

RECLAMATION

Managing Water in the West

Middle Rio Grande River Maintenance Program Comprehensive Plan and Guide

Appendix D: Independent Review Comments

Middle Rio Grande Project, New Mexico
Upper Colorado Region



Mission Statements

The U.S. Department of the Interior protects America's natural resources and heritage, honors our cultures and tribal communities, and supplies the energy to power our future.

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

Middle Rio Grande River Maintenance Program Comprehensive Plan and Guide

Appendix D: Independent Review Comments

Middle Rio Grande Project, New Mexico Upper Colorado Region

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Acronyms and Abbreviations

MRG	Middle Rio Grande
Plan	The Middle Rio Grande River Maintenance Plan Part 1
Plan and Guide	The Middle Rio Grande River Maintenance Comprehensive Plan and Guide
SRH-1D	Sedimentation and River Hydraulics One-Dimensional Model
SRH-2D	Sedimentation and River Hydraulics Two-Dimensional Model
USACE	U.S. Army Corps of Engineers

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Introduction

An independent review of the technical approach and analyses used in the Middle Rio Grande River Maintenance Comprehensive Plan and Guide (Plan and Guide) was requested by the Upper Colorado Region. This request was part of the overall re-evaluation of the Middle Rio Grande River Maintenance Program. The desired outcome from the review was an evaluation of the Plan and Guide's:

- New reach-based river maintenance strategies and goals
- Technical approach to assessing these strategies based on geomorphology, engineering, economic, and environmental criteria
- Possible improvements

The scope of the review was as follows:

- Limited to science and technical matters
- Does not involve policy or compliance with law (Federal, State, and local)
- Does not involve Rio Grande Water Operations or the Middle Rio Grande Endangered Species Collaborative Program

The independent review panel was made up of the following individuals:

- Chester Watson, who was a professor at Colorado State University and has extensive experience in geomorphology, river restoration, and hydraulic engineering.
- Steve Harris, who leads Rio Grande Restoration, a nonprofit river advocacy organization, and participates in the Middle Rio Grande Endangered Species Collaborative Program;
- Robert Strand, who is a hydraulic engineer with wide ranging expertise in engineering and maintenance on western river systems and has a long history working on the Middle Rio Grande.

The panel members participated in two workshops on the Plan and Guide, reviewed the document, and submitted short technical memoranda with their comments (see below). The first workshop was conducted to collect feedback from the panel members on the planned technical strategy assessment approach. This feedback helped refine our approach. The second workshop was conducted after the strategy assessment was complete to present how the comments from the

first workshop were incorporated, the results of the strategy assessment, and to collect feedback on how to best present the results to a general audience. They also provided input on the future River Maintenance Program plans (the Next Steps in Chapter 16 of the main report).

The results from the first workshop are organized by the questions provided to the independent reviewers in the following table. Each reviewer’s comments, as well as Reclamations responses to those comments are presented. The “Plan” referenced in the following table is the Middle Rio Grande River Maintenance Plan Part 1 Report dated May 2007. The “Final Draft Part 2 Report” as referenced below has been renamed the Middle Rio Grande River Maintenance Program Comprehensive Plan and Guide. The memoranda from each independent reviewer after each workshop are included after the table of comments.

Independent Review Comments from April 2010 Meeting

1) Does the Plan have a sound technical approach with adequate detail to address and support its conclusion and recommendations?

<i>Reviewer</i>	<i>Comment</i>	<i>Reclamation Response</i>
Watson	The Plan has a sound technical approach; however, conclusions and recommendations seem to be missing. Perhaps the conclusion and recommendations will be added as the Part 2 of the documentation is completed.	Thank you. See chapters 5–15 of the Final Draft Part 2 Report for conclusions and recommendations for each reach and chapter 16 for an overall summary and recommendations.
Strand	The Plan has a sound technical approach. The description of the factors going into the analyses is very detailed. I am assuming that the sample applications we saw at the end of the 2-day presentation will become incorporated into the Part 2 Report as will the eventual Conclusions and Recommendations.	Thank you. See chapters 5–15 of the Final Draft Part 2 Report for conclusions and recommendations for each reach and chapter 16 for an overall summary and recommendations.
Harris	No comment.	

2) Does the Plan ensure that best strategies are selected and avoid the appearance of confirming past technical decisions without a fresh approach and review?

<i>Reviewer</i>	<i>Comment</i>	<i>Reclamation Response</i>
Watson	The approach provides an organized framework for significant detail and input from a range of participants which should serve to avoid the appearance of confirming past decisions.	Thank you.
Watson	Best management strategies is a difficult term to adequately define, and perhaps could be defined by satisfying a positive ranking for each of the 45 attributes.	The maintenance plan took a step back to look at the system as whole and define a reach scale approach for River Maintenance. New goals and strategies have been defined. Geomorphic and meander analyses plus hydraulic and sediment modeling are used to evaluate the strategies. A new literature review of potential methods with a rigorous internal cost analysis was performed. See chapter 4 of the Final Draft Part 2 Report for how strategies are selected for further study. All strategies are first screened for suitability to meet reach conditions, then attributes scored and strategy effectiveness divided by cost calculated. The best overall strategies for a reach are recommended for further study. Please note that a similar process based on more detailed modeling is planned for strategy selection in the reach feasibility and design stages.
Watson	Consideration should be given to ranking the attributes, for example, unless the second attribute, sediment continuity, is satisfied, it is unlikely that habitat, reasonable maintenance cost, or most of the other attributes will be achieved.	All strategies are based on satisfying sediment continuity. See section C1.6.5 of appendix C of the Final Draft Part 2 Report for information on how the balance between sediment transport capacity and supply is the key factor for strategy selection.

2) Does the Plan ensure that best strategies are selected and avoid the appearance of confirming past technical decisions without a fresh approach and review?

<i>Reviewer</i>	<i>Comment</i>	<i>Reclamation Response</i>
Strand	Certainly if all applicable strategies are evaluated thoroughly, the best management strategies should become apparent. This approach is certainly defensible and should avoid the appearance of confirming past decisions.	A new suite of strategies were defined. All strategies are initially considered for all reaches, see table 4.8. for the strategy suitability assessment and recommendations. Suitable strategies are examined in more detail for recommendations for feasibility assessments in each reach (again with more in-depth analyses).
Harris	Develop additional stated objectives (Part I Section 1.4 “Future Conditions and Strategies”) e.g. “it is in the interest of cost containment to create self-sustaining channel conditions wherever possible” and “the infrastructure protection goal may be met, in some cases, by relocating facilities, such as levees, when costly reconstruction is being considered”. (At least make certain to consider these elements in the strategy identification process.)	See section 3.2.1 of the Final Draft Part 2 Report that describes the updated goal of Channel Sustainability. Several Economics Attributes (see section 4.7.3) assess ongoing costs: Frequency of Maintenance, Amount of Maintenance, Frequency of Adaptive Management, and Amount of Adaptive Management. These attributes (along with all others) are used in the scoring to determine which strategies are recommended for further study. Section 3.3.4 describes the Increase Available Area Strategy.
Harris	Identify locations where “increasing area available to river” make sense from a long-term perspective (such as when meander belt width is unacceptably constrained). Whether or not the strategy is selected, identifying areas where the strategy might be desirable positions the Program to discover such opportunities when and if they should arise (in reach characterizations).	Maps in the modeling report (appendix B) show where the meander belt analysis predicts likely potential areas of impact on infrastructure. For example, Increase Available Area is recommended for further study in the Isleta Diversion Dam to Rio Puerco Reach even though the meander belt analysis shows the calculated belt essentially fits within the current lateral constraints.

3) Are there areas in the overall Plan that warrant further investigations, collaboration with others, additional resources?

<i>Reviewer</i>	<i>Comment</i>	<i>Reclamation Response</i>
Watson	I have suggested that variability and uncertainty should be considered in some of the modeling efforts. This will require additional resources. Portland District, USACE, was contacted and cooperation in this matter can likely be achieved, however, it is a part of a large, on-going (not as yet completely reviewed) project.	Sensitivity analyses are discussed in the section 3.3 of appendix B.
Strand	I note that the 1975 Water Year hydrograph is repeated 60 times to represent the long-term hydrology in the one-dimensional model. The 1975 hydrograph has a 8% greater volume and a 10% smaller peak than the long term median hydrograph. However, the 1975 hydrograph has a smaller volume in the base flow period and a greater volume during the “runoff” period. One suggestion would be to run a repeatable 3-year sequence of “dry, average, and wet” years. A sensitivity analysis of alternative hydrographs would be helpful in making a decision as to the “best” applicable hydrology.	Sensitivity to the hydrologic input is discussed in section 3.3 of appendix B.
Strand	The use of 105 cross sections to represent 200 miles of Rio Grande channel leaves me uneasy. Again a sensitivity analysis of the approach used versus one in which all agg-deg cross sections are utilized for a selected test reach or two might well allay those concerns or lead to some modified approach to defining the channel geometry for modeling purposes.	The differences in water surface elevation, channel depth, and channel velocity of the maintenance plan model cross sections and the full set of aggradation/degradation cross sections are described in appendix B. More detailed modeling will be performed in each reach project analysis.

3) Are there areas in the overall Plan that warrant further investigations, collaboration with others, additional resources?

<i>Reviewer</i>	<i>Comment</i>	<i>Reclamation Response</i>
Harris	In the interest of a more nearly self-sustaining Program, conduct a study of the requirements for channel-forming flow volumes in each reach (2.2.3 or 2.3.1).	This is best accomplished in each reach strategy feasibility analysis. We recognize higher peak flows provide benefits to maintain channel capacity, but it should be noted that Water Operations are outside of River Maintenance authority.
Harris	Articulate a process of cross-consulting with external flood control, water operations and biological management authorities/activities to ensure synthesis of objectives between river maintenance these programs (chapter 3).	See Part 1 Report (chapter 3 and appendix B) for examples of project based coordination. It is the Program's intent, upon completion of this Part 2 Report, to present the Maintenance Plan Reports at stakeholder meetings to help accomplish this cross-consulting on a river-wide basis.
Harris	Convene an interdisciplinary team, with expertise in adaptive management to design an appropriately detailed plan for monitoring and adaptively managing the Program. (2.3.7).	This is best accomplished in each reach strategy feasibility analysis because reaches have different conditions and potential for adaptive management. It should be noted that the Maintenance Program already collects data for long term monitoring and informally applies adaptive management.

4) Please share your views of the Strengths, Weaknesses, and Gaps for the description of the Plan

<i>Reviewer</i>	<i>Comment</i>	<i>Reclamation Response</i>
Watson	Strengths of the plan include the numerous alternatives that must be evaluated by the participant: methods, attributes, assessments, goals, etc.	Thank you.

4) Please share your views of the Strengths, Weaknesses, and Gaps for the description of the Plan

<i>Reviewer</i>	<i>Comment</i>	<i>Reclamation Response</i>
Watson	Weaknesses of the plan, perhaps, could also be related to the same numerous alternatives, in that a participant could be distracted from a fresh new approach because of the level of detail in the Plan evaluation. My guess is that the large number of participants involved in formulating the Plan will deter this potential trap.	Each increasingly detailed level of screening and analysis has a reduced number of strategies to be considered. There were 66 potential strategy reach combinations (11 reaches and 6 strategies), which were reduced to 39 recommended for further study. Team members with geomorphic, engineering, and ecological expertise had input into strategy assessment development.
Watson	The report is incomplete at the time of this review, and gaps are expected.	
Strand	The greatest strength of the Plan is the requirement to evaluate a wide array of goals, methods, attributes, and strategies before making a decision.	Thank you.
Strand	The primary weakness is the same requirement. The team may get bogged down in details that are really not required to make a proper decision on a maintenance program. Hopefully, completion of the Plan Report will make the entire process description more cohesive.	Each increasingly detailed level of screening and analysis has a reduced number of strategies to be considered. There were 66 potential strategy reach combinations (11 reaches and 6 strategies), which were reduced to 39 recommended for further study. Team members with geomorphic, engineering, and ecological expertise had input into strategy assessment development. Care was taken to cohesively describe the assessment process and to control the level of detail in the Main Report, while maintaining transparency of the process with full documentation in the appendices.
Harris	No comment.	

5) Has the Plan development team missed any critical considerations and is there any else that you would like to add to critique and improve the plan?

<i>Reviewer</i>	<i>Comment</i>	<i>Reclamation Response</i>
Watson	The long-term sediment modeling that David V discussed was very interesting to me due to my recent experience with similar modeling. Providing variability and uncertainty assessment in the model result would, perhaps, improve the value of the effort, if resources are available.	Sensitivity analyses are discussed in the section 3.3 of the Modeling Report and in the technical memo in appendix B.
Watson	How sensitive is the resulting equilibrium condition to the discharge hydrograph used, sediment gradation changes, sediment supply or other parameters?	Sensitivity analyses are discussed in the section 3.3 of the Modeling Report, which is appendix B.
Watson	The discussion of long-term equilibrium in relation to the planform evolution model could be interpreted as implying that either A6 or M8 from the planform evolution model (Massong et al. 2010) is the expected outcome of the management plan. Could we consider A3 or other planform for some of the reaches and by maintaining that planform, sustain good silvery minnow and willow flycatcher habitat?	The planform evolution model shows that the channel may move between stages depending upon changes in water and sediment supply. Desirable planform stages could be defined in each reach strategy feasibility analysis because different reaches have different evolution trajectories.
Watson	Monitoring can be an important asset that can be used to trigger implementation of adaptive management. Without good monitoring data management may be difficult. Consider setting aside separate resources for monitoring and have monitoring as a primary task for a team member.	It should be noted that the Maintenance Program already collects data for long-term monitoring and informally applies adaptive management. Additional data collection and adaptive management are best defined in each reach strategy feasibility analysis because different reaches have different needs.
Strand	Although the reach analysis concept is a good one, there needs to be a consistent effort to evaluate the overall sediment transport continuity of the entire river system.	Upstream and downstream sediment continuity will continue to be evaluated in the reach feasibility and project design analyses.

5) Has the Plan development team missed any critical considerations and is there any else that you would like to add to critique and improve the plan?

<i>Reviewer</i>	<i>Comment</i>	<i>Reclamation Response</i>
Strand	What about monitoring, evaluation, and feedback?	It should be noted that the Maintenance Program already collects data for long-term monitoring and informally applies adaptive management. Additional data collection and adaptive management are best defined in each reach strategy feasibility analysis because different reaches have different needs.
Harris	Add to selection process, the screening of strategies to ensure that they not preclude later application of non-structural approaches, such as land use changes and flow management (part 2).	Land use changes and flow management are not part of the authorization for the MRG River Maintenance. Consideration of nonstructural approaches will continue to be included in future reach feasibility assessments.
Harris	Include in the Plan an inventory of ecosystem services in the MRG, screen services for relevance to the Program and predict change. (World Resources Institute; see link in References.) (2.5.4)	Ecosystem services are not specifically inventoried, but are considered in the Habitat Value and Need Reach Characteristic and Ecosystem Function Assessment discussions by reach. After ecosystem services have been inventoried, they can be included in River Maintenance Planning.
Harris	Similarly, describe situations where managed flows might achieve Program objectives, whether or not they are feasible, short term. (reach characterizations, Part 2 strategies)	Flow management is not part of the authorization for the MRG River Maintenance.
Harris	Implement an Annual Work Plan planning process which includes the following elements: priority reaches, projects to be initiated, ongoing work, previous year monitoring results, current year monitoring plan, adaptive management analysis. (1.3). Conduct annual meeting with stakeholders.	This is accomplished internally on an annual basis and on a site basis with key stakeholders. Consideration will be given to annual meetings with key stakeholders on a more comprehensive basis.

5) Has the Plan development team missed any critical considerations and is there any else that you would like to add to critique and improve the plan?

<i>Reviewer</i>	<i>Comment</i>	<i>Reclamation Response</i>
Harris	The Plan should recognize Cochiti Reservoir “Spawning Spike” releases and discuss whether and how these sorts of operations might contribute to river maintenance objectives. (3.5)	Flow management is not part of the authorization for the MRG River Maintenance. Current “Spawning Spike” releases appear to be too small to cause significant channel changes.

6) Does the Plan make use of the best available scientific and engineering information on the river condition and potential management strategies and methods?

<i>Reviewer</i>	<i>Comment</i>	<i>Reclamation Response</i>
Watson	Having little or no actual experience in applying the Plan methodology I suggest that interaction between methods and between attributes could be considered. For example, if the method is some form of bank stabilization, the method may be rated as favorable. However, if the reach is incising and by reducing sediment supply by bank stabilization, should the method be favorably reviewed?	Interactions between reach conditions and strategies are considered in selecting suitable strategies. Interactions between methods and local conditions will be considered in the reach feasibility and project design analyses.
Watson	Is sediment augmentation (perhaps sediment bypassing through or around the reservoirs) being given strong consideration? Though difficult, restoring sediment continuity may be less costly than many of the local methods.	Section 3.3.6 Manage Sediment Strategy discusses sediment augmentation.
Strand	The literature cited and the list of methods and strategies described indicate a very complete understanding of the “state of the art” on the part of the authors.	Thank you.

6) Does the Plan make use of the best available scientific and engineering information on the river condition and potential management strategies and methods?

<i>Reviewer</i>	<i>Comment</i>	<i>Reclamation Response</i>
Harris	Commit to consulting the river restoration literature, perhaps beginning with the paper River Restoration, cited in the References section of this memo (Wohl 2005). (2.3.5)	The review of river restoration literature is documented in the citations in appendix A: Middle Rio Grande Maintenance and Restoration Methods. Wohl (2005) is included.

7) Are there data or analyses needs that should be considered for inclusion to better meet the goals and objectives of the plan?

<i>Reviewer</i>	<i>Comment</i>	<i>Reclamation Response</i>
Watson	Are the resources available to model sediment supply and transport that characterize desirable planforms within the planform evolution model presented by Massong et al. 2010? For example, can we characterize the sediment gradation and sediment supply/transport to result in A3 for some of the reaches?	This is a good question, and more investigation is needed to define how to reach and maintain a particular stage of the planform model. These analyses might be accomplished in the reach strategy feasibility analyses, but may not be needed for all reaches. The 2D sediment modeling in the Bosque del Apache NWR and in the reservoir pool of Elephant Butte provide information to predict likely planforms and could be used to analyze sensitivity to sediment gradation and sediment supply/transport. Mobile bed physical modeling may also be appropriate.
Watson	As I recall, the data required for modeling several of the reaches was not available; perhaps these could be developed?	Data was requested from USACE for the Velarde to Otowi reaches. Pueblo approval is in progress. Data for the Elephant Butte Dam to Caballo Reservoir Reach is in progress.

7) Are there data or analyses needs that should be considered for inclusion to better meet the goals and objectives of the plan?

<i>Reviewer</i>	<i>Comment</i>	<i>Reclamation Response</i>
Watson	Is the best data available to substantiate the value of transitional characteristics in habitat assessment? For example, if the A3 planform seems to be an appropriate habitat for the silvery minnow and has been identified as a transitional planform by Massong et al. (2010), will better data convince biologists that intervention to maintain A3 is a reasonable path? The same argument applies to mature willow forest.	This is an excellent suggestion for further investigation. Specific data has not been developed to answer these questions but sediment/vegetation modeling could provide data.
Strand	At some point it may become desirable to apply additional modeling capabilities; i.e., two- and three-dimensional modeling of hydraulics and sediment transport.	2D sediment modeling in the Bosque del Apache NWR and in the reservoir pool of Elephant Butte has been performed. More detailed modeling is planned for reach feasibility assessments and project design.
Harris	Convene an interdisciplinary team, with expertise in adaptive management to design an appropriately detailed plan for monitoring and adaptively managing the Program. (2.3.7)	This is best accomplished in each reach strategy feasibility analysis because different reaches have different monitoring and adaptive management needs.

8) Is the future vision of the River Maintenance Program based upon sound scientific and engineering methodology and supported by the data and analyses?

<i>Reviewer</i>	<i>Comment</i>	<i>Reclamation Response</i>
Watson	Is the future vision of the River Maintenance Program clearly stated, or do we develop an understanding of that vision from the objectives that are stated?	Chapter 1 plus the updated goals and the strategies in chapter 3 flesh out the vision defined in the Part 1 Report.

8) Is the future vision of the River Maintenance Program based upon sound scientific and engineering methodology and supported by the data and analyses?

<i>Reviewer</i>	<i>Comment</i>	<i>Reclamation Response</i>
Watson	Reduce and/or eliminate aggradation in the Middle Rio Grande is an authorized goal for the MRG Project. If the channel is incised or is beginning to recover from incision, should aggradation be reduced or eliminated?	The updated goals and the strategies in chapter 3 plus the strategy suitability analysis by reach should prevent trying to reduce aggradation in inappropriate reaches. It is important to consider how to reduce the long term trend of aggradation in the reaches near Elephant Butte and in the reservoir even though there has been recent degradation.
Watson	Reach-based strategies are very reasonable objectives; however, considerations between reaches are at least equally important.	Upstream and downstream impacts are considered; see section C1.6.5 Strategy Effects on Geomorphology in appendix C.
Strand	Is the vision of the River Maintenance Program to incorporate this Plan as the Criteria for assessing and implementing future Rio Grande maintenance activities? If so, I think it is based upon the best available scientific and engineering methodology today. However, let's keep it open to changes in the "state of the art" and the results of the Bureau's own monitoring and evaluating results.	Yes. This plan is the first step to updates of new technology and new information on evolution of the reaches. See chapter 1 for more information.
Harris	I recommend that the team revisit its goals before finalizing the Plan. Develop a vision statement. This might that include language like "maintenance activities will contribute to overall restoration of MRG river ecosystems [that are less maintenance-intensive, more self-sustaining]".	The updated goals in section 3.2 include channel sustainability and ecosystem compatibility.

Reviewer Memoranda

Memorandum

TO: Robert S. Padilla, P.E.
Supervisory Hydraulic Engineer
Bureau of Reclamation

FROM: Chester C. Watson, P.E., Ph.D.
Principal Investigator
Biedenharn Group, LLC

SUBJECT: Rio Grande Maintenance Program Review

DATE: 27 APRIL 2010

In accordance with your instructions, I have reviewed the relevant Middle Rio Grande and River Maintenance Program technical reports and have prepared this written summary of the review, reporting in the format of *Questions for Reviewers* as listed in your correspondence. I believe that the plan structure developed by you and your co-workers will be of significant value to maintenance activities on the Middle Rio Grande.

I look forward to participation and attendance in future meetings to share recommendations and comments on the Plan. Please do not hesitate to contact me if I can provide additional comment on the following questions.

Thank you for the opportunity to participate.

My comments follow:

- a) **Does the Plan have a sound technical approach with adequate detail to address and support its conclusions and recommendations?**
 - i) The Plan has a sound technical approach; however, conclusions and recommendations seem to be missing.
 - ii) Perhaps the conclusion and recommendations will be added as the Part 2 of the documentation is completed.

b) Does the Plan ensure that best management strategies are selected and avoid the appearance of confirming past technical decisions without a fresh approach and review?

- i) The approach provides an organized framework for significant detail and input from a range of participants which should serve to avoid the appearance of confirming past decisions.
- ii) Best management strategies is a difficult term to adequately define, and perhaps could be defined by satisfying a positive ranking for each of the 45 attributes.
- iii) Consideration should be given to ranking the attributes, for example, unless the second attribute, sediment continuity, is satisfied, it is unlikely that habitat, reasonable maintenance cost, or most of the other attributes will be achieved.
- iv) Sediment continuity is equally important for within-reach and between-reach considerations.

c) Are there areas in the overall Plan that warrants further investigations, collaboration with others, additional resources?

- i) I have suggested that variability and uncertainty should be considered in some of the modeling efforts. This will require additional resources. Portland District, USACE, was contacted and cooperation in this matter can likely be achieved, however, it is a part of a large, on-going (not as yet completely reviewed) project.

d) Please share your views of the Strengths, Weaknesses, and Gaps for the description of the Plan.

- i) Strengths of the plan include the numerous alternatives that must be evaluated by the participant: methods, attributes, assessments, goals, etc.
- ii) Weaknesses of the plan, perhaps, could also be related to the same numerous alternatives, in that a participant could be distracted from a

fresh new approach because of the level of detail in the Plan evaluation. My guess is that the large number of participants involved in formulating the Plan will deter this potential trap.

iii) The report is incomplete at the time of this review, and gaps are expected.

e) Has the Plan development team missed any critical considerations and is there anything else that you would like to add to critique and improve the plan?

- i) The long-term sediment modeling that David V discussed was very interesting to me due to my recent experience with similar modeling. Providing variability and uncertainty assessment in the model result would, perhaps, improve the value of the effort, if resources are available.
- ii) How sensitive is the resulting equilibrium condition to the discharge hydrograph used, sediment gradation changes, sediment supply or other parameters?
- iii) The discussion of long-term equilibrium in relation to the planform evolution model could be interpreted as implying that either A6 or M8 from the planform evolution model (Massong et al 2010) is the expected outcome of the management plan. Could we consider A3 or other planform for some of the reaches and by maintaining that planform, sustain good silvery minnow and willow flycatcher habitat?
- iv) Monitoring can be an important asset that can be used to trigger implementation of adaptive management. Without good monitoring data management may be difficult.
- v) Consider setting aside separate resources for monitoring and have monitoring as a primary task for a team member.

f) Does the Plan make use of the best available scientific and engineering information on the river condition and potential management strategies and methods?

- i) Having little or no actual experience in applying the Plan methodology I suggest that interaction between methods and between attributes could be considered. For example, if the method is some form of bank stabilization, the method may be rated as favorable. However, if the reach is incising and by reducing sediment supply by bank stabilization, should the method be favorably reviewed?
- ii) Is sediment augmentation (perhaps sediment bypassing through or around the reservoirs) being given strong consideration? Though difficult, restoring sediment continuity may be less costly than many of the local methods.

g) Are there data or analyses needs that should be considered for inclusion to better meet the goals and objectives of the plan?

- i) Are the resources available to model sediment supply and transport that characterize desirable planforms within the planform evolution model presented by Massong et al 2010. For example, can we characterize the sediment gradation and sediment supply/transport to result in A3 for some of the reaches?
- ii) As I recall, the data required for modeling several of the reaches was not available; perhaps these could be developed?
- iii) Is the best data available to substantiate the value of transitional characteristics in habitat assessment? For example, if the A3 planform seems to be an appropriate habitat for the silvery minnow and has been identified as a transitional planform by Massong et al (2010), will better data convenience biologists that intervention to maintain A3 is a reasonable path? The same argument applies to mature willow forest.

h) Is the future vision of the River Maintenance Program based upon sound scientific and engineering methodology and supported by the data and analyses?

- i)** Is the future vision of the River Maintenance Program clearly stated, or do we develop an understanding of that vision from the objectives that are stated?
- ii)** Reduce and/or eliminate aggradation in the Middle Rio Grande is an authorized goal for the MRG Project. If the channel is incised or is beginning to recover from incision, should aggradation be reduced or eliminated?
- iii)** Reach-based strategies are very reasonable objectives; however, considerations between reaches are at least equally important.

Memorandum

TO: Robert S. Padilla, P.E.
Supervisory Hydraulic Engineer
Bureau of Reclamation

FROM: Chester C. Watson, P.E., PhD
Principal Engineer
Biedenharn Group, LLC

SUBJECT: Rio Grande Maintenance Program Review

DATE: 30 September 2011

Please consider this memo as my final formal comments pertaining to the maintenance program review, including Chapter 16: Summary and Recommendations.

My previous written comments and topics discussed have been addressed and I am satisfied that the River Maintenance Program provides either solutions to any potential issues or incorporates the flexibility to address unforeseen circumstances. Sections 16.2.5 Project Design and Implementation and 16.2.6 System-wide Assessments are important statements of the planning and design issues that provide the flexibility to address unforeseen circumstances.

As we have discussed, monitoring will be very important in realization of adaptive management for the Program. Resources for directing and managing the monitor program will be extremely important to the success of the adaptive management initiative.

The forethought and diligence in preparing the draft River Maintenance Program is impressive, and in my opinion, well worth the effort.

TO: Robert Padilla
Supervisory Hydraulic Engineer - ALB-240

FROM: Robert I. Strand

SUBJECT: Independent Review of Rio Grande Maintenance Plan

I have reviewed all of the available Plan documents and supporting material. The following comments follow the "Questions for Reviewers" format contained in the presentation given on April 12 and 13 in Albuquerque.

Overall, I believe the Plan is a very comprehensive and well thought out approach for evaluating the merits and priorities of future Rio Grande maintenance activities. I appreciate the opportunity to participate.

Does the Plan have a sound technical approach with adequate detail to address and support its conclusions and recommendations?

- The plan has a sound technical approach. The description of the factors going into the analyses is very detailed. I am assuming that the sample applications we saw at the end of the two-day presentation will become incorporated into the Part 2 Report as will the eventual Conclusions and Recommendations.

Does the Plan ensure that best management strategies are selected and avoid the appearance of confirming past technical decisions without a new fresh approach and review?

- Certainly if all applicable strategies are evaluated thoroughly, the best management strategies should become apparent. This approach is certainly defensible and should avoid the appearance of confirming past decisions.

Are there areas in the overall Plan that warrant further investigations, collaboration with others, additional resources?

- I do have a couple of items that I would like to see evaluated to confirm the approach being used in the river modeling.
- I note that the 1975 Water Year hydrograph is repeated 60 times to represent the long term hydrology in the one-dimensional model. The 1975 hydrograph has a 8% greater volume and a 10% smaller peak than the long term median hydrograph. However, the 1975 hydrograph has a smaller volume in the base flow period and a greater volume during the "runoff" period. One suggestion would be to run a repeatable 3-year sequence of "dry, average, and wet" years. A sensitivity analysis of alternative

hydrographs would be helpful in making a decision as to the “best” applicable hydrology.

- The use of 105 cross sections to represent 200 miles of Rio Grande channel leaves me uneasy. Again a sensitivity analysis of the approach used versus one in which all agg-deg cross sections are utilized for a selected test reach or two might well allay those concerns or lead to some modified approach to defining the channel geometry for modeling purposes.

Please share your views of the Strengths, Weaknesses, and Gaps for the description of the Plan

- The greatest strength of the Plan is the requirement to evaluate a wide array of goals, methods, attributes, and strategies before making a decision.
- The primary weakness is the same requirement. The team may get bogged down in details that are really not required to make a proper decision on a maintenance program
- Hopefully completion of the Plan Report will make the entire process description more cohesive

Has the Plan development team missed any critical considerations and is there anything else that you would like to add to critique and approve upon the Plan?

- Although the reach analysis concept is a good one, there needs to be a consistent effort to evaluate the overall sediment transport continuity of the entire river system.
- What about monitoring, evaluation, and feedback?

Does the Plan make use of the best available scientific and engineering information on the river conditions and potential management strategies and methods?

- The literature cited and the list of methods and strategies described indicate a very complete understanding of the “state of the art” on the part of the authors.

Are there other data or analyses needs that should be considered to better meet the goals and objectives of the Plan?

- At some point it may become desirable to apply additional modeling capabilities; i.e., 2 and 3 dimensional modeling of hydraulics and sediment transport.

Is the future vision of the River Maintenance Program based upon sound scientific and engineering methodology and supported by the data and analyses?

- Is the vision of the River Maintenance Program to incorporate this Plan as the Criteria for assessing and implementing future Rio Grande maintenance activities? If so, I think it is based upon the best available scientific and engineering methodology today. However, let's keep it open to changes in the "state of the art" and the results of the Bureau's own monitoring and evaluating results.

Middle Rio Grande River Maintenance Plan: Independent Review

Submitted by Steve Harris (Order No. 08PG430077)

April 27, 2010

Lacking an essential competence in scientific and technical matters, my memo discusses some process issues, consideration of which may lead to improvement in the planning and performance of the subject Middle Rio Grande (MRG) River Maintenance Program (referred to throughout this memo as either “The Plan” or “The Program”).

Subjects include: goal-setting, coordination/integration with related programs and emerging environmental compliance issues. I hope that this memo will engender productive discussion among members of the planning team and result in new approaches in the Plan.

“In recent decades ecologists have learned that attempts to maximize individual variables in a complex, multi-variant system tend to cause the system to falter. The lesson seems to be that if the system is managed single-mindedly for the production of one output, the overall system tends to decline, often precipitously” (DeBuys 2001). As treatments of the original “symptom” are applied, new distortions (symptoms) appear, as the system responds. In the MRG, this principle has been manifested as a long cycle of engineering treatments: drains constructed to reclaim seeped lands, levees constructed to protect drainage facilities, maintenance projects to protect levees—all with the effect of further and further constraining the Rio Grande and disrupting its underlying processes.

Despite the Bureau’s charge to the Plan’s reviewers that we avoid suggesting changes to river policy and current management, a productive move toward a goal of treating causes of river dysfunction rather than its symptoms will require developing a more holistic approach to MRG river management.

Program Goals- The setting of goals is the critical first step in any natural resource planning effort. A richer set of goals in the Plan will arguably tend to result in better strategies. I recommend that the team revisit its goals before finalizing the Plan.

The Part 1 Report lists six goals which are based on statutory authorities (Section 1.2, page 7). Those goals, which originated under the 1948-49 Congressional authorizations suggests that a rigidly conventional mission remains in place for the MRG River Maintenance Program (USBR 2007).

- *Effective Transport of Water and Sediment* is the critical, long-term goal which has vexed the MRG since at least the 1920’s when the effects of destructive land use practices on the upper watershed resulted in severe alteration of channel elevation and capacity in the MRG. The infrastructure, aggradation and degradation goals emanate from this primary goal.
- *Infrastructure Protection* ought to be conditional. If it may entail high ongoing costs to protect a structure, relocation or other strategies must be considered.
- The *Conservation of Surface Water* goal can be viewed as aspiring to eliminate the impacts of seepage and channel dysfunction which resulted from the aforementioned watershed alteration, and which arguably expresses the intent of the

MRG River Maintenance Plan Review-Steve Harris

original MRG Project authorization. (A caution: if, for purposes of the Plan, water conservation is to be viewed more broadly than conveyance efficiency, a host of extraneous considerations may be introduced into Program practices, including prohibition of project-induced increases in net depletions). The water conservation goal should not be read as discouraging flow management.

The Environmental Goal: With the more recent addition of an Endangered Species habitat improvement goal, the river maintenance game changes dramatically. Now, treatments designed to improve (or restore) river function, should simultaneously improve (or restore) habitat values for silvery minnow and willow flycatcher. The layer of complexity which this adds to the mission: increased habitat heterogeneity, “construction” of backwater and side-channel river features, etc. are adequately represented in the Plan’s habitat attributes, but I would suggest that the ESA goal effectively transforms the whole enterprise from a mere “river maintenance” mission into the realm of “river rehabilitation”, a much more proactive and creative concept. A way should be found to articulate this in the Plan, perhaps by adding a “Vision” section (a new Part 1 Ch. 1.1).

“Restoration of the physical characteristics of the hydrology and geomorphology is necessary to any restoration of the system’s biological component” (Fullerton 2003). Accommodating a goal that fully recognizes a mandate to improve ecosystem conditions via management of channel morphology and function, does more than add sticky semantic or legal questions, it helps assure that, for the life of the Plan, the Program commits to a high degree of adaptability in undertaking its geomorphological mission. The Plan now requires appropriate reference to emerging science and policy, including a need to address the contemporary social and environmental needs in the MRG.

The planning team has already considered whether river maintenance can be conducted in ways that will lead to decreasing necessity for construction, maintenance and other interventions. In many areas, such as the Albuquerque Reach, near-perpetual maintenance may be required. Other segments might be more easily made self-sustaining by “letting the river do the work”. Self-sustaining projects will undoubtedly rate better in cost efficiency analyses. Consider that managing flows to help shape channel form, whether inserted into the process now or later, might make this sustainability objective less quixotic.

RECOMMENDATIONS:

- Develop a vision statement. This might include language like “maintenance activities will contribute to overall restoration of MRG river ecosystems [that are less maintenance-intensive, more self-sustaining]”.
- Develop additional stated objectives (Part I Section 1.4 “Future Conditions and Strategies”) e.g. “it is in the interest of cost containment to create self-sustaining channel conditions wherever possible” and “the infrastructure protection goal may be met, in some cases, by relocating facilities, such as levees, when costly reconstruction is being considered”. (At least make certain to consider these elements in the strategy identification process.)

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- Commit to consulting the river restoration literature, perhaps beginning with the paper River Restoration, cited in the References section of this memo (Wohl 2005). (2.3.5)
- In the interest of a more nearly self-sustaining Program, conduct a study of the requirements for channel-forming flow volumes in each reach (2.2.3 or 2.3.1).

Conformance with Emerging Policies- As of this writing, comment has closed on the President's Council on Environmental Quality's proposed *National Objectives, Principles and Standards for Water Resources Implementation Studies*. Although the rule will be revised from the previously published draft, it is possible to predict that the present Plan will be subject to guidance by the draft's 13 Principles (CEQ 2009). No matter how Reclamation considers the plan to be subject to the policy, the planning team is advised to incorporate these principles into the present process.

Four of the new CEQ Principles are highlighted here:

"B. Account for ecosystem services"- This provision is intended to alert planners to a suite of less-obvious values which may be impacted by water resource development. The new policy requires identifying "an explicit list of services that an ecosystem provides." I suggest that an inventory of MRG ecosystem services would include: supplying drinking and irrigation water; food and forage production; groundwater recharge; water quality improvement; nutrient cycling; sediment storage; prevention of soil erosion, waterlogging and salinization; fire protection; flood attenuation; cultural and spiritual support; primary production (overall biological support), fish and wildlife habitat and recreation.

In further screening the comprehensive list of ecosystem service for their relevance to the Program, planners are likely to find themselves be directed to: water delivery, aquatic and riparian habitat, flood attenuation, sediment transport, groundwater recharge, cultural value to tribal entities and biological production services. In the ultimate step, planners would analyze to detect changes in the provision of these services that might result from the Program.

"C. Avoid unwise use of floodplains... and other ecologically valuable areas- This Principle requires that "studies...give full and equal treatment to nonstructural approaches that avoid and minimize actions and changes that ... adversely impact floodplain functions {and} preserve and **restore** the hydrologic and natural resources functions and the integrity of floodplains" (bold emphasis is mine). Strategies that reconnect floodplain to channel are to be given greater weight than in the past. "Soft engineering" may be preferred to structural flood control, for example. Note the inclusion of a restoration component (CEQ 2009).

"D. Utilize watershed and ecosystem based approaches"-This Principle is clearly intended to encourage a view of the whole MRG as a functioning system, to integrate applied and social sciences and coordinate with other authorities (watershed approach) and the interconnection of ecosystem functions and processes with economic considerations (ecosystem approach). River maintenance is thus pressed to move beyond

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its former, single-purpose focus and accept responsibility to “account for [its] cumulative human effects on ecosystems, via explicit considerations of impacts and tradeoffs...in a systematic manner”. (CEQ 2009) This guidance also suggests increasing application of an adaptive management design at the front end of planning.

“M. Collaborate implementation study activities broadly”-The practice of collaboration affected Federal agencies, and with Tribal, regional, state, local, and non-governmental entities to realize more comprehensive and better informed problem resolutions will be required under the new policy.

RECOMMENDATIONS:

- Add to selection process, the screening of strategies to ensure that they not preclude later application of non-structural approaches, such as land use changes and flow management (part 2).
- Include in the Plan an inventory of ecosystem services in the MRG, screen services for relevance to the Program and predict change. (World Resources Institute; see link in References.) (2.5.4)
- Identify locations where “increasing area available to river” make sense from a long term perspective (such as when meander belt width is unacceptably constrained). Whether or not the strategy is selected, identifying areas where the strategy might be desirable positions the Program to discover such opportunities when and if they should arise. (in reach characterizations)
- Similarly, describe situations where managed flows might achieve Program objectives, whether or not they are feasible, short term. (reach characterizations, Part 2 strategies)

Relationship to Other Programs- River Maintenance in the MRG must take cognizance of projects that would traditionally be considered external to its mission, since several of these are inextricably linked to Program outcomes.

A number of Corps of Engineers *flood control projects* are authorized in the planning area and at least one has received an appropriation, *i.e.* San Acacia reach. Design decisions taken for a San Acacia Levee Project may conflict with, or dictate, Program implementation in that reach. There is some potential for a “chicken-egg” dilemma to occur here. Collaboration among the Program, Corps, NM Interstate Stream Commission, local land use officials and the Fish and Wildlife Service is obviously desirable, if the best outcome is to be reached. A broadly conceived, avowedly holistic River Maintenance Program could make certain that opportunities for river restoration (including channel realignment, land acquisition, levee set-back or deconstruction) are analyzed early in Corps’ assessments for this and any subsequent flood control projects.

Reclamation’s *Water Operations* are a key variable in Program outcomes, and are especially significant in wet years. River Maintenance should be closely involved in formulation of Water Operations Division’s Annual Operating Plan. Cognizance should of opportunities for managed flows as a Program strategy.

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The *Middle Rio Grande Endangered Species Collaborative Program* (ESACP) has several facets that influence river maintenance. Its institutional identity as a sort of umbrella under which MRG stakeholders make river management decisions, suggests that river maintenance strategies should both provide input to and receive direction from the ESACP. ESACP's *Habitat Restoration Workgroup* will send up projects throughout the planning area, including many which rely upon physical management of aquatic and riparian habitat. These will depend, in some measure, upon coordination with the river maintenance Program. Another facet of the ESACP, *the San Acacia Reach Workgroup*, has the potential to evolve into a broadly collaborative effort at holistic management of this important reach. The Plan should recognize that it is in a symbiotic relationship with, and should deliberately inform, the ESACP's Long Term Plan, as well as the Biological Assessment/Biological Opinion for action agencies within ESACP.

RECOMMENDATIONS:

- Implement an Annual Work Plan planning process which includes the following elements: priority reaches, projects to be initiated, ongoing work, previous year monitoring results, current year monitoring plan, adaptive management analysis. (1.3). Conduct annual meeting with stakeholders.
- The Plan should recognize Cochiti Reservoir "Spawning Spike" releases and discuss whether and how these sorts of operations might contribute to river maintenance objectives. (3.5)
- Articulate a process of cross-consulting with external flood control, water operations and biological management authorities/activities to ensure synthesis of objectives between river maintenance these programs. (Chapter 3)

A Few Notes on Adaptive Management, Uncertainty and Scale- There is no steady state for rivers. If the river is not striving for dynamic equilibrium, it is another sort of water conveyance. Its processes and functions are so complex that our best science cannot accurately predict the outcomes of attempts to manage it. On structural engineering projects, any uncertainty would be closely analyzed and eliminated. This is not possible when we undertake to engineer a river. Given the complexity and dynamics of the subject river, its inscrutable will and the inherent uncertainty of project outcomes, I believe that a carefully designed adaptive management regime and commitment to monitoring is an absolute prerequisite for Program success. And, while I agree with the reach-specific approach taken by the Plan, some way(s) should be found to evaluate local strategies in the context of the whole MRG planning area.

I would be pleased to provide any further assistance the team considers appropriate and useful, in working toward a fresh, new approach.

RECOMMENDATION:

Convene an interdisciplinary team, with expertise in adaptive management to design an appropriately detailed plan for monitoring and adaptively managing the Program. (2.3.7)

MRG River Maintenance Plan Review-Steve Harris

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Last Word from Luna Leopold: “...the hydrologic system is a highly interconnected plumbing network. Changes made in one part of the system have influences downstream. The continued functioning of the system is of great importance. To test whether the system is operating satisfactorily by economic and legal criteria alone will not guarantee its continued health. What is needed is some deeper feeling.”

Middle Rio Grande River Maintenance Plan: Independent Review

Submitted to Albuquerque Area USBOR (Order No. 08PG430077)

Reviewer: Steve Harris, Rio Grande Restoration

September 30, 2011

Reviewer's Disclaimer: I am not an engineer and thus unqualified to discuss technical aspects of The U.S. Bureau of Reclamation Middle Rio Grande River Maintenance Plan (Plan). If I possess any qualification for this task, it is that I am a long-time observer of the Rio Grande and thus conversant with the physical and socio-political landscape of the Middle Rio Grande Valley (MRG). My review, therefore, will focus on the decision-making processes described in the Plan, and their prospects for success.

I commend the United States Bureau of Reclamation's Sedimentation and River Hydraulics Group and Albuquerque River Analysis Division (Group) for having produced a very thoughtful and thorough Plan for conducting the agency's River Maintenance Program. It is clearly cognizant of recent advances in river engineering knowledge and practice. The Group itself has conducted a great deal of research into the behavior of the Rio Grande. Perhaps most importantly, the Bureau's Albuquerque office has some decades of experience managing the congressionally mandated MRG Project, a long-term attempt to manage problems of channel instability, water delivery efficiency and periodic flooding. From these sources Bureau engineers have gained a vision of the Rio Grande's peculiar character, its unhelpful tendencies and dynamic disequilibrium. This Plan is the result of this hard-won knowledge. If the Plan seems detail-laden to the lay reader (and it does), it is because the natural resource management issues it addresses are breathtakingly complex.

Until recently, river maintenance actions were predicated entirely upon the mandates of the Flood Control Acts of 1948 and 1950, whose emphasis on "control" has straitjacketed the river with a great deal of durable infrastructure (*e.g.* placement of 100,000 jetty jacks). Today, with the addition of the "Ecological Compatibility" requirement, the MRG River Maintenance game is changing. Now, Bureau engineers must focus on a new management function for the Rio Grande; they are responsible for somehow maintaining aquatic and avian habitat, while still attending to their core mission of maintaining water conveyance.

We know that the Rio Grande between Velarde and San Marcial has become a severely dysfunctional waterway. Its degraded segments possess greatly simplified channels, more narrow and swift than under pre-development conditions; in this process, which is still continuing, much habitat has been lost. In its aggraded segments, the channel leaks water to the surrounding landscape, resulting in remarkably large water losses. The irony is that much of the river's present dysfunction is a result of structures built to domesticate it.

In an earlier memo to the Group, I suggested a principle that might help to explain how the river got to such a state. *"In recent decades ecologists have learned that attempts to maximize individual variables in a complex, multi-variant system tends to cause the system to falter. The lesson seems to be that if the system is managed single-mindedly for the production of one output, the overall system tends to decline, often precipitously"* (DeBuys

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2001). As treatments of the original “symptom” are applied, new distortions (symptoms) appear, as the system responds to the laws of physics.

In the MRG, this principle has been manifested as a long cycle of engineering treatments: drains constructed to reclaim seeped lands, levees built to protect drainage and other infrastructure, maintenance projects launched to protect levees and infrastructure—all with the effect of further and further constraining the Rio Grande’s flood channels and disrupting its underlying processes, including the conveyance of sediment.

Having been set upon its present course, MRG society can ill afford to not continue to maintain the river. Continuance of its remaining functions—interregional water supply, the viability of its farms and biological processes—is of paramount importance to a region that rests on this foundation. A way must be sought to break the cycle of single-purpose “fixes” and their unintended consequences.

The question becomes “what does 21st Century river maintenance look like in the MRG?” My answer is that it should look a great deal like “River Restoration”—a popular but somewhat misleading term for a set of coordinated activities designed to prevent further degradation and preserve valued human resources. If rigorously applied and adequately funded, the Plan can be an adequate road map for such an uncertain journey.

The core of the Plan is the Reach Strategy formulation. Assuming, as I do, that sufficient information and analysis of the geomorphic characteristics and trends in each reach have been collected, the strategies to be considered should offer sufficient flexibility for effective implementation. Inclusion of the “Increase Area Available to the River Strategy” suggests that purchase of easement and levee setback tactics will get due consideration, wherever they may be appropriate. I urge RM Program management to consider these tactics more broadly than in the past.

A significant strength: the continued development of geomorphic models promises to increase confidence in the validity of RM Program’s evaluation of the results of its activities.

A point of substantial uncertainty is correctly determining the relative priority among the reaches and the sites within the reach. Here non-RM Program scientists and stakeholders can make a great contribution to deciding where to place RM Program resources. Implementing priorities promises to be critically constrained by trends in federal funding. Rather than crippling the RM Program, perhaps this projected resource scarcity will serve to make RM activities more effective.

I am confident that the Plan allows the least invasive actions to be applied in the future. While some “soft engineering” actions are frankly experimental, the inherent uncertainty of the river maintenance enterprise and the Plan’s stated dedication to adaptive management will permit the Bureau to become more proficient at predicting what will be cost effective in a given condition.

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Specific Recommendations:

1. (To the Group) Review reach strategies (and outcomes) in the context of the whole MRG. Such “holistic” reviews should take place in the process of assessing the outcomes/effects of previous actions and in the formulation of annual work plans.
2. (To the Area Manager and other Bureau decision-makers)
 - a. Implement the Plan in collaboration with Corps of Engineers flood risk management activities. There are five congressionally authorized flood control project, the most advanced of which is in the critical San Acacia Reach (C.7 and C.8). One great difficulty is that the Corps’ project planning and approval processes do not allow for much adaptation, and yet River Maintenance analyses can clearly suggest where levee alignments are either vulnerable to undercutting or constrain RM activities. A formal coordinating function may be necessary to harmonize RM and flood risk reduction in key reaches. This is a key consideration in San Acacia.
 - b. Similarly, implement the Plan in Collaboration with the MRGES Collaborative Program’s Habitat Restoration workgroup. This task is facilitated by the Bureau’s present role in the Collaborative Program, but should be maintained and included in the formal coordinating process suggested above. To avoid red tape and potentially adverse outcomes, Congressional assistance may be necessary or desirable.
 - c. Integrate Bureau Water Operations functions into the Plan over time. Be alert to the potential of flow (especially high flow) management to enhance river management objectives.
 - d. Consider integrating RM adaptive management processes into the MRGESACP Adaptive Management Program, as it is developed.
 - e. Strengthen stakeholder collaboration by: making more frequent opportunities for consultation in the individual reaches; and by working with local floodplain managers, county commissions, riverside landowners farm and environmental organizations.
3. (To all) Consider the Plan to be a tool for river restoration activities and a benefit to endangered species recovery efforts.

From a funder’s perspective, the most desirable goal would be to achieve a self-sustaining river system. But for the River Maintenance Program to discontinue the process of controlling, and thus disrupting, the middle Rio Grande would require widespread change in the way institutions and people manage the river, in essence returning the floodplain to the river. Until public attitudes and institutional missions are reformed toward such a goal, the best the Rio Grande can hope for is a improvement of the balancing act (maintaining both favorable resource conditions and riverine integrity) suggested by the Plan.

This suggests that appropriate levels of funding must be available to the RM Program in the long term.

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Unique Terms

The analysis approach is discussed in section 4.1 of the main report, Middle Rio Grande River Maintenance Program Comprehensive Plan and Guide.

Evaluation Factors. For this analysis, we rated strategy implementation effects by the attribute of three evaluation factor for each suitable strategy in each reach:

- Engineering Effectiveness Evaluation Factor (as scored by the Attributes for Strategy Performance and River Maintenance Function)
- Ecosystem Function Evaluation Factor (as scored by the attributes for the SWFL and RGSM)
- Economic Evaluation Factor

Goals. Goals are outcome statements that describe desired conditions on the Middle Rio Grande. The updated goals are:

- Support Channel Sustainability
- Protect Riverside Infrastructure and Resources
- Be Ecosystem Compatible
- Provide Effective Water Delivery

Planform Stages. See appendix C, section C1.4.1.3, for a description of the Middle Rio Grande Planform Evolution Model. For further clarification, please refer to Mesong et al. 2010. The planform stages progress from Stage 1–3 on a common pathway; Stages A4–A6 are aggrading conditions, and Stages M4–M8 are migrating conditions. The planform stages, as listed in the previous described order, are as follows:

- Stage 1 (Mobile sand-bed channel)
- Stage 2 (Vegetating bar channel)
- Stage 3 (Main channel with side channels)
- Stage A4 (Aggrading single channel)
- Stage A5 (Aggrading plugged channel)
- Stage A6 (Aggrading avulsed channel)
- Stage M4 (Narrow single channel)
- Stage M5 (Sinuous thalweg channel)
- Stage M6 (Migrating bend channel)

- Stage M7 (Migrating with cutoff channel)
- Stage M8 (Cutoff is now main channel)

Reach Characteristics. Reach characteristics are overall assessments of the existing conditions of the reach to provide information used in prioritizing reaches and in rating the strategy effects by reach. Reach characteristics are:

- Channel Instability Reach Characteristic
- Water Delivery Impact Reach Characteristic
- Infrastructure, Public Health, and Safety Reach Characteristic
- Habitat Value and Need Reach Characteristic (as reflected by southwestern willow flycatcher [SWFL] and Rio Grande silvery minnow [RGSM])

Strategies: Strategies are the basic approaches to achieving the goals on a reach-wide basis, and methods are the means to implement those strategies. The variety of river management practices considered for implementation on the Middle Rio Grande is grouped into six basic strategies:

- Promote Elevation Stability
- Promote Alignment Stability
- Reconstruct and Maintain Channel Capacity
- Increase Available Area to the River
- Rehabilitate Channel and Flood Plain
- Manage Sediment