areas may deposit in new bars, which would be more connected to the main channel and suitable for vegetation growth. Cleared areas may become zones of sediment deposition and vegetation may re-grow, making re-clearing necessary for benefits to continue.	Islands/bars that are more connected to the main channel can provide silvery minnow with a greater variety of depth and velocity habitat types. Provides low velocity habitat during high flows for adult fish. Increased overbank flooding creates variable depth and velocity habitat types including silvery minnow nursery habitat during spring runoff and aids in increasing egg and larval entrainment. Loss of habitat may be temporarily negative depending on site specific details and proximity to flycatcher territories, however, sediment accumulation forming new bars or islands could promote new seed source establishment and potentially young native successional stands to develop into flycatcher habitat. By reducing further degradation of the channel and lowering of the water table, the flood plain has a better chance of connectivity which is better overall for the flycatcher.
Bank Line Embayment	Depends on project design and scope. May be positive for silvery minnow by providing more low velocity habitat for silvery minnow. Depends on project design and scope. May provide more surface water for vegetation and possibly attract flycatchers establishing territories.	Historical areas of channel slow water velocity and shallow bank line are restored/rehabilitated. Bank line embayments are zones of sediment deposition and have a finite lifespan without periodic re-excavation.	Slow water velocity and shallow depth bank line habitat. Increase in egg retention and availability of nursery larval habitat during high flow. Increases probability of native vegetation growth and potential for flycatcher habitat.
Pilot Cuts Through Sediment Plugs	Depends on project design and scope. Projects may be designed to improve silvery minnow habitat or may decrease habitat diversity by creating a monotypic channel for water conveyance. Projects may be designed to improve flycatcher habitat via berm placement techniques that encourage sediment	Connecting small channels through sediment plugs results in plug material being transported downstream to re-establish preplug riverine conditions. Restores flow velocity and depth conditions found in the main river channel. Allows sediment transport to continue, which may possibly provide new bars and islands downstream.	Allows sediment transport to continue, which may possibly provide new areas for riparian vegetation establishment. While the sediment plugs block main channel flows, silvery minnow do utilize overbank channels through the riparian corridor created by the plug. There is increased potential for silvery

Table 35. Predicted Endangered Species, Geomorphic and Habitat Effects for River Maintenance Methods Proposed on the MRG

Method	Endangered Species Effects	Geomorphic Effects	Habitat Effects
	transport and deposition downstream for example, or may decrease habitat diversity by creating a monotypic channel for water conveyance that would decrease the chance of overbank flooding potential.		minnow stranding during receding flow conditions.
Side Channels (High Flow, Perennial, and Oxbow Re-establishment)	Generally positive for silvery minnow, provides greater habitat diversity. Generally positive for flycatcher, provides greater vegetation potential and increases water surface elevation. During construction, vegetation may need to be cleared, but long-term benefits could outweigh the disadvantages.	Important to natural systems for passage of peak flows. Sediment tends to fill in high-flow side channels over time. Can decrease peak-flow water surface elevation and may decrease sediment transport capacity until sediment blocks the side channel. Periodic inlets and outlet sediment removal may be needed to maintain project benefits. Side channels result in raising the ground water table and can supply surface flows to overbank and flood plain areas. Can reconnect the flood plain to the channel, creating areas with variable depth and velocity.	Can result in higher ground water table, increasing the health of the riparian zone. Can reconnect the flood plain to the channel, creating nursery habitat for silvery minnow with variable depth and velocity habitats. Provides low velocity habitat during high flows for adult fish and developing larvae. Increase in retention of eggs and larvae during high flows. Raising the ground water table to provide water to developing riparian areas increases vegetation health. Periods of increased surface flows, particularly during mid-May to mid-June, increases probability of flycatcher territory establishment in areas with suitable habitat.
Longitudinal Bank Lowering or Compound Channels	Generally positive for silvery minnow, reduces flow needed to inundate overbank habitat. Generally positive for flycatchers and flycatcher habitat, reduces flow needed to inundate overbank habitat.	Lowered bank line can promote increases in channel width and decreases in main channel velocity, depth, shear stress, and sediment transport capacity. Reduces potential for channel degradation, thereby maintaining a higher water table and more connectivity with backwaters, side channels and flood plain. Increases overbank flooding, creating areas of variable depth and velocity.	Promotes overbank flooding favorable for establishment of riparian vegetation as well as creating variable depth and velocity habitat. Reduces potential for channel degradation, thereby maintaining a higher water table and more connectivity with backwaters and side channels. Increased overbank flooding creates variable depth and velocity habitat types including silvery minnow nursery habitat during spring runoff. Increased overbank flooding maintains moist soil conditions during flycatcher territory establishment. Growth of native riparian vegetation can enhance habitat conditions for the flycatcher.

Table 35. Predicted Endangered Species, Geomorphic and Habitat Effects for River Maintenance Methods Proposed on the MRG

Method	Endangered Species Effects	Geomorphic Effects	Habitat Effects
Longitudinal Dikes	Generally negative for silvery minnow habitat, reduces habitat complexity and sinuosity. Generally negative for flycatcher habitat, reduces habitat complexity and sinuosity. Construction activity is very intensive and requires a high amount of maintenance.	Can create a zone of higher main channel velocity resulting in increased sediment transport capacity. This can potentially cause the channel to deepen and create a sediment depositional zone downstream. Can decrease overbank flow area and can result in more uniform channel velocity and depth.	Can decrease overbank flows, reducing the health of riparian zone. This can be partially mitigated by providing culverts for wetting the riparian zone. Can result in more uniform channel velocity and depth.
Levee Strengthening	No change for silvery minnow, maintains current conditions. Depends on project design, scope and location. Projects would typically be in areas away from flycatchers as flycatchers are typically located away from pre-existing levees and closer to the river or other water sources, and projects would also allow increased infrastructure capability to handle overbank flooding between the river and the levee. Maintenance activity would be invasive to nearby vegetation	The geomorphic response associated with levee installation has already occurred for the levee strengthening method. Initial levee construction generally resulted in flood plain narrowing. Raising or enlarging the levee causes very minor or no geomorphic effects. Small amounts of clearing may be required to enlarge the levee and reduce the side slope. May allow channel relocation nearer to levee.	Initial levee construction and the accompanying flood plain narrowing affect the habitat. Raising or enlarging the levee causes very minor o no habitat effects. Small amounts of clearing may be required to enlarge the levee and reduce the side slope.
Jetty/Snag Removal	Generally positive for silvery minnow, allows for bank migration and flood plain connectivity. Depends on project design and scope. By destabilizing the bank, could increase the possibility of lateral migration of the river or channel widening.	Jetty removal may result in channel widening and increased flood plain connectivity. Channel widening is less likely to occur where the riparian vegetation root zone provides more bank stability than the jetties. Channel widening (unless hampered by existing vegetation) could reduce channel flow depth and velocity.	The habitat may not change if the existing vegetation has more effect on bank stability than the jetties themselves. Otherwise, channel widening could reduce channel flow depth and velocity and create more bank line habitat.
Bank Protection/Stabilization			
Longitudinal Features			
Riprap Revetment	Generally negative for silvery minnow habitat, reduces habitat complexity and sinuosity. Rip rap structures may provide habitat for predatory fishes. Depends on project design, scope and location. Bank protection would protect suitable habitat if present, but vegetation may already be declining in value in reaches	Eliminates bank erosion; causes local scour and channel deepening. Studies about longer reach response are contradictory. Can be susceptible to flanking if upstream channel migration occurs. Prevents bend migration and the establishment of new depositional zones. Eliminates sediment supplied from local bank erosion. The point bar can remain connected to the main	Prevents bend migration and the establishment of new depositional zones where vegetation could become established. Eliminates sediment supplied from local bank erosion. The steep bank angle on the outside of the bend limits fish cover, except for the riprap interstitial spaces. The point bar remains connected to the

Table 35. Predicted Endangered Species, Geomorphic and Habitat Effects for River Maintenance Methods Proposed on the MRG

Method	Endangered Species Effects	Geomorphic Effects	Habitat Effects
	where incision is to the point where lateral migration is occurring to such an extent that riprap revetment is necessary.	channel. The flow velocity, depth, and bank angle would be greater than typically found in natural channels along the outside bank of a river bend. Interstices within the riprap could host low-energy "pockets" along the bank.	main channel and remains static. The flow velocity and depth are greater than typically found in natural channels along the outside bank of a river bend.
Other Type of Revetments	Effects are essentially the same as riprap revetments.	Effects are essentially the same as riprap revetments.	Effects are essentially the same as riprap revetments
Longitudinal Stone Toe with Bioengineering	Effects are essentially the same as riprap revetments.	Similar to riprap revetment.	Same as riprap revetment. Bioengineering provides very minimal benefits to riparian community.
Trench Filled Riprap	Effects are essentially the same as riprap revetments.	Bank erosion processes continue until erosion reaches the location of the trench. After launching, response is the same as for riprap revetment.	Same as riprap revetment.
Riprap Windrow	Effects are essentially the same as riprap revetments.	Same as trench filled riprap.	Same as riprap revetment.
Deformable Stone Toe/Bioengineering and Bank Lowering	Depends on project design and scope. Projects may be designed to improve silvery minnow habitat or may decrease habitat diversity by creating a high velocity area with little habitat diversity. Projects may be designed to improve flycatcher habitat and lowering the banks on terraced locations could promote overbank flooding potential.	The design is intended to allow bend migration at a slower rate than without protection. River maintenance may still be required in the future. Water surface elevations could be lower with bank lowering. After installation, and before the toe of the riprap becomes mobile, the channel bed may scour along the deformable bank line. Bank erosion occurs during peak-flow events, which mobilizes the small-sized riprap along the bank toe. Future bank migration would allow new depositional surfaces to be established.	If flood plain is created behind the stone toe and vegetation becomes established before the toe is lost, an expanded riparian area could develop. Future bank migration would allow new depositional surfaces to establish, which would become new riparian areas.
Bioengineering	Depends on project design and scope. Projects may be designed to improve silvery minnow habitat or may decrease habitat diversity by creating a high velocity area with little habitat diversity. Bioengineering would not be a standalone method, and further analysis would need to be completed on a project specific description. May have long-term benefits to flycatchers.	Vegetation has the lowest erosion resistance of all available methods. Plantings require time to become established before any bank protection is realized. Lateral and down-valley bank line movement can continue because bioengineering does not permanently fix the bank location. Allows more natural movement of river channel.	If the technique is successful, it could promote the establishment and development of riparian vegetation without significant armament to the bank line. Allows more natural movement of river channel.

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Method	Endangered Species Effects	Geomorphic Effects	Habitat Effects
Riparian Vegetation Establishment	Effects of this type of project may be mixed. Initially vegetation may provide low velocity refuge areas during overbank periods. Long-term establishment of vegetation may add to channel narrowing which is negative for silvery minnow. Generally positive for flycatchers and flycatcher habitat. Encouraging new native growth could provide suitable habitat once mature.	Can cause sediment deposition in overbank areas due to increased flow resistance. Sediment deposition in the overbank can increase main channel sediment transport capacity by raising the bank height.	Directly adds to the amount of riparian vegetation. Increased growth of riparian vegetation in overbank areas can enhance habitat conditions for both the flycatcher and the silvery minnow. Encroachment of mature vegetation may eventually lead to a narrower and more confined channel which is negative for silvery minnow habitat.
Transverse Features or Flow Deflection Techniques	Depends on project design and scope. Projects may be designed to improve silvery minnow habitat since they tend to create variable depth and velocity habitat, which increases complexity. In general, transverse features decrease bank erosion and deepen the main channel locally.	These methods may cause local sediment deposition between structures and/or local scalloping along the bank line. Flow is deflected away from the bank line, thereby altering secondary currents and flow fields in the bend. Eddies, increased turbu-lence, and velocity shear zones are created. Methods induce local channel deepening at the tip. Shear stress increases in the center of the channel, which maintains sediment transport and flow capacity. Sediment deposition between structures may allow establishment of islands, bars, and backwater areas. Channel deepening and tip scour could occur locally	Sediment deposition between structures may allow establishment of riparian vegetation and backwater areas. Channel deepening and tip scour could occur locally. Depending on site specific details, bendway weirs would allow for overbank flooding conditions for flycatchers. Local scour could provide habitat diversity and deep habitat during low flow conditions.
Bendway Weirs	Depends on project design and scope. Projects may be designed to improve silvery minnow habitat since they tend to create variable depth and velocity habitat, which increases complexity. Could trap sediment and encourage new vegetation growth. No significant effect on flycatcher habitat.	The location of the thalweg is shifted away from the outer bank line. Local scour at the tip occurs because of the three-dimensional flow patterns. Secondary currents are interrupted, and flows are redirected away from the bank. The outer bank can become a zone of lower velocity. The combined effect of the tip scour and lower velocity along the bank line creates a flow condition of variable depth and velocity. Scalloping also can occur along the bank line or sediment deposition between structures depending upon local conditions and bendway weir geometry. Can reduce local sediment supplied from bank erosion because the current river alignment is maintained.	Same as transverse features or flow deflection techniques above.

Table 35. Predicted Endangered Species, Geomorphic and Habitat Effects for River Maintenance Methods Proposed on the MRG

Method	Endangered Species Effects	Geomorphic Effects	Habitat Effects
Spur Dikes	Depends on project design and scope. Projects may be designed to improve silvery minnow habitat since they tend to create variable depth and velocity habitat, which increases complexity. Could trap sediment and encourage new vegetation growth. No significant effect on flycatcher habitat.	Spur dikes block the flow up to bank height, thus shifting the thalweg alignment to the dike tips. Peak flow capacity can be reduced initially until the channel adjusts. The channel adjusts to the presence of spur dikes by forming a deeper, narrower cross section with additional scour downstream of each spur dike. Sediment deposition can occur between spur dikes. There is a greater tendency for sediment deposition between spur dikes than the other transverse features.	Same as transverse features or flow deflection techniques above. There is a greater tendency for sediment deposition between spur dikes than the other transverse features.
Vanes or Barbs	Depends on project design and scope. Projects may be designed to improve silvery minnow habitat since they tend to create variable depth and velocity habitat, which increases complexity. Could trap sediment and encourage new vegetation growth. No significant effect on flycatcher habitat.	These structures redirect flow from the bank toward the channel center and reduce local bank erosion while providing a downstream scour hole. Sediment deposition or bank scalloping can occur along the outer bank, depending upon spacing.	Same as transverse features or flow deflection techniques above.
J-Hook	Depends on project design and scope. Projects may be designed to improve silvery minnow habitat since they tend to create variable depth and velocity habitat, which increases complexity. Could trap sediment and encourage new vegetation growth. No significant effect on flycatcher habitat.	Redirects flow away from eroding banks, the same as vanes or barbs, with an added downstream-pointing "J" configuration. The J-hook creates an additional scour hole pool and can produce a local downstream riffle. Remainder of the geomorphic response is the same as for vanes.	Same as transverse features or flow deflection techniques described above. Additional pool habitat is created by the J-hook.
Trench Filled Bendway Weirs	Depends on project design and scope. Projects may be designed to improve silvery minnow habitat since they tend to create variable depth and velocity habitat, which increases complexity. Could trap sediment and encourage new vegetation growth. No significant effect on flycatcher habitat.	Once the bank erosion reaches the bendway weir tips, the flow is redirected away from the eroding bank. The location of the thalweg is shifted away from the outer bank line. Local scour at the tip occurs because of the three-dimensional flow patterns. Secondary currents are interrupted. The outer bank can become a zone of lower velocity.	Provided the bendway weirs constructed in a trench remain intact, the habitat characteristics will be about the same as bendway weirs constructed in the channel.
Boulder Groupings	Generally projects are designed to provide refuge areas for silvery minnow during low flow. Projects may be designed to also provide	Creates a zone of local scour immediately downstream of the boulders. Creates areas of variable depth and velocity. Creates velocity shear zones.	Can provide structure and habitat for fish.

Table 35. Predicted Endangered Species, Geomorphic and Habitat Effects for River Maintenance Methods Proposed on the MRG

Method	Endangered Species Effects	Geomorphic Effects	Habitat Effects
	some level of bank protection. Could trap sediment and encourage new vegetation growth. No significant effect on flycatcher habitat.	Effects are localized to the immediate vicinity of the boulders. Increases channel roughness at high flows. Adds complexity to the system.	
Rootwads	Generally, projects are designed to create refuge areas for silvery minnow during low flow. Projects may be designed also to provide some level of bank protection. Silvery minnow response to past projects has been mixed. Could trap sediment and encourage new vegetation growth. No significant effect on flycatcher habitat.	Creates local scour pools and areas of variable velocity. Increases flow resistance along the bank line, which dissipates energy, traps and retains sediments, and creates turbulence that can move the main current away from the bank line. Adds complexity to the system. Variable depth and velocity conditions can be created. Some potential for creating areas of sediment deposition (depending on specific placement). Cottonwood tree rootwads have a design span of about 5 years; therefore, this method has been used with many other methods to create habitat.	Adds complexity to the system. Variable depth and velocity conditions can be created. Some potential for creating areas of sediment deposition (depending on specific placement), which is generally beneficial for establishing and developing riparian vegetation. Can provide structure and habitat for silvery minnow. Isolated pools are often maintained in scour pools caused by debris, including rootwads. This can serve as refugia habitat for silvery minnow during low-low periods. Similar to large woody debris (LWD). Could trap sediment and encourage new native vegetative growth.
Large Woody Debris	Generally, projects create refuge areas for silvery minnow during low flow. Projects may be designed also to provide some level of bank protection. Silvery minnow response to past projects has been mixed. Could trap sediment and encourage new vegetation growth. No significant effect on flycatcher habitat.	LWD can provide local stream cover and scour pool formations, deflect flows, and increases depth and velocity complexity. Can promote side channel formation and maintenance. LWD in the Middle Rio Grande can lead to sediment deposition, including formation of islands, in reaches with large sand material loads. Could establish new sediment deposition areas. LWD constructed from cottonwood trees last about 3–5 years.	Adds complexity to the system. Sediment deposition can create areas where new riparian vegetation becomes established. Can create variable depth and velocity habitat. Can provide structure and habitat for fish. May provide for habitat diversity in areas with monotypic flow patterns and refugia habitat during low flows. These habitats also may provide refuge for predatory fishes. Increased areas of moist or flooded soil conditions could assist in flycatcher territory establishment and native vegetation recruitment.
CROSS CHANNEL (RIVER SPANNING) FEATURES			
Grade Control	Depends on project design and scope. Sediment deposition upstream of the structure may provide backwater habitat for silvery minnow and willow flycatcher. In general, river spanning grade control methods would not prevent the trend of	Grade control can reduce the gradient upstream by controlling the bed elevation and dissipating energy in discrete steps. At least during low flows, the upstream water surface is raised, depend-ing on structure height above the bed. Upstream velocity is reduced. There can be a local	Increased upstream connectivity with side channels at low flows, creating variable depth and velocity habitat. By preventing future upstream local degradation, the current level of flood plain connectivity can continue. Increased upstream water

Table 35. Predicted Endangered Species, Geomorphic and Habitat Effects for River Maintenance Methods Proposed on the MRG

Method	Endangered Species Effects	Geomorphic Effects	Habitat Effects
	continued downstream incision in degrading reaches, which may cause issues with upstream fish passage requiring adaptive management. Channel spanning features would be designed to provide for upstream fish passage.	effect on sediment transport, scour, and deposition, depending on the structure characteristics. For low-head structures (1–2 feet), the amount of up-stream sediment storage is low and usually does not cause downstream bed level lowering as a result of upstream sediment storage. In supply-limited reaches, channel degradation downstream of the structure will continue as a result of excessive sediment transport capacity. The slope of the down-stream apron would be designed to provide fish passage and prevent local scour downstream from the structure. Due to the potential for the con-tinuation of the downstream channel incision trend, adaptive management may be necessary to provide for continued fish pas-sage. Reduces channel degra-dation upstream of this feature and can promote overbank flooding and raise the water table. Backwater areas could develop upstream, which also would raise the water table. If downstream degradation continued, the water table would be lowered.	levels (except for peak flows) likely would increase vegetative health and could attract flycatchers, particularly if overbank flooding conditions occurred during territory establishment. Low downstream apron slopes would be designed for fish passage
Deformable Riffles	Same as grade control above.	During low-flow conditions, where these structures are fixed, the effects upon channel morphology are described in the "grade control" response above. When the riprap material forming the riffle launches or deforms downstream, the bed can lower a relatively small amount.	Same as grade control above.
Rock Sills	Same as grade control above.	Riverbed elevation is held constant, while rock launches into the downstream scour hole. Since the bed is fixed, the effects on geomorphology are the same as for grade control.	Same as grade control above.
Riprap Grade Control (With or Without Seepage)	Same as grade control above.	Riprap is flexible and deforms into a scour hole. Can be at bed level or above. Can have short or long low-slope apron. Because the bed is fixed, the effects upon geomorphology are the same as for grade control.	Same as grade control above.

Table 35. Predicted Endangered Species, Geomorphic and Habitat Effects for River Maintenance Methods Proposed on the MRG

Method	Endangered Species Effects	Geomorphic Effects	Habitat Effects
Gradient Restoration Facility (GRF)	Same as grade control above.	Bed is fixed. The effects upon geomorphology are the same as for grade control.	Same as grade control above.
Low-Head Stone Weirs (Loose Rock)	Same as grade control above. Provides pool habitat which could become low flow silvery minnow refugia.	These structures typically are constructed above the bed elevation without grout. During low flows, there is an abrupt change in the water surface elevation through the structures, creating an upstream backwater effect. Generally, these structures do not raise the water surface during high flows. Sediment continuity can be re-established after the scour pool and tailout deposit are formed. A series of structures can dissipate energy and reduce channel degradation. Can interrupt secondary currents and move main current to the center of the channel if constructed in bendways.	Same as grade control above. Can provide pool habitat. Fish usually can pass through the interstitial spaces between weir stones.
Conservation Easements	Similar to effects of infrastructure relocation or setback.	Allows space for existing fluvial processes to continue, which can preserve flood plain connectivity. Allows more natural river movement with variable depth and velocity and promotes greater area of undisturbed streamside terrain.	Allows more natural river movement and promotes greater area of undisturbed habitat.
CHANGE SEDIMENT SUPPLY			
Increase Sediment Supply	Generally positive for silvery minnow habitat in downstream reaches, to find sediment equilibrium and control degradation. Within project area, reach effects would depend on project design and scope. Perched river channels have greater connectivity with flood plain but may be more prone to channel drying at low-flow conditions. Generally positive for flycatchers as it would provide a greater likelihood of overbank flooding.	Where the river is lacking in sediment, adding sediment can stabilize or even reverse channel incision. Adding sand-sized sediment can reduce bed material size, especially where coarser material is available in an incising channel. May result in sand deposits in pools, reduction of gravel riffle height, decreased depth, and increased width-to-depth ratio. Additional sediment could result in the establishment of river bars and terraces. Could increase the potential for overbank flooding and raise the water table elevation.	Additional sediment could result in establishing river bars and terraces, which would be conducive to establishing and developing riparian areas. Could increase the potential for overbank flooding and raise the water table elevation.
Decrease Sediment Supply	Effects would depend on current status of sediment supply. Within project area, reach effects would depend on project design and scope.	Where the river has excess sediment supply, reducing or removing the sediment supply can stabilize or reverse aggradational trends. Reduction	In general, more uniform depth and velocity habitat would result, which decreases habitat complexity for the silvery minnow. The

Table 35. Predicted Endangered Species, Geomorphic and Habitat Effects for River Maintenance Methods Proposed on the MRG

Method	Endangered Species Effects	Geomorphic Effects	Habitat Effects
	Perched river channels have greater connectivity with flood plain but may be more prone to drying. Projects that decrease sediment supply are generally negative for flycatchers as it may change the aggadational trend that promotes overbank flooding.	of sediment supply could cause the bed material to coarsen. In general, a more uniform channel depth and velocity would result. In addition, the tendency for the channel to braid and form split delta channels would be reduced. Water table may fall.	opportunity for the channel to braid and form distributary channels would be reduced, providing less opportunity for riparian growth.

consultation. The morphology changes from a specific method in an isolated location are expected to be local in nature and have a negligible effect on the reach morphology. It is anticipated that river maintenance projects at multiple site locations, implemented as part of a river maintenance strategy for a reach, may have a cumulative effect and a noticeable impact on the dynamics of the reach. It is expected that the reach effects of multiple river maintenance projects could be similar to the geomorphic effects of the river maintenance strategy that best describes the projects (see section 6.1.1). Reach monitoring would be accomplished to determine the actual geomorphic and biological effects. Monitoring also will help determine the threshold for the number of projects, for both a reach and a given river maintenance strategy, needed to be implemented for the cumulative geomorphic effects to affect changes in the morphology on a reach basis. The coupling of different methods together at specific project sites would need to be analyzed on a case-by-case basis, since the number of possible variations would be too numerous to list in this BA. This would be additional information that would be provided to better define a project and its effects. As needed, additional details of the effects tiered off this programmatic river maintenance BA would be developed and provided to the Service.

6.2.2 Effects of River Maintenance Support Activities

6.2.2.1 Roads and Dust Abatement

This activity primary involves vegetation removal for access to sites and watering of the roads and construction area. Access roads are generally out of the wetted area. Impacts to silvery minnow would be specific to pumping locations for the dust abatement. Pumping of water directly from the portions of the Rio Grande occupied by silvery minnow will be avoided in times when it is very likely that larval fish or eggs would be entrained into the pump. Screening of the pump intake and prioritizing pumping from irrigation/drain facilities, when possible, minimizes this take. If water is pumped from the river for dust abatement purposes, it would likely be pumped at a rate between 1.8 and 2.2 cfs for 4–8 minutes to fill a water truck. This would be a minimal impact to river flows, equating to a decrease in flows of approximately 0.2% for river flows of 1,000 cfs and approximately 0.1% for river flows of 1,500 cfs for 4–8 minutes. This activity has an insignificant effect on the silvery minnow and habitat for flycatchers.

Creation and maintenance of access roads have a bigger impact on flycatchers due to the destruction of established habitat. Reclamation biologists will work with the project lead to minimize the acreage of roads that would be within suitable habitats. Any work that involves vegetation clearing would be scheduled outside of times when flycatchers may be in the area.

6.2.2.2 Stockpiles and Storage Yards

Reclamation is proposing to continue using existing stockpile and storage locations. These are all located outside of the flood plain. Periodically, these sites require vegetation clearing (mowing and trimming), grading, graveling, drainage, and/or fencing. There are no impacts to silvery minnow due to stockpiles and storage yards. There are no impacts to flycatchers as there is no suitable habitat within existing storage yards and storage yards as they are located outside the flood plain.

6.2.2.3 Borrow and Quarry Areas

Reclamation is proposing to continue using existing borrow and quarry locations. These are all located outside of the flood plain and outside of critical habitat for either species. There are no impacts to silvery minnow or flycatchers; there is no suitable habitat within existing quarries.

6.2.2.4 Data Collection Activities

Data collection efforts are conducted through using boats, all terrain vehicles, and pedestrian travel (walking on land and wading in the river). The majority of the data collection methods are nondestructive in nature, requiring only short-term impacts of human presence within the area. The main exceptions are monitoring rangelines, subsurface monitoring, and water or sediment sampling. Subsurface monitoring requires disturbing the earth to collect samples or provide a soil characterization. Reclamation is proposing to continue using existing rangelines. Periodically these sites require vegetation clearing (mowing and trimming). There are no impacts to silvery minnow due to rangeline clearing or soil collections in the dry. There would be negative impacts to silvery minnow due to sampling in the wet, though impacts would be minimal due to the small area generally affected (less than 1 acre annually). Impacts to flycatchers will be minimal near rangelines or soil collection sites, and coordination between the Reclamation biologist and project lead would ensure ground crews keep their distance from territories during the summer. Any work that involves vegetation clearing would be scheduled outside of times when flycatchers may be in the area. Annually, the average total area affected for all data collection activities (wet and dry) is less than 16 acres. Impacts may include disturbance due to activity within the river and disturbance of sediment, which may affect turbidity and dissolved oxygen.

6.2.2.5 River Maintenance Implementation Techniques

There are various techniques that have been developed by river maintenance as the standard way (BMPs) to implement the methods that are designed for river maintenance project sites. All construction has negative impacts to endangered species. However, the benefits of using the described implementation techniques may help minimize the impact for the project overall. The benefits and construction impacts of the techniques are described in table 36. Project-specific documents will describe which of these techniques may be implemented to reduce impacts to species.

Table 36. Standard Implementation Techniques Used in Middle Rio Grande River Maintenance Projects

	Implementation Technique	Benefits of Implementation Techniques	Construction Impacts to Silvery Minnow	Construction Impacts to Willow Flycatcher
1	River diversion	Minimizes downstream turbidity impact during construction.	During berm construction minnows may be affected directly by construction equipment and the placement of material.	Generally no vegetation impacts.
2	River reconnection	Minimizes the amount of time construction equipment needed to work in the wet.	During construction, minnows may be affected directly by construction equipment.	Minimal vegetation impacts; work is done outside the active channel area.
3	Dewatering	Coupled with the river diversion technique to provide isolation of the project site from the main flow area. This technique minimizes the amount of time construction equipment needs to work in the wet.	During construction, minnows may be affected directly by construction equipment and drying of the river bed that may desiccate silvery minnow. This technique would be done in conjunction with river diversions, which may minimize the impacts to silvery minnow.	Depends on project design and scope. Short-term dewatering should have few impacts to established vegetation.

Table 36. Standard Implementation Techniques Used in Middle Rio Grande River Maintenance Projects

	Implementation Technique	Benefits of Implementation Techniques	Construction Impacts to Silvery Minnow	Construction Impacts to Willow Flycatcher
4	River crossings	Minimizes disturbance acreage in the wet by defining a set path for the construction equipment to follow. Equipment moves slowly across the river and are part of an equipment caravan. River crossings also are typically grouped temporally to minimize the time of disturbance for river crossings.	Minnows may be impacted by equipment crossing the river.	Generally no vegetation impacts.
5	Working platforms	Once working platforms are constructed, work occurs in the dry. This technique minimizes the amount of time construction equipment needs to work in the wet.	During working platform construction, minnows may be affected directly by construction equipment and being crushed by material placement. Water work warning should minimize this risk.	Generally no vegetation impacts.
6	Partial excavation of banks	This technique minimizes the amount of time construction equipment needed to work in the wet.	During construction in wet, minnows may be affected directly by construction equipment and being crushed by material placement in construction area. Water work warning should minimize this risk.	This may require removing vegetation that may impact flycatcher habitat.
7	Top of bank work	This means equipment was able to reach the desired placement area and elevation from the existing bank line without having the equipment actively in the river or needing to partially excavate the bank.	During construction in wet, minnows may be affected directly by construction equipment and being crushed by material placement construction area. Water work warning should minimize this risk.	This may require removing vegetation that may impact flycatcher habitat.

Table 36. Standard Implementation Techniques Used in Middle Rio Grande River Maintenance Projects

	Implementation Technique	Benefits of Implementation Techniques	Construction Impacts to Silvery Minnow	Construction Impacts to Willow Flycatcher
8	Amphibious construction	Typically, this method is employed when minimal disturbance of the dry portion of the project area is desirable, such as to minimize the loss of bank vegetation. This technique minimizes the disturbance to bank riparian areas.	During construction, minnows may be affected directly by construction equipment.	Generally no vegetation impacts.
9	Material placement	This technique helps prevent the formation of isolated pools or channels, which could trap fish or other species.	During construction, minnows may be affected directly by construction equipment and being crushed by material placement construction area. Water work warning should minimize this risk. Prevent-ing the formation of isolated pools decreases the like-lihood of stranding.	This may require removing vegetation that may impact flycatcher habitat.
10	Material removal	This technique helps prevent the formation of isolated pools or channels, which could trap fish or other species.	During construction, minnows may be affected directly by construction equipment and being stranded within the construction area. Preventing the formation of isolated pools decreases the likelihood of stranding.	This may require removing vegetation that may impact flycatcher habitat.
11	Infrastructure relocation	This technique may avoid the need to perform river maintenance activities in the river.	Work is generally out of the river channel and would have minimal impacts to silvery minnow.	This may require removing vegetation that may impact flycatcher habitat.

6.2.3 Unanticipated and Interim Work

The methods that are used for unanticipated and interim work for river maintenance are described within the river maintenance methods used (table 35). These include riprap revetments, levee strengthening, and riprap windrows. The effects of these methods would be similar to that described in table 35 for each method except that there may not be flexibility in the timing of the work that is needed and so may have greater effects on endangered species.

6.2.4 River Maintenance Site Size and Distribution Effects

Two general types of effects (direct and indirect) were evaluated for endangered species and their habitat from MRG river maintenance activities. Direct effects from implementation of river maintenance projects have been described in the previous subsection of section 6.2 and are dependent on project design and scope. Indirect or long-term effects for endangered species are geared more towards the long-term changes that may occur within a reach or upstream and downstream. Indirect effects are expected to be local for the implementation of individual river maintenance projects and related to the river maintenance methods used (section 6.2.1). The indirect effects from the implementation of multiple river maintenance projects within a river maintenance strategy are described in section 6.1. Effects to the silvery minnow and willow flycatcher are described, respectively, in sections 6.2.4.1 and 6.2.4.2.

6.2.4.1 Silvery Minnow

An estimated direct impact on silvery minnow from river maintenance activities occurring in the wet area of the river was developed by using information presented in section 3.6. Section 3.6.5 predicts future acreage impacts for river maintenance projects within each occupied reach. Density of silvery minnow (tables 37 and 38) is provided from Rio Grande population monitoring survey data (Dudley and Platania 2012). The mean density estimates for the slivery minnow from population monitoring data are presented for each month. Highest densities of silvery minnow generally occur in late spring and summer months (May and June) when maintenance work in the river historically has been restricted due to the occurrence of higher water depths associated with the snow melt runoff. Silvery minnow are presumed to be absent, and no critical habitat is associated with the Velarde to Rio Chama and Rio Chama to Otowi Bridge Reaches.

No survey data is available for Cochiti Dam to Angostura Diversion Dam, so that reach is not analyzed for density impact effects. All work in the wet is anticipated to have a direct effect and is likely to adversely affect silvery minnow and silvery minnow critical habitat.

Table 37. Mean Monthly Catch Rate (Silvery Minnow per 100 Square Meters [m^2]) from Rio Grande Population Monitoring Survey Data 1993–2011 (Not all reaches or months had equal numbers of surveys.)

	Angostura Diversion Dam		Isleta Diversion Dam to Rio Puerco		Rio Puerco to San Acacia Diversion Dam		San Acacia Diversion Dam to Arroyo de las Cañas		Arroyo de las Cañas to San Antonio Bridge		San Antonio Bridge to RM 78		RM 78 to Full Pool Elephant Butte Reservoir Level	
Month	**Mean**	**SE**	**Mean**	**SE**	**Mean**	**SE**	**Mean**	**SE**	**Mean**	**SE**	**Mean**	**SE**	**Mean**	**SE**
1	**2.2**	1.5	**17.4**	14.9	**2.0**	1.4	**8.0**	5.7	**5.3**	2.7	**14.2**	13.6	**2.9**	2.2
2	**2.0**	0.5	**2.9**	1.0	**2.1**	0.5	**14.9**	4.9	**21.1**	11.2	**20.4**	11.5	**6.1**	1.8
3	**3.2**	1.3	**1.4**	0.7	**2.1**	1.1	**2.6**	1.0	**6.8**	4.9	**4.0**	3.4	**6.4**	4.8
4	**2.0**	0.7	**21.9**	16.8	**5.2**	3.3	**10.3**	4.3	**4.6**	2.2	**0.8**	0.3	**1.0**	0.3
5	**8.6**	6.3	**1.9**	0.6	**44.9**	43.4	**8.3**	3.9	**5.2**	2.5	**4.2**	3.2	**4.9**	2.9
6	**12.4**	4.0	**27.8**	9.0	**11.5**	4.6	**13.8**	5.7	**5.1**	1.8	**8.1**	4.1	**7.2**	2.2
7	**22.1**	9.0	**29.1**	10.5	**97.5**	45.3	**49.4**	17.3	**22.8**	9.2	**44.1**	30.2	**31.0**	18.2
8	**10.9**	2.9	**9.4**	2.7	**14.3**	9.2	**20.8**	8.4	**27.2**	11.2	**14.7**	12.3	**12.3**	4.7
9	**5.7**	1.7	**8.5**	2.9	**5.6**	3.0	**14.6**	5.8	**11.0**	4.8	**2.5**	1.9	**5.3**	1.7
10	**4.5**	1.1	**10.6**	4.0	**5.1**	1.7	**15.5**	4.7	**21.1**	9.1	**14.8**	8.1	**9.6**	4.2
11	**7.4**	3.7	**13.5**	5.6	**3.2**	1.6	**13.9**	9.8	**28.8**	22.3	**8.7**	8.6	**1.3**	0.9
12	**3.9**	1.4	**26.5**	15.1	**2.6**	0.7	**10.5**	2.4	**7.0**	2.0	**7.9**	6.0	**12.8**	5.6

Table 38. Estimated 10-year Total Impact to Rio Grande Silvery Minnow and Their Habitat from Average Acreage River Maintenance Work Occurring Within the Wet for Each Reach

10-year Average Estimated Impacts	Number Acres	Number m^2	Mean RGSM/100 m^2	Standard Error	Anticipated Decadal Impact (Number RGSM)
Angostura Diversion Dam to Isleta Diversion Dam	186	752,723	8.2	1.8	61,347
Isleta Diversion Dam to Rio Puerco	106	428,971	13.1	4.2	56,024
Rio Puerco to San Acacia Diversion Dam	49	198,298	27.8	12.9	55,206
San Acacia Diversion Dam to Arroyo de las Cañas	79	319,705	20.4	3.9	65,220
Arroyo de las Cañas to San Antonio Bridge	96	388,502	19.3	6.3	74,826

San Antonio Bridge to River Mile 78	155	627,270	12.7	3.6	79,600
River Mile 78 to Full Pool Elephant Butte Reservoir Level	235	951,022	9.7	1.9	91,774
10-year impact (number silvery minnows) based on mean density and average project size					483,997

Impacts from projects in the wet that are conducted outside of the summer months would have less impact on silvery minnows due to densities being lower. During times of high silvery minnow densities, the amount of take that would be estimated during a specific project would be higher. The proportional impact to the population at large is the same and related to the acreage, whether densities of silvery minnow are high or low when the project is taking place.

Using the average acreage of work within the wet and population numbers extrapolated for 10 years, approximately half a million silvery minnow may be impacted due to river maintenance activities in a 10-year timeframe (see table 37). If the maximum estimated acreage is used, this number increases to around 1.5 million minnows that would be impacted by river maintenance projects. It is unlikely that this full amount would be lethally impacted due to their ability to sense and avoid construction activity. Additionally, BMPs (section 3.6.4.5) would minimize the amount of take during construction.

6.2.4.2 Effects on Flycatchers

Estimates on flycatcher habitat directly impacted by river maintenance proposed activities over the 10-year analysis period were completed by comparing the average acreage of 'dry' potential area to be impacted within the reach by river maintenance activities (table 14 in section 3.7) to the approximate acreage of suitable flycatcher habitat using data from vegetation mapping and reconnaissance work completed in 2002 and 2008.

The river maintenance area between Velarde and Cochiti Reservoir has minimal areas of suitable flycatcher habitat patches. According to Southwestern Willow Flycatcher Habitat Reconnaissance – Upper Rio Grande from the Colorado State Line to Cochiti Reservoir, New Mexico, by Ahlers 2009, the most suitable habitat within this entire stretch is located just north of Cochiti Reservoir. In total, from the New Mexico State line to Cochiti Reservoir (excluding areas that were not accessible), 89 river miles and approximately 5,334 total acres were evaluated, and 11.9% of the area was considered either suitable or marginally suitable for flycatchers. Some areas were not quantified, either because they were on tribal property or because they were inaccessible.

Using the 11.9% average of suitable/marginally suitable habitat and the average of 60 acres of flood plain area per river mile, the following was assumed. Flood plains are defined in this context as being areas typically confined within the levees or natural geographic constraints. The one exception is in the San Marcial area, where flood plain also includes riparian vegetation to the west of the levees.

- Velarde to Rio Chama Reach (dry) (13 river miles) had an estimated 780 acres of flood plain area or potentially 92 acres of suitable habitat in 2008.

- Rio Chama to Otowi Bridge Reach (dry) (14 river miles) had an estimated 840 acres of flood plain area or potentially 100 acres of suitable habitat in 2008.

Because suitable habitat within the Cochiti Dam to Angostura Diversion Dam and Angostura Diversion Dam to Isleta Diversion Dam Reaches have not been quantified, the assumptions used to describe the Velarde to Rio Chama and Rio Chama to Otowi Bridge Reaches were also used for these reaches and resulted in the following:

- Cochiti Dam to Angostura Diversion Dam (dry) (23 river miles) has 1,380 acres of flood plain area or potentially 164 acres of suitable habitat.

- Angostura Diversion Dam to Isleta Diversion Dam (dry) (41 river miles) has 2,460 acres of flood plain area or potentially 292 acres of suitable habitat.

In 2002, a mapping effort (Callahan and White 2004) was conducted by Reclamation's Denver Technical Service Center staff based on the vegetation classification system done by Hink and Ohmart (1984). The 2002 vegetation codes were compared to the 2008 codes for further classification of suitability for flycatchers. Polygons that did not match up to the 2008 codes were excluded to maintain consistency, so the total flood plain acreage is likely underestimated for this reach. Using this system for this area, it was determined that:

- Isleta Diversion Dam to Rio Puerco (dry) area consists of 42 miles and 5,893 acres of flood plain area and potentially 826 acres of suitable or marginally suitable habitat. This area (in 2002) had a higher potential for flycatcher establishment considering roughly 14% of the area had either suitable or marginally suitable areas and a wider flood plain when compared to those reaches farther north.

Using the 2008 vegetation classification system from Southwestern Willow Flycatcher Habitat Suitability 2008 – Highway 60 Downstream to Elephant Butte Reservoir, New Mexico by Ahlers et al. in 2010, the potential suitable or marginally suitable habitat values were determined for the remaining reaches. These values indicate that:

- Rio Puerco to San Acacia Diversion Dam (dry) (11 miles) has 2,513 acres of flood plain area or potentially 640 acres of suitable or marginally suitable habitat. Approximately 25% of the area was considered either suitable or marginally suitable for flycatchers.

- San Acacia Diversion Dam to Arroyo de las Cañas (dry) (21 miles) has 3,930 acres of flood plain area and 377 acres of suitable or marginally suitable habitat. Approximately 10% of the area was considered either suitable or marginally suitable for flycatchers.

- Arroyo de las Cañas to San Antonio Bridge (dry) (8 miles) has 2,247 acres of flood plain area and 115 acres of marginally suitable habitat (no polygons within this reach were considered suitable). Approximately 5% of the area was considered either suitable or marginally suitable for flycatchers.

- San Antonio Bridge to River Mile 78 (dry) (9 miles) has 4,049 acres of flood plain area and 492 acres of suitable or marginally suitable habitat. Approximately 12% of the area was considered either suitable or marginally suitable for flycatchers.

- River Mile 78 to River Mile 62 (dry) (16 miles) has 11,006 acres of flood plain area and 925 acres of suitable or marginally suitable habitat. Approximately 8% of the area was considered either suitable or marginally suitable for flycatchers.

Given the two independent variables of construction area (using the average in the dry) and flycatcher suitable or marginally suitable habitat, the percent probability of the river maintenance project site implementation impacting flycatcher habitat was derived assuming the variables are random in nature and independent of each other within the total possible flood plain area. This exercise essentially provided an approximate acreage with the probability that the implementation effort would overlap the suitable or marginally suitable habitat for flycatchers. The percent probability and total acreage of flycatcher habitat that may be impacted is listed in table 39. It is also important to note that. due to best management practices (section 3.6.4.5), areas of suitable habitat would be intentionally avoided if possible; so this exercise is likely an overestimate of habitat that would be impacted by river maintenance activities. Obviously, consistency in data varies due to the timeframe differences as well as the methodology in determining the suitability. However, this analysis attempts to provide a rough estimate of potential flycatcher habitat that may be impacted by river maintenance (including rangeline maintenance) over the next 10 years.

6.2.4.3 Effects on Pecos Sunflower

Currently the only recognized Pecos Sunflower population within the river maintenance action area is located specifically on the Rhodes property south of Arroyo de las Cañas. Reclamation will survey areas to determine if Pecos sunflower is present in the area prior to work and will design projects to avoid impacts that may affect the Pecos sunflower population.

Table 39. Average Estimated Impacts to Flycatcher Suitable Habitat from River Maintenance Projects Occurring in the Riparian Area of the Rio Grande

Reach	Average River Maintenance Impact Acreage Over 10-Year Period	Acreage Suitable or Marginally Suitable Derived from 2008 or 2002 Reconnaissance or Vegetation Mapping	Total Possible Flood Plain Acreage Derived from 2008 or 2002 Reconnaissance or Vegetation Mapping	Percent Probability that Construction Efforts Would Occur Within Suitable Habitat	Total Acreage of Suitable Habitat Directly Impacted by Construction Activities Over 10-Year Period
Velarde to Rio Chama, dry	45	92	780	0.68%	5.31
Rio Chama to Otowi Bridge, dry	43	100	840	0.61%	5.12
Cochiti Dam to Angostura Diversion Dam, dry	111	164	1,380	0.96%	13.19
Angostura Diversion Dam to Isleta Diversion Dam, dry	103	292	2,460	0.50%	12.23
Isleta Diversion Dam to Rio Puerco, dry	60	826	5,893	0.14%	8.41
Rio Puerco to San Acacia Diversion Dam, dry	27	640	2,513	0.27%	6.88
San Acacia Diversion Dam to Arroyo de las Cañas, dry	43	377	3,930	0.10%	4.12
Arroyo de las Cañas to San Antonio Bridge, dry	54	115	2,247	0.12%	2.76
San Antonio Bridge to River Mile 78, dry	85	492	4,049	0.26%	10.33
River Mile 78 to Full Pool Elephant Butte Reservoir Level, dry	130	925	11,006	0.1%	10.93

6.3 Effects from Other Reclamation MRG Project Proposed Maintenance Activities

The geomorphic effects to the MRG of the other described MRG Project maintenance actions are expected to be insignificant. There is a small hydrologic effect of work associated with other MRG Project maintenance actions, when compared to existing condition, by improving the conveyance of water to the MRG. The drainage benefits are to developed areas, meaning that they benefit human activities and infrastructure. They do not necessarily benefit listed species. Two general types of effects (direct and indirect) were evaluated for endangered species and their habitat from other MRG Project maintenance activities. The specific impacts for each species are described below. Direct effects from implementation of other MRG Project maintenance activities are dependent on types of activities performed. Long-term effects for endangered species (indirect effects) also may occur due to the long-term changes that may occur within a reach or upstream and downstream. Effects from the LFCC O&M and Project drain maintenance are described in section 6.3.1 and 6.3.2, respectively.

6.3.1 LFCC O&M

6.3.1.1 Silvery Minnow

There are sporadic captures of silvery minnow within the LFCC. Reclamation opportunistically sampled the LFCC in 2010 and 2012. Silvery minnow were detected at 5 of the 26 sites sampled (figure 5). A total of 12 silvery minnow were collected in over 1,700 m^2 sampled. This equates to 0.7 silvery minnow per 100 m^2 or roughly 42,700 minnows within the LFCC from San Acacia Diversion Dam to RM 60. Sediment removal within this section is likely to adversely affect silvery minnow with direct effects due to dredging operations and indirect effects due to less suitable habitat within the LFCC with the removal of shallow, low velocity areas that silvery minnow use. Vegetation control and road maintenance would have little impact on silvery minnow due to it being conducted in the dry along the banks of the LFCC. Maintenance of the structure itself may or may not have adverse impacts because some of the projects may be able to be conducted in the dry. Those that require work within the channel may have adverse impacts to silvery minnow.

The LFCC is not considered part of critical habitat. Dredging of the LFCC near to the river may have a small hydrologic effect on the water in the river if the level of the LFCC is lower than the riverbed. This effect is likely very small but may adversely affect silvery minnow critical habitat. The existence of the LFCC may slightly increase seepage from the river in the reaches where there are perched channel conditions and contribute to drying, but the magnitude of this effect is likely small. Furthermore, the seepage rates from the river into the LFCC would be largest when the river stage was high and smallest when the stage was low. The proposed maintenance will not significantly change the elevation of the LFCC. Water levels within the LFCC are also a driver of this seepage; these water levels are controlled by pumping of water by the Bosque del Apache and Reclamation and operations of the check dams within the LFCC.

6.3.1.2 Willow Flycatcher

Flycatchers have been known to migrate through less desirable habitat, including the narrow growth around the LFCC, or to nest in areas in close proximity to roads. For this reason and to be in compliance with the Migratory Bird Treaty Act (MBTA) of 1918, areas would not be mowed within the April 15–August 15 period. Because mowing activities would ensure a 3-year rotation or mowing of about one-third of the area along the banks, habitat would remain for migration activity. Maintenance of the LFCC would have minimal impacts to flycatchers north of RM 62. The maintenance could be beneficial to flycatchers to ensure efficient delivery of water reaching flycatchers occupying habitat in areas south of the action area described in this BA. Dredging of the LFCC has a small hydrologic effect on the nearby vegetation. This effect is likely very small but may adversely affect flycatcher critical habitat.

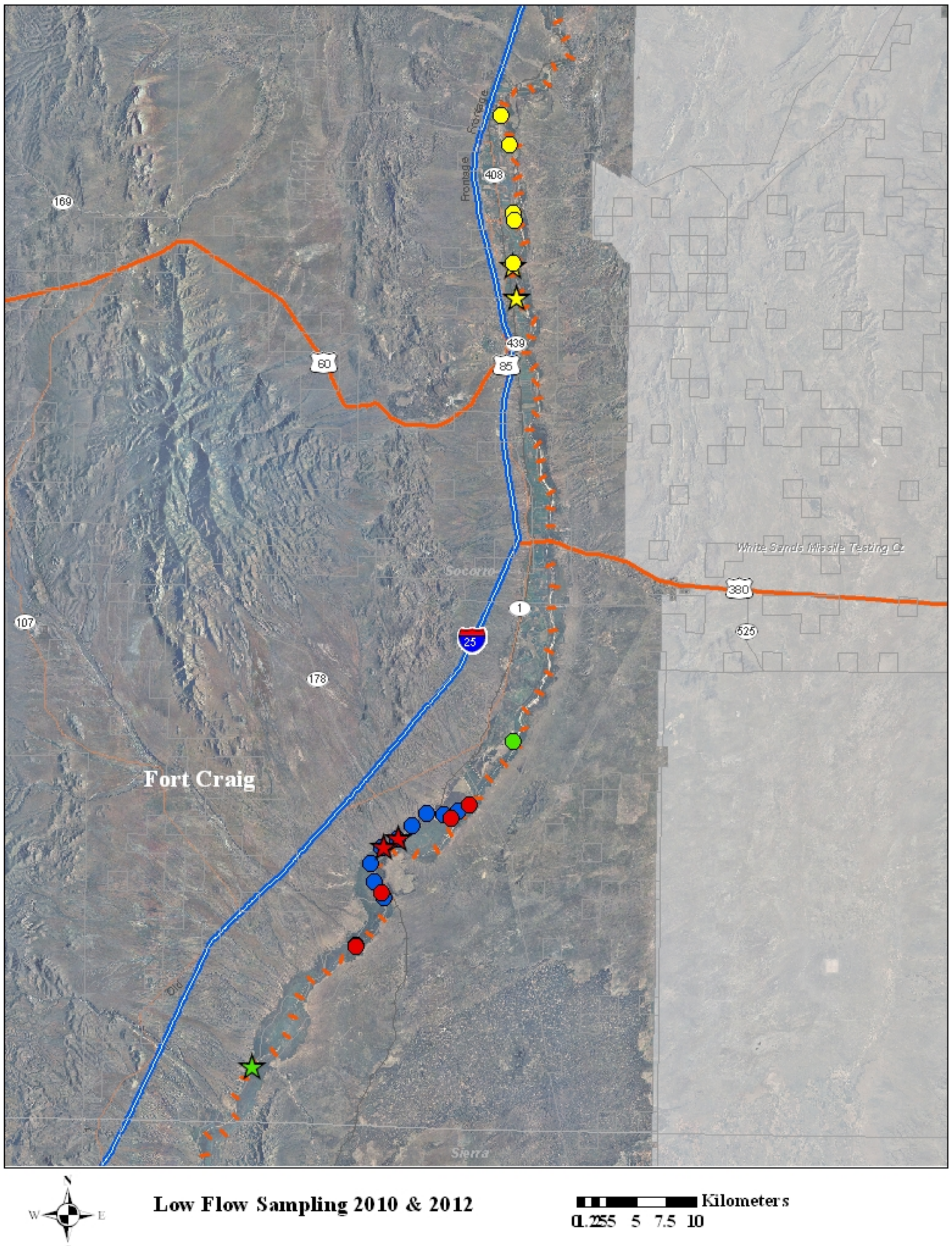

Figure 5. Presence/absence of silvery minnow at LFCC sites in 2010 and 2012. Stars indicate silvery minnow present at site. Green – February 2010, Yellow – March 2010, Red – September 2010, Blue – February 2012.

6.3.2 Project Drain Maintenance

6.3.2.1 Silvery Minnow

There have been no recent surveys for silvery minnow within the Project drains. Cowley et al. (2007) surveyed within the Peralta Canals that are on the east side of the river. They found that silvery minnow were present within the drainage system, especially during irrigation season and dry periods in the river. It is expected that many of the drains in the MRG would contain low levels of silvery minnow. Work within the wet portions of the drains is likely to adversely affect silvery minnow with direct effects due to dredging operations and indirect effects due to less suitable habitat within the Project drains with the removal of shallow, low velocity areas that silvery minnow use.

Using the estimated density of silvery minnow developed for the LFCC, we would estimate that, on average, 1,500 silvery minnow would be impacted annually by work within the Project drains. It appears that, during non-irrigation season, densities of silvery minnow are lower. Work conducted during this season would have a smaller impact on the species. These drains are not considered part of the critical habitat. Dredging of the drains near the river may have a small hydrologic effect on the water in the river if the level of the drain is lower than the riverbed. This effect is likely very small but may adversely affect silvery minnow critical habitat.

6.3.2.2 Willow Flycatcher

Flycatchers have been known to migrate through less desirable habitat, including the narrow growth around the State drains or nest in areas in close proximity to roads. For this reason and to be in compliance with the MBTA, areas would not be mowed within the April 15–August 15 period. Most drains are located outside of suitable flycatcher habitat, but maintenance on the San Juan Drain, for example, would have more of an impact to flycatcher habitat because there are flycatcher territories in close proximity to the drain. Coordination between the Reclamation biologist and the project lead for drain maintenance would need to take place to ensure maintenance actions would not have any effect to flycatchers. Dredging of the drains has a small hydrologic effect on the nearby vegetation. This effect is likely very small but may adversely affect flycatcher critical habitat.

6.3.2.3 Pecos Sunflower

The population of Pecos sunflower (figure 6) located on La Joya State Wildlife Area exists along the La Joya Drain. Water from the drain augments the wetlands on the wildlife area from direct irrigation and possibly from seepage. Any maintenance that would affect flow or seepage of water from this drain may have an adverse affect on the Pecos sunflower population. Project areas near occupied

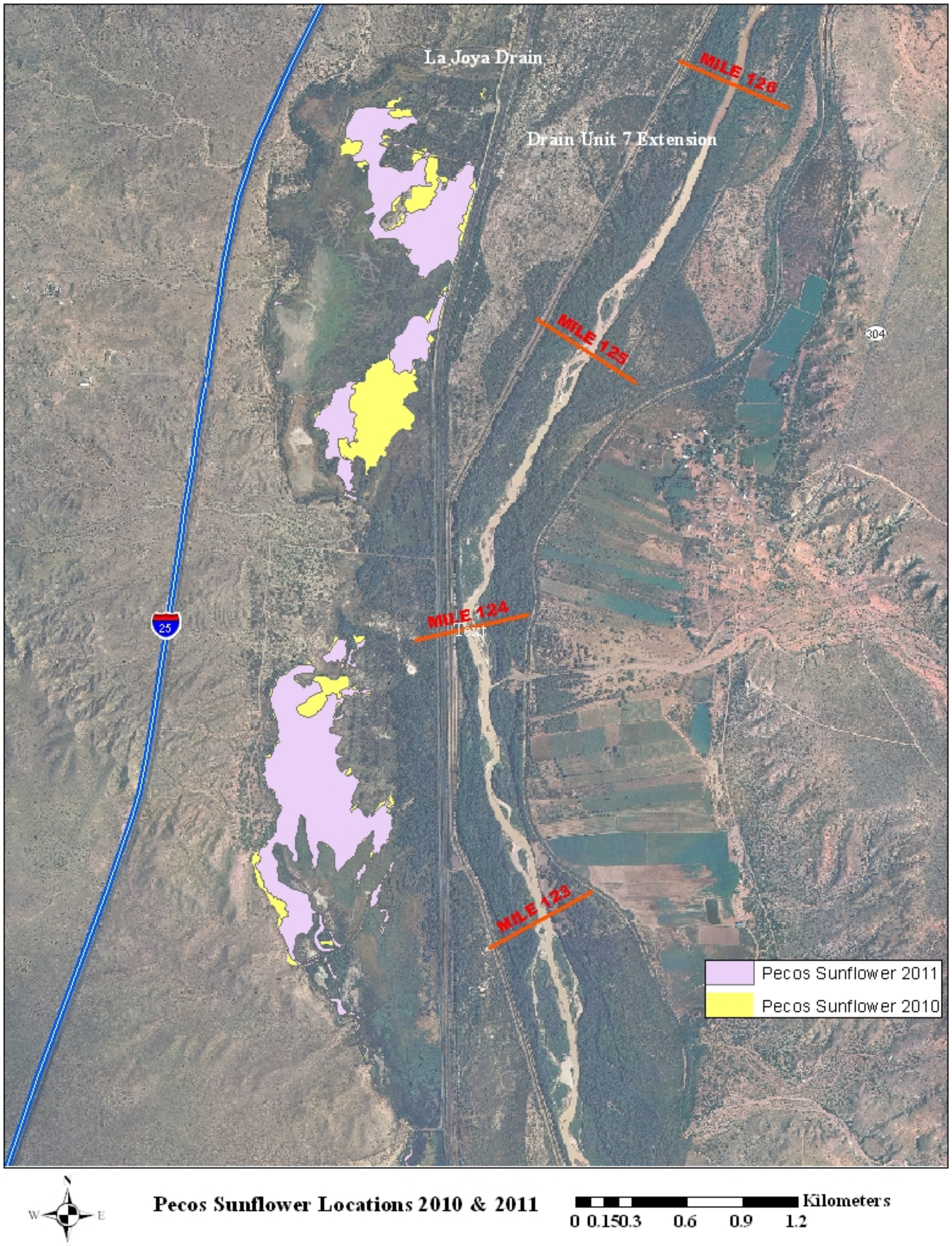

Figure 6. Extant of area occupied by Pecos sunflower on La Joya State Wildlife Management Area.

Pecos sunflower habitats will be surveyed prior to any work. If Pecos sunflower are present within the needed maintenance area, Reclamation will develop a plan to avoid impact to the sunflower populations. Work on specific project sites on the La Joya Drain System would need to be analyzed on a case-by-case basis. The Rhodes population is not affected by work along the LFCC or the Project drains.

6.4 Effects from the MRGCD Proposed Maintenance Activities

The MRGCD constructs, maintains, modifies, repairs, and replaces irrigation and flood control structures and facilities throughout its boundaries to ensure the proper functioning of these works for their intended purposes. These activities may have effects to the listed species.

Regular ongoing activities occur in specific geographic areas and may occur quite frequently (often daily), for example, the presence of men and equipment in these areas. However, these are previously disturbed and regularly accessed areas, so it is unlikely that listed species will be present; therefore, effects to the listed species will be minimal.

Regular, as-needed activities occur throughout the MRGCD with similar effects as above but occur with lesser frequency. Although these areas also are previously disturbed or modified, reduced frequency of access increases the possibility that listed species may be present.

Some activities are performed with much less frequency, dictated by changing needs or conditions. These may occur at anytime and anywhere throughout the MRGCD but are not expected to occur frequently. Due to the infrequent nature, there often is considerable planning in advance of these activities. These activities may affect listed species; specific projects that are beyond the scope of regular maintenance may need project specific consultation tiered off this BA to fully determine and mitigate for these effects. Certain activities may occur under extreme or unexpected conditions that pose an immediate risk to human life or property. Should this situation occur, an immediate response is required.

The effects of all the types of activities are similar and are mainly due to the physical presence of men/machinery and the associated noise as well as modification of habitat due to vegetation control/removal and confinement of the channel to existing infrastructure.

6.4.1 Silvery Minnow

Cowley et al. (2007) performed a fish survey within the Peralta Canals that are on the east side of the river. They found that silvery minnow were present within the drainage system, especially during irrigation season and dry periods in the river. Work within the wet portions of the drains and canals is likely to adversely affect silvery minnow with direct effects due to dredging operations and indirect effects due to less suitable habitat within the MRGCD drains and canals with removing shallow, low velocity areas that silvery minnow use. It appears that, during non-irrigation season, densities of silvery minnow are lower. Work conducted during this season would have less impact on the species. The MRGCD's drains and canals are not considered part of critical habitat. Dredging of the MRGCD's drains and canals near to the river may have a small hydrologic effect on the water in the river if the level of these facilities is lower than the riverbed. This effect is likely very small but may adversely affect silvery minnow critical habitat.

6.4.2 Willow Flycatcher

Flycatchers have been known to migrate through less desirable habitat, including the narrow growth around the drains and other canals as well as nest in areas in close proximity to roads. Coordination between MRGCD and the Service for maintenance actions involving removal of established vegetation would need to take place to ensure maintenance actions would not have any effect to flycatchers. Dredging of the MRGCD's drains and canals has a small hydrologic effect on the nearby vegetation. This effect is likely very small but may adversely affect flycatcher critical habitat.

6.4.3 Pecos Sunflower

The population of Pecos sunflower located on La Joya State Wildlife Area exists along the La Joya Drain. Water from the drain augments the wetlands on the wildlife area from direct irrigation and possibly from seepage. Any maintenance that would affect flow or seepage of water from this drain may have an adverse effect on the Pecos sunflower population. Maintenance near occupied Pecos sunflower habitats will be surveyed prior to any work. If Pecos sunflower are present within the needed maintenance area, Reclamation will work with the Service to develop a plan to avoid impact to the sunflower populations. Work on specific project sites near the La Joya Drain System would need to be analyzed on a case-by-case basis. The Rhodes population is not affected by work on MRGCD facilities.

6.5 Summary of Effects Analysis

In summary, two general types of effects (direct and indirect) were evaluated for endangered species and their habitat from MRG maintenance activities. Direct effects from implementation of river maintenance projects were described in section 6.2 and are dependent on project design and scope. Direct effects from maintenance on the LFCC and Project drains were described in section 6.3 and depend on types of activities performed.

Indirect effects for endangered species are geared more towards the long-term changes that may occur within a reach or upstream and downstream. Indirect effects are expected to be local for the implementation of individual river maintenance projects and dependent on the river maintenance methods used. These are described in section 6.2.1. The indirect effects from the implementation of multiple river maintenance projects within a river maintenance strategy are described in section 6.1. The indirect effects from other MRG Project maintenance actions are expected to be negligible. The determinations for all maintenance activities and proposed actions to the slivery minnow, willow flycatcher, and Pecos Sunflower are described, respectively, in sections 6.5.1, 6.5.2, and 6.5.3.

6.5.1 Silvery Minnow

6.5.1.1 Direct Effects

Direct effects are caused by activities that occur within occupied portions of the river, LFCC, or State drains, and MRGCD facilities. Best management practices have been and will continue to be used to minimize negative effects to silvery minnow. Analysis from sections 6.2 and 6.3 indicates that the potential acreage of impacted silvery minnow habitat would *likely adversely affect approximately 500,000 silvery minnows and 905 acres of their critical habitat over a 10-year timeframe.*

6.5.1.2 Indirect Effects

These are effects that occur after maintenance activities are complete and are due to geomorphic changes in the river as a result of the maintenance activities. Indirect effects are expected to be localized from implementation of individual river maintenance projects and dependent on the river maintenance methods used and location of the project. These are described in section 6.2.1. The indirect effects from the implementation of projects as part of a river maintenance strategy within a reach are described in section 6.1. The long-term effect of implementing river maintenance strategies on the habitat within the river are expected as a whole to be positive to the silvery minnow because they were designed to minimize future river maintenance needs and direct impacts to the river. Local indirect effects at river maintenance project sites may have positive and negative impacts to silvery minnow depending on the river maintenance methods used. For example, river maintenance methods that strive to create more complexity in the river or reconnect the flood plain may have long-term benefits to silvery minnow. However, river maintenance methods that create a deep, fast channel that may be more efficient for water delivery would have negative consequences for silvery minnow habitat. Reclamation is not proposing specific river maintenance projects at this time, but indirect effects caused by river maintenance activities do have the potential to be beneficial, but also may *adversely affect silvery minnow and silvery minnow critical habitat.*

The indirect effects from other MRG Project maintenance actions are expected to be negligible but may adversely affect silvery minnow and their habitat.

6.5.2 Willow Flycatcher

6.5.2.1 Direct Effects

Direct effects are caused by activities that occur within existing or developing suitable habitat or in close proximity to historic flycatcher territories. Best management practices (as described in section 3.6.4.5, 3.7.1, and 3.7.2) have been and will continue to be used to minimize negative effects to flycatchers. BMPs to note include, but may not be limited to, avoiding construction from April 15–August 15, conducting annual surveys to ensure flycatcher territories are identified, and ensuring at least a one-fourth-mile ‘buffer’ between construction activities and known flycatcher territories. Analysis from section 6.6 indicates that the likely potential acreage of impacted flycatcher habitat would be minimal in the next 10 years. However, direct effects caused by construction activities do have the potential to *likely to adversely affect flycatchers or flycatcher critical habitat.*

6.5.2.2 Indirect Effects

These are effects due to maintenance activities that occur away from historical flycatcher territories or existing or developing suitable habitat and/or while flycatchers have not arrived to their breeding grounds. They also include effects that occur due to geomorphic changes in the river as a result of the maintenance activities. Indirect effects are expected to be local for the implementation of individual river maintenance projects and dependent on the river maintenance methods used. These are described in section 6.2.1. The indirect effects from the implementation of multiple river maintenance projects within a river maintenance strategy are described in section 6.1. The long-term effect of implementing river maintenance strategies on the habitat within the river corridor are expected, as a whole, to be positive to the flycatcher because they were designed to minimize future river maintenance needs and direct impacts to the river. Local indirect effects at river maintenance project sites may have positive and negative impacts to flycatcher depending on the river maintenance methods used. For example, river maintenance methods that modify the river channel tend to change overbank flooding occurrences, frequency or locations, and also vegetation composition over time. These effects can occur upstream of or downstream from the site as well. Implementing these methods can be positive or negative depending on characteristics at the specific location. In some instances, like channel relocation for example, over the long term, it may actually be beneficial for the flycatchers because this activity mimics the historically ever changing and meandering river system and the dynamic system of vegetation being created in a new area, as the old vegetation matures. In general, river maintenance methods that reduce channel incision, promote flood plain connectivity, and provide a greater potential for overbank flooding are more beneficial for flycatchers than river maintenance methods that would increase the flood-flow capacity within the channel and lower the water table. Similar to direct effects, indirect effects from maintenance activities do have the potential to be beneficial but also may *adversely affect flycatchers or flycatcher critical habitat.*

6.5.3 Pecos Sunflower

Impacts to Pecos sunflower are possible due to maintenance actions, specifically Project drain maintenance on the La Joya Drain that occurs within occupied habitat or in close proximity to Pecos sunflower populations or changes in water delivery to those areas. Project areas near occupied Pecos sunflower habitats will be surveyed prior to any work. If Pecos sunflower are present within the needed maintenance area, Reclamation will work with the Service to develop a plan to avoid impact to the sunflower populations.

6.5.3.1 Direct and indirect effects

With these measures in place, maintenance activities are *not likely to adversely affect Pecos sunflower*.