FINAL REPORT

VALUE ENGINEERING STUDY REPORT

RIO DE FLAG FLOOD CONTROL PROJECT

MAINSTEM CHANNEL IMPROVEMENTS

City of Flagstaff, Arizona

U.S. Army Engineer District

Los Angeles Corps of Engineers

January 25 – 29, 2010

Prepared by

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Contract Number W912PL-09-D-0011

March 19, 2010

VALUE ENGINEERING STUDY
RIO DE FLAG
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SUMMARY

Rio de Flag Channel (RDF) and Clay Avenue Wash (CAW) traverse the heavily urbanized areas of the city of Flagstaff with a combined drainage basin area of approximately 15 square miles within the city. The existing channel is significantly undersized for conveying stormwater during flood events. Typical of flood channels through urbanized areas, the channel intersects with numerous streets, highways and railroads. The existing system is notably deficient near the proposed confluence area, and topographic and land-use constraints have imposed limitations to hydraulic efficiency for both the existing system and the proposed system.

A feasibility study was conducted from 1996 to 2000, and that study found it advantageous to improve the regional drainage system to protect people and property. The U.S. Army Corps of Engineers and its local sponsor, the City of Flagstaff, have united their efforts in recent years in the planning and design of this flood-control system. Many design alternatives have been formulated and value engineering efforts have been made in order to address the urban constraints and the technically challenging geological, environmental, and right-of-way factors. The latest design is referenced in this study as the 90% design plan of April 2009. This involved two value engineering studies conducted in 2001 and 2005. Two major design elements have already been constructed: the Clay Avenue Wash Detention Basin and the Butler Avenue Undercrossing (a 16-foot-diameter tunnel).

Due to the increase in the project's costs from the 30% design level to the latest 90% plan, further investigation of cost-saving measures is needed. This Value Engineering Workshop was conducted specifically to address this concern. Since there are many prior value engineering studies and cost estimates, this workshop intends to focus on the current design elements shown in the 90% Plans and Specifications (April 2009) as well as on construction issues.

Technical issues discussed which are critical to value engineering are highlighted below:

1. The Clay Avenue Wash Detention Basin and the lower RDF Butler crossing have been completed.
2. Basalt exists along the project alignment and any deeper construction will cost more for excavation and disposal; for some reaches, basalt deposition extends the entire depth of the proposed channel.
3. Route 66 and the Five Point intersection need to be maintained for through traffic (the ADOT prefers to have a one-lane closure only during construction).
4. Railroad right-of-way encroachment is necessary east of Beaver, and deep construction shoring is expensive. The BNSF Railway is still open to negotiation.
5. The lower reach of RDF is the open channel is located primarily within BNSF Railway ownership area. Widening the channel will involve community acceptance and assumption of the right-of-way costs.
6. There are many locations that require water and sewer relocation. A gas line along RDF near City Hall (Route 66 to Birch) and a trailer park in the upper CAW will be

impacted by the project. Mitigation cost is high for each trailer bearing potential impact.

7. Flood Walls A and B are 5 feet high from the ground, and area residents are concerned about potential aesthetic impacts.
8. Aesthetic values and recreational functions currently provided are factors to be considered in addition to flood protection.
9. A precast arch was adopted at 30% design, and 90% design where closed conduits are desired. The rationale for this design is rapid construction and less traffic impact.
10. Precast reinforced concrete arch culverts have not commonly or frequently been applied in most regional flood-control and urban drainage projects in local areas or nationwide in general. The possible scarcity of manufacturing sources and the uncertain familiarity of contractors with reliable methods of construction may carry with it a high risk of price escalation for bid as well as delivery issues during the construction period. Traditional construction methods for underground conduits such as reinforced concrete box may have to be reconsidered.
11. The U.S. Army Corps of Engineers requires reinforced concrete slabs and walls to have a larger concrete thickness to cover steel bars compared to Department of Transportation design standards, and this may carry with it high transportation costs for any precast elements.
12. For levees and walls, 3-foot freeboard is required, but the open channel flow within a closed conduit typically does not require 3-foot freeboard. Costly construction for overly conservative design is not necessary.
13. Although not in the current design, upper RDF detention within the Thorpe Park area may be considered.
14. Although not in the current design, the realignment of RDF and CAW along Phoenix Avenue may be reconsidered to avoid construction inside the BNSF Railway rights of way downstream of Beaver Street.
15. Previous cost estimates should be evaluated for differences in the construction items, and unit costs and local construction cost data should also be referenced.

A total of 14 initial alternatives were created by the Value Engineering Team. These resulted from technical discussions, function analyses, and cost-savings considerations. The advantages and disadvantages of each initial alternative were identified as shown in Appendix A, entitled “Initial Alternatives”.

Based on the evaluation, the fourteen initial alternatives were regrouped and/or combined into nine priority alternatives by the Value Engineering Team, as shown in Appendix A and in the summary table entitled “Priority Alternatives” under Alternative Evaluation.

Each of the nine priority alternatives (referred to as the “Current Design”) is compared to the 90% Plan (referred to as the “Original Design”) for its construction cost savings. Construction feasibility and hydraulic adequacy were evaluated to ensure project feasibility. Additional costs or savings (or impacts or benefits) related to rights-of-way, utilities, basalt excavation and disposal, other environmental remediation, aesthetic issues, real estate value issues, and recreational impacts were noted in the comparison.

The results of the value engineering are summarized as follows:

High-Ranking Alternatives

Alternative 1:

Upper RDF – Replace 28’ wide, 8’ to 10’ high RC arch culverts with 18’ wide by 8’ high RCB culverts

Lower RDF – Replace 24’-28’ wide, 10’ to 16’ high RC arch culverts with 24’-28’ wide, 10’-16’ high RCB culverts.

Clay Avenue Wash – Replace 24’ wide, 8’ high RC arch culverts with 20’ wide, 8’ high RCB culverts except for the confluence reach downstream of the Five Point intersection. Remove grade control drops at Malpais Lane and at the RDF confluence. Due to backwater and mild slope, the confluence reach may not be reduced but improving confluence as shown in Alternative 2 may reduce backwater and benefit the CAW system design.

This alternative can potentially save more than $10 million with a major advantage in standard RCB construction in lieu of special design, manufacturing, delivery, installation and inspection for RC arch culverts. Reducing culvert width will definitely benefit construction cost including reducing basalt excavation, reinforced concrete, and shoring.

Medium- or Medium-High-Ranking Alternatives

Alternative 2:

Realign the RDF channel upstream of Beaver to join CAW immediately north of Phoenix Avenue with a new culvert (2A) or open channel (2B) junction structure. This will eliminate the extensive confluence of the Original Design and approximately 150 feet of CAW 24’-wide arch culvert downstream of Phoenix Avenue. This will also allow for reduction of the RDF culvert from 28’ wide to 24’ wide downstream of the new junction (to the end of the Original-Design Junction Structure).

This alternative is expected to result in more than $1.5 (2A) to $2 million in savings and have the added benefits of fewer construction disturbance areas and opportunities for integrated function of flood-control, water quality management, and park and open space development in the new junction and in the existing RDF channel area.

Alternative 3:

From Route 66 to Bonita, replace the 28’ wide RC arch culvert with a dual drainage system – a composite channel with RCB below a grass-lined open channel similar to the existing channel.

This is expected to save approximately $2.72 million.

Alternative 5:

From Beal to Thorpe, replace the flood wall (5' above the ground) with channel conveyance improvements (these may begin from downstream of Thorpe).

This is expected to save $2 million, primarily in the bridge work reduction (note that the flood wall will raise the road and require a longer and more highly elevated bridge).

Alternative 7:

From the Five Point intersection to McCracken, replace the 24' wide, 8' high RC arch culvert with an RC channel which is 18' wide and 8' high.

This will result in approximately $1.6 million dollars in savings; however, adjacent land uses may be limited and real estate values may be adversely affected.

Alternative 8:

From Bonita to Sitgreaves, replace the 28' wide, 8' high RC arch culvert with an earthen channel.

This is expected to save approximately $1.7 million. No additional right of way is required, as it is within the City's jurisdiction.

Low- or Medium-Low-Ranking Alternatives

Alternative 4A: Realign the RC arch culvert through the trailer park upstream of Blackbird Roost. The trailer park impact-reduction was offset by the additional length of the culvert. Cost savings are $130,000, and that amount can be increased if RCB is used instead of RC arch culvert.

Alternative 4B: Replace RC channel upstream of the trailer park with earthen channel. Savings of $310,000 are expected; however, a new right of way will be required, which may offset the saving.

Alternative 6: Use of the existing BNSF track areas for construction will reduce the shoring cost. Depending on the tracks to be removed and replaced and the side slopes allowed for excavation, this may result in savings ranging from $38,850 to $527,700.

Alternative 9: From Birch to Route 66, replace the RC arch culvert with an earthen channel. This alternative may save up to $660,000 (without right-of-way and utility-relocation fee), however; this is not desirable, as it requires a much wider section than the existing channel and will cause serious impacts to the existing uses along the channel and require expensive transition structures at each street crossing or new bridges.

Implementation Recommendation

Prior to the 100% Plan preparation, it is recommended that the high-, medium-high, and medium-ranking alternatives (these can be combined) be considered for the flood control system of Rio de Flag. The optimal design configurations need to be obtained by further detailed hydraulic and structural calculations and modeling. Unit costs for critical cost items such as reinforced concrete, shoring, basalt excavation and basalt disposal should be further investigated to determine the final cost estimates.

PROJECT BACKGROUND

Project Area, Studies and Design

Rio de Flag Channel is a tributary of the San Francisco Wash, which in turn flows into the Little Colorado River. The stream originates on the southwestern slopes of the San Francisco Peaks near Flagstaff, Arizona. The total drainage area of the watershed is approximately 116 square miles with 15 square miles within the City of Flagstaff. Clay Avenue Wash is a major tributary to the west and is part of the project.

This Value Engineering Study was conducted based on an understanding of many issues related to the floodplain of the Rio de Flag Channel (RDF) and the Clay Avenue Wash (CAW). Being a regional channel system transporting large quantities of stormwater during major events through major highways, streets, business centers, recreational areas and heavily developed residential areas, floodplain management and flood protection have been priority foci of the U.S. Army Corps of Engineers, the City and nearby communities during past decades.

A feasibility study for the Rio de Flag Flood Control Project was authorized under House Resolution 2425 dated May 17, 1994. That study provided a comprehensive review of the drainage basin within the City and incoming flows from upstream drainage basins (see attached Reference CD). Subject to the feasibility study, a 30% Plan was prepared in 2005 which was subsequently refined, modified, and detailed during final design. The latest version of the final design is shown in the 90% Plans and Specifications included in the attached Reference CD. During the feasibility design study, a Value Engineering Workshop was conducted in 2001. Near the completion of the 30% Plan, a value engineering workshop was conducted in 2005. Several alternatives under the previous Value Engineering workshops have been implemented in the current design or in the previous construction. The previous Value Engineering Study reports were reviewed to ensure the continuity of the value engineering efforts (see 2001 and 2005 Value Engineering Report in the attached Reference CD).

A general view of the project area is shown in the attached Study Area Map taken from the Feasibility Report. Following the street and stationing reference map are aerial photographic maps showing the proposed channel alignments with the 100-year floodplain and local storm drain overlay maps.

- Street and Stationing Reference Map prepared by WRC Consulting Services, Inc. (this reference map is to be used throughout the document).
- Detailed Aerial Photo Maps showing the Rio de Flag Channel upstream of its confluence with CAW (Panel Nos. 1, 2, and 3) prepared by Mr. Thomas Hieb of the City of Flagstaff with alignments provided by Robert Morse of the U.S. Army Corps of Engineers.
- Detailed Aerial Photo Map showing the confluence reaches of the Rio de Flag Channel and the Clay Avenue Wash (Panel No. 4)
- Detailed Aerial Photo Maps showing the confluence reaches of the Rio de Flag Channel and the Clay Avenue Wash (Panel Nos. 5 and 6)

- Detailed Aerial Photo Map showing the Clay Avenue Wash upstream of the confluence reach from the Five Point intersection to the upstream end near the detention basin outlet (Panel No. 7).

Hydraulic Concern

It was noted during the technical discussions of this workshop that the channel costs are high within the confluence and adjacent reaches. Special efforts were made to observe the hydraulic characteristics of these areas. The 100-year flood is the design level for the 90% Plan, and the design discharges are 1,800, 2,100, and 1,400, respectively, for Upper RDF, Lower RDF, and CAW.

The exiting drainage courses for Rio de Flag and Clay Avenue Wash are shown in the attached figure. In contrast to the 90% Plan, which has a defined confluence of Rio de Flag and Clay Avenue Wash near Beaver Street north of Phoenix Avenue, Clay Avenue wash flows easterly along East Butler Avenue after the Five Point intersection while RDF is currently flowing into storm drains downstream of Phoenix Avenue (see attached figure for Existing Channel alignments). The existing channel is very limited in its hydraulic capacity (see Existing Channel Capacity calculations in the attached Reference CD). Flow-breakout potentials and flooding areas are extensive, as shown in the project and floodplain aerial photographs observed previously. This is especially true for the confluence area. Clay Avenue Wash has a mild gradient in this area, which results in hydraulic inefficiency. Under the proposed conditions, the mild gradient and high backwater from the Rio de Flag Channel extends to upstream of the Five Point intersection, which severely limits the potential for a cost-effective design.

Geology and Environmental Concerns

Geotechnical information was presented at the workshop and is included in the attached Reference CD. The most important geologic feature of the Rio de Flag Flood-Control Project is the presence and relative hardness of basalt bedrock along several reaches of the proposed RDF and CAW alignments. It erupted in several pulses on top of pre-existing soils and a soft sandstone bedrock starting approximately one million years ago via activities that formed the San Francisco Peaks. The problematic issues with basalt include higher excavation and disposal costs and slow construction speed. The narrower and deeper the excavation, the more impacts there are on construction time and costs.

The attached table shows how several reaches encounter basalt and the estimated depth of basalt excavation based on the 90% Plan invert profiles. These data were applied to value engineering in formatting alternatives which may involve fewer costs for basalt excavation and disposal and less disruption to the normal construction schedule.

Because excavations of channels for this project are to be forced within narrow confining lines to protect and to avoid relocation of any infrastructure (primarily buildings, historical buildings, and the BNSF Railway lines), the working space for excavations will be highly confined in most reaches. When one reach has a lower invert, it affects the depth of the upstream reaches as well as the related basalt-excavation costs. Forcing one part of the channel to a less than ideal

lower elevation has a ripple effect throughout the alignment, and many dozens of iterations of full length of channel designs have been created in an effort to balance the interests of all stakeholders while still conveying the requisite amount of water.

The basalt bedrock is present continuously along the existing Rio de Flag channel (and beneath the project's footprint) from the upstream start of construction (the Beal Road bridge over the Rio de Flag channel) downstream to the US Route 66 bridge, and from Route 66 almost all the way to the downstream end of project, which is the recently completed stormwater conveyance tunnel beneath Butler Avenue. The basalt along this reach is buried by as little as a few inches to as much as 10 to 15 feet of soil and fills.

The only gap in the basalt bedrock is the segment in the project's Rio de Flag channel realignment at the BNSF tracks undercrossing to the "confluence area" south of those tracks, where the realigned Clay Avenue Wash will be joined to this realigned Rio de Flag channel in a complex underground culvert connection. It is most fortuitous to have no basalt bedrock in those locations.

The basalt near the surface to the west of the project's San Francisco Street undercrossing is deeply weathered and may afford some excavation cost reduction. It does, though, harden considerably at depth and above the final project excavation depth. A similar but much deeper decrease of basalt hardness is present in the block between the Birch and Aspen Avenues undercrossings. The project's floodwall north and east of Francis Short Pond and west of the rear of Navajo Drive residences will be founded mostly in soil that overlies basalt bedrock.

Clay Avenue Wash is a tributary of Rio de Flag that will be joined to Rio de Flag in a new realignment north of Phoenix Avenue and south of the BNSF tracks. Excavations for the Clay Avenue Wash will be in or above basalt bedrock for over half the total length of its project channel. The part that is not underlain by basalt extends from the McCracken property that is west of the Malpais Lane undercrossing of the Clay Avenue Wash, continuing downstream through the Five Point intersection and about one third of the way northward on Mikes Pike.

Geological and Environmental Hazards

Geological hazards on this job are few. No issues with slope stability (other than the stability of the excavated deep underground culvert cuts during construction), liquefaction, faults, fault zones or seismicity are anticipated.

The only known environmental hazard is pre-existing environmental contamination from releases of hydrocarbon products from several ex-commercial operations along the channel courses, and from one ex-creosote treatment site, where wood poles were preserved in the late 1800's. A formal Brownfields Action initiated by the City of Flagstaff is addressing part of the creosote-release issue, although not all of it that is needed to be done to construct this project. A voluntary effort to clean up heavy oil released from asphalt manufacturing has been discussed, exclusive of the Corps of Engineers, but the concepts being pursued there, too, will not sufficiently clean the area such that no further cleanup will be needed in advance of construction. Excavated contaminated soils will have to be removed from the project, or

placed in locations were they cannot be leached or washed back into the Rio de Flag flows. The compactness of the project area dictates removal of such excavated material in most cases. No site remediation will be required of the Corps by the State of Arizona on any of these properties in order to construct this project; no over-ex is required. We simply have to prevent what is left behind from contaminating Rio de Flag flows.

Along the re-alignment of the Clay Avenue Wash, four gasoline contaminant plumes will be cut through by project excavations, along with a cut through one diesel fuel tank pit. All sources of contamination have been identified and removed, and those source properties have been remediated to ADEQ standards. The contamination we will intersect is that left behind beneath streets (except for the diesel tank pit). One coal-tar type creosote release site (not remediated, but the source is known and is gone) will be cut through by this project. Reiterations of channel alignments in and adjacent to that space are undergoing another review and series of changes, so the amount of the release that will be excavated for this project cannot be determined. It may turn out that all of it is excavated and removed.

Along the Rio de Flag channel, two empty, not-in-use concrete diesel fuel bunkers of the BNSF will have to be removed, as they are in the line of the realigned channel. Probing suggests that neither bunker has leaked.

An extensive area of channel more than 2,000 feet in length has been subjected to the release of heavy oils used in asphalt manufacture, adjacent to a business property from which such materials are and have been sold by multiple vendors over many years. No point source has been identified. No contaminant migration path to the project channel has been identified. No cleanup activity has been undertaken. The U.S. Army Corps of Engineers is designing various engineered impermeable barriers to assure that whatever parts of this contaminant are left in place beneath the project and between the project and the source(s) cannot leach or migrate into the waters of the Rio de Flag after the project's completion.

Construction to Date

Two major design elements from early design plans have been constructed to date:

(1) The Clay Avenue Wash (CAW) Detention Basin at the upstream end of the CAW improvement.

(2) The Butler Avenue Crossing of the Rio de Flag Channel at the downstream end of the RDF improvement.

The next phase of construction would be the open channel reach of the Rio de Flag from BNSF Railway property to Butler Avenue.

VALUE ENGINEERING OBJECTIVE, FOCUS, AND PROCESS

The Value Engineering workshop was conducted from January 25 to January 29 following the Society of American Value Engineers and U.S. Army Corps of Engineers Value Engineering Standards for Value Engineering. The scope of work developed prior to this workshop was modified slightly based on the project-specific needs discussed at the workshop and summarized below. Without frequent replacement needs, life cycle cost analysis is not applicable to this project and was not provided during the meeting.

Since many planning studies, value engineering, and design efforts were made over the past two decades, the present value engineering workshop has focused on one primary project function, which is to manage stormwater conveyance capacity safely with minimal costs. The 90% Plan design elements are the basis of this value engineering.

To increase stormwater capacity, the following measures are typically applied: reduce discharge by retention, enlarge channel depth, increase bank height (with levees, walls, and/or berms), enlarge channel width, steepen grades, and/or reduce flow resistance. These measures have been considered in the Rio de Flag Flood Control Project, and it is believed that stormwater conveyance capacities are offered by the 90% Plan according to the U.S. Army Corps of Engineers design standards (refer to the 90% Plan Design Summary Table under Project Description).

Conveyance Measures

The fundamental approach to this value engineering was to review the measures proposed in the 90% Plan and investigate any potential alternatives to the proposed open channels, culverts and flood walls which may offer cost savings and will preserve the necessary flow-conveyance function.

Construction Methods

In addition to conveyance measures, construction methods were reviewed during value engineering in order to address the costs related to basalt excavation and disposal in many reaches (see Basalt Excavation Depth Table under Geotechnical Features) and extensive shoring activities along the CAW and the RDF, including areas in the close vicinity of existing development and railroad facilities.

Cost Basis

Of equal importance to the conveyance and construction measures, the cost-estimate basis was reviewed, as there are many iterations of designs and estimates, and the U.S. construction industry has gone through boom-and-bust periods during the periods of previous work. In addition to the unit-cost data resulting from the U.S. Army Corps of Engineers MCASES application, local construction input was researched by the City. A fair cost comparison was made using the appropriate and same-cost basis for a given alternative, referred to as the “Current Design”, with the corresponding elements for the 90% Plan referred to as the “Original Design”.

PROJECT DESCRIPTIONS: 90% Plan

A summary of the 90% Plan design elements is listed in the attached tables. In general, the proposed Rio de Flag channel downstream of Bonito Avenue is a reinforced concrete channel. The lower reach from the downstream end of the BNSF Railway property to Butler is a trapezoidal earthen channel with turf mat lining for erosion control. The remaining reaches are cast-in-place reinforced slab and walls coupled with a precast reinforced arch on top of the walls.

For Clay Avenue Wash, there is a rectangular concrete channel upstream of Chateau Drive and a precast reinforced arch with reinforced concrete slabs and walls in the remaining reaches.

Many local storm drains connect to the regional flood control system, as shown on the floodplain aerial maps, and proper junctions and backwater control should be part of the detailed design (not in the 90% Plan).

COST INFORMATION

The U.S. Army Corps of Engineers (USACE) presented the following three sets of cost estimates:

2006 Estimates: 30% Plan
2009 Estimates: 90% Plan Estimates Prior to In-House Review
2010 Estimates: 90% Plan Revised Estimates Based on In-House Review

The 2006 and 2009 estimates are $55 million and $84 million dollars, respectively, for total project construction, including the major project cost items shown in the table below. These costs cover Land, Easements, Rights-of-Way, Relocation, and Disposal Areas (LERRD), roads, bridges, planning, design, and construction management. The increase from $55 to $84 million from 2006 to 2009 was due to the availability of plans, profiles, sections and construction details at the 90% design level as well as more-defined utilities, rights-of-way and environmental mitigation costs (see attached 2006 and 2009 estimates).

The costs of contaminated site characterization have been a project cost (a cost-shared item). The costs of removal of those contaminants during the construction, however, will not be calculated as a project cost and will not be paid nor their cost shared by the U.S. Army Corps of Engineers. The remediation costs were estimated at nearly $3 million dollars (included in the $84 million cost estimates of 2009)

Using the 2009 estimates, the percentage for each major project element is summarized as follows:

CATEGORY	2009 COST DATA	PERCENTAGE
Channel and Basin Construction	$52.6 million	63%
LERRD	$24.6 million	29%
Roads and Bridges Construction	$0.62 million	1%
Planning, Engineering & Design	$3.35 million	4%
Construction Management	$2.90 million	3%
Total	$84.08 million	100%

Of the $52.6 million for channel construction cost, the following list shows the costs for each reach and environmental remediation.

Upper RDF: $14.0 million plus $1.3 million for Flood Walls A and B

Confluence Reach: $5.49 million

Lower RDF: $11.97 million

Clay Avenue Wash: $17.35 million

Constructed Elements: $8.5 million for Clay Avenue Wash Detention Basin and the Butler Avenue Tunnel

Environmental Remediation: $2.96 million

The 2006 data for channel/basin construction and LERRD are $32 million and $12 million, respectively. The Channel Construction cost has been slightly reduced to $49 million in the January 2010 estimates and the total project construction cost has been reduced to $77 millions. In addition to a comparison of the in-house estimates, the City was requested to provide local unit costs for a fair-market cost evaluation. The attached table compares the unit costs of the USACE in-house estimates to those from the City, based on current local construction costs. It should be noted that the USACE unit cost seems to be lower than the City's unit cost for channel construction, such as for reinforced concrete and rock excavation. The City data were applied in the workshop to both the 90% Plan and the alternative design, where applicable (where channel type or channel size changes).

VALUE ENGINEERING ALTERNATIVES AND COST SAVING ANALYSIS

A total of fourteen alternatives were formulated collectively during the technical sessions by the value engineering team. Based on an evaluation of the initial fourteen alternatives, nine priority alternatives were selected for further review. These nine alternatives and their associated cost savings are summarized in the attached tables with reference to the initial alternative numbers. Descriptions of the original and alternative design scenarios as well as cost saving calculations for the nine Priority Alternatives and the initial fourteen alternatives are presented in Appendix A, which includes the notes of an evaluation of the advantages and disadvantages for each alternative.

RECOMMENDATIONS

Rankings of the nine alternatives are shown below, based on the effectiveness of cost savings, implementation feasibility, no significant right-of-way or utility relocation needs, no additional hydraulic, geologic, or environmental concerns, and compatible with special construction consideration for the crossings at San Francisco/Route 66 and the Five Point intersection.

Alternative Recommendations

High-Ranking Alternatives

Alternative 1:

Upper RDF – Replace 28’ wide, 8’ to 10’ high RC arch culverts with 18’ wide by 8’ high RCB culverts

Lower RDF – Replace 24’-28’ wide, 10’ to 16’ high RC arch culverts with 24’-28’ wide, 10’-16’ high RCB culverts.

Clay Avenue Wash – Replace 24’ wide, 8’ high RC arch culverts with 20’ wide, 8’ high RCB culverts except for the confluence reach downstream of the Five Point intersection. Remove grade control drops at Malpais Lane and at the RDF confluence. Due to backwater and mild slope, the confluence reach may not be reduced but improving confluence as shown in Alternative 2 may reduce backwater and benefit the CAW system design.

This alternative can potentially save more than $10 million with a major advantage in standard RCB construction in lieu of special design, manufacturing, delivery, installation and inspection for RC arch culverts. Reducing culvert width will definitely benefit construction cost including reducing basalt excavation, reinforced concrete, and shoring.

Medium- or Medium-High-Ranking Alternatives

Alternative 2:

Realign the RDF channel upstream of Beaver to join CAW immediately north of Phoenix Avenue with a new culvert (2A) or open channel (2B) junction structure. This will eliminate the extensive confluence of the Original Design and approximately 150 feet of CAW 24’-wide arch culvert downstream of Phoenix Avenue. This will also allow for reduction of the RDF culvert from 28’ wide to 24’ wide downstream of the new junction (to the end of the Original-Design Junction Structure).

This alternative is expected to result in more than $1.5 (2A) to $2 million in savings and have the added benefits of fewer construction disturbance areas and opportunities for integrated function of flood-control, water quality management, and park and open space development in the new junction and in the existing RDF channel area.

Alternative 3:

From Route 66 to Bonita, replace the 28' wide RC arch culvert with a dual drainage system – a composite channel with RCB below a grass-lined open channel similar to the existing channel.

This is expected to save approximately $2.72 million.

Alternative 5:

From Beal to Thorpe, replace the flood wall (5' above the ground) with channel conveyance improvements (these may begin from downstream of Thorpe).

This is expected to save $2 million, primarily in the bridge work reduction (note that the flood wall will raise the road and require a longer and more highly elevated bridge).

Alternative 7:

From the Five Point intersection to McCracken, replace the 24' wide, 8' high RC arch culvert with an RC channel which is 18' wide and 8' high.

This will result in approximately $1.6 million dollars in savings; however, adjacent land uses may be limited and real estate values may be adversely affected.

Alternative 8:

From Bonita to Sitgreaves, replace the 28' wide, 8' high RC arch culvert with an earthen channel.

This is expected to save approximately $1.7 million. No additional right of way is required, as it is within the City's jurisdiction.

Low- or Medium-Low-Ranking Alternatives

Alternative 4A: Realign the RC arch culvert through the trailer park upstream of Blackbird Roost. The trailer park impact-reduction was offset by the additional length of the culvert. Cost savings are $130,000, and that amount can be increased if RCB is used instead of RC arch culvert.

Alternative 4B: Replace RC channel upstream of the trailer park with earthen channel. Savings of $310,000 are expected; however, a new right of way will be required, which may offset the saving.

Alternative 6: Use of the existing BNSF track areas for construction will reduce the shoring cost. Depending on the tracks to be removed and replaced and the side slopes allowed for excavation, this may result in savings ranging from $38,850 to $527,700.

Alternative 9: From Birch to Route 66, replace the RC arch culvert with an earthen channel. This alternative may save up to $660,000 (without right-of-way and utility-relocation fee), however; this is not desirable, as it requires a much wider section than the existing channel and will cause serious impacts to the existing uses along the channel and require expensive transition structures at each street crossing or new bridges.

Implementation Recommendation

Prior to the 100% Plan preparation, it is recommended that the high-, medium-high, and medium-ranking alternatives (these can be combined) be considered for the flood control system of Rio de Flag. The optimal design configurations need to be obtained by further detailed hydraulic and structural calculations and modeling. Unit costs for critical cost items such as reinforced concrete, shoring, basalt excavation and basalt disposal should be further investigated to determine the final cost estimates.

DAILY WORKSHOP AGENDA AND ATTENDANCE

The daily agenda are shown in this section and the daily attendee lists are attached as Appendix B.

APPENDIX A

PRIORITY ALTERNATIVES

INITIAL ALTERNATIVES

NOTES

This appendix includes the study results presented in the form of fully developed value engineering alternatives that include descriptions of the original design, descriptions of the alternative design configurations, opportunities and risks associated with the alternatives, sketches, and calculations. The Priority Alternatives were those filtered through the evaluation and selection process relating to the fourteen initial concepts, referred to as the Initial Alternatives. Descriptions of the original and current designs and the related advantages and disadvantages for the full Initial Alternatives are grouped under Priority Alternatives.

It should be noted that the cost estimates for priority alternatives attached are not necessarily representative of the final cost outcome for each alternative. Some of these alternatives have components that are mutually exclusive, so they may not be added together. However, several reaches of RCBs recommended under Priority Alternative 1 may be replaced or supplemented by shortened confluence, open channels, composite channels, and reduced shoring to achieve optimal hydraulic and cost efficiencies.

The cost calculations are intended only as a guide to the approximate results that might be expected from an implementation of the alternatives. These are provided for value engineering ranking and alternative selection. These should be verified with more-detailed designs, analyses, and estimates prior to 100% design.

PRIORITY ALTERNATIVES

Corresponding Initial Alternative No.

Original and Current Design Descriptions

Advantages and Disadvantages

Cost Summary

Back-Up Quantity and Channel Cost Estimates

Back-Up Utility R/W Notes and Costs

Hydraulic Profiles for Current Design (Alt 1)

INITIAL ALTERNATIVES

Original and Current Design Descriptions

Advantages and Disadvantages

APPENDIX B

DAILY AGENDA AND ATTENDEES

Value Engineering Workshop Agenda

Rio de Flag

Flagstaff, Arizona

January 25-29, 2010

Monday January 25

8:00 - 8:30 AM	Team Introduction and Organization – WRC, COE, City, Other
8:30 – 9:00 AM	Workshop Introduction- WRC
9:00 - 9:20 AM	Project Background - Goals, Schedule, Status – COE, City
9:20 – 9:50 AM	Issues and Constraints – City, COE
9:50 - 10:00 AM	Break
10:00 - 12:00 AM	Design Review: Latest Plans and Special Construction Specifications n- COE
12:00 AM -1:00 PM	Lunch Break
1:00 PM - 3:00 PM	COE Design Review: Previous Alternatives, VE Recommendations, and First Final Plans - COE, City

3:10 PM – 5:00 PM Site Reconnaissance

Tuesday January 26

8:00 - 10:20 AM	Project Analysis/ Function Analysis/Cost Analysis
10:20 - 10:30 AM	Break
10:30 AM - 12:00 PM	Technical Discussions - Civil, Structure, Geotechnical, Utility, Traffic Control, Construction Methods, Maintenance and Estimates
12:00 - 1:30 PM	Lunch Break and Site Reconnaissance
1:30 - 3:00 PM	Technical Discussions - Civil, Structure, Geotechnical, Utility, Traffic Control, Construction Methods, Estimates
3:00 - 3:10 PM	Break
3:10 - 5:30 PM	Evaluation of Potential Improvements

Wednesday, January 27

8:00 - 10:20 AM	Priority Alternative Recommendation Development
10:20 - 10:30 AM	Break
10:30 AM – 12:00 PM	Priority Alternative Recommendation Development
12:00 - 1:00 PM	Lunch Break
1:00 - 3:00 PM	Priority Alternative Recommendation Development
3:00 - 3:10 PM	Break
3:10 - 5:30 PM	Quantity and Cost Saving Estimates

Thursday January 28

8:00 – 10:00 AM	Quantity and Cost Saving Estimates
10:20 - 10:30 AM	Break
10:30 AM – 12:00 PM	Quantity and Cost Saving Estimates
12:00 - 1:00 PM	Lunch Break
1:00 - 3:00 PM	Quantity and Cost Saving Estimates
3:00 - 3:10 PM	Break
3:10 - 5:30 PM	Quantity and Cost Saving Estimates

Friday January 29

8:00 - 10:00 AM	Final Recommendations and Cost Saving Summary
10:00 - 11:30 AM	VE Study Conclusions

End of Study