STUDENT SUMMER INTERNSHIP TECHNICAL REPORT

2D Dam-Break Analysis of L Lake and PAR Pond Dams Using HEC-RAS

DOE-FIU SCIENCE & TECHNOLOGY WORKFORCE DEVELOPMENT PROGRAM

Date submitted:
December 20, 2019

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Florida International University:
Ravi Gudavalli Ph.D. Program Manager
Leonel Lagos Ph.D., PMP® Program Director

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Office of Environmental Management
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ABSTRACT

The Savannah River Site (SRS) has two high hazard dams, the Steel Creek Dam and the PAR Pond Dam. Because of this classification steps must be taken to prepare in the event of a dam breach. In 1991 Bechtel Savannah River Inc. preformed a dam break analysis under Probable Maximum Flood (PMF) and a fair-weather condition. However, no inundation maps were produced from the study. Moreover, newer modeling programs have better output capabilities such as time series animations. The goal of this project was to take the previous data used in the original study to develop inundation maps needed for emergency response. From the new results it was shown that all roads downstream of the dams will be overtopped in the event of a breach. While the visual results of this project are adequate, further refinement of the model is needed to improve numerical results.
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1. INTRODUCTION

In 1991 a dam-break study was conducted for the high hazard dams located at L Lake and PAR Pond on the Savannah River Site (Bechtel 1991). Two scenarios were considered, overtopping from a Probable Maximum Flood (PMF), and a fair-weather dam-break for either or both dams. Unfortunately, no inundation map was developed from the study. The purpose of this project was to redo the original dam-break study with improved data and methodology to generate inundation maps to assist with emergency response and evacuation plans.

The program used in the original study DamBRK, which was developed by the National Weather Service, is no longer supported. The Hydrologic Engineering Center’s River Analysis System (HEC-RAS) is a free to download river analysis modeling program developed by the US Army Corps of Engineers capable of 1D and 2D hydraulic calculations. Version 5.0.7 (released March 2019) was used for this project.
2. EXECUTIVE SUMMARY

This research work has been supported by the DOE-FIU Science & Technology Workforce Initiative, an innovative program developed by the US Department of Energy’s Environmental Management (DOE-EM) and Florida International University’s Applied Research Center (FIU-ARC). During the summer of 2019, a DOE Fellow intern Amanda Yancoskie spent 10 weeks doing a summer internship at the Savannah River Site under the supervision and guidance of Dr. Grace Maze. The intern’s project was initiated on May 28, 2019, and continued through August 1, 2019 with the objective of developing inundation maps in the event of a failure of the high hazard dams located on site.
3. RESEARCH DESCRIPTION

1/3 arc-second (10m) digital elevation models (DEM) for the area were retrieved from the US Geological Survey National Map download client. The original cross-section data from the 1991 study was incomplete; files were missing, and some cross section were synthesized. While DEM data does not contain bathymetry values, for this study it is not critical since the stream bed is relatively shallow and an extreme high flow scenario is being considered, making the bathymetry negligible.

The DEM data is input into HEC-RAS Mapper module and converted into an HDF file (Figure 1). Then, the perimeter of the 2D flood area and 1D storage areas were drawn (outlined in blue) based off the plotted contours (Figure 2). A 2D flood area was used because of the size of the flood basin, elevation range, the flood waves potential to back flow into upstream tributaries, and data availability (US Army Corps, 2016a). No land use layer was input into the program so a single friction (Manning’s n) coefficient (0.07) was used throughout the 2D area. This lower value used results in a lower resistance to flows resulting in an increased downstream velocity (Bechtel 1991). The grid for the 2D flood basin was generated from 250x250 ft cells. A finer grid resolution was not possible because of the size of the flood basin and the computational limits of HEC-RAS. Both L Lake and PAR Pond were input as 1D storage areas because the DEM do not contain elevation values below the water surfaces. An elevation vs volume curve was available and used for both storage areas (Table 3, Table 4).

Figure 1: Terrain (ft) After Being Converted from a DEM to An HDF File
The majority of dams that have failed have been earthen dams (US Army Corps, 2014). The two dams on site, Steel Creek Dam and PAR Pond Dam, are earthen dams and are considered high hazard based on the Federal Energy Regulatory Commission (FERC) federal guidelines for dam safety (2004).
The dams are input as storage area/2D area connections using simplified dam geometric data (Table 7). In the connection data editor, only the dam’s cross-section is displayed (Figure 3, Figure 4) The Steel Creek Dam at L Lake has 6 ft diameter conduit with an upper and lower sluice gate. PAR Pond Dam consists of a weir connected to an 8x8 ft channel. Both outlets were modeled with a pool elevation vs discharge curve (Table 5, Table 6). The Steel Creek Dam sluice gates were assumed to be fully open in all cases.

As in the previous study, the dams were set to breach when they were overtopped by 1.5 ft during PMF conditions (Figure 5). A fair-weather breach was set to be due to a piping failure (Figure 6). In the dual dam break during fair weather conditions the PAR Pond Dam is set to fail 3 hours after the Steel Creek Dam to achieve maximum flooding potential in the downstream reaches.
Flow data was taken directly from the 1991 study (Bechtel 1991). Inflow hydrographs for L Lake and PAR Pond found in appendix A (Table 1, Table 2). Flow for the upstream part of the Savanah River was set at 87,100 cfs for the PMF simulation and 9,000 cfs for the fair-weather simulations. For the fair-weather simulations, the initial water levels in the storage areas were set to their respective normal operating pools (Table 7). For the PMF simulation the initial water surface elevation was assumed to be 2 feet above the normal operating pools.

For details regarding the specific hydraulic methodologies HEC-RAS uses please refer to the Hydraulic Reference Manual (2016b).
4. RESULTS AND ANALYSIS

Figure 7: Maximum Depth (ft) During PMF Conditions.
Figure 8: Maximum Depth (ft) During Fair-Weather Conditions with Both Dams Failing
Figure 9: Maximum Depth (ft) During Fair-Weather Conditions with Only Steel Creek Dam Failing
Figure 10: Maximum Depth (Ft) During Fair-Weather Conditions with Only PAR Pond Dam Failing
5. CONCLUSION

Maximum flooding occurs under PMF conditions with the failure of both dams (Figure 7). PAR Pond Dam fails first, 16 hours and 32 minutes after the start of the simulation with the Steel Creek Dam failing 6 minutes later. In all cases, the bridges and roads spanning Steel Creek and Lower Three Runs will be inundated and potentially washed away. The Burtons Ferry Highway south of the storage areas will be partially flooded during PMF dam failure, dual dam fair-weather failure, and PAR pond dam failure under fair weather conditions.

Possible future work would include adding bathometric data to current model, developing a Manning’s n layer, preforming a sensitivity analysis on higher vs lower Manning’s n values, and a contaminant transport analysis.
6. REFERENCES


APPENDIX A.

Table 1: Inflow Data for L Lake

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Figure 11: PMF Inflow Hydrograph to L Lake Reservoir
Table 2: Inflow Data for PAR Pond

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Figure 12: PMF Inflow Flood Hydrograph to PAR Pond Reservoir
Table 3: Elevation vs Volume Curve Values for L Lake

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Figure 13: Elevation vs Volume Curve for L Lake

Table 4: Elevation vs Volume Curve Values for PAR Pond

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Figure 14: Elevation vs Volume Curve for PAR Pond

Table 5: Steel Creek Dam Outlet Rating Curve Values

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Figure 15: Steel Creek Dam Outlet Rating Curve - Fully Open
Table 6: PAR Pond Dam Outlet Rating Curve Values

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Figure 16: PAR Pond Dam Outlet Rating Curve

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### Table 8: Breach Parameters for L Lake and PAR Pond Dams

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