State of Hawaii
DEPARTMENT OF LAND AND NATURAL RESOURCES
Engineering Division
Honolulu, Hawaii 96813

July 23, 2021

Board of Land and Natural Resources
State of Hawaii
Honolulu, Hawaii

Request Approval of Variance of Hawaii Administrative Rules Title 13, Subtitle 7, Chapter 190.1, Section 13-190.1-4 (3); Spillway constructed in natural ground, for Huinawai Reservoir (KA-0104), Kauai.

Dam Owners:	McBryde Resources, Inc. Mr. Dan Sargent, Vice President/Manager P.O. Box 8 Eleele, HI 96705
	Alexander and Baldwin, Inc Mr. Jerrod Schreck, Senior Vice President Land Stewardship 822 Bishop Street Honolulu, HI 96813
Location:	Lawai, Kauai
Tax Map Key:	(4) 2-5-010:043

Background on Variance Request

Huinawai Reservoir was constructed in 1902 as an irrigation reservoir. Currently, it serves the McBryde Lawai agricultural lands and also supplies non-potable water to the National Botanical Gardens and Kuku'iula development.

Huinawai Dam is classified as a high hazard potential dam, as a failure of the dam will result in probable loss of human life. In February 2021, a hydrologic and hydraulic analysis was completed by Kleinschmidt Associates. The report indicates that the existing spillway is not able to pass the required flood event, the probable maximum flood (PMF), with adequate freeboard. The existing spillway may also be susceptible to erosion due to the anticipated high flow velocities in the spillway during the PMF.

The owners are working on a design to improve the spillway, however the site topography and the increased spillway channel width required for the dam to meet minimum safety requirements results in the proposed spillway extending into the manmade embankment. Designing a spillway over the manmade embankment portion of the dam is not desired as it introduces additional potential failure modes. Therefore, the Department's Dam Safety Administrative Rules minimum design requirements for regulated dams stipulates that earthen spillways be constructed in natural ground.

The extent of spillway foundation and limits of the existing dam embankment are difficult to identify as there are no-preconstruction maps or as-built drawings. However, the conceptual spillway is proposed to be located at the same location as the existing spillway but will require excavation of a portion of the embankment.

Although this proposed spillway design does not meet the Department's minimum design requirements, dam safety mitigative features will be required to be incorporated into the new spillway design to address dam safety concerns and minimize risks.

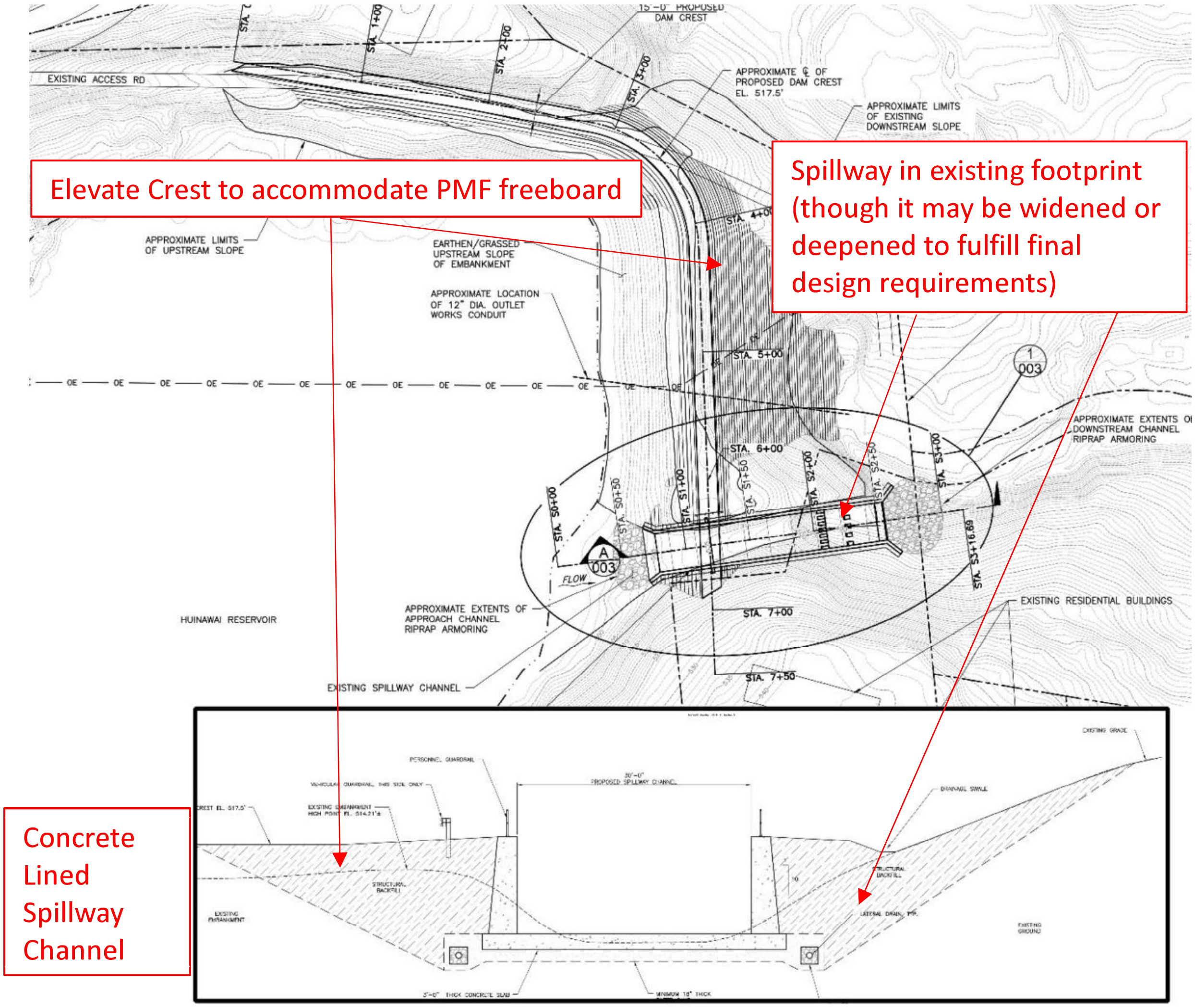
Therefore, a variance is being requested to allow the spillway design to encroach into the existing dam embankment. The conceptual design of the spillway has been developed by the owner's engineer to help visualize the anticipated scope and extent of the proposed spillway at the dam site.

Conceptual Design Overview

The conceptual design is a concrete channel spillway constructed in the same location as the existing spillway, as shown in Figure 1. The conceptual spillway design includes a dam raise, ranging from 1.5 to 5.5 feet due to the uneven embankment crest. The dam raise accommodates additional storage in the reservoir during rain events, allowing for a spillway with similar dimensions as the existing spillway to pass the PMF event with adequate freeboard, reducing the risk of failure of the structure.

The final spillway channel design improvements would be required to be submitted to the department for approval and would be reviewed by the dam safety program to ensure that current standards of practice and mitigative design features are incorporated to minimize the potential of spillway incidents or failures.

Figure 1. Key elements of Conceptual Design for remediation to Huinawai Reservoir



<u>Legal Authority</u>

HRS Chapter 179D- 6(b) 1-6 General Powers and duties of the board of land and natural resources

§179D-6 General powers and duties of the board of land and natural resources.

(b) The board shall administer the dam and reservoir safety program established by this chapter. In carrying out this chapter, the board shall cooperate, advise, consult, contract, and enter into cooperative agreements with the United States government or any of its agencies, other state agencies, and the county governments or any of their agencies. In the performance of its duties, the board shall:

(1) Establish by rules adopted under chapter 91, policies, requirements, or standards governing the design, construction, operation, maintenance, enlargement, alteration, repair, removal, and inspection of dams, reservoirs, and appurtenant works for the protection of life and property from structural failure of dams and reservoirs;

(5) Require the owners to apply for, and obtain from the board written approval of plans and specifications on the construction of any new dam or reservoir or the enlargement of any dam or reservoir prior to commencement of any work;

(6) Require the owners to file an application and secure the written approval of the board before commencing the repair, alteration, or removal of a dam or reservoir, including the alteration or removal of a dam or reservoir so that it no longer constitutes a dam or reservoir as defined in this chapter. Repairs shall not be deemed to apply to routine maintenance not affecting the safety of the structure;

Hawaii Administrative Rules Title 13 Chapter 190.1, Section 4(3)

§13-190.1-4 <u>**Minimum design requirements.**</u> <u>**(a)**</u> **Regulated dams and reservoirs shall incorporate the following minimum design requirements:**

(1) Embankment slopes that are not steeper than 2.5 horizontal to 1 vertical unless a specific design for a steeper slope shows that the embankment is stable and capable of being safely maintained;
(2) An embankment crest that has a minimum width of ten feet;
(3) Earthen spillways that are constructed in natural ground; and
(4) A low-level outlet shall be designed to drain the reservoir by gravity flow.

Recommendations

That the Board of Land and Natural Resources approve the following:

1. Authorize a Variance of Hawaii Administrative Rules Title 13, Subtitle 7, Chapter 190.1, Section 13-190.1-4 (3) for spillway improvements to the Huinawai Reservoir (KA-0104) on the island of Kauai.

2. Authorize the dam safety program staff to work with the owner on the extent and application of the approved variance.

Respectfully submitted,

CARTY S. CHANG
Chief Engineer

APPROVED FOR SUBMITTAL:

Suzanne D. Case

SUZANNE D. CASE, Chairperson
Board of Land and Natural Resources

ATTACHMENTS:

A. Huinawai Reservoir Conceptual Level Spillway Design, Dated June 2021

HUINAWAI RESERVOIR CONCEPTUAL LEVEL SPILLWAY DESIGN

HUINAWAI RESERVOIR

HI# KA-0104, NATDAM HI00104

Prepared for:

McBryde Resources, Inc.
Kauai, Hawaii

Prepared by:

Kleinschmidt Associates

June 2021

Kleinschmidt

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1.0 INTRODUCTION

The Huinawai Dam is owned and operated by McBryde Resources, Inc. (McBryde), and located in the town of Lawai on the island of Kauai, Hawaii. The dam impounds the Huinawai Reservoir. Based on the Department of Land and Natural Resources (DLNR) 2016 inspection, Huinawai has documented deficiencies that need addressing or further study (DLNR 2017).

The 2017 DLNR report identified deficiency No. 6, "Perform hydrologic and hydraulic studies. This study should be performed to determine if the existing spillway is capable of passing the inflow design flood and if the unlined portions of the spillway may be subject to significant erosion." (DLNR 2017). The hydrologic and hydraulic analysis were completed in 2021 and the results are presented in Kleinschmidt's Hydrologic and Hydraulic Analysis report, dated February 2021. The existing spillway at Huinawai Reservoir was determined to not be able to pass the probable maximum flood (PMF), which is equal to the inflow design flood (IDF), and meet the DLNR freeboard requirements. The existing spillway is also susceptible to erosion due to the anticipated flow velocities in the spillway during the PMF event. The conceptual spillway design presented in this report addresses the spillway capacity and high velocities during the PMF event.

The hydraulic model and project drawings utilize the NAVD88 datum (Orthometric based on CORS and Geoid12B) as provided in the Digital Elevation Model (DEM) from the surveyor (Dudek 2020). References to the left and right are for a viewer looking downstream.

2.0 PROJECT OVERVIEW AND PURPOSE

2.1 Project Overview

The Huinawai Reservoir is an irrigation reservoir formed by the Huinawai Dam. The dam is an embankment structure that is approximately 335 feet long and 48 feet high. The dam has an uncontrolled, overflow earthen spillway on the right (south) end of its crest. The spillway is approximately 35 feet wide at the upstream end, which reduces to approximately 20 feet at the end of the rock armored section at its terminus. The spillway has a crest elevation of approximately 506.3 feet, normal pool elevation is 498.5 feet, and the embankment dam crest elevation is approximately 514.0 feet on average however ranges from about elevation 512 to 516 feet. Two outlet conduits, one 12 inches in diameter and the other 18 inches in diameter, control normal flows out of the Huinawai Reservoir and extend east through the dam and south through an old irrigation tunnel to the upstream end of Aepo Reservoir. The reservoir is approximately 7.9 acres in area with an impoundment volume of 75 acre-feet at normal pool elevation. The drainage area of the dam is approximately 0.32 square miles. Flow through the earthen spillway discharges off an approximately 12- to 15-foot-tall drop into an unlined, irregularly shaped channel that rejoins the natural stream approximately 20 feet downstream of the drop off (LFR 2007). The Hanini Reservoir and dam are located approximately 0.25 miles upstream of Huinawai Reservoir within the Huinawai watershed. The location of the Huinawai and Hanini Reservoirs are shown in Figure 2-1.

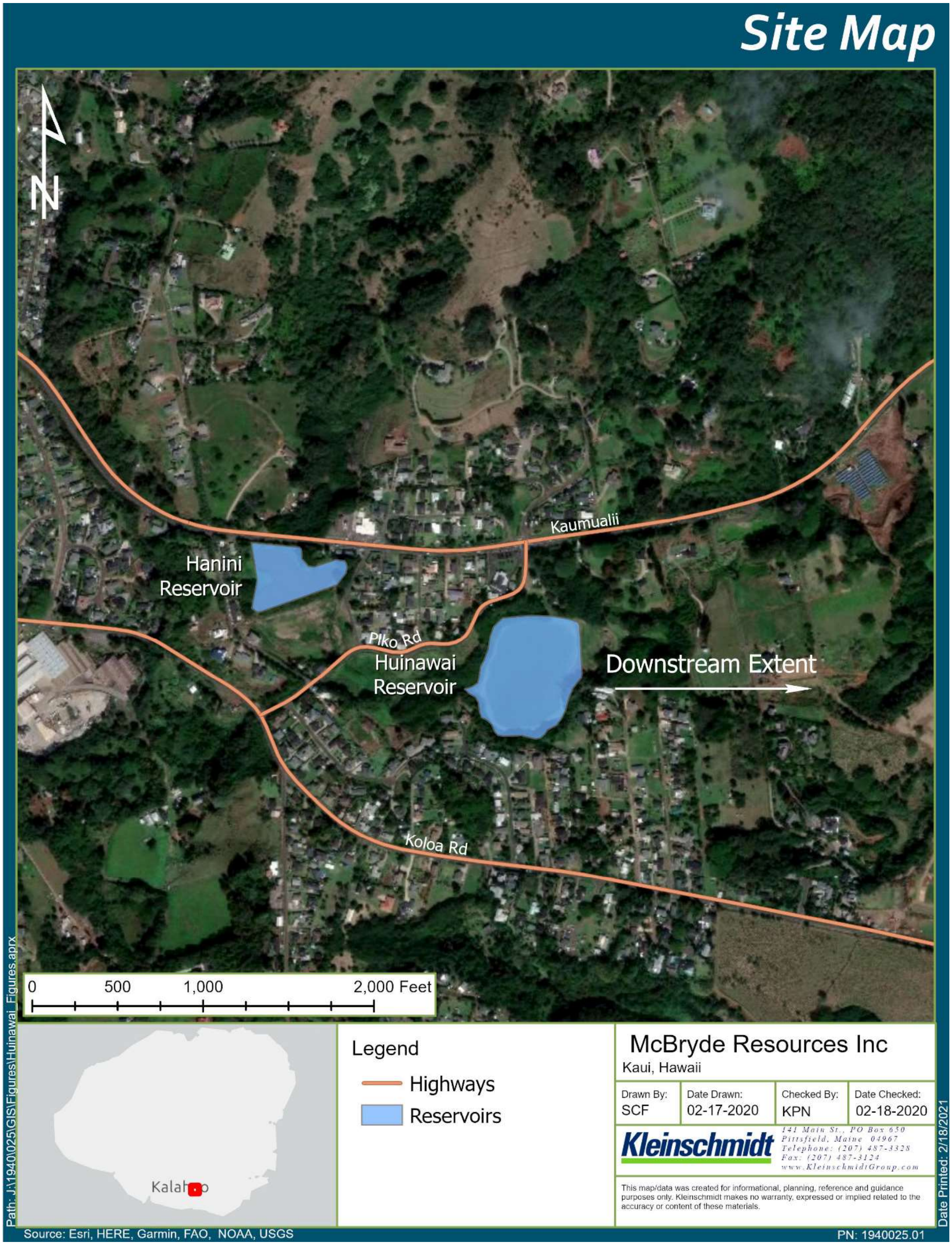

Figure 2-1 Location Map

2.2 Purpose

To meet the DLNR requirements for passing the PMF event, modifications to the existing spillway and embankment are required. This report and attached drawings present a conceptual spillway modification option that addresses deficiency No. 6 from the 2017 DLNR inspection report while also allowing the conceptual spillway to stay in the same location as the existing spillway. The conceptual spillway extends beyond the current McBryde property limits, however, McBryde is evaluating the property easements that allow them to construct the conceptual spillway structure as shown on the drawings in Appendix B.

The conceptual spillway design includes construction of a concrete channel to contain the flood flows and provide erosion protection against the high-water velocity during the PMF event. A concrete stilling basin with energy dissipation features will be installed at the downstream toe to reduce the velocities before the flow returns to the natural stream channel. The dam crest has also been raised to elevation 517.5 feet to increase storage during storm events and reduce the required spillway size. Additional protective features, such as engineered backfill, filter and drainage elements, and cutoff walls will also be installed to reduce the likelihood of initiating internal erosion.

The DLNR Hawaii Administrative Rules (Rules) states under Section 13-190.1-4 (3), the minimum design requirements for regulated dams and reservoirs shall incorporate earthen spillways that are constructed in natural ground. The conceptual spillway is in the same location as the existing spillway but will require excavation of the existing embankment to allow for proper foundation preparation and backfill placement and compaction. DLNR has indicated that a variance to the DLNR Rules would not be required for the conceptual spillway if it is in the same location and has a similar width as the existing spillway, but this should be confirmed with DLNR.

3.0 HYDROLOGIC AND HYDRAULIC ANALYSIS

3.1 Hydrologic Analysis

The PMF and 100-year inflows to the Huinawai Reservoir were determined using the U.S Army Corps of Engineers (USACE) Hydrologic Modeling System (HEC-HMS) software, and the results are summarized in the Kleinschmidt's Hydrologic and Hydraulic Analysis report, dated February 2021.

The HEC-HMS model produced the following results for the 100-year precipitation event. The model produced a peak inflow of 682 cubic feet per second (cfs) from the Hanini Reservoir discharge and peak inflow of 385 cfs into the Huinawai basin.

The HEC-HMS model produced the following results for the PMP event. The model produced a peak inflow of 1,676 cfs from the Hanini Reservoir discharge and peak inflow of 829 cfs into the Huinawai basin.

3.2 Hydraulic Analysis

A two-dimensional (2D) hydraulic model of the conceptual spillway was developed using the USACE HEC-RAS Version 5.0.7 software. The geometric data and mapping were compiled and completed using the RAS Mapper extension, which is built into the HEC-RAS software, and the results were analyzed and post-processed using RAS Mapper. The results of the analysis are summarized in the Kleinschmidt's Hydrologic and Hydraulic Analysis report, dated February 2021.

The peak water surface elevation during the 100-year storm and the PMF events for the existing conditions at Huinawai Reservoir are summarized in Table 3-1 below.

Table 3-1 Summary of Peak Headpond Elevations – Existing Spillway Configuration at Huinawai Reservoir

Hydrologic Condition	Peak Headpond Elevation (feet)	Overtopping Depth[1] (feet)	Overtopping Duration (Minutes)	Spillway Flow Depth (feet)	Peak Spillway Discharge (cfs)
1-Percent Annual Exceedance (100-year)	510.3	0	0	4.5	727
PMF	513.8	1.6	57	7.5	1994

1. Overtopping depth based on a minimum crest elevation of 512.2 feet.

The existing condition configuration of Huinawai Reservoir and spillway do not have sufficient capacity to safely pass the PMF event without overtopping the dam and the embankment dam does not meet the DLNR freeboard requirements.

3.3 Conceptual Spillway Modifications

To reduce the spillway size, a dam raise is proposed as part of the conceptual spillway design. The dam crest is proposed to be raised to elevation 517.5 feet, which is equal to about a 1.5-to-5.5-foot raise depending on the location along the current dam crest. The dam crest raise allows the conceptual spillway to have similar dimensions to the current spillway. The spillway invert is set at elevation 506 feet, matching the existing invert elevation, and the crest width is 30 feet. The conceptual design includes a 42-foot-long horizontal apron at the upstream entrance to the spillway, a trapezoidal-shaped chute through the existing spillway, and then transitions into a 2.5H:1V sloped chute that continues to the toe of the dam.

A one-dimensional (1D) model of the spillway was built in HEC-RAS. The 2D model of the spillway resulted in localized instabilities at the toe of the dam, which were avoided using a 1D steady state model. Additional refinement of the terrain in future design iterations could address this issue. The 1D model was calibrated to match the 2D model using boundary conditions and ineffective flow areas. The ineffective flow areas were placed to match the extent of one-dimensional flows from the 2D model, to correctly avoid including eddies forming along the edges of the downstream area. The concrete spillway was represented using cross sections along the dam profile and tied into the existing terrain downstream of the dam. Energy dissipation measures were not modeled in HEC-RAS.

The PMF was routed through the conceptual spillway configuration and the results are summarized in Table 3-2 below. The headpond elevation and spillway discharge were chosen to match that shown in the 2D model of the proposed spillway.

Table 3-2 Summary of Peak Headpond Elevations – Conceptual Spillway Configuration at Huinawai Reservoir

Hydrologic Condition	Peak Headpond Elevation (feet)	Overtopping Depth[1] (feet)	Overtopping Duration (Minutes)	Spillway Flow Depth (feet)	Peak Spillway Discharge (cfs)
PMF	514.1	0	0	8	1998

1. Overtopping depth based on a proposed crest elevation of 517.5 feet.

With the raised crest elevation, the proposed spillway passes the PMF event while maintaining 3-feet of freeboard to accommodate wave action at the embankment dam. The minimum 3-feet of freeboard was estimated based on similar, nearby projects. The site-specific freeboard requirements will be calculated during final design. The maximum pond elevation of 514.1 feet does not impact upstream landowners but upstream impacts should be verified when dam crest and pool elevations are finalized during final design.

The PMF water surface profile along the spillway chute was calculated using HEC-RAS. For steep spillway channels passing flow that is supercritical the water surface can be greater than the calculated profile because of air entrainment, which causes a phenomenon known as air bulking. Using the USACE air entrainment method, the air entrained water surface profile was also calculated for the spillway chute. Both profiles are shown in Figure 3-1.

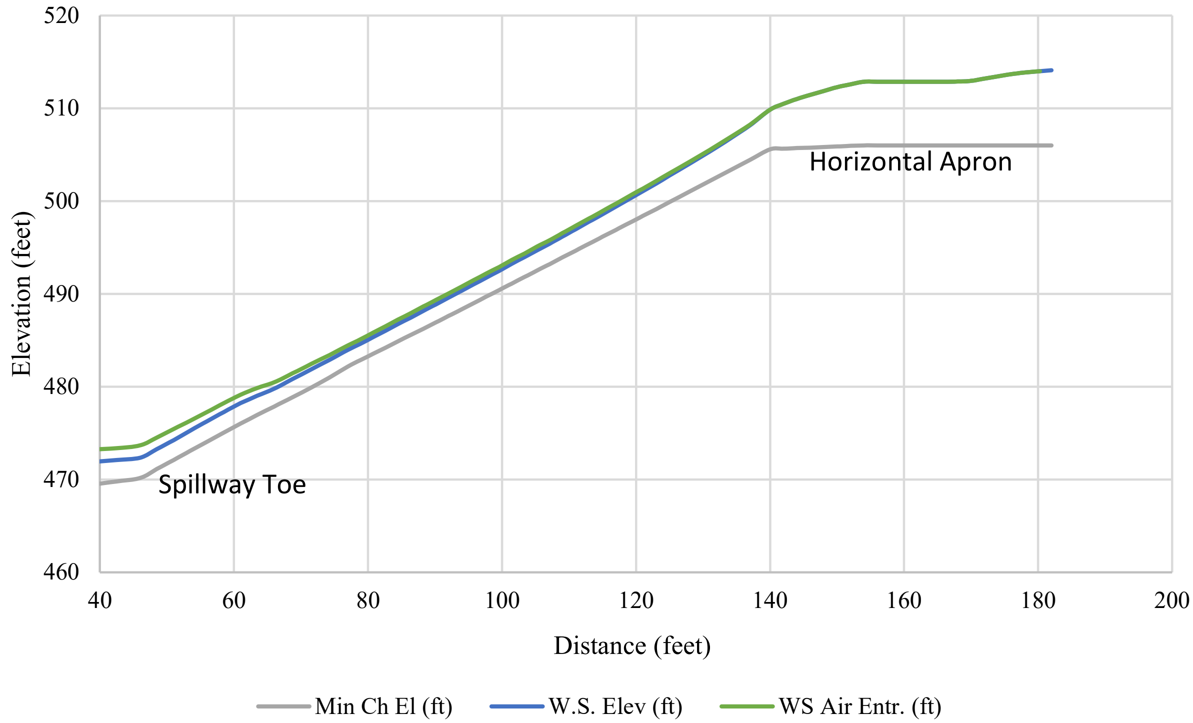

Figure 3-1 Spillway PMF Water Surface Profile

An additional energy dissipation structure is required at the downstream toe of the spillway to reduce the high velocities at the spillway discharge. For this conceptual design, the US Bureau of Reclamation (USBR) Design of Small Dams guidance was used to size a hydraulic jump stilling basin. Based on a Froude number (6.18) and velocity (47 feet/second) at the base of the spillway, a Type III stilling basin was chosen. The stilling basin dimensions are listed in Table 3-3 below. Additional information, including a typical sketch, are included in Appendix A.

Table 3-3 Stilling Basin Dimensions

Conjugate[1] Depth 1, d1 (feet)	2.2
Conjugate Depth 2, d2 (feet)	18.2
Basin Length, L (feet)	45.4
Chute Block Height (feet)	2.2
Chute Block Width (feet)	2.2
Chute Block Spacing (feet)	2.2
Baffle Block Height (feet)	3.9
Baffle Block Width (feet)	2.93
Baffle Block Spacing (feet)	2.93

1. Conjugate depths refer to the depth of flow upstream (d1) and downstream (d2) of the hydraulic jump.

4.0 CONCEPTUAL SPILLWAY MODIFICATIONS

4.1 Conceptual Spillway Configuration

The conceptual spillway configuration consists of a riprap and concrete lined approach channel, an uncontrolled overtopping concrete slab, a concrete discharge channel flowing into a concrete stilling basin with baffle blocks. Riprap is located downstream of the stilling basin to limit erosion at the toe of the structure. The conceptual spillway configuration is presented on drawings in Appendix B.

The proposed spillway configuration has the same width and invert elevation as the existing spillway. Theses dimensions were not modified to allow the conceptual spillway configuration to stay in the same location as the existing spillway. Keeping the spillway in the existing spillway location allows for discharge flows to be directed back into the existing downstream stream channel and would not require relocation of the outlet works. However, the conceptual spillway as shown in Appendix B extends outside the existing property limits. McBryde is evaluating the property easement that would allow for construction of the conceptual spillway at the current spillway location.

4.2 Key Design Features

The conceptual spillway channel is concrete lined to prevent deterioration of the embankment while passing flow. The walls of the spillway will vary over the length of the embankment from 11 feet tall along the chute to 20 feet tall in the stilling basin area. The walls are at least two feet higher than the highest calculated water height, including air bulking during the PMF event. The walls are battered vertically with a slope of at least 1H:10V to allow for proper compaction of engineering backfill adjacent to the spillway walls. Waterstops will be installed between all construction joints to prevent seepage of water out of and into the spillway. The spillway approach and downstream channel will be lined with riprap to armor the slopes and help prevent undercutting of the spillway. A cutoff wall below and up the sides of the spillway will be installed along the crest of the dam to lengthen seepage paths and a second concrete cutoff wall, which may need to include a sheet pile cutoff below the concrete portion, will be installed at the end of the stilling basin to prevent back cutting of the flow and prevent undermining of the stilling basin slab.

A new stilling basin is located at the bottom of the spillway discharge channel, near the toe of the embankment dam. The stilling basin induces a hydraulic jump of the spillway flows and lowers the velocity of the water being discharged from the reservoir before returning to the existing stream channel. The stilling basin side walls are relatively tall compared to the rest of the spillway walls, due to the energy associated with the flow passing over the slope of the dam.

An underdrain system is located downstream of the upstream cutoff wall and extends under the spillway discharge channel and stilling basin. The underdrain system consists of filter compatible sand extending under the concrete discharge channel with drain pipes surrounded in gravel. The underdrain sand will be filter compatible with the embankment soil to reduce the likelihood of initiating internal erosion. The drain pipes are located under the spillway discharge channel at each concrete joint and along both sides of the spillway discharge channel. The drain pipes discharge at the wingwalls of the stilling basin allowing seepage to be monitored for sediment transport and flow rates.

4.3 Final Design Considerations

The conceptual spillway design provided in this report is based on preliminary analyses and our understanding of the project. The final spillway design will require additional field information and additional analyses to inform the design and final location of the spillway.

The proposed stilling basin has relatively tall side walls which could result in increased construction costs and these walls could potentially be more difficult to maintain and repair due to their height. During final design, consideration should be given to improving the energy dissipation along the concrete discharge channel, potentially by adding steps to the spillway or baffle blocks in the spillway discharge channel. Lowering the velocities within the spillway discharge channel and widening the spillway, will likely lower the required stilling basin length and side wall heights. Adding energy dissipation structures to the spillway discharge channel to reduce the footprint of the stilling basin and armoring will require widening or deepening of the spillway as velocities are reduced by the energy dissipation features. Scour protection at the toe of the spillway will need to be evaluated to determine the extent of rip rap armoring and the requirements for the cut off wall.

The conceptual spillway and stilling basin designs are based on estimates provided by 1D and 2D HEC-RAS models. However, HEC-RAS software is not suitable for accurately modeling steep, rapidly varying profiles along spillways and within stilling basins, as is shown in the conceptual design. Three dimensional (3D) and/or physical modeling will be required to finalize design dimensions and parameters. Additional energy dissipation measures, especially baffles or stepped spillway designs, will require 3D modeling for accuracy. The final design will also need to consider the impacts of the depth and extents of spillway discharge flows.

The State's Probable Maximum Precipitation (PMP) maps are currently being updated based on improved hydrologic data. The work is scheduled to be completed in early 2022 with results anticipated in the summer of 2022. The changes to the PMP are anticipated to increase the PMF event at most, if not all, dams in Hawaii. The larger PMF event may require larger spillways to pass the PMF.

The conceptual spillway design is currently located at the existing spillway location, but the larger PMP event may require a larger spillway width which could require excavation of the existing embankment. If the widening of the spillway extends to the left, excavation would be in the existing embankment and a variance to the DLNR Rules would be required. Finalizing the spillway design should occur after the PMP is finalized as DLNR has indicated they would require all spillways, regardless of recently completed work, to pass the updated PMP and PMF.

5.0 CONCLUSIONS AND RECOMMENDATIONS

5.1 Conclusions and Recommendations

The conceptual spillway configuration presented in this report and attached drawings meets the DLNR Rules for passing the current PMF event. The footprint of the conceptual spillway extends beyond the current McBryde property limits, however, McBryde is reviewing the property easements that allow them to construct the conceptual spillway structure. McBryde should confirm with DLNR that the conceptual spillway configuration location as shown on the drawings in Appendix B does not require a variance to the DLNR Rules.

The conceptual spillway configuration should be further developed and optimized during final design to reduce flow depths in the stilling basin and velocities within the spillway channel by widening the spillway discharge channel and/or adding energy dissipation structures to the spillway discharge channel. By optimizing the spillway design features, construction costs and long-term maintenance costs could be lowered however, the final design will likely require widening of the spillway to accommodate these design changes. Also, as noted in Section 4.3 above, DLNR is updating the PMP which will likely result in increases in flood flows which would require a larger spillway to pass the flood flows. If the spillway is widened to the left from its current location and into the existing embankment, a variance to the DLNR Rules may be required. Deepening of the spillway may be an option instead of widening, however; a variance to the DLNR Rules may be required and should be confirmed with DLNR.

6.0 REFERENCES

Department of Land and Natural Resources (DLNR). 2017. Huinawai Reservoir (KA-0104), Kauai Visual Dam Safety Inspection. March 6, 2017.

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US Bureau of Reclamation (USBR). 1987. Design of Small Dams.

APPENDIX A

H&H MODELING CONCEPTUAL SPILLWAY AND STILLING BASIN DESIGN

Kleinschmidt

We provide practical ***solutions*** *for complex renewable energy, water, and environmental projects.*

PROJECT NAME:	**Huinawai Spillway Design**	**CLIENT:**	**McBryde**
PROJECT NO:	**1940025**	**PROJECT LOCATION:**	**Lawai, HI**
SUBJECT:	**H&H Modeling Conceptual Spillway & Stilling Basin Design**		
PROJECT MANAGER:	**Rebecca Allen**		
TECHNICAL LEAD/ADVISOR:	**Jennifer Jones**		
ENGINEER:	**ISHA DEO**		

REV.	NAME		DATE	COMMENTS
1	Performed By:	IPD	4/26/21	1D Steady HEC-RAS Model Type-III Stilling Basin Design Calculations
	Checked By:	MPH	4/28/2021	
	TA Approval:	JSJ	5/6/2021	
	Performed By:			
	Checked By:			
	TA Approval:			
	Performed By:			
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	TA Approval:			

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HEC-RAS QA-QA Review Form 2020

	Project	1940025.01		
	Plan	1, 2, 3		
	Model Type	2D / 1D		
	HEC-RAS Version	5.0.7		
	Developed by	MPH / ID		
	Reviewed by	SCF / MPH		
	Date	2/4/2021 4/28/2021		
		Initial Comment	**Response**	**Backcheck**
1	**General**			
1.1	**Unit System**	US Customary		
1.2	**Description**	Missing	I updated this, except for the LiDAR information. Do you have details on the consultant who collected it, the date, and the two datums?	I will update this information as we receive it from the surveyor.
1.3	**Project Directory**	Good		
2	**Geometry**			
2.1	**Description**	Missing	Added description	Good
2.2	**OD Geometry**	N/A		
2.2.1	**Storage Areas**			
2.3	**1D Geometry**			
2.3.1	**River Reach naming**	Good		
2.3.2	**Junctions**	N/A		
2.3.3	**Cross Sections**			
2	**Reach Lengths**	Good		
2	**Manning's n Values**	Good		
2	**Bank Stations**	Good		
2	**Cont/Ex Coefficients**	Good		
2	**Ineffective Flow Areas**	Good		
2	**Levees**	N/A		
2	**Block Obstructions**	N/A		
2	**Terrain vs. Sta-El**	Good		
2	**Skew**	N/A		
2	**Htab Parameters**	Good		
2.3.4	**Bridges/Culverts**	N/A		
2	**Description**			
2	**Placement of crossing**			
2	**Deck Roadway**			
2	**Piers**			
2	**Slopeing Abutments**			
2	**Bridge Modeling Approach**			
2	**Culvert**			
2	**Multiple Opening**			
2	**Htab parameters**			
2	**Skew**			
2	**Optional items**			
2.3.5	**Inline Structures**	N/A		
2	**Description**			
2	**Placement of structure**			
2	**Weir/embankment**			
2	**Gates**			
2	**Culverts**			
2	**Outlet RC**			
2	**Outlet TS**			
2	**Pilot Flow**			
2.3.6	**Lateral Structures**	N/A		
2	**Description**			
2	**Headwater Position**			
2	**Tailwater Connection**			
2	**Weir length vs. CL length**			
2	**Overflow Comp. Method**			
2	**Placement of structure**			
2	**Weir/embankment**			
2	**Gates**			
2	**Culverts**			
2	**Diversion RC**			
2	**Outlet TS**			
2.4	**2D Geometry**			
2.4.1	**2D Areas**			
2	**Default n value used**	0.06		
2	**Cell Center Spacing**	40ft - good		
2	**Number of cells**	5-7 across conveyance areas		
2	**5-7 cells across primary conveyances**	Good		
2	**Breaklines**	Good		
2	**Refinement Regions**	Good - I like how you layered the regions. I have never thought of using them as you did here		
2	**BC Lines**	Good		
2	**Manning's n Override Regions**	Why are there thin "gaps" between discritized areas? The default n value will be used here? n value of 10 makes sense to simulate the obsructions of the house - is this typical? Reservoir 24 has a significant area downstream of the dam covered with homes and I am modeling it with 0.1 as the previous study had done - I am wondering if we should bump those up?	A Manning's n = 10 Chris Goodell had recommended on a previous project for very large structures in the model. We could seek a better explanation from him, obviously large structures are going to cause a lot of roughness, moreso than rocks or trees would. Also explained to me by Chris, each side of a cell is assigned a different Manning's value based on whatever underlying layer covers 50% or more of the side. The polygons don't all need to be perfectly abutting, as if the gaps intersect a cell side they'er likely <50%. However, this might be more of an issue for small cells. Based on how RAS does this, it would be possible for a cell to have a different Manning's n for each side.	Reduced to 0.1 per our discussions.
2	**Perimeter extents**	Possibly extend further downstream - this may be unecessary if no backwatering is to occur.	Doesn't seem like this is necessary? The terrain slope at the end of the mesh is about 0.07 ft/ft	Okay - Good
2.4.2	**SA/2D Area Connections**	N/a		
2	**From/To locations**			
2	**Weir/embankment**			
2	**Weir Coefficient**			
2	**Gates**			
2	**Culverts**			
2.4.3	**Terrains**			
2	**Terrain Associations**	Good		
2	**Unused Terrains removed?**	Needs to be cleaned up	I removed some of the older Existing Conditions terrains, but I did leave some of the potential modification terrains	Good
2	**Terrain resolution**	Good		
2.4.4	**Land Classification**	Good		
2	**Land Classification Associations**			

2	Land Classification Areas			
2	Land Classification resolution			
3	**Flow Files**			
3.1	**Steady Flow File**	N/A		
3.1.1	Description			
3.1.2	Profiles			
3.1.3	Reach Boundary Conditions			
3.2	**Unsteady Flow File**			
3.2.1	Description	Missing		
3.2.2	Boundary Conditions	Hanini inflow slope of 0.01 seems to low is that the spillway slope? 100yr has a slope of 0.01 for Huinawai inflow but I think this should be 0.001 - I updated that.		
3.2.3	Initial Conditions	What is the purpose of the restart file? It seems like you are just setting and initial elevation in the mesh with standard initial conditons? Should we be starting the reservoir elevation at the crest of the spillway? This would be the most conservative condition and is likely to occur if there are preceding rainfall events before either the 100yr or PMP storm event	Yes, I had been targeting what the terrain indicated was the typical pond elevation (based on the non-burned bathymetry). Sure, to be consistent with the assumption that we made for the Hanini plan in HMS (assuming full pond) I have updated the hotstart plan to fill up to the spillway crest.	Good
4	**Plan Files**			
4.1	**Steady Flow File**			
4.1.1	Description	Good		
4.1.2	Correct Geometry/Flow files	Good		
4.1.3	Calculation Options/Tolerances	Good		
4.2	**Unsteady Flow File**			
4.2.1	Description	Missing		Good
4.2.2	Correct Geometry/Flow files	Wrong geometry assosiated with 100yr existing - a 1D terrain mod geometry was being referenced. I also reviewed the mapper output and it looks like the 100yr used a different geometry than the PMF - there are two meshes in this geometry with downstream of Huinawai modeled as a seperate mesh.	I ran the 100-year flood with the single mesh geometry.	Good
4.2.3	Calculation Options/Tolerances			
4	General			
4	2D Flow Options	Good		
4	1D/2D Options			
4	Advanced Time Step Control	Courant controled		
4	1D Mixed Flow Options			
4.2.4	Breach Parameters			
4.2.5	Computation Interval	Good - courant controlled with max of 1.1 and min of 0.05		
5	**Output**	Re-run 100yr with correct geometry. Re-run both with updates hydrographs from HMS		
5.1	**Profile Plot**			
5.2	**Cross Section Plot**			
5.3	**Summaries of Errors, Warnings, Notes**			
5.4	**RAS Mapper**			
5.4.1	Velocity Plot	Good		
5.4.2	Courant Plot	Good		
5.5	**Compute Messages**	Some consistent small errors for the 100yr - could possibly be worked out to reduce computation time.		
5.6	**Log Output File**	Computation log shows low error percentage - good		

Analysis Description

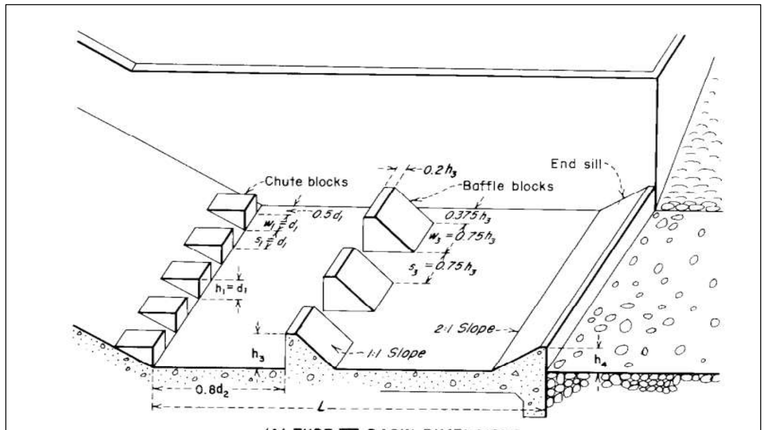
The purpose of this analysis is to determine preliminary dimensions for the Huinawai spillway hydraulic jump stilling basin.

Assumptions

1 - Froude numbers at the base of the spillway >4.5 and velocities are approximately 50 ft/s max.
2 - A Type III stilling basin is selected based on the Froude numbers and velocities

Reference

USBR. 1987. *Design of Small Dams*

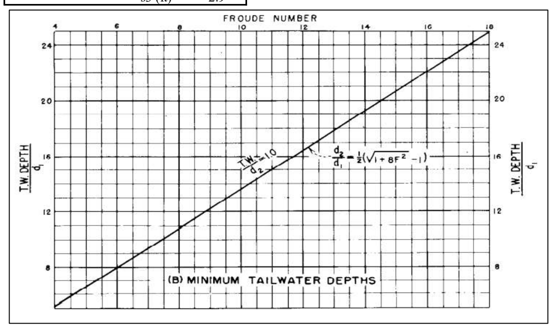


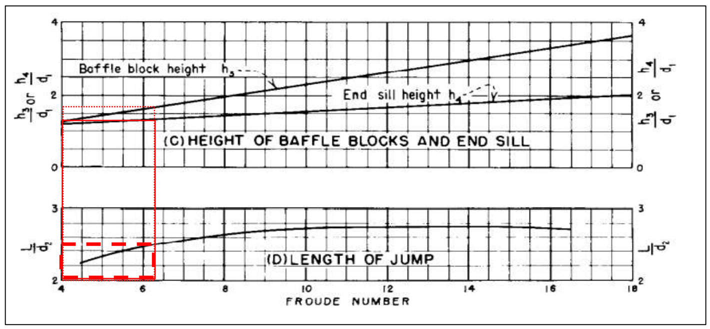
(A) TYPE III BASIN DIMENSIONS

Use red boxes to note selected values based on Froude Numbers

Stilling Basin Dimensions

Conjugate Depth 1, d1 (ft) =	2.2	
Conjugate Depth 2, d2 (ft) =	18.2	
Froude Number, F =	6.2	
L/d2 =	2.5	Look up in Graph
Basin Length, L (ft) =	45.4	
h1 (ft) =	2.2	
w1 (ft) =	2.2	
s1 (ft) =	2.2	
h4/d1 =	1.3	Look up in Graph
End Sill height, h4 (ft) =	2.9	
h3/d1 =	1.75	Look up in Graph
Block Height, h3 (ft) =	3.9	
w3 (ft) =	2.9	
s3 (ft) =	2.9	





Appendix B

Conceptual Level Spillway Design Drawings

McBRYDE RESOURCES, INC.

KAUA'I, HAWAI'I

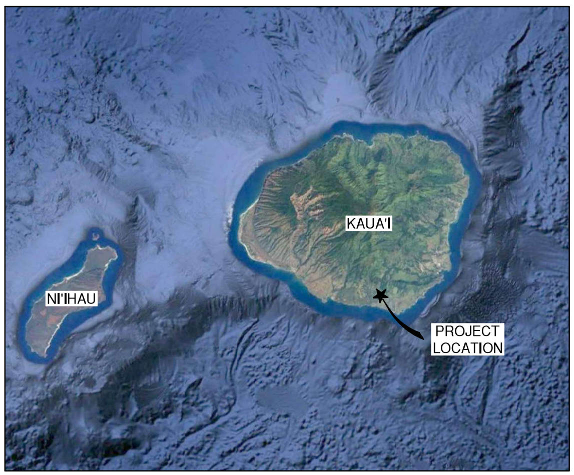
HUINAWAI DAM - DAM ID: KA-0102

TMK (4) 2-5-010:043

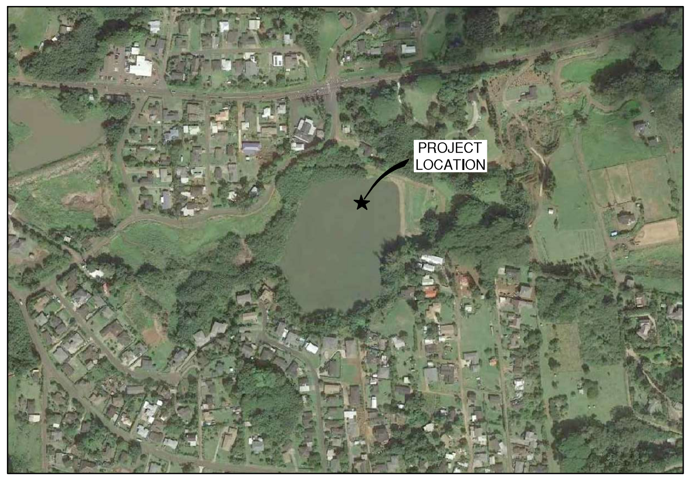
CONCEPTUAL LEVEL SPILLWAY DESIGN

DRAWING LIST

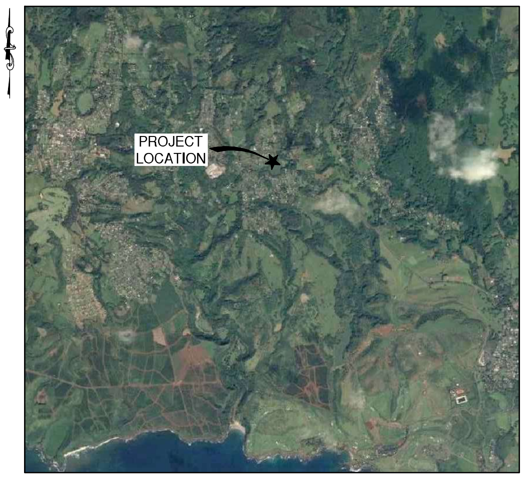
SHEET NO.	SHEET DESCRIPTION	DATE	REVISION	STATUS
001	EXISTING CONDITIONS PLAN	06-03-21	A	CONCEPTUAL DESIGN
002	PROPOSED CONDITIONS PLAN	06-03-21	A	CONCEPTUAL DESIGN
003	PROPOSED CONDITIONS SPILLWAY CHANNEL PLAN AND PROFILE	06-03-21	A	CONCEPTUAL DESIGN
004	PROPOSED CONDITIONS PROFILE ALONG NEW CREST AND SPILLWAY CROSS SECTION	06-03-21	A	CONCEPTUAL DESIGN



KAUA'I MAP



SITE MAP



VICINITY MAP

24x36 = FULL SCALE

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KAUAI, HI

HUINAWAI DAM
CONCEPTUAL LEVEL SPILLWAY DESIGN

EXISTING CONDITIONS PLAN

No.	Revision	Date	Drawn	Checked
A	CONCEPTUAL LEVEL SPILLWAY DESIGN	06-03-21	CFT	RAA

Designed	Drawn	Checked	Project No.	Date Revised	Drawing No.
-	CFT	RAA	1940-025	05-14-21	001

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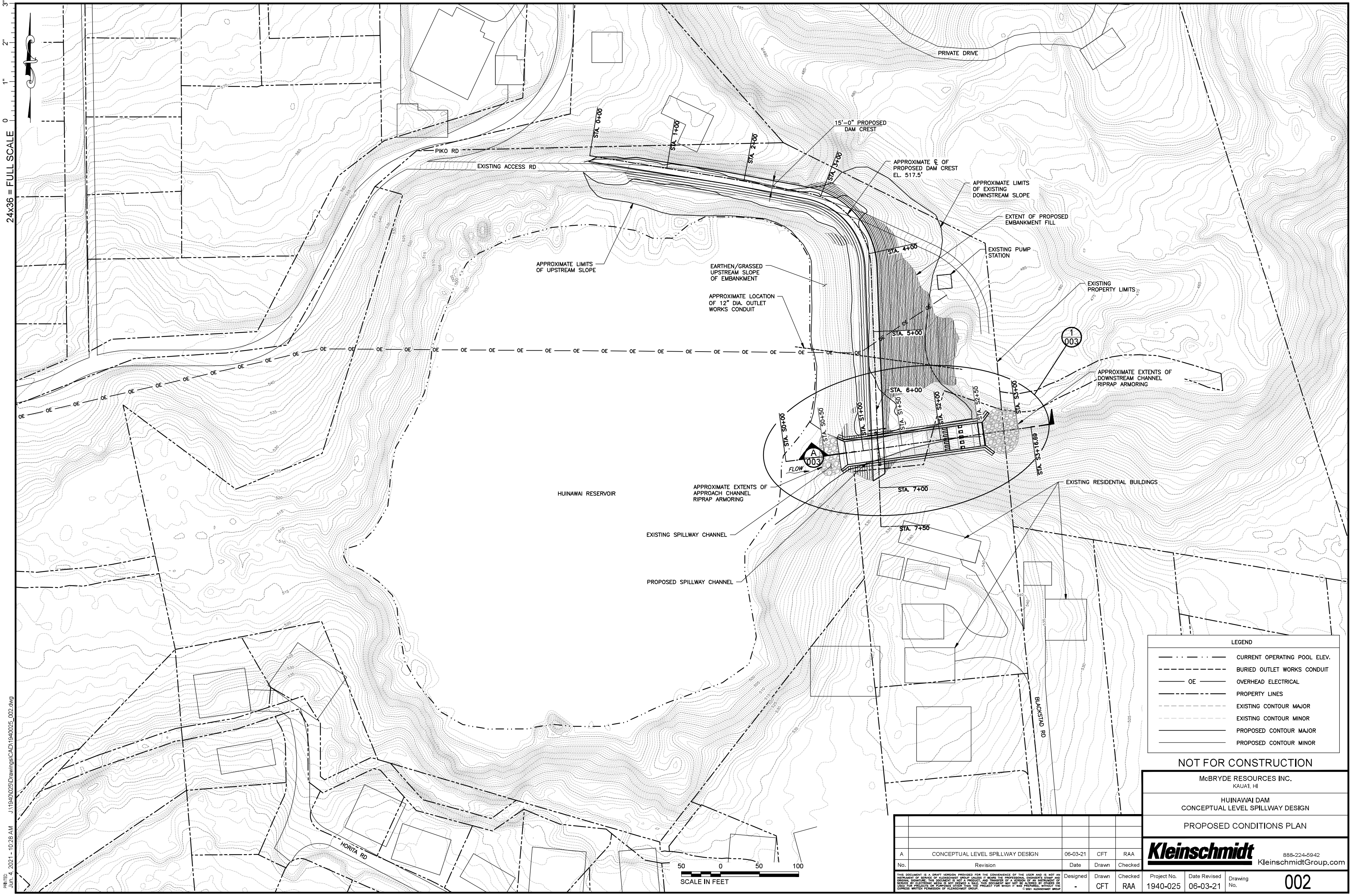

24x36 = FULL SCALE

LEGEND	
— · — · —	CURRENT OPERATING POOL ELEV.
— — — —	BURIED OUTLET WORKS CONDUIT
—— OE ——	OVERHEAD ELECTRICAL
—— - ——	PROPERTY LINES
- - - -	EXISTING CONTOUR MAJOR
- - - -	EXISTING CONTOUR MINOR
———	PROPOSED CONTOUR MAJOR
———	PROPOSED CONTOUR MINOR

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HUINAWAI DAM
CONCEPTUAL LEVEL SPILLWAY DESIGN

PROPOSED CONDITIONS PLAN

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No.	Revision	Date	Drawn	Checked
A	CONCEPTUAL LEVEL SPILLWAY DESIGN	06-03-21	CFT	RAA

Designed	Drawn	Checked	Project No.	Date Revised	Drawing No.
-	CFT	RAA	1940-025	06-03-21	002

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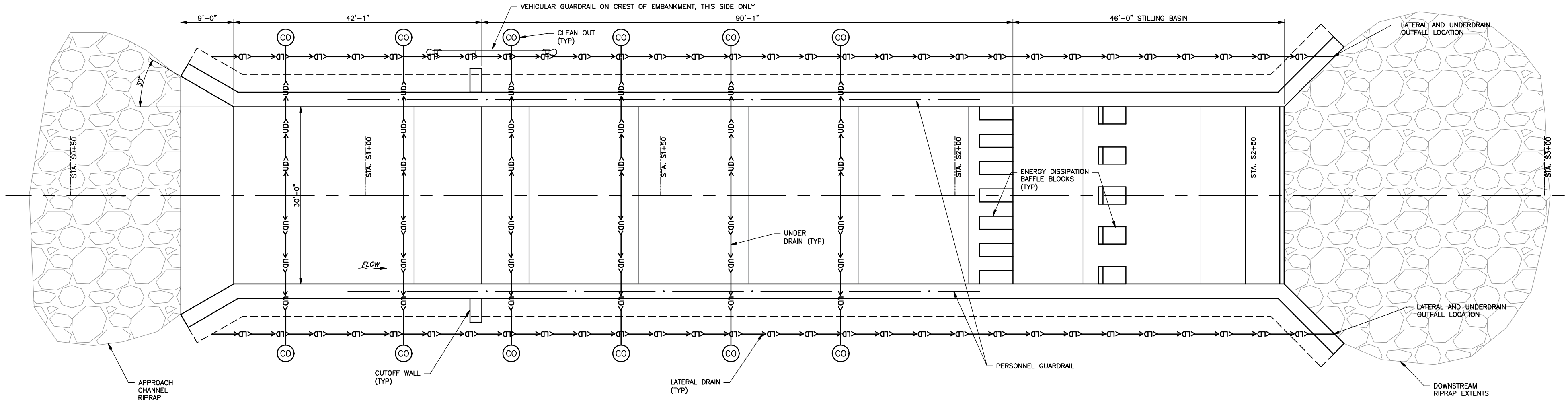
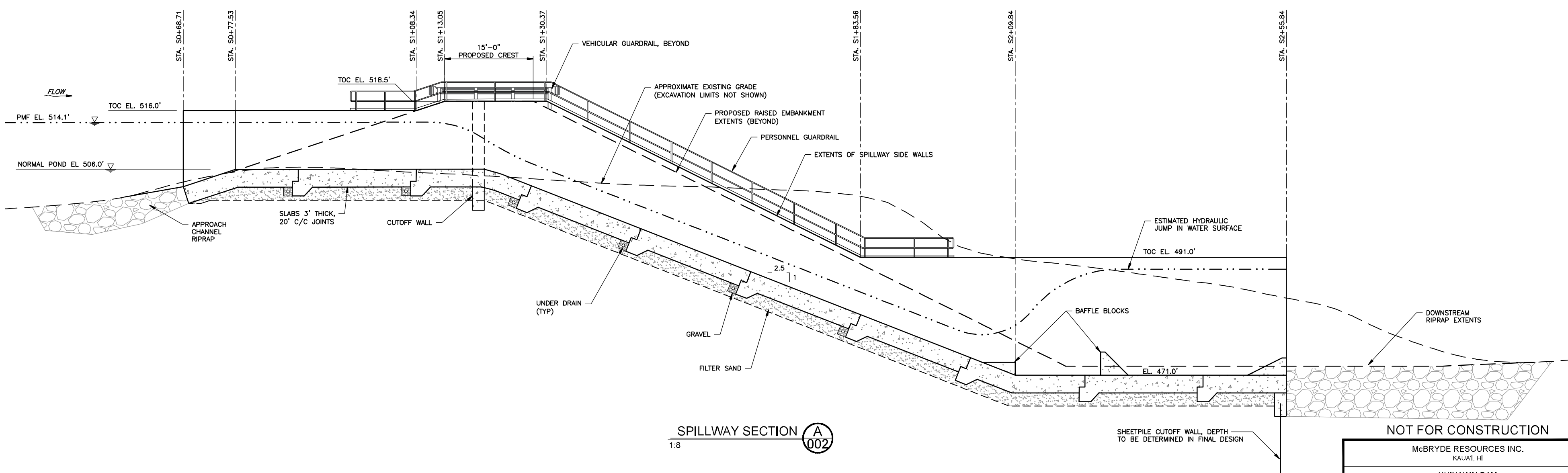


SPILLWAY PLAN DETAIL 1/002
1:8



SPILLWAY SECTION A/002
1:8

LEGEND	
→UD→	UNDER DRAIN
←LD←	LATERAL DRAIN
CO	CLEAN OUT

8 0 8 16
SCALE IN FEET

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KAUAI, HI

HUINAWAI DAM
CONCEPTUAL LEVEL SPILLWAY DESIGN

PROPOSED CONDITIONS
NEW SPILLWAY CHANNEL PLAN AND PROFILE

No.	Revision	Date	Drawn	Checked
A	CONCEPTUAL LEVEL SPILLWAY DESIGN	06-03-21	CFT	RAA

Designed	Drawn	Checked	Project No.	Date Revised	Drawing No.
-	CFT	RAA	1940-025	06-03-21	003

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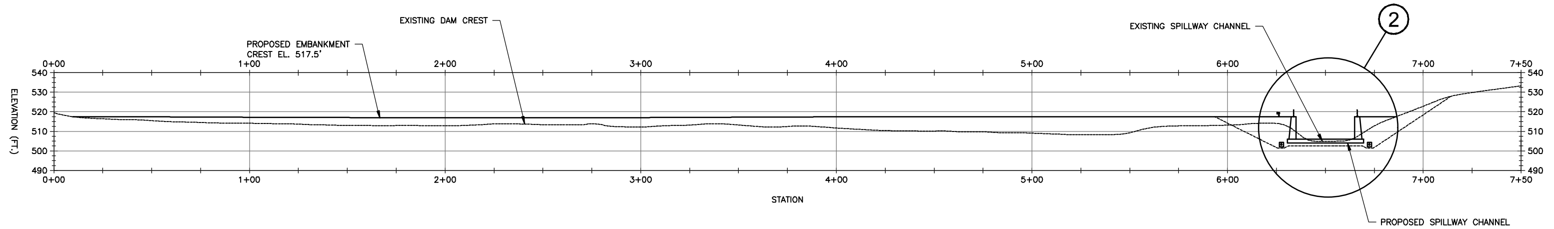
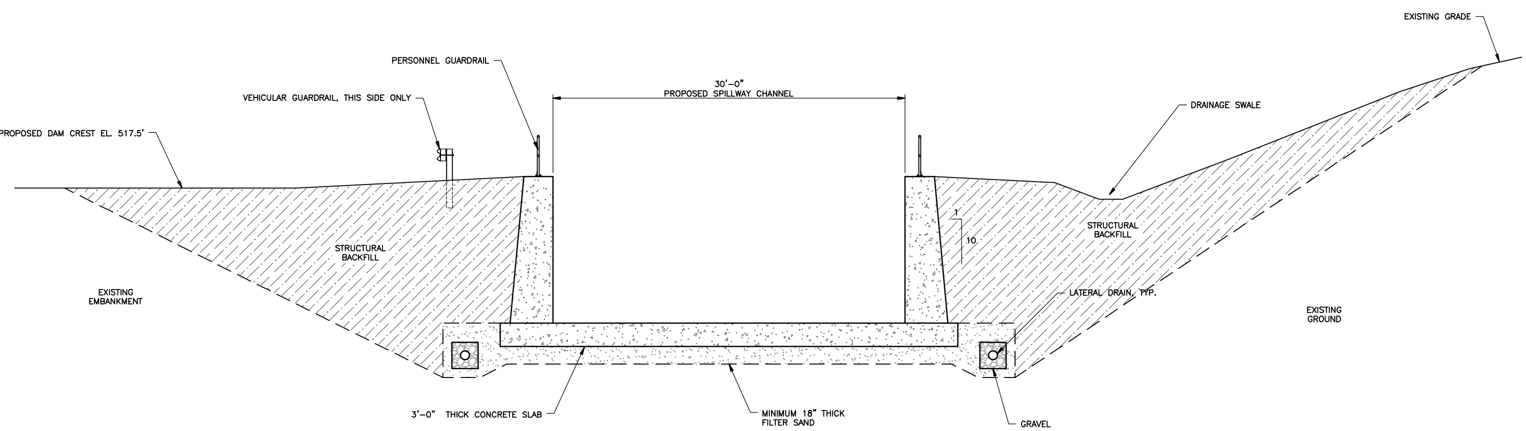


PROFILE ALONG PROPOSED EMBANKMENT CREST
1:30

30 0 30 60
SCALE IN FEET



PROPOSED SPILLWAY CHANNEL DETAIL 2
1:5

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McBRYDE RESOURCES INC.
KAUAI, HI

HUINAWAI DAM
CONCEPTUAL LEVEL SPILLWAY DESIGN

PROPOSED CONDITIONS
PROFILE ALONG NEW CREST & NEW SPILLWAY

No.	Revision	Date	Drawn	Checked
A	CONCEPTUAL LEVEL SPILLWAY DESIGN	06-03-21	CFT	RAA

Designed	Drawn	Checked	Project No.	Date Revised	Drawing No.
-	CFT	RAA	1940-025	06-03-21	004

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