NAU CENE 486C

Spring 2018

60% Design Report for San Simon Barrier Dam Evaluation

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批注 [1]: Page numbers should be aligned

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Table of Abbreviations

- Admin: Administrator
- ArcGIS: Aeronautical Reconnaissance Coverage Geographic Information System
- BLM: Bureau of Land Management
- C: City Importance Coefficient
- DFA: Dam Failure Analysis
- EIT: Engineering In Training
- f: Social and Environmental Impact Index
- HEC-RAS: Hydrologic Engineering Center’s River Analysis System
- h: Cultural Relics and other Factors
- I: Facility Importance Factor
- L: Human Cultural Landscape Coefficient
- l: Biological Environmental Coefficient
- NAU: Northern Arizona University
- N: Risk Population Coefficient
- PE: Practicing Engineer
- Principle: Principal Engineer
- P: Pollution Industrial Coefficient
- R: Channel Form Factor
- SSBD: San Simon Barrier Dam
- Tech: Technician

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Acknowledgments:

The San Simon Barrier Dam Engineering Team would like to acknowledge and thank the instructors of NAU's Senior Capstone course, CENE 486C, including Mark Lamer, Alarick Reiboldt, Dianne McDonnell, and Bill Mancini. The team would also like to thank Dr. Wilbert Odem for taking the time out of his schedule to accommodate the teams questions and concerns about the project. Finally, the team would like to thank the staff at the Bureau of Land Management office in Safford, Arizona for providing this project prompt and maintaining consistent communication throughout the lifecycle of the project.

1.0 Project Introduction:

The Bureau of Land Management (BLM) requested that student engineers from Northern Arizona University (NAU) conduct a Dam Failure Analysis (DFA) on the San Simon Barrier Dam (SSBD). The SSBD is located roughly four miles to the Southeast of Safford and 2.5 miles

Southeast of Solomon in the Southeast corner of Arizona. The location of Safford can be seen below in Figure 1 [1] in perspective to the rest of the state of Arizona, the dams location in reference to Safford and Solomon can be seen in Appendix A.

Figure 1. Location of Safford, AZ on map of Arizona [1]

The SSBD analysis project was requested because of a change in regional growth. When construction of the dam system first began in the 1920s with the most recent dam, the San Simon Barrier Dam, construction beginning in 1979, the towns of Solomon and Safford were relatively small with a minimal population [2,3]. As time has progressed these towns have grown, the City of Safford has grown by roughly 550% between the 1930s and 2010 [4,5]. The significant growth in a relatively short amount of time has caused concern about the Barrier Dams hazard rating and if it is still appropriate with the increase in population, and the resulting increase in economic activity. The engineering team was tasked with analyzing the effects if the dam were to fail during a peak flow as outlined in the Flood Insurance Study of Graham County [6]. This analysis was first performed by creating a basic HEC-RAS simulation of the channel to gauge expected results of a large storm event. A more complex HEC-RAS model was then constructed and run for a peak flow storm event. The results of this event were then analyzed to determine the water level over the downstream agricultural fields. These levels were then used to estimate possible economic damage.

批注 **[2]:** We are not doing this anymore are we?

This project was primarily concerned with flow data, topographic data of the area, and various files often collected by state and federal government agencies. This information is cited and referenced throughout the report when appropriate and is used for the analysis of the dam to estimate expected flows and channel dimensions.

批注 [3]: Does this fit/is it necessary?

批注 [4]: Not sure that this has to be included, the first part is our methodology and not why were doing this and the second paragraph doesnt really add much to the introduction.

2.0 Technical Considerations:

批注 [5]: completed through the alternatives

Technical Sections: These will vary by project requirements and type, however it should be noted that these sections cover the majority of the work completed for CENE 486. Detail as per your scope and deliverables. Generally these sections should be used to support any engineering decisions, objectives, and deliverables. Support should address the methods used, results obtained, and relevance/value to the project; it is expected that each technical section will be title and separated into these different categories. The report appendices should be used extensively to support this section via additional documents, calculations, testing/analysis results, images, etc…

For research based projects teams should justify the standard methods used, variables being tested/controlled, statistical analysis utilized, calibration methods, and verification methods.

2.1 Field Work:

The fieldwork for this project involved a site visit where the team also met with the client, BLM at their field office in Safford, AZ. This field visit included pictures and observations of the spillway structure and local surrounding lands. There was also a very brief survey of the dam, which was later confirmed with original construction documents.

2.1.1 Methods

The primary benefit of the field visit was to gather observation data to be used later in the analysis and contribute to the overall understanding of the project. The survey that happened during the site visit was used to gather basic geometric data of the dam, that was later corroborated by the initial construction documents. Surveying required two groups, the first, set up an auto level on the Northeast side of the spillway while the second group, found several key locations, using a leveling rod and the auto level these groups were able to determine several important dimensions of the spillway and dam structure.

批注 [6]: It is too long, Could we separate into dif sentences?

2.1.2 Results

The observations included the density of overgrowth both upstream and downstream of the spillway, as can be seen in Figure 2. The amount of sediment transfer that has occured at the site, which can be illustrated in Figure 4 and where it is evident that at least one row of baffle blocks has been buried in sediment and brush.The initial survey data can be seen below in Figure 3, with the original construction documents in Appendix B.

Figure 2: Overgrowth surrounding Spillway

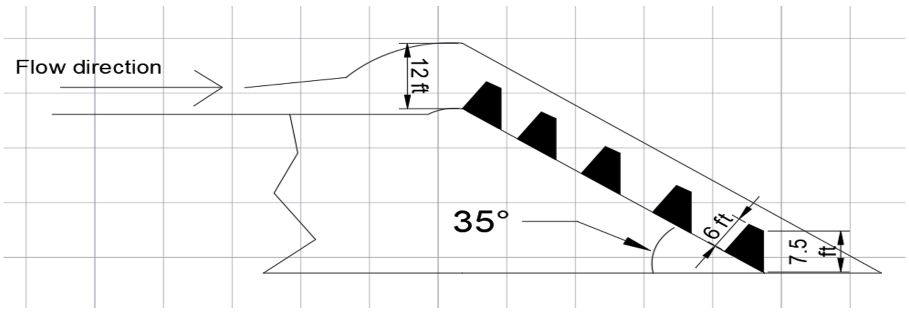

Figure 3: Groups Survey Data

Figure 4: Buried Baffle Blocks

2.1.3 Relevance

The data gathered during fieldwork was vital to understanding the system the team would be analyzing as well as allowing for models to be run of the system to estimate the extent of damage that would occur in flood conditions.

批注 [7]: seems redundant and fluffy

2.2 Testing/Analysis:

Predominate Testing/Analysis Performed: Analyses (laboratory, software, hand, etc…) that were performed. Complete detail of experimental designs/methods/procedures/raw data can be put in an Appendix, but results should be summarized in the main narrative.

2.2.1 Methods

Hydrologic Engineering Center - River Analysis System (HEC-RAS) is a one-dimensional hydraulic simulation program based on four kinds of analysis of rivers. The first being a stable flow model, next an unstable flow model, sediment transport models, and finally a water quality analysis model if necessary. It can simulate the flow of natural riverbed or human-made channels to determine the water level as its primary goal is to carry out flood studies and identify flooded areas. HEC-RAS consists of a series of programs, tools, and uses for processing georeferenced data, and teams can import geometric data into HEC-RAS. The HEC-geoRAS file collects data on the geometry of the study area, including river beds, cross-sections, waterways and more. Hydraulic calculations can obtain velocity and depth results. Finally, the program can communicate with ArcGIS for processing to create a severity index map showing locations of pooling.

2.2.2 Results:

2.2.2.1 HEC- RAS Model:

2.2.2.2 ArcGIS Results:

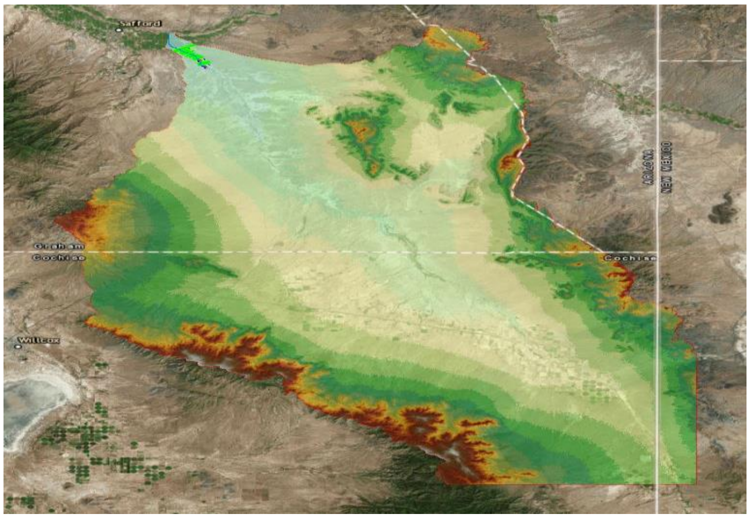

Figure 5: ArcGIS map of San Simon Basin

2.2.3 Relevance

2.3 Economic Analysis:

2.3.1 Methods

The team's approach was based on the local economic structure of the risk cost assessment methods. The costs of agricultural, residential, commercial, industrial and public property were studied in detail. The team calculate the cost-benefit ratio after a dam failure to assess the impact of the economic performance. By analyzing the peak flow rate, the team calculated the danger area of the dam failure. The risk is mainly due to the damage caused by floods to the downstream residential and agricultural land. From the perspective of the consequence loss assessment, losses can be divided into loss of life, economic loss and social and environmental losses [7]. In this project, the team is focused on economic loss rather than loss of life or social/environmental impact.

批注 **[8]:** What does his mean in laymans terms

批注 **[9]:** I thought we were focusing on Agriculture and infrastructure

批注 **[10]:** Yes you r right

批注 **[11]:** Hun?

批注 **[12]:** It is about the risk

批注 **[13]:** This Paragraph should sate that we are only concerned with economic losses not loss of life or the social/environmental impact.

2.3.1.1 Economic losses:

Economic losses include direct economic losses and indirect economic losses.

批注 [14]: Should explain what these are and their extent?

2.3.2 Results

2.3.3 Relevance

In the economic risk analysis, smaller risk comes at a price, specifically as the risk is reduced it often corresponds to a direct increase in costs. Because the reduction of the risk needs to pay the price, whether it is reducing the probability of failure through reinforcing measures or reducing the risk of loss through precautionary measures, all involve investments of human, financial and material resources. The determination of an acceptable risk criterion is a matter of resolving the issue of "what is safe before it is perceived as safe." Therefore, the following criteria should be met for accepting acceptable risk criteria (1) The principle of consistency, that is, the risk accepted by the original project and the risk of the new plan should be the same on the measured values. (2) As low as reasonably practicable. With dams, unnecessary risks cannot be accepted, but reasonable risks must be recognized, and the dangers of significant hazards should be minimized. As the project has a low risk, it is more difficult to reduce the risk. (3) Affect the controllable principle, that is, the new plan can not increase the risk of the original project and its risk impact should be controlled within a minimal range [8].

批注 [16]: Are we not trying to change the hazard rating?

3.0 Final Design Recommendations:

This section fully discusses all engineering aspects and how they have been executed to provide a final recommendation that addresses the overall objectives/needs of the project. Be sure to address all direct external impacts related to the project as part of this section. This should include:

For client based projects it should detail how you selected your final designs with full justification. Must include all alternatives considered and demonstrate how you arrived at your chosen design using results based information. This can be done with decision matrices or bimodal results. A decision matrix should completely explain/justify all weighting and ranking systems you developed.

For research based projects it should it should detail your ultimate findings and suggestions for moving forward with full justification. This must address the major testing/analysis performed, compliance to standard testing methods, and validity of results obtained.

For all projects this section will include summaries and excerpts from additional deliverables as required by your client/tech advisor/grading instructor. These items must be include as part of the final report, however detailed supporting documents should be provided in the appendices. These may include construction drawings, site plans, survey maps, analysis results tables and printouts, operations and maintenance plans, photo logs, etc…

3.1 Hazard Rating Recommendation:

The hazard ratings and their qualifying requirements can be seen below in Table 1. The results of the HEC-RAS analysis were used to create a choropleth map of the area surrounding the dam, where depth of flood water is represented by color. The choropleth map can be seen in Appendix C. It can then be seen that the fields downstream of the spillway will be covered in an average of # inches of water and the town of Solomon, (the closest population center to the dam) is expected to receive # inches of water at the deepest point. The economic losses when evaluated using the methods described in section 2.3 of this document show that on an economic basis the dams rating should be a %%%%%%. Then, with the criteria set forth by "FEMA Hazard Potential Classification Systems for Dams", stating the standard for loss of life concerns, a flood is expected to/ to not cause any concern for loss of life [9]. With these two factors in consideration the team recommends that the SSBD~~San Simone Barrier Dam~~ have a hazard rating of #######.

批注 [17]: Use terminology from FEMA

Table 1: Hazard Ratings and Qualifying Criteria [9]

Hazard Potential Classification	Loss of Human Life	Economic, Environmental, Lifeline Losses
Low	None expected	Low and generally limited to owner
Significant	None expected	Yes
High	Probable. One or more expected	Yes (but not necessary for this classification)

3.2 Economic Impact of Recommendation:

Cost of Implementing the Design (for client based projects): This section will provide a complete, detailed breakdown of costs that the client will incur in implementing the design.

3.2.1 BLM Funding Change:

The SSBD was originally given a Low hazard rating, this compared to the team recommended hazard rating of $$$$, is what determines the funding changes that can be expected by the BLM. It is expected that the BLM should/ should not receive a funding increase, with the goal of maintaining the SSBD.

This change in funding is recommended, because with the dDam having a higher hazard rating the economic damages incurred will have increased. In order to properly protect the the community downstream from these damages it is recommended that the funding for maintenance of this dam is increased.

The funding should not be changed because there does not appear to be an increase protection concerns. Meaning that the current funding for maintenance of the structure if spent appropriately should prove to be sufficient to maintain the dams integrity.

批注 [18]: Use whichever of these is appropriate after analysis.

3.2.2 Economic Risk to Community:

3.3 Statistical Analysis:

Statistical Analysis (for research based project): This section must provide significant statistical evaluation supporting and justifying your conclusion/recommendations/findings indicating that they are relevant and functional.

4.0 Summary of Engineering Work:

Refer to your proposal and summarize how the project was carried out in regards to changes in scope and schedule, why these changes happened, and how they affected your project.

4.1 Expected Results Change:

(Flood conditions are not significant to cause concern)

4.1.1 Changes Cause:

4.1.2 Scope Changes:

4.1.3 Schedule Changes:

4.1.3.1 Gantt Chart Changes:

The Gantt chart has changed because of changes in the plan and different work reports. At various times, the teams will report and summarize existing work. However, the final project end time will not be changed.The Gantt charts described can be found in Appendix D and E respectively.

批注 **[19]:** This Needs to be explained and expanded after the project is completed

批注 **[20]:** Agree,

批注 **[21]:** When I writing these, I was confused by the so many change of the section lol. So I divided all the content into some subsections.

4.1.4 Effects of Changes:

Changes to the plan will not affect the overall project. The team will make different arrangements to achieve the most efficient operation. That will improve the utilization of time so that the project can be completed on time or ahead of schedule.

批注 **[22]:** What hardships/solutions were encountered

批注 **[23]:** we can talk about how project went from dam breach analysis to flood event analysis of channel only, and how we went from trying to find 100 & 500 yr storm flows to settling on our peak flow from construction documents.

5.0 Summary of Engineering Costs:

The cost of the San Simon Dam Breach Analysis project includes variable costs as well as fixed costs, while keeping in mind industry-specific rates for the jobs. This is be provided in the table below as well as a combination of the total costs. Fixed costs are constant and do not depend on output or activity levels. Variable costs are the costs that vary with the volume of production in total costs. The project only needs to provide dam failure analysis and support data collection, not including dam reconstruction and restoration work.

5.1 Changes to Staffing:

5.1.1 Original Staffing Estimate:

The San Simon DBA project began in the Fall 2017 semester and concluded at the end of the school year in the Spring of 2018. The staffing for this project was vital for its completion. This staffing is based off of the overall expected needs of the project and the expected work required. The original staffing estimates can be seen in Appendix E.

5.1.2 Actual Staffing Requirement:

批注 **[24]:** Probably needs more after we complete the work.

批注 **[25]:** Yes

As the San Simon DBA project progressed from the conceptual stage to the analysis stage, the project developed and staffing changes occured. These staffing changes came from an increase in research time, and changes in the expected outcome of the analysis. These changes in workload, can clearly be seen in the Actual Required Staffing table in Appendix F.

5.2 Changes to Costs:

5.2.1 Original Costs Estimate:

The San Simon DBA project cost have been estimated using the industry rates for given positions. This will be provided in Table 1, as well as a composite of total costs. The costs include the services cost and hardware cost, and are dependent on the Original Staffing hours which is discussed above in section 5.1.1. This project is only required to provide the dam breach analysis, and supporting data collection.

Table 2: Estimated Staffing Costs Break Down

	Cost Per Hour	Estimated #of Hours	Estimated Cost For Project
Principle	$92.75	137	$12,706.75
Manager	$95.50	27	$2,578.50
PE	$69.75	86	$5,998.50
EIT	$50.50	62	$3,131.00
Drafter	$37.75	19	$717.25
Intern	$22.50	60	$1,350.00
Survey	$41.25	140	$5,775.00
Tech	$41.25	52	$2,145.00
Admin	$35.50	1	$35.50

Total:	$34,437.50

The team has estimated that for the foreseen circumstances the total project engineering costs was expected to be $34,437.50. In preparation for non-engineering costs that were not calculated in this proposal as well has possible unforeseen circumstances a multiplier of 1.5 was applied to this estimate. Leaving the final proposed cost to be $51,656.25.

5.2.2 Actual Costs Incurred:

The actual cost of engineering work for this project varied from the original estimate. The changes in personnel costs can be seen below in Table 2. With these changes the total engineering costs totals $######. This final cost is less than/greater than the initial proposed cost of $51,656.25 this leads to $### in savings/additional costs over the initial estimate..

Table 3: Actual Staffing Costs Break Down

	Cost Per Hour	Actual # of Hours	Actual Cost For Project
Principle	$92.75		
Manager	$95.50		
PE	$69.75		
EIT	$50.50		
Drafter	$37.75		
Intern	$22.50		
Survey	$41.25		
Tech	$41.25		

Admin	$35.50		
		Total:	

5.3 Causes for changes to Staffing and Costs:

The majority of cost changes came from changes in staffing needs. The reasons for staffing changes are discussed above in section 5.1.2. The cost changes in hours can be seen below in Table 4. Table 4 also illustrates the cost changes associated with the staffing changes.

Table 4: Estimated vs. Actual Staffing Hours

Position:	**Estimated # of Hours:**	**Actual # of Hours:**	**Cost Change for Project:**
Principle	137		
Manager	27		
PE	86		
EIT	62		
Drafter	19		
Intern	60		
Survey	140		
Tech	52		
Admin	1		
		Total:	

批注 **[26]:** Move to section 5.2.2 ?

6.0 Conclusion:

批注 **[27]:** Dont break up into subsections

Provide a conclusion that outlines the finality of the project and capacity of the results to meet the original objectives. Be specific, clearly identifying the objectives and whether or not the project has met them.

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7.0 References:

1. Google Maps. [Online]. Available: https://www.google.com/maps/@32.7999373,-109.6429961,9967m/data=!3m1!1e3?hl=en&authuser=0. [Accessed: 23-Feb-2018].
2. "San Simon Erosion Control Structures." BLM Office, Safford.
3. G. E. Baier, "San Simon Barrier Structure General Plan Sheet." Stafford District, Stafford, May-1979.
4. "Safford, Arizona," Wikipedia, 23-Feb-2018. [Online]. Available: https://en.wikipedia.org/wiki/Safford,_Arizona. [Accessed: 23-Feb-2018].
5. Arizona Department of Commerce Communications Division, Safford Community Profile. Phoenix, Az: Arizona Department of Commerce, 2008.
6. Federal Emergency Management Agency, Flood Insurance Study Graham County, Arizona and Incorporated Areas. United States of America, 2007.
7. Whatever document We got the Social Environmental Impact Index or the info for 2.3.1
8. Citations For Section 2.3.3
9. Federal guidelines for dam safety: hazard potential classification system for dams. Washington, D.C., Az: U.S. Dept. of Homeland Security, Federal Emergency Management Agency, 2004, pp. 5–6.
10. G. E. Baier, "Typical Reinforced Concrete Chute x-Station Details." Stafford District, Stafford, May-1979.

批注 **[28]:** IEEE format

批注 **[29]:** Needs to be cited!!

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8.0 Appendices:

Appendix A: SSBD location in relation to Safford AZ

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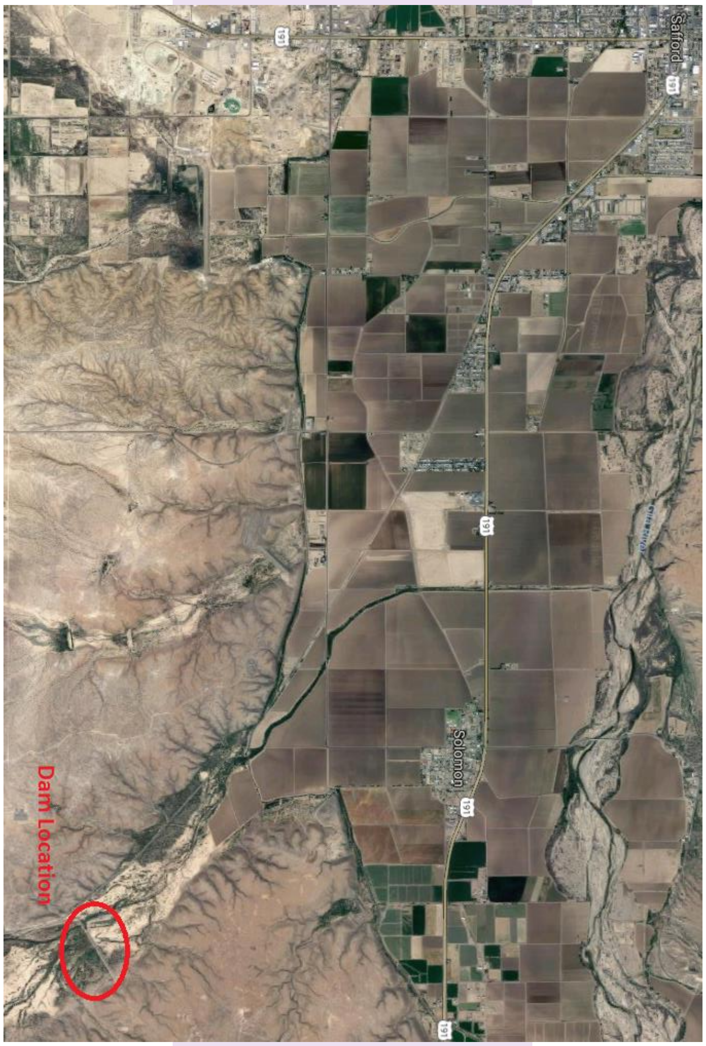
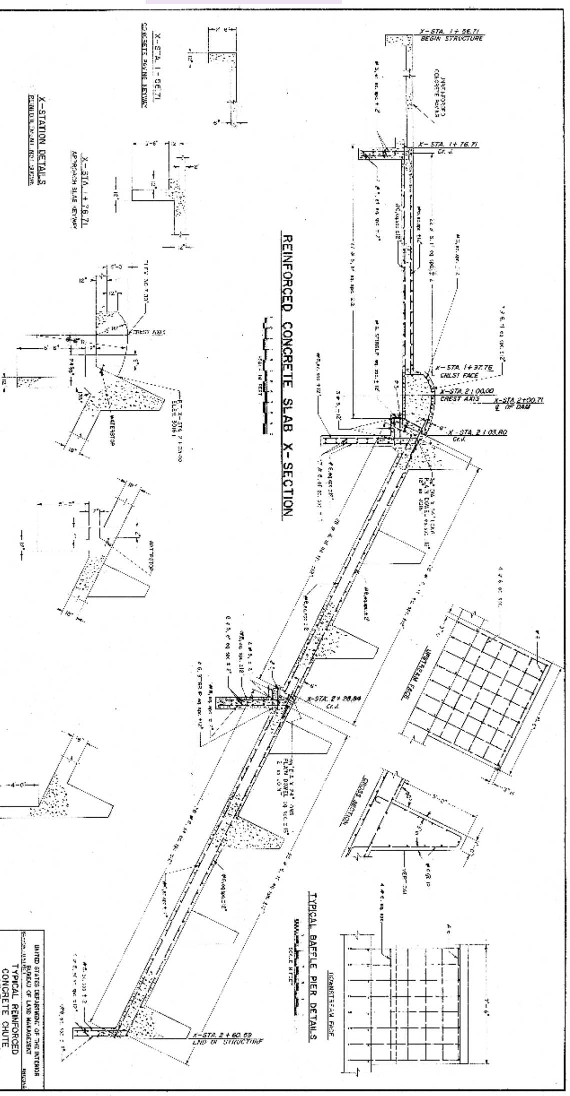


Appendix B: Original Construction Drawings of the Spillway Structure [10]


REINFORCED CONCRETE SLAB X-SECTION
TYPICAL BAFFLE PIER DETAILS
X-STATION DETAILS
TYPICAL REINFORCED CONCRETE CHUTE

Appendix C: Choropleth Map of Flood Area

批注 [30]: We probably don't need to include appendices until our final submittal unless they are needed for whats written in the document.

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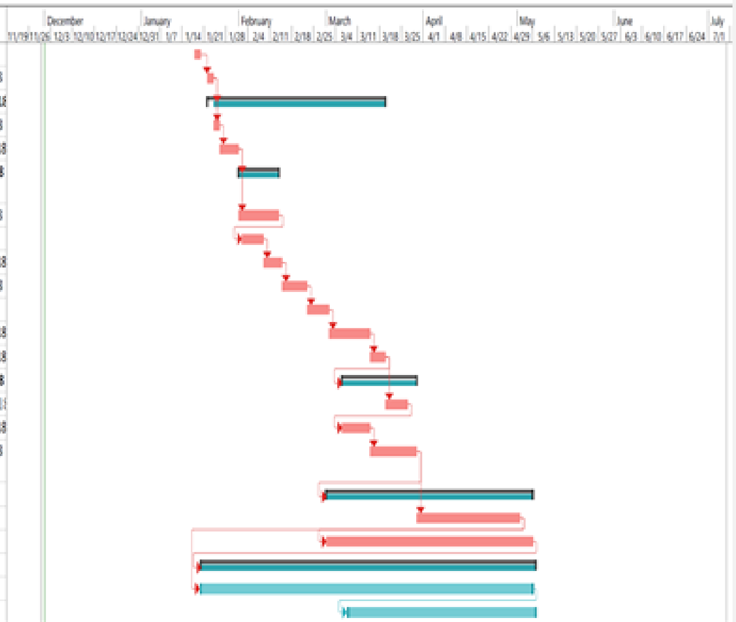
Appendix D: Original Gantt Chart

批注 [31]: This is a bit blurry

ID	Task Name	Duration	Start	Finish
1	**Field Investigation**	2 days	Thu 1/18/18	Fri 1/19/18
2	**Hydrology**	2 days	Mon 1/22/18	Tue 1/23/18
3	**Hydraulic Analysis**	**41 days**	**Mon 1/22/18**	**Mon 3/19/18**
4	Geometric Parameters	2 days	Wed 1/24/18	Thu 1/25/18
5	Routing and Reservoir Effect	4 days	Fri 1/26/18	Wed 1/31/18
6	Dam Breach Failure Method and Parameters	**9 days**	**Thu 2/1/18**	**Tue 2/13/18**
7	Piping Failure	9 days	Thu 2/1/18	Tue 2/13/18
8	Overtopping Failure	5 days	Fri 2/2/18	Thu 2/8/18
9	Peak Flow Estimation	4 days	Fri 2/9/18	Wed 2/14/18
10	Steady Flow Analysis	6 days	Thu 2/15/18	Thu 2/22/18
11	Unsteady Flow Analysis	5 days	Fri 2/23/18	Thu 3/1/18
12	Sediment Transport Analysis	9 days	Fri 3/2/18	Wed 3/14/18
13	Flood Map - Severity Index	3 days	Thu 3/15/18	Mon 3/19/18
14	**Socio-Economic Impacts**	**18 days**	**Tue 3/6/18**	**Thu 3/29/18**
15	Define Flood Concern Area	5 days	Tue 3/20/18	Mon 3/26/18
16	Considered Loss sources	7 days	Tue 3/6/18	Wed 3/14/18
17	Map of AO including Districts and types of Structures	11 days	Thu 3/15/18	Thu 3/29/18
18	**Project Deliverables**	**48 days**	**Thu 3/1/18**	**Sat 5/5/18**
19	DBA report	23 days	Fri 3/30/18	Tue 5/1/18
20	Presentations	48 days	Thu 3/1/18	Sat 5/5/18
21	**Project Management**	**77 days**	**Sat 1/20/18**	**Sun 5/6/18**
22	Meetings	77 days	Sat 1/20/18	Sat 5/5/18
23	Website	43 days	Thu 3/8/18	Sun 5/6/18



Appendix E: Updated Gantt Chart

Appendix F: Original Staffing Estimation

	Staff (hrs.)									Task
Task	Principle	Manager	PE	EIT	Drafter	Intern	Survey	Tech	Admin	Total
Research DBA	2	0	0	2	0	6	0	0	0	10
Research Arizona Dam Regulations	2	0	0	2	0	12	0	0	0	16
Rainfall Data	1	0	1	3	0	6	0	0	0	11
Section Topography of area	3	0	2	3	0	6	24	0	0	38
Channel Shape Analysis	2	0	2	3	0	6	12	0	0	25
Topo Map of Stafford and Dam Area	3	0	2	1	0	3	24	0	0	33
Geometric Models of Channel	25	0	12	6	0	0	12	6	0	61
Set Up Model of Main Channel	25	0	12	2	0	0	0	12	0	51
Set up Model of Floodplain	25	0	12	2	0	0	0	12	0	51
Run Hec Ras Analysis	10	0	6	1	0	0	0	10	0	27
Define Flood Concern Area	3	0	2	1	0	2	6	0	0	14
Meetings to confirm Plan of Progression	1	1	1	1	1	1	1	1	1	9
List of Possible Considerations	3	0	2	2	0	2	0	0	0	9

Average Costs Associated With properties	2	0	2	2	0	6	0	0	0	12
Map of AO including districts and types of structures	3	0	3	6	6	2	12	0	0	32
Final Report and Submittal	3	2	3	1	12	2	1	1	0	25
Site Visit	24	24	24	24	0	6	48	10	0	160
Staff Total	137	27	86	62	19	60	140	52	1	584

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Appendix G: Actual Staffing Requirement Staffing

	Staff (hrs.)									Task Total
Task	Principle	Manager	PE	EIT	Drafter	Intern	Survey	Tech	Admin	
Research DBA										
Research Arizona Dam Regulations										
Rainfall Data										
Section Topography of area										
Channel Shape Analysis										
Topo Map of Stafford and Dam Area										
Geometric Models of Channel										
Set Up Model of Main Channel										
Set up Model of Floodplain										
Run Hec Ras Analysis										
Define Flood Concern Area										
Meetings to confirm Plan of Progression										
List of Possible Considerations										

Average Costs Associated With properties										
Map of AO including districts and types of structures										
Final Report and Submittal										
Site Visit										
Staff Total										