Parsons Brinckerhoff
Value Engineering

P.B.V.E.

VALUE STUDY NO. 02- 09
FINAL REPORT

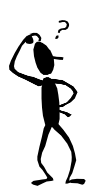
CONDUCTED FOR: Northern Arizona University/Navajo County

SUBJECT: Show Low Creek Reservoir System Evaluation

DATES: September 9-12, 2002

TEAM MEMBERS:

Bill Cox	Navajo County
Tom Hieb	Navajo County
Ron Solomon	Town of Taylor
Bill Jenkins	Az Department of Water Resources
Jim Janecek	Northern Arizona University
Jim Swaisgood	Swaisgood Consulting
Charlie Schlinger	Northern Arizona University
Rod Curtis	Parsons Brinckerhoff



RECOMMENDATIONS AND IMPLEMENTATION PHASE

"WHAT DOES THE TEAM RECOMMEND?"

"WHY?"

A. Recommendations

B. Design Suggestions

C. Sketches, Calculations, Attachments

A. VALUE ENGINEERING RECOMMENDATIONS

Introduction

Parsons Brinckerhoff is very pleased to have had the opportunity to lead this fine team of professionals in a value analysis of Lone Pine Dam, Schoens Dam, and the stretch of Show Low Creek between them. The Baseline for this analysis was Lone Pine Dam Alternative 4 plus the Schoens Dam concept, as recommended in the Draft Show Low Creek Reservoir System Evaluation, prepared by Northern Arizona University, College of Engineering and Technology, and dated September 9, 2002.

After participating in a site visit of both dams and the surrounding area, the team followed a four-phase value analysis process:

- **Identify Potential** For Value Enhancement. Key techniques included:
  - "EF2C Model" – The Team analyzed the Baseline by dividing it into its significant elements and then determining various aspects of each element – the function(s) it provides; its contribution to initial costs; its contribution to O&M costs; and its contribution to project complexity. This model helps the Team to identify the elements of the Baseline that have the highest potential for value enhancement. **Note**: the rating scale used in the EF2C Model was from +5 (adds very significantly to O&M/Complexity) to –5 (significantly reduces O&M/Complexity).
  - "F.A.S.T. Diagram" – The Team arranged the numerous Baseline functions into a logical flowchart, using the simple questions: How? and Why?. The goal of the function analysis techniques is to ensure that the Team has a thorough understanding of the Baseline concept prior to seeking alternate concepts. This is one of the strengths of the value method.
  - As a result of this analysis, the Team selected five Elements of the Baseline for further study, as detailed in Section 1.H. of the Study Record.
- **Generate Ideas** (aka "brainstorming")
  - The Team then generated 54 ideas in a creative session, during which judgment is suspended and all ideas are captured.

- **Evaluate Ideas**. A three-cut process was used to evaluate and trim the 54 ideas, retaining only the ones most likely to yield a true value enhancement.

- **Develop Recommendations.** The ideas surviving the three cut evaluation process were then developed into **4 Value Engineering Recommendations and 5 Design Suggestions**, which are presented in this section of the report.

The V.E. process is fully documented in the **Study Record** portion of this report, and the reader is encouraged to review it. Among other things, it demonstrates the significant effort used by the team to develop the recommendations and design suggestions.

Recommendation No. 1 - - Remove Lone Pine Dam – Revise Bridge and Roadway

Description

The V.E. Team agrees with the Draft Show Low Creek Reservoir System Evaluation (the baseline for this V.E. Study), that the preferred course of action regarding Lone Pine Dam would be to remove it, and place the material in the spillway and in old borrow areas used to obtain material for the dam.

The baseline concept is to replace the dam with an approximately 400 ft long single-span bridge, in order to maintain County Road 129, which crosses the dam, in its present location. The V.E. Team developed several potential alternatives to this baseline:

- A. Construct the bridge on the present alignment, but shorten it significantly by retaining as much of the dam for bridge approaches and abutments as practical. **(See Sketch)**
- B. Use shorter spans to reduce the bridge cost.
- C. Relocate the road and bridge upstream to a better crossing location.
- D. Relocate the road upstream to a location that would permit the use of a low-flow crossing instead of the proposed bridge. **(See Sketch)**

All of these concepts would require more investigation to determine feasibility and impact on project cost, but the Team believes they all have good potential to reduce the life-cycle cost of the Lone Pine project while still achieving the required functions related to dam safety and retention of the County Road.

Feasibility Considerations

This recommendation would only affect feasibility of the major portion of the baseline – removal of the dam – if a significant portion of the existing dam embankment were to be left in place, as envisioned in alternative A above. In that case, the resulting opening would have to pass the design storm while still providing a significant reduction in bridge length. The V.E. Team believes that this is likely to be feasible upon further investigation and design work.

Constructing bridge pier foundations in the area of the existing dam would require geotechnical investigation, but the Team believes that this would be unlikely to challenge the feasibility of the shorter span concept – as in B above.

A relocation of the County Road would require permitting and approval by the United States Forest Service. Although this would be an added project effort, the Team believes that approval from USFS could be obtained.

Functionality

Removal of the dam under this recommendation would, of course, continue to provide the basic function of the Lone Pine portion of the overall project. The functions of the County Road would be affected if it were to be significantly relocated and if a low-water crossing approach were taken. Trip lengths might increase, and the road would be closed during infrequent flood events. Given the small volume of traffic, however, (approximately 200 vehicles per day) and the availability of detours, the Team felt that a relocated road would continue to provide an acceptable level of function.

Life-Cycle Cost

The value engineering team did not attempt an estimate of the cost impact of the various alternatives, but believes that good potential exists to reduce significantly the life-cycle costs of the project. If a road relocation were selected, Navajo County personnel would be able to design and construct this work, saving a considerable expense in comparison with the baseline bridge which would require outside engineering and construction.

Note: The baseline estimate did not include any funds for bridge approaches, but the V.E. Team believes such work would be a requirement of the bridge replacement. We roughly estimated this cost at $650,000 including 30% contingency.

Recommendation No. 2 - - Streambed Stabilization Alternatives

Description

This recommendation describes several alternatives to be considered for the stabilization of Show Low Creek once Lone Pine Dam is removed:

- A. Remove only as much of the dam as necessary to ensure that the remaining structure would be classified as "low hazard". (preferred by the V.E. Team)
- B. Construct a temporary berm to control sediment.
- C. Create a stable, natural appearing channel to approximate pre-reservoir conditions.

Feasibility

This option (A above) appears to be more feasible than removing the entire dam, because it would result in less environmental disturbance and would potentially have easier permitting requirements. There would be some risk of catastrophic failure of the remaining structure during extreme flow events.

Functionality

This recommendation would retain the project function related to the removal of Lone Pine Dam, in that the unsafe classification would be eliminated. The following additional functions might also be provided:

- Possible groundwater recharge benefits
- Possibility of creating a wetland at the site
- The remaining structure would trap sediment and mitigate sediment problems downstream (especially at Schoens Dam).
- The area of disturbance would be limited.

Life-Cycle Cost

Leaving a smaller structure in place would decrease the initial cost of construction, but would increase operating and maintenance costs, in comparison with a complete removal of the dam. The V.E. Team did not attempt to estimate the overall life-cycle impact of this recommendation. This should be accomplished during future project scoping work.

If the remaining structure should ever fail during a flood event, a significant future capital cost might be required to repair or remove it.

Recommendation No. 3 - - Slope Stabilization Alternatives – Schoens Dam Reservoir

Description

This recommendation describes alternatives regarding the stabilization of the landslide deposits discussed in the Draft Evaluation Report. This recommendation would be pertinent only if the County decides to pursue a larger, permanent pool behind Schoens Dam.

The V.E. Team recommends that the permanent pool elevation be lowered such that the risk of destabilizing the landslide deposits is eliminated or reduced to an acceptable level. This would avoid the need for direct efforts to stabilize the deposits. Note that "permanent pool" in this context refers to a future elevation in conjunction with the establishment of a reservoir. The Draft Evaluation Report estimated this as Elevation 5770.

Alternatively, if the higher pool elevation is required, we recommend that stabilization should be pursued only for critical areas.

In either case, Navajo County should obtain an expert opinion on slope stability, the risk of landslides, how the risk depends on pool elevation, and identification of areas prone to landslide activity.

Feasibility

The baseline concept for slope stabilization is to flatten slopes to 4 (horizontal) to 1 (vertical). The alternatives covered under this recommendation are also technically feasible, but may result in a higher risk of slope failure. The V.E. Team did not attempt to assess the relative risks. This should be done as part of the expert assessment mentioned above.

Functionality

The alternative preferred by the V.E. Team – lowering the permanent pool elevation – would provide the basic function of the baseline element (slope stabilization), and might even enhance this function given that the existing deposits would not be disturbed. The impact of this recommendation on the overall function of the Schoens Dam reservoir, however, would need to be analyzed.

Stabilization only in critical areas would provide a reduced function in comparison to the baseline, but depending on the results of the expert assessment, the function provided might well be acceptable for the intended purpose. If the resulting pool elevation were to be the same as envisioned by the baseline, then the functions associated with the reservoir would be unaffected.

Life-Cycle Cost

Either of the identified alternatives to the baseline would be likely to result in reduced construction and O&M costs. In the case of the reduced pool elevation, the cost reductions would need to be compared with the impact on the functionality and efficiency of the pool for recreation, irrigation, and flood control. The V.E. Team believes that such a tradeoff might be in the County's favor.

Recommendation No. 4 - - Reservoir Sealing Concept

Description

This recommendation describes the course of action, regarding reservoir sealing, that the V.E. Team believes would be necessary if the County decides to develop a permanent pool behind Schoens Dam. The baseline concept is to do nothing to seal the reservoir, primarily due to the high cost involved. The V.E. Team recommends an attempt to identify problem areas before filling the reservoir, and then to seal those areas using a combination of grout, geomembrane, and soil. We also recommend monitoring and evaluation of water level data to assess further the potential for seepage losses at Schoens Dam.

Feasibility

The value engineering team considers this recommendation to be technically feasible.

Functionality

The basic functions associated with the envisioned reservoir would be difficult to achieve if nothing is done to seal the reservoir, based on what is known of the geology in the area. There is a fairly high degree of uncertainty associated with the recommended concept, but the Team thinks it is essential to control seepage somehow if the County hopes to store water permanently at high levels within the reservoir. The concept presented appeared to the Team to be the most functional and cost-effective method.

Life-Cycle Cost

The recommended concept could be very expensive in regard to capital cost. Its impact on O&M costs would not be known until after the reservoir was filled and a determination made of remaining seepage quantity.

B. DESIGN SUGGESTIONS

The value engineering team did not advance the following ideas as V.E. Recommendations, but did consider them to be worthy of some further investigation:

1. Slope Stabilization - - One potential way to eliminate the danger associated with the potential instability of landslide deposits along the banks of the reservoir would be merely to restrict public access within a prescribed distance of the high-risk areas.

2. US Forest Service/Corps of Engineers Negotiation - - We suggest that the County enter into a negotiation with these agencies at its earliest convenience. This would help to set the course of action regarding Lone Pine and Schoens Dams and reduce the risk of problems appearing later in the concept and design phases of the eventual project.

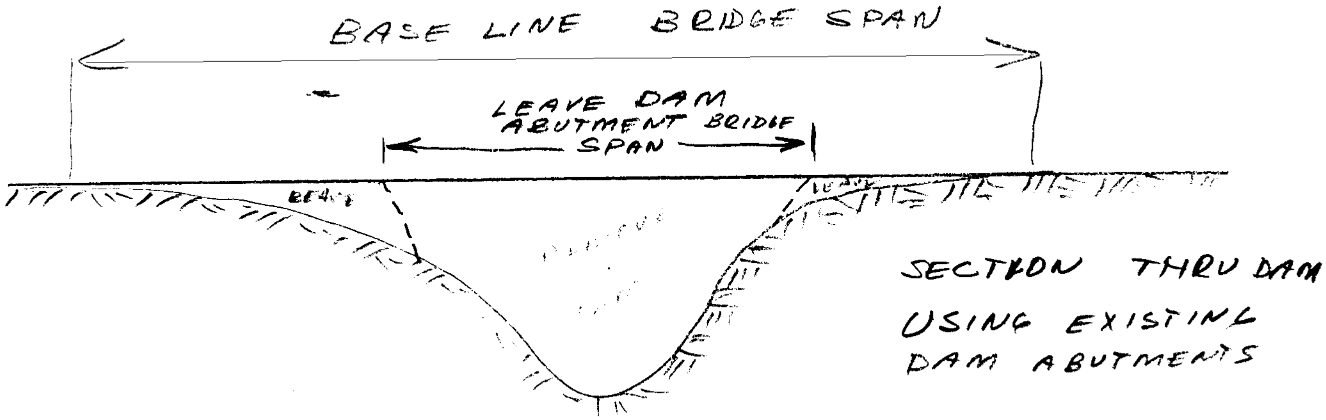
3. Pinedale Road - - We suggest that the potential impact of a Schoens Reservoir on Pinedale Road be dropped as a scope consideration. We noted during the study that land to relocate this road would likely be readily and inexpensively available should the need arise in the future.

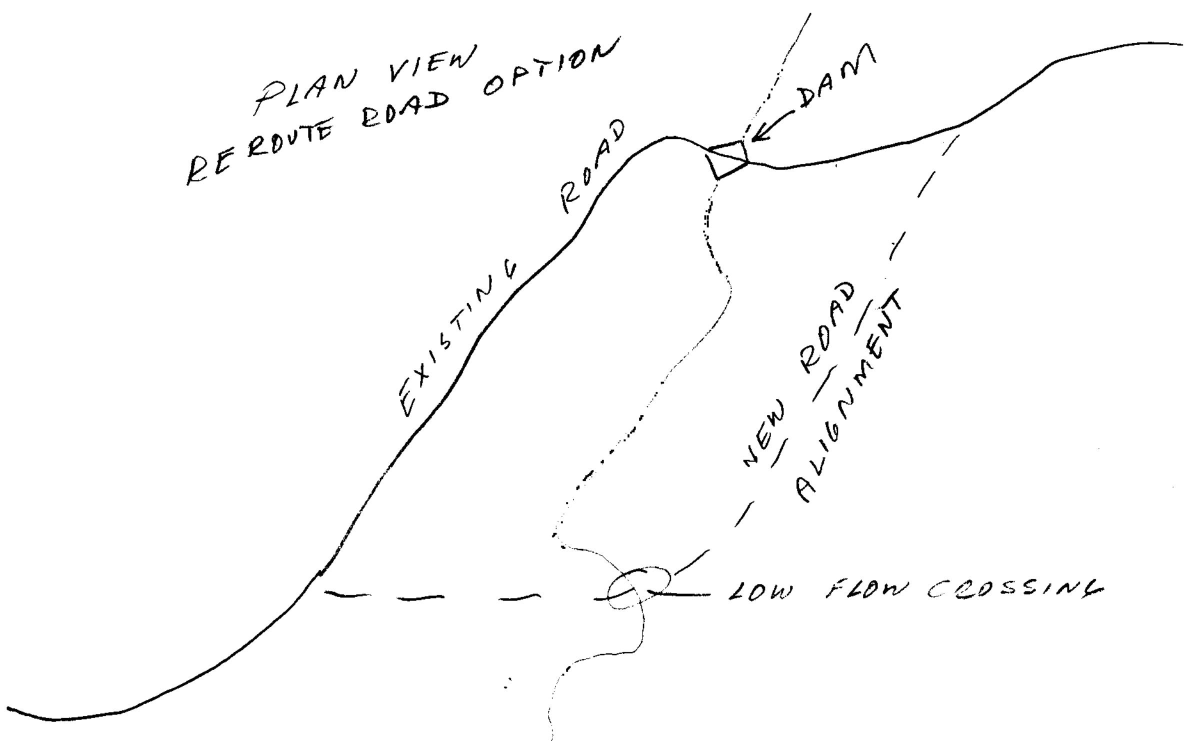
4. Spillway Outlet Erosion- Schoens - - During our field visit, the value engineering team observed existing erosion at the downstream end of this spillway, and the potential for more erosion. We suggest future consideration of this situation by the County.

5. Water Rights - - We suggest that the NAU team conduct more investigation into the impact that existing water rights would have on this project.

REC. #1

C. SKETCHES/CALCULATIONS





V.E. Study Record

PHASE ONE

"WHERE IS THE POTENTIAL FOR VALUE IMPROVEMENT?"

Value Engineering Overview

1.A. Describe Subject
1.B. Design Presentation
1.C. Personal Contacts
1.D. Documents Used
1.E. Field Trip
1.F. Element/Function/Cost/Complexity Model
1.G. FAST Diagram
1.H. Elements Selected for Analysis

Value Engineering Overview

- ✓ V = F/C (Optimize The Relationship Between *Required* Function and *Life-Cycle* Cost)
- ✓ Not "Cost Reduction" -per se (No Quotas!)
- ✓ Search For The "Second Right Answer" (Not a Peer Review, Design Review, or an Audit !!)
- ✓ A Consensus-Building, Problem-Solving Tool
- ✓ Check Agendas At The Door! (But Bring Your Creativity and Teamwork!)
- ✓ The "Big Three Questions" of Value Engineering:
    - Is It Feasible?
    - Would It Provide The Required Function?
    - Would It Have a Lower Life-Cycle Cost?
- ✓ Work Hard and Have Fun!!

P.B.V.E.

1. IDENTIFY POTENTIAL

1.A. DESCRIBE SUBJECT (Major elements, costs, complexities, problems, constraints)

The Silver Creek Watershed Advisory Committee (SCWAC) has identified concerns with the existing reservoir system along Show Low Creek. The "system" in this context includes the Lone Pine and Schoens Dams and reservoirs, as well as the reach of Show Low Creek connecting the two impoundments. SCWAC seeks to identify and fund feasible improvements to the reservoir system.

The Show Low Creek Reservoir System Evaluation and Recommendations Project includes the following Scope Tasks, as described in the Final Proposal, dated June 19, 2001:

- Task 1 - Review of Existing Studies
- Task 2 - Data Collection and Import
- Task 3 - Site Examinations
- Task 4 - Recharge Evaluations
- Task 5 - Preferred Alternative Identification and Development
- Task 6 - Value Analysis of Remedial Alternatives/Improvements
- Task 7 - Prepare Design Concepts and Construction Cost Estimates

This value study will fulfill Scope Task 6.

Scope of Value Study

The baseline for this value study will be the Preferred Alternatives for Lone Pine Dam and Schoens Dam, as developed during Scope Tasks 1-5. Alternative approaches considered during the Project will also be reviewed by the value analysis team.

Value Analysis is not "Peer Review". It is a specific problem-solving methodology intended to be an important part of the overall Project effort.

Two specific constraints to the value analysis of this project have been identified as of this writing:

- Lone Pine Dam must be removed from the ADWR Unsafe Dam List.
- Schoens Dam will not be removed.

As with all value engineering work, the Team will also be constrained by the "Big Three Questions of VE" : Would it work? Would it provide the required function? Would it have a lower life-cycle cost.? In order to make a V.E. Recommendation for project change, the V.E. Team must believe that the answers to all three are "Yes"– or would likely be so upon further analysis by the Project Team. Ideas which do not rise to this level, but in which the Team retains an interest, may be offered as Design Suggestions. All other ideas will be dropped.

1.B. DESIGN PRESENTATION

1. Presenters:

- Charles Schlinger, PE PhD, Northern Arizona University
- Jim Janecek, Northern Arizona University

2. Guest:

- Dee Johnson, Silver Creek Irrigation District

3. Significant Items Discussed:

- Project conceived in 2000/2001
- Work began in fall of 2001
- Three constraints to the Evaluation (and the VA Study):
    - Preserve Flood Control – Schoens Dam
    - Remove Lone Pine Dam From The ADWR List of Unsafe, Non-Emergency Facilities.
    - No Reservoir Improvements at Lone Pine
- First Five Tasks of Evaluation Essentially Complete. VA Study Is Task 6

- Jim Janecek presented and discussed the four alternative concepts considered for Lone Pine (No 4 is recommended) and the concept considered for Schoens:

    - 1. Reclassify Dam as Roadway Embankment with 10′ CMP's
    - 2. Construct Cutoff Wall at Dam and Enlarge Spillway ($3.5M)
    - 3. Construct Downstream Slope at Dam and Enlarge Spillway ($1.2M)
    - 4. Remove Dam and Build Bridge ($2.6M)

    - SCHOENS : Continue Grout Curtain into Abutments; Reservoir Seepage Reduction; Slope Stabilization; Spillway Improvements; Raise Pinedale Road. ($7.4M)

- Question as to whether No. 3 would work given voids in limestone; Yes
- No. 3 would not eliminate seepage, only eliminate danger to dam and move seepage downstream.
- No. 3 does not prevent sinkholes on upstream side.
- Existence of alternate pathways for seepage makes No. 3 only a moderate probability of success.
- On No. 3, the primary function of the additional slope fill is to hold seepage blanket in place, not to prevent upstream slope failure.
- Total pumping from aquifer per recent report is 25,000 acre-feet per year.
- Impact on water rights if dam is removed – needs to be determined. 13,000 acre-feet per year at Lone Pine – transferred to Schoens ? May need to increase this amount.
- Lone Pine Dam is approximately 100′ high
- Cutoff wall in No. 2 would be approximately 100′ below bottom of dam. Coconino Formation material may not be that far below dam.
- State law specifies that an embankment less than 25′ high and impounding less than 50 acre-feet, or one that is less than 6′ high for any impoundment is not a dam – consideration regarding No. 4
- Potentially a sediment trap would remain in place if dam removed.
- Schoens Dam set to pass maximum 500cfs.
- A permanent pool at Schoens could be up to elev 5477 maximum in order to maintain the 500 cfs constraint.
- Maximum flow thru Taylor and Snowflake given as 2500 cfs.

- Pinedale Road would be inundated by pool. Schoens concept includes estimate to raise the road. Note: property owner may wish to relocate onto his land.
- Inundation of Forest land may require mitigation.
- Road at Lone Pine carries approximately 200 vehicles per day – increasing. Safety across dam is not up to standard.
- ADWR has a small fund for dam repair, but Lone Pine does not rank high on the priority list.
- It was noted that there is community interest in keeping Lone Pine.
- Would removal of Lone Pine reduce total recharge? A consideration.

1.C. PERSONAL CONTACTS

A. NAME	ORGANIZATION	PHONE	NOTES
None Noted			

1. D. DOCUMENTS USED

- **Show Low Creek Reservoir System Evaluation Draft Report – 9/9,2002**
- **Silver Creek Watershed Hydrography Map**
- **Assessment of Quaternary Surficial Deposits and Undifferentiated Permian Sedimentary Rocks of Schoens Reservoir – Kirk Anderson – 7/8,2002**
- **Reconnaissance-Level Flood Control Study – Lone Pine Dam – ADWR/Dames and Moore – 7/1981 Final Report**
- **Geotechnical Investigations Report- Mogollon Project – Navajo County/ECI Engineers – 2/1994**
- **Hydrographic Survey Report for Silver Creek Watershed – ADWR – 11/30/1990**
- **Grouting Report – Schoens Dam – Navajo County/SHB Engineers – 3/1987**
- **Soil Survey – Holbrook-Show Low Area – USDA/SCS - 4/1964**
- **Schoens Dam Emergency Spillway Reconstruction – Navajo County - Report 1987**
- **Preliminary Geologic Evaluation Report – Schoens Dam – SHB – 10/1981**

1.E. FIELD TRIP

Significant Observations:

- **Lone Pine**
  - Rock fill toe - downstream side
  - No new sinkholes observed.
  - Significant head-cutting in the spillway
  - Basalt in area of spillway – potential source for rock fill
  - Spillway has dumped fill.

- **Schoens**
  - Noted prevalence in Kaibab formation outcrops in reservoir floor
  - Landslide deposits – on slopes both sides upstream
  - Pinedale Road at head of potential pool. Would need relocation or raising

1.F. ELEMENT/FUNCTION/COST/COMPLEXITY ("EF2C") MODEL

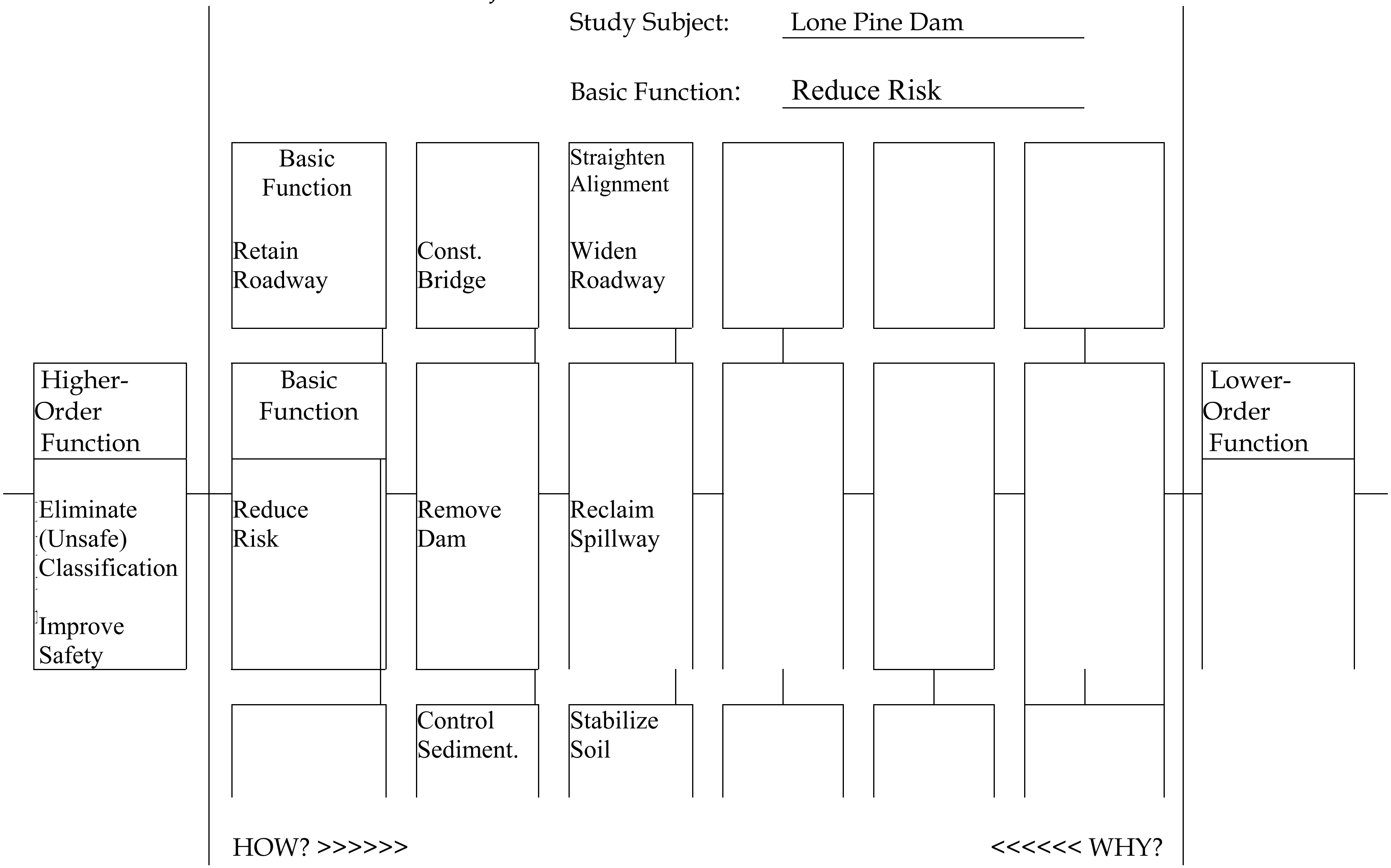
ELEMENT	FUNCTIONS	COSTS Const.	O&M	COMPLEXITY LEVEL
Dam Removal (Lone Pine)	Eliminate (Low-Water) Crossing	$570,000	-5	1
	Improve Safety			
	Satisfy Regulators			
Reclamation	Stabilize Soil	$65,000	2	1
	Control Erosion			
Stream Bed Stabilization	Control Sedimentation	$75,000	2	2
Bridge	Retain Road	$1,950,000	1	4
	Widen Road			
Approach Roadway	Improve Safety	$650,000	0	1
	Straighten Alignment			
	Widen Road			
Water Rights	Establish Feasibility	$???	0	1
Grout Curtain (Schoens)	Reduce Seepage	$310,000	0	2
	Maintain Safety			
Reservoir Sealing	Reduce Seepage	$2,600,000	5	5
	Reduce Recharge			
Slope Stabilization and Reclamation	Stabilize Landslide	$2,800,000	2	3
	Maintain Safety			

1.F Continued				
ELEMENT	**FUNCTIONS**	**COSTS** Const.	O&M	**COMPLEXITY LEVEL**
Spillway Improvement (Schoens)	Reduce Erosion	$500,000	-2	1
	Preserve Spillway			
Permitting (Schoens)	Satisfy Regulators	??	0	3
	Satisfy (Prop.) Owners			
Pinedale Road Relocation	Maintain (traffic) Circulation	$500,000	0	1
	Prevent Inundation			

1.G. F.A.S.T. DIAGRAM - OVERALL SUBJECT

Study Subject: Lone Pine Dam

Basic Function: Reduce Risk



1.H. ELEMENTS SELECTED FOR ANALYSIS

ELEMENT	SELECTION CRITERIA
Slope Stabilization and Reclamation (Schoens)	Construction cost and complexity
Dam Removal and Reclamation (Lone Pine)	Cost and functionality
Streambed Stabilization (Lone Pine)	Functionality
Bridge (Lone Pine)	Construction cost and complexity
Reservoir Sealing (Schoens)	Overall cost, functionality, complexity

NOTE: An "Element" is a portion of the whole which performs the same function(s), regardless of the method used to provide that function.

PHASE
TWO

“WHAT ELSE WILL PROVIDE THE REQUIRED FUNCTIONS?”

Another Size?
Another Shape?
Another Material?
Another Time?
Another Sequence?
Another Quantity?
Another Method?

2.A.Generate Many Ideas!

2.B. Narrowing (First Cut)

2. A/B. IDEA GENERATION RECORD/FIRST CUT

Idea Description	Score	Retain?
Slope Stabilization and Reclamation		
1. Is it absolutely necessary – what is risk?	2	Yes
2. Vegetative stabilization	1	No
3. Just take care of worst slopes	2	Yes
4. Obtain evaluation and recommendations from a pro.	5	Yes
5. Restrict access – eg buoy line	2	Yes
6. Is there a higher pool level at which the risk is acceptable?	3	Yes
7. Do nothing	1	No
8. Soil nailing – ground reinforcing	0	No
9. Take care of areas near dam	2	Yes
Reservoir Sealing		
1. Pump groundwater to offset seepage losses	1	No
2. Line with material from Lone Pine Dam removal	1	No
3. Allow it to seal through natural processes	1	No
4. Evaluate seepage losses for Schoens using water level gages	6	Yes
5. Membranes over sinkholes and fissure areas	1	No
6. Concrete grout sinkholes and fissure areas	6	Yes
7. Only line sinkhole and fissure areas	2	Yes
8. Two or more thin geomembrane layers	0	No
9. Use slope layback and LP dam removal material for liner	3	Yes
10. Build berms to limits area of recharge	2	Yes
11. Blasting to reduce permeability	0	No
12. Grout entire reservoir area	0	No
13. Use local source of bentonite (Taylor) for lining	1	No
14. Construct a perimeter seal on the Kaibab	2	Yes
Dam Removal/Bridge		
1. Don't build it (remove dam)	0	No
2. Build upstream of dam and leave dam in place	2	Yes
3. Bridge on top of dam	0	No
4. Realign road , low flow crossing , remove dam	4	Yes
5. Lower dam and leave road on dam	0	No
6. Lower and armor dam and leave road on dam	2	Yes
7. Slope flattening, widen road, lower spillway, increase capac	3	Yes

Dam Removal/Bridge (continued)

8. Divert Show Low Creek	0	No
9. Rockfill buttress dam downstream of LP dam, lower dam, lower and improve spillway	3	Yes
10. Replace earthen dam with rockfill dam	1	No
11. Utilize portions of existing dam for abutments	2	Yes
12. Use intermediate spans instead of free span	2	Yes
13. Reduce length by constructing abutment at slope change	3	Yes
14. Reduce width of bridge (baseline = 38′)	0	No
15. Lower the bridge	1	No
16. Different (shorter) location for bridge	2	Yes
17. Build bridge, leave dam in place	0	No
18. Do not remove the dam	2	Yes
19. Move excavated material to spillway and borrow pit	1	No
20. Grout foundation and downstream slope flattening	3	Yes
21. Monitoring program to address ADWR concerns	6	Yes

Streambed Stabilization

1. Construct a sacrificial berm and low flow channel -detain sediment transport during frequent floods	3	Yes
2. Construct a low permanent sediment retention structure	3	Yes
3. Create a channel to match pre-existing channel/slope	4	Yes
4. Remove all sediment	0	No
5. Bioremediation and dewater sediment	0	to No. 3
6. Riprap with rock removed from dam	1	No
7. Negotiate with USFS and USACE for well-defined scope before starting any dam removal project	3	Yes
8. Do nothing	0	No
9. Rockfill filter	1	No
10. Create wetland, with effluent from Show Low	1	No

PHASE
THREE

"WILL IT WORK?"

"WILL IT PROVIDE THE REQUIRED FUNCTIONS?"

"DOES IT HAVE A LOWER LIFE-CYCLE COST?"

3.A. Grouping
3.B. Matrix Analysis
3.C. Advantages/Disadvantages

EVALUATE FEASIBILITY

3.A. GROUPING – GROUP RETAINED IDEAS INTO CATEGORIES FOR FURTHER ANALYSIS

NO.	CATEGORY DESCRIPTION	IDEAS INCLUDED (LIST NUMBERS ONLY)
	Lone Pine (Bill, Ron, Jim S)	B 2,4,6,7,9,11.12.13,16,18,20,21
	Schoens (Charles, Jim J., Tom)	RS 4,6,7,9,10,14; SSR 1,3,4,5,6,9; SBS 1,2,3,7

3.B. IDEAS COMPARISON MATRIX (Second Cut)

Category: **Bridge/Dam 1 of 2**

Criteria: ***Key: Feasible? Functional? L.C.C.?***

A. Life-Cycle Cost

B. Feasibility (of doing and of success)

C. Chance of Repairs Needed

D. Reduction of Primary Risk – Safety Impact

E.

F.

G.

	F	E	D	C	B	A
B						Aor B?
C					B or C?	Aor C?
D				C or D?	B or D?	Aor D?
E			Dor E?	C or E?	B or E?	Aor E?
F		E or F?	Dor F?	C or F?	B or F?	A orF?
G	F or G?	Eor G?	DorG?	C or G?	B or G?	Aor G?

NOTE: Team considered all criteria equal Weight

IDEAS	G	F	E	D	C	B	A	Total	Keep?
Scores				X	X	X	X		
Weights									
2. Build bridge upstream and leave dam				3	4	4	4	15	Yes
4. Re-route road with low-flow crossing, keep dam.				4	4	5	5	18	Yes
6. Lower and armor dam – road on dam				1	2	3	4	10	No
7. Slope flattening and lower the spillway				3	3	4	5	15	Yes
9. Rock dam downstream				4	3	4	4	15	Yes
11. Reduce bridge length by using part of dam **(includes No. 13)**				5	5	5	5	20	Yes
12. Intermediate piers to reduce span				5	5	5	5	20	Yes

3.B. IDEAS COMPARISON MATRIX (Second Cut)

Category: **Bridge/Dam 2 of 2**

Criteria: ***Key: Feasible? Functional? L.C.C.?***

A. Life-Cycle Cost

B. Feasibility

C. Chance For Repair Needs

D. Reduction of Primary Risk – Safety Impact

E.

F.

G.

	F	E	D	C	B	A
B						Aor B?
C					B or C?	Aor C?
D				C or D?	B or D?	Aor D?
E			Dor E?	C or E?	B or E?	Aor E?
F		E or F?	Dor F?	C or F?	B or F?	A orF?
G	F or G?	Eor G?	DorG?	C or G?	B or G?	Aor G?

NOTE: All Criteria Equal Weight

IDEAS	G	F	E	D	C	B	A	Total	Keep?
Scores									
Weights									
16. Different, shorter, location for bridge				5	5	5	5	20	Yes
18. Do not remove dam. (included in other ideas)									No
20. Grout foundation and downstream slope flatten				4	3	4	2	13	No
21. Monitoring prog. to address ADWR concerns				3	2	5	5	15	Yes

3.B. IDEAS COMPARISON MATRIX (Second Cut)

Category: **Streambed Stabilization**

Criteria: ***Key: Feasible? Functional? L.C.C.?***

A. Negative Impacts – Downstream Stabilization

B. Capital Costs

C. O&M Costs

D. Permitting Feasibility

E. Life Span

F. Liability

G. Probability of Success

	F	E	D	C	B	A
B						Aor B?
C					B or C?	Aor C?
D				C or D?	B or D?	Aor D?
E			Dor E?	C or E?	B or E?	Aor E?
F		E or F?	Dor F?	C or F?	B or F?	A orF?
G	F or G?	Eor G?	DorG?	C or G?	B or G?	Aor G?

IDEAS	G	F	E	D	C	B	A	Total	Keep?
Scores	6	4	1	2	1	5	2		
Weights	6	4	1	2	1	5	2		
1. Construct "sacrificial" berm	12	8	2	4	3	15	4	48	Yes
2. Construct low permanent sediment-retention structure	12	8	3	2	2	10	8	45	Yes
3. Create channel to match pre-existing channel.	12	8	3	2	2	10	8	45	Yes
7. Negotiate with USFS/ACE well-defined scope	18	12	2	6	3	15	12	68	Yes

3.B. IDEAS COMPARISON MATRIX (Second Cut)

Category: **Slope Stabilization and Reclamation**

Criteria: ***Key: Feasible? Functional? L.C.C.?***

Criteria						
A. Negative Impacts – Downstream Stabilization						
B. Capital Costs						Aor B?
C. O&M Costs					B or C?	Aor C?
D. Permitting Feasibility				C or D?	B or D?	Aor D?
E. Life Span			Dor E?	C or E?	B or E?	Aor E?
F. Liability		E or F?	Dor F?	C or F?	B or F?	A orF?
G. Probability of Success	F or G?	Eor G?	DorG?	C or G?	B or G?	Aor G?

IDEAS	G	F	E	D	C	B	A	Total	Keep?
Scores	6	4	1	2	1	5	2		
Weights	6	4	1	2	1	5	2		
3. Just take care of worst slopes (critical areas) **(includes No. 9)**	12	8	2	4	1	5	4	36	Yes
4. Obtain an expert opinion of need **(includes No. 1)**	18	12	3	6	3	15	6	63	Yes
5. Restrict access	6	4	1	6	1	10	2	30	DS
6. Lower permanent pool	12	8	3	4	2	15	6	50	Yes

3.B. IDEAS COMPARISON MATRIX (Second Cut)

Category: **Reservoir Sealing**

Criteria: ***Key: Feasible? Functional? L.C.C.?***

Criteria						
A. Negative Impacts – Downstream Stabilization						
B. Capital Costs						Aor B?
C. O&M Costs					B or C?	Aor C?
D. Permitting Feasibility				C or D?	B or D?	Aor D?
E. Life Span			Dor E?	C or E?	B or E?	Aor E?
F. Liability		E or F?	Dor F?	C or F?	B or F?	A orF?
G. Probability of Success	F or G?	Eor G?	DorG?	C or G?	B or G?	Aor G?

IDEAS	G	F	E	D	C	B	A	Total	Keep?
Scores	6	4	1	2	1	5	2		
Weights	6	4	1	2	1	5	2		
4. Evaluate seepage losses at Schoens using water Level data.	12	8	2	6	3	15	6	52	Yes
6. Grout sinkholes and fissure areas **(Includes No. 7)**	12	8	3	4	2	10	6	45	Yes
9. Line entire reservoir with local materials	6	8	3	2	2	5	4	30	No
10. Build berms to limit area of recharge	6	8	2	2	1	5	2	26	No
14. Construct a perimeter seal on the Kaibab	6	8	3	2	3	5	4	31	No

3.C. THIRD CUT - LIST CATEGORIES/IDEAS, IDENTIFY ADVANTAGES AND DISADVANTAGES.

Key: Impact on Feasibility, Functionality, Life-Cycle Cost !!

CATEGORY/IDEAS	ADVANTAGES	DISADVANTAGES	RETAIN?
B2 Build bridge; leave dam	No dam removal costs	May not eliminate unsafe classification	NO
	Eliminates road collapse hazard	Spillway crossing hazard	
	Maintains existing recharge potential	Spillway improvements still required	
B4 Reroute road to low flow crossing; remove dam	Eliminates unsafe dam classification	Not necessarily an all-weather crossing	YES
	In-house engineering and construction	Low flow crossing maintenance costs	
	Reduces downstream hazards	Requires USFS approval	
	Eliminates spillway improvement costs.	Removes existing recharge potential	
	Potential lower cost than bridge		
B7 Flatten downstream slope and lower spillway	No dam removal costs	Spillway crossing hazard remains	NO
	May be least expensive alternative	May not eliminate unsafe classification	
	Maintains existing recharge potential		
B9 Rock dam downstream and lower spillway	SAME AS IDEA 7		NO
B11 Reduce bridge length	Reduce bridge and spillway improve. costs	None perceived	YES
by using dam abutments	Elim. unsafe classif.; reduces DS hazard		

3.C. THIRD CUT - LIST CATEGORIES/IDEAS, IDENTIFY ADVANTAGES AND DISADVANTAGES.

Key: Impact on Feasibility, Functionality, Life-Cycle Cost !!

CATEGORY/IDEAS	ADVANTAGES	DISADVANTAGES	RETAIN?
B12 Use piers to reduce bridge spans	(This will be determined by the design process.)		YES
B16 Different bridge location	Same as No. 11	Increased approach costs	YES
B21 Monitoring Program	Lower cost	Does not reduce risk of dam failure	DS
	Aid in taking dam of unsafe list		
	Provides early warning of possible safety problems		
SBS 1 Construct a “sacrificial” berm	No import of fill	Faster downstream sedimentation	YES
	Non-structural	Headcutting headaches	
	Saves cost compared to complete dam removal		
SBS 2 Low, permanent sediment structure	Reduces sedimentation	Higher O&M	YES
	May allow wetland		
	Additional recharge		
SBS 3 Channel to match pre-reservoir channel	Lower O&M	Uncertain lifespan	YES
	Aesthetic value	Higher complexity	

3.C. THIRD CUT - LIST CATEGORIES/IDEAS, IDENTIFY ADVANTAGES AND DISADVANTAGES.

Key: Impact on Feasibility, Functionality, Life-Cycle Cost !!

CATEGORY/IDEAS	ADVANTAGES	DISADVANTAGES	RETAIN?
SBS 7 USFS/ACE Negotiation	No surprises, clear direction	None perceived	DS
	Low cost		
SSR 3 Address only critical areas	Lower cost	Higher risk of slope failure	YES
	Reduced O&M		
SSR 4 Obtain expert opinion of need	Clearer assessment of risk	Possibly more action required	YES
	Possibly no action would be needed		
SSR 6 Lower the permanent pool	Lower cost	Less water impounded	YES
	Reduced O&M		
	Reduced permitting		
	Greater flooding control		
RS 4 Evaluate Schoens seepage losses	Better assessment of risk	Unknown delay	YES
RS 6Grout and membrane cover	Less expensive than covering entire reserv.	High cost remains	YES
For outcrop areas only	Smaller area of disturbance	Uncertainty remains	