DEPT. COMM. NO. 338

MAMALAHOA HIGHWAY (ROUTE 11) FLOOD MITIGATION STUDY

Ka‘u District Vicinity of Milepost 60
Island of Hawaii

Submitted to:

State of Hawai‘i
Department of Transportation
Hawai‘i District Office

December 2024

Submitted By

SSFM INTERNATIONAL, INC.

Project Managers, Planners, & Engineers

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1 EXECUTIVE SUMMARY

1.1 BACKGROUND AND PURPOSE

There is well-documented flooding on Route 11 (Māmalahoa Highway) near Mile Post (MP) 60 which frequently causes the highway to close (more than eight times since 2012). Route 11 is a portion of Māmalahoa Highway that acts as the main artery into the southern tip of the island and is also the only route that connects the two main towns of the Kaʻu District. The closure of this highway poses a major safety issue for the surrounding residents, being their lifeline to medical services and an emergency evacuation route. The highway was constructed prior to 1962 and lacks drainage infrastructure within this low-lying segment. The Legislature of the State of Hawaiʻi, has requested that the Department of Transportation (DOT) prioritize remediation of the flooding issues present on Route 11 around MP 60 as a safety project with the first step being to submit a report detailing it's plan for remediation, including an estimated budget, to the Legislature. This was formalized as Senate Concurrent Resolutions S.C.R. NO. 51 S.D.1 and 63 S.D.1 and a copy of each can be found in *Appendix A* of this report.

DOT contracted SSFM International, Inc. in June 2024 to perform this study and report.

1.2 OBSERVATIONS AND FINDINGS

SSFM performed multiple site visits to document field conditions during flood events both within the DOT Highway right of way and on the properties mauka of the highway which contribute to the drainage areas causing the flooding. Through these field investigations and interviews with residents in the area it is evident that the volume of water flowing toward the roadway has been increasing over time. There is evidence of man-made levees and ditches from the Plantation Era that were formally used to divert water to specific locations to protect downstream facilities. These areas were likely lava fields with significant capacity to infiltrate water. In some cases, these diversions appear to now be failing due to lack of maintenance, changes in drainage patterns, and size of storm events. The areas that formally allow water to infiltrate are now filled with sediment and no longer dispose of the water. This seems to be a major factor in why the flooding along the highway, roughly between the Hilea Bridge and Whittington Park has worsened over the last decade or so.

With that in mind, it is possible that the drainage patterns and volume of water impacting the highway will continue to change (likely increase) in the future. Each flood event carves new pathways and pushes sediment into different areas. It may be difficult to construct roadway improvements that will mitigate all storm events and the associated closures that maybe necessary. However, raising the roadway elevation and installing drainage infrastructure would limit the impacts during smaller storm events.

The most effective approach would be a broad scale collaborative effort between DOT, other State and Local Agencies, as well as property owners/managers to evaluate whether modifications to the land on the upstream/mauka side of the watershed, such as new levees or diversion ditches, could reduce the stormwater volume that makes it to the highway without negatively impacting other resources. This broader effort could proceed while DOT continues to advance plans for the area they own and maintain within the highway right of way.

1.3 POTENTIAL ALTERNATIVES/OPTIONS

The following alternatives were based on the 50-year design storm and can be evaluated in the future for larger or smaller storm events. Please see *Appendix B* for the technical data and *Appendix C* for exhibits relating to the alternatives outlined below.

Vicinity of Milepost 60

- Alternative 1 – Reconstruct an approximately 3,400' segment of Route 11. The roadway profile elevation would be raised approximately 8-10' above the existing roadway elevation to place it above the 50-year flood water surface elevation. The mauka fill slope would be hardened to mitigate erosion. Water currently flooding the roadway near MP 60 would now be blocked until reaching a sufficient elevation to overtop the raised roadway. Based on the preliminary analysis approximately 600' of roadway would overtop after a sufficient duration. This would result in the need for the continued need for road closures (though less frequent) under this scenario.
- Alternative 2 – Similar to Alternative 1 except appropriately sized box culverts would be constructed under the raised roadway to convey the water. Preliminary analysis, to set a baseline, included 6 – 12'x6' culverts modeled for the 50-year storm. This reduced the highway overtopping mentioned above to a range of 0.2 to 0.5 feet which is a significant improvement. Future analysis can consider increasing culvert size to attempt to mitigate overtopping entirely.
- Alternative 3 – Similar to Alternative 1, except a retention basin would be excavated (size/depth to be determined during detailed design) within the adjacent private property mauka of the highway, to store water and increase storage capacity to reduce roadway overtopping. When evaluating this for the 50-year storm event it became evident that the size of the basin required would be massive and larger than the available land mauka of the highway. Thus, this alternative was likely deemed not feasible.

Vicinity of Milepost 58.7 (aka Kāwā Flats)

- This area was previously studied, and an Environmental Assessment was completed along with Construction Drawings; however, constructed was not completed. Since this area is still flooding and contributing to the impassible roads during heavy rain events, we recommend improving it as part of the same project as the MP 60 mitigation (at least for permitting and design purposes; construction could be phased).
- As a baseline study, the previous design (July 2018) which proposed raising the highway elevation approximately 10' and installing 6-12'x8' box culverts was modeled based on the latest hydrology and hydraulics. Given the larger stormwater flows encountered there would still be highway overtopping under this condition. Future analysis can determine how increasing the culvert size and/or raising the highway elevation further could mitigate this situation.

1.4 RECOMMENDATIONS

Based on the observations and conclusions mentioned above, the following are our recommendations:

- Move forward with preliminary engineering and environmental permitting for a project that raises the road and installs culverts at both MP 58.7 and 60. Combine both locations into a single project to expedite the process. The construction can be phased based on available funding. Further study

and modeling will be required to determine the appropriate number, size, and location of the culverts and most importantly any impacts concentrating flows in these areas may have to downstream resources.

- Concurrently initiate discussions with the appropriate parties about ways to address the water further mauka.
- Continue efforts to install flood monitors, cameras, and other technology to keep the public informed of anticipated and on-going road closures and durations.
- Continue maintaining the area of MP 58.7 by clearing roadside vegetation and sediment build-up and grading on the downstream/makai side to provide positive drainage and/or infiltration of stormwater build-up.

Additional right of way or drainage easements will be required. In addition, operations & maintenance (O&M) of the area will need to increase depending upon rainfall intensity and frequency of storms.

1.5 ANTIPATED TIMELINE

It is anticipated that it would take approximately three years to have the project ready to start construction. A draft CPM schedule is included in *Appendix D* for reference.

The construction duration would likely be another 18 to 24 months.

1.6 ROUGH ORDER OF MAGNITUDE COST

The improvements required at both MP 58.7 and 60 would be major construction projects requiring significant amounts of fill, large concrete box culverts, utility pole relocation and many other associated items including temporary bypass roads. For budgeting purposes, the following costs can be assumed (in 2024 dollars):

MP 60	Rough Order of Magnitude Construction Cost	$30,000,000
MP 58.7	Rough Order of Magnitude Construction Cost	$25,000,000
	Total Combined Construction Cost	$55,000,000
	Planning/Design/Permitting Cost (15%)	$8,250,000
	Estimated Total Project Cost*	**$63,250,000**

*Does not include land acquisition cost

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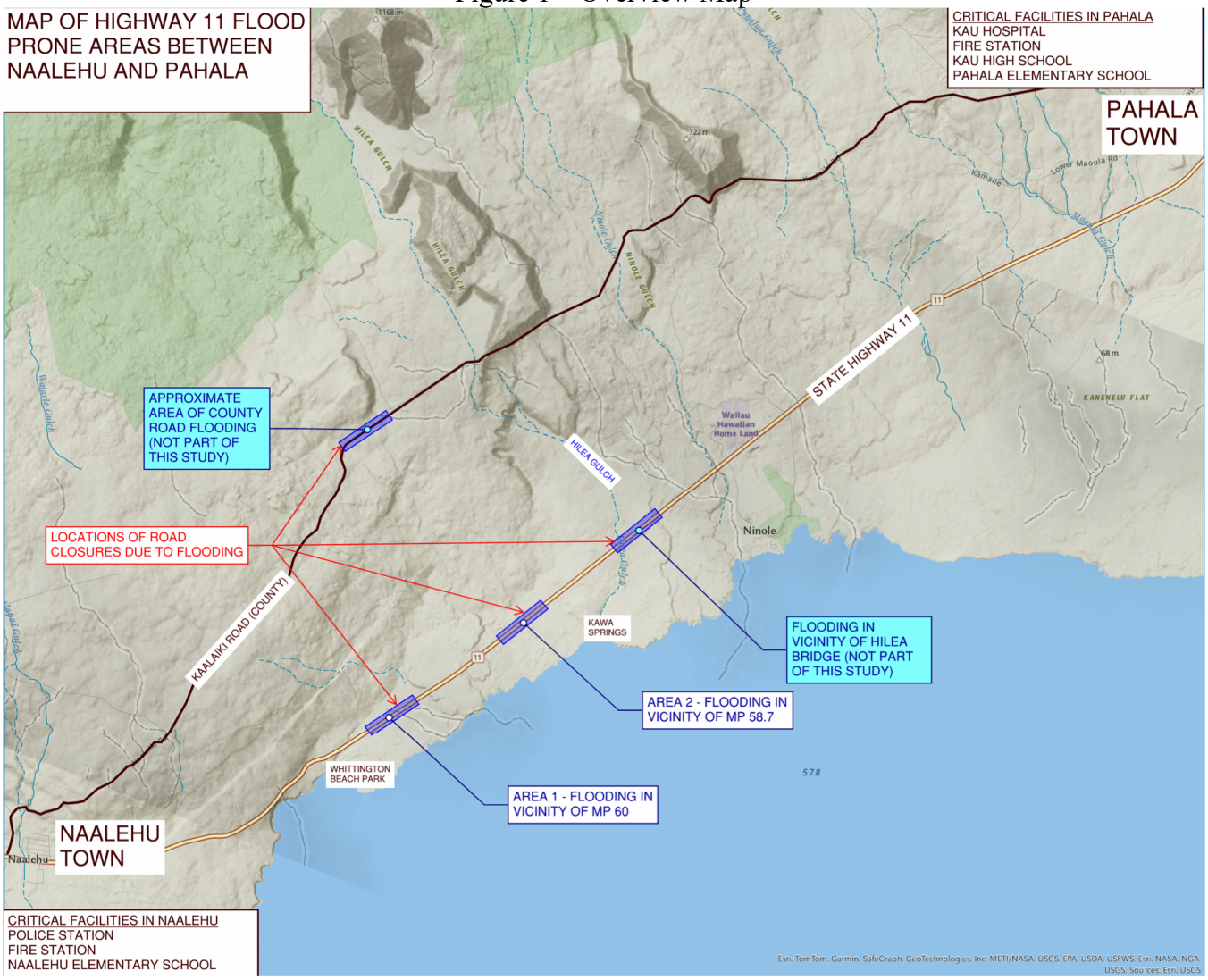
2 SCOPE OF WORK

The following tasks were part of this study.

2.1 RESEARCH/FIELD INVESTIGATION

SSFM conducted several site visits and interviews with both DOT and local residents in the area from June to September 2024 to gather information and understand the flooding situation. This included not only investigation along the highway where the overtopping was occurring, but also exploration of the drainage areas mauka that were contributing significant amount of water to the roadway areas. In August 2024 the island was indirectly hit by Hurricane Hone which was a massive storm event that caused closure of several stretches of the State Highway. Figure 1 below shows an overview map of the areas of concern between Pahala and Naalehu.

Figure 1 – Overview Map



The focus of this study is Area 1 and 2 as shown on the map. With a primary component being determining why flooding had started occurring within the last several years near MP 60 when historically it was only

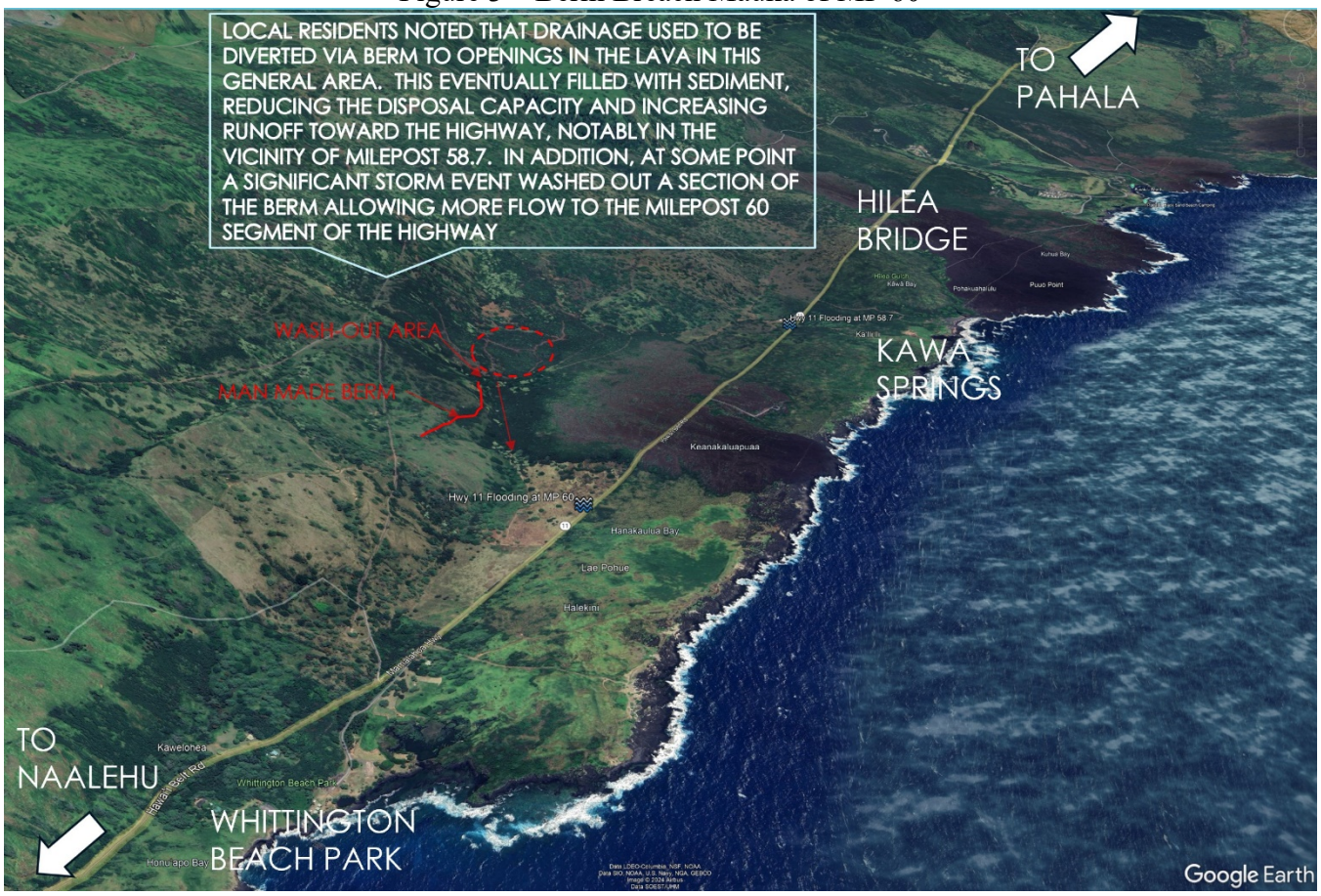
the area of MP 58.7 (Kāwā Flats) that was inundated. The general limits of flooding through this area are highlighted in Figure 2 below.

Figure 2 – Area of Water Overtopping Near MP 60

Based on information provided during interviews, as well as driving/hiking through the mauka drainage areas, it was discovered that a man-made levee had been damaged and breached during a previous storm event likely changing the volume of water that made it to the highway at MP 60. This in combination with larger storm events and gradual changes in drainage patterns is likely the reason for this previously dry area starting to flood over recent years.

Figure 3 below illustrates the location of the levee and damage referenced above. Photos of the area can be found in *Section 4 – Photos* in this report.

Figure 3 – Berm Breach Mauka of MP 60



2.2 MODEL EXISTING HYDROLOGY AND HYDRAULICS

The second task completed as part of this study was to model the existing condition to get an idea of the volume of stormwater, velocity, and flow patterns in the area. Both the segment of highway near MP 60 as well as 58.7 was included since they are both areas that contribute to the road closure situation.

The results of this exercise can be found in *Appendix B*.

2.3 DEVELOP CONCEPTUAL ALTERNATIVES/OPTIONS

Using the results from the modeling exercise in *Section 2.2* above, SSFM evaluated conceptual alternatives to mitigate the flooding. Due to the massive volume of water that the model shows to be entering the highway right of way, there are limited options to address the issue. The highway will need to be raised significantly to a point above the 50-year flood elevation (which was used for the purpose of this study). For the segment of highway near MP 60, to accomplish this approximately 3,400 feet of roadway would need to be raised with a portion being 8-10 feet above the existing elevation. Three alternatives were considered under this scenario.

- Alternative 1 – Reconstruct an approximately 3,400' segment of Route 11. The roadway profile elevation would be raised approximately 8-10' above the existing roadway elevation to place it above the 50-year flood water surface elevation. The mauka fill slope would be hardened to mitigate erosion. Water currently flooding the roadway near MP 60 would now be blocked until reaching a sufficient elevation to overtop the raised roadway.
- Alternative 2 – Similar to Alternative 1 except appropriately sized box culverts would be constructed under the raised roadway to convey the water. Preliminary analysis to set a baseline included 6 – 12'x6' culverts modeled for the 50-year storm.
- Alternative 3 – Similar to Alternative 1, except a retention basin would be excavated (size/depth TBD) within the adjacent private property mauka of the highway, to store water and increase storage capacity to reduce roadway overtopping.

For the area near MP 58.7, since this is a low point the only feasible option is assumed to be raising the highway and installing culverts. For the purposes of this study, the design that was developed for a previous project in 2018 was used and checked against the updated model to determine how these larger flood volumes would impact it. Similar to Alternative 2 at MP 60, this included large box culverts (in this case 6 - 12'x8') under a raised road (approximately 10' above existing elevation).

Refer to *Appendix C* for exhibits showing these conceptual alternatives. Section 2.4 below discusses the model results when implementing them.

2.4 MODEL OF ALTERNATIVES

The alternatives outline in *Section 2.3* were then put into the model developed to determine the likely impacts. A summary is shown below. Refer to *Appendix B* for a detailed breakdown of the methodology and outcomes.

MP 60

- Alternative 1 - Based on the preliminary analysis approximately 600' of roadway would overtop after a sufficient duration. This would result in the need for the continued need for road closures (though less frequent) under this scenario.
- Alternative 2 – This reduced the highway overtopping mentioned above to 0.2 to 0.5 feet which was a significant improvement. Future analysis can consider increasing culvert size to attempt to mitigate overtopping entirely.
- Alternative 3 – When evaluating this for the 50-year storm event it became evident that the size of the basin required would be massive and larger than the available land mauka of the highway. Thus, likely deemed not feasible.

MP 58.7

- Due to the larger volume of water depicted by the model flowing toward this low spot in the highway, the culvert size will need to increase, and/or the highway elevation will need to be raised to prevent overtopping.

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3 RECOMMENDATIONS

Based on the scope of work performed as described in *Section 2* above, SSFM has the following takeaways and recommendations.

Of the three conceptual alternatives described to mitigate flooding near MP 60, it would seem Alternative 2 is the most feasible. While Alternatives 1 and 2 would likely reduce the frequency of roadway closures during lesser events, the impacts of blocking the water are unknown at this time and could cause other negative impacts to adjacent properties and would likely create problems in other areas. The major element to evaluate for Alternative will be how concentrating the flow through the culvert area impacts the downstream reaches near the ocean. This would need to be studied during the environmental assessment phase. The same is true for the area near MP 58.7 as the situation would be similar.

With that in mind, the following are the suggested steps moving forward.

- Move forward with preliminary engineering and environmental permitting for a project that raises the road and installs culverts at both MP 58.7 and 60. Combine both locations into a single project to expedite the process. The construction can be phased based on available funding. Further study and modeling will be required to determine the appropriate number, size, and location of the culverts and most importantly any impacts concentrating flows in these areas may have to downstream resources.
- Concurrently initiate discussions with the appropriate parties about ways to address the water further mauka.
- Continue efforts to install flood monitors, cameras, and other technology to keep the public informed of anticipated and on-going road closures and durations.
- Continue maintaining the area of MP 58.7 by clearing roadside vegetation and sediment build-up and grading to provide positive drainage and/or infiltration of stormwater build-up.

4 TIMELINE AND BUDGET

4.1 TIMELINE

The major milestones that need to be completed for the project would include the following:

- Preliminary Design and Environmental Permitting (including all the technical studies necessary to support it)
- Final Design
- Utility Agreements and Relocations
- Right of Way/Easement Mapping and Acquisition
- Advertising and Bidding
- Construction

It is anticipated that it would take approximately three years to have the project ready to start construction. A draft CPM schedule is included in *Appendix D* for reference.

The construction duration would likely be another 18 to 24 months.

4.2 ROUGH ORDER OF MAGNITUDE COST

Major Construction Elements Include:

- Construct temporary bypass road
- Relocate utilities
- Acquire property and/or easements
- Demolish existing roadway
- Construct 8’ to 10’ (maybe more in some sections) of fill to raise the roadway elevation
- Construct roadway pavement structure
- Construct large concrete box culverts
- Construct drainage swales to transition and route stormwater to new culverts as needed as well as slope hardening such as riprap
- Reconstruct access driveways to adjacent properties
- Replace fencing
- Install guardrail and concrete barriers
- Install new striping and signage
- Remove temporary bypass road and return to pre-existing condition
- Other miscellaneous items

The improvements required at both MP 58.7 and 60 would be major construction projects requiring significant amounts of fill, large concrete box culverts, and many other associated items including temporary bypass roads. A rough order of magnitude construction cost for the improvements in the vicinity of MP 60 is around $30M, and around $25M for MP 58.7. This equates to a combined construction cost of $55M. Note that there is a large contingency included due to the conceptual nature of the design and this is intended for general budgeting purposes only. The number will be refined as the project is better defined. In addition to the construction costs, planning, design, and permitting will be required and costs are anticipated to be between $8M and $9M. This does not include any cost for land acquisition.

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5 PHOTOS

5.1 MP 58.7

Photo 1 – Hurricane Hone Flooding (Looking toward Pahala)

Photo 2 – Sediment on Roadway After Hurricane Hone (Looking Toward Pahala)

Photo 3 – Makai Roadside (Looking Toward Naalehu)

Photo 4 – Makai Roadside (Looking Toward Naalehu)

Photo 5 – Makai Roadside (Looking Toward Pahala)

5.2 MP 60

Photo 6 – Flooding During Hurricane Hone (Looking toward Pahala)

Photo 7 – Debris Cleanup After Hurricane Hone (Looking toward Pahala)

Photo 8 – MP 60 on Dry Day (Looking Toward Naalehu)

Photo 9 - MP 60 on Dry Day (Looking Toward Pahala)

5.3 MAUKA DRAINAGE AREAS

Photo 10 – Example of Diversion Berm

Photo 11 – Example of Diversion Ditch

Photo 12 - Example of Larger Diversion Ditch

Photo 13 - Former Lava Field Now Filled with Sediment

Photo 14 – Blown Out Levee Above MP 60 (Looking Southwest)

Photo 15- Blown Out Levee Above MP 60 (Looking Northwest)

APPENDIX A – SENATE RESOLUTION

APPENDIX B – HYDROLOGY AND HYDRAULICS STUDY

APPENDIX C – ALTERNATIVE EXHIBITS

APPENDIX D – DRAFT TIMELINE

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RECEIVED By DOT-DIR
3:28 pm, Jun 14 2024

The Senate
Ka ʻAha Kenekoa

STATE CAPITOL
HONOLULU, HAWAIʻI 96813

May 28, 2024

Mr. Ed Sniffen
Director
Department of Transportation
869 Punchbowl Street
Honolulu, HI 96813

Dear Director Sniffen:

I transmit herewith copies of Senate Resolution Nos. 21, 51, 69, 71, 82, 86, 88, 92, 99, 105, 120, 121, and 139, which were adopted by the Senate of the Thirty-Second Legislature of the State of Hawai'i, Regular Session of 2024.

Sincerely,

CAROL TANIGUCHI
Clerk of the Senate

Enclosures

THE SENATE
THIRTY-SECOND LEGISLATURE, 2024
STATE OF HAWAII

S.R. NO. 51 S.D. 1

SENATE RESOLUTION

REQUESTING THE DEPARTMENT OF TRANSPORTATION TO PRIORITIZE REMEDIATION OF THE FLOODING ISSUES PRESENT ON ROUTE 11 AROUND MILE POST SIXTY AS A SAFETY PROJECT.

WHEREAS, there is well-documented flooding on Route 11 near Mile Post 60, on Hawaii Island; and

WHEREAS, flooding frequently causes the highway to close; and

WHEREAS, Route 11 is a portion of Mamalahoa Highway that acts as the main artery into the southern tip of the island, and is also the only route that connects the two main towns of the Ka'ū district; and

WHEREAS, the closure of this highway poses a major safety issue for the surrounding residents, being their lifeline to medical services and an emergency evacuation route; and

WHEREAS, the highway was constructed before 1962 and lacks drainage elements within this low-lying section; and

WHEREAS, Mamalahoa Highway has closed at least six times since 2012 due to flooding; and

WHEREAS, the Legislature has previously included funds for maintenance of this highway in the budget and attempted to pass remedial legislation; and

WHEREAS, the Department of Transportation has considered installing flood monitoring systems and raising the highway as much as ten feet and installing culverts; now, therefore,

BE IT RESOLVED by the Senate of the Thirty-second Legislature of the State of Hawaii, Regular Session of 2024, that the Department of Transportation is requested to prioritize

remediation of the flooding issues present on Route 11 around Mile Post 60 as a safety project; and

BE IT FURTHER RESOLVED that the Department of Transportation is requested to submit a report detailing its plan for remediation, including an estimated budget, to the Legislature no later than twenty days prior to the convening of the Regular Session of 2025; and

BE IT FURTHER RESOLVED that certified copies of this Resolution be transmitted to the Director of Transportation and Mayor of Hawaii County.

I hereby certify that this is a full, true, and correct copy of the original filed in this office.

Dated: MAY 2 8 2024

Assistant Clerk of the Senate
State of Hawai'i

THE SENATE
THIRTY-SECOND LEGISLATURE, 2024
STATE OF HAWAII

S.C.R. NO. 63 S.D. 1

SENATE CONCURRENT RESOLUTION

REQUESTING THE DEPARTMENT OF TRANSPORTATION TO PRIORITIZE REMEDIATION OF THE FLOODING ISSUES PRESENT ON ROUTE 11 AROUND MILE POST SIXTY AS A SAFETY PROJECT.

WHEREAS, there is well-documented flooding on Route 11 near Mile Post 60, on Hawaii Island; and

WHEREAS, flooding frequently causes the highway to close; and

WHEREAS, Route 11 is a portion of Mamalahoa Highway that acts as the main artery into the southern tip of the island, and is also the only route that connects the two main towns of the Kaʻū district; and

WHEREAS, the closure of this highway poses a major safety issue for the surrounding residents, being their lifeline to medical services and an emergency evacuation route; and

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WHEREAS, the Legislature has previously included funds for maintenance of this highway in the budget and attempted to pass remedial legislation; and

WHEREAS, the Department of Transportation has considered installing flood monitoring systems and raising the highway as much as ten feet and installing culverts; now, therefore,

BE IT RESOLVED by the Senate of the Thirty-second Legislature of the State of Hawaii, Regular Session of 2024, the

House of Representatives concurring, that the Department of Transportation is requested to prioritize remediation of the flooding issues present on Route 11 around Mile Post 60 as a safety project; and

BE IT FURTHER RESOLVED that the Department of Transportation is requested to submit a report detailing its plan for remediation, including an estimated budget, to the Legislature no later than twenty days prior to the convening of the Regular Session of 2025; and

BE IT FURTHER RESOLVED that certified copies of this Concurrent Resolution be transmitted to the Director of Transportation and Mayor of Hawaii County.

Mamalahoa Highway (Highway 11) Drainage Improvements

Kau, Hawaii

HYDROLOGY AND HYDRAULICS STUDY

DRAFT

DECEMBER 2024

Prepared For: SSFM International

Prepared By: WEST Consultants, Inc.

This work was prepared b

Justin W. Griffit
Expiration D

JUSTIN W. GRIFFITHS
LICENSED PROFESSIONAL ENGINEER
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Appendix B Continued

1. Introduction

1.1. Purpose and Scope

WEST Consultants, Inc. (WEST) was retained by SSFM International (SSFM) to conduct hydrologic and hydraulic (H&H) analyses along Mamalahoa Highway (Highway 11) at milepost (MP) 58.7 and 60 in Kau, Hawaii (Big Island). These two locations are subject to substantial and repeated flooding during storm events, which creates hazardous conditions for vehicular traffic and pedestrians. Additionally, this flooding can persist for an impactful amount of time and often closes the roadway until the ponded water adequately drains; because Highway 11 (Hwy. 11) is the only route connecting the two main towns of Kau (Naalehu and Pahala), closures affect any travel needs (e.g., work commutes and shopping) and the passage of emergency vehicles.

The purpose of these analyses is to provide H&H results in support of drainage improvement design alternatives that reduce or eliminate flooding at the aforementioned MPs. This report presents the methodology, assumptions, and existing and proposed conditions results considering the 50-year design storm event. WEST anticipates that this report will be amended later to include additional storm events (e.g., 2-, and 100-year frequencies).

1.2. Study Location

The study area is located in the district of Kau on the south end of the Big Island. As previously mentioned, the two locations of concern are along Hwy. 11 at MP 58.7 and MP 60; more specifically, they are approximately 3.5 miles and 5 miles northeast of Naalehu, respectively (see Figure 1-1). The MPs are located on the windward side of the Big Island, which is characterized by its lush vegetation. It also makes this area subject to prevalent trade winds, and more frequent and intense rain events.

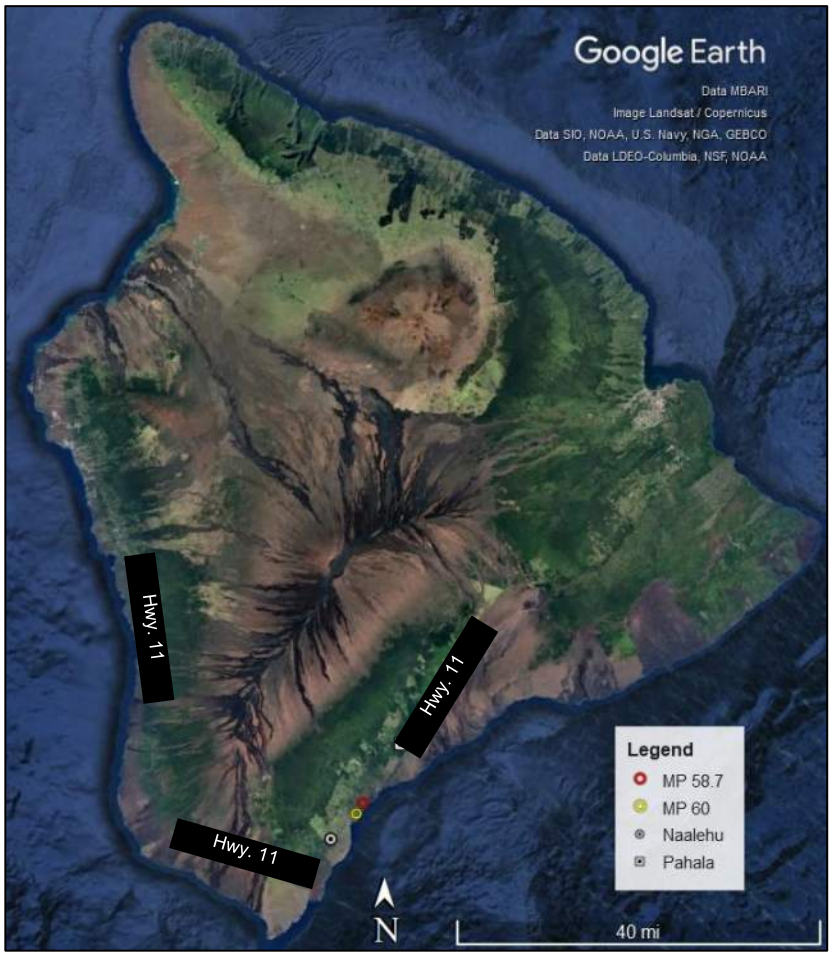


Figure 1-1. Vicinity Map (Google Earth 2024)

2. Hydrologic and Hydraulic Model Development

The United States Army Corps of Engineers (USACE) HEC-RAS (version 6.5) software was used to perform the hydrologic and hydraulic modeling; separate models were developed to perform the hydrologic and hydraulic computations. The sub-sections below provide further information regarding the modeling methodologies and parametric selections.

2.1. Modeling Approach

The study area is contained within ungaged watersheds; therefore, streamflow measurements (e.g., temporally continuous or annual) are not available and flood frequency analyses could not be conducted to determine peak flow discharges. Since multiple flow paths enter MP 58.7 and MP 60 non-uniformly, WEST developed a two-dimensional (2D) rain-on-grid (ROG) HEC-RAS model to determine the rate and timing of flow (i.e., hydrographs) entering the vicinity of the MP sites; this model will be referred to as the hydrologic model.

The hydraulic model was developed using the hydrologic model's results as inflow boundary conditions. Compared to the hydrologic model, these hydrographs were routed over a smaller computational domain, which utilized a further refined 2D mesh coupled to more rigorous governing flow equations.

This segregated approach was primarily implemented to reduce the computational expense (e.g., simulation run times) of the hydraulics model to allow for the consideration of various design alternatives, refinement, and debugging (if necessary). Two important distinctions between the model versions are summarized below (see Section 2.3 and Section 2.4 for more details about the specific model setups):

- Computational Domain: The computational domain in the hydrology model is necessarily larger than the hydraulics model as it must encompass the entirety of the applicable watersheds. For reference, the hydraulics model domain extends approximately 2,500 feet mauka of Hwy. 11 and is roughly 98% smaller than the hydrology model domain. Furthermore, due to the complexity of the hydrology model computations, (i.e., temporal precipitation and infiltration calculations) the larger modeling domain becomes even more prohibitive.
- Governing Equations: The hydrology and hydraulics model's computational schemes were set to diffusion wave and full momentum (i.e., the full set of shallow water equations), respectively. WEST felt that due to the potential impacts of the proposed alternatives, the acceleration terms in the shallow water equations were important; however, model stability and runtimes would be negatively impacted if the full momentum equations were used in the hydrology model.

2.1.1. Watershed Delineation

The watersheds contributing flow to the MP study areas were delineated in StreamStats, a tool developed by the United States Geological Survey (USGS), as shown in Figure 2-1. The MP 60 watershed is approximately 25.5 square miles; it originates from a ridgeline extending southwest of the Mauna Loa peak and features average slopes of approximately 0.07 feet per feet (ft/ft).

The three tributary watersheds which drain to MP 58.7 are approximately 0.6, 1.2, and 14.0 square miles (15.8 square miles total). The headwaters of the largest watershed contributing flow to MP 58.7 are approximately 7 miles south of the MP 60 headwaters, just north of the Kau Forest Reserve, and features average slopes of approximately 0.09 ft/ft.

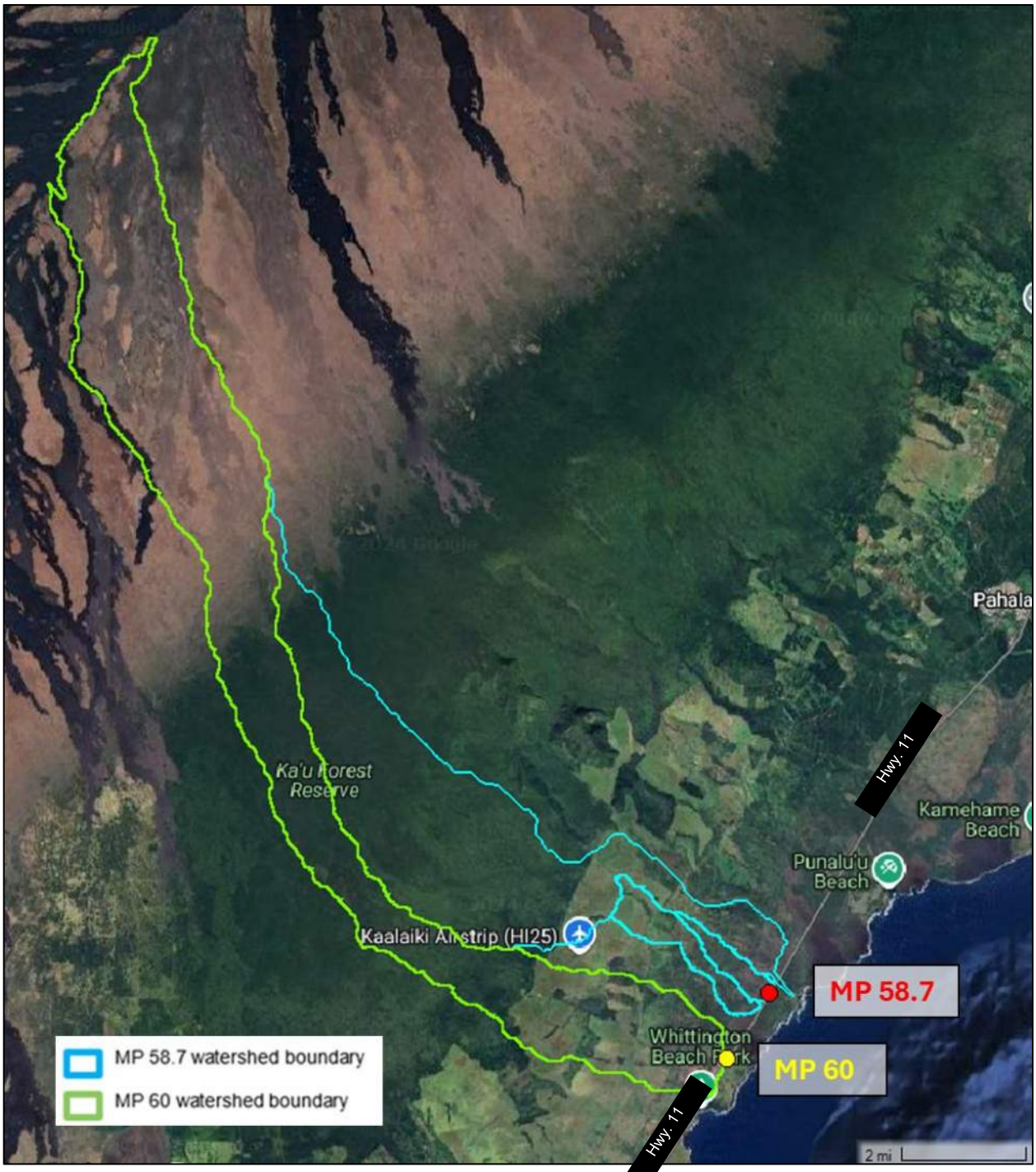


Figure 2-1. Watershed Delineations for MP 60 and MP 58.7 (StreamStats)

2.1.2. Modeling Domain and Computational Mesh

The model domain perimeter was developed beyond the delineated watersheds tributary to the MP sites. This ensures that the excess precipitation (i.e., runoff) is captured within the model domain and that the volume of flow is not underestimated. Runoff that develops outside of the watersheds will travel towards the perimeter of the model domain and exit the model via a normal depth boundary condition.

The computational mesh footprint is coincident between the hydrology and hydraulic models. The base/background mesh consisted of 100-foot hexagonal elements to reduce numerical diffusion due to multi-directional flow; mesh refinement regions were added in the areas surrounding the MP sites using 10-foot square elements (see Figure 2-2).

Breaklines were added throughout the modeling domain (e.g., typically at berms and roads) to enforce cell face alignment such that water movement mimicked reality and flow leakage across cells was minimized.

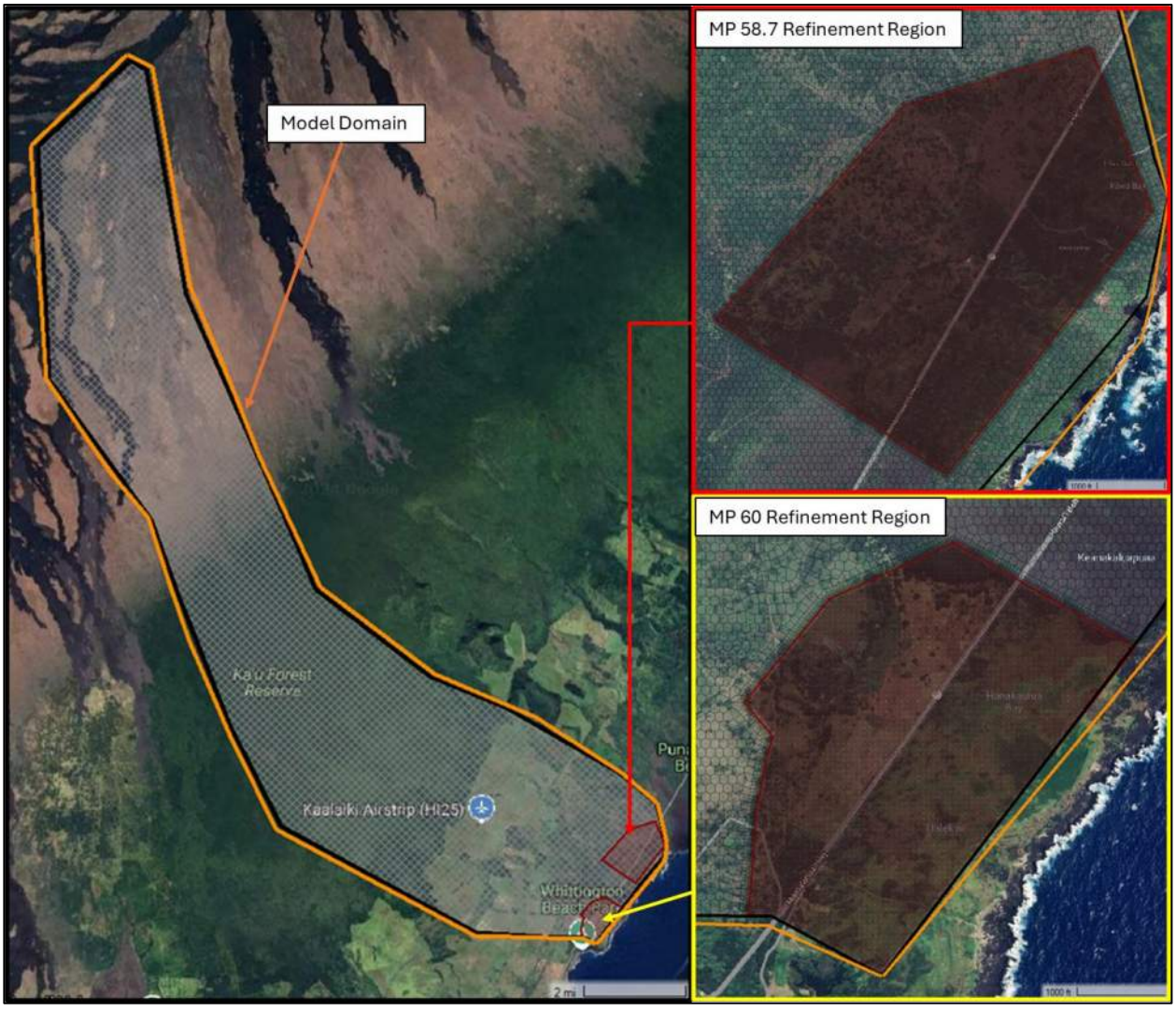


Figure 2-2. HEC-RAS Model Domain and MP Refinement Regions

2.2. Data Collection

Terrain, land use/cover, and surface roughness (Manning's *n*-values) information was obtained for use in both the hydrology and hydraulic models and is discussed in the below sub-sections. As previously stated, the data specific to the hydrology or hydraulic model will be detailed in Section 2.3 and Section 2.4, respectively.

2.2.1. Terrain Data

Terrain data for the study area was obtained from the 3.3-foot (one-meter) 2018 - 2020 National Oceanic and Atmospheric Administration (NOAA) and U.S. Geological Survey (USGS) Digital Elevation Model (DEM), which was developed from a converted LiDAR (Light Detection and Ranging) point cloud (NOAA-USGS, 2024). This dataset was the best available information at the study commencement in July 2024 and was considered appropriate for the hydrologic and hydraulic analyses.

2.2.2. Land Use

The land use classifications were based on the Coastal Change Analysis Program (C-CAP) High-Resolution Land Cover from the NOAA Office for Coastal Management. The latest 2010 C-CAP data, in raster format, was downloaded from the NOAA C-CAP website (NOAA, 2024a). The primary land use categories are barren land, evergreen forest, and scrub-shrub in the upper watershed (mountainous region). Pasture-hay, grassland-herbaceous, barren land, and scrub-shrub covers are present in the vicinity of the MP study areas (see Figure 2-3).

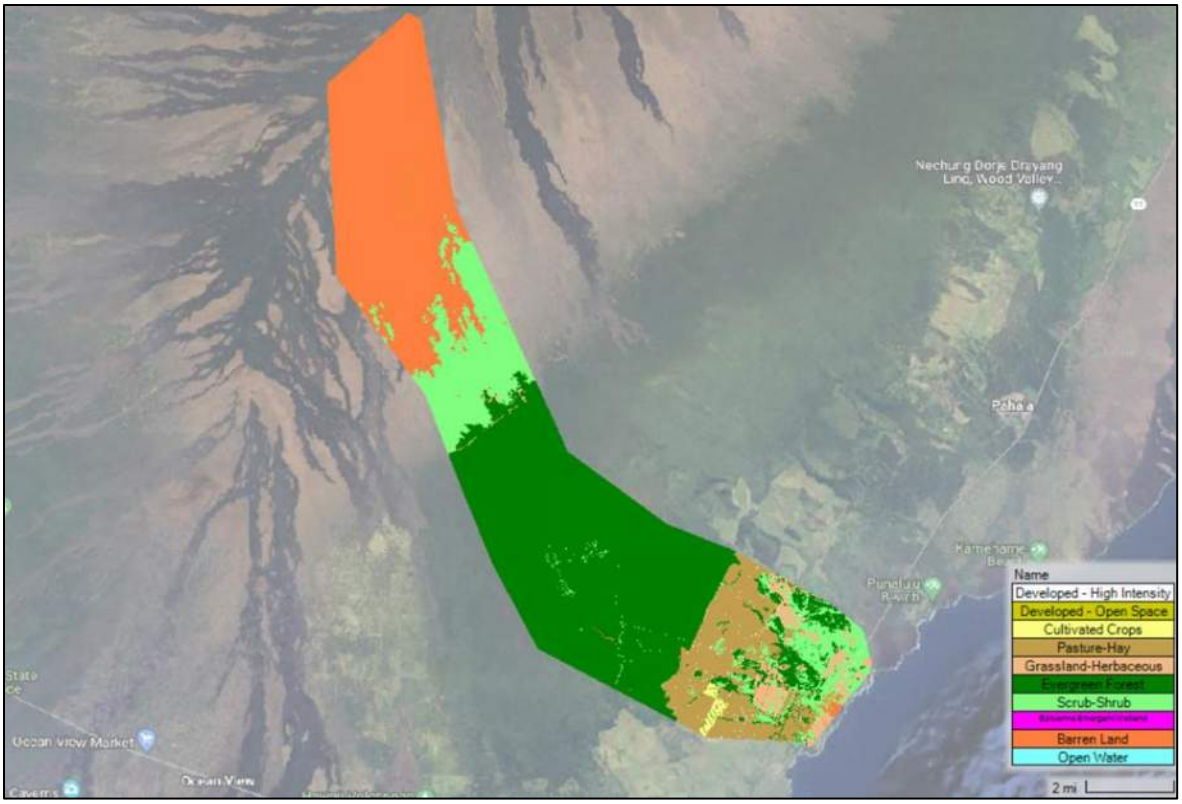


Figure 2-3. Land Use Map for the HEC-RAS Model Domain

2.2.3. Manning's *n*-values

The Manning's *n*-values were selected based on the land use raster dataset (C-CAP), aerial imagery, and available field reconnaissance information. The deterministic values represent professional engineering experience and judgment and are within the recommended range outlined in the HEC-RAS 2D Manual (USACE, 2023).

Table 2-1. Manning's *n*-value Assignments

Land Use (Classification)	Manning's *n*-values
Barren Land	0.03
Scrub-Shrub	0.08
Evergreen Forest	0.15
Grassland-Herbaceous	0.05
Developed - High Intensity	0.025
Pasture-Hay	0.045
Cultivated Crops	0.05
Developed - Open Space	0.035
Estuarine Emergent Wetland	0.06

2.3. Hydrology Model

The hydrology model was developed to determine the hydrographs of the multiple flow paths entering the MP study areas. The hydrology model utilizes the 2D ROG capabilities in HEC-RAS to estimate the infiltration, excess precipitation, and flow routing upstream of the MP sites. Simulations were verified to run until peak flows had passed through the downstream model boundary condition.

The below model controls were set to the following:

- Computation interval (time step): 0.3 seconds (fixed)
- Governing Equations: Diffusion Wave
- Water surface tolerance: 0.01 feet
- Simulation time window: 24 hours

The below sub-sections describe the data specific to the development of the hydrology model.

2.3.1. Infiltration

The Soil Conservation Service (SCS, now NRCS) curve number (CN) method was used to model precipitation losses from infiltration. This is an empirical surface runoff method where CNs are assigned based on the associated hydrologic soil group (HSG) and land use/cover. The CNs estimate the amount of soil storage and initial rainfall losses (initial abstraction-I_a) over a given area.

I_a is a function of soil storage (S) and was defined as:

$$I_a = 0.2S$$

S is defined as:

$$S = \frac{1{,}000}{CN} - 10$$

The soil data was obtained from the Soil Survey Geographic Database through the U.S. Department of Agriculture (USDA) Natural Resources Conservation Service's Web Soil Survey tool (USDA, 2024). These databases contain various soil related information, including the HSG, which describes runoff potential of saturated soils (USDA, 2009):

- Type A (Low runoff potential): This soil type typically contains less than 10 percent clay and more than 90 percent sand or gravel, with more gravel or sand textures.
- Type B (Moderate to low runoff potential): This soil type typically contains between 10 and 20 percent clay and 50 to 90 percent sand, with loamy sand or sandy loam textures.
- Type C (Moderate to high runoff potential): This soil type typically contains between 20 and 40 percent clay and less than 50 percent sand, with loam, silt loam, sandy clay, clay loam, and silty clay loam textures.
- Type D (High runoff potential): This soil type typically contains greater than 40 percent clay and less than 50 percent sand, with a clay texture.

The primary HSG soil types within the study area are A and D. Some lava flows are not rated and were therefore assigned as HSG A and D, according to the lava flow runoff property classes of "very low" and "very high", respectively.

To determine CNs for the model domain, the land use and HSG raster datasets were intersected to create polygons with unique land use and HSG combinations. The CNs were then assigned to each land use/HSG category per Table 2-2, which were based on the TR-55 manual (USDA, 1986). Further consideration was given to the quality of land use cover and how that may impact the CNs; a "good" cover quality condition, which represents greater than 75 percent vegetative coverage, was selected for the deterministic analyses.

Lastly, CNs can be adjusted based on the antecedent moisture condition (AMC), where AMC I, AMC II, and AMC III represent dry, average, and wet conditions, respectively. For this study, AMC II was assumed to be appropriate.

Table 2-2. Curve Number Assignments

Land Use (Classification)	HSG	CN
Barren Land	A	72
	B	82
	C	87
	D	89
Cultivated Crops	A	64
	B	75
	C	82
	D	85
Evergreen Forest	A	30
	B	55
	C	70
	D	77
Grassland-Herbaceous	A	39
	B	61
	C	74
	D	80
Pasture-Hay	A	39
	B	61
	C	74
	D	80
Scrub-Shrub	A	30
	B	48
	C	65
	D	73

2.3.2. Precipitation

2.3.2.1 Design Storm Events

Spatially distributed and temporally varied precipitation storm events were developed for the 24-hour duration of the 50-year recurrence interval. The precipitation files were generated using the following procedure:

- Gridded NOAA Atlas 14 partial duration series data (NOAA, 2024b) for the computational domain were downloaded. These datasets estimate the average rainfall depths for various recurrence intervals and storm durations.
- Because the study area watershed exceeds 10 square-miles, a depth area reduction factor was applied based on Technical Paper No. 43, Rainfall-Frequency Atlas of the Hawaiian Islands (U.S. Weather Bureau, 1962). The total watershed area in the model domain is approximately 41.3 square miles, therefore, a depth area reduction factor of 0.95 was applied.
- Nested hyetographs were generated from 50-year NOAA Atlas 14 precipitation depths using the USACE HEC-HMS (version 4.12) software for 24-hour storm durations implementing the alternating block method (Chow et al., 1988). The alternating block method creates a hyetograph at a selected time interval by taking the difference between precipitation depths at successive storm durations (i.e., cumulative precipitation depths are converted to incremental precipitation depths) and arranging the incremental depths into a hyetograph. As an example, for a selected time interval of 5 minutes, cumulative precipitation depths are interpolated for every 5-minute interval of the storm event. These cumulative depths are converted to 5-minute incremental precipitation depths by taking the difference between depths at successive durations. The largest 5-minute incremental depth is used as the peak of the hyetograph. The remaining incremental 5-minute depths are arranged around the storm peak in descending order, alternating on either side of the peak until each incremental depth has been incorporated into the hyetograph. This confirms that the estimated rainfall depth for a given storm duration is preserved within the hyetograph (e.g., the 5-minute peak of the hyetograph is equal to the 5-minute NOAA Atlas 14 depth, the 15-minute peak of the hyetograph is equal to the 15-minute NOAA Atlas 14 depth, etc.). The peak intensity position can be defined based on user preference; for this analysis, the 24-hour duration storms were generated with a peak intensity position at 50 percent of the total storm duration (i.e., hour 12 of the simulation window). Note that all hyetographs had a selected time interval of 5 minutes.
- The nested hyetographs were normalized to create generic storm distributions for the model domain. The gridded partial duration series data for each study frequency event were then clipped to the model domain (including a buffer zone). This clipped gridded partial duration series data was converted to a *.dss file that varies the precipitation temporally according to the normalized storm distributions. These precipitation storm event files were input into the hydrology model as an internal boundary condition.

The precipitation depths at the MP 60 site, shown in Table 2-3, were used to estimate hyetographs for the model domain; the 50-year, 24-hour hyetograph is shown on Figure 2-4.

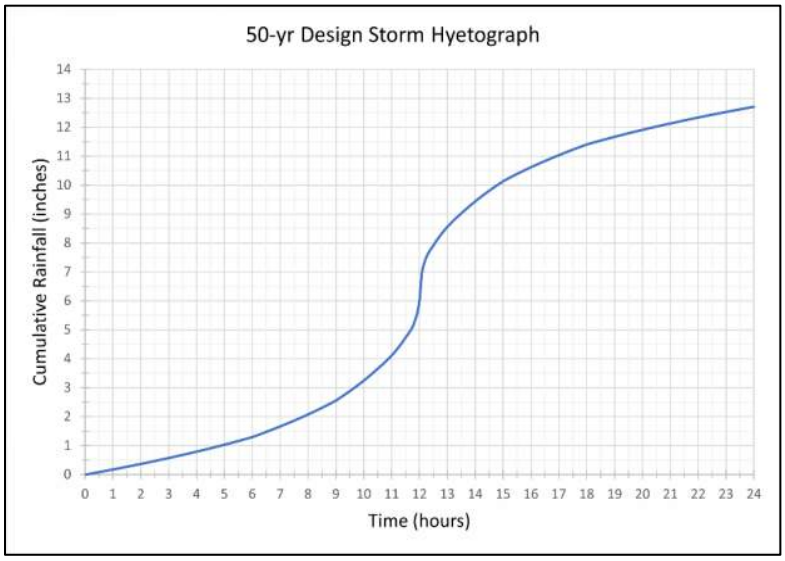


Figure 2-4. 50-year Design Storm Hyetograph at MP 60

Table 2-3. Rainfall Depth at MP 60

Duration	50-year (inches)
5 minutes	0.92
10 minutes	1.37
15 minutes	1.72
30 minutes	2.42
60 minutes	3.18
2 hours	4.44
3 hours	5.36
6 hours	7.57
12 hours	10.10
24 hours	12.70

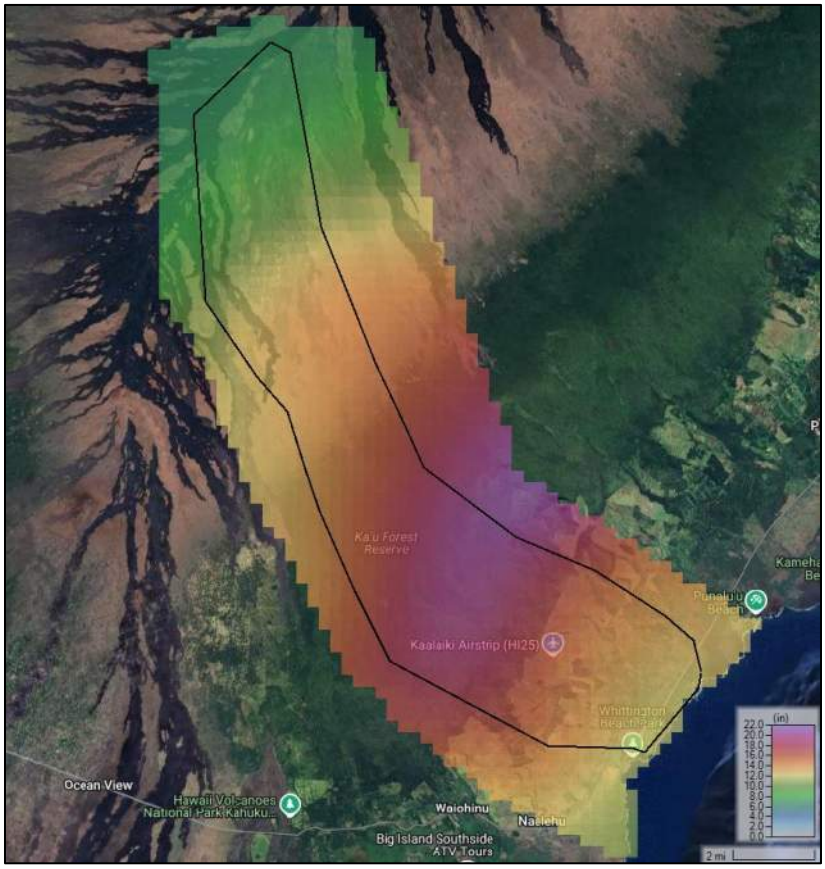


Figure 2-5. Spatially Varied Total Rainfall Precipitation Data

Developing a spatially distributed rainfall file was necessary to capture the variability from the orographic rains applicable to the MP watersheds. For example, Figure 2-5 illustrates the 50-year, 24-hour total precipitation depth varying by approximately 13 inches in the model domain, from approximately 20 inches within the Kau Forest Reserve, to approximately 7 inches at the watershed headwaters near Mauna Loa.

2.3.2.2 August 2024 Storm Event

A large storm event in the vicinity of the study area, whose peak occurred on August 24, 2024, generated over 11 inches of rainfall and resulted in the flooding of Hwy. 11 at both MP sites. WEST collected NEXRAD total storm precipitation radar data at station PHWA (South Shore FAA). There is an absence of radar readings encircling the station (see the yellow circle in Figure 2-6); this missing data was filled in with an estimation of mean perimeter precipitation values.

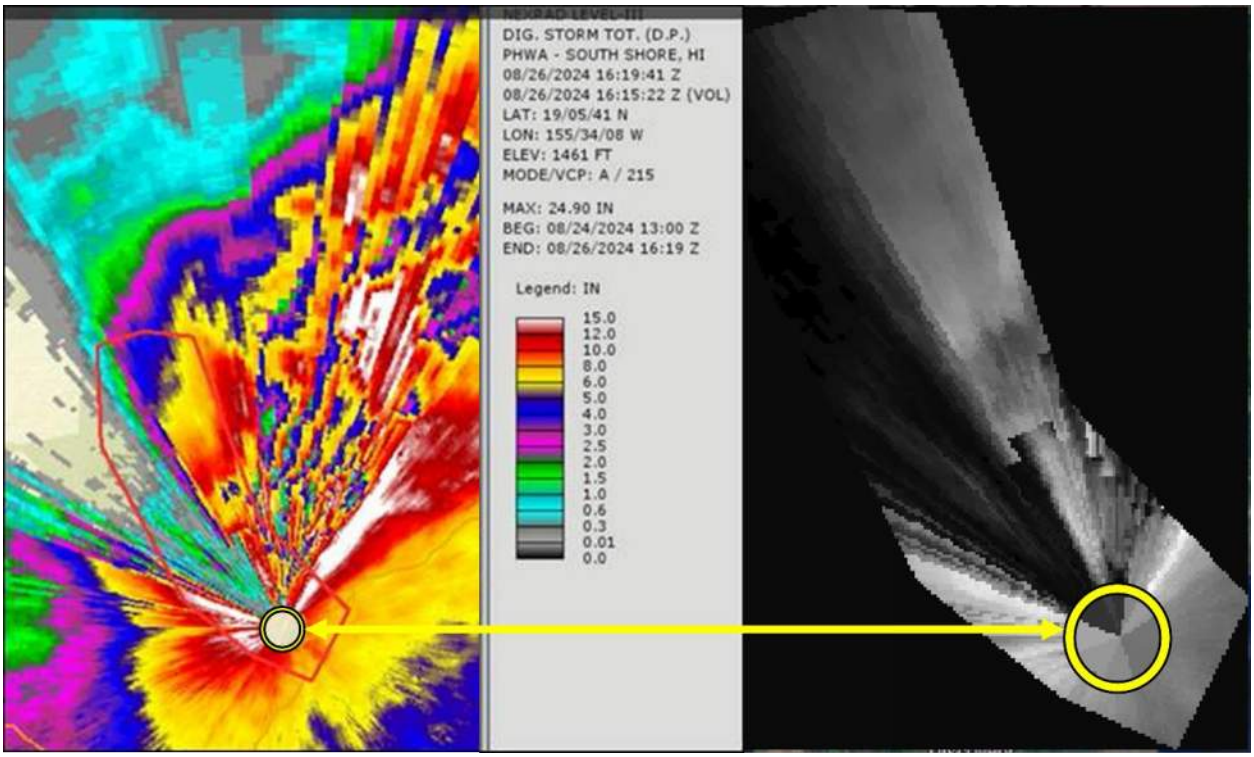


Figure 2-6. NEXRAD Cumulative Storm Precipitation Values

To generate the data needed in the HEC-RAS software, precipitation values were extracted from the NEXRAD data across several time intervals at 17 locations throughout the model domain (see Figure 2-7). The resulting hyetographs were then normalized to determine a representative rainfall distribution: The four highest total precipitation values, which include MP 58.7 and MP 60, all show good agreement (see Figure 2-8); the US 2 Right distribution was ultimately selected as the distribution scalar to create the August 2024 storm *.dss file for use in HEC-RAS.

Figure 2-7. August 2024 Storm Precipitation Extraction Locations

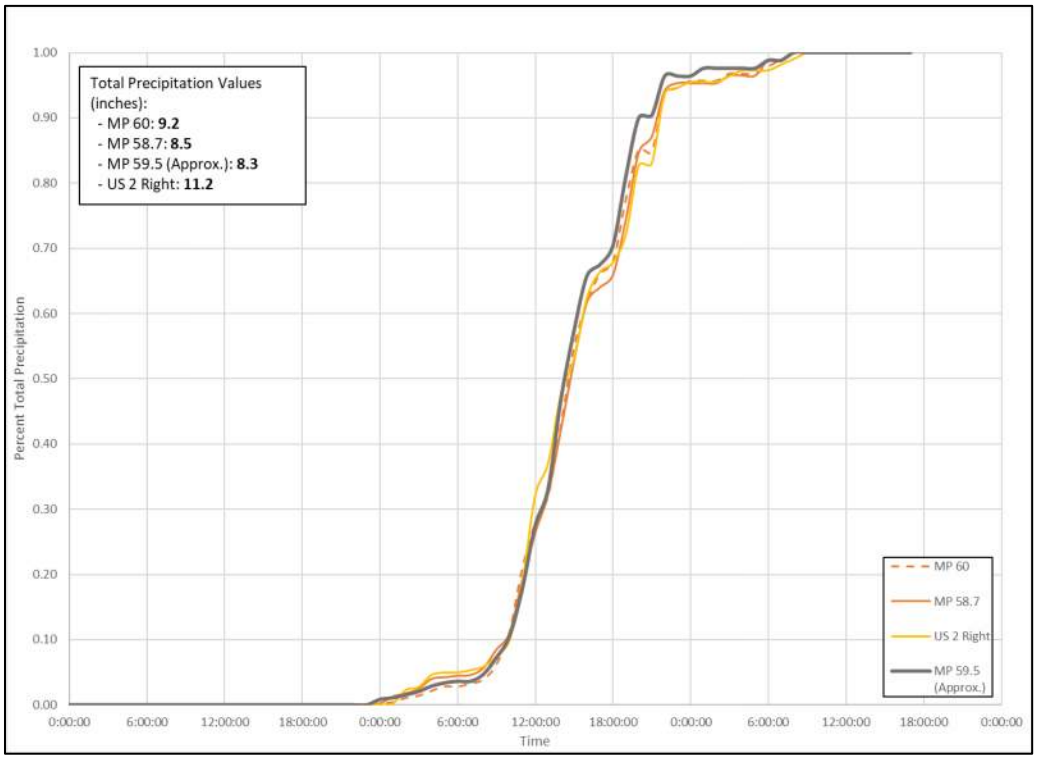


Figure 2-8. August 2024 Storm S-Graphs at Four Key Locations

2.4. Hydraulic Model

The hydraulic model was developed in HEC-RAS to route flow through the MP areas and estimate the 50-year storm depths and velocities. The hydraulic model only considers flow from the hydrographs (i.e., no ROG) and utilizes the 2D capabilities in HEC-RAS to of the flow routing through the MP study areas.

The below model controls were set to the following:

- Computation interval (time step): 0.1 seconds (fixed)
- Governing Equations: SWE-ELM (Full Momentum)
- Water surface tolerance: 0.05 feet
- Simulation time window: 18 hours

The following sub-sections describe the data specific to the development of the hydraulic model.

2.4.1. Boundary Conditions

2.4.1.1 Inflows

The runoff which is anticipated to enter the MP 58.7 domain was identified through examination of the surface terrain and particle tracing from the hydrology model results (see the white lines in Figure 2-9) and originates from the north, west, and southwest (see Figure 2-9) directions. The entering flow was discretized into 26 segments defined as either concentrated flow, shallow flow, or no flow. See Exhibit 11 in Appendix B for a detailed graphic of the discretized boundary condition lines and their respective hydrographs.

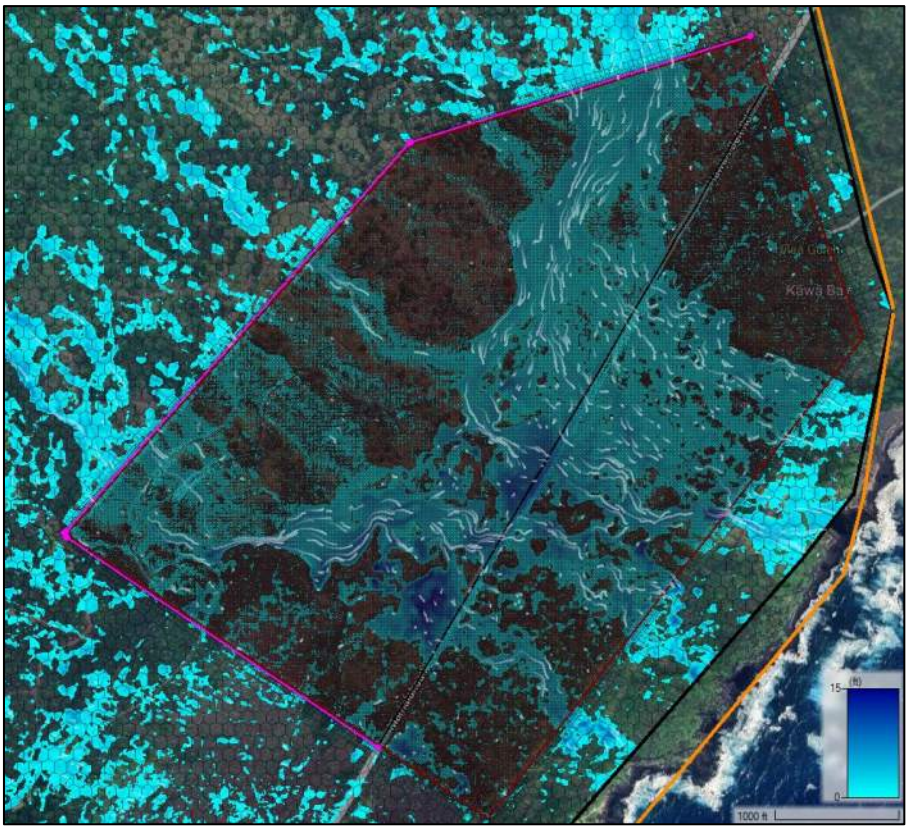


Figure 2-9. Flow Entering MP 58.7 Study Area

Volume accumulation data was extracted just downstream of the boundary condition lines for the hydrology and hydraulic models. The total volume of flow entering the MP 58.7 site, at hour 18 of the simulations, was 10020.7 acre-ft (ac-ft) and 10056.0 ac-ft for the hydrology and hydraulic models, respectively. The 0.3 percent relative difference in

flow volume is minor and thus validates the flow translated from the hydrology model to the hydraulic model.

Runoff enters the MP 60 domain from the north, northeast, northwest, and southwest (see Figure 2-10, where the white lines represent particle tracing) directions. Similar to MP 58.7, the inflows were discretized into 14 segments defined as either concentrated flow, shallow flow, or no flow. See Exhibit 11 in Appendix B for a detailed graphic of the discretized boundary condition lines and their respective hydrographs.

Volume accumulation data was extracted just downstream of the boundary condition lines for the hydrology and hydraulic models. The total volume of flow entering the MP 60 site at hour 18 of the simulations was 4903.5 ac-ft and 4929.1 ac-ft for the hydrology and hydraulic models, respectively. The small relative difference of 0.5 percent is insignificant and thus validates the flow translations between the models.

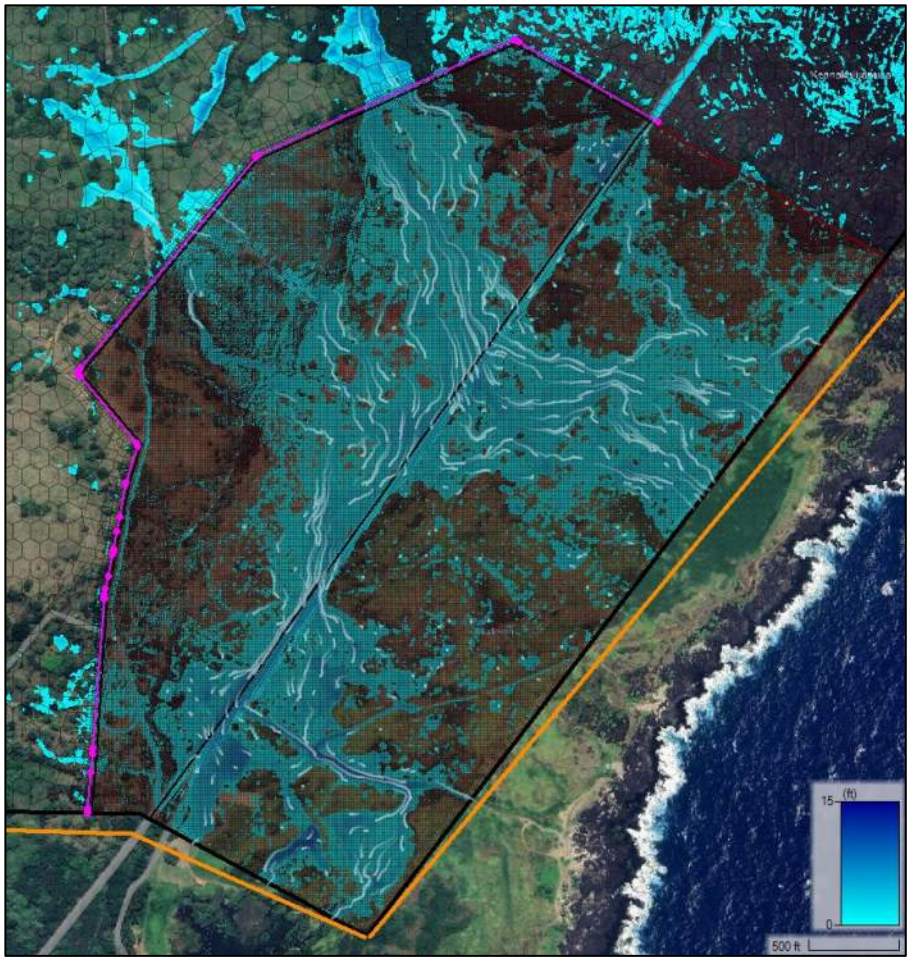


Figure 2-10. Flow Entering MP 60 Study Area

2.4.1.2 Outflows

Flows approaching the downstream boundary of the model domain will exit via a normal depth boundary condition with a friction slope of 0.02 ft/ft. The boundary condition was located approximately 2000 feet and 1400 feet makai of Hwy. 11 at MP 58.7 and MP 60, respectively; this ensures that the normal depth settings do not propagate upstream and impact the results in the vicinity of Hwy. 11.

3. Existing Conditions Hydraulics Results

The existing conditions hydraulics analyses establish the baseline characteristics of the study area; in addition to helping form an overall numerical understanding of the factors impacting the MPs, it also serves as a tool to evaluate the impacts and effectiveness of the proposed mitigation alternatives. This section presents the results of the simulations under existing conditions, highlighting velocities, depths, water surface elevations, and areas of potential flooding.

3.1. Design Storm Events

3.1.1. 50-year Event

At MP 60, the flow crosses the roadway at multiple locations and continues makai to the downstream extents of the model domain. The depth of water varies from approximately one foot to a maximum of six feet along the Hwy. 11 profiles (see Figure 3-1). The maximum velocities of approximately 20 feet per second (ft/s) largely occur mauka from Hwy. 11, as the flow travels down the steep terrain towards the roadway; in general, the velocities across Hwy. 11 are less than 10 ft/s.

See Exhibits 1 and 2 in Appendix B for the maximum 50-year depth (with water surface elevation contours) and velocity maps, respectively.

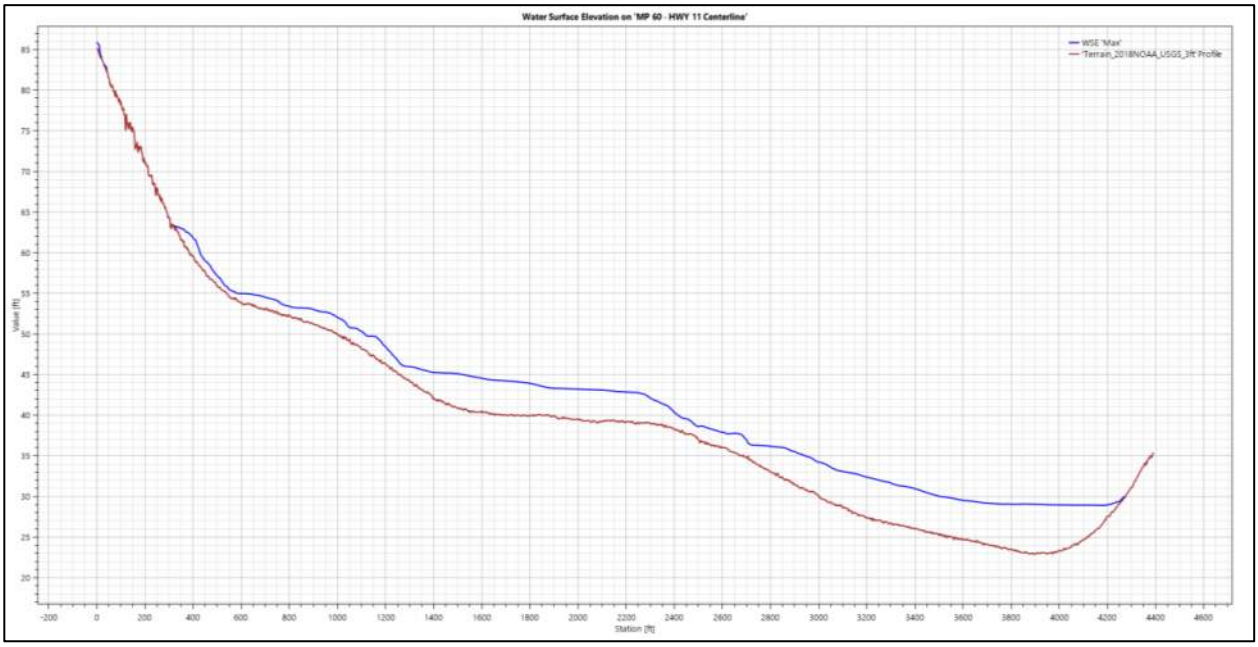


Figure 3-1. Water Surface Elevation Across the Hwy. 11 Centerline at MP 60

Figure 3-2. Profile Station Map for Figure 3-1 (MP 60)

At MP 58.7, similar to MP 60, runoff completely overtops Hwy. 11 as it travels makai with a maximum depth of approximately 12 feet (see Figure 3-3). Across Hwy. 11, the maximum velocities generally do not exceed eight ft/s. See Exhibits 3 and 4 in Appendix B for the maximum 50-year depth (with water surface elevation contours) and velocity maps, respectively.

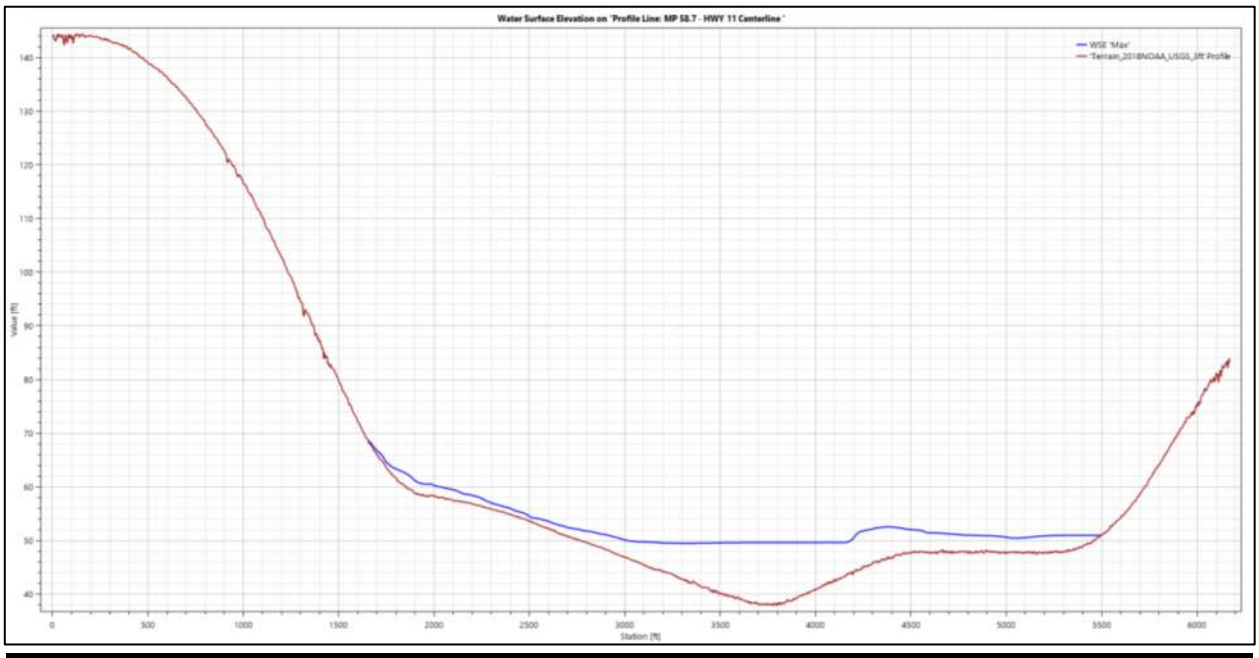


Figure 3-3. Water Surface Elevation Across the Hwy. 11 Centerline at MP 58.7

Figure 3-4. Profile Station Map for Figure 3-3 (MP 58.7)

3.2. Model Sensitivity

This section presents the sensitivity analyses conducted during both the hydrologic and hydraulic model development process. This analysis helps identify the solution convergence under the least computationally exhaustive model setup. The following sensitivity analyses were conducted:

- Computational Mesh: The background hexagonal grid cell size was simulated at 120-, 110-, 100-, 90-, and 75-feet; peak flow convergence was satisfied at 100 feet. In the vicinity of the MP sites, refinement regions were simulated with 30-, 20-, and 10-foot square cells. Ultimately, the 10-foot square cells were selected in these areas.
- Downstream boundary condition: Several normal depth friction slopes and tidal conditions (i.e., a known water surface elevation) were simulated; flooding and peak flows along Hwy. 11 at the MP sites were unaffected.
- Manning's *n*-values: Three sets of Manning's *n*-values were simulated in the hydrology model.
    - 0.15 throughout the entire model domain.
    - 0.15 within the floodplain and 0.05 in concentrated flow paths.
    - Based on land use/cover.

  Ultimately, Mannings *n*-values based on land use/cover were selected. Discussions with SSFM during the preliminary stages of model development indicated depths may be higher than anecdotally expected. Consequently, and subject to additional validation, the Manning's *n*-values based on land cover/use were typically set to the lower end of acceptable ranges.

- Computational interval (time step): The time step was refined during the model development to reduce the water surface errors within their set tolerance. This sensitivity analysis was more applicable to the hydraulic model because of the increased governing equation set rigor.
- Curve numbers: The curve number variability was explored for predominate land covers (e.g., scrub-shrub) through consideration of cover quality (i.e., poor, fair, or good).

3.3. Model Validation

The details of the procedures and results of the model validation efforts are discussed herein; by comparing the simulated results with independent calculations and observed data, the model's capability to replicate real-world conditions and natural processes can be assessed. This not only reinforces the credibility of the model, but also identifies any discrepancies and areas for improvement.

Unfortunately, this study is not equipped with streamflow and precipitation gages; making model validation challenging. Regardless, WEST attempted order-of-magnitude checks using USGS peak flow regression equations and a recent storm from August 2024.

3.3.1. Peak Flow Comparison

The 50-year peak flow rates from the hydraulic model were compared to the current USGS regression equations (USGS, 2023) for the delineated watersheds at the MPs (see Table 3-1). The 50-year peak flow rate at MP 60 is from a single watershed, while the peak flow value for MP 58.7 is the sum of the three tributary watersheds that contribute flow (see Section 2.1.1). When considering both MPs, the 50-year hydraulic model peak flow rates are approximately two to four times higher; however, given the uncertainty of the regression equations (e.g., average standard prediction error of 156 percent) and the fact that the hydraulic model results fell within the 90 percent confidence interval of the regression equations, WEST deemed these differences acceptable.

Table 3-1. Peak Flow Comparison

MP Site	50-Year Peak Flow (cfs)	
	Hydraulic Model[1]	USGS Regression Equations
58.7	10,839	5,810
60	4,124	1,090

[1] The hydraulic model peak flows were extracted at the coordinates used to generate the StreamStats report(s).

3.3.2. August 2024 Storm Event

The H&H modeling simulation for the August 2024 storm event produced a maximum depth of approximately eight feet at MP 58.7 (see Figure 3-5). The post-event reconnaissance performed by others documented details of the flooding conditions through video capture, photographs, and field notes. From debris deposition on Hwy. 11 at MP 58.7, the maximum water depth was estimated to be approximately six feet.

Although the model produces a maximum depth approximately two feet greater than what was estimated in the field, it is likely that the observed debris accumulation does not reflect the peak flooding level at Hwy. 11; remnant sedimentation levels are often produced during the relatively quiescent flow occurring during the falling hydrograph limb and thus may tend to underestimate the maximum depth of flooding. In consideration of these measurements and other factors that complicate replicating actual storm events, WEST believes the differences are within realistic tolerance ranges.

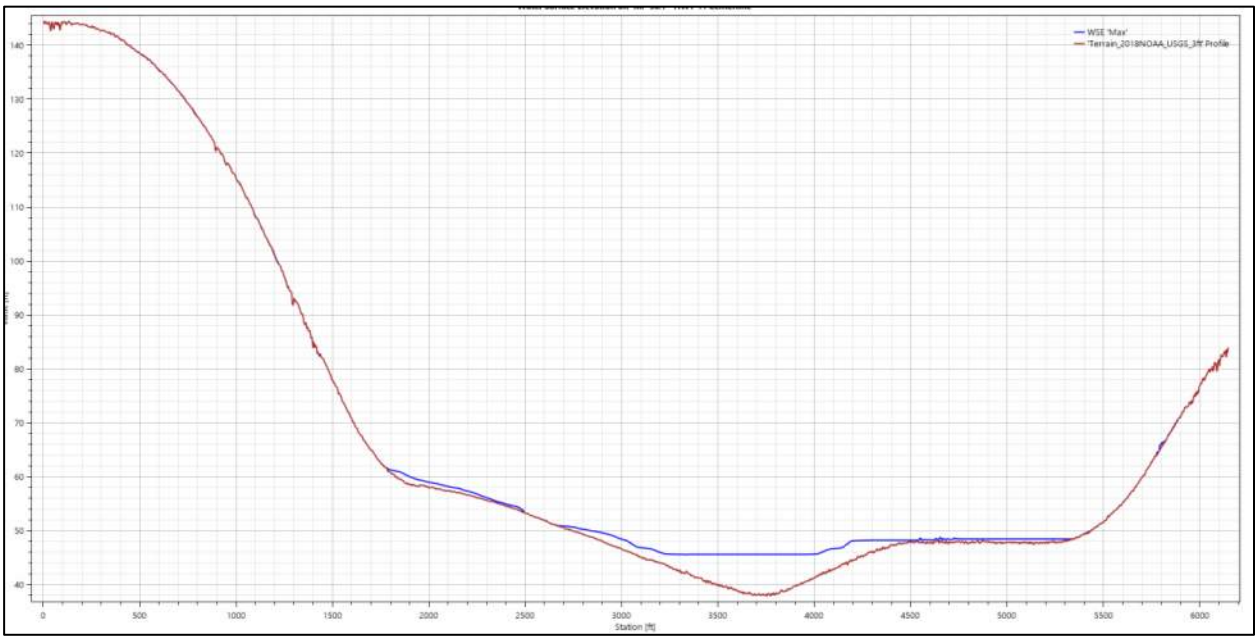


Figure 3-5. Water Surface Elevation and Existing Terrain along Hwy. 11 Centerline at MP 58.7

4. Proposed Drainage Improvement Alternatives

The identified proposed drainage improvement alternatives were segregated by MP and outlined within their respective sections below.

4.1. Mile Post 60

4.1.1. Alternative 1

In this alternative, Hwy. 11 was raised approximately eight to ten feet above the existing grade, for approximately 3,400 feet, to span the 50-year floodplain identified in the hydraulics model (see Figure 4-1).

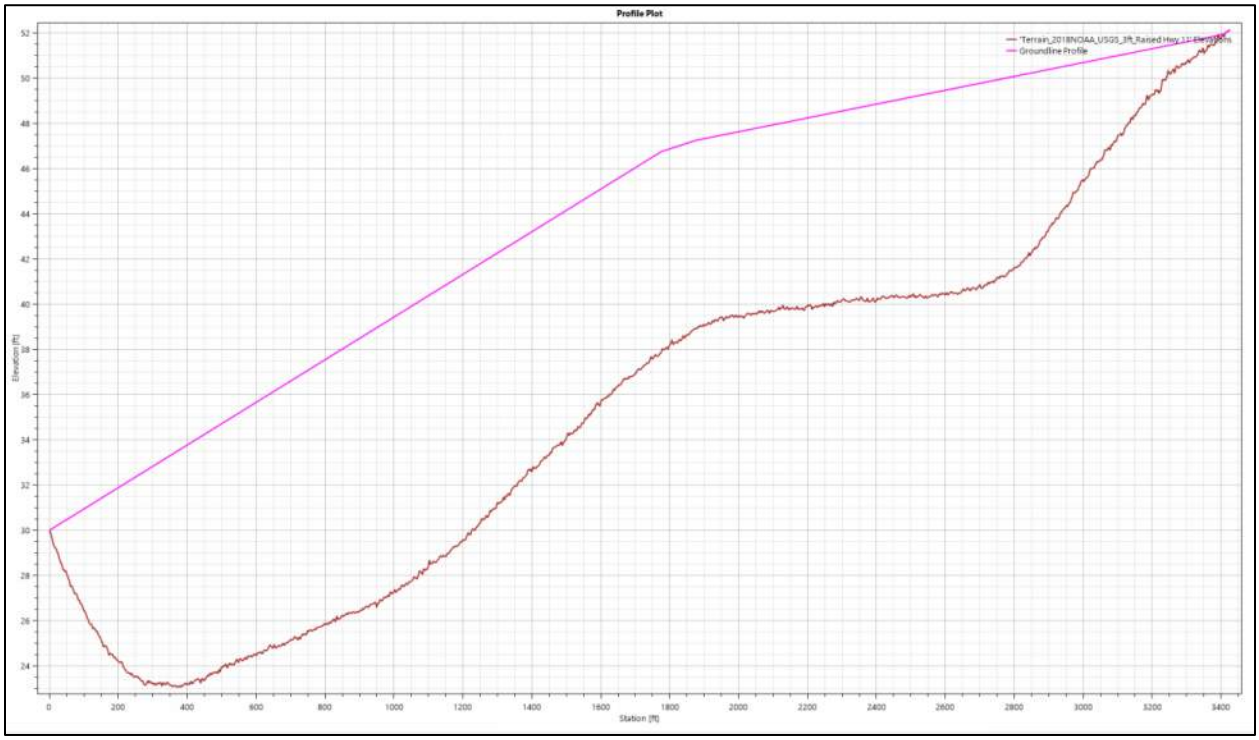


Figure 4-1. Raised Hwy. 11 Profile and Existing Terrain at MP 60

For a majority of the proposed profile, the results show that Hwy. 11 remains dry. As can be seen in Figure 4-1, the general terrain grade trends southerly (right to left in Figure 4-1). Therefore, the water that flows southeasterly in the existing conditions, is now impounded by the raised Hwy. 11 and travels southwesterly. The additional flow piles up to maximum depths of approximately 14 feet, which creates an overtopping condition; specifically, approximately 600 feet of the southern portion of the raised Hwy. 11 experiences overtopping depths that vary up to a maximum of approximately three feet.

See Exhibits 5 and 6 in Appendix B for the maximum 50-year depths and velocity maps, respectively.

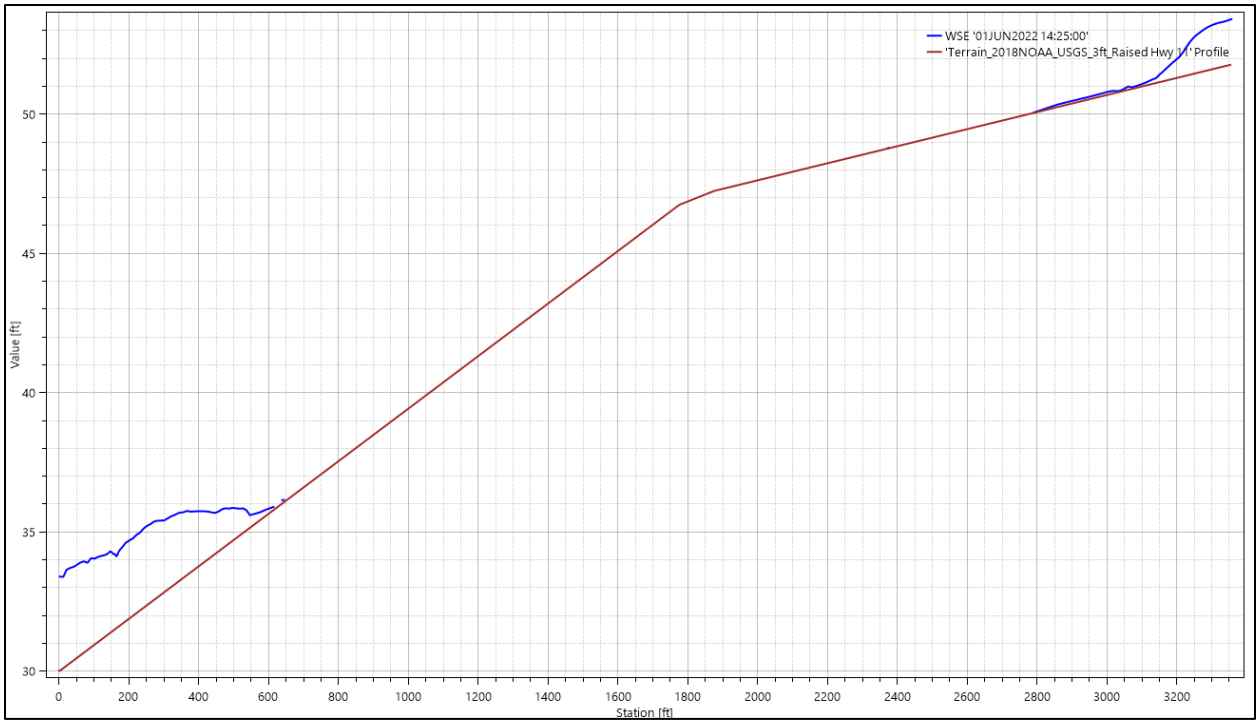


Figure 4-2. Water Surface Elevation and Raised Hwy. 11 Terrain along Centerline at MP 60

4.1.2. Alternative 2

This alternative adds 6 – 12-foot x 6-foot RCBs to the proposed Hwy. 11 fill used in Alternative 1; the culverts were placed approximately 2,200 feet from the southern tie-in, which is generally in line with the incoming tributary flow. The model results indicate that the culverts help to slightly improve the upstream ponding condition noted in Alternative 1; comparatively, the water overtopping the southern raised section of Hwy. 11 is reduced within a range of approximately 0.2 feet to 0.5 feet.

At the outlet of the culverts, channelization occurs at the toe of the raised Hwy. 11 which conveys water parallel to the proposed fill before continuing downstream. Because of the lack of flow release, this tailwater ponding likely influences the effectiveness of the culverts. Thus, the exploration of grading in this area may be warranted as part of future work.

It is also worth noting that the southwesterly flow direction and runoff coalescence near the proposed southern tie-in location promotes future consideration of additional culverts and modifications to Hwy. 11 in this area.

See Exhibits 7 and 8 in Appendix B for the maximum 50-year depths and velocity maps, respectively.

4.1.3. Alternative 3

In this alternative, flow impoundment in the form of a retention or detention basin mauka of Hwy. 11 was explored. To enhance a basin's effectiveness, it should ideally be located just upstream of Hwy. 11 to maximize the potential for runoff capture. Thus, for the purposes of these analyses, that siting criterion was used. WEST understands that the State does not currently own the land necessary for placement of basin(s) in this area; nevertheless, WEST felt it constructive to understand preliminary design implications assuming drainage easements could be obtained.

To determine the approximate footprint needed for the basin(s), the following steps were implemented:

- Quantify the water capture volume: This was accomplished by extracting the tributary 50-year inflow volume to the proposed basin area from the hydraulics model (see Figure 4-3). The volume of approximately 4,238 ac-ft is reflective of the 18-hour simulation runtime; while this is less than the entire 24-hour duration, it captures the peak flow and indirectly accounts for detention conditions where runoff is not only retained, but attenuated and released.

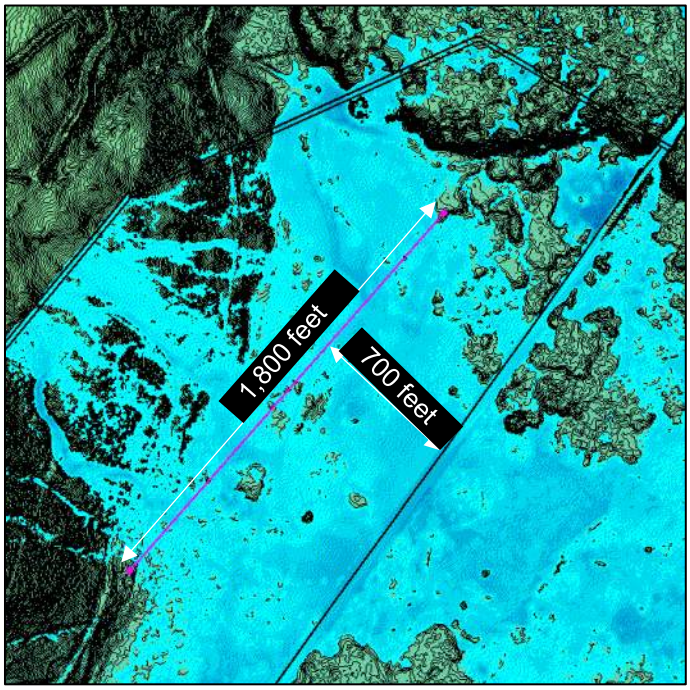


Figure 4-3. Proposed Basin Area for Alternative 3

- Identify the basin width: The respective 50-year floodplain widths were identified as this assumes complete capture of tributary flows without additional conveyance features (e.g., channels or levees). From the hydraulics model, this width was approximately 1,800 feet.

- Select a design depth: This value is subjective and contingent upon various design objectives. In recognition of this analysis being at the feasibility stage, a value of ten feet was chosen.

- Determine the basin length (in the flow direction): From the inflow volume, width, and selected depth, the basin length was determined to be approximately 10,250 feet.

When the basin length of 10,250 feet is compared to the available distance (i.e., from the inflow line to Hwy. 11) of approximately 700 feet, a significant shortfall is noted. While this is based on preliminary assumptions and parameters which can be varied myriad ways, the potential relative lack of adequacy is underscored when compared to Alternative 1 and Alternative 2.

4.2. Mile Post 58.7

4.2.1. Alternative 1

This alternative was based on the previous Hwy. 11 drainage improvement plans from July 2018 (Federal Aid Project No. STP-011-2(36)). Specific to the WEST analyses:

- Hwy. 11 was raised for a length of approximately 1,200 feet, to a maximum elevation of approximately 48 feet (NGVD88); the roadway tie-in locations were at approximate elevations of 47 feet and 45 feet at the north and south ends, respectively (see Figure 4-4). This proposed profile effectively represents a maximum fill of approximately ten feet above the existing terrain.

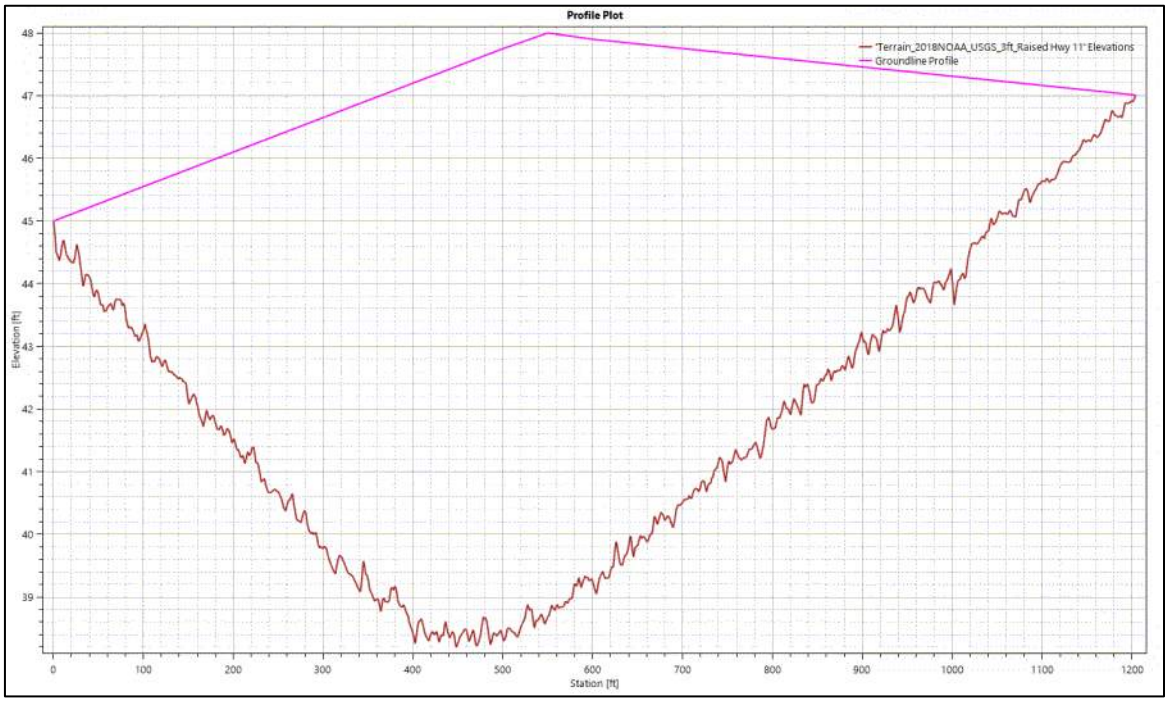


Figure 4-4. Raised Hwy. 11 Profile at MP 58.7

- 6 – 12-foot x 8-foot reinforced concrete box (RCB) culverts were added approximately 500 feet north of the southern roadway tie-in; this location also represents the approximate low-point makau of Hwy. 11 to improve drainage efficiency.

- Minor grading was included in the model at the upstream and downstream culvert faces to promote positive drainage.

The model results indicate approximately two feet of inundation across the proposed Hwy. 11 profile; the peak flows occur at approximately hour 13 of the simulation and are summarized in Table 2-1. Please note that all of the included peak flows were extracted directly from the hydraulic model; the total culvert plus Hwy. 11 overtopping won't necessarily exactly equal the upstream flow due primarily to timing and divergent flow patterns.

Table 4-1. MP 58.7 Alternative 1 Peak Flow Comparison

MP Site	50-year Peak Flow (cfs)
Upstream of Hwy. 11	12,411
Total Through Culverts	3,845
Hwy. 11 Overtopping	8,922

See Exhibits 9 and 10 in Appendix B for the maximum 50-year depths and velocity maps, respectively.

5. Summary and Conclusions

Hwy. 11 has historically, and most likely will continue to, experience inundation events that prevent safe passage of vehicular and pedestrian-type traffic. Two locations, MP 58.7 and MP 60, were specifically recognized as locations of concern. This study investigated the existing flooding conditions using numerical models. Preliminary alternatives to mitigate the impacts of runoff at these locations were also evaluated.

The first step in these analyses was to quantify the flow rates and volumes tributary to the two MPs using ROG methodology implemented in a 2D HEC-RAS environment. To that end, the approximately 15.8 square-mile and 25.5 square-mile watersheds at MP 58.7 and MP 60, respectively, were modeled for the 50-year, 24-hour design storm event. Order-of-magnitude hydrologic model validation and calibration checks were performed using regional regression equations and the recent August 2024 storm event that resulted in the flooding and temporary closure of Hwy. 11.

From the hydrologic model, hydrographs were extracted and input as upstream boundary conditions to the hydraulics model(s); two categories of hydraulics models were developed in HEC-RAS for the 50-year storm event: 1. An existing conditions model and, 2. Proposed conditions models. The existing conditions model established baseline results (e.g., depths and velocities) to compare against the proposed conditions models.

The proposed conditions models consisted of three drainage improvement alternatives at MP 60 and one alternative at MP 58.7 to mitigate the 50-year design storm. At MP 60, the following alternatives were analyzed:

- Alternative 1: Raising Hwy. 11 to prevent overtopping.
- Alternative 2: Adding culverts to the elevated Hwy. 11 (using the Alternative 1 proposed Hwy. 11 profile).
- Alternative 3: Preliminary retention/detention basin sizing.

At MP 58.7, the previously proposed improvements of raising Hwy. 11 with six - 6 – 12-foot x 8-foot RCBs near the stream channel thalweg were modeled to understand their effectiveness considering the updated hydrology.

When the three presented alternatives at MP 60 are compared, Alternative 2 presents the best opportunity to create dry-lane availability at Hwy. 11. WEST understands that the degree to which the roadway flooding is satisfactorily mitigated (e.g., considering inundation extents, depths, flooding duration, etc.) is subjective; in that vein, Alternative 2 should not be considered final, but as a solid foundation for future evaluation and potential revisions as the design progresses and other driving factors are considered.

The design modeled at MP 58.7 resulted in 50-year overtopping depths of approximately two feet. To reduce these flooding depths, increasing the culvert sizes and/or further modifying the Hwy. 11 profile is recommended. Runoff diversions upstream in the watershed could also be explored, however, care must be taken to ensure that flooding is not increased at other locations.

Considering the feasibility stage of these analyses, WEST anticipates that the presented alternatives will be revised as part of future work; these may include, but are not limited to, changes to the structural configuration (e.g., location, quantity, and size of culverts) and/or alternative grouping scenarios (e.g., detention combined with culvert conveyance). Additionally, bracketing design storm events, such as the 2-year and 100-year frequencies, may also be analyzed to understand the performance variability of the proposed alternatives.

6. References

Chow, V.T., D.R. Maidment, and L.W. Mays (1988). Applied hydrology. McGraw Hill Book Company, New York, NY.

FEMA (2017). Flood Insurance Study, Hawaii Country, Hawaii. Federal Emergency Management Agency (FEMA).

Google Earth (2024). Imagery Date November 19, 2023, accessed July 2024.

NOAA (2024a). Office for Coastal Management: NOAA's Coastal Change Analysis Program (C-CAP) 2010 Regional Land Cover Data - Coastal United States, online at https://coast.noaa.gov/digitalcoast/data/ccaphighres.html, accessed July 2024.

NOAA (2024b). National Oceanic and Atmospheric Administration (NOAA), Hydrometeorological Design Studies Center Precipitation Frequency Data Server (PFDS) NOAA Atlas 14 Time Series Data. NOAA's National Weather Service, online at https://hdsc.nws.noaa.gov/hdsc/pfds/pfds_series.html, accessed July 2024.

NOAA-USGS (2024). 2018 - 2020 NOAA USGS Lidar: Hawaii, HI, online at https://noaa-nos-coastal-lidar-pds.s3.amazonaws.com/laz/geoid12b/9635/index.html, accessed July 2024.

USACE (2023). HEC-RAS 2D User's Manual.

USDA (1986). TR 55 Urban Hydrology for Small Watersheds. USDA Natural Resource Conservation Service.

USDA (2009). Part 630 Hydrology National Engineering handbook: Chapter 7 Hydrologic Soil Groups. USDA Natural Resource Conservation Service.

USDA (2024). U.S. Department of Agriculture (USDA) Natural Resources Conservation Service, Soil Survey Geographic Database: Hawaii, online at https://websoilsurvey.sc.egov.usda.gov/App/HomePage.htm, accessed July 2024.

USGS (2023). Mitchell, J.N., Wagner, D.M., and Veilleux, A.G. Magnitude and frequency of floods on Kaua'i, O'ahu, Moloka'i, Maui, and Hawai'i, State of Hawai'i, based on data through water year 2020. USGS Scientific Investigations Report 2023-5014.

U.S. Weather Bureau (1962). Technical Paper No. 43, Rainfall-Frequency Atlas of the Hawaiian Islands for Areas to 200 Square Miles, Durations to 24 Hours, and Return Periods from 1 to 100 Years. U.S. Weather Bureau, Washington D.C.

Appendix A:
Hydrology Model Results and Supporting Data

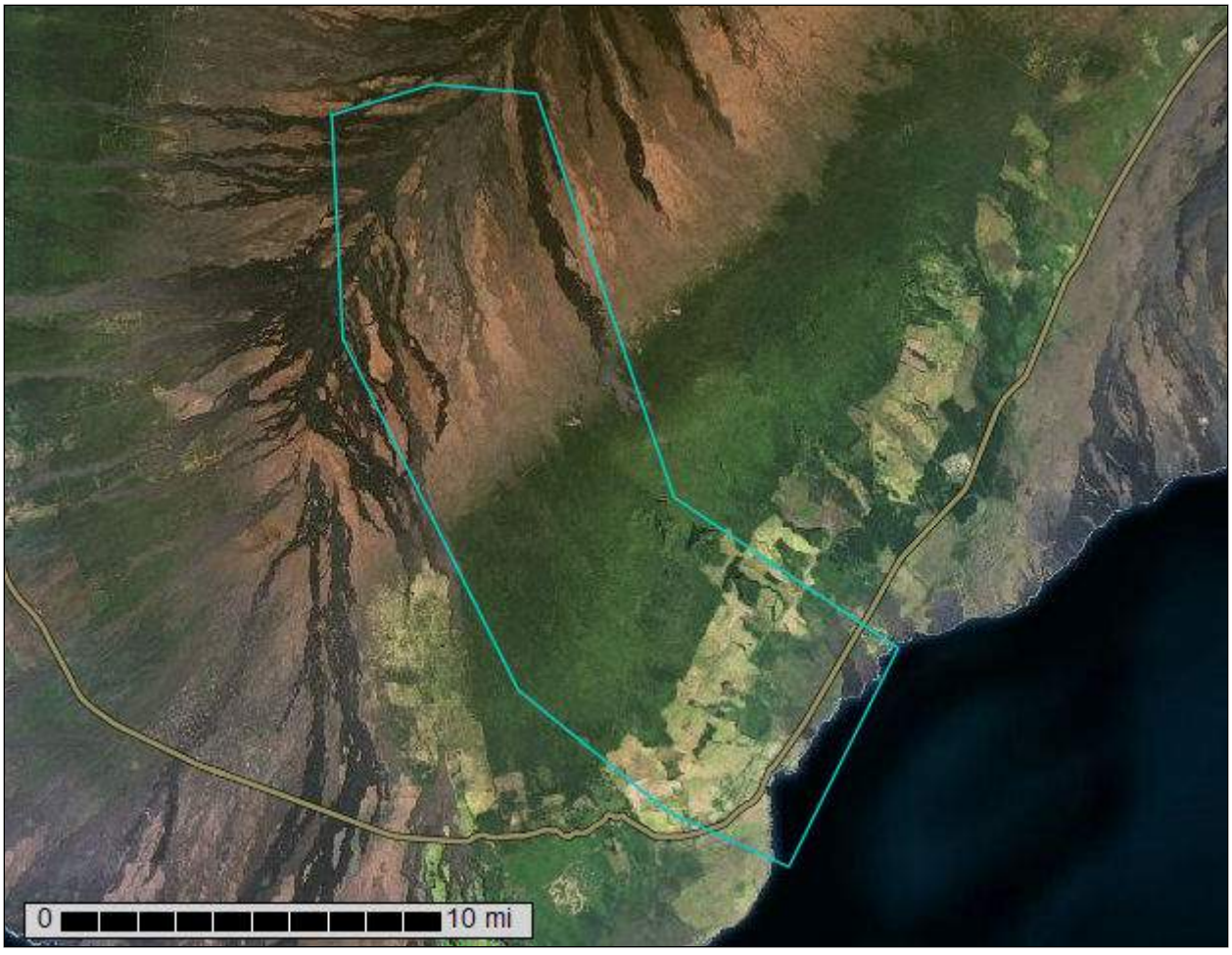
Exhibit 1

United States Department of Agriculture

Natural Resources Conservation Service

A product of the National Cooperative Soil Survey, a joint effort of the United States Department of Agriculture and other Federal agencies, State agencies including the Agricultural Experiment Stations, and local participants

Custom Soil Resource Report for Hawaii Volcanoes National Park, Hawaii, and Island of Hawaii Area, Hawaii



June 27, 2024

Preface

Soil surveys contain information that affects land use planning in survey areas. They highlight soil limitations that affect various land uses and provide information about the properties of the soils in the survey areas. Soil surveys are designed for many different users, including farmers, ranchers, foresters, agronomists, urban planners, community officials, engineers, developers, builders, and home buyers. Also, conservationists, teachers, students, and specialists in recreation, waste disposal, and pollution control can use the surveys to help them understand, protect, or enhance the environment.

Various land use regulations of Federal, State, and local governments may impose special restrictions on land use or land treatment. Soil surveys identify soil properties that are used in making various land use or land treatment decisions. The information is intended to help the land users identify and reduce the effects of soil limitations on various land uses. The landowner or user is responsible for identifying and complying with existing laws and regulations.

Although soil survey information can be used for general farm, local, and wider area planning, onsite investigation is needed to supplement this information in some cases. Examples include soil quality assessments (http://www.nrcs.usda.gov/wps/portal/nrcs/main/soils/health/) and certain conservation and engineering applications. For more detailed information, contact your local USDA Service Center (https://offices.sc.egov.usda.gov/locator/app?agency=nrcs) or your NRCS State Soil Scientist (http://www.nrcs.usda.gov/wps/portal/nrcs/detail/soils/contactus/?cid=nrcs142p2_053951).

Great differences in soil properties can occur within short distances. Some soils are seasonally wet or subject to flooding. Some are too unstable to be used as a foundation for buildings or roads. Clayey or wet soils are poorly suited to use as septic tank absorption fields. A high water table makes a soil poorly suited to basements or underground installations.

The National Cooperative Soil Survey is a joint effort of the United States Department of Agriculture and other Federal agencies, State agencies including the Agricultural Experiment Stations, and local agencies. The Natural Resources Conservation Service (NRCS) has leadership for the Federal part of the National Cooperative Soil Survey.

Information about soils is updated periodically. Updated information is available through the NRCS Web Soil Survey, the site for official soil survey information.

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Contents

How Soil Surveys Are Made

Soil surveys are made to provide information about the soils and miscellaneous areas in a specific area. They include a description of the soils and miscellaneous areas and their location on the landscape and tables that show soil properties and limitations affecting various uses. Soil scientists observed the steepness, length, and shape of the slopes; the general pattern of drainage; the kinds of crops and native plants; and the kinds of bedrock. They observed and described many soil profiles. A soil profile is the sequence of natural layers, or horizons, in a soil. The profile extends from the surface down into the unconsolidated material in which the soil formed or from the surface down to bedrock. The unconsolidated material is devoid of roots and other living organisms and has not been changed by other biological activity.

Currently, soils are mapped according to the boundaries of major land resource areas (MLRAs). MLRAs are geographically associated land resource units that share common characteristics related to physiography, geology, climate, water resources, soils, biological resources, and land uses (USDA, 2006). Soil survey areas typically consist of parts of one or more MLRA.

The soils and miscellaneous areas in a survey area occur in an orderly pattern that is related to the geology, landforms, relief, climate, and natural vegetation of the area. Each kind of soil and miscellaneous area is associated with a particular kind of landform or with a segment of the landform. By observing the soils and miscellaneous areas in the survey area and relating their position to specific segments of the landform, a soil scientist develops a concept, or model, of how they were formed. Thus, during mapping, this model enables the soil scientist to predict with a considerable degree of accuracy the kind of soil or miscellaneous area at a specific location on the landscape.

Commonly, individual soils on the landscape merge into one another as their characteristics gradually change. To construct an accurate soil map, however, soil scientists must determine the boundaries between the soils. They can observe only a limited number of soil profiles. Nevertheless, these observations, supplemented by an understanding of the soil-vegetation-landscape relationship, are sufficient to verify predictions of the kinds of soil in an area and to determine the boundaries.

Soil scientists recorded the characteristics of the soil profiles that they studied. They noted soil color, texture, size and shape of soil aggregates, kind and amount of rock fragments, distribution of plant roots, reaction, and other features that enable them to identify soils. After describing the soils in the survey area and determining their properties, the soil scientists assigned the soils to taxonomic classes (units). Taxonomic classes are concepts. Each taxonomic class has a set of soil characteristics with precisely defined limits. The classes are used as a basis for comparison to classify soils systematically. Soil taxonomy, the system of taxonomic classification used in the United States, is based mainly on the kind and character of soil properties and the arrangement of horizons within the profile. After the soil

scientists classified and named the soils in the survey area, they compared the individual soils with similar soils in the same taxonomic class in other areas so that they could confirm data and assemble additional data based on experience and research.

The objective of soil mapping is not to delineate pure map unit components; the objective is to separate the landscape into landforms or landform segments that have similar use and management requirements. Each map unit is defined by a unique combination of soil components and/or miscellaneous areas in predictable proportions. Some components may be highly contrasting to the other components of the map unit. The presence of minor components in a map unit in no way diminishes the usefulness or accuracy of the data. The delineation of such landforms and landform segments on the map provides sufficient information for the development of resource plans. If intensive use of small areas is planned, onsite investigation is needed to define and locate the soils and miscellaneous areas.

Soil scientists make many field observations in the process of producing a soil map. The frequency of observation is dependent upon several factors, including scale of mapping, intensity of mapping, design of map units, complexity of the landscape, and experience of the soil scientist. Observations are made to test and refine the soil-landscape model and predictions and to verify the classification of the soils at specific locations. Once the soil-landscape model is refined, a significantly smaller number of measurements of individual soil properties are made and recorded. These measurements may include field measurements, such as those for color, depth to bedrock, and texture, and laboratory measurements, such as those for content of sand, silt, clay, salt, and other components. Properties of each soil typically vary from one point to another across the landscape.

Observations for map unit components are aggregated to develop ranges of characteristics for the components. The aggregated values are presented. Direct measurements do not exist for every property presented for every map unit component. Values for some properties are estimated from combinations of other properties.

While a soil survey is in progress, samples of some of the soils in the area generally are collected for laboratory analyses and for engineering tests. Soil scientists interpret the data from these analyses and tests as well as the field-observed characteristics and the soil properties to determine the expected behavior of the soils under different uses. Interpretations for all of the soils are field tested through observation of the soils in different uses and under different levels of management. Some interpretations are modified to fit local conditions, and some new interpretations are developed to meet local needs. Data are assembled from other sources, such as research information, production records, and field experience of specialists. For example, data on crop yields under defined levels of management are assembled from farm records and from field or plot experiments on the same kinds of soil.

Predictions about soil behavior are based not only on soil properties but also on such variables as climate and biological activity. Soil conditions are predictable over long periods of time, but they are not predictable from year to year. For example, soil scientists can predict with a fairly high degree of accuracy that a given soil will have a high water table within certain depths in most years, but they cannot predict that a high water table will always be at a specific level in the soil on a specific date.

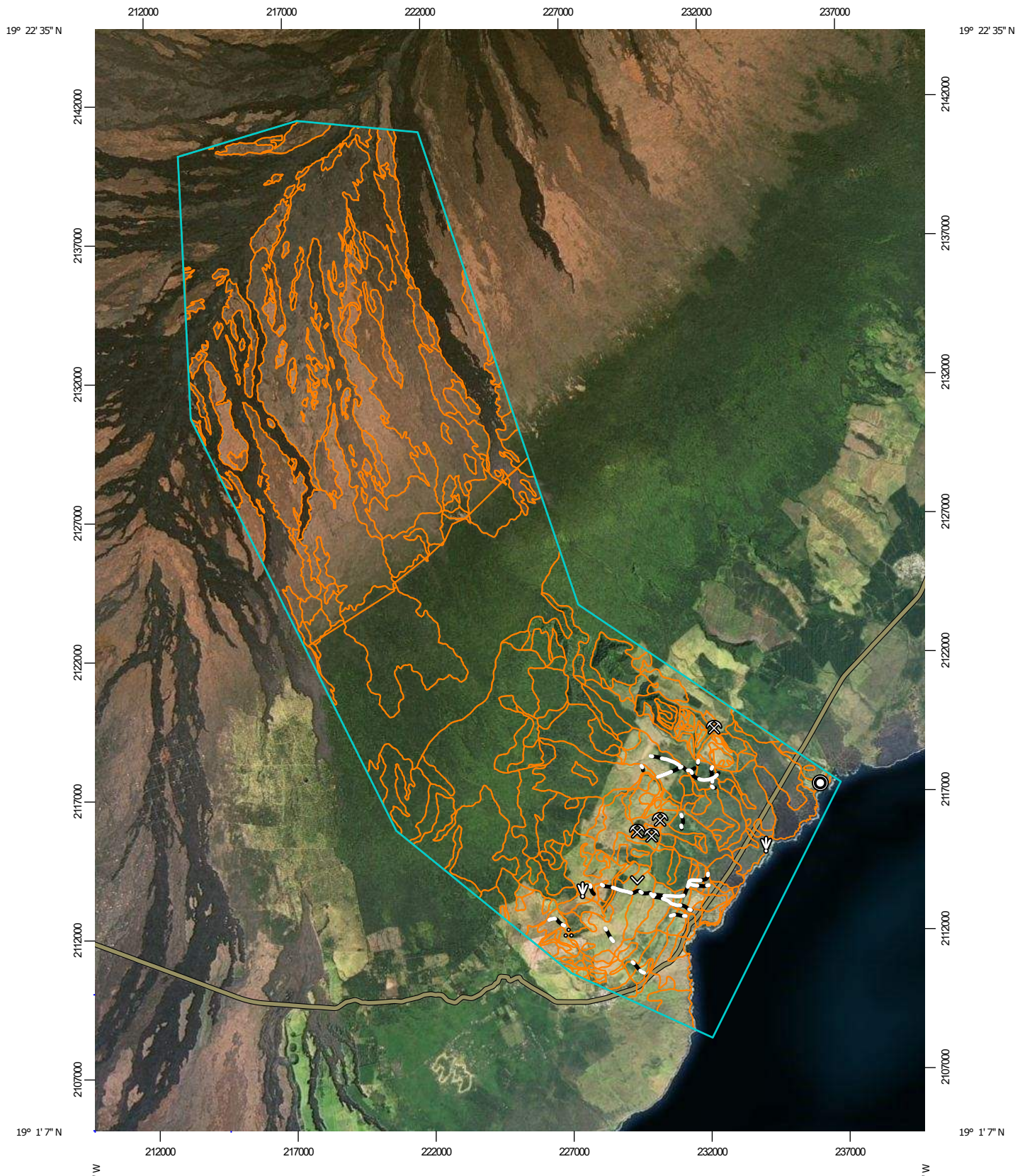
After soil scientists located and identified the significant natural bodies of soil in the survey area, they drew the boundaries of these bodies on aerial photographs and

identified each as a specific map unit. Aerial photographs show trees, buildings, fields, roads, and rivers, all of which help in locating boundaries accurately.

Soil Map

The soil map section includes the soil map for the defined area of interest, a list of soil map units on the map and extent of each map unit, and cartographic symbols displayed on the map. Also presented are various metadata about data used to produce the map, and a description of each soil map unit.

Custom Soil Resource Report
Soil Map



Map Scale: 1:194,000 if printed on A portrait (8.5" x 11") sheet.

N

Meters
0 2500 5000 10000 15000

Feet
0 5000 10000 20000 30000

Map projection: Web Mercator Corner coordinates: WGS84 Edge tics: UTM Zone 5N WGS84

MAP LEGEND

Area of Interest (AOI)
- Area of Interest (AOI)

Soils
- Soil Map Unit Polygons
- Soil Map Unit Lines
- Soil Map Unit Points

Special Point Features
- Blowout
- Borrow Pit
- Clay Spot
- Closed Depression
- Gravel Pit
- Gravelly Spot
- Landfill
- Lava Flow
- Marsh or swamp
- Mine or Quarry
- Miscellaneous Water
- Perennial Water
- Rock Outcrop
- Saline Spot
- Sandy Spot
- Severely Eroded Spot
- Sinkhole
- Slide or Slip
- Sodic Spot
- Spoil Area
- Stony Spot
- Very Stony Spot
- Wet Spot
- Other
- Special Line Features

Water Features
- Streams and Canals

Transportation
- Rails
- Interstate Highways
- US Routes
- Major Roads
- Local Roads

Background
- Aerial Photography

MAP INFORMATION

The soil surveys that comprise your AOI were mapped at 1:24,000.

Please rely on the bar scale on each map sheet for map measurements.

Source of Map: Natural Resources Conservation Service
Web Soil Survey URL:
Coordinate System: Web Mercator (EPSG:3857)

Maps from the Web Soil Survey are based on the Web Mercator projection, which preserves direction and shape but distorts distance and area. A projection that preserves area, such as the Albers equal-area conic projection, should be used if more accurate calculations of distance or area are required.

This product is generated from the USDA-NRCS certified data as of the version date(s) listed below.

Soil Survey Area: Hawaii Volcanoes National Park, Hawaii
Survey Area Data: Version 13, Sep 8, 2023

Soil Survey Area: Island of Hawaii Area, Hawaii
Survey Area Data: Version 16, Sep 8, 2023

Your area of interest (AOI) includes more than one soil survey area. These survey areas may have been mapped at different scales, with a different land use in mind, at different times, or at different levels of detail. This may result in map unit symbols, soil properties, and interpretations that do not completely agree across soil survey area boundaries.

Soil map units are labeled (as space allows) for map scales 1:50,000 or larger.

Date(s) aerial images were photographed: Jan 1, 1999—Dec 31, 2003

The orthophoto or other base map on which the soil lines were compiled and digitized probably differs from the background

MAP LEGEND

MAP INFORMATION

imagery displayed on these maps. As a result, some minor shifting of map unit boundaries may be evident.

Map Unit Legend

Map Unit Symbol	Map Unit Name	Acres in AOI	Percent of AOI
10	Lava flows, `a`a, 2 to 20 percent slopes	20,391.1	22.9%
12	Lava flows, pahoehoe, 2 to 20 percent slopes	7,372.7	8.3%
14	Lava flows complex, 2 to 20 percent slopes	9,297.5	10.5%
16	Cinder land, 20 to 40 percent slopes	7.8	0.0%
164	Lava flows-Kekake complex, 2 to 20 percent slopes	145.7	0.2%
169	Iwalani-Lava flows complex, moist, 2 to 10 percent slopes	51.0	0.1%
401	Ihuanu-Lava flows, `a`a complex, 10 to 20 percent slopes, MLRA 160	449.4	0.5%
402	Ihuanu very cobbly medial silt loam, 10 to 20 percent slopes, MLRA 160	391.4	0.4%
403	Ihuanu very cobbly medial silt loam, 2 to 10 percent slopes, MLRA 160	340.0	0.4%
406	Lava flows-Iwalani complex, 10 to 20 percent slopes	336.3	0.4%
407	Iwalani-Lava flows complex, 2 to 10 percent slopes	799.9	0.9%
408	Iwalani-Lava flows complex, 10 to 20 percent slopes	118.1	0.1%
515	Pahipa-Puali association, 2 to 20 percent slopes	341.2	0.4%
519	Lalaau very cobbly highly decomposed plant material, 2 to 10 percent slopes	238.9	0.3%
534	Kahaluu-Lava flows complex, 2 to 10 percent slopes	184.6	0.2%
Subtotals for Soil Survey Area		**40,465.6**	**45.5%**
Totals for Area of Interest		**88,942.7**	**100.0%**

Map Unit Symbol	Map Unit Name	Acres in AOI	Percent of AOI
10	Lava flows, `a`a, 2 to 20 percent slopes	1,156.8	1.3%
12	Lava flows, pahoehoe, 2 to 20 percent slopes	48.0	0.1%
169	Iwalani-Lava flows complex, moist, 2 to 10 percent slopes	21.7	0.0%

Map Unit Symbol	Map Unit Name	Acres in AOI	Percent of AOI
271	Lava flows-Kanohina complex, 2 to 20 percent slopes	840.9	0.9%
272	Kanohina ashy very fine sandy loam, 2 to 10 percent slopes	439.1	0.5%
402	Ihuanu very cobbly medial silt loam, 10 to 20 percent slopes, MLRA 160	6.3	0.0%
403	Ihuanu very cobbly medial silt loam, 2 to 10 percent slopes, MLRA 160	6.6	0.0%
407	Iwalani-Lava flows complex, 2 to 10 percent slopes	4.4	0.0%
511	Akihi very cobbly hydrous silt loam, 10 to 20 percent slopes, MLRA 159B	1,740.6	2.0%
512	Akihi very cobbly hydrous silt loam, 2 to 10 percent slopes, MLRA 159B	1,194.7	1.3%
513	Hilea hydrous silty clay loam, 10 to 20 percent slopes	5,329.8	6.0%
514	Hilea hydrous silty clay loam, 3 to 10 percent slopes	6,036.7	6.8%
515	Pahipa-Puali association, 2 to 20 percent slopes	8,790.0	9.9%
516	Alapai hydrous silty clay loam, 3 to 10 percent slopes	858.5	1.0%
517	Alapai hydrous silty clay loam, 10 to 20 percent slopes	715.5	0.8%
518	Alapai hydrous silty clay loam, 20 to 35 percent slopes	214.9	0.2%
519	Lalaau very cobbly highly decomposed plant material, 2 to 10 percent slopes	540.9	0.6%
520	Naalehu medial silty clay loam, 35 to 70 percent slopes	53.5	0.1%
521	Naalehu medial silty clay loam, 3 to 10 percent slopes	202.7	0.2%
522	Naalehu medial silty clay loam, 10 to 20 percent slopes	729.0	0.8%
523	Naalehu medial silty clay loam, 20 to 35 percent slopes	379.4	0.4%
527	Alapai hydrous silty clay loam, 35 to 70 percent slopes	254.7	0.3%
528	Alapai hydrous silty clay loam, 0 to 3 percent slopes	311.8	0.4%
529	Honuapo-Hilea complex, 10 to 20 percent slopes	1,748.6	2.0%
530	Hilea-Lava flows complex, 3 to 10 percent slopes	763.5	0.9%

Map Unit Symbol	Map Unit Name	Acres in AOI	Percent of AOI
531	Hilea-Lava flows complex, 10 to 20 percent slopes	190.5	0.2%
532	Honuapo hydrous silt loam, 3 to 10 percent slopes	2,294.2	2.6%
533	Honuapo-Hilea complex, 20 to 35 percent slopes	249.3	0.3%
534	Kahaluu-Lava flows complex, 2 to 10 percent slopes	2,387.8	2.7%
536	Puueo extremely cobbly medial silt loam, 2 to 10 percent slopes	382.8	0.4%
538	Naalehu medial silt loam, 0 to 3 percent slopes	75.8	0.1%
539	Kanohina-Lava flows complex, 10 to 20 percent slopes	1,694.1	1.9%
540	Kanohina-Lava flows complex, 20 to 35 percent slopes	845.4	1.0%
541	Lava flows-Puueo complex, 2 to 20 percent slopes	1,090.6	1.2%
558	Akihi-Alapai complex, 40 to 70 percent slopes	1,588.4	1.8%
568	Honuapo hydrous silt loam, 10 to 20 percent slopes	398.5	0.4%
569	Puueo extremely cobbly medial silt loam, 10 to 20 percent slopes	245.8	0.3%
734	Kanohina-Lava flows complex, 2 to 10 percent slopes	1,212.0	1.4%
Subtotals for Soil Survey Area		**45,043.5**	**50.6%**
Totals for Area of Interest		**88,942.7**	**100.0%**

Map Unit Descriptions

The map units delineated on the detailed soil maps in a soil survey represent the soils or miscellaneous areas in the survey area. The map unit descriptions, along with the maps, can be used to determine the composition and properties of a unit.

A map unit delineation on a soil map represents an area dominated by one or more major kinds of soil or miscellaneous areas. A map unit is identified and named according to the taxonomic classification of the dominant soils. Within a taxonomic class there are precisely defined limits for the properties of the soils. On the landscape, however, the soils are natural phenomena, and they have the characteristic variability of all natural phenomena. Thus, the range of some observed properties may extend beyond the limits defined for a taxonomic class. Areas of soils of a single taxonomic class rarely, if ever, can be mapped without including areas of other taxonomic classes. Consequently, every map unit is made up of the soils or miscellaneous areas for which it is named and some minor components that belong to taxonomic classes other than those of the major soils.

Most minor soils have properties similar to those of the dominant soil or soils in the map unit, and thus they do not affect use and management. These are called noncontrasting, or similar, components. They may or may not be mentioned in a particular map unit description. Other minor components, however, have properties and behavioral characteristics divergent enough to affect use or to require different management. These are called contrasting, or dissimilar, components. They generally are in small areas and could not be mapped separately because of the scale used. Some small areas of strongly contrasting soils or miscellaneous areas are identified by a special symbol on the maps. If included in the database for a given area, the contrasting minor components are identified in the map unit descriptions along with some characteristics of each. A few areas of minor components may not have been observed, and consequently they are not mentioned in the descriptions, especially where the pattern was so complex that it was impractical to make enough observations to identify all the soils and miscellaneous areas on the landscape.

The presence of minor components in a map unit in no way diminishes the usefulness or accuracy of the data. The objective of mapping is not to delineate pure taxonomic classes but rather to separate the landscape into landforms or landform segments that have similar use and management requirements. The delineation of such segments on the map provides sufficient information for the development of resource plans. If intensive use of small areas is planned, however, onsite investigation is needed to define and locate the soils and miscellaneous areas.

An identifying symbol precedes the map unit name in the map unit descriptions. Each description includes general facts about the unit and gives important soil properties and qualities.

Soils that have profiles that are almost alike make up a *soil series*. Except for differences in texture of the surface layer, all the soils of a series have major horizons that are similar in composition, thickness, and arrangement.

Soils of one series can differ in texture of the surface layer, slope, stoniness, salinity, degree of erosion, and other characteristics that affect their use. On the basis of such differences, a soil series is divided into *soil phases*. Most of the areas shown on the detailed soil maps are phases of soil series. The name of a soil phase commonly indicates a feature that affects use or management. For example, Alpha silt loam, 0 to 2 percent slopes, is a phase of the Alpha series.

Some map units are made up of two or more major soils or miscellaneous areas. These map units are complexes, associations, or undifferentiated groups.

A *complex* consists of two or more soils or miscellaneous areas in such an intricate pattern or in such small areas that they cannot be shown separately on the maps. The pattern and proportion of the soils or miscellaneous areas are somewhat similar in all areas. Alpha-Beta complex, 0 to 6 percent slopes, is an example.

An *association* is made up of two or more geographically associated soils or miscellaneous areas that are shown as one unit on the maps. Because of present or anticipated uses of the map units in the survey area, it was not considered practical or necessary to map the soils or miscellaneous areas separately. The pattern and relative proportion of the soils or miscellaneous areas are somewhat similar. Alpha-Beta association, 0 to 2 percent slopes, is an example.

An *undifferentiated group* is made up of two or more soils or miscellaneous areas that could be mapped individually but are mapped as one unit because similar interpretations can be made for use and management. The pattern and proportion

of the soils or miscellaneous areas in a mapped area are not uniform. An area can be made up of only one of the major soils or miscellaneous areas, or it can be made up of all of them. Alpha and Beta soils, 0 to 2 percent slopes, is an example.

Some surveys include *miscellaneous areas*. Such areas have little or no soil material and support little or no vegetation. Rock outcrop is an example.

Hawaii Volcanoes National Park, Hawaii

10—Lava flows, `a`a, 2 to 20 percent slopes

Map Unit Setting

National map unit symbol: 2km4h
Elevation: 0 to 13,680 feet
Mean annual precipitation: 7 to 80 inches
Mean annual air temperature: 41 to 86 degrees F
Frost-free period: 180 to 365 days
Farmland classification: Not prime farmland

Map Unit Composition

Lava flows, `a`a: 100 percent
Estimates are based on observations, descriptions, and transects of the mapunit.

Description of Lava Flows, `a`a

Setting

Landform: Aa lava flows
Down-slope shape: Linear
Across-slope shape: Linear, convex
Parent material: Aa lava

Typical profile

C - 0 to 39 inches: cobbles
R - 39 to 49 inches: bedrock

Properties and qualities

Slope: 2 to 20 percent
Surface area covered with cobbles, stones or boulders: 10.0 percent
Depth to restrictive feature: 20 to 60 inches to lithic bedrock
Drainage class: Excessively drained
Runoff class: Very low
Capacity of the most limiting layer to transmit water (Ksat): Low to moderately low (0.00 to 0.06 in/hr)
Available water supply, 0 to 60 inches: Very low (about 0.4 inches)

Interpretive groups

Land capability classification (irrigated): 8
Land capability classification (nonirrigated): 8
Hydric soil rating: No

12—Lava flows, pahoehoe, 2 to 20 percent slopes

Map Unit Setting

National map unit symbol: 2km4k
Elevation: 0 to 13,680 feet
Mean annual precipitation: 7 to 80 inches
Mean annual air temperature: 41 to 86 degrees F
Frost-free period: 365 days

Farmland classification: Not prime farmland

Map Unit Composition

Lava flows, pahoehoe: 100 percent
Estimates are based on observations, descriptions, and transects of the mapunit.

Description of Lava Flows, Pahoehoe

Setting

Landform: Pahoehoe lava flows
Down-slope shape: Linear
Across-slope shape: Linear, convex
Parent material: Pahoehoe lava

Typical profile

R - 0 to 10 inches: bedrock

Properties and qualities

Slope: 2 to 20 percent
Depth to restrictive feature: 0 to 2 inches to lithic bedrock
Runoff class: Very high
Capacity of the most limiting layer to transmit water (Ksat): Low to moderately low (0.00 to 0.06 in/hr)
Available water supply, 0 to 60 inches: Very low (about 0.0 inches)

Interpretive groups

Land capability classification (irrigated): 8
Land capability classification (nonirrigated): 8
Hydric soil rating: No

14—Lava flows complex, 2 to 20 percent slopes

Map Unit Setting

National map unit symbol: 2km4m
Elevation: 0 to 13,680 feet
Mean annual precipitation: 7 to 80 inches
Mean annual air temperature: 41 to 86 degrees F
Frost-free period: 365 days
Farmland classification: Not prime farmland

Map Unit Composition

Lava flows, `a`a: 55 percent
Lava flows, pahoehoe: 45 percent
Estimates are based on observations, descriptions, and transects of the mapunit.

Description of Lava Flows, `a`a

Setting

Landform: Aa lava flows
Down-slope shape: Linear
Across-slope shape: Linear, convex
Parent material: Aa lava

Typical profile

C - 0 to 39 inches: cobbles
R - 39 to 49 inches: bedrock

Properties and qualities

Slope: 2 to 20 percent
Surface area covered with cobbles, stones or boulders: 10.0 percent
Depth to restrictive feature: 20 to 79 inches to lithic bedrock
Drainage class: Excessively drained
Runoff class: Very low
Capacity of the most limiting layer to transmit water (Ksat): Low to moderately low (0.00 to 0.06 in/hr)
Available water supply, 0 to 60 inches: Very low (about 0.4 inches)

Interpretive groups

Land capability classification (irrigated): 8
Land capability classification (nonirrigated): 8
Hydric soil rating: No

Description of Lava Flows, Pahoehoe

Setting

Landform: Pahoehoe lava flows
Down-slope shape: Linear
Across-slope shape: Linear, convex
Parent material: Pahoehoe lava

Typical profile

R - 0 to 10 inches: bedrock

Properties and qualities

Slope: 2 to 20 percent
Depth to restrictive feature: 0 to 2 inches to lithic bedrock
Runoff class: Very high
Capacity of the most limiting layer to transmit water (Ksat): Low to moderately low (0.00 to 0.06 in/hr)
Available water supply, 0 to 60 inches: Very low (about 0.0 inches)

Interpretive groups

Land capability classification (irrigated): 8
Land capability classification (nonirrigated): 8
Hydric soil rating: No

16—Cinder land, 20 to 40 percent slopes

Map Unit Setting

National map unit symbol: 2km4p
Elevation: 0 to 13,680 feet
Mean annual precipitation: 7 to 80 inches
Mean annual air temperature: 41 to 86 degrees F
Frost-free period: 365 days

Farmland classification: Not prime farmland

Map Unit Composition

Cinder land: 100 percent
Estimates are based on observations, descriptions, and transects of the mapunit.

Description of Cinder Land

Setting

Landform: Cinder cones
Down-slope shape: Linear
Across-slope shape: Convex, linear
Parent material: Cinders

Typical profile

C - 0 to 79 inches: gravel

Interpretive groups

Land capability classification (irrigated): 8s
Land capability classification (nonirrigated): 8s
Hydric soil rating: No

164—Lava flows-Kekake complex, 2 to 20 percent slopes

Map Unit Setting

National map unit symbol: 2km71
Elevation: 3,500 to 7,000 feet
Mean annual precipitation: 20 to 50 inches
Mean annual air temperature: 54 to 57 degrees F
Frost-free period: 365 days
Farmland classification: Not prime farmland

Map Unit Composition

Lava flows, pahoehoe: 80 percent
Kekake and similar soils: 20 percent
Estimates are based on observations, descriptions, and transects of the mapunit.

Description of Lava Flows, Pahoehoe

Setting

Landform: Pahoehoe lava flows
Down-slope shape: Linear
Across-slope shape: Linear, convex
Parent material: Pahoehoe lava

Typical profile

R - 0 to 10 inches: bedrock

Properties and qualities

Slope: 2 to 20 percent
Depth to restrictive feature: 0 to 2 inches to lithic bedrock
Drainage class: Well drained
Runoff class: Very high

Capacity of the most limiting layer to transmit water (Ksat): Low to moderately low (0.00 to 0.06 in/hr)
Available water supply, 0 to 60 inches: Very low (about 0.0 inches)

Interpretive groups

Land capability classification (irrigated): 8
Land capability classification (nonirrigated): 8
Hydric soil rating: No

Description of Kekake

Setting

Landform: Pahoehoe lava flows
Landform position (two-dimensional): Summit, shoulder, backslope, footslope
Landform position (three-dimensional): Mountainflank
Down-slope shape: Linear
Across-slope shape: Linear, convex
Parent material: Organic material over pahoehoe lava

Typical profile

Oa - 0 to 5 inches: gravelly highly decomposed plant material
2R - 5 to 15 inches: bedrock

Properties and qualities

Slope: 2 to 20 percent
Depth to restrictive feature: 2 to 10 inches to lithic bedrock
Drainage class: Moderately well drained
Runoff class: High
Capacity of the most limiting layer to transmit water (Ksat): Low to moderately low (0.00 to 0.06 in/hr)
Depth to water table: More than 80 inches
Frequency of flooding: None
Frequency of ponding: None
Maximum salinity: Nonsaline to very slightly saline (0.0 to 2.0 mmhos/cm)
Available water supply, 0 to 60 inches: Very low (about 1.2 inches)

Interpretive groups

Land capability classification (irrigated): 7s
Land capability classification (nonirrigated): 7s
Hydrologic Soil Group: D
Ecological site: R161AY003HI - Isomesic Savanna, R161BY001HI - Dry Ustic Isomesic Shrubland
Hydric soil rating: No

169—Iwalani-Lava flows complex, moist, 2 to 10 percent slopes

Map Unit Setting

National map unit symbol: 2km76
Elevation: 3,500 to 5,400 feet
Mean annual precipitation: 40 to 60 inches
Mean annual air temperature: 54 to 57 degrees F

Frost-free period: 365 days
Farmland classification: Not prime farmland

Map Unit Composition

Iwalani, moist, and similar soils: 60 percent
Lava flows, pahoehoe: 40 percent
Estimates are based on observations, descriptions, and transects of the mapunit.

Description of Iwalani, Moist

Setting

Landform: Ash fields on pahoehoe lava flows
Landform position (two-dimensional): Backslope
Landform position (three-dimensional): Side slope
Down-slope shape: Linear
Across-slope shape: Linear, convex
Parent material: Basic volcanic ash and/or cinders over pahoehoe lava

Typical profile

A - 0 to 2 inches: medial loam
Bw - 2 to 3 inches: medial very fine sandy loam
A' - 3 to 5 inches: medial loamy sand
B'w - 5 to 10 inches: medial very fine sandy loam
2R - 10 to 20 inches: bedrock

Properties and qualities

Slope: 2 to 10 percent
Depth to restrictive feature: 2 to 10 inches to lithic bedrock
Drainage class: Well drained
Runoff class: High
Capacity of the most limiting layer to transmit water (Ksat): Low to moderately low (0.00 to 0.06 in/hr)
Depth to water table: More than 80 inches
Frequency of flooding: None
Frequency of ponding: None
Maximum salinity: Nonsaline to very slightly saline (0.0 to 2.0 mmhos/cm)
Available water supply, 0 to 60 inches: Very low (about 1.5 inches)

Interpretive groups

Land capability classification (irrigated): 7s
Land capability classification (nonirrigated): 7s
Hydrologic Soil Group: D
Ecological site: R161AY003HI - Isomesic Savanna
Other vegetative classification: Transition Zone Ohia-Koa-Mamane Forest (F161AY500HI)
Hydric soil rating: No

Description of Lava Flows, Pahoehoe

Setting

Landform: Pahoehoe lava flows
Down-slope shape: Linear
Across-slope shape: Linear, convex
Parent material: Pahoehoe lava

Typical profile

R - 0 to 10 inches: bedrock

Properties and qualities

Slope: 2 to 10 percent
Depth to restrictive feature: 0 to 2 inches to lithic bedrock
Drainage class: Well drained
Runoff class: High
Capacity of the most limiting layer to transmit water (Ksat): Low to moderately low (0.00 to 0.06 in/hr)
Available water supply, 0 to 60 inches: Very low (about 0.0 inches)

Interpretive groups

Land capability classification (irrigated): 8
Land capability classification (nonirrigated): 8
Hydric soil rating: No

401—Ihuanu-Lava flows, `a`a complex, 10 to 20 percent slopes, MLRA 160

Map Unit Setting

National map unit symbol: 2w03v
Elevation: 3,500 to 5,400 feet
Mean annual precipitation: 40 to 50 inches
Mean annual air temperature: 54 to 57 degrees F
Frost-free period: 270 to 365 days
Farmland classification: Not prime farmland

Map Unit Composition

Ihuanu and similar soils: 60 percent
Lava flows, `a`a: 40 percent
Estimates are based on observations, descriptions, and transects of the mapunit.

Description of Ihuanu

Setting

Landform: Ash fields on aa lava flows
Landform position (two-dimensional): Backslope
Landform position (three-dimensional): Side slope
Down-slope shape: Linear
Across-slope shape: Linear, convex
Parent material: Basic volcanic ash over aa lava

Typical profile

A/2C1 - 0 to 2 inches: very cobbly medial silt loam
2C2/Bw - 2 to 20 inches: extremely cobbly medial sandy loam
2C3 - 20 to 22 inches: extremely gravelly coarse sand
2R - 22 to 26 inches: bedrock

Properties and qualities

Slope: 10 to 20 percent
Depth to restrictive feature: 20 to 40 inches to lithic bedrock
Drainage class: Well drained

Runoff class: Very low
Capacity of the most limiting layer to transmit water (Ksat): Low to moderately low (0.00 to 0.06 in/hr)
Depth to water table: More than 80 inches
Frequency of flooding: None
Frequency of ponding: None
Maximum salinity: Nonsaline to very slightly saline (0.0 to 2.0 mmhos/cm)
Available water supply, 0 to 60 inches: Very low (about 1.4 inches)

Interpretive groups
Land capability classification (irrigated): 7s
Land capability classification (nonirrigated): 7s
Hydrologic Soil Group: A
Ecological site: R161AY003HI - Isomesic Savanna, R160XY006HI - Isomesic Savanna
Hydric soil rating: No

Description of Lava Flows, `a`a

Setting
Landform: Aa lava flows
Down-slope shape: Linear
Across-slope shape: Linear, convex
Parent material: Aa lava

Typical profile
C - 0 to 39 inches: cobbles
R - 39 to 49 inches: bedrock

Properties and qualities
Slope: 10 to 20 percent
Surface area covered with cobbles, stones or boulders: 10.0 percent
Depth to restrictive feature: 20 to 60 inches to lithic bedrock
Drainage class: Excessively drained
Runoff class: Very low
Capacity of the most limiting layer to transmit water (Ksat): Low to moderately low (0.00 to 0.06 in/hr)
Available water supply, 0 to 60 inches: Very low (about 0.4 inches)

Interpretive groups
Land capability classification (irrigated): 8
Land capability classification (nonirrigated): 8
Hydric soil rating: No

402—Ihuanu very cobbly medial silt loam, 10 to 20 percent slopes, MLRA 160

Map Unit Setting
National map unit symbol: 2w03s
Elevation: 3,500 to 5,400 feet
Mean annual precipitation: 40 to 50 inches

Mean annual air temperature: 54 to 57 degrees F
Frost-free period: 270 to 365 days
Farmland classification: Not prime farmland

Map Unit Composition

Ihuanu and similar soils: 95 percent
Minor components: 5 percent
Estimates are based on observations, descriptions, and transects of the mapunit.

Description of Ihuanu

Setting

Landform: Ash fields on aa lava flows
Landform position (two-dimensional): Backslope
Landform position (three-dimensional): Side slope
Down-slope shape: Linear
Across-slope shape: Linear, convex
Parent material: Basic volcanic ash over aa lava

Typical profile

A/2C1 - 0 to 2 inches: very cobbly medial silt loam
2C2/Bw - 2 to 20 inches: extremely cobbly medial sandy loam
2C3 - 20 to 22 inches: extremely gravelly coarse sand
2R - 22 to 26 inches: bedrock

Properties and qualities

Slope: 10 to 20 percent
Depth to restrictive feature: 20 to 40 inches to lithic bedrock
Drainage class: Well drained
Runoff class: Very low
Capacity of the most limiting layer to transmit water (Ksat): Low to moderately low (0.00 to 0.06 in/hr)
Depth to water table: More than 80 inches
Frequency of flooding: None
Frequency of ponding: None
Maximum salinity: Nonsaline to very slightly saline (0.0 to 2.0 mmhos/cm)
Available water supply, 0 to 60 inches: Very low (about 1.4 inches)

Interpretive groups

Land capability classification (irrigated): 7s
Land capability classification (nonirrigated): 7s
Hydrologic Soil Group: A
Ecological site: R160XY006HI - Isomesic Savanna, R161AY003HI - Isomesic Savanna
Hydric soil rating: No

Minor Components

Lava flows, `a`a

Percent of map unit: 5 percent
Landform: Aa lava flows
Down-slope shape: Linear
Across-slope shape: Linear, convex
Hydric soil rating: No

403—Ihuanu very cobbly medial silt loam, 2 to 10 percent slopes, MLRA 160

Map Unit Setting

National map unit symbol: 2w03r
Elevation: 3,500 to 5,400 feet
Mean annual precipitation: 40 to 50 inches
Mean annual air temperature: 54 to 57 degrees F
Frost-free period: 270 to 365 days
Farmland classification: Not prime farmland

Map Unit Composition

Ihuanu and similar soils: 95 percent
Minor components: 5 percent
Estimates are based on observations, descriptions, and transects of the mapunit.

Description of Ihuanu

Setting

Landform: Ash fields on aa lava flows
Landform position (two-dimensional): Backslope
Landform position (three-dimensional): Side slope
Down-slope shape: Linear
Across-slope shape: Linear, convex
Parent material: Basic volcanic ash over aa lava

Typical profile

A/2C1 - 0 to 2 inches: very cobbly medial silt loam
2C2/Bw - 2 to 20 inches: extremely cobbly medial sandy loam
2C3 - 20 to 22 inches: extremely gravelly coarse sand
2R - 22 to 26 inches: bedrock

Properties and qualities

Slope: 2 to 10 percent
Depth to restrictive feature: 20 to 40 inches to lithic bedrock
Drainage class: Well drained
Runoff class: Very low
Capacity of the most limiting layer to transmit water (Ksat): Low to moderately low (0.00 to 0.06 in/hr)
Depth to water table: More than 80 inches
Frequency of flooding: None
Frequency of ponding: None
Maximum salinity: Nonsaline to very slightly saline (0.0 to 2.0 mmhos/cm)
Available water supply, 0 to 60 inches: Very low (about 1.4 inches)

Interpretive groups

Land capability classification (irrigated): 7s
Land capability classification (nonirrigated): 7s
Hydrologic Soil Group: A

Ecological site: R160XY006HI - Isomesic Savanna, R161AY003HI - Isomesic Savanna
Hydric soil rating: No

Minor Components

Lava flows, `a`a
Percent of map unit: 5 percent
Landform: Aa lava flows
Down-slope shape: Linear
Across-slope shape: Linear, convex
Hydric soil rating: No

406—Lava flows-Iwalani complex, 10 to 20 percent slopes

Map Unit Setting
National map unit symbol: 2kmbq
Elevation: 3,500 to 5,400 feet
Mean annual precipitation: 40 to 50 inches
Mean annual air temperature: 54 to 57 degrees F
Frost-free period: 365 days
Farmland classification: Not prime farmland

Map Unit Composition
Lava flows, pahoehoe: 70 percent
Iwalani and similar soils: 30 percent
Estimates are based on observations, descriptions, and transects of the mapunit.

Description of Lava Flows, Pahoehoe

Setting
Landform: Pahoehoe lava flows
Down-slope shape: Linear
Across-slope shape: Linear, convex
Parent material: Pahoehoe lava

Typical profile
R - 0 to 10 inches: bedrock

Properties and qualities
Slope: 10 to 20 percent
Depth to restrictive feature: 0 to 2 inches to lithic bedrock
Drainage class: Well drained
Runoff class: Very high
Capacity of the most limiting layer to transmit water (Ksat): Low to moderately low (0.00 to 0.06 in/hr)
Available water supply, 0 to 60 inches: Very low (about 0.0 inches)

Interpretive groups
Land capability classification (irrigated): 8
Land capability classification (nonirrigated): 8

Hydric soil rating: No

Description of Iwalani

Setting

Landform: Ash fields on pahoehoe lava flows
Landform position (two-dimensional): Summit, shoulder, backslope, footslope
Landform position (three-dimensional): Mountainflank
Down-slope shape: Linear
Across-slope shape: Linear, convex
Parent material: Basic volcanic ash and/or cinders over pahoehoe lava

Typical profile

A - 0 to 2 inches: medial loam
Bw - 2 to 3 inches: medial very fine sandy loam
A' - 3 to 5 inches: medial loamy sand
B'w - 5 to 10 inches: medial very fine sandy loam
2R - 10 to 20 inches: bedrock

Properties and qualities

Slope: 10 to 20 percent
Depth to restrictive feature: 2 to 10 inches to lithic bedrock
Drainage class: Well drained
Runoff class: High
Capacity of the most limiting layer to transmit water (Ksat): Low to moderately low (0.00 to 0.06 in/hr)
Depth to water table: More than 80 inches
Frequency of flooding: None
Frequency of ponding: None
Maximum salinity: Nonsaline to very slightly saline (0.0 to 2.0 mmhos/cm)
Available water supply, 0 to 60 inches: Very low (about 1.5 inches)

Interpretive groups

Land capability classification (irrigated): 7s
Land capability classification (nonirrigated): 7s
Hydrologic Soil Group: D
Ecological site: R161AY003HI - Isomesic Savanna, R160XY006HI - Isomesic Savanna
Hydric soil rating: No

407—Iwalani-Lava flows complex, 2 to 10 percent slopes

Map Unit Setting

National map unit symbol: 2kmbr
Elevation: 3,500 to 5,400 feet
Mean annual precipitation: 40 to 50 inches
Mean annual air temperature: 54 to 57 degrees F
Frost-free period: 365 days
Farmland classification: Not prime farmland

Map Unit Composition

Iwalani and similar soils: 60 percent
Lava flows, pahoehoe: 40 percent
Estimates are based on observations, descriptions, and transects of the mapunit.

Description of Iwalani

Setting

Landform: Ash fields on pahoehoe lava flows
Landform position (two-dimensional): Backslope
Landform position (three-dimensional): Side slope
Down-slope shape: Linear
Across-slope shape: Linear, convex
Parent material: Basic volcanic ash and/or cinders over pahoehoe lava

Typical profile

A - 0 to 2 inches: medial loam
Bw - 2 to 3 inches: medial very fine sandy loam
A' - 3 to 5 inches: medial loamy sand
B'w - 5 to 10 inches: medial very fine sandy loam
2R - 10 to 20 inches: bedrock

Properties and qualities

Slope: 2 to 10 percent
Depth to restrictive feature: 2 to 10 inches to lithic bedrock
Drainage class: Well drained
Runoff class: High
Capacity of the most limiting layer to transmit water (Ksat): Low to moderately low (0.00 to 0.06 in/hr)
Depth to water table: More than 80 inches
Frequency of flooding: None
Frequency of ponding: None
Maximum salinity: Nonsaline to very slightly saline (0.0 to 2.0 mmhos/cm)
Available water supply, 0 to 60 inches: Very low (about 1.5 inches)

Interpretive groups

Land capability classification (irrigated): 7s
Land capability classification (nonirrigated): 7s
Hydrologic Soil Group: D
Ecological site: R161AY003HI - Isomesic Savanna, R160XY006HI - Isomesic Savanna
Hydric soil rating: No

Description of Lava Flows, Pahoehoe

Setting

Landform: Pahoehoe lava flows
Down-slope shape: Linear
Across-slope shape: Linear, convex
Parent material: Pahoehoe lava

Typical profile

R - 0 to 10 inches: bedrock

Properties and qualities

Slope: 2 to 10 percent
Depth to restrictive feature: 0 to 2 inches to lithic bedrock

Drainage class: Well drained
Runoff class: High
Capacity of the most limiting layer to transmit water (Ksat): Low to moderately low (0.00 to 0.06 in/hr)
Available water supply, 0 to 60 inches: Very low (about 0.0 inches)

Interpretive groups

Land capability classification (irrigated): 8
Land capability classification (nonirrigated): 8
Hydric soil rating: No

408—Iwalani-Lava flows complex, 10 to 20 percent slopes

Map Unit Setting

National map unit symbol: 2kmbs
Elevation: 3,500 to 5,400 feet
Mean annual precipitation: 40 to 50 inches
Mean annual air temperature: 54 to 57 degrees F
Frost-free period: 365 days
Farmland classification: Not prime farmland

Map Unit Composition

Iwalani and similar soils: 70 percent
Lava flows, pahoehoe: 30 percent
Estimates are based on observations, descriptions, and transects of the mapunit.

Description of Iwalani

Setting

Landform: Ash fields on pahoehoe lava flows
Landform position (two-dimensional): Backslope
Landform position (three-dimensional): Side slope
Down-slope shape: Linear
Across-slope shape: Linear, convex
Parent material: Basic volcanic ash and/or cinders over pahoehoe lava

Typical profile

A - 0 to 2 inches: medial loam
Bw - 2 to 3 inches: medial very fine sandy loam
A' - 3 to 5 inches: medial loamy sand
B'w - 5 to 10 inches: medial very fine sandy loam
2R - 10 to 20 inches: bedrock

Properties and qualities

Slope: 10 to 20 percent
Depth to restrictive feature: 2 to 10 inches to lithic bedrock
Drainage class: Well drained
Runoff class: High
Capacity of the most limiting layer to transmit water (Ksat): Low to moderately low (0.00 to 0.06 in/hr)
Depth to water table: More than 80 inches

Frequency of flooding: None
Frequency of ponding: None
Maximum salinity: Nonsaline to very slightly saline (0.0 to 2.0 mmhos/cm)
Available water supply, 0 to 60 inches: Very low (about 1.5 inches)

Interpretive groups

Land capability classification (irrigated): 7s
Land capability classification (nonirrigated): 7s
Hydrologic Soil Group: D
Ecological site: R161AY003HI - Isomesic Savanna, R160XY006HI - Isomesic Savanna
Hydric soil rating: No

Description of Lava Flows, Pahoehoe

Setting

Landform: Pahoehoe lava flows
Down-slope shape: Linear
Across-slope shape: Linear, convex
Parent material: Pahoehoe lava

Typical profile

R - 0 to 10 inches: bedrock

Properties and qualities

Slope: 10 to 20 percent
Depth to restrictive feature: 0 to 2 inches to lithic bedrock
Drainage class: Well drained
Runoff class: Very high
Capacity of the most limiting layer to transmit water (Ksat): Low to moderately low (0.00 to 0.06 in/hr)
Available water supply, 0 to 60 inches: Very low (about 0.0 inches)

Interpretive groups

Land capability classification (irrigated): 8
Land capability classification (nonirrigated): 8
Hydric soil rating: No

515—Pahipa-Puali association, 2 to 20 percent slopes

Map Unit Setting

National map unit symbol: 2kmd1
Elevation: 4,000 to 6,000 feet
Mean annual precipitation: 60 to 100 inches
Mean annual air temperature: 52 to 59 degrees F
Frost-free period: 365 days
Farmland classification: Not prime farmland

Map Unit Composition

Pahipa and similar soils: 50 percent
Puali and similar soils: 40 percent

Minor components: 10 percent
Estimates are based on observations, descriptions, and transects of the mapunit.

Description of Pahipa

Setting

Landform: Ash fields on aa lava flows
Landform position (two-dimensional): Backslope
Landform position (three-dimensional): Side slope
Down-slope shape: Linear
Across-slope shape: Linear, convex
Parent material: Basic volcanic ash over aa lava

Typical profile

Oe - 0 to 2 inches: moderately decomposed plant material
A - 2 to 8 inches: hydrous silty clay loam
2A - 8 to 16 inches: gravelly highly organic hydrous silt loam
2Bw1/3C1 - 16 to 30 inches: very cobbly hydrous silty clay loam
3C2/2Bw2 - 30 to 39 inches: extremely cobbly hydrous silty clay loam
3R - 39 to 49 inches: bedrock

Properties and qualities

Slope: 2 to 20 percent
Depth to restrictive feature: 20 to 40 inches to lithic bedrock
Drainage class: Well drained
Runoff class: Low
Capacity of the most limiting layer to transmit water (Ksat): Low to moderately low (0.00 to 0.06 in/hr)
Depth to water table: More than 80 inches
Frequency of flooding: None
Frequency of ponding: None
Maximum salinity: Nonsaline to very slightly saline (0.0 to 2.0 mmhos/cm)
Available water supply, 0 to 60 inches: Low (about 5.1 inches)

Interpretive groups

Land capability classification (irrigated): 4e
Land capability classification (nonirrigated): 4e
Hydrologic Soil Group: C
Ecological site: F159BY500HI - Udic Forest
Other vegetative classification: Ohia-Koa/Hapuu-Kanawao Forest (F159BY500HI)
Hydric soil rating: No

Description of Puali

Setting

Landform: Ash fields on pahoehoe lava flows
Landform position (two-dimensional): Backslope
Landform position (three-dimensional): Side slope
Down-slope shape: Linear
Across-slope shape: Linear, convex
Parent material: Basic volcanic ash over pahoehoe lava

Typical profile

Oe - 0 to 4 inches: moderately decomposed plant material
A - 4 to 10 inches: highly organic hydrous silt loam
Bw - 10 to 18 inches: cobbly hydrous silty clay loam
2R - 18 to 28 inches: bedrock

Properties and qualities

Slope: 2 to 20 percent
Depth to restrictive feature: 2 to 20 inches to lithic bedrock
Drainage class: Well drained
Runoff class: High
Capacity of the most limiting layer to transmit water (Ksat): Low to moderately low (0.00 to 0.06 in/hr)
Depth to water table: More than 80 inches
Frequency of flooding: None
Frequency of ponding: None
Maximum salinity: Nonsaline to very slightly saline (0.0 to 2.0 mmhos/cm)
Available water supply, 0 to 60 inches: Low (about 3.4 inches)

Interpretive groups

Land capability classification (irrigated): 4e
Land capability classification (nonirrigated): 4e
Hydrologic Soil Group: D
Ecological site: F159BY500HI - Udic Forest
Other vegetative classification: Ohia-Koa/Hapuu-Kanawao Forest (F159BY500HI)
Hydric soil rating: No

Minor Components

Lithic endoaquands

Percent of map unit: 10 percent
Landform: Ash fields on pahoehoe lava flows
Landform position (two-dimensional): Backslope
Landform position (three-dimensional): Side slope
Down-slope shape: Linear
Across-slope shape: Linear, convex
Hydric soil rating: Yes

519—Lalaau very cobbly highly decomposed plant material, 2 to 10 percent slopes

Map Unit Setting

National map unit symbol: 2kmd5
Elevation: 1,000 to 7,000 feet
Mean annual precipitation: 60 to 150 inches
Mean annual air temperature: 52 to 59 degrees F
Frost-free period: 365 days
Farmland classification: Not prime farmland

Map Unit Composition

Lalaau and similar soils: 95 percent
Minor components: 5 percent
Estimates are based on observations, descriptions, and transects of the mapunit.

Description of Lalaau

Setting

Landform: Aa lava flows
Landform position (two-dimensional): Backslope
Landform position (three-dimensional): Side slope
Down-slope shape: Linear
Across-slope shape: Linear, convex
Parent material: Organic material over aa lava

Typical profile

Oa/2C1 - 0 to 3 inches: very cobbly highly decomposed plant material
2C2 - 3 to 53 inches: cobbles
2R - 53 to 63 inches: bedrock

Properties and qualities

Slope: 2 to 10 percent
Depth to restrictive feature: 40 to 60 inches to lithic bedrock
Drainage class: Well drained
Runoff class: Low
Capacity of the most limiting layer to transmit water (Ksat): Low to moderately low (0.00 to 0.06 in/hr)
Depth to water table: More than 80 inches
Frequency of flooding: None
Frequency of ponding: None
Maximum salinity: Nonsaline to very slightly saline (0.0 to 2.0 mmhos/cm)
Available water supply, 0 to 60 inches: Very low (about 1.4 inches)

Interpretive groups

Land capability classification (irrigated): 7s
Land capability classification (nonirrigated): 7s
Hydrologic Soil Group: A
Ecological site: R161AY003HI - Isomesic Savanna, R160XY006HI - Isomesic Savanna
Hydric soil rating: No

Minor Components

Lava flows, `a`a

Percent of map unit: 5 percent
Landform: Aa lava flows
Down-slope shape: Linear
Across-slope shape: Linear, convex
Hydric soil rating: No

534—Kahaluu-Lava flows complex, 2 to 10 percent slopes

Map Unit Setting

National map unit symbol: 2kmdn
Elevation: 3,500 to 7,000 feet

Mean annual precipitation: 60 to 150 inches
Mean annual air temperature: 52 to 57 degrees F
Frost-free period: 365 days
Farmland classification: Not prime farmland

Map Unit Composition

Kahaluu and similar soils: 60 percent
Lava flows, pahoehoe: 40 percent
Estimates are based on observations, descriptions, and transects of the mapunit.

Description of Kahaluu

Setting

Landform: Ash fields on pahoehoe lava flows
Landform position (two-dimensional): Backslope
Landform position (three-dimensional): Side slope
Down-slope shape: Linear
Across-slope shape: Linear, convex
Parent material: Organic material over pahoehoe lava

Typical profile

Oa - 0 to 5 inches: highly decomposed plant material
2R - 5 to 15 inches: bedrock

Properties and qualities

Slope: 2 to 10 percent
Depth to restrictive feature: 1 to 10 inches to lithic bedrock
Drainage class: Well drained
Runoff class: High
Capacity of the most limiting layer to transmit water (Ksat): Low to moderately low (0.00 to 0.06 in/hr)
Depth to water table: More than 80 inches
Frequency of flooding: None
Frequency of ponding: None
Maximum salinity: Nonsaline to very slightly saline (0.0 to 2.0 mmhos/cm)
Available water supply, 0 to 60 inches: Very low (about 1.1 inches)

Interpretive groups

Land capability classification (irrigated): 7s
Land capability classification (nonirrigated): 7s
Hydrologic Soil Group: D
Ecological site: R161AY003HI - Isomesic Savanna, F159BY500HI - Udic Forest
Other vegetative classification: Ohia-Koa/Hapuu-Kanawao Forest (F159BY500HI)
Hydric soil rating: No

Description of Lava Flows, Pahoehoe

Setting

Landform: Pahoehoe lava flows
Down-slope shape: Linear
Across-slope shape: Linear, convex
Parent material: Pahoehoe lava

Typical profile

R - 0 to 10 inches: bedrock

Properties and qualities

Slope: 2 to 10 percent

Depth to restrictive feature: 0 to 2 inches to lithic bedrock
Drainage class: Well drained
Runoff class: High
Capacity of the most limiting layer to transmit water (Ksat): Low to moderately low (0.00 to 0.06 in/hr)
Available water supply, 0 to 60 inches: Very low (about 0.0 inches)

Interpretive groups

Land capability classification (irrigated): 8
Land capability classification (nonirrigated): 8
Hydric soil rating: No

Island of Hawaii Area, Hawaii

10—Lava flows, `a`a, 2 to 20 percent slopes

Map Unit Setting

National map unit symbol: 2klfr
Elevation: 0 to 13,680 feet
Mean annual precipitation: 7 to 80 inches
Mean annual air temperature: 41 to 86 degrees F
Frost-free period: 180 to 365 days
Farmland classification: Not prime farmland

Map Unit Composition

Lava flows, `a`a: 100 percent
Estimates are based on observations, descriptions, and transects of the mapunit.

Description of Lava Flows, `a`a

Setting

Landform: Aa lava flows
Down-slope shape: Linear
Across-slope shape: Linear, convex
Parent material: Aa lava

Typical profile

C - 0 to 39 inches: cobbles
R - 39 to 49 inches: bedrock

Properties and qualities

Slope: 2 to 20 percent
Surface area covered with cobbles, stones or boulders: 10.0 percent
Depth to restrictive feature: 20 to 60 inches to lithic bedrock
Drainage class: Excessively drained
Runoff class: Very low
Capacity of the most limiting layer to transmit water (Ksat): Low to moderately low (0.00 to 0.06 in/hr)
Available water supply, 0 to 60 inches: Very low (about 0.4 inches)

Interpretive groups

Land capability classification (irrigated): 8
Land capability classification (nonirrigated): 8
Hydric soil rating: No

12—Lava flows, pahoehoe, 2 to 20 percent slopes

Map Unit Setting

National map unit symbol: 2klft
Elevation: 0 to 13,680 feet
Mean annual precipitation: 7 to 80 inches
Mean annual air temperature: 41 to 86 degrees F
Frost-free period: 365 days

Farmland classification: Not prime farmland

Map Unit Composition

Lava flows, pahoehoe: 100 percent
Estimates are based on observations, descriptions, and transects of the mapunit.

Description of Lava Flows, Pahoehoe

Setting

Landform: Pahoehoe lava flows
Down-slope shape: Linear
Across-slope shape: Linear, convex
Parent material: Pahoehoe lava

Typical profile

R - 0 to 10 inches: bedrock

Properties and qualities

Slope: 2 to 20 percent
Depth to restrictive feature: 0 to 2 inches to lithic bedrock
Runoff class: Very high
Capacity of the most limiting layer to transmit water (Ksat): Low to moderately low (0.00 to 0.06 in/hr)
Available water supply, 0 to 60 inches: Very low (about 0.0 inches)

Interpretive groups

Land capability classification (irrigated): 8
Land capability classification (nonirrigated): 8
Hydric soil rating: No

169—Iwalani-Lava flows complex, moist, 2 to 10 percent slopes

Map Unit Setting

National map unit symbol: 2klg1
Elevation: 3,500 to 5,400 feet
Mean annual precipitation: 40 to 60 inches
Mean annual air temperature: 54 to 57 degrees F
Frost-free period: 365 days
Farmland classification: Not prime farmland

Map Unit Composition

Iwalani, moist, and similar soils: 60 percent
Lava flows, pahoehoe: 40 percent
Estimates are based on observations, descriptions, and transects of the mapunit.

Description of Iwalani, Moist

Setting

Landform: Ash fields on pahoehoe lava flows
Landform position (two-dimensional): Backslope
Landform position (three-dimensional): Side slope
Down-slope shape: Linear
Across-slope shape: Linear, convex

Parent material: Basic volcanic ash and/or cinders over pahoehoe lava

Typical profile

A - 0 to 2 inches: medial loam
Bw - 2 to 3 inches: medial very fine sandy loam
A' - 3 to 5 inches: medial loamy sand
B'w - 5 to 10 inches: medial very fine sandy loam
2R - 10 to 20 inches: bedrock

Properties and qualities

Slope: 2 to 10 percent
Depth to restrictive feature: 2 to 10 inches to lithic bedrock
Drainage class: Well drained
Runoff class: High
Capacity of the most limiting layer to transmit water (Ksat): Low to moderately low (0.00 to 0.06 in/hr)
Depth to water table: More than 80 inches
Frequency of flooding: None
Frequency of ponding: None
Maximum salinity: Nonsaline to very slightly saline (0.0 to 2.0 mmhos/cm)
Available water supply, 0 to 60 inches: Very low (about 1.5 inches)

Interpretive groups

Land capability classification (irrigated): 7s
Land capability classification (nonirrigated): 7s
Hydrologic Soil Group: D
Ecological site: R161AY003HI - Isomesic Savanna
Other vegetative classification: Transition Zone Ohia-Koa-Mamane Forest (F161AY500HI)
Hydric soil rating: No

Description of Lava Flows, Pahoehoe

Setting

Landform: Pahoehoe lava flows
Down-slope shape: Linear
Across-slope shape: Linear, convex
Parent material: Pahoehoe lava

Typical profile

R - 0 to 10 inches: bedrock

Properties and qualities

Slope: 2 to 10 percent
Depth to restrictive feature: 0 to 2 inches to lithic bedrock
Drainage class: Well drained
Runoff class: High
Capacity of the most limiting layer to transmit water (Ksat): Low to moderately low (0.00 to 0.06 in/hr)
Available water supply, 0 to 60 inches: Very low (about 0.0 inches)

Interpretive groups

Land capability classification (irrigated): 8
Land capability classification (nonirrigated): 8
Hydric soil rating: No

271—Lava flows-Kanohina complex, 2 to 20 percent slopes

Map Unit Setting

National map unit symbol: 2klg7
Elevation: 0 to 1,000 feet
Mean annual precipitation: 20 to 50 inches
Mean annual air temperature: 72 to 75 degrees F
Frost-free period: 365 days
Farmland classification: Not prime farmland

Map Unit Composition

Lava flows, pahoehoe: 60 percent
Kanohina and similar soils: 40 percent
Estimates are based on observations, descriptions, and transects of the mapunit.

Description of Lava Flows, Pahoehoe

Setting

Landform: Pahoehoe lava flows
Down-slope shape: Linear
Across-slope shape: Linear, convex
Parent material: Pahoehoe lava

Typical profile

R - 0 to 10 inches: bedrock

Properties and qualities

Slope: 2 to 20 percent
Depth to restrictive feature: 0 to 2 inches to lithic bedrock
Drainage class: Well drained
Runoff class: Very high
Capacity of the most limiting layer to transmit water (Ksat): Low to moderately low (0.00 to 0.06 in/hr)
Available water supply, 0 to 60 inches: Very low (about 0.0 inches)

Interpretive groups

Land capability classification (irrigated): 8
Land capability classification (nonirrigated): 8
Hydric soil rating: No

Description of Kanohina

Setting

Landform: Ash fields on pahoehoe lava flows
Landform position (two-dimensional): Summit, backslope, shoulder, footslope
Landform position (three-dimensional): Mountainflank
Down-slope shape: Linear
Across-slope shape: Linear, convex
Parent material: Basic volcanic ash over pahoehoe lava

Typical profile

A - 0 to 1 inches: ashy very fine sandy loam
Bw - 1 to 3 inches: ashy sandy loam
C - 3 to 6 inches: ashy loamy sand
2R - 6 to 16 inches: bedrock

Properties and qualities

Slope: 2 to 20 percent
Depth to restrictive feature: 2 to 20 inches to lithic bedrock
Drainage class: Well drained
Runoff class: High
Capacity of the most limiting layer to transmit water (Ksat): Low to moderately low (0.00 to 0.06 in/hr)
Depth to water table: More than 80 inches
Frequency of flooding: None
Frequency of ponding: None
Maximum salinity: Nonsaline to very slightly saline (0.0 to 2.0 mmhos/cm)
Available water supply, 0 to 60 inches: Very low (about 0.6 inches)

Interpretive groups

Land capability classification (irrigated): 7s
Land capability classification (nonirrigated): 7s
Hydrologic Soil Group: D
Ecological site: R161AY008HI - Isohyperthermic Ustic Naturalized Grassland
Hydric soil rating: No

272—Kanohina ashy very fine sandy loam, 2 to 10 percent slopes

Map Unit Setting

National map unit symbol: 2klg8
Elevation: 0 to 1,000 feet
Mean annual precipitation: 20 to 50 inches
Mean annual air temperature: 72 to 75 degrees F
Frost-free period: 365 days
Farmland classification: Not prime farmland

Map Unit Composition

Kanohina and similar soils: 90 percent
Minor components: 10 percent
Estimates are based on observations, descriptions, and transects of the mapunit.

Description of Kanohina

Setting

Landform: Ash fields on pahoehoe lava flows
Landform position (two-dimensional): Backslope
Landform position (three-dimensional): Side slope
Down-slope shape: Linear
Across-slope shape: Linear, convex
Parent material: Basic volcanic ash over pahoehoe lava

Typical profile

A - 0 to 1 inches: ashy very fine sandy loam
Bw - 1 to 3 inches: ashy sandy loam
C - 3 to 6 inches: ashy loamy sand
2R - 6 to 16 inches: bedrock

Properties and qualities

Slope: 2 to 10 percent
Depth to restrictive feature: 2 to 20 inches to lithic bedrock
Drainage class: Well drained
Runoff class: High
Capacity of the most limiting layer to transmit water (Ksat): Low to moderately low (0.00 to 0.06 in/hr)
Depth to water table: More than 80 inches
Frequency of flooding: None
Frequency of ponding: None
Maximum salinity: Nonsaline to very slightly saline (0.0 to 2.0 mmhos/cm)
Available water supply, 0 to 60 inches: Very low (about 0.6 inches)

Interpretive groups

Land capability classification (irrigated): 7s
Land capability classification (nonirrigated): 7s
Hydrologic Soil Group: D
Ecological site: R161AY008HI - Isohyperthermic Ustic Naturalized Grassland
Hydric soil rating: No

Minor Components

Lava flows, pahoehoe

Percent of map unit: 10 percent
Landform: Pahoehoe lava flows
Down-slope shape: Linear
Across-slope shape: Linear, convex
Hydric soil rating: No

402—Ihuanu very cobbly medial silt loam, 10 to 20 percent slopes, MLRA 160

Map Unit Setting

National map unit symbol: 2w03s
Elevation: 3,500 to 5,400 feet
Mean annual precipitation: 40 to 50 inches
Mean annual air temperature: 54 to 57 degrees F
Frost-free period: 270 to 365 days
Farmland classification: Not prime farmland

Map Unit Composition

Ihuanu and similar soils: 95 percent
Minor components: 5 percent
Estimates are based on observations, descriptions, and transects of the mapunit.

Description of Ihuanu

Setting

Landform: Ash fields on aa lava flows
Landform position (two-dimensional): Backslope
Landform position (three-dimensional): Side slope
Down-slope shape: Linear
Across-slope shape: Linear, convex
Parent material: Basic volcanic ash over aa lava

Typical profile

A/2C1 - 0 to 2 inches: very cobbly medial silt loam
2C2/Bw - 2 to 20 inches: extremely cobbly medial sandy loam
2C3 - 20 to 22 inches: extremely gravelly coarse sand
2R - 22 to 26 inches: bedrock

Properties and qualities

Slope: 10 to 20 percent
Depth to restrictive feature: 20 to 40 inches to lithic bedrock
Drainage class: Well drained
Runoff class: Very low
Capacity of the most limiting layer to transmit water (Ksat): Low to moderately low (0.00 to 0.06 in/hr)
Depth to water table: More than 80 inches
Frequency of flooding: None
Frequency of ponding: None
Maximum salinity: Nonsaline to very slightly saline (0.0 to 2.0 mmhos/cm)
Available water supply, 0 to 60 inches: Very low (about 1.4 inches)

Interpretive groups

Land capability classification (irrigated): 7s
Land capability classification (nonirrigated): 7s
Hydrologic Soil Group: A
Ecological site: R160XY006HI - Isomesic Savanna, R161AY003HI - Isomesic Savanna
Hydric soil rating: No

Minor Components

Lava flows, `a`a

Percent of map unit: 5 percent
Landform: Aa lava flows
Down-slope shape: Linear
Across-slope shape: Linear, convex
Hydric soil rating: No

403—Ihuanu very cobbly medial silt loam, 2 to 10 percent slopes, MLRA 160

Map Unit Setting

National map unit symbol: 2w03r
Elevation: 3,500 to 5,400 feet
Mean annual precipitation: 40 to 50 inches
Mean annual air temperature: 54 to 57 degrees F
Frost-free period: 270 to 365 days
Farmland classification: Not prime farmland

Map Unit Composition

Ihuanu and similar soils: 95 percent
Minor components: 5 percent
Estimates are based on observations, descriptions, and transects of the mapunit.

Description of Ihuanu

Setting

Landform: Ash fields on aa lava flows
Landform position (two-dimensional): Backslope
Landform position (three-dimensional): Side slope
Down-slope shape: Linear
Across-slope shape: Linear, convex
Parent material: Basic volcanic ash over aa lava

Typical profile

A/2C1 - 0 to 2 inches: very cobbly medial silt loam
2C2/Bw - 2 to 20 inches: extremely cobbly medial sandy loam
2C3 - 20 to 22 inches: extremely gravelly coarse sand
2R - 22 to 26 inches: bedrock

Properties and qualities

Slope: 2 to 10 percent
Depth to restrictive feature: 20 to 40 inches to lithic bedrock
Drainage class: Well drained
Runoff class: Very low
Capacity of the most limiting layer to transmit water (Ksat): Low to moderately low (0.00 to 0.06 in/hr)
Depth to water table: More than 80 inches
Frequency of flooding: None
Frequency of ponding: None
Maximum salinity: Nonsaline to very slightly saline (0.0 to 2.0 mmhos/cm)
Available water supply, 0 to 60 inches: Very low (about 1.4 inches)

Interpretive groups

Land capability classification (irrigated): 7s
Land capability classification (nonirrigated): 7s
Hydrologic Soil Group: A

Ecological site: R160XY006HI - Isomesic Savanna, R161AY003HI - Isomesic Savanna
Hydric soil rating: No

Minor Components

Lava flows, `a`a
Percent of map unit: 5 percent
Landform: Aa lava flows
Down-slope shape: Linear
Across-slope shape: Linear, convex
Hydric soil rating: No

407—Iwalani-Lava flows complex, 2 to 10 percent slopes

Map Unit Setting
National map unit symbol: 2klgt
Elevation: 3,500 to 5,400 feet
Mean annual precipitation: 40 to 50 inches
Mean annual air temperature: 54 to 57 degrees F
Frost-free period: 365 days
Farmland classification: Not prime farmland

Map Unit Composition
Iwalani and similar soils: 60 percent
Lava flows, pahoehoe: 40 percent
Estimates are based on observations, descriptions, and transects of the mapunit.

Description of Iwalani

Setting
Landform: Ash fields on pahoehoe lava flows
Landform position (two-dimensional): Backslope
Landform position (three-dimensional): Side slope
Down-slope shape: Linear
Across-slope shape: Linear, convex
Parent material: Basic volcanic ash and/or cinders over pahoehoe lava

Typical profile
A - 0 to 2 inches: medial loam
Bw - 2 to 3 inches: medial very fine sandy loam
A' - 3 to 5 inches: medial loamy sand
B'w - 5 to 10 inches: medial very fine sandy loam
2R - 10 to 20 inches: bedrock

Properties and qualities
Slope: 2 to 10 percent
Depth to restrictive feature: 2 to 10 inches to lithic bedrock
Drainage class: Well drained
Runoff class: High

Capacity of the most limiting layer to transmit water (Ksat): Low to moderately low (0.00 to 0.06 in/hr)
Depth to water table: More than 80 inches
Frequency of flooding: None
Frequency of ponding: None
Maximum salinity: Nonsaline to very slightly saline (0.0 to 2.0 mmhos/cm)
Available water supply, 0 to 60 inches: Very low (about 1.5 inches)

Interpretive groups
Land capability classification (irrigated): 7s
Land capability classification (nonirrigated): 7s
Hydrologic Soil Group: D
Ecological site: R161AY003HI - Isomesic Savanna, R160XY006HI - Isomesic Savanna
Hydric soil rating: No

Description of Lava Flows, Pahoehoe

Setting
Landform: Pahoehoe lava flows
Down-slope shape: Linear
Across-slope shape: Linear, convex
Parent material: Pahoehoe lava

Typical profile
R - 0 to 10 inches: bedrock

Properties and qualities
Slope: 2 to 10 percent
Depth to restrictive feature: 0 to 2 inches to lithic bedrock
Drainage class: Well drained
Runoff class: High
Capacity of the most limiting layer to transmit water (Ksat): Low to moderately low (0.00 to 0.06 in/hr)
Available water supply, 0 to 60 inches: Very low (about 0.0 inches)

Interpretive groups
Land capability classification (irrigated): 8
Land capability classification (nonirrigated): 8
Hydric soil rating: No

511—Akihi very cobbly hydrous silt loam, 10 to 20 percent slopes, MLRA 159B

Map Unit Setting
National map unit symbol: 2w03q
Elevation: 750 to 4,410 feet
Mean annual precipitation: 60 to 150 inches
Mean annual air temperature: 61 to 68 degrees F
Frost-free period: 365 days
Farmland classification: Not prime farmland

Map Unit Composition

Akihi and similar soils: 100 percent
Estimates are based on observations, descriptions, and transects of the mapunit.

Description of Akihi

Setting

Landform: Ash fields on aa lava flows
Landform position (three-dimensional): Side slope
Down-slope shape: Linear
Across-slope shape: Linear
Parent material: Aa lava basic volcanic ash

Typical profile

A/2C1 - 0 to 10 inches: very cobbly hydrous silt loam
Bw/2C2 - 10 to 35 inches: very cobbly hydrous silty clay loam
2R - 35 to 45 inches: bedrock

Properties and qualities

Slope: 10 to 20 percent
Depth to restrictive feature: 20 to 40 inches to lithic bedrock
Drainage class: Well drained
Runoff class: Very low
Capacity of the most limiting layer to transmit water (Ksat): Low to moderately low (0.00 to 0.06 in/hr)
Depth to water table: More than 80 inches
Frequency of flooding: None
Frequency of ponding: None
Maximum salinity: Nonsaline to very slightly saline (0.0 to 2.0 mmhos/cm)
Available water supply, 0 to 60 inches: Low (about 3.8 inches)

Interpretive groups

Land capability classification (irrigated): 6s
Land capability classification (nonirrigated): 6s
Hydrologic Soil Group: B
Ecological site: F159BY500HI - Udic Forest
Other vegetative classification: Ohia-Koa/Hapuu-Kanawao Forest (F159BY500HI)
Hydric soil rating: No

512—Akihi very cobbly hydrous silt loam, 2 to 10 percent slopes, MLRA 159B

Map Unit Setting

National map unit symbol: 2w03p
Elevation: 1,160 to 4,180 feet
Mean annual precipitation: 60 to 150 inches
Mean annual air temperature: 61 to 68 degrees F
Frost-free period: 365 days
Farmland classification: Not prime farmland

Map Unit Composition

Akihi and similar soils: 100 percent
Estimates are based on observations, descriptions, and transects of the mapunit.

Description of Akihi

Setting

Landform: Ash fields on aa lava flows
Down-slope shape: Linear
Across-slope shape: Linear
Parent material: Basic volcanic ash over aa lava

Typical profile

A/2C1 - 0 to 10 inches: very cobbly hydrous silt loam
Bw/2C2 - 10 to 35 inches: very cobbly hydrous silty clay loam
2R - 35 to 45 inches: bedrock

Properties and qualities

Slope: 2 to 10 percent
Depth to restrictive feature: 20 to 40 inches to lithic bedrock
Drainage class: Well drained
Runoff class: Very low
Capacity of the most limiting layer to transmit water (Ksat): Low to moderately low (0.00 to 0.06 in/hr)
Depth to water table: More than 80 inches
Frequency of flooding: None
Frequency of ponding: None
Maximum salinity: Nonsaline to very slightly saline (0.0 to 2.0 mmhos/cm)
Available water supply, 0 to 60 inches: Low (about 3.8 inches)

Interpretive groups

Land capability classification (irrigated): 6s
Land capability classification (nonirrigated): 6s
Hydrologic Soil Group: B
Ecological site: F159BY500HI - Udic Forest
Other vegetative classification: Ohia-Koa/Hapuu-Kanawao Forest (F159BY500HI)
Hydric soil rating: No

513—Hilea hydrous silty clay loam, 10 to 20 percent slopes

Map Unit Setting

National map unit symbol: 2klh6
Elevation: 1,000 to 4,000 feet
Mean annual precipitation: 60 to 150 inches
Mean annual air temperature: 61 to 70 degrees F
Frost-free period: 365 days
Farmland classification: Not prime farmland

Map Unit Composition

Hilea and similar soils: 100 percent
Estimates are based on observations, descriptions, and transects of the mapunit.

Description of Hilea

Setting

Landform: Ash fields on pahoehoe lava flows
Landform position (two-dimensional): Backslope
Landform position (three-dimensional): Side slope
Down-slope shape: Linear
Across-slope shape: Linear, convex
Parent material: Basic volcanic ash over pahoehoe lava

Typical profile

Oa - 0 to 0 inches: highly decomposed plant material
A - 0 to 8 inches: hydrous silty clay loam
Bw - 8 to 19 inches: hydrous silty clay loam
2R - 19 to 29 inches: bedrock

Properties and qualities

Slope: 10 to 20 percent
Depth to restrictive feature: 8 to 20 inches to lithic bedrock
Drainage class: Well drained
Runoff class: High
Capacity of the most limiting layer to transmit water (Ksat): Low to moderately low (0.00 to 0.06 in/hr)
Depth to water table: More than 80 inches
Frequency of flooding: None
Frequency of ponding: None
Maximum salinity: Nonsaline to very slightly saline (0.0 to 2.0 mmhos/cm)
Available water supply, 0 to 60 inches: Low (about 3.6 inches)

Interpretive groups

Land capability classification (irrigated): 4e
Land capability classification (nonirrigated): 4e
Hydrologic Soil Group: D
Ecological site: F159BY500HI - Udic Forest
Other vegetative classification: Ohia-Koa/Hapuu-Kanawao Forest (F159BY500HI)
Hydric soil rating: No

514—Hilea hydrous silty clay loam, 3 to 10 percent slopes

Map Unit Setting

National map unit symbol: 2klh7
Elevation: 1,000 to 4,000 feet
Mean annual precipitation: 60 to 150 inches
Mean annual air temperature: 61 to 70 degrees F
Frost-free period: 365 days
Farmland classification: Not prime farmland

Map Unit Composition

Hilea and similar soils: 100 percent
Estimates are based on observations, descriptions, and transects of the mapunit.

Description of Hilea

Setting

Landform: Ash fields on pahoehoe lava flows
Landform position (two-dimensional): Backslope
Landform position (three-dimensional): Side slope
Down-slope shape: Linear
Across-slope shape: Linear, convex
Parent material: Basic volcanic ash over pahoehoe lava

Typical profile

Oa - 0 to 0 inches: highly decomposed plant material
A - 0 to 8 inches: hydrous silty clay loam
Bw - 8 to 19 inches: hydrous silty clay loam
2R - 19 to 29 inches: bedrock

Properties and qualities

Slope: 3 to 10 percent
Depth to restrictive feature: 8 to 20 inches to lithic bedrock
Drainage class: Well drained
Runoff class: High
Capacity of the most limiting layer to transmit water (Ksat): Low to moderately low (0.00 to 0.06 in/hr)
Depth to water table: More than 80 inches
Frequency of flooding: None
Frequency of ponding: None
Maximum salinity: Nonsaline to very slightly saline (0.0 to 2.0 mmhos/cm)
Available water supply, 0 to 60 inches: Low (about 3.6 inches)

Interpretive groups

Land capability classification (irrigated): 4s
Land capability classification (nonirrigated): 4s
Hydrologic Soil Group: D
Ecological site: F159BY500HI - Udic Forest
Other vegetative classification: Ohia-Koa/Hapuu-Kanawao Forest (F159BY500HI)
Hydric soil rating: No

515—Pahipa-Puali association, 2 to 20 percent slopes

Map Unit Setting

National map unit symbol: 2klh8
Elevation: 4,000 to 6,000 feet
Mean annual precipitation: 60 to 100 inches
Mean annual air temperature: 52 to 59 degrees F
Frost-free period: 365 days
Farmland classification: Not prime farmland

Map Unit Composition

Pahipa and similar soils: 50 percent
Puali and similar soils: 40 percent
Minor components: 10 percent

Estimates are based on observations, descriptions, and transects of the mapunit.

Description of Pahipa

Setting

Landform: Ash fields on aa lava flows
Landform position (two-dimensional): Backslope
Landform position (three-dimensional): Side slope
Down-slope shape: Linear
Across-slope shape: Linear, convex
Parent material: Basic volcanic ash over aa lava

Typical profile

Oe - 0 to 2 inches: moderately decomposed plant material
A - 2 to 8 inches: hydrous silty clay loam
2A - 8 to 16 inches: gravelly highly organic hydrous silt loam
2Bw1/3C1 - 16 to 30 inches: very cobbly hydrous silty clay loam
3C2/2Bw2 - 30 to 39 inches: extremely cobbly hydrous silty clay loam
3R - 39 to 49 inches: bedrock

Properties and qualities

Slope: 2 to 20 percent
Depth to restrictive feature: 20 to 40 inches to lithic bedrock
Drainage class: Well drained
Runoff class: Low
Capacity of the most limiting layer to transmit water (Ksat): Low to moderately low (0.00 to 0.06 in/hr)
Depth to water table: More than 80 inches
Frequency of flooding: None
Frequency of ponding: None
Maximum salinity: Nonsaline to very slightly saline (0.0 to 2.0 mmhos/cm)
Available water supply, 0 to 60 inches: Low (about 5.1 inches)

Interpretive groups

Land capability classification (irrigated): 4e
Land capability classification (nonirrigated): 4e
Hydrologic Soil Group: C
Ecological site: F159BY500HI - Udic Forest
Other vegetative classification: Ohia-Koa/Hapuu-Kanawao Forest (F159BY500HI)
Hydric soil rating: No

Description of Puali

Setting

Landform: Ash fields on pahoehoe lava flows
Landform position (two-dimensional): Backslope
Landform position (three-dimensional): Side slope
Down-slope shape: Linear
Across-slope shape: Linear, convex
Parent material: Basic volcanic ash over pahoehoe lava

Typical profile

Oe - 0 to 4 inches: moderately decomposed plant material
A - 4 to 10 inches: highly organic hydrous silt loam
Bw - 10 to 18 inches: cobbly hydrous silty clay loam
2R - 18 to 28 inches: bedrock

Properties and qualities

Slope: 2 to 20 percent
Depth to restrictive feature: 2 to 20 inches to lithic bedrock
Drainage class: Well drained
Runoff class: High
Capacity of the most limiting layer to transmit water (Ksat): Low to moderately low (0.00 to 0.06 in/hr)
Depth to water table: More than 80 inches
Frequency of flooding: None
Frequency of ponding: None
Maximum salinity: Nonsaline to very slightly saline (0.0 to 2.0 mmhos/cm)
Available water supply, 0 to 60 inches: Low (about 3.4 inches)

Interpretive groups

Land capability classification (irrigated): 4e
Land capability classification (nonirrigated): 4e
Hydrologic Soil Group: D
Ecological site: F159BY500HI - Udic Forest
Other vegetative classification: Ohia-Koa/Hapuu-Kanawao Forest (F159BY500HI)
Hydric soil rating: No

Minor Components

Lithic endoaquands

Percent of map unit: 10 percent
Landform: Ash fields on pahoehoe lava flows
Landform position (two-dimensional): Backslope
Landform position (three-dimensional): Side slope
Down-slope shape: Linear
Across-slope shape: Linear, convex
Hydric soil rating: Yes

516—Alapai hydrous silty clay loam, 3 to 10 percent slopes

Map Unit Setting

National map unit symbol: 2klh9
Elevation: 1,600 to 4,000 feet
Mean annual precipitation: 90 to 150 inches
Mean annual air temperature: 61 to 70 degrees F
Frost-free period: 365 days
Farmland classification: All areas are prime farmland

Map Unit Composition

Alapai and similar soils: 100 percent
Estimates are based on observations, descriptions, and transects of the mapunit.

Description of Alapai

Setting

Landform: Ash fields on lava flows
Landform position (two-dimensional): Backslope
Landform position (three-dimensional): Side slope
Down-slope shape: Linear
Across-slope shape: Linear, convex
Parent material: Basic volcanic ash over basalt

Typical profile

Ap1 - 0 to 7 inches: hydrous silty clay loam
Ap2 - 7 to 15 inches: hydrous silty clay loam
B/A - 15 to 27 inches: hydrous silty clay loam
Bw1 - 27 to 36 inches: hydrous silty clay loam
Bw2 - 36 to 43 inches: hydrous silty clay loam
Bw3 - 43 to 50 inches: hydrous silty clay loam
Bw4 - 50 to 57 inches: hydrous silty clay loam
Bw5 - 57 to 66 inches: hydrous silty clay loam
Bw6 - 66 to 70 inches: hydrous silty clay loam
Bw7 - 70 to 74 inches: hydrous silty clay loam

Properties and qualities

Slope: 3 to 10 percent
Depth to restrictive feature: More than 80 inches
Drainage class: Well drained
Runoff class: Very low
Capacity of the most limiting layer to transmit water (Ksat): Moderately high to high (0.71 to 1.98 in/hr)
Depth to water table: More than 80 inches
Frequency of flooding: None
Frequency of ponding: None
Maximum salinity: Nonsaline to very slightly saline (0.0 to 2.0 mmhos/cm)
Available water supply, 0 to 60 inches: High (about 12.0 inches)

Interpretive groups

Land capability classification (irrigated): 3e
Land capability classification (nonirrigated): 3e
Hydrologic Soil Group: B
Ecological site: F159BY500HI - Udic Forest
Other vegetative classification: Ohia-Koa/Hapuu-Kanawao Forest (F159BY500HI)
Hydric soil rating: No

517—Alapai hydrous silty clay loam, 10 to 20 percent slopes

Map Unit Setting

National map unit symbol: 2klhb
Elevation: 1,600 to 4,000 feet
Mean annual precipitation: 90 to 150 inches
Mean annual air temperature: 61 to 70 degrees F
Frost-free period: 365 days

Farmland classification: Not prime farmland

Map Unit Composition

Alapai and similar soils: 100 percent
Estimates are based on observations, descriptions, and transects of the mapunit.

Description of Alapai

Setting

Landform: Ash fields on lava flows
Landform position (two-dimensional): Backslope
Landform position (three-dimensional): Side slope
Down-slope shape: Linear
Across-slope shape: Linear, convex
Parent material: Basic volcanic ash over basalt

Typical profile

Ap1 - 0 to 7 inches: hydrous silty clay loam
Ap2 - 7 to 15 inches: hydrous silty clay loam
B/A - 15 to 27 inches: hydrous silty clay loam
Bw1 - 27 to 36 inches: hydrous silty clay loam
Bw2 - 36 to 43 inches: hydrous silty clay loam
Bw3 - 43 to 50 inches: hydrous silty clay loam
Bw4 - 50 to 57 inches: hydrous silty clay loam
Bw5 - 57 to 66 inches: hydrous silty clay loam
Bw6 - 66 to 70 inches: hydrous silty clay loam
Bw7 - 70 to 74 inches: hydrous silty clay loam

Properties and qualities

Slope: 10 to 20 percent
Depth to restrictive feature: More than 80 inches
Drainage class: Well drained
Runoff class: Very low
Capacity of the most limiting layer to transmit water (Ksat): Moderately high to high (0.71 to 1.98 in/hr)
Depth to water table: More than 80 inches
Frequency of flooding: None
Frequency of ponding: None
Maximum salinity: Nonsaline to very slightly saline (0.0 to 2.0 mmhos/cm)
Available water supply, 0 to 60 inches: High (about 12.0 inches)

Interpretive groups

Land capability classification (irrigated): 4e
Land capability classification (nonirrigated): 4e
Hydrologic Soil Group: B
Ecological site: F159BY500HI - Udic Forest
Other vegetative classification: Ohia-Koa/Hapuu-Kanawao Forest (F159BY500HI)
Hydric soil rating: No

518—Alapai hydrous silty clay loam, 20 to 35 percent slopes

Map Unit Setting

National map unit symbol: 2klhc
Elevation: 1,600 to 4,000 feet
Mean annual precipitation: 90 to 150 inches
Mean annual air temperature: 61 to 70 degrees F
Frost-free period: 365 days
Farmland classification: Not prime farmland

Map Unit Composition

Alapai and similar soils: 100 percent
Estimates are based on observations, descriptions, and transects of the mapunit.

Description of Alapai

Setting

Landform: Ash fields on lava flows
Landform position (two-dimensional): Backslope
Landform position (three-dimensional): Side slope
Down-slope shape: Linear
Across-slope shape: Linear, convex
Parent material: Basic volcanic ash over basalt

Typical profile

Ap1 - 0 to 7 inches: hydrous silty clay loam
Ap2 - 7 to 15 inches: hydrous silty clay loam
B/A - 15 to 27 inches: hydrous silty clay loam
Bw1 - 27 to 36 inches: hydrous silty clay loam
Bw2 - 36 to 43 inches: hydrous silty clay loam
Bw3 - 43 to 50 inches: hydrous silty clay loam
Bw4 - 50 to 57 inches: hydrous silty clay loam
Bw5 - 57 to 66 inches: hydrous silty clay loam
Bw6 - 66 to 70 inches: hydrous silty clay loam
Bw7 - 70 to 74 inches: hydrous silty clay loam

Properties and qualities

Slope: 20 to 35 percent
Depth to restrictive feature: More than 80 inches
Drainage class: Well drained
Runoff class: Low
Capacity of the most limiting layer to transmit water (Ksat): Moderately high to high (0.71 to 1.98 in/hr)
Depth to water table: More than 80 inches
Frequency of flooding: None
Frequency of ponding: None
Maximum salinity: Nonsaline to very slightly saline (0.0 to 2.0 mmhos/cm)
Available water supply, 0 to 60 inches: High (about 12.0 inches)

Interpretive groups

Land capability classification (irrigated): 6e

Land capability classification (nonirrigated): 6e
Hydrologic Soil Group: B
Ecological site: F159BY500HI - Udic Forest
Other vegetative classification: Ohia-Koa/Hapuu-Kanawao Forest (F159BY500HI)
Hydric soil rating: No

519—Lalaau very cobbly highly decomposed plant material, 2 to 10 percent slopes

Map Unit Setting

National map unit symbol: 2klhd
Elevation: 1,000 to 7,000 feet
Mean annual precipitation: 60 to 150 inches
Mean annual air temperature: 52 to 59 degrees F
Frost-free period: 365 days
Farmland classification: Not prime farmland

Map Unit Composition

Lalaau and similar soils: 95 percent
Minor components: 5 percent
Estimates are based on observations, descriptions, and transects of the mapunit.

Description of Lalaau

Setting

Landform: Aa lava flows
Landform position (two-dimensional): Backslope
Landform position (three-dimensional): Side slope
Down-slope shape: Linear
Across-slope shape: Linear, convex
Parent material: Organic material over aa lava

Typical profile

Oa/2C1 - 0 to 3 inches: very cobbly highly decomposed plant material
2C2 - 3 to 53 inches: cobbles
2R - 53 to 63 inches: bedrock

Properties and qualities

Slope: 2 to 10 percent
Depth to restrictive feature: 40 to 60 inches to lithic bedrock
Drainage class: Well drained
Runoff class: Low
Capacity of the most limiting layer to transmit water (Ksat): Low to moderately low (0.00 to 0.06 in/hr)
Depth to water table: More than 80 inches
Frequency of flooding: None
Frequency of ponding: None
Maximum salinity: Nonsaline to very slightly saline (0.0 to 2.0 mmhos/cm)
Available water supply, 0 to 60 inches: Very low (about 1.4 inches)

Interpretive groups

Land capability classification (irrigated): 7s

Land capability classification (nonirrigated): 7s
Hydrologic Soil Group: A
Ecological site: R161AY003HI - Isomesic Savanna, R160XY006HI - Isomesic Savanna
Hydric soil rating: No

Minor Components

Lava flows, `a`a
Percent of map unit: 5 percent
Landform: Aa lava flows
Down-slope shape: Linear
Across-slope shape: Linear, convex
Hydric soil rating: No

520—Naalehu medial silty clay loam, 35 to 70 percent slopes

Map Unit Setting
National map unit symbol: 2klhf
Elevation: 0 to 1,200 feet
Mean annual precipitation: 30 to 60 inches
Mean annual air temperature: 70 to 75 degrees F
Frost-free period: 365 days
Farmland classification: Not prime farmland

Map Unit Composition
Naalehu and similar soils: 100 percent
Estimates are based on observations, descriptions, and transects of the mapunit.

Description of Naalehu

Setting
Landform: Ash fields on pahoehoe lava flows
Landform position (two-dimensional): Backslope
Landform position (three-dimensional): Side slope
Down-slope shape: Linear
Across-slope shape: Linear, convex
Parent material: Basic volcanic ash over pahoehoe lava

Typical profile
Ap1 - 0 to 11 inches: medial silt loam
Ap2 - 11 to 17 inches: medial silt loam
Bw1 - 17 to 28 inches: hydrous silty clay loam
Bw2 - 28 to 37 inches: hydrous silty clay loam
2Bwb - 37 to 44 inches: hydrous silty clay loam
3Bwb - 44 to 59 inches: hydrous silty clay loam

Properties and qualities
Slope: 40 to 70 percent
Depth to restrictive feature: More than 80 inches
Drainage class: Well drained

Runoff class: Medium
Capacity of the most limiting layer to transmit water (Ksat): Moderately high to high (0.57 to 1.98 in/hr)
Depth to water table: More than 80 inches
Frequency of flooding: None
Frequency of ponding: None
Maximum salinity: Nonsaline to very slightly saline (0.0 to 2.0 mmhos/cm)
Available water supply, 0 to 60 inches: High (about 11.8 inches)

Interpretive groups
Land capability classification (irrigated): 7e
Land capability classification (nonirrigated): 7e
Hydrologic Soil Group: B
Ecological site: F161BY501HI - Kona Weather Ustic Forest
Hydric soil rating: No

521—Naalehu medial silty clay loam, 3 to 10 percent slopes

Map Unit Setting
National map unit symbol: 2klhg
Elevation: 0 to 1,200 feet
Mean annual precipitation: 30 to 60 inches
Mean annual air temperature: 70 to 75 degrees F
Frost-free period: 365 days
Farmland classification: Prime farmland if irrigated

Map Unit Composition
Naalehu and similar soils: 100 percent
Estimates are based on observations, descriptions, and transects of the mapunit.

Description of Naalehu

Setting
Landform: Ash fields on pahoehoe lava flows
Landform position (two-dimensional): Backslope
Landform position (three-dimensional): Side slope
Down-slope shape: Linear
Across-slope shape: Linear, convex
Parent material: Basic volcanic ash over pahoehoe lava

Typical profile
Ap1 - 0 to 11 inches: medial silt loam
Ap2 - 11 to 17 inches: medial silt loam
Bw1 - 17 to 28 inches: hydrous silty clay loam
Bw2 - 28 to 37 inches: hydrous silty clay loam
2Bwb - 37 to 44 inches: hydrous silty clay loam
3Bwb - 44 to 59 inches: hydrous silty clay loam

Properties and qualities
Slope: 3 to 10 percent
Depth to restrictive feature: More than 80 inches
Drainage class: Well drained

Runoff class: Low
Capacity of the most limiting layer to transmit water (Ksat): Moderately high to high (0.57 to 1.98 in/hr)
Depth to water table: More than 80 inches
Frequency of flooding: None
Frequency of ponding: None
Maximum salinity: Nonsaline to very slightly saline (0.0 to 2.0 mmhos/cm)
Available water supply, 0 to 60 inches: High (about 11.8 inches)

Interpretive groups
Land capability classification (irrigated): 3e
Land capability classification (nonirrigated): 3e
Hydrologic Soil Group: B
Ecological site: F161BY501HI - Kona Weather Ustic Forest
Hydric soil rating: No

522—Naalehu medial silty clay loam, 10 to 20 percent slopes

Map Unit Setting
National map unit symbol: 2klhh
Elevation: 0 to 1,200 feet
Mean annual precipitation: 30 to 60 inches
Mean annual air temperature: 70 to 75 degrees F
Frost-free period: 365 days
Farmland classification: Not prime farmland

Map Unit Composition
Naalehu and similar soils: 100 percent
Estimates are based on observations, descriptions, and transects of the mapunit.

Description of Naalehu

Setting
Landform: Ash fields on pahoehoe lava flows
Landform position (two-dimensional): Backslope
Landform position (three-dimensional): Side slope
Down-slope shape: Linear
Across-slope shape: Linear, convex
Parent material: Basic volcanic ash over pahoehoe lava

Typical profile
Ap1 - 0 to 11 inches: medial silt loam
Ap2 - 11 to 17 inches: medial silt loam
Bw1 - 17 to 28 inches: hydrous silty clay loam
Bw2 - 28 to 37 inches: hydrous silty clay loam
2Bwb - 37 to 44 inches: hydrous silty clay loam
3Bwb - 44 to 59 inches: hydrous silty clay loam

Properties and qualities
Slope: 10 to 20 percent
Depth to restrictive feature: More than 80 inches
Drainage class: Well drained

Runoff class: Low
Capacity of the most limiting layer to transmit water (Ksat): Moderately high to high (0.57 to 1.98 in/hr)
Depth to water table: More than 80 inches
Frequency of flooding: None
Frequency of ponding: None
Maximum salinity: Nonsaline to very slightly saline (0.0 to 2.0 mmhos/cm)
Available water supply, 0 to 60 inches: High (about 11.8 inches)

Interpretive groups
Land capability classification (irrigated): 4e
Land capability classification (nonirrigated): 4e
Hydrologic Soil Group: B
Ecological site: F161BY501HI - Kona Weather Ustic Forest
Hydric soil rating: No

523—Naalehu medial silty clay loam, 20 to 35 percent slopes

Map Unit Setting
National map unit symbol: 2klhj
Elevation: 0 to 1,200 feet
Mean annual precipitation: 30 to 60 inches
Mean annual air temperature: 70 to 75 degrees F
Frost-free period: 365 days
Farmland classification: Not prime farmland

Map Unit Composition
Naalehu and similar soils: 100 percent
Estimates are based on observations, descriptions, and transects of the mapunit.

Description of Naalehu

Setting
Landform: Ash fields on pahoehoe lava flows
Landform position (two-dimensional): Backslope
Landform position (three-dimensional): Side slope
Down-slope shape: Linear
Across-slope shape: Linear, convex
Parent material: Basic volcanic ash over pahoehoe lava

Typical profile
Ap1 - 0 to 11 inches: medial silt loam
Ap2 - 11 to 17 inches: medial silt loam
Bw1 - 17 to 28 inches: hydrous silty clay loam
Bw2 - 28 to 37 inches: hydrous silty clay loam
2Bwb - 37 to 44 inches: hydrous silty clay loam
3Bwb - 44 to 59 inches: hydrous silty clay loam

Properties and qualities
Slope: 20 to 40 percent
Depth to restrictive feature: More than 80 inches
Drainage class: Well drained

Runoff class: Medium
Capacity of the most limiting layer to transmit water (Ksat): Moderately high to high (0.57 to 1.98 in/hr)
Depth to water table: More than 80 inches
Frequency of flooding: None
Frequency of ponding: None
Maximum salinity: Nonsaline to very slightly saline (0.0 to 2.0 mmhos/cm)
Available water supply, 0 to 60 inches: High (about 11.8 inches)

Interpretive groups
Land capability classification (irrigated): 6e
Land capability classification (nonirrigated): 6e
Hydrologic Soil Group: B
Ecological site: F161BY501HI - Kona Weather Ustic Forest
Hydric soil rating: No

527—Alapai hydrous silty clay loam, 35 to 70 percent slopes

Map Unit Setting
National map unit symbol: 2klhn
Elevation: 1,000 to 1,900 feet
Mean annual precipitation: 60 to 90 inches
Mean annual air temperature: 61 to 70 degrees F
Frost-free period: 365 days
Farmland classification: Not prime farmland

Map Unit Composition
Alapai, lower precipitation, and similar soils: 100 percent
Estimates are based on observations, descriptions, and transects of the mapunit.

Description of Alapai, Lower Precipitation

Setting
Landform: Ash fields on lava flows
Landform position (two-dimensional): Backslope
Landform position (three-dimensional): Side slope
Down-slope shape: Linear
Across-slope shape: Linear, convex
Parent material: Basic volcanic ash

Typical profile
Ap - 0 to 9 inches: hydrous silty clay loam
Bw1 - 9 to 17 inches: hydrous silty clay loam
Bw2 - 17 to 23 inches: hydrous silty clay loam
Bw3 - 23 to 31 inches: hydrous silty clay loam
Bw4 - 31 to 40 inches: hydrous silty clay loam
Bw5 - 40 to 48 inches: hydrous silty clay loam
Bw6 - 48 to 54 inches: hydrous silty clay loam
Bw7 - 54 to 65 inches: hydrous silty clay loam
Bw8 - 65 to 74 inches: hydrous silty clay loam

Properties and qualities

Slope: 35 to 70 percent
Depth to restrictive feature: More than 80 inches
Drainage class: Well drained
Runoff class: High
Capacity of the most limiting layer to transmit water (Ksat): Moderately high to high (0.57 to 1.98 in/hr)
Depth to water table: More than 80 inches
Frequency of flooding: None
Frequency of ponding: None
Maximum salinity: Nonsaline to very slightly saline (0.0 to 2.0 mmhos/cm)
Available water supply, 0 to 60 inches: High (about 12.0 inches)

Interpretive groups

Land capability classification (irrigated): 7e
Land capability classification (nonirrigated): 7e
Hydrologic Soil Group: B
Ecological site: F159BY500HI - Udic Forest
Hydric soil rating: No

528—Alapai hydrous silty clay loam, 0 to 3 percent slopes

Map Unit Setting

National map unit symbol: 2klhp
Elevation: 1,600 to 4,000 feet
Mean annual precipitation: 90 to 150 inches
Mean annual air temperature: 61 to 70 degrees F
Frost-free period: 365 days
Farmland classification: All areas are prime farmland

Map Unit Composition

Alapai and similar soils: 100 percent
Estimates are based on observations, descriptions, and transects of the mapunit.

Description of Alapai

Setting

Landform: Ash fields on pahoehoe lava flows
Landform position (two-dimensional): Backslope
Landform position (three-dimensional): Side slope
Down-slope shape: Linear
Across-slope shape: Linear, convex
Parent material: Basic volcanic ash over basalt

Typical profile

Ap1 - 0 to 7 inches: hydrous silty clay loam
Ap2 - 7 to 15 inches: hydrous silty clay loam
B/A - 15 to 27 inches: hydrous silty clay loam
Bw1 - 27 to 36 inches: hydrous silty clay loam
Bw2 - 36 to 43 inches: hydrous silty clay loam
Bw3 - 43 to 50 inches: hydrous silty clay loam

Bw4 - 50 to 57 inches: hydrous silty clay loam
Bw5 - 57 to 66 inches: hydrous silty clay loam
Bw6 - 66 to 70 inches: hydrous silty clay loam
Bw7 - 70 to 74 inches: hydrous silty clay loam

Properties and qualities

Slope: 0 to 3 percent
Depth to restrictive feature: More than 80 inches
Drainage class: Well drained
Runoff class: Very low
Capacity of the most limiting layer to transmit water (Ksat): Moderately high to high (0.71 to 1.98 in/hr)
Depth to water table: More than 80 inches
Frequency of flooding: None
Frequency of ponding: None
Maximum salinity: Nonsaline to very slightly saline (0.0 to 2.0 mmhos/cm)
Available water supply, 0 to 60 inches: High (about 12.0 inches)

Interpretive groups

Land capability classification (irrigated): 1
Land capability classification (nonirrigated): 1
Hydrologic Soil Group: B
Ecological site: F159BY500HI - Udic Forest
Hydric soil rating: No

529—Honuapo-Hilea complex, 10 to 20 percent slopes

Map Unit Setting

National map unit symbol: 2klhq
Elevation: 1,200 to 4,000 feet
Mean annual precipitation: 60 to 150 inches
Mean annual air temperature: 59 to 70 degrees F
Frost-free period: 365 days
Farmland classification: Not prime farmland

Map Unit Composition

Honuapo and similar soils: 70 percent
Hilea and similar soils: 30 percent
Estimates are based on observations, descriptions, and transects of the mapunit.

Description of Honuapo

Setting

Landform: Ash fields on pahoehoe lava flows
Landform position (two-dimensional): Backslope
Landform position (three-dimensional): Side slope
Down-slope shape: Linear
Across-slope shape: Linear, convex
Parent material: Basic volcanic ash over pahoehoe lava

Typical profile

Ap - 0 to 19 inches: hydrous silt loam

Bw1 - 19 to 26 inches: hydrous silty clay loam
Bw2 - 26 to 30 inches: very paragravelly hydrous silty clay loam
Bw3 - 30 to 39 inches: hydrous silty clay loam
2R - 39 to 49 inches: bedrock

Properties and qualities

Slope: 10 to 20 percent
Depth to restrictive feature: 20 to 40 inches to lithic bedrock
Drainage class: Well drained
Runoff class: Low
Capacity of the most limiting layer to transmit water (Ksat): Low to moderately low (0.00 to 0.06 in/hr)
Depth to water table: More than 80 inches
Frequency of flooding: Occasional
Frequency of ponding: None
Maximum salinity: Nonsaline to very slightly saline (0.0 to 2.0 mmhos/cm)
Available water supply, 0 to 60 inches: Moderate (about 7.4 inches)

Interpretive groups

Land capability classification (irrigated): 4e
Land capability classification (nonirrigated): 4e
Hydrologic Soil Group: C
Ecological site: F159BY500HI - Udic Forest
Hydric soil rating: No

Description of Hilea

Setting

Landform: Ash fields on pahoehoe lava flows
Landform position (two-dimensional): Backslope
Landform position (three-dimensional): Side slope
Down-slope shape: Linear
Across-slope shape: Linear, convex
Parent material: Basic volcanic ash over pahoehoe lava

Typical profile

Oa - 0 to 0 inches: highly decomposed plant material
A - 0 to 8 inches: hydrous silty clay loam
Bw - 8 to 19 inches: hydrous silty clay loam
2R - 19 to 29 inches: bedrock

Properties and qualities

Slope: 10 to 20 percent
Depth to restrictive feature: 8 to 20 inches to lithic bedrock
Drainage class: Well drained
Runoff class: High
Capacity of the most limiting layer to transmit water (Ksat): Low to moderately low (0.00 to 0.06 in/hr)
Depth to water table: More than 80 inches
Frequency of flooding: None
Frequency of ponding: None
Maximum salinity: Nonsaline to very slightly saline (0.0 to 2.0 mmhos/cm)
Available water supply, 0 to 60 inches: Low (about 3.6 inches)

Interpretive groups

Land capability classification (irrigated): 4e
Land capability classification (nonirrigated): 4e

Hydrologic Soil Group: D
Ecological site: F159BY500HI - Udic Forest
Hydric soil rating: No

530—Hilea-Lava flows complex, 3 to 10 percent slopes

Map Unit Setting

National map unit symbol: 2klhr
Elevation: 1,000 to 4,000 feet
Mean annual precipitation: 60 to 150 inches
Mean annual air temperature: 61 to 70 degrees F
Frost-free period: 365 days
Farmland classification: Not prime farmland

Map Unit Composition

Hilea, cobbly, and similar soils: 70 percent
Lava flows, pahoehoe: 30 percent
Estimates are based on observations, descriptions, and transects of the mapunit.

Description of Hilea, Cobbly

Setting

Landform: Ash fields on pahoehoe lava flows
Landform position (two-dimensional): Backslope
Landform position (three-dimensional): Side slope
Down-slope shape: Linear
Across-slope shape: Linear, convex
Parent material: Basic volcanic ash over pahoehoe lava

Typical profile

Oa - 0 to 0 inches: highly decomposed plant material
A - 0 to 8 inches: cobbly hydrous silty clay loam
Bw - 8 to 19 inches: hydrous silty clay loam
2R - 19 to 29 inches: bedrock

Properties and qualities

Slope: 3 to 10 percent
Depth to restrictive feature: 8 to 20 inches to lithic bedrock
Drainage class: Well drained
Runoff class: High
Capacity of the most limiting layer to transmit water (Ksat): Low to moderately low (0.00 to 0.06 in/hr)
Depth to water table: More than 80 inches
Frequency of flooding: None
Frequency of ponding: None
Maximum salinity: Nonsaline to very slightly saline (0.0 to 2.0 mmhos/cm)
Available water supply, 0 to 60 inches: Low (about 3.6 inches)

Interpretive groups

Land capability classification (irrigated): 4s
Land capability classification (nonirrigated): 4s

Hydrologic Soil Group: D
Ecological site: F159BY500HI - Udic Forest
Hydric soil rating: No

Description of Lava Flows, Pahoehoe

Setting
Landform: Pahoehoe lava flows
Down-slope shape: Linear
Across-slope shape: Linear, convex
Parent material: Pahoehoe lava

Typical profile
R - 0 to 10 inches: bedrock

Properties and qualities
Slope: 3 to 10 percent
Depth to restrictive feature: 0 to 2 inches to lithic bedrock
Drainage class: Well drained
Runoff class: High
Capacity of the most limiting layer to transmit water (Ksat): Low to moderately low (0.00 to 0.06 in/hr)
Available water supply, 0 to 60 inches: Very low (about 0.0 inches)

Interpretive groups
Land capability classification (irrigated): 8
Land capability classification (nonirrigated): 8
Hydric soil rating: No

531—Hilea-Lava flows complex, 10 to 20 percent slopes

Map Unit Setting
National map unit symbol: 2klhs
Elevation: 1,000 to 4,000 feet
Mean annual precipitation: 60 to 150 inches
Mean annual air temperature: 61 to 70 degrees F
Frost-free period: 365 days
Farmland classification: Not prime farmland

Map Unit Composition
Hilea, cobbly, and similar soils: 70 percent
Lava flows, pahoehoe: 30 percent
Estimates are based on observations, descriptions, and transects of the mapunit.

Description of Hilea, Cobbly

Setting
Landform: Ash fields on pahoehoe lava flows
Landform position (two-dimensional): Backslope
Landform position (three-dimensional): Side slope
Down-slope shape: Linear

Across-slope shape: Linear, convex
Parent material: Basic volcanic ash over pahoehoe lava

Typical profile

Oa - 0 to 0 inches: highly decomposed plant material
A - 0 to 8 inches: cobbly hydrous silty clay loam
Bw - 8 to 19 inches: hydrous silty clay loam
2R - 19 to 29 inches: bedrock

Properties and qualities

Slope: 10 to 20 percent
Depth to restrictive feature: 8 to 20 inches to lithic bedrock
Drainage class: Well drained
Runoff class: High
Capacity of the most limiting layer to transmit water (Ksat): Low to moderately low (0.00 to 0.06 in/hr)
Depth to water table: More than 80 inches
Frequency of flooding: None
Frequency of ponding: None
Maximum salinity: Nonsaline to very slightly saline (0.0 to 2.0 mmhos/cm)
Available water supply, 0 to 60 inches: Low (about 3.6 inches)

Interpretive groups

Land capability classification (irrigated): 4e
Land capability classification (nonirrigated): 4e
Hydrologic Soil Group: D
Ecological site: F159BY500HI - Udic Forest
Hydric soil rating: No

Description of Lava Flows, Pahoehoe

Setting

Landform: Pahoehoe lava flows
Down-slope shape: Linear
Across-slope shape: Linear, convex
Parent material: Pahoehoe lava

Typical profile

R - 0 to 10 inches: bedrock

Properties and qualities

Slope: 10 to 20 percent
Depth to restrictive feature: 0 to 2 inches to lithic bedrock
Drainage class: Well drained
Runoff class: Very high
Capacity of the most limiting layer to transmit water (Ksat): Low to moderately low (0.00 to 0.06 in/hr)
Available water supply, 0 to 60 inches: Very low (about 0.0 inches)

Interpretive groups

Land capability classification (irrigated): 8
Land capability classification (nonirrigated): 8
Hydric soil rating: No

532—Honuapo hydrous silt loam, 3 to 10 percent slopes

Map Unit Setting

National map unit symbol: 2klht
Elevation: 1,200 to 4,000 feet
Mean annual precipitation: 60 to 150 inches
Mean annual air temperature: 59 to 68 degrees F
Frost-free period: 365 days
Farmland classification: All areas are prime farmland

Map Unit Composition

Honuapo and similar soils: 100 percent
Estimates are based on observations, descriptions, and transects of the mapunit.

Description of Honuapo

Setting

Landform: Ash fields on pahoehoe lava flows
Landform position (two-dimensional): Backslope
Landform position (three-dimensional): Side slope
Down-slope shape: Linear
Across-slope shape: Linear, convex
Parent material: Basic volcanic ash over pahoehoe lava

Typical profile

Ap - 0 to 19 inches: hydrous silt loam
Bw1 - 19 to 26 inches: hydrous silty clay loam
Bw2 - 26 to 30 inches: very paragravelly hydrous silty clay loam
Bw3 - 30 to 39 inches: hydrous silty clay loam
2R - 39 to 49 inches: bedrock

Properties and qualities

Slope: 3 to 10 percent
Depth to restrictive feature: 20 to 40 inches to lithic bedrock
Drainage class: Well drained
Runoff class: Low
Capacity of the most limiting layer to transmit water (Ksat): Low to moderately low (0.00 to 0.06 in/hr)
Depth to water table: More than 80 inches
Frequency of flooding: Occasional
Frequency of ponding: None
Maximum salinity: Nonsaline to very slightly saline (0.0 to 2.0 mmhos/cm)
Available water supply, 0 to 60 inches: Moderate (about 7.4 inches)

Interpretive groups

Land capability classification (irrigated): 3e
Land capability classification (nonirrigated): 3e
Hydrologic Soil Group: C
Ecological site: F159BY500HI - Udic Forest
Hydric soil rating: No

533—Honuapo-Hilea complex, 20 to 35 percent slopes

Map Unit Setting

National map unit symbol: 2klhv
Elevation: 1,200 to 4,000 feet
Mean annual precipitation: 60 to 150 inches
Mean annual air temperature: 59 to 70 degrees F
Frost-free period: 365 days
Farmland classification: Not prime farmland

Map Unit Composition

Honuapo and similar soils: 70 percent
Hilea and similar soils: 30 percent
Estimates are based on observations, descriptions, and transects of the mapunit.

Description of Honuapo

Setting

Landform: Ash fields on pahoehoe lava flows
Landform position (two-dimensional): Backslope
Landform position (three-dimensional): Side slope
Down-slope shape: Linear
Across-slope shape: Linear, convex
Parent material: Basic volcanic ash over pahoehoe lava

Typical profile

Ap - 0 to 19 inches: hydrous silt loam
Bw1 - 19 to 26 inches: hydrous silty clay loam
Bw2 - 26 to 30 inches: very paragravelly hydrous silty clay loam
Bw3 - 30 to 39 inches: hydrous silty clay loam
2R - 39 to 49 inches: bedrock

Properties and qualities

Slope: 20 to 35 percent
Depth to restrictive feature: 20 to 40 inches to lithic bedrock
Drainage class: Well drained
Runoff class: Medium
Capacity of the most limiting layer to transmit water (Ksat): Low to moderately low (0.00 to 0.06 in/hr)
Depth to water table: More than 80 inches
Frequency of flooding: Occasional
Frequency of ponding: None
Maximum salinity: Nonsaline to very slightly saline (0.0 to 2.0 mmhos/cm)
Available water supply, 0 to 60 inches: Moderate (about 7.4 inches)

Interpretive groups

Land capability classification (irrigated): 6e
Land capability classification (nonirrigated): 6e
Hydrologic Soil Group: C
Ecological site: F159BY500HI - Udic Forest
Hydric soil rating: No

Description of Hilea

Setting

Landform: Ash fields on pahoehoe lava flows
Landform position (two-dimensional): Backslope
Landform position (three-dimensional): Side slope
Down-slope shape: Linear
Across-slope shape: Linear, convex
Parent material: Basic volcanic ash over pahoehoe lava

Typical profile

Oa - 0 to 0 inches: highly decomposed plant material
A - 0 to 8 inches: hydrous silty clay loam
Bw - 8 to 19 inches: hydrous silty clay loam
2R - 19 to 29 inches: bedrock

Properties and qualities

Slope: 20 to 35 percent
Depth to restrictive feature: 8 to 20 inches to lithic bedrock
Drainage class: Well drained
Runoff class: Very high
Capacity of the most limiting layer to transmit water (Ksat): Low to moderately low (0.00 to 0.06 in/hr)
Depth to water table: More than 80 inches
Frequency of flooding: None
Frequency of ponding: None
Maximum salinity: Nonsaline to very slightly saline (0.0 to 2.0 mmhos/cm)
Available water supply, 0 to 60 inches: Low (about 3.6 inches)

Interpretive groups

Land capability classification (irrigated): 6e
Land capability classification (nonirrigated): 6e
Hydrologic Soil Group: D
Ecological site: F159BY500HI - Udic Forest
Hydric soil rating: No

534—Kahaluu-Lava flows complex, 2 to 10 percent slopes

Map Unit Setting

National map unit symbol: 2klhw
Elevation: 3,500 to 7,000 feet
Mean annual precipitation: 60 to 150 inches
Mean annual air temperature: 52 to 57 degrees F
Frost-free period: 365 days
Farmland classification: Not prime farmland

Map Unit Composition

Kahaluu and similar soils: 60 percent
Lava flows, pahoehoe: 40 percent
Estimates are based on observations, descriptions, and transects of the mapunit.

Description of Kahaluu

Setting

Landform: Ash fields on pahoehoe lava flows
Landform position (two-dimensional): Backslope
Landform position (three-dimensional): Side slope
Down-slope shape: Linear
Across-slope shape: Linear, convex
Parent material: Organic material over pahoehoe lava

Typical profile

Oa - 0 to 5 inches: highly decomposed plant material
2R - 5 to 15 inches: bedrock

Properties and qualities

Slope: 2 to 10 percent
Depth to restrictive feature: 1 to 10 inches to lithic bedrock
Drainage class: Well drained
Runoff class: High
Capacity of the most limiting layer to transmit water (Ksat): Low to moderately low (0.00 to 0.06 in/hr)
Depth to water table: More than 80 inches
Frequency of flooding: None
Frequency of ponding: None
Maximum salinity: Nonsaline to very slightly saline (0.0 to 2.0 mmhos/cm)
Available water supply, 0 to 60 inches: Very low (about 1.1 inches)

Interpretive groups

Land capability classification (irrigated): 7s
Land capability classification (nonirrigated): 7s
Hydrologic Soil Group: D
Ecological site: R161AY003HI - Isomesic Savanna, F159BY500HI - Udic Forest
Other vegetative classification: Ohia-Koa/Hapuu-Kanawao Forest (F159BY500HI)
Hydric soil rating: No

Description of Lava Flows, Pahoehoe

Setting

Landform: Pahoehoe lava flows
Down-slope shape: Linear
Across-slope shape: Linear, convex
Parent material: Pahoehoe lava

Typical profile

R - 0 to 10 inches: bedrock

Properties and qualities

Slope: 2 to 10 percent
Depth to restrictive feature: 0 to 2 inches to lithic bedrock
Drainage class: Well drained
Runoff class: High
Capacity of the most limiting layer to transmit water (Ksat): Low to moderately low (0.00 to 0.06 in/hr)
Available water supply, 0 to 60 inches: Very low (about 0.0 inches)

Interpretive groups

Land capability classification (irrigated): 8

Land capability classification (nonirrigated): 8
Hydric soil rating: No

536—Puueo extremely cobbly medial silt loam, 2 to 10 percent slopes

Map Unit Setting

National map unit symbol: 2klhy
Elevation: 0 to 1,200 feet
Mean annual precipitation: 30 to 60 inches
Mean annual air temperature: 70 to 75 degrees F
Frost-free period: 365 days
Farmland classification: Not prime farmland

Map Unit Composition

Puueo and similar soils: 90 percent
Minor components: 10 percent
Estimates are based on observations, descriptions, and transects of the mapunit.

Description of Puueo

Setting

Landform: Ash fields on aa lava flows
Landform position (two-dimensional): Backslope
Landform position (three-dimensional): Side slope
Down-slope shape: Linear
Across-slope shape: Linear, convex
Parent material: Basic volcanic ash over aa lava

Typical profile

2C1/A1 - 0 to 7 inches: extremely cobbly medial silt loam
2C2/A2 - 7 to 18 inches: extremely cobbly medial silt loam
2C3 - 18 to 30 inches: cobbles
2R - 30 to 40 inches: bedrock

Properties and qualities

Slope: 2 to 10 percent
Depth to restrictive feature: 20 to 40 inches to lithic bedrock
Drainage class: Somewhat excessively drained
Runoff class: Very low
Capacity of the most limiting layer to transmit water (Ksat): Low to moderately low (0.00 to 0.06 in/hr)
Depth to water table: More than 80 inches
Frequency of flooding: None
Frequency of ponding: None
Maximum salinity: Nonsaline to very slightly saline (0.0 to 2.0 mmhos/cm)
Available water supply, 0 to 60 inches: Very low (about 2.9 inches)

Interpretive groups

Land capability classification (irrigated): 6s
Land capability classification (nonirrigated): 6s
Hydrologic Soil Group: A

Ecological site: F161BY501HI - Kona Weather Ustic Forest
Hydric soil rating: No

Minor Components

Lava flows, `a`a
Percent of map unit: 10 percent
Landform: Aa lava flows
Down-slope shape: Linear
Across-slope shape: Linear, convex
Hydric soil rating: No

538—Naalehu medial silt loam, 0 to 3 percent slopes

Map Unit Setting
National map unit symbol: 2klj0
Elevation: 0 to 1,200 feet
Mean annual precipitation: 30 to 60 inches
Mean annual air temperature: 70 to 75 degrees F
Frost-free period: 365 days
Farmland classification: Prime farmland if irrigated

Map Unit Composition
Naalehu and similar soils: 100 percent
Estimates are based on observations, descriptions, and transects of the mapunit.

Description of Naalehu

Setting
Landform: Ash fields on pahoehoe lava flows
Landform position (two-dimensional): Backslope
Landform position (three-dimensional): Side slope
Down-slope shape: Linear
Across-slope shape: Linear, convex
Parent material: Basic volcanic ash over pahoehoe lava

Typical profile
Ap1 - 0 to 11 inches: medial silt loam
Ap2 - 11 to 17 inches: medial silt loam
Bw1 - 17 to 28 inches: hydrous silty clay loam
Bw2 - 28 to 37 inches: hydrous silty clay loam
2Bwb - 37 to 44 inches: hydrous silty clay loam
3Bwb - 44 to 59 inches: hydrous silty clay loam

Properties and qualities
Slope: 0 to 3 percent
Depth to restrictive feature: More than 80 inches
Drainage class: Well drained
Runoff class: Very low
Capacity of the most limiting layer to transmit water (Ksat): Moderately high to high (0.57 to 1.98 in/hr)

Depth to water table: More than 80 inches
Frequency of flooding: None
Frequency of ponding: None
Maximum salinity: Nonsaline to very slightly saline (0.0 to 2.0 mmhos/cm)
Available water supply, 0 to 60 inches: High (about 11.8 inches)

Interpretive groups

Land capability classification (irrigated): 1
Land capability classification (nonirrigated): 1
Hydrologic Soil Group: B
Ecological site: F161BY501HI - Kona Weather Ustic Forest
Hydric soil rating: No

539—Kanohina-Lava flows complex, 10 to 20 percent slopes

Map Unit Setting

National map unit symbol: 2klj1
Elevation: 0 to 1,000 feet
Mean annual precipitation: 20 to 50 inches
Mean annual air temperature: 72 to 75 degrees F
Frost-free period: 365 days
Farmland classification: Not prime farmland

Map Unit Composition

Kanohina, cobbly, and similar soils: 70 percent
Lava flows, pahoehoe: 30 percent
Estimates are based on observations, descriptions, and transects of the mapunit.

Description of Kanohina, Cobbly

Setting

Landform: Ash fields on pahoehoe lava flows
Landform position (two-dimensional): Backslope
Landform position (three-dimensional): Side slope
Down-slope shape: Linear
Across-slope shape: Linear, convex
Parent material: Basic volcanic ash over pahoehoe lava

Typical profile

A - 0 to 7 inches: ashy cobbly very fine sandy loam
Bw - 7 to 15 inches: ashy cobbly loam
2R - 15 to 25 inches: bedrock

Properties and qualities

Slope: 10 to 20 percent
Depth to restrictive feature: 2 to 20 inches to lithic bedrock
Drainage class: Well drained
Runoff class: High
Capacity of the most limiting layer to transmit water (Ksat): Low to moderately low (0.00 to 0.06 in/hr)
Depth to water table: More than 80 inches
Frequency of flooding: None

Frequency of ponding: None
Maximum salinity: Nonsaline to very slightly saline (0.0 to 2.0 mmhos/cm)
Available water supply, 0 to 60 inches: Very low (about 1.8 inches)

Interpretive groups

Land capability classification (irrigated): 7s
Land capability classification (nonirrigated): 7s
Hydrologic Soil Group: D
Ecological site: F161BY501HI - Kona Weather Ustic Forest
Hydric soil rating: No

Description of Lava Flows, Pahoehoe

Setting

Landform: Pahoehoe lava flows
Down-slope shape: Linear
Across-slope shape: Linear, convex
Parent material: Pahoehoe lava

Typical profile

R - 0 to 10 inches: bedrock

Properties and qualities

Slope: 10 to 20 percent
Depth to restrictive feature: 0 to 2 inches to lithic bedrock
Drainage class: Well drained
Runoff class: Very high
Capacity of the most limiting layer to transmit water (Ksat): Low to moderately low (0.00 to 0.06 in/hr)
Available water supply, 0 to 60 inches: Very low (about 0.0 inches)

Interpretive groups

Land capability classification (irrigated): 8
Land capability classification (nonirrigated): 8
Hydric soil rating: No

540—Kanohina-Lava flows complex, 20 to 35 percent slopes

Map Unit Setting

National map unit symbol: 2klj2
Elevation: 0 to 1,000 feet
Mean annual precipitation: 20 to 50 inches
Mean annual air temperature: 72 to 75 degrees F
Frost-free period: 365 days
Farmland classification: Not prime farmland

Map Unit Composition

Kanohina, cobbly, and similar soils: 70 percent
Lava flows, pahoehoe: 30 percent
Estimates are based on observations, descriptions, and transects of the mapunit.

Description of Kanohina, Cobbly

Setting

Landform: Ash fields on pahoehoe lava flows
Landform position (two-dimensional): Backslope
Landform position (three-dimensional): Side slope
Down-slope shape: Linear
Across-slope shape: Linear, convex
Parent material: Basic volcanic ash over pahoehoe lava

Typical profile

A - 0 to 7 inches: ashy cobbly very fine sandy loam
Bw - 7 to 15 inches: ashy cobbly loam
2R - 15 to 25 inches: bedrock

Properties and qualities

Slope: 20 to 35 percent
Depth to restrictive feature: 2 to 20 inches to lithic bedrock
Drainage class: Well drained
Runoff class: Very high
Capacity of the most limiting layer to transmit water (Ksat): Low to moderately low (0.00 to 0.06 in/hr)
Depth to water table: More than 80 inches
Frequency of flooding: None
Frequency of ponding: None
Maximum salinity: Nonsaline to very slightly saline (0.0 to 2.0 mmhos/cm)
Available water supply, 0 to 60 inches: Very low (about 1.8 inches)

Interpretive groups

Land capability classification (irrigated): 7s
Land capability classification (nonirrigated): 7s
Hydrologic Soil Group: D
Ecological site: F161BY501HI - Kona Weather Ustic Forest
Hydric soil rating: No

Description of Lava Flows, Pahoehoe

Setting

Landform: Pahoehoe lava flows
Down-slope shape: Linear
Across-slope shape: Linear, convex
Parent material: Pahoehoe lava

Typical profile

R - 0 to 10 inches: bedrock

Properties and qualities

Slope: 20 to 35 percent
Depth to restrictive feature: 0 to 2 inches to lithic bedrock
Drainage class: Well drained
Runoff class: Very high
Capacity of the most limiting layer to transmit water (Ksat): Low to moderately low (0.00 to 0.06 in/hr)
Available water supply, 0 to 60 inches: Very low (about 0.0 inches)

Interpretive groups

Land capability classification (irrigated): 8

Land capability classification (nonirrigated): 8
Hydric soil rating: No

541—Lava flows-Puueo complex, 2 to 20 percent slopes

Map Unit Setting

National map unit symbol: 2klj3
Elevation: 0 to 1,200 feet
Mean annual precipitation: 30 to 60 inches
Mean annual air temperature: 70 to 75 degrees F
Frost-free period: 365 days
Farmland classification: Not prime farmland

Map Unit Composition

Lava flows, `a`a: 70 percent
Puueo and similar soils: 30 percent
Estimates are based on observations, descriptions, and transects of the mapunit.

Description of Lava Flows, `a`a

Setting

Landform: Aa lava flows
Down-slope shape: Linear
Across-slope shape: Linear, convex
Parent material: Aa lava

Typical profile

C - 0 to 39 inches: cobbles
R - 39 to 49 inches: bedrock

Properties and qualities

Slope: 2 to 20 percent
Surface area covered with cobbles, stones or boulders: 10.0 percent
Depth to restrictive feature: 20 to 60 inches to lithic bedrock
Drainage class: Excessively drained
Runoff class: Very low
Capacity of the most limiting layer to transmit water (Ksat): Low to moderately low (0.00 to 0.06 in/hr)
Available water supply, 0 to 60 inches: Very low (about 0.4 inches)

Interpretive groups

Land capability classification (irrigated): 8
Land capability classification (nonirrigated): 8
Hydric soil rating: No

Description of Puueo

Setting

Landform: Ash fields on aa lava flows
Landform position (two-dimensional): Backslope
Landform position (three-dimensional): Side slope

Down-slope shape: Linear
Across-slope shape: Linear, convex
Parent material: Basic volcanic ash over aa lava

Typical profile

2C1/A1 - 0 to 7 inches: extremely cobbly medial silt loam
2C2/A2 - 7 to 18 inches: extremely cobbly medial silt loam
2C3 - 18 to 30 inches: cobbles
2R - 30 to 40 inches: bedrock

Properties and qualities

Slope: 2 to 20 percent
Depth to restrictive feature: 20 to 40 inches to lithic bedrock
Drainage class: Somewhat excessively drained
Runoff class: Very low
Capacity of the most limiting layer to transmit water (Ksat): Low to moderately low (0.00 to 0.06 in/hr)
Depth to water table: More than 80 inches
Frequency of flooding: None
Frequency of ponding: None
Maximum salinity: Nonsaline to very slightly saline (0.0 to 2.0 mmhos/cm)
Available water supply, 0 to 60 inches: Very low (about 2.9 inches)

Interpretive groups

Land capability classification (irrigated): 6s
Land capability classification (nonirrigated): 6s
Hydrologic Soil Group: A
Ecological site: F161BY501HI - Kona Weather Ustic Forest
Hydric soil rating: No

558—Akihi-Alapai complex, 40 to 70 percent slopes

Map Unit Setting

National map unit symbol: 2kljb
Elevation: 1,200 to 4,400 feet
Mean annual precipitation: 59 to 150 inches
Mean annual air temperature: 59 to 70 degrees F
Frost-free period: 365 days
Farmland classification: Not prime farmland

Map Unit Composition

Akihi and similar soils: 50 percent
Alapai and similar soils: 35 percent
Minor components: 15 percent
Estimates are based on observations, descriptions, and transects of the mapunit.

Description of Akihi

Setting

Landform: Ash fields on aa lava flows
Landform position (two-dimensional): Backslope

Landform position (three-dimensional): Side slope
Down-slope shape: Linear
Across-slope shape: Linear, convex
Parent material: Basic volcanic ash over aa lava

Typical profile

A/2C1 - 0 to 10 inches: very cobbly hydrous silt loam
Bw/2C2 - 10 to 35 inches: very cobbly hydrous silty clay loam
2R - 35 to 45 inches: bedrock

Properties and qualities

Slope: 40 to 70 percent
Depth to restrictive feature: 20 to 40 inches to lithic bedrock
Drainage class: Well drained
Runoff class: Very high
Capacity of the most limiting layer to transmit water (Ksat): Low to moderately low (0.00 to 0.06 in/hr)
Depth to water table: More than 80 inches
Frequency of flooding: None
Frequency of ponding: None
Maximum salinity: Nonsaline to very slightly saline (0.0 to 2.0 mmhos/cm)
Available water supply, 0 to 60 inches: Low (about 3.8 inches)

Interpretive groups

Land capability classification (irrigated): 7e
Land capability classification (nonirrigated): 7e
Hydrologic Soil Group: B
Ecological site: F159BY500HI - Udic Forest
Hydric soil rating: No

Description of Alapai

Setting

Landform: Ash fields on lava flows
Landform position (two-dimensional): Backslope
Landform position (three-dimensional): Side slope
Down-slope shape: Linear
Across-slope shape: Linear, convex
Parent material: Basic volcanic ash over basalt

Typical profile

Ap1 - 0 to 7 inches: hydrous silty clay loam
Ap2 - 7 to 15 inches: hydrous silty clay loam
B/A - 15 to 27 inches: hydrous silty clay loam
Bw1 - 27 to 36 inches: hydrous silty clay loam
Bw2 - 36 to 43 inches: hydrous silty clay loam
Bw3 - 43 to 50 inches: hydrous silty clay loam
Bw4 - 50 to 57 inches: hydrous silty clay loam
Bw5 - 57 to 66 inches: hydrous silty clay loam
Bw6 - 66 to 70 inches: hydrous silty clay loam
Bw7 - 70 to 74 inches: hydrous silty clay loam

Properties and qualities

Slope: 40 to 70 percent
Depth to restrictive feature: More than 80 inches
Drainage class: Well drained
Runoff class: High

Capacity of the most limiting layer to transmit water (Ksat): Moderately high to high (0.71 to 1.98 in/hr)
Depth to water table: More than 80 inches
Frequency of flooding: None
Frequency of ponding: None
Maximum salinity: Nonsaline to very slightly saline (0.0 to 2.0 mmhos/cm)
Available water supply, 0 to 60 inches: High (about 12.0 inches)

Interpretive groups

Land capability classification (irrigated): 7e
Land capability classification (nonirrigated): 7e
Hydrologic Soil Group: B
Ecological site: F159BY500HI - Udic Forest
Hydric soil rating: No

Minor Components

Honuapo

Percent of map unit: 10 percent
Landform: Ash fields on pahoehoe lava flows
Landform position (two-dimensional): Backslope
Landform position (three-dimensional): Side slope
Down-slope shape: Linear
Across-slope shape: Linear, convex
Hydric soil rating: No

Rock outcrop, basalt

Percent of map unit: 5 percent
Landform: Pahoehoe lava flows
Landform position (two-dimensional): Backslope
Landform position (three-dimensional): Side slope
Down-slope shape: Linear
Across-slope shape: Linear, convex
Hydric soil rating: No

568—Honuapo hydrous silt loam, 10 to 20 percent slopes

Map Unit Setting

National map unit symbol: 2kljn
Elevation: 1,200 to 3,000 feet
Mean annual precipitation: 59 to 118 inches
Mean annual air temperature: 63 to 70 degrees F
Frost-free period: 365 days
Farmland classification: Not prime farmland

Map Unit Composition

Honuapo and similar soils: 85 percent
Minor components: 15 percent
Estimates are based on observations, descriptions, and transects of the mapunit.

Description of Honuapo

Setting

Landform: Ash fields on pahoehoe lava flows
Landform position (two-dimensional): Backslope
Landform position (three-dimensional): Side slope
Down-slope shape: Linear
Across-slope shape: Linear, convex
Parent material: Volcanic ash over pahoehoe lava

Typical profile

Ap - 0 to 19 inches: hydrous silt loam
Bw1 - 19 to 26 inches: hydrous silty clay loam
Bw2 - 26 to 30 inches: very paragravelly hydrous silty clay loam
Bw3 - 30 to 39 inches: hydrous silty clay loam
2R - 39 to 49 inches: bedrock

Properties and qualities

Slope: 10 to 20 percent
Depth to restrictive feature: 20 to 40 inches to lithic bedrock
Drainage class: Well drained
Runoff class: Low
Capacity of the most limiting layer to transmit water (Ksat): Low to moderately low (0.00 to 0.06 in/hr)
Depth to water table: More than 80 inches
Frequency of flooding: Occasional
Frequency of ponding: None
Maximum salinity: Nonsaline to very slightly saline (0.0 to 2.0 mmhos/cm)
Available water supply, 0 to 60 inches: Moderate (about 7.4 inches)

Interpretive groups

Land capability classification (irrigated): 4e
Land capability classification (nonirrigated): 4e
Hydrologic Soil Group: C
Ecological site: F159BY500HI - Udic Forest
Hydric soil rating: No

Minor Components

Alapai

Percent of map unit: 10 percent
Landform: Ash fields on lava flows
Landform position (two-dimensional): Backslope
Landform position (three-dimensional): Side slope
Down-slope shape: Linear
Across-slope shape: Linear, convex
Hydric soil rating: No

Akihi

Percent of map unit: 5 percent
Landform: Ash fields on aa lava flows
Landform position (two-dimensional): Backslope
Landform position (three-dimensional): Side slope
Down-slope shape: Linear
Across-slope shape: Linear, convex
Hydric soil rating: No

569—Puueo extremely cobbly medial silt loam, 10 to 20 percent slopes

Map Unit Setting

National map unit symbol: 2kljp
Elevation: 0 to 1,200 feet
Mean annual precipitation: 35 to 47 inches
Mean annual air temperature: 70 to 75 degrees F
Frost-free period: 365 days
Farmland classification: Not prime farmland

Map Unit Composition

Puueo and similar soils: 90 percent
Minor components: 10 percent
Estimates are based on observations, descriptions, and transects of the mapunit.

Description of Puueo

Setting

Landform: Ash fields on aa lava flows
Landform position (two-dimensional): Backslope
Landform position (three-dimensional): Side slope
Down-slope shape: Linear
Across-slope shape: Linear, convex
Parent material: Basic volcanic ash over aa lava

Typical profile

2C1/A1 - 0 to 7 inches: extremely cobbly medial silt loam
2C2/A2 - 7 to 18 inches: extremely cobbly medial silt loam
2C3 - 18 to 30 inches: cobbles
2R - 30 to 40 inches: bedrock

Properties and qualities

Slope: 10 to 20 percent
Surface area covered with cobbles, stones or boulders: 0.0 percent
Depth to restrictive feature: 20 to 40 inches to lithic bedrock
Drainage class: Somewhat excessively drained
Runoff class: Very low
Capacity of the most limiting layer to transmit water (Ksat): Low to moderately low (0.00 to 0.06 in/hr)
Depth to water table: More than 80 inches
Frequency of flooding: None
Frequency of ponding: None
Maximum salinity: Nonsaline to very slightly saline (0.0 to 2.0 mmhos/cm)
Available water supply, 0 to 60 inches: Low (about 3.1 inches)

Interpretive groups

Land capability classification (irrigated): 6s
Land capability classification (nonirrigated): 6s
Hydrologic Soil Group: A
Ecological site: F161BY501HI - Kona Weather Ustic Forest

Hydric soil rating: No

Minor Components

Lava flows, `a`a

Percent of map unit: 10 percent
Landform: Aa lava flows
Down-slope shape: Linear
Across-slope shape: Linear, convex
Hydric soil rating: No

734—Kanohina-Lava flows complex, 2 to 10 percent slopes

Map Unit Setting

National map unit symbol: 2l0wq
Elevation: 0 to 1,000 feet
Mean annual precipitation: 20 to 50 inches
Mean annual air temperature: 72 to 75 degrees F
Frost-free period: 365 days
Farmland classification: Not prime farmland

Map Unit Composition

Kanohina and similar soils: 60 percent
Lava flows, pahoehoe: 30 percent
Minor components: 10 percent
Estimates are based on observations, descriptions, and transects of the mapunit.

Description of Kanohina

Setting

Landform: Pahoehoe lava flows, ash fields
Landform position (two-dimensional): Summit, backslope, shoulder, footslope
Landform position (three-dimensional): Mountainflank, side slope
Down-slope shape: Linear
Across-slope shape: Linear, convex
Parent material: Basaltic volcanic ash over pahoehoe lava

Typical profile

A - 0 to 4 inches: ashy very fine sandy loam
C1 - 4 to 5 inches: gravelly ashy loamy sand
C2 - 5 to 7 inches: ashy loam
2R - 7 to 17 inches: bedrock

Properties and qualities

Slope: 2 to 10 percent
Depth to restrictive feature: 2 to 20 inches to lithic bedrock
Drainage class: Well drained
Runoff class: Very high
Capacity of the most limiting layer to transmit water (Ksat): Low to moderately low (0.00 to 0.06 in/hr)
Depth to water table: More than 80 inches

Frequency of flooding: None
Frequency of ponding: None
Maximum salinity: Nonsaline to very slightly saline (0.0 to 2.0 mmhos/cm)
Available water supply, 0 to 60 inches: Very low (about 1.6 inches)

Interpretive groups

Land capability classification (irrigated): 7s
Land capability classification (nonirrigated): 7s
Hydrologic Soil Group: D
Ecological site: R161AY008HI - Isohyperthermic Ustic Naturalized Grassland
Hydric soil rating: No

Description of Lava Flows, Pahoehoe

Setting

Landform: Pahoehoe lava flows
Landform position (two-dimensional): Summit, backslope, shoulder, footslope
Landform position (three-dimensional): Mountainflank
Down-slope shape: Linear
Across-slope shape: Linear, convex
Parent material: Pahoehoe lava

Typical profile

R - 0 to 10 inches: bedrock

Properties and qualities

Slope: 2 to 10 percent
Depth to restrictive feature: 0 to 2 inches to lithic bedrock
Runoff class: Very high
Capacity of the most limiting layer to transmit water (Ksat): Low to moderately low (0.00 to 0.06 in/hr)
Available water supply, 0 to 60 inches: Very low (about 0.0 inches)

Interpretive groups

Land capability classification (irrigated): 8s
Land capability classification (nonirrigated): 8s
Hydrologic Soil Group: C
Hydric soil rating: No

Minor Components

Vitric haplustands

Percent of map unit: 10 percent
Landform: Aa lava flows, ash fields
Landform position (two-dimensional): Summit, backslope, shoulder, footslope
Landform position (three-dimensional): Mountainflank, side slope
Down-slope shape: Linear
Across-slope shape: Linear, convex
Hydric soil rating: No

Soil Information for All Uses

Soil Properties and Qualities

The Soil Properties and Qualities section includes various soil properties and qualities displayed as thematic maps with a summary table for the soil map units in the selected area of interest. A single value or rating for each map unit is generated by aggregating the interpretive ratings of individual map unit components. This aggregation process is defined for each property or quality.

Soil Qualities and Features

Soil qualities are behavior and performance attributes that are not directly measured, but are inferred from observations of dynamic conditions and from soil properties. Example soil qualities include natural drainage, and frost action. Soil features are attributes that are not directly part of the soil. Example soil features include slope and depth to restrictive layer. These features can greatly impact the use and management of the soil.

Hydrologic Soil Group

Hydrologic soil groups are based on estimates of runoff potential. Soils are assigned to one of four groups according to the rate of water infiltration when the soils are not protected by vegetation, are thoroughly wet, and receive precipitation from long-duration storms.

The soils in the United States are assigned to four groups (A, B, C, and D) and three dual classes (A/D, B/D, and C/D). The groups are defined as follows:

Group A. Soils having a high infiltration rate (low runoff potential) when thoroughly wet. These consist mainly of deep, well drained to excessively drained sands or gravelly sands. These soils have a high rate of water transmission.

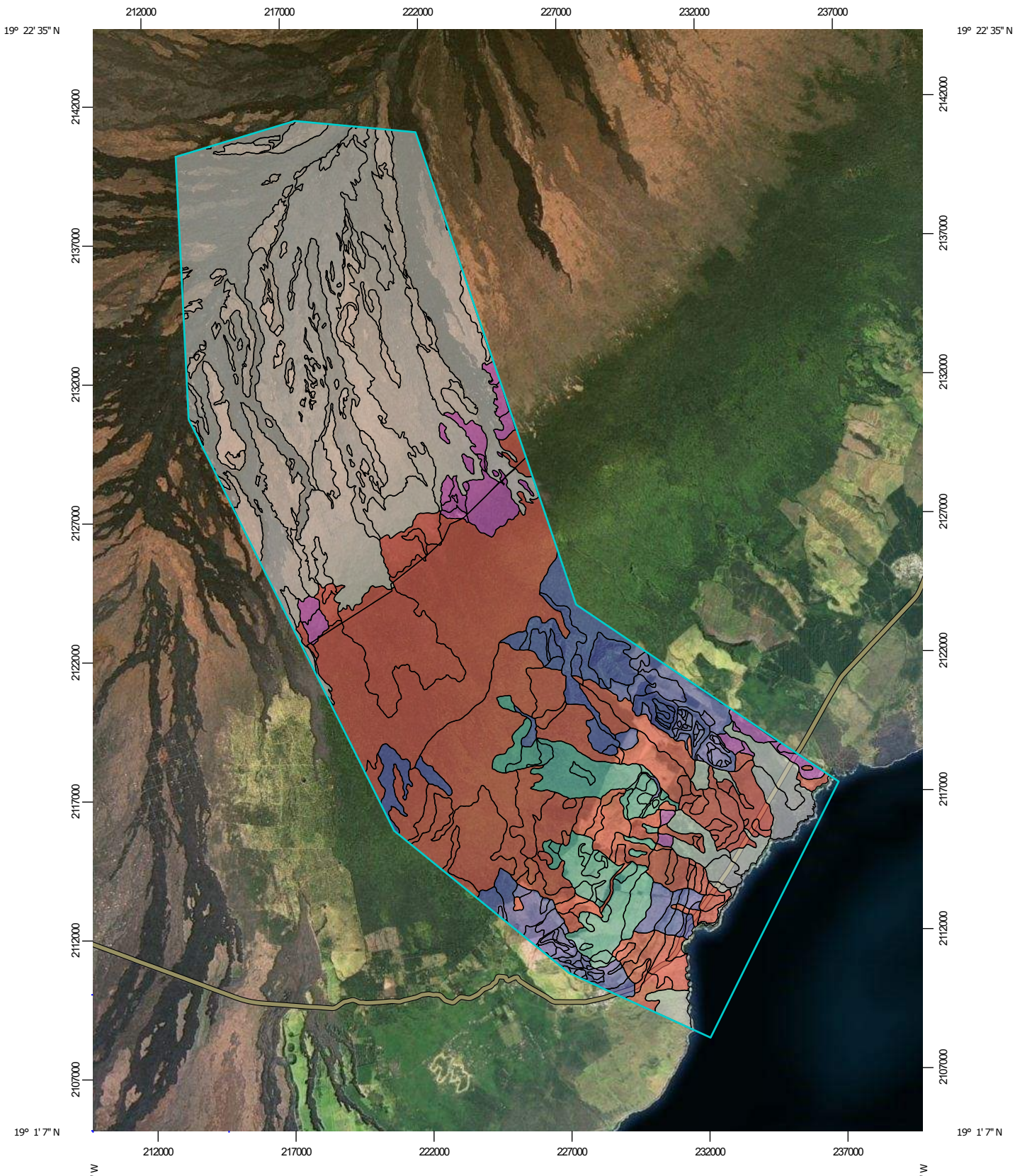
Group B. Soils having a moderate infiltration rate when thoroughly wet. These consist chiefly of moderately deep or deep, moderately well drained or well drained soils that have moderately fine texture to moderately coarse texture. These soils have a moderate rate of water transmission.

Group C. Soils having a slow infiltration rate when thoroughly wet. These consist chiefly of soils having a layer that impedes the downward movement of water or soils of moderately fine texture or fine texture. These soils have a slow rate of water transmission.

Group D. Soils having a very slow infiltration rate (high runoff potential) when thoroughly wet. These consist chiefly of clays that have a high shrink-swell potential, soils that have a high water table, soils that have a claypan or clay layer at or near the surface, and soils that are shallow over nearly impervious material. These soils have a very slow rate of water transmission.

If a soil is assigned to a dual hydrologic group (A/D, B/D, or C/D), the first letter is for drained areas and the second is for undrained areas. Only the soils that in their natural condition are in group D are assigned to dual classes.

Map—Hydrologic Soil Group



MAP LEGEND

Area of Interest (AOI)

Area of Interest (AOI)

Soils

Soil Rating Polygons

A

A/D

B

B/D

C

C/D

D

Not rated or not available

Soil Rating Lines

A

A/D

B

B/D

C

C/D

D

Not rated or not available

Soil Rating Points

A

A/D

B

B/D

C

C/D

D

Not rated or not available

Water Features

Streams and Canals

Transportation

Rails

Interstate Highways

US Routes

Major Roads

Local Roads

Background

Aerial Photography

MAP INFORMATION

The soil surveys that comprise your AOI were mapped at 1:24,000.

Please rely on the bar scale on each map sheet for map measurements.

Source of Map: Natural Resources Conservation Service
Web Soil Survey URL:
Coordinate System: Web Mercator (EPSG:3857)

Maps from the Web Soil Survey are based on the Web Mercator projection, which preserves direction and shape but distorts distance and area. A projection that preserves area, such as the Albers equal-area conic projection, should be used if more accurate calculations of distance or area are required.

This product is generated from the USDA-NRCS certified data as of the version date(s) listed below.

Soil Survey Area: Hawaii Volcanoes National Park, Hawaii
Survey Area Data: Version 13, Sep 8, 2023

Soil Survey Area: Island of Hawaii Area, Hawaii
Survey Area Data: Version 16, Sep 8, 2023

Your area of interest (AOI) includes more than one soil survey area. These survey areas may have been mapped at different scales, with a different land use in mind, at different times, or at different levels of detail. This may result in map unit symbols, soil properties, and interpretations that do not completely agree across soil survey area boundaries.

Soil map units are labeled (as space allows) for map scales 1:50,000 or larger.

Date(s) aerial images were photographed: Jan 1, 1999—Dec 31, 2003

The orthophoto or other base map on which the soil lines were compiled and digitized probably differs from the background

MAP LEGEND

MAP INFORMATION

imagery displayed on these maps. As a result, some minor shifting of map unit boundaries may be evident.

Table—Hydrologic Soil Group

Map unit symbol	Map unit name	Rating	Acres in AOI	Percent of AOI
10	Lava flows, `a`a, 2 to 20 percent slopes		20,391.1	22.9%
12	Lava flows, pahoehoe, 2 to 20 percent slopes		7,372.7	8.3%
14	Lava flows complex, 2 to 20 percent slopes		9,297.5	10.5%
16	Cinder land, 20 to 40 percent slopes		7.8	0.0%
164	Lava flows-Kekake complex, 2 to 20 percent slopes		145.7	0.2%
169	Iwalani-Lava flows complex, moist, 2 to 10 percent slopes	D	51.0	0.1%
401	Ihuanu-Lava flows, `a`a complex, 10 to 20 percent slopes, MLRA 160	A	449.4	0.5%
402	Ihuanu very cobbly medial silt loam, 10 to 20 percent slopes, MLRA 160	A	391.4	0.4%
403	Ihuanu very cobbly medial silt loam, 2 to 10 percent slopes, MLRA 160	A	340.0	0.4%
406	Lava flows-Iwalani complex, 10 to 20 percent slopes		336.3	0.4%
407	Iwalani-Lava flows complex, 2 to 10 percent slopes	D	799.9	0.9%
408	Iwalani-Lava flows complex, 10 to 20 percent slopes	D	118.1	0.1%
515	Pahipa-Puali association, 2 to 20 percent slopes	D	341.2	0.4%
519	Lalaau very cobbly highly decomposed plant material, 2 to 10 percent slopes	A	238.9	0.3%
534	Kahaluu-Lava flows complex, 2 to 10 percent slopes	D	184.6	0.2%
Subtotals for Soil Survey Area			**40,465.6**	**45.5%**
Totals for Area of Interest			**88,942.7**	**100.0%**

Map unit symbol	Map unit name	Rating	Acres in AOI	Percent of AOI
10	Lava flows, `a`a, 2 to 20 percent slopes		1,156.8	1.3%
12	Lava flows, pahoehoe, 2 to 20 percent slopes		48.0	0.1%
169	Iwalani-Lava flows complex, moist, 2 to 10 percent slopes	D	21.7	0.0%
271	Lava flows-Kanohina complex, 2 to 20 percent slopes		840.9	0.9%
272	Kanohina ashy very fine sandy loam, 2 to 10 percent slopes	D	439.1	0.5%
402	Ihuanu very cobbly medial silt loam, 10 to 20 percent slopes, MLRA 160	A	6.3	0.0%
403	Ihuanu very cobbly medial silt loam, 2 to 10 percent slopes, MLRA 160	A	6.6	0.0%
407	Iwalani-Lava flows complex, 2 to 10 percent slopes	D	4.4	0.0%
511	Akihi very cobbly hydrous silt loam, 10 to 20 percent slopes, MLRA 159B	B	1,740.6	2.0%
512	Akihi very cobbly hydrous silt loam, 2 to 10 percent slopes, MLRA 159B	B	1,194.7	1.3%
513	Hilea hydrous silty clay loam, 10 to 20 percent slopes	D	5,329.8	6.0%
514	Hilea hydrous silty clay loam, 3 to 10 percent slopes	D	6,036.7	6.8%
515	Pahipa-Puali association, 2 to 20 percent slopes	D	8,790.0	9.9%
516	Alapai hydrous silty clay loam, 3 to 10 percent slopes	B	858.5	1.0%
517	Alapai hydrous silty clay loam, 10 to 20 percent slopes	B	715.5	0.8%
518	Alapai hydrous silty clay loam, 20 to 35 percent slopes	B	214.9	0.2%
519	Lalaau very cobbly highly decomposed plant material, 2 to 10 percent slopes	A	540.9	0.6%

Map unit symbol	Map unit name	Rating	Acres in AOI	Percent of AOI
520	Naalehu medial silty clay loam, 35 to 70 percent slopes	B	53.5	0.1%
521	Naalehu medial silty clay loam, 3 to 10 percent slopes	B	202.7	0.2%
522	Naalehu medial silty clay loam, 10 to 20 percent slopes	B	729.0	0.8%
523	Naalehu medial silty clay loam, 20 to 35 percent slopes	B	379.4	0.4%
527	Alapai hydrous silty clay loam, 35 to 70 percent slopes	B	254.7	0.3%
528	Alapai hydrous silty clay loam, 0 to 3 percent slopes	B	311.8	0.4%
529	Honuapo-Hilea complex, 10 to 20 percent slopes	C	1,748.6	2.0%
530	Hilea-Lava flows complex, 3 to 10 percent slopes	D	763.5	0.9%
531	Hilea-Lava flows complex, 10 to 20 percent slopes	D	190.5	0.2%
532	Honuapo hydrous silt loam, 3 to 10 percent slopes	C	2,294.2	2.6%
533	Honuapo-Hilea complex, 20 to 35 percent slopes	C	249.3	0.3%
534	Kahaluu-Lava flows complex, 2 to 10 percent slopes	D	2,387.8	2.7%
536	Puueo extremely cobbly medial silt loam, 2 to 10 percent slopes	A	382.8	0.4%
538	Naalehu medial silt loam, 0 to 3 percent slopes	B	75.8	0.1%
539	Kanohina-Lava flows complex, 10 to 20 percent slopes	D	1,694.1	1.9%
540	Kanohina-Lava flows complex, 20 to 35 percent slopes	D	845.4	1.0%
541	Lava flows-Puueo complex, 2 to 20 percent slopes		1,090.6	1.2%
558	Akihi-Alapai complex, 40 to 70 percent slopes	B	1,588.4	1.8%

Map unit symbol	Map unit name	Rating	Acres in AOI	Percent of AOI
568	Honuapo hydrous silt loam, 10 to 20 percent slopes	C	398.5	0.4%
569	Puueo extremely cobbly medial silt loam, 10 to 20 percent slopes	A	245.8	0.3%
734	Kanohina-Lava flows complex, 2 to 10 percent slopes	D	1,212.0	1.4%
Subtotals for Soil Survey Area			**45,043.5**	**50.6%**
Totals for Area of Interest			**88,942.7**	**100.0%**

Rating Options—Hydrologic Soil Group

Aggregation Method: Dominant Condition

Component Percent Cutoff: None Specified

Tie-break Rule: Higher

References

American Association of State Highway and Transportation Officials (AASHTO). 2004. Standard specifications for transportation materials and methods of sampling and testing. 24th edition.

American Society for Testing and Materials (ASTM). 2005. Standard classification of soils for engineering purposes. ASTM Standard D2487-00.

Cowardin, L.M., V. Carter, F.C. Golet, and E.T. LaRoe. 1979. Classification of wetlands and deep-water habitats of the United States. U.S. Fish and Wildlife Service FWS/OBS-79/31.

Federal Register. July 13, 1994. Changes in hydric soils of the United States.

Federal Register. September 18, 2002. Hydric soils of the United States.

Hurt, G.W., and L.M. Vasilas, editors. Version 6.0, 2006. Field indicators of hydric soils in the United States.

National Research Council. 1995. Wetlands: Characteristics and boundaries.

Soil Survey Division Staff. 1993. Soil survey manual. Soil Conservation Service. U.S. Department of Agriculture Handbook 18. http://www.nrcs.usda.gov/wps/portal/nrcs/detail/national/soils/?cid=nrcs142p2_054262

Soil Survey Staff. 1999. Soil taxonomy: A basic system of soil classification for making and interpreting soil surveys. 2nd edition. Natural Resources Conservation Service, U.S. Department of Agriculture Handbook 436. http://www.nrcs.usda.gov/wps/portal/nrcs/detail/national/soils/?cid=nrcs142p2_053577

Soil Survey Staff. 2010. Keys to soil taxonomy. 11th edition. U.S. Department of Agriculture, Natural Resources Conservation Service. http://www.nrcs.usda.gov/wps/portal/nrcs/detail/national/soils/?cid=nrcs142p2_053580

Tiner, R.W., Jr. 1985. Wetlands of Delaware. U.S. Fish and Wildlife Service and Delaware Department of Natural Resources and Environmental Control, Wetlands Section.

United States Army Corps of Engineers, Environmental Laboratory. 1987. Corps of Engineers wetlands delineation manual. Waterways Experiment Station Technical Report Y-87-1.

United States Department of Agriculture, Natural Resources Conservation Service. National forestry manual. http://www.nrcs.usda.gov/wps/portal/nrcs/detail/soils/home/?cid=nrcs142p2_053374

United States Department of Agriculture, Natural Resources Conservation Service. National range and pasture handbook. http://www.nrcs.usda.gov/wps/portal/nrcs/detail/national/landuse/rangepasture/?cid=stelprdb1043084

United States Department of Agriculture, Natural Resources Conservation Service. National soil survey handbook, title 430-VI. http://www.nrcs.usda.gov/wps/portal/nrcs/detail/soils/scientists/?cid=nrcs142p2_054242

United States Department of Agriculture, Natural Resources Conservation Service. 2006. Land resource regions and major land resource areas of the United States, the Caribbean, and the Pacific Basin. U.S. Department of Agriculture Handbook 296. http://www.nrcs.usda.gov/wps/portal/nrcs/detail/national/soils/?cid=nrcs142p2_053624

United States Department of Agriculture, Soil Conservation Service. 1961. Land capability classification. U.S. Department of Agriculture Handbook 210. http://www.nrcs.usda.gov/Internet/FSE_DOCUMENTS/nrcs142p2_052290.pdf

Exhibit 2

MP 60

Region ID: HI
Workspace ID: HI20240405041010255000
Clicked Point (Latitude, Longitude): 19.08814, -155.54827
Time: 2024-04-04 21:10:32 -0700

Collapse All

Basin Characteristics

Parameter Code	Parameter Description	Value	Unit
BASINPERIM	Perimeter of the drainage basin as defined in SIR 2004-5262	59.5	miles
BSLDEM10M	Mean basin slope computed from 10 m DEM	9.55	percent
CENTROIDY	Basin centroid vertical (y) location in state plane units	2126450	meters
COMPRAT	A measure of basin shape related to basin perimeter and drainage area	3.32	dimensionless
CSL10_85	Change in elevation divided by length between points 10 and 85 percent of distance along main channel to basin divide - main channel method not known	367	feet per mi

Parameter Code	Parameter Description	Value	Unit
DRNAREA	Area that drains to a point on a stream	25.5	square miles
ELEV	Mean Basin Elevation	5360	feet
ELEV10FT	Elevation at 10 percent from outlet along longest flow path slope using DEM	1190	feet
ELEV10FT3D	Elevation at 10 percent from outlet along longest flow path slope using 3D line	1190	feet
ELEV85FT	Elevation at 85 percent from outlet along longest flow path slope using DEM	8070	feet
ELEV85FT3D	Elevation at 85 percent from outlet along longest flow path slope using 3D line	8070	feet
ELEVMAX	Maximum basin elevation	9200	feet
I24H100Y	Maximum 24-hour precipitation that occurs on average once in 100 years	15.6	inches
I24H10Y	Maximum 24-hour precipitation that occurs on average once in 10 years	9.8	inches
I24H25Y	Maximum 24-hour precipitation that occurs on average once in 25 years	12.1	inches
I24H2Y	Maximum 24-hour precipitation that occurs on average once in 2 years - Equivalent to precipitation intensity index	5.96	inches
I24H500Y	Maximum 24-hour precipitation that occurs on average once in 500 years	20	inches
I24H50Y	Maximum 24-hour precipitation that occurs on average once in 50 years	13.8	inches
I24H5Y	Maximum 24-hour precipitation that occurs on average once in 5 years	8.13	inches
I48H100Y	Maximum 48-hour precipitation that occurs on average once in 100 years	21.3	inches
I48H10Y	Maximum 48-hour precipitation that occurs on average once in 10 years	12.8	inches
I48H25Y	Maximum 48-hour precipitation that occurs on average once in 25 years	16	inches
I48H2Y	Maximum 48-hour precipitation that occurs on average once in 2 years	7.63	inches
I48H500Y	Maximum 48-hour precipitation that occurs on average once in 500 years	28.1	inches
I48H50Y	Maximum 48-hour precipitation that occurs on average once in 50 years	18.6	inches

Parameter Code	Parameter Description	Value	Unit
I48H5Y	Maximum 48-hour precipitation that occurs on average once in 5 years	10.5	inches
I60M100Y	Maximum 60-min precipitation that occurs on average once in 100 years	3.79	inches
I60M10Y	Maximum 60-min precipitation that occurs on average once in 10 years	2.61	inches
I60M25Y	Maximum 60-min precipitation that occurs on average once in 25 years	3.09	inches
I60M2Y	Maximum 60-min precipitation that occurs on average once in 2 years	1.72	inches
I60M500Y	Maximum 60-min precipitation that occurs on average once in 500 years	4.59	inches
I60M50Y	Maximum 60-min precipitation that occurs on average once in 50 years	3.45	inches
I60M5Y	Maximum 60-min precipitation that occurs on average once in 5 years	2.23	inches
I6H100Y	6-hour precipitation that is expected to occur on average once in 100 years	9.25	inches
I6H10Y	Maximum 6-hour precipitation that occurs on average once in 10 years	5.88	inches
I6H25Y	Maximum 6-hour precipitation that occurs on average once in 25 years	7.18	inches
I6H2Y	Maximum 6-hour precipitation that occurs on average once in 2 years	3.7	inches
I6H500Y	Maximum 6-hour precipitation that occurs on average once in 500 years	11.9	inches
I6H50Y	Maximum 6-hour precipitation that occurs on average once in 50 years	8.2	inches
I6H5Y	Maximum 6-hour precipitation that occurs on average once in 5 years	4.93	inches
IMPNLCD01	Percentage of impervious area determined from NLCD 2001 impervious dataset	0.19	percent
LC01BARE	Percentage of area barren land, NLCD 2001 category 31	36	percent
LC01CROP	Percentage of area crop, NLCD 2001 category	0	percent
LC01DEV	Percentage of land-use from NLCD 2001 classes 21-24	2.41	percent
LC01DEVHI	Percentage of area developed, high intensity, NLCD 2001 category 24	0	percent

Parameter Code	Parameter Description	Value	Unit
LC01DEVMD	Percentage of area developed, medium intensity, NLCD 2001 category 23	0	percent
LC01EVERG	Percentage of area evergreen forest, NLCD 2001 category 42	29	percent
LC01OPNLO	Percentage of area developed, open space and low intensity combined, NLCD2001 cat. 21 and 22	2	percent
LFPLENGTH	Length of longest flow path	25	miles
MINBELEV	Minimum basin elevation	15.9	feet
PERM12IN	Area-weighted average soil permeability for top 12 inches of soil	8.14	inches per hour
PERM24IN	Area-weighted average soil permeability for top 24 inches of soil	7.81	inches per hour
PRECIP	Mean Annual Precipitation	52.4	inches
RELIEF	Maximum - minimum elevation	9190	feet
RELRELF	Basin relief divided by basin perimeter	155	feet per mi
SLOP30_10M	Percent area with slopes greater than 30 percent from 10-meter NED	1	percent
SLPFM3D	Change in elevation divided by length between points 10 and 85 percent of distance along the longest flow path to the basin divide, LFP from 3D grid	368	feet per mi

Peak-Flow Statistics

Peak-Flow Statistics Parameters [Hawaii Peakflow 10 southern Hawaii Island 2023 5014]

Parameter Code	Parameter Name	Value	Units	Min Limit	Max Limit
I48H500Y	I48H500Y	28.1	inches	12.41	48.9

Peak-Flow Statistics Flow Report [Hawaii Peakflow 10 southern Hawaii Island 2023 5014]

PIL: Lower 90% Prediction Interval, PIU: Upper 90% Prediction Interval, ASEp: Average Standard Error of Prediction, SE: Standard Error (other -- see report)

Statistic	Value	Unit	PIL	PIU	ASEp
50-percent AEP flood	314	ft^3/s	31.8	3110	138
20-percent AEP flood	530	ft^3/s	54.6	5150	136
10-percent AEP flood	692	ft^3/s	68.2	7020	140

Statistic	Value	Unit	PIL	PIU	ASEp
4-percent AEP flood	913	ft^3/s	83	10000	149
2-percent AEP flood	1090	ft^3/s	92.7	12800	156
1-percent AEP flood	1270	ft^3/s	101	16000	164
0.5-percent AEP flood	1470	ft^3/s	110	19700	171
0.2-percent AEP flood	1740	ft^3/s	120	25300	182

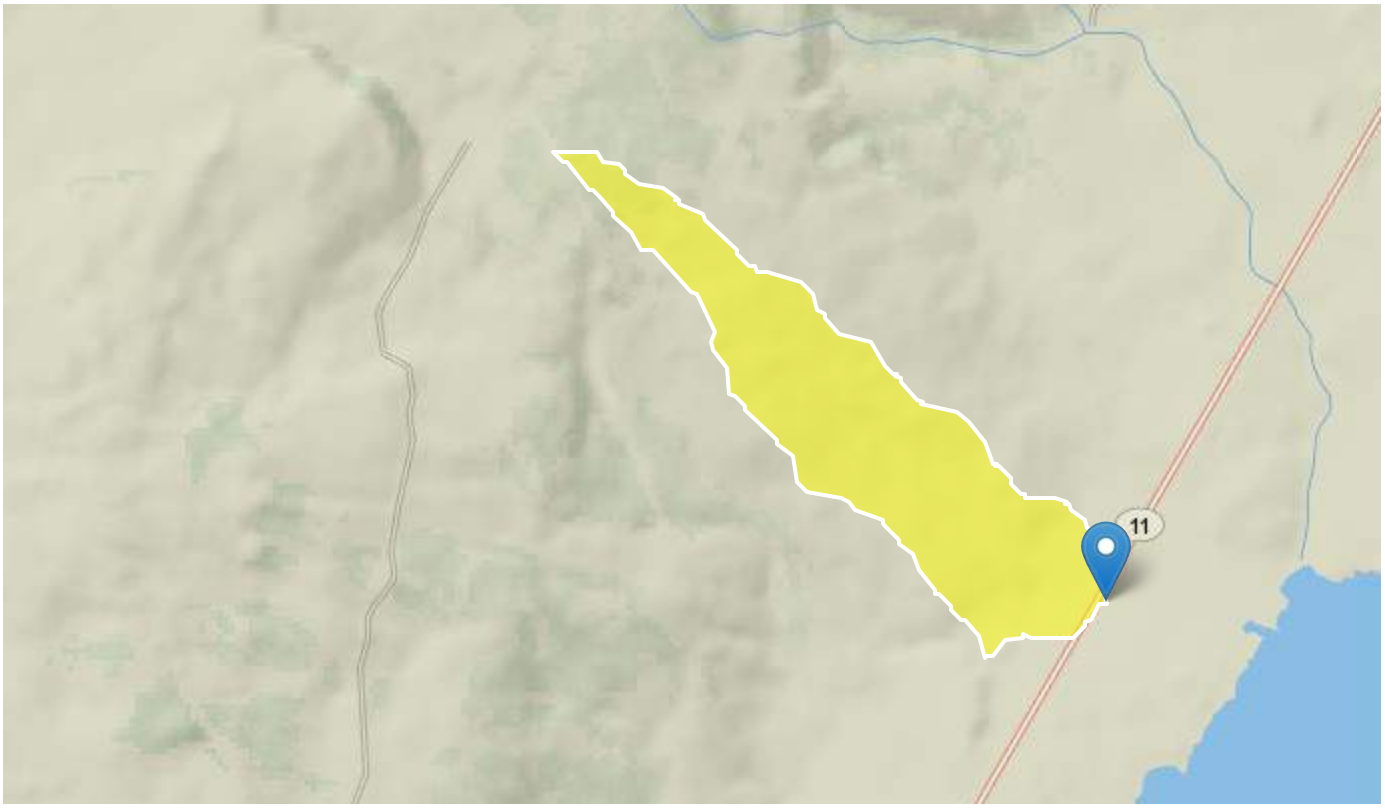
Peak-Flow Statistics Citations

Mitchell, J.N., Wagner, D.M., and Veilleux, A.G.2023, Magnitude and frequency of floods on Kauaʻi, Oʻahu, Molokaʻi, Maui, and Hawaiʻi, State of Hawaiʻi, based on data through water year 2020: U.S. Geological Survey Scientific Investigations Report 2023–5014, 66 p. plus 4 appendixes (https://doi.org/10.3133/sir20235014)

Application Version: 4.19.4
StreamStats Services Version: 1.2.22
NSS Services Version: 2.2.1

MP 58.7 (0.6 sq. mi)

Region ID: HI
Workspace ID: HI20240405035245293000
Clicked Point (Latitude, Longitude): 19.11206, -155.53325
Time: 2024-04-04 20:53:07 -0700



Collapse All

Basin Characteristics

Parameter Code	Parameter Description	Value	Unit
BASINPERIM	Perimeter of the drainage basin as defined in SIR 2004-5262	6.04	miles
BSLDEM10M	Mean basin slope computed from 10 m DEM	11.8	percent
CENTROIDY	Basin centroid vertical (y) location in state plane units	2117582	meters
COMPRAT	A measure of basin shape related to basin perimeter and drainage area	2.26	dimensionless

Parameter Code	Parameter Description	Value	Unit
CSL10_85	Change in elevation divided by length between points 10 and 85 percent of distance along main channel to basin divide - main channel method not known	599	feet per mi
DRNAREA	Area that drains to a point on a stream	0.57	square miles
ELEV	Mean Basin Elevation	454	feet
ELEV10FT	Elevation at 10 percent from outlet along longest flow path slope using DEM	70.3	feet
ELEV10FT3D	Elevation at 10 percent from outlet along longest flow path slope using 3D line	69.5	feet
ELEV85FT	Elevation at 85 percent from outlet along longest flow path slope using DEM	1030	feet
ELEV85FT3D	Elevation at 85 percent from outlet along longest flow path slope using 3D line	1030	feet
ELEVMAX	Maximum basin elevation	1210	feet
I24H100Y	Maximum 24-hour precipitation that occurs on average once in 100 years	15.6	inches
I24H10Y	Maximum 24-hour precipitation that occurs on average once in 10 years	9.79	inches
I24H25Y	Maximum 24-hour precipitation that occurs on average once in 25 years	12.1	inches
I24H2Y	Maximum 24-hour precipitation that occurs on average once in 2 years - Equivalent to precipitation intensity index	5.88	inches
I24H500Y	Maximum 24-hour precipitation that occurs on average once in 500 years	19.8	inches
I24H50Y	Maximum 24-hour precipitation that occurs on average once in 50 years	13.8	inches
I24H5Y	Maximum 24-hour precipitation that occurs on average once in 5 years	8.09	inches
I48H100Y	Maximum 48-hour precipitation that occurs on average once in 100 years	22.4	inches
I48H10Y	Maximum 48-hour precipitation that occurs on average once in 10 years	13.3	inches
I48H25Y	Maximum 48-hour precipitation that occurs on average once in 25 years	16.8	inches

Parameter Code	Parameter Description	Value	Unit
I48H2Y	Maximum 48-hour precipitation that occurs on average once in 2 years	7.74	inches
I48H500Y	Maximum 48-hour precipitation that occurs on average once in 500 years	29.7	inches
I48H50Y	Maximum 48-hour precipitation that occurs on average once in 50 years	19.5	inches
I48H5Y	Maximum 48-hour precipitation that occurs on average once in 5 years	10.8	inches
I60M100Y	Maximum 60-min precipitation that occurs on average once in 100 years	3.71	inches
I60M10Y	Maximum 60-min precipitation that occurs on average once in 10 years	2.55	inches
I60M25Y	Maximum 60-min precipitation that occurs on average once in 25 years	3.03	inches
I60M2Y	Maximum 60-min precipitation that occurs on average once in 2 years	1.67	inches
I60M500Y	Maximum 60-min precipitation that occurs on average once in 500 years	4.44	inches
I60M50Y	Maximum 60-min precipitation that occurs on average once in 50 years	3.38	inches
I60M5Y	Maximum 60-min precipitation that occurs on average once in 5 years	2.18	inches
I6H100Y	6-hour precipitation that is expected to occur on average once in 100 years	9.13	inches
I6H10Y	Maximum 6-hour precipitation that occurs on average once in 10 years	5.84	inches
I6H25Y	Maximum 6-hour precipitation that occurs on average once in 25 years	7.12	inches
I6H2Y	Maximum 6-hour precipitation that occurs on average once in 2 years	3.63	inches
I6H500Y	Maximum 6-hour precipitation that occurs on average once in 500 years	11.6	inches
I6H50Y	Maximum 6-hour precipitation that occurs on average once in 50 years	8.12	inches
I6H5Y	Maximum 6-hour precipitation that occurs on average once in 5 years	4.88	inches

Parameter Code	Parameter Description	Value	Unit
IMPNLCD01	Percentage of impervious area determined from NLCD 2001 impervious dataset	0.11	percent
LC01BARE	Percentage of area barren land, NLCD 2001 category 31	0	percent
LC01CROP	Percentage of area crop, NLCD 2001 category	0	percent
LC01DEV	Percentage of land-use from NLCD 2001 classes 21-24	1.47	percent
LC01DEVHI	Percentage of area developed, high intensity, NLCD 2001 category 24	0	percent
LC01DEVMD	Percentage of area developed, medium intensity, NLCD 2001 category 23	0	percent
LC01EVERG	Percentage of area evergreen forest, NLCD 2001 category 42	4	percent
LC01OPNLO	Percentage of area developed, open space and low intensity combined, NLCD2001 cat. 21 and 22	2	percent
LFPLENGTH	Length of longest flow path	2.14	miles
MINBELEV	Minimum basin elevation	36	feet
PERM12IN	Area-weighted average soil permeability for top 12 inches of soil	2.74	inches per hour
PERM24IN	Area-weighted average soil permeability for top 24 inches of soil	2.37	inches per hour
PRECIP	Mean Annual Precipitation	52.6	inches
RELIEF	Maximum - minimum elevation	1170	feet
RELRELF	Basin relief divided by basin perimeter	194	feet per mi
SLOP30_10M	Percent area with slopes greater than 30 percent from 10-meter NED	0	percent
SLPFM3D	Change in elevation divided by length between points 10 and 85 percent of distance along the longest flow path to the basin divide, LFP from 3D grid	547	feet per mi

Peak-Flow Statistics

Peak-Flow Statistics Parameters [Hawaii Peakflow 10 southern Hawaii Island 2023 5014]

Parameter Code	Parameter Name	Value	Units	Min Limit	Max Limit
I48H500Y	I48H500Y	29.7	inches	12.41	48.9

Peak-Flow Statistics Flow Report [Hawaii Peakflow 10 southern Hawaii Island 2023 5014]

PIL: Lower 90% Prediction Interval, PIU: Upper 90% Prediction Interval, ASEp: Average Standard Error of Prediction, SE: Standard Error (other -- see report)

Statistic	Value	Unit	PIL	PIU	ASEp
50-percent AEP flood	353	ft^3/s	36.2	3450	138
20-percent AEP flood	605	ft^3/s	63.1	5800	136
10-percent AEP flood	795	ft^3/s	79.4	7960	140
4-percent AEP flood	1060	ft^3/s	97.7	11500	149
2-percent AEP flood	1260	ft^3/s	109	14600	156
1-percent AEP flood	1480	ft^3/s	119	18400	164
0.5-percent AEP flood	1710	ft^3/s	129	22600	171
0.2-percent AEP flood	2040	ft^3/s	142	29200	182

Peak-Flow Statistics Citations

Mitchell, J.N., Wagner, D.M., and Veilleux, A.G.2023, Magnitude and frequency of floods on Kauaʻi, Oʻahu, Molokaʻi, Maui, and Hawaiʻi, State of Hawaiʻi, based on data through water year 2020: U.S. Geological Survey Scientific Investigations Report 2023–5014, 66 p. plus 4 appendixes (https://doi.org/10.3133/sir20235014)

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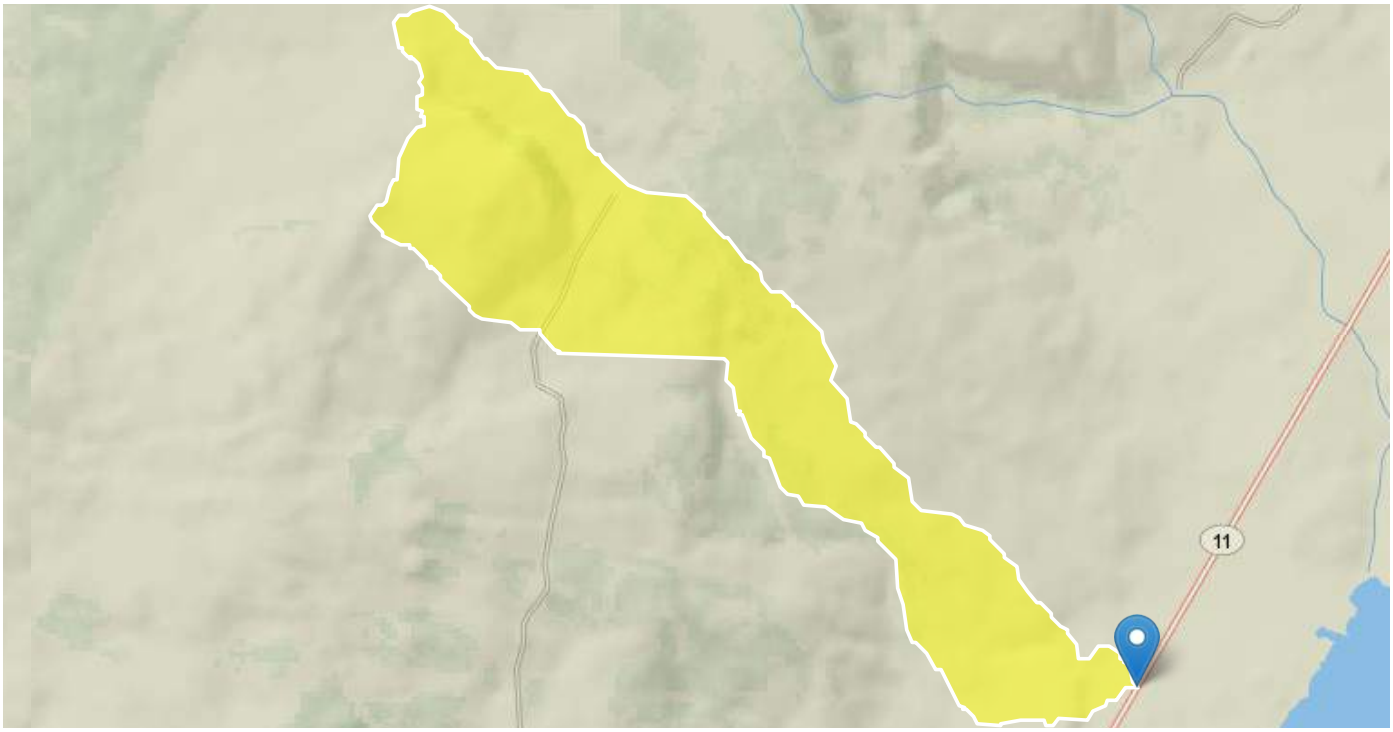
Application Version: 4.19.4
StreamStats Services Version: 1.2.22
NSS Services Version: 2.2.1

MP 58.7 (1.2 sq. mi)

Region ID: HI
Workspace ID: HI20240628183517682000
Clicked Point (Latitude, Longitude): 19.10855, -155.53585
Time: 2024-06-28 11:35:38 -0700



Collapse All

Basin Characteristics

Parameter Code	Parameter Description	Value	Unit
BASINPERIM	Perimeter of the drainage basin as defined in SIR 2004-5262	9.64	miles
BSLDEM10M	Mean basin slope computed from 10 m DEM	13.9	percent
COMPRAT	A measure of basin shape related to basin perimeter and drainage area	2.49	dimensionless
CSL10_85	Change in elevation divided by length between points 10 and 85 percent of distance along main channel to basin divide - main channel method not known	512	feet per mi
DRNAREA	Area that drains to a point on a stream	1.195	square miles
ELEV	Mean Basin Elevation	1007	feet

Parameter Code	Parameter Description	Value	Unit
ELEV10FT	Elevation at 10 percent from outlet along longest flow path slope using DEM	94	feet
ELEV10FT3D	Elevation at 10 percent from outlet along longest flow path slope using 3D line	93	feet
ELEV85FT	Elevation at 85 percent from outlet along longest flow path slope using DEM	1427	feet
ELEV85FT3D	Elevation at 85 percent from outlet along longest flow path slope using 3D line	1428	feet
ELEVMAX	Maximum basin elevation	1808	feet
I24H100Y	Maximum 24-hour precipitation that occurs on average once in 100 years	16.91	inches
I24H10Y	Maximum 24-hour precipitation that occurs on average once in 10 years	10.63	inches
I24H25Y	Maximum 24-hour precipitation that occurs on average once in 25 years	13.09	inches
I24H2Y	Maximum 24-hour precipitation that occurs on average once in 2 years - Equivalent to precipitation intensity index	6.4	inches
I24H500Y	Maximum 24-hour precipitation that occurs on average once in 500 years	21.5	inches
I24H50Y	Maximum 24-hour precipitation that occurs on average once in 50 years	15	inches
I24H5Y	Maximum 24-hour precipitation that occurs on average once in 5 years	8.79	inches
I48H100Y	Maximum 48-hour precipitation that occurs on average once in 100 years	25.08	inches
I48H10Y	Maximum 48-hour precipitation that occurs on average once in 10 years	14.92	inches
I48H25Y	Maximum 48-hour precipitation that occurs on average once in 25 years	18.78	inches
I48H2Y	Maximum 48-hour precipitation that occurs on average once in 2 years	8.7	inches
I48H500Y	Maximum 48-hour precipitation that occurs on average once in 500 years	33.22	inches
I48H50Y	Maximum 48-hour precipitation that occurs on average once in 50 years	21.86	inches
I48H5Y	Maximum 48-hour precipitation that occurs on average once in 5 years	12.16	inches
I60M100Y	Maximum 60-min precipitation that occurs on average once in 100 years	4.04	inches

Parameter Code	Parameter Description	Value	Unit
I60M10Y	Maximum 60-min precipitation that occurs on average once in 10 years	2.79	inches
I60M25Y	Maximum 60-min precipitation that occurs on average once in 25 years	3.31	inches
I60M2Y	Maximum 60-min precipitation that occurs on average once in 2 years	1.83	inches
I60M500Y	Maximum 60-min precipitation that occurs on average once in 500 years	4.84	inches
I60M50Y	Maximum 60-min precipitation that occurs on average once in 50 years	3.68	inches
I60M5Y	Maximum 60-min precipitation that occurs on average once in 5 years	2.39	inches
I6H100Y	6-hour precipitation that is expected to occur on average once in 100 years	9.94	inches
I6H10Y	Maximum 6-hour precipitation that occurs on average once in 10 years	6.37	inches
I6H25Y	Maximum 6-hour precipitation that occurs on average once in 25 years	7.76	inches
I6H2Y	Maximum 6-hour precipitation that occurs on average once in 2 years	3.98	inches
I6H500Y	Maximum 6-hour precipitation that occurs on average once in 500 years	12.6	inches
I6H50Y	Maximum 6-hour precipitation that occurs on average once in 50 years	8.84	inches
I6H5Y	Maximum 6-hour precipitation that occurs on average once in 5 years	5.33	inches
LAT_CENT	Latitude of Basin Centroid	19.1237	decimal degrees
LC11BARE	Percentage of barren from NLCD 2011 class 31	0.6	percent
LC11CROP	Percentage of area of cultivated crops from NLCD 2011 class 82	0	percent
LC11DEV	Percentage of developed (urban) land from NLCD 2011 classes 21-24	0	percent
LC11FOREST	Percentage of forest from NLCD 2011 classes 41-43	21.1	percent
LC11GRASS	Percent of area covered by grassland/herbaceous using 2011 NLCD	6.7	percent
LC11IMP	Average percentage of impervious area determined from NLCD 2011 impervious dataset	0.7	percent
LC11PAST	Percentage of area of pasture area from NLCD 2011 class 81	42.4	percent

Parameter Code	Parameter Description	Value	Unit
LC11SHRUB	Percent of area covered by shrubland using 2011 NLCD	28.6	percent
LFPLENGTH	Length of longest flow path	3.48	miles
LONG_CENT	Longitude Basin Centroid	155.5564	decimal degrees
MINBELEV	Minimum basin elevation	51	feet
PERM12IN	Area-weighted average soil permeability for top 12 inches of soil	11.327	inches per hour
PERM24IN	Area-weighted average soil permeability for top 24 inches of soil	11.107	inches per hour
PRECIP	Mean Annual Precipitation	58.557	inches
RELIEF	Maximum - minimum elevation	1757	feet
RELRELF	Basin relief divided by basin perimeter	182	feet per mi
SLOP30_10M	Percent area with slopes greater than 30 percent from 10-meter NED	5.9	percent
SLPFM3D	Change in elevation divided by length between points 10 and 85 percent of distance along the longest flow path to the basin divide, LFP from 3D grid	468	feet per mi

Peak-Flow Statistics

Peak-Flow Statistics Parameters [Hawaii Peakflow 10 southern Hawaii Island 2023 5014]

Parameter Code	Parameter Name	Value	Units	Min Limit	Max Limit
I48H500Y	I48H500Y	33.22	inches	12.41	48.9

Peak-Flow Statistics Flow Report [Hawaii Peakflow 10 southern Hawaii Island 2023 5014]

PIL: Lower 90% Prediction Interval, PIU: Upper 90% Prediction Interval, ASEp: Average Standard Error of Prediction, SE: Standard Error, PC: Percent Correct (other -- see report)

Statistic	Value	Unit	PIL	PIU	ASEp
50-percent AEP flood	447	ft^3/s	46.4	4310	138
20-percent AEP flood	790	ft^3/s	83.5	7480	136
10-percent AEP flood	1050	ft^3/s	106	10400	140
4-percent AEP flood	1420	ft^3/s	133	15200	149
2-percent AEP flood	1710	ft^3/s	149	19600	156
1-percent AEP flood	2020	ft^3/s	165	24700	164
0.5-percent AEP flood	2350	ft^3/s	180	30700	171

Statistic	Value	Unit	PIL	PIU	ASEp
0.2-percent AEP flood	2810	ft^3/s	199	39700	182

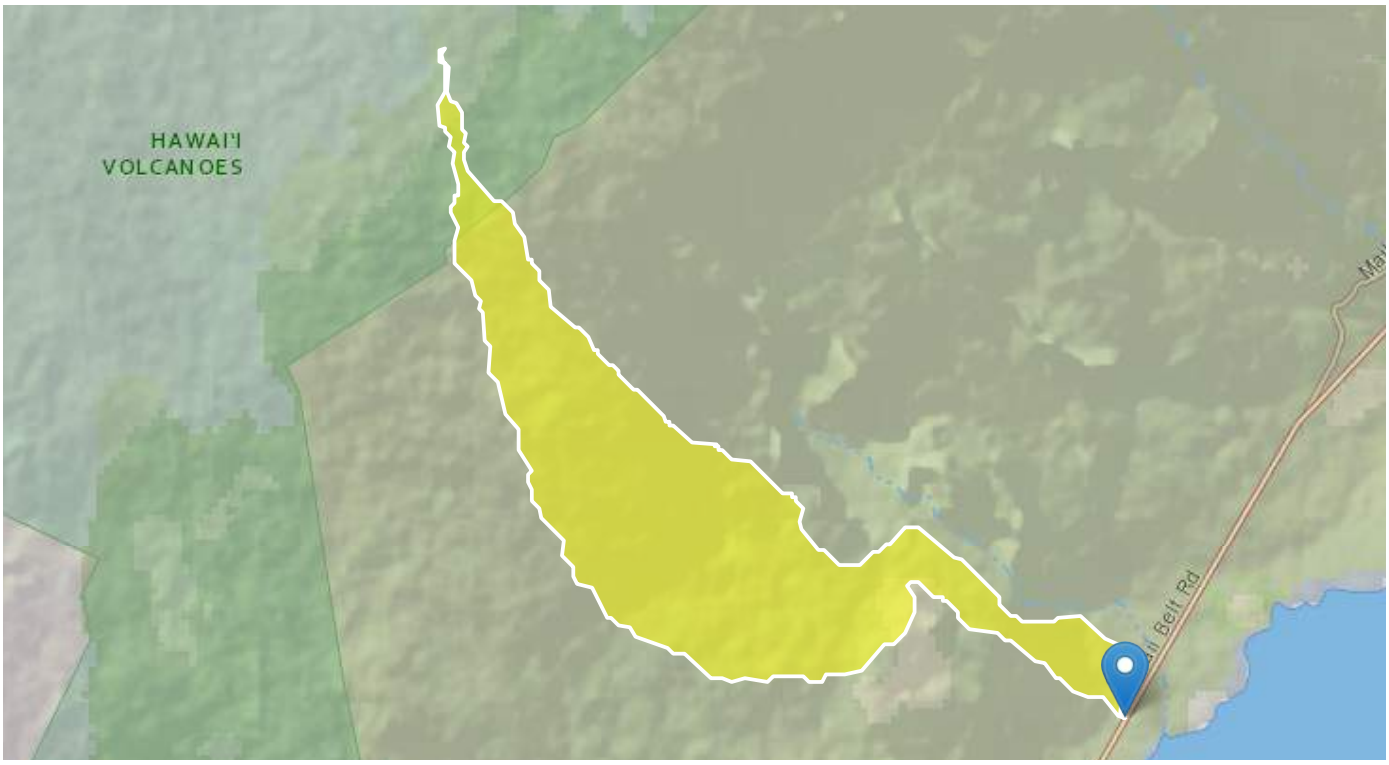
Peak-Flow Statistics Citations

Mitchell, J.N., Wagner, D.M., and Veilleux, A.G.2023, Magnitude and frequency of floods on Kauaʻi, Oʻahu, Molokaʻi, Maui, and Hawaiʻi, State of Hawaiʻi, based on data through water year 2020: U.S. Geological Survey Scientific Investigations Report 2023–5014, 66 p. plus 4 appendixes (https://doi.org/10.3133/sir20235014)

Application Version: 4.21.0
StreamStats Services Version: 1.2.22
NSS Services Version: 2.2.1

MP 58.7 (14.0 sq. mi)

Region ID: HI
Workspace ID: HI20240628180056828000
Clicked Point (Latitude, Longitude): 19.11561, -155.53160
Time: 2024-06-28 11:01:20 -0700



Collapse All

Basin Characteristics

Parameter Code	Parameter Description	Value	Unit
BASINPERIM	Perimeter of the drainage basin as defined in SIR 2004-5262	37.77	miles
BSLDEM10M	Mean basin slope computed from 10 m DEM	11.7	percent
COMPRAT	A measure of basin shape related to basin perimeter and drainage area	2.84	dimensionless
CSL10_85	Change in elevation divided by length between points 10 and 85 percent of distance along main channel to basin divide - main channel method not known	497	feet per mi
DRNAREA	Area that drains to a point on a stream	14.035	square miles

Parameter Code	Parameter Description	Value	Unit
ELEV	Mean Basin Elevation	3195	feet
ELEV10FT	Elevation at 10 percent from outlet along longest flow path slope using DEM	429	feet
ELEV10FT3D	Elevation at 10 percent from outlet along longest flow path slope using 3D line	428	feet
ELEV85FT	Elevation at 85 percent from outlet along longest flow path slope using DEM	5672	feet
ELEV85FT3D	Elevation at 85 percent from outlet along longest flow path slope using 3D line	5671	feet
ELEVMAX	Maximum basin elevation	6447	feet
I24H100Y	Maximum 24-hour precipitation that occurs on average once in 100 years	20.82	inches
I24H10Y	Maximum 24-hour precipitation that occurs on average once in 10 years	13.28	inches
I24H25Y	Maximum 24-hour precipitation that occurs on average once in 25 years	16.22	inches
I24H2Y	Maximum 24-hour precipitation that occurs on average once in 2 years - Equivalent to precipitation intensity index	8.19	inches
I24H500Y	Maximum 24-hour precipitation that occurs on average once in 500 years	26.39	inches
I24H50Y	Maximum 24-hour precipitation that occurs on average once in 50 years	18.51	inches
I24H5Y	Maximum 24-hour precipitation that occurs on average once in 5 years	11.07	inches
I48H100Y	Maximum 48-hour precipitation that occurs on average once in 100 years	30.38	inches
I48H10Y	Maximum 48-hour precipitation that occurs on average once in 10 years	18.4	inches
I48H25Y	Maximum 48-hour precipitation that occurs on average once in 25 years	22.96	inches
I48H2Y	Maximum 48-hour precipitation that occurs on average once in 2 years	11.02	inches
I48H500Y	Maximum 48-hour precipitation that occurs on average once in 500 years	40.02	inches
I48H50Y	Maximum 48-hour precipitation that occurs on average once in 50 years	26.59	inches

Parameter Code	Parameter Description	Value	Unit
I48H5Y	Maximum 48-hour precipitation that occurs on average once in 5 years	15.14	inches
I60M100Y	Maximum 60-min precipitation that occurs on average once in 100 years	4.69	inches
I60M10Y	Maximum 60-min precipitation that occurs on average once in 10 years	3.26	inches
I60M25Y	Maximum 60-min precipitation that occurs on average once in 25 years	3.84	inches
I60M2Y	Maximum 60-min precipitation that occurs on average once in 2 years	2.18	inches
I60M500Y	Maximum 60-min precipitation that occurs on average once in 500 years	5.66	inches
I60M50Y	Maximum 60-min precipitation that occurs on average once in 50 years	4.27	inches
I60M5Y	Maximum 60-min precipitation that occurs on average once in 5 years	2.8	inches
I6H100Y	6-hour precipitation that is expected to occur on average once in 100 years	11.88	inches
I6H10Y	Maximum 6-hour precipitation that occurs on average once in 10 years	7.69	inches
I6H25Y	Maximum 6-hour precipitation that occurs on average once in 25 years	9.31	inches
I6H2Y	Maximum 6-hour precipitation that occurs on average once in 2 years	4.9	inches
I6H500Y	Maximum 6-hour precipitation that occurs on average once in 500 years	15.08	inches
I6H50Y	Maximum 6-hour precipitation that occurs on average once in 50 years	10.58	inches
I6H5Y	Maximum 6-hour precipitation that occurs on average once in 5 years	6.48	inches
LAT_CENT	Latitude of Basin Centroid	19.152	decimal degrees
LC11BARE	Percentage of barren from NLCD 2011 class 31	0.1	percent
LC11CROP	Percentage of area of cultivated crops from NLCD 2011 class 82	0	percent
LC11DEV	Percentage of developed (urban) land from NLCD 2011 classes 21-24	0	percent

Parameter Code	Parameter Description	Value	Unit
LC11FOREST	Percentage of forest from NLCD 2011 classes 41-43	81.6	percent
LC11GRASS	Percent of area covered by grassland/herbaceous using 2011 NLCD	2.3	percent
LC11IMP	Average percentage of impervious area determined from NLCD 2011 impervious dataset	0.1	percent
LC11PAST	Percentage of area of pasture area from NLCD 2011 class 81	8.8	percent
LC11SHRUB	Percent of area covered by shrubland using 2011 NLCD	7.1	percent
LFPLENGTH	Length of longest flow path	14.05	miles
LONG_CENT	Longitude Basin Centroid	155.6081	decimal degrees
MINBELEV	Minimum basin elevation	60	feet
PERM12IN	Area-weighted average soil permeability for top 12 inches of soil	2.004	inches per hour
PERM24IN	Area-weighted average soil permeability for top 24 inches of soil	1.622	inches per hour
PRECIP	Mean Annual Precipitation	91.64	inches
RELIEF	Maximum - minimum elevation	6387	feet
RELRELF	Basin relief divided by basin perimeter	169	feet per mi
SLOP30_10M	Percent area with slopes greater than 30 percent from 10-meter NED	2.6	percent
SLPFM3D	Change in elevation divided by length between points 10 and 85 percent of distance along the longest flow path to the basin divide, LFP from 3D grid	455	feet per mi

Peak-Flow Statistics

Peak-Flow Statistics Parameters [Hawaii Peakflow 10 southern Hawaii Island 2023 5014]

Parameter Code	Parameter Name	Value	Units	Min Limit	Max Limit
I48H500Y	I48H500Y	40.02	inches	12.41	48.9

Peak-Flow Statistics Flow Report [Hawaii Peakflow 10 southern Hawaii Island 2023 5014]

PIL: Lower 90% Prediction Interval, PIU: Upper 90% Prediction Interval, ASEp: Average Standard Error of Prediction, SE: Standard Error, PC: Percent Correct (other -- see report)

Statistic	Value	Unit	PIL	PIU	ASEp
50-percent AEP flood	663	ft^3/s	67.5	6510	138
20-percent AEP flood	1230	ft^3/s	127	11900	136
10-percent AEP flood	1680	ft^3/s	167	16900	140
4-percent AEP flood	2320	ft^3/s	212	25400	149
2-percent AEP flood	2840	ft^3/s	243	33200	156
1-percent AEP flood	3390	ft^3/s	271	42500	164
0.5-percent AEP flood	3980	ft^3/s	298	53200	171
0.2-percent AEP flood	4810	ft^3/s	332	69800	182

Peak-Flow Statistics Citations

Mitchell, J.N., Wagner, D.M., and Veilleux, A.G.2023, Magnitude and frequency of floods on Kauaʻi, Oʻahu, Molokaʻi, Maui, and Hawaiʻi, State of Hawaiʻi, based on data through water year 2020: U.S. Geological Survey Scientific Investigations Report 2023–5014, 66 p. plus 4 appendixes (https://doi.org/10.3133/sir20235014)

Application Version: 4.21.0
StreamStats Services Version: 1.2.22
NSS Services Version: 2.2.1

Exhibit 3

HEC-RAS - River Analysis System

Project File: C:\Users\jgriffiths\Desktop\Hwy 11\BigIslandHwy11RO.prj

Project Name: Big Island Hwy11 ROG

Plan Name: Hwy11_SoilADLess3_50yr_DW (t=0.3)

Short ID: 50yr_DW_t=0.3

Starting Time: 31May2022 2400

Ending Time: 01Jun2022 2400

```
################################################
#                                              #
#                                              #
#       1D and 2D Unsteady Flow Module         #
#                                              #
#                                              #
#          HEC-RAS 6.5 February 2024           #
#                                              #
#             03DEC24 at 17:21:06              #
#                                              #
################################################
```

US Inflow	DS Outflow	Lat Hydro	SA Hydro	Groundwater	Diversions	Precip Excess	Precip Excess
(Acre Feet)		(Inches)					
*********	**********	*********	********	**********	**********	**********	**********

0.0000000000

Start 1D Reach	Final 1D Reach	Starting SA's	Final SA's
**********	**********	**********	**********

*** Volume Accounting for 2D Flow Area in Acre Feet ***

2D Area	Starting Vol	Ending Vol	Cum Inflow	Cum Outflow
Error	Percent Error	Precip Excess	Precip Excess (incl. precip)	
		(Acre Feet)	(Inches)	
*******	**********	**********	**********	**********
*****	**********	**********	**********	
Hwy58.7-60		5161.	35090.	29930.
0.1264	0.000360	35090.	10.71	

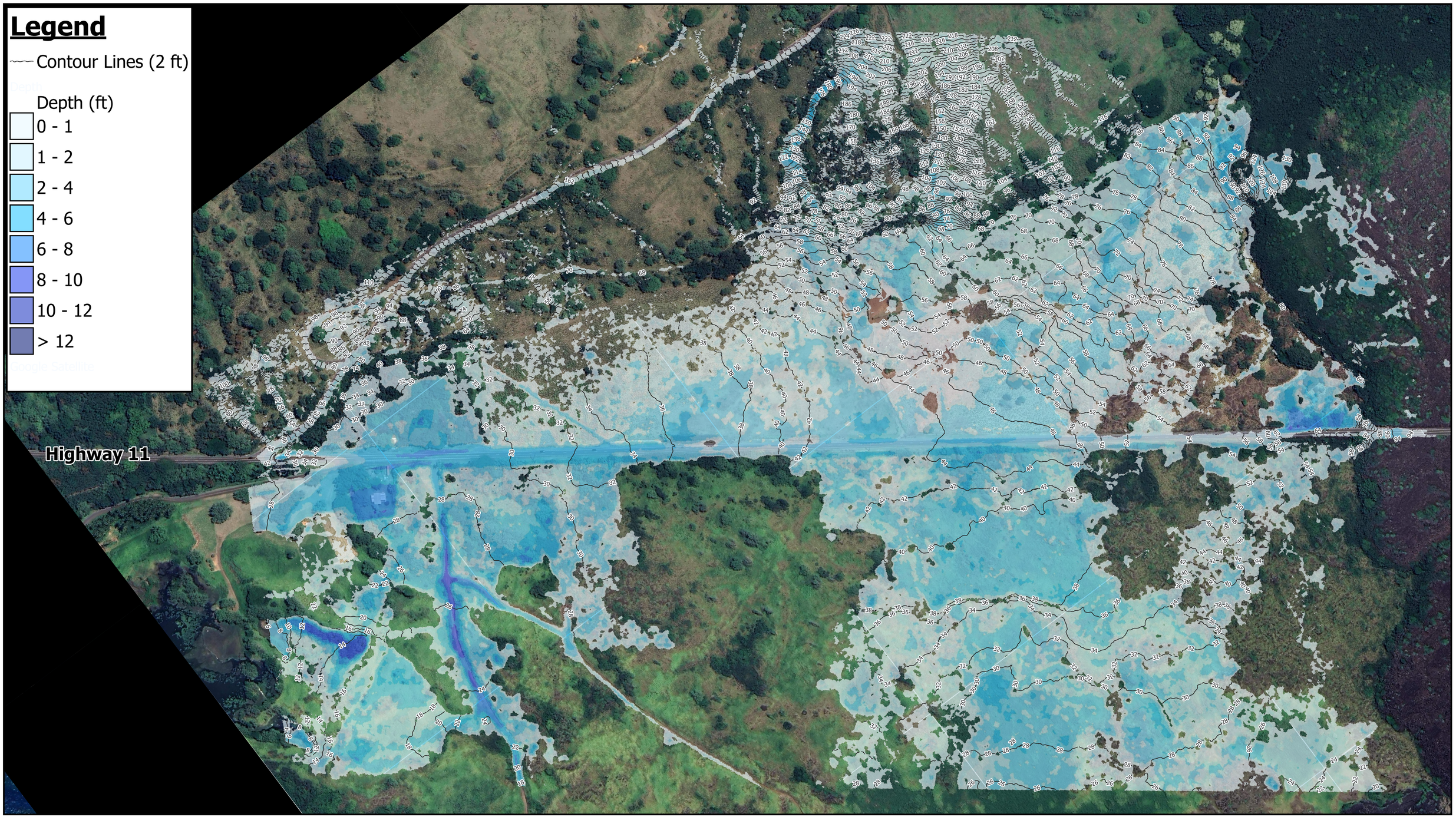
*** Total Volume Accounting (for the entire model) in Acre Feet ***

Total Boundary Flux of Water In	35090.
Total Boundary Flux of Water Out	29930.
Starting Volume	0.0000000000
Ending Volume	5161.
Precipitation Excess (Acre Feet)	35090.
Precipitation Excess (inches)	10.71

Error	Percent Error
*****	**********
0.1264	0.000360

Appendix B:
Hydraulic Model Results and Supporting Data

Exhibit 1



SSFM International
Innovate | Adapt | Sustain

ENGINEER: JUSTIN W. GRIFFITHS
FIRM: WEST CONSULTANTS, INC.
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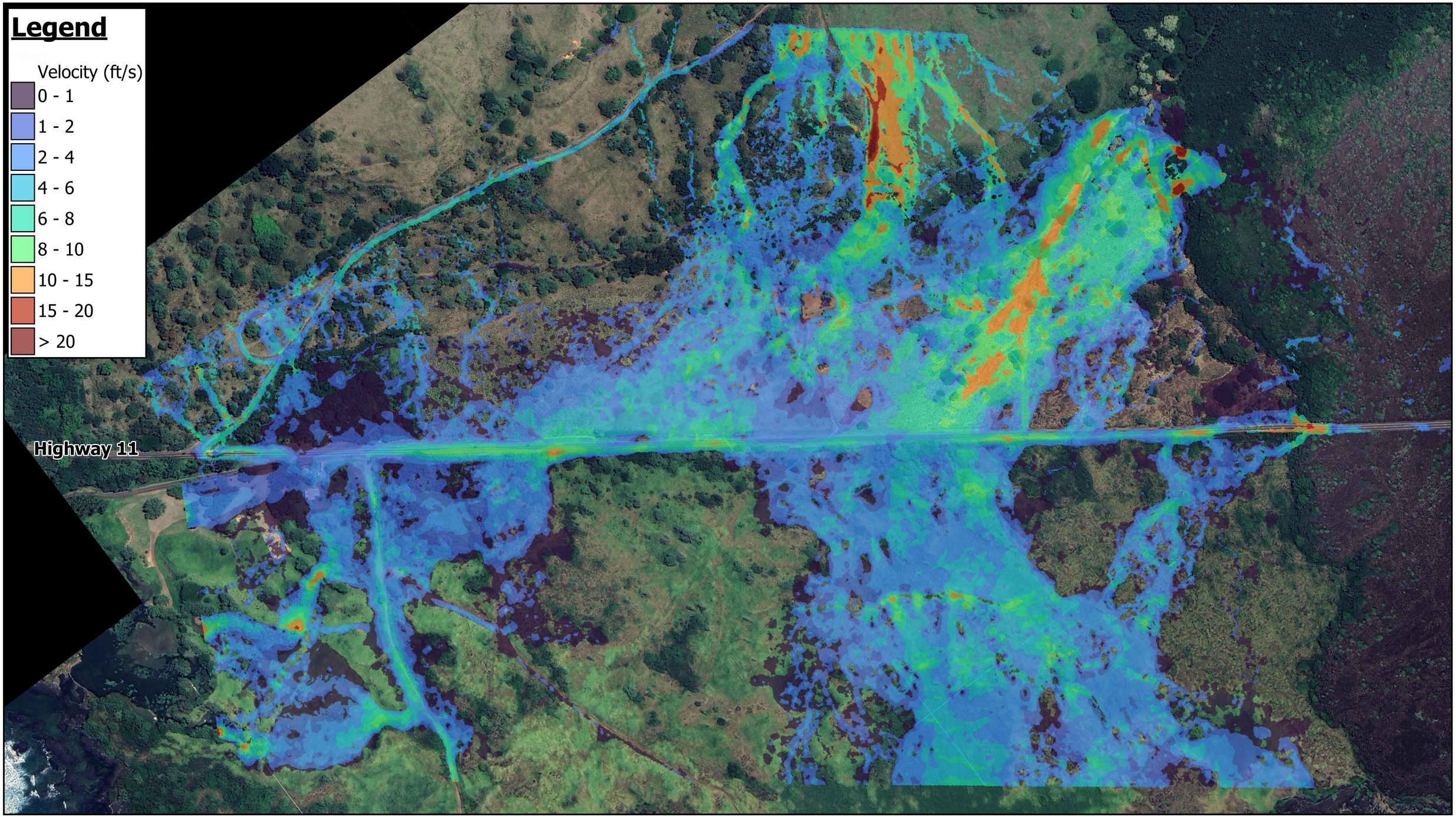
SAN DIEGO, CA 92127-1644
PHONE: 858-487-9378
DATE: DECEMBER 2024

WEST CONSULTANTS
WATER | ENVIRONMENTAL | SEDIMENTATION | TECHNOLOGY

MAMALAHOA HIGHWAY (HWY 11) DRAINAGE IMPROVEMENTS MP 60: 50-YEAR MAX DEPTH EXISTING CONDITIONS

0 250 500 ft

Exhibit 2



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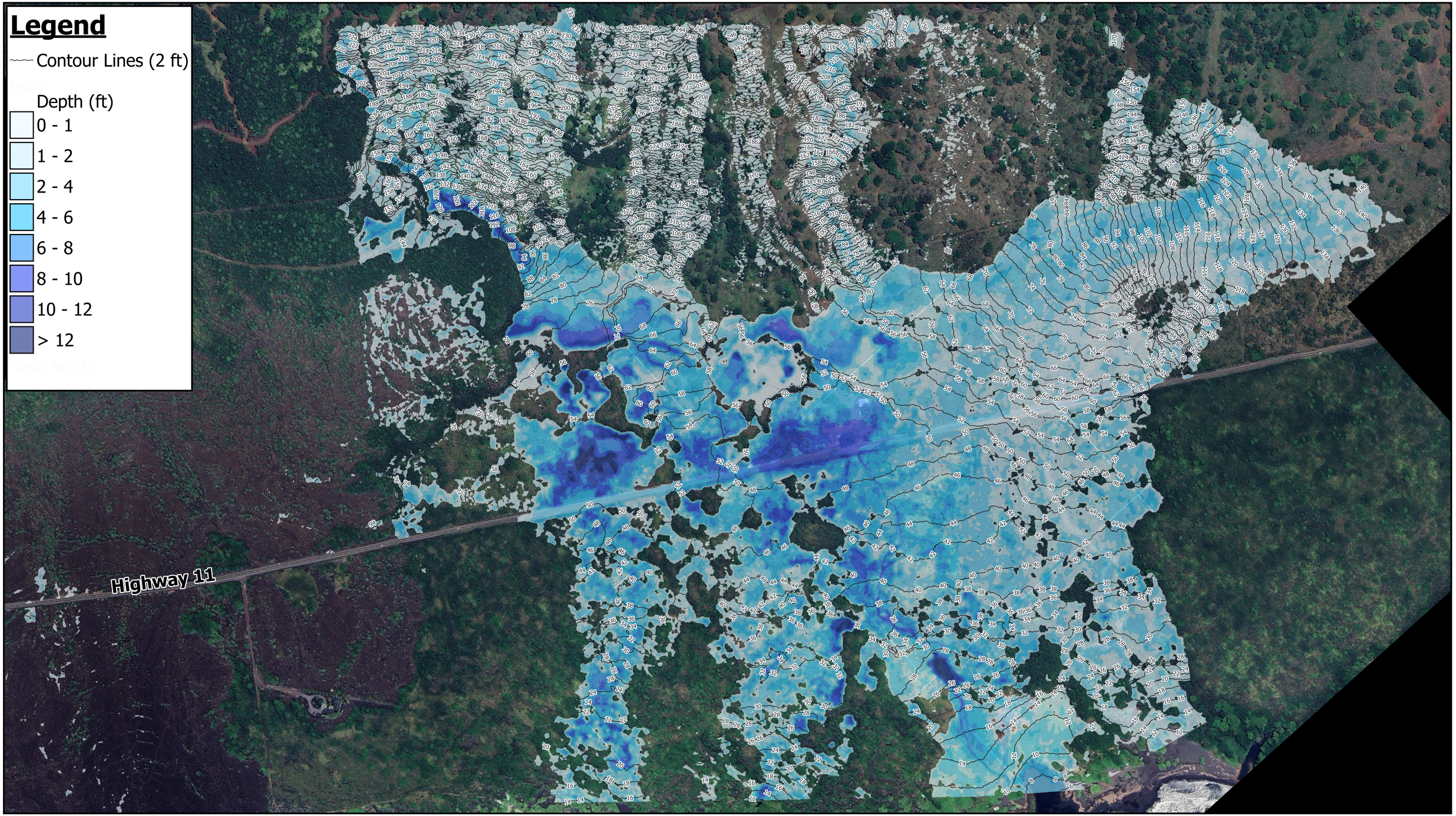
MAMALAHOA HIGHWAY (HWY 11) DRAINAGE IMPROVEMENTS MP 60: 50-YEAR MAX VELOCITY EXISTING CONDITIONS

0 250 500 ft

Exhibit 3



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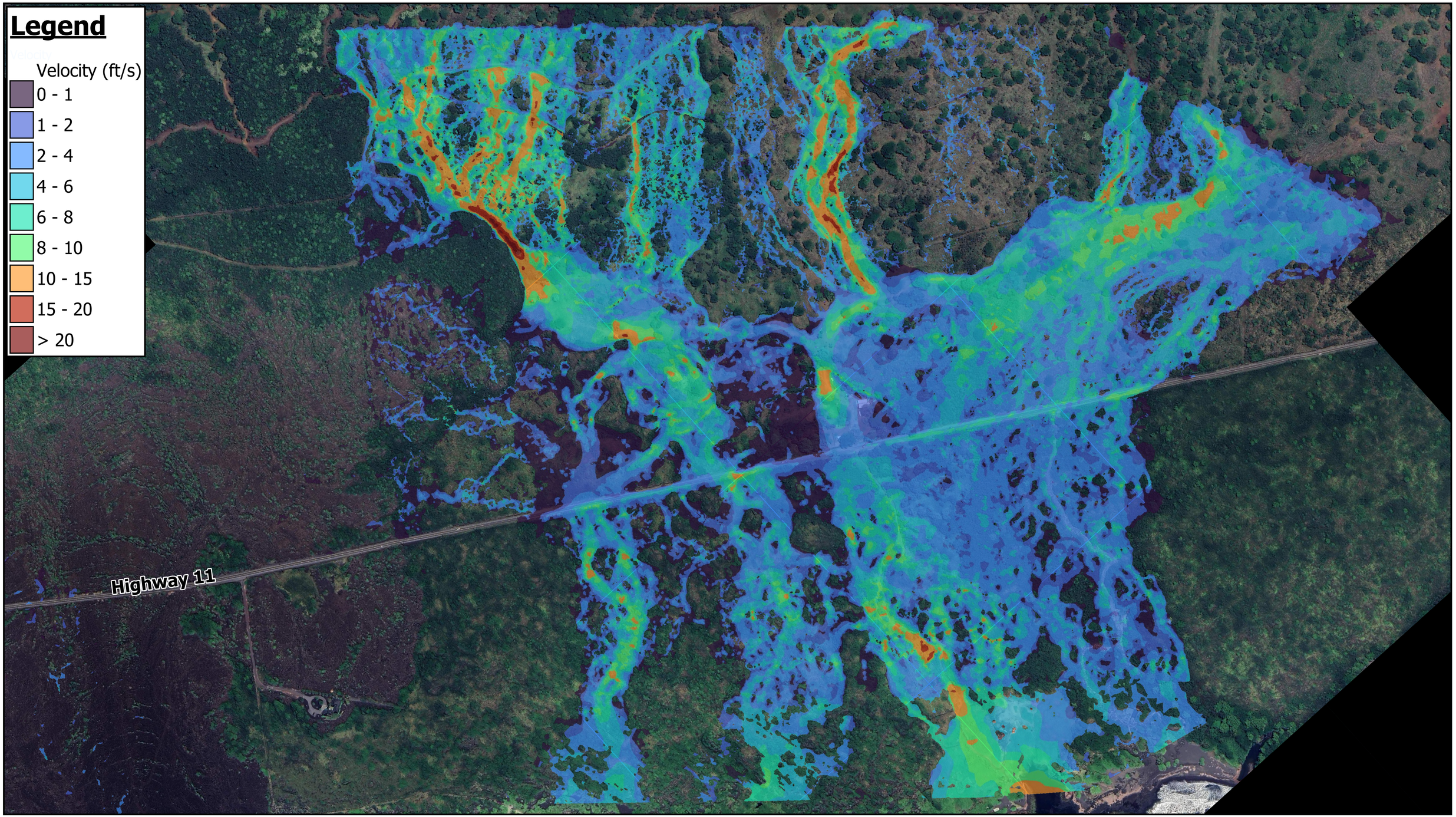
MAMALAHOA HIGHWAY (HWY 11) DRAINAGE IMPROVEMENTS MP 58.7: 50-YEAR MAX DEPTH EXISTING CONDITIONS

0 250 500 ft

Exhibit 4



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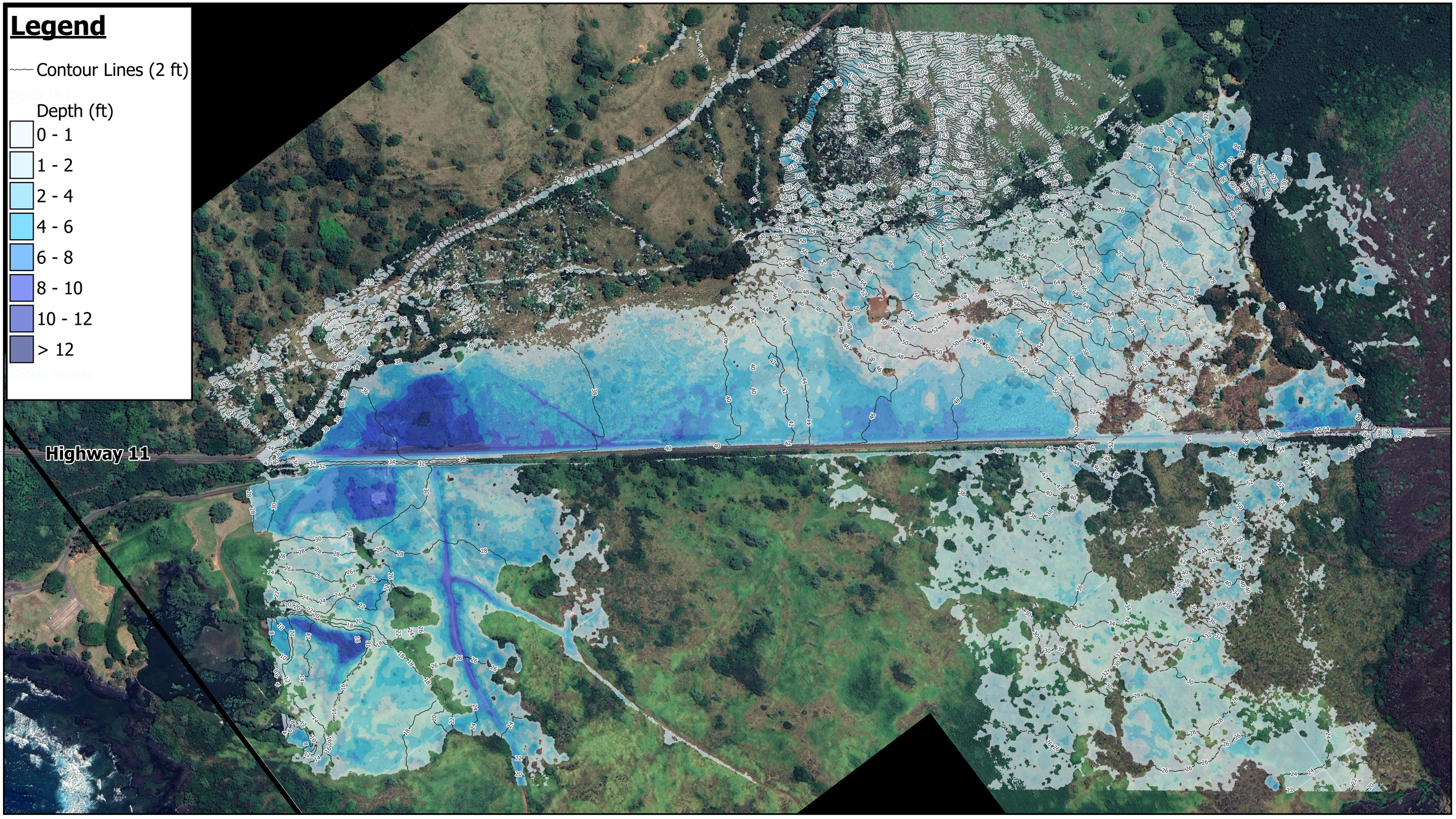
PHONE: 858-487-9378
DATE: DECEMBER 2024

WEST CONSULTANTS
WATER | ENVIRONMENTAL | SEDIMENTATION | TECHNOLOGY

MAMALAHOA HIGHWAY (HWY 11) DRAINAGE IMPROVEMENTS MP 58.7: 50-YEAR MAX VELOCITY EXISTING CONDITIONS

0 250 500 ft

Exhibit 5



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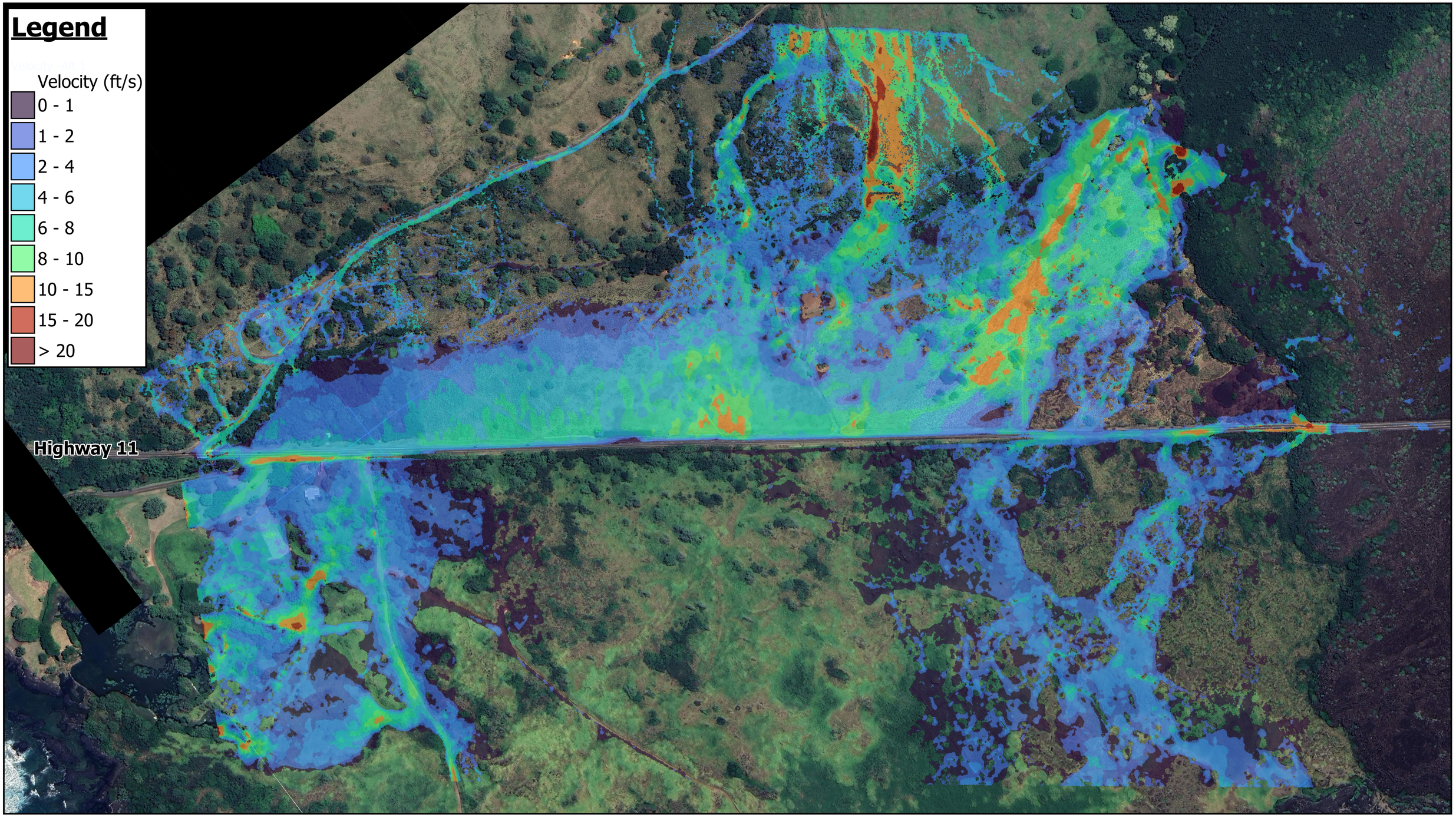
ENGINEER: JUSTIN W. GRIFFITHS
FIRM: WEST CONSULTANTS, INC.
ADDRESS: WEST CONSULTANTS, INC.
11440 W. BERNARDO COURT, STE 360
SAN DIEGO, CA 92127-1644
PHONE: 858-487-9378
DATE: DECEMBER 2024

WEST CONSULTANTS
WATER | ENVIRONMENTAL | SEDIMENTATION | TECHNOLOGY

MAMALAHOA HIGHWAY (HWY 11) DRAINAGE IMPROVEMENTS MP 60: 50-YEAR MAX DEPTH ALTERNATIVE 1

0 250 500 ft

Exhibit 6



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MAMALAHOA HIGHWAY (HWY 11) DRAINAGE IMPROVEMENTS MP 60: 50-YEAR MAX VELOCITY ALTERNATIVE 1

0 250 500 ft

Exhibit 7

Legend

Countour Lines (2 ft)

Depth (ft)

- 0 - 1
- 1 - 2
- 2 - 4
- 4 - 6
- 6 - 8
- 8 - 10
- 10 - 12
- > 12

Highway 11

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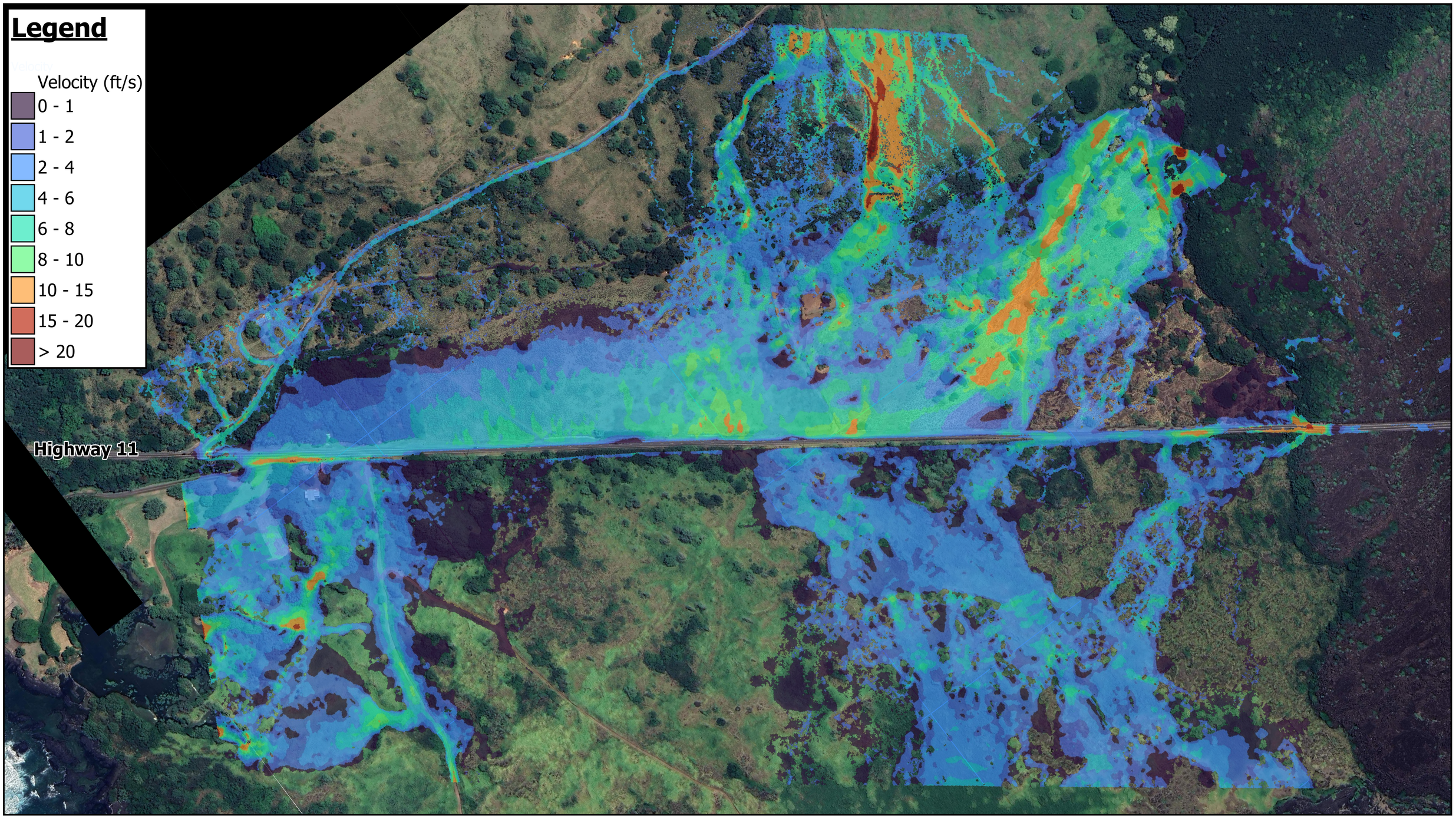
MAMALAHOA HIGHWAY (HWY 11)
DRAINAGE IMPROVEMENTS
MP 60: 50-YEAR MAX DEPTH
ALTERNATIVE 2

0 250 500 ft

Exhibit 8



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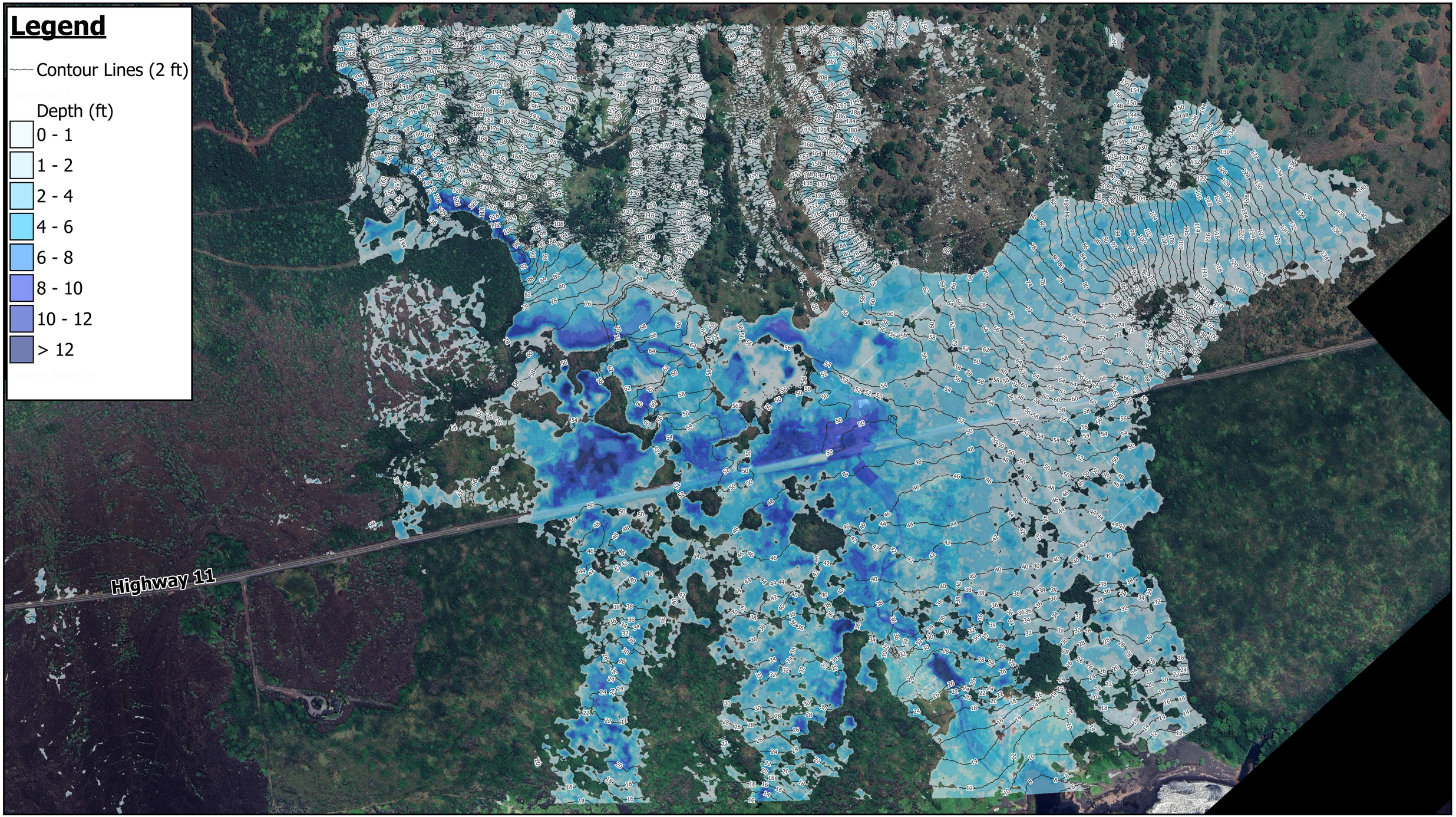
MAMALAHOA HIGHWAY (HWY 11) DRAINAGE IMPROVEMENTS MP 60: 50-YEAR MAX VELOCITY ALTERNATIVE 2

0 250 500 ft

Exhibit 9



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WEST CONSULTANTS
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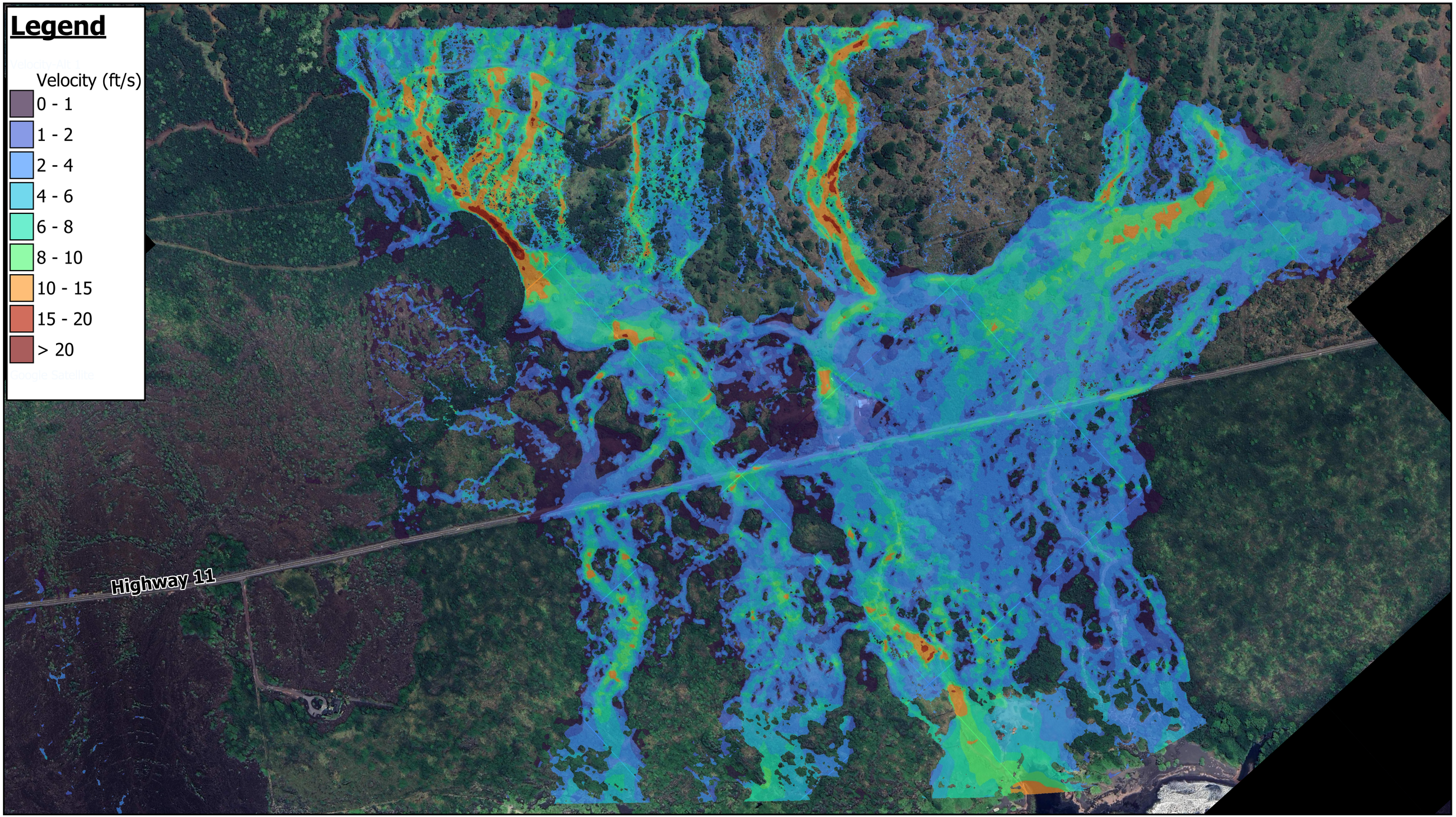
MAMALAHOA HIGHWAY (HWY 11) DRAINAGE IMPROVEMENTS MP 58.7: 50-YEAR MAX DEPTH ALTERNATIVE 1

0 250 500 ft

Exhibit 10



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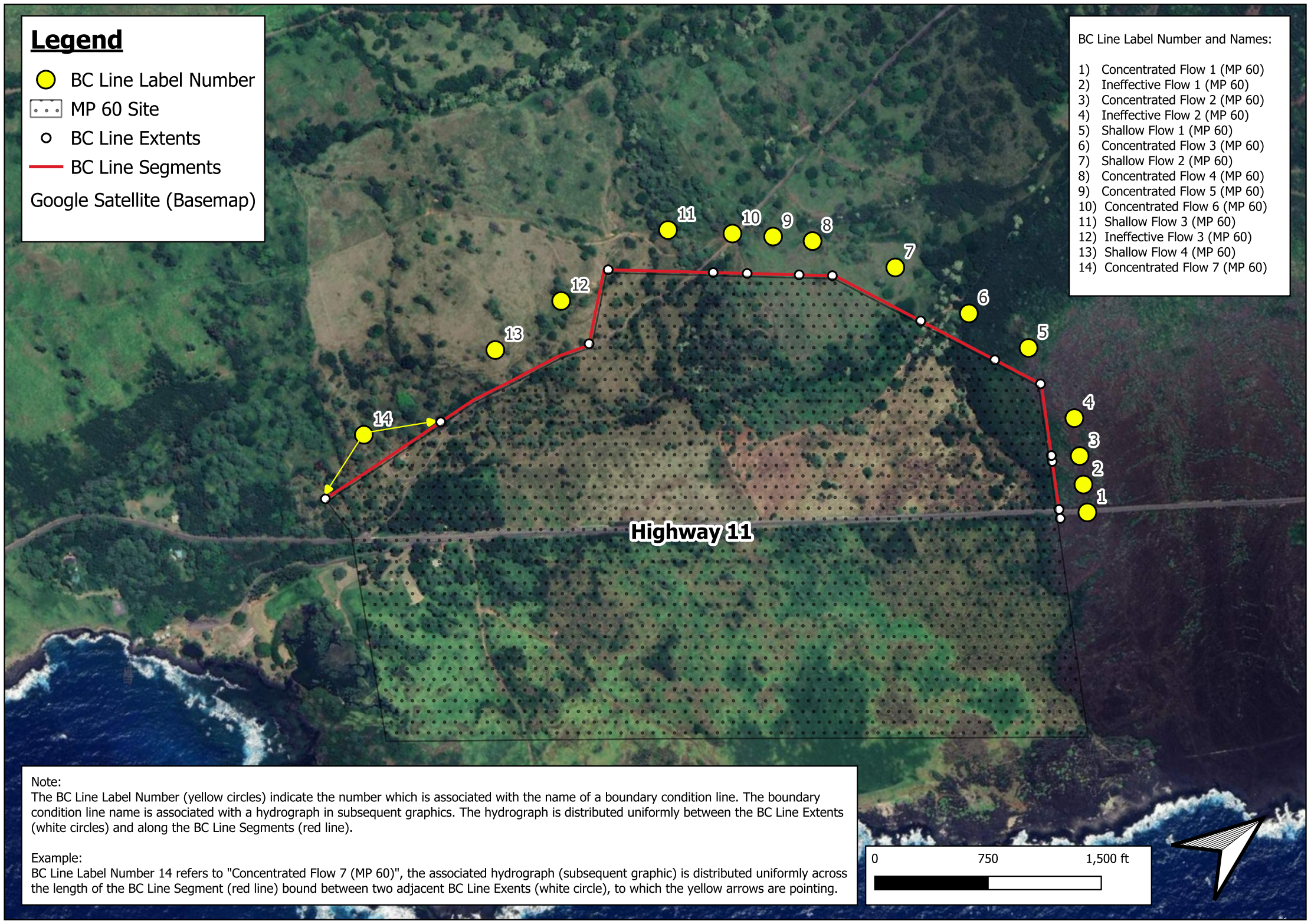
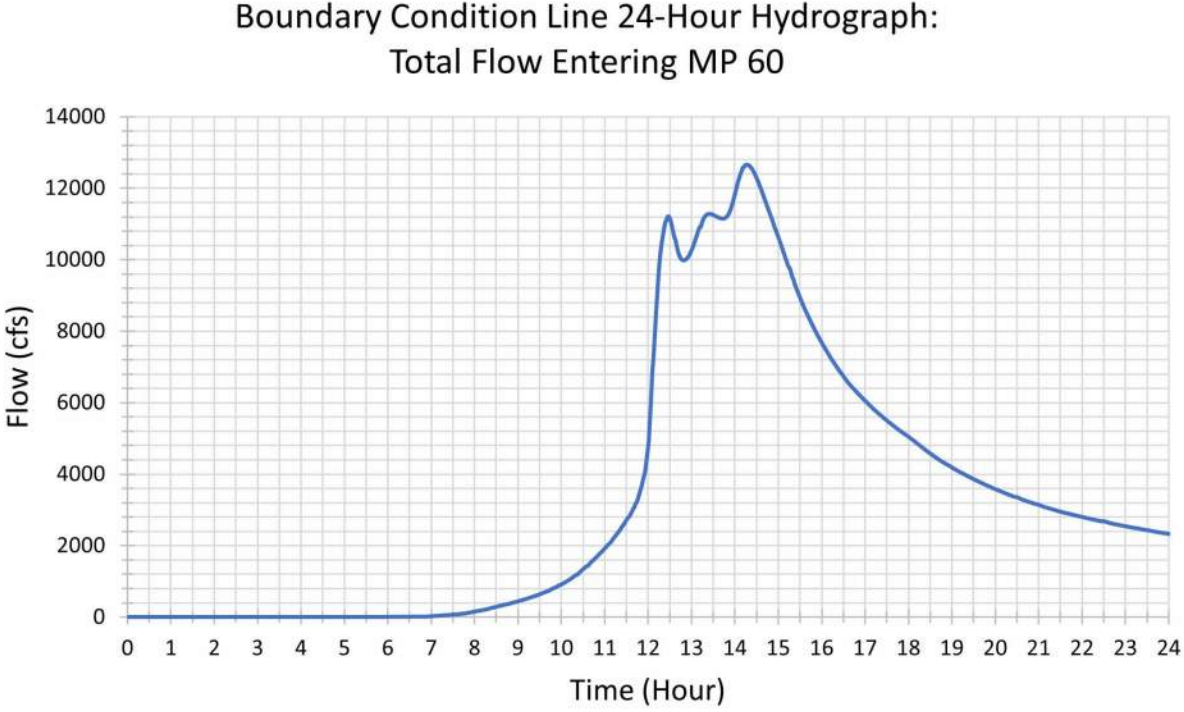
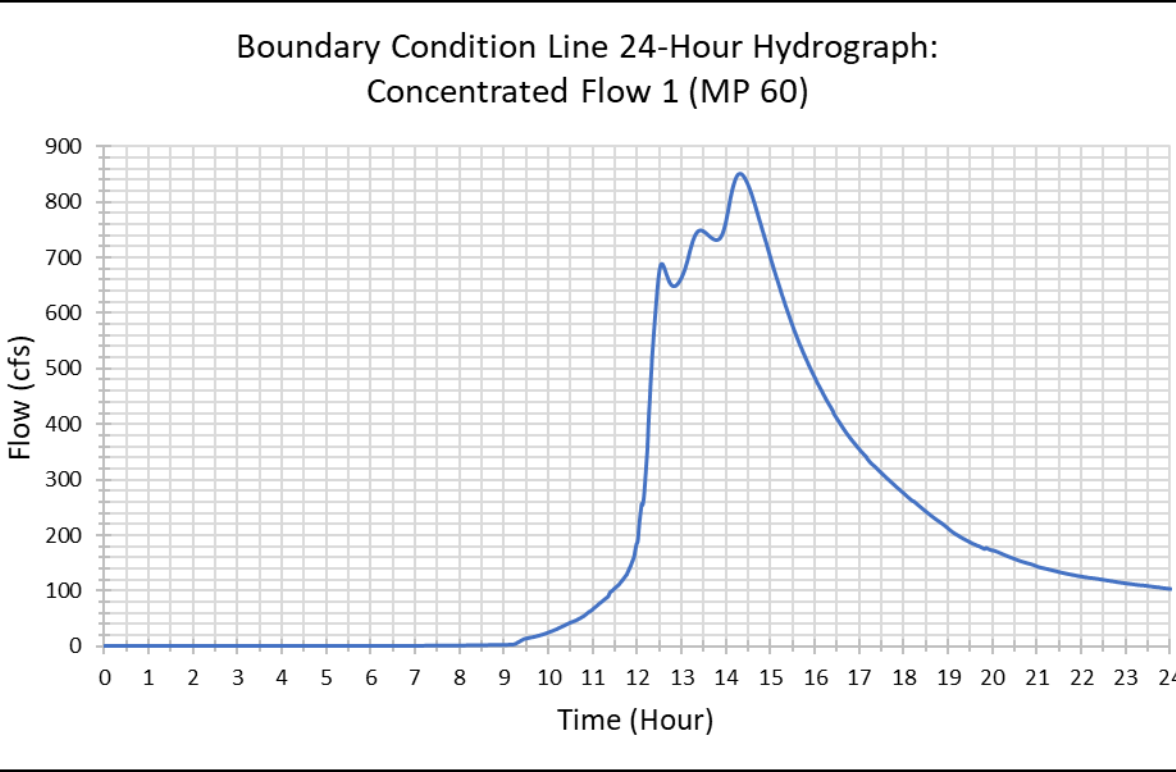
MAMALAHOA HIGHWAY (HWY 11) DRAINAGE IMPROVEMENTS MP 58.7: 50-YEAR MAX VELOCITY ALTERNATIVE 1

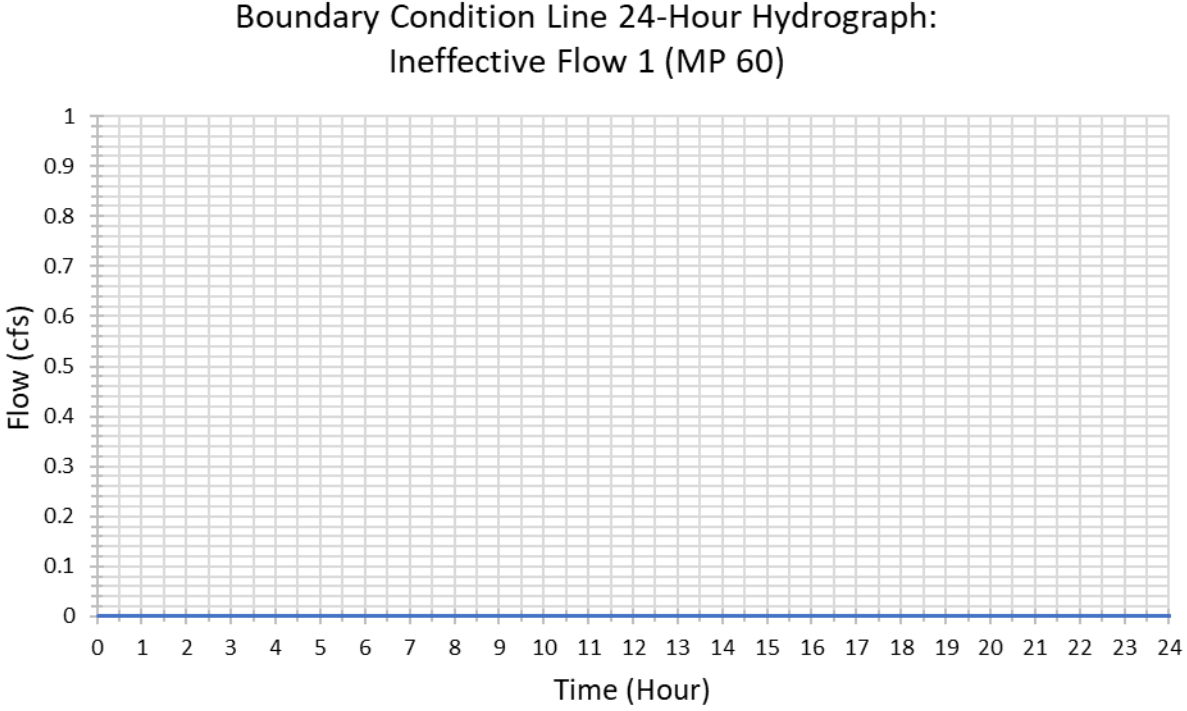
0 250 500 ft

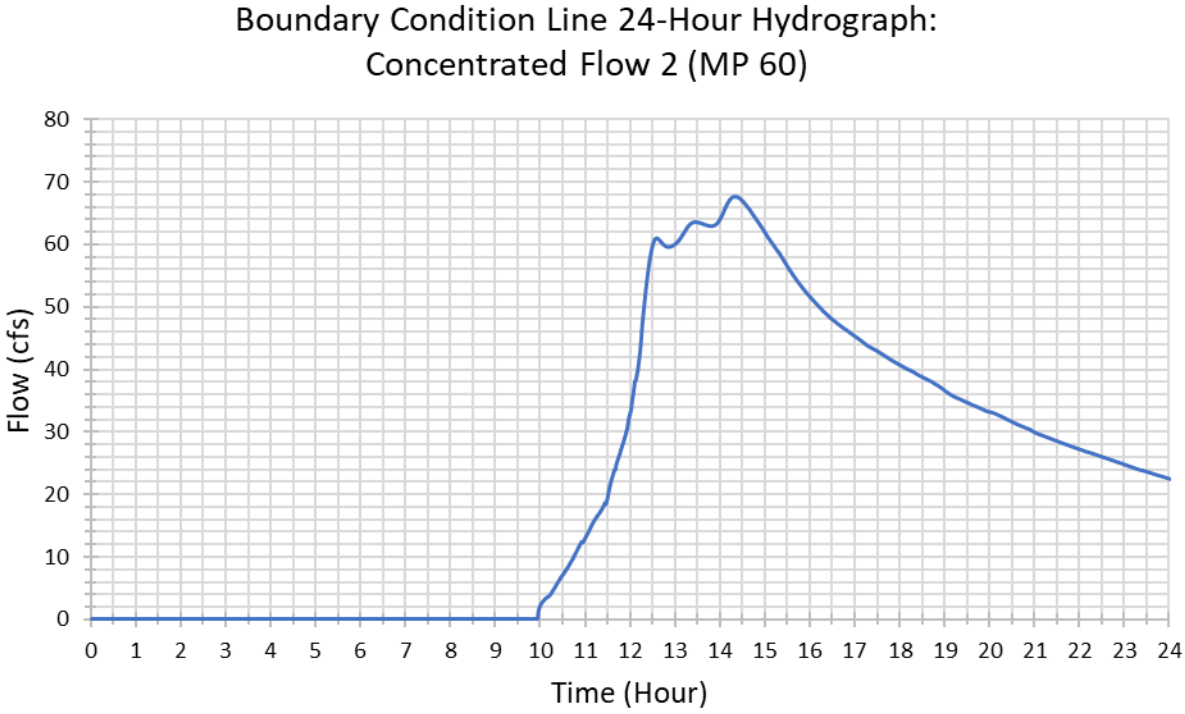
Exhibit 11

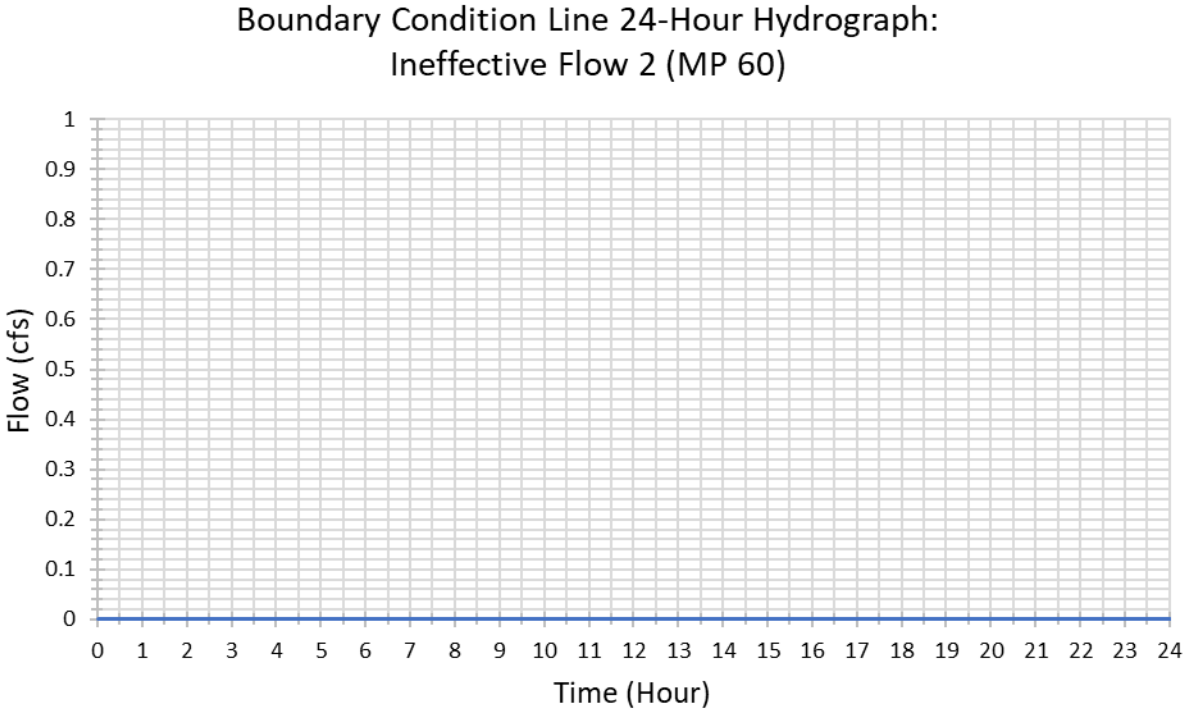

Legend
BC Line Label Number
MP 60 Site
BC Line Extents
BC Line Segments
Google Satellite (Basemap)
BC Line Label Number and Names:
1) Concentrated Flow 1 (MP 60)
2) Ineffective Flow 1 (MP 60)
3) Concentrated Flow 2 (MP 60)
4) Ineffective Flow 2 (MP 60)
5) Shallow Flow 1 (MP 60)
6) Concentrated Flow 3 (MP 60)
7) Shallow Flow 2 (MP 60)
8) Concentrated Flow 4 (MP 60)
9) Concentrated Flow 5 (MP 60)
10) Concentrated Flow 6 (MP 60)
11) Shallow Flow 3 (MP 60)
12) Ineffective Flow 3 (MP 60)
13) Shallow Flow 4 (MP 60)
14) Concentrated Flow 7 (MP 60)
Highway 11
Note:
The BC Line Label Number (yellow circles) indicate the number which is associated with the name of a boundary condition line. The boundary condition line name is associated with a hydrograph in subsequent graphics. The hydrograph is distributed uniformly between the BC Line Extents (white circles) and along the BC Line Segments (red line).
Example:
BC Line Label Number 14 refers to "Concentrated Flow 7 (MP 60)", the associated hydrograph (subsequent graphic) is distributed uniformly across the length of the BC Line Segment (red line) bound between two adjacent BC Line Exents (white circle), to which the yellow arrows are pointing.
0
750
1,500 ft

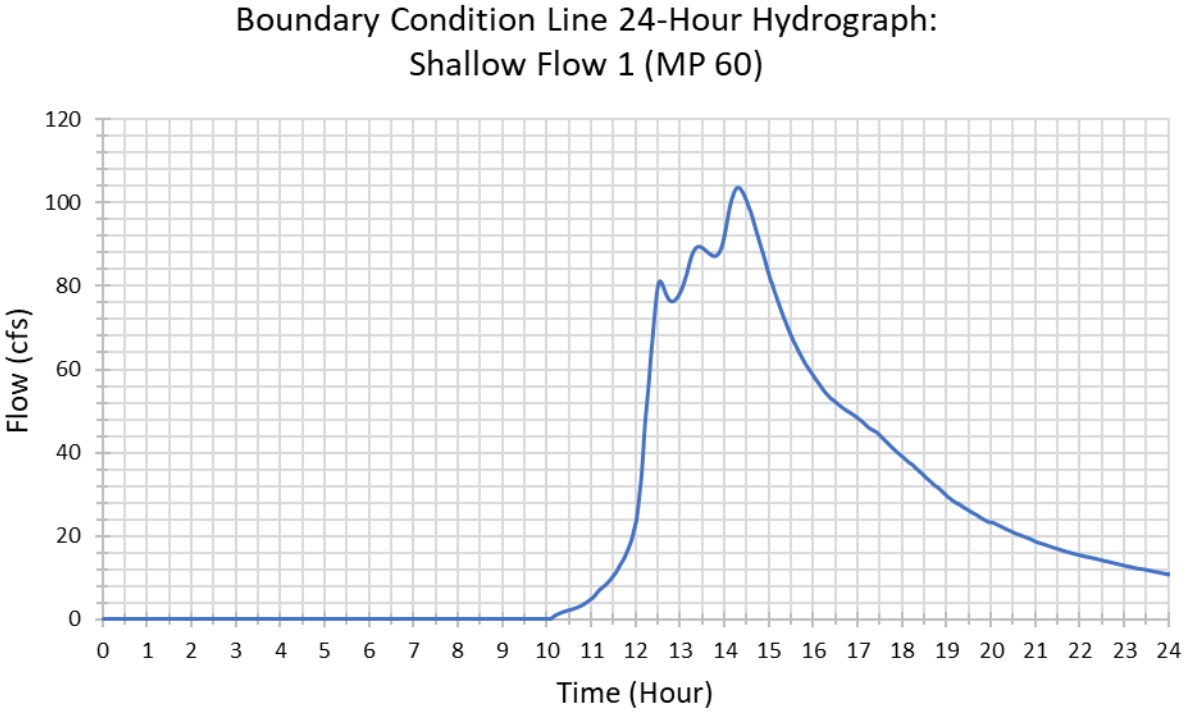

Boundary Condition Line 24-Hour Hydrograph:
Total Flow Entering MP 60
Flow (cfs)
14000
12000
10000
8000
6000
4000
2000
0
0 1 2 3 4 5 6 7 8 9 10 11 12 13 14 15 16 17 18 19 20 21 22 23 24
Time (Hour)

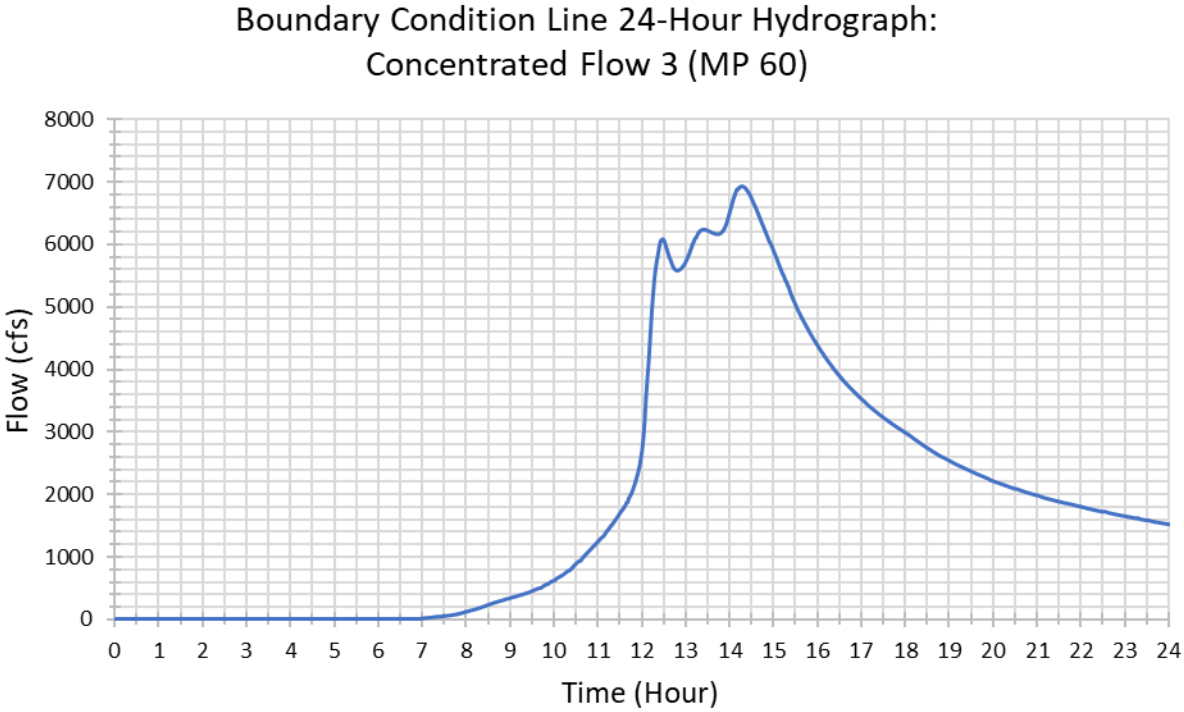

Boundary Condition Line 24-Hour Hydrograph:
Concentrated Flow 1 (MP 60)
Flow (cfs)
900
800
700
600
500
400
300
200
100
0
0 1 2 3 4 5 6 7 8 9 10 11 12 13 14 15 16 17 18 19 20 21 22 23 24
Time (Hour)

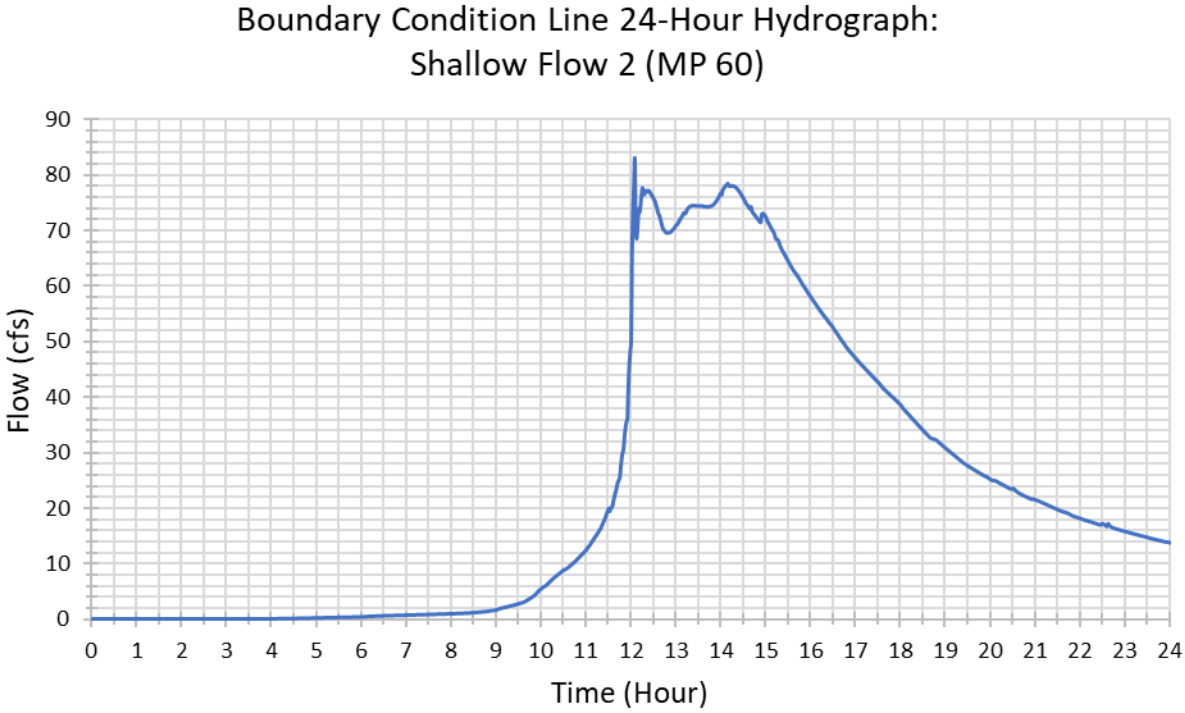

Boundary Condition Line 24-Hour Hydrograph:
Ineffective Flow 1 (MP 60)
Flow (cfs)
1
0.9
0.8
0.7
0.6
0.5
0.4
0.3
0.2
0.1
0
0 1 2 3 4 5 6 7 8 9 10 11 12 13 14 15 16 17 18 19 20 21 22 23 24
Time (Hour)

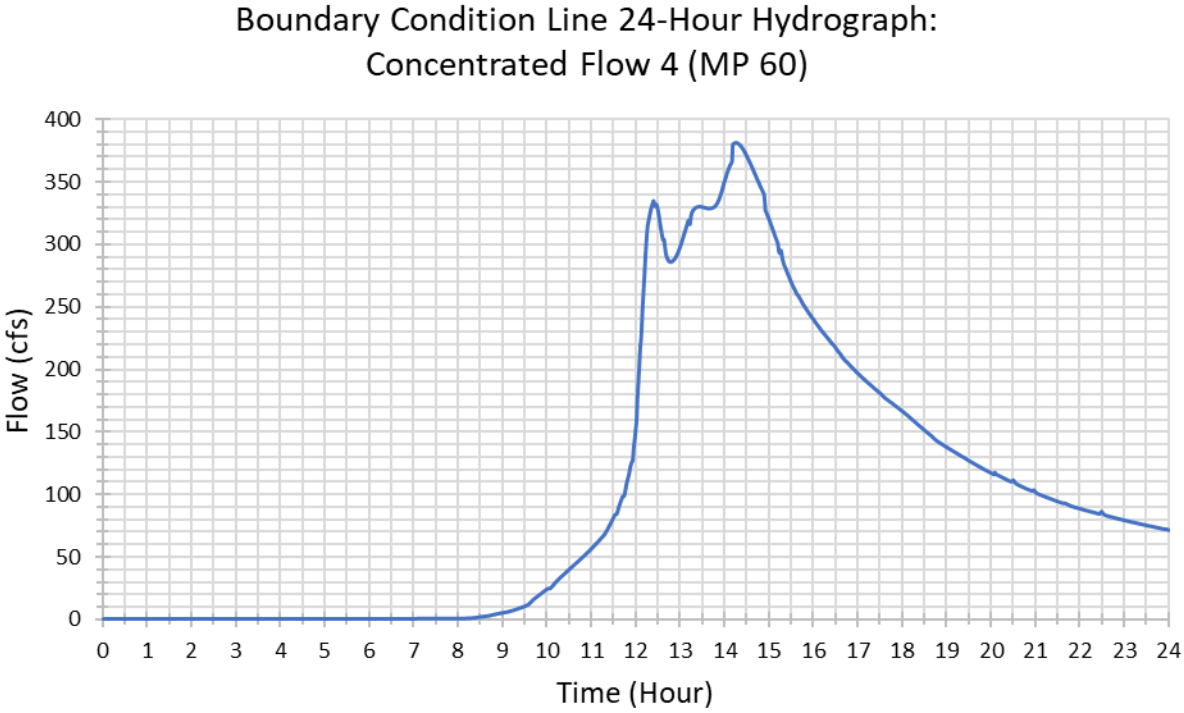

Boundary Condition Line 24-Hour Hydrograph:
Concentrated Flow 2 (MP 60)
Flow (cfs)
80
70
60
50
40
30
20
10
0
0 1 2 3 4 5 6 7 8 9 10 11 12 13 14 15 16 17 18 19 20 21 22 23 24
Time (Hour)

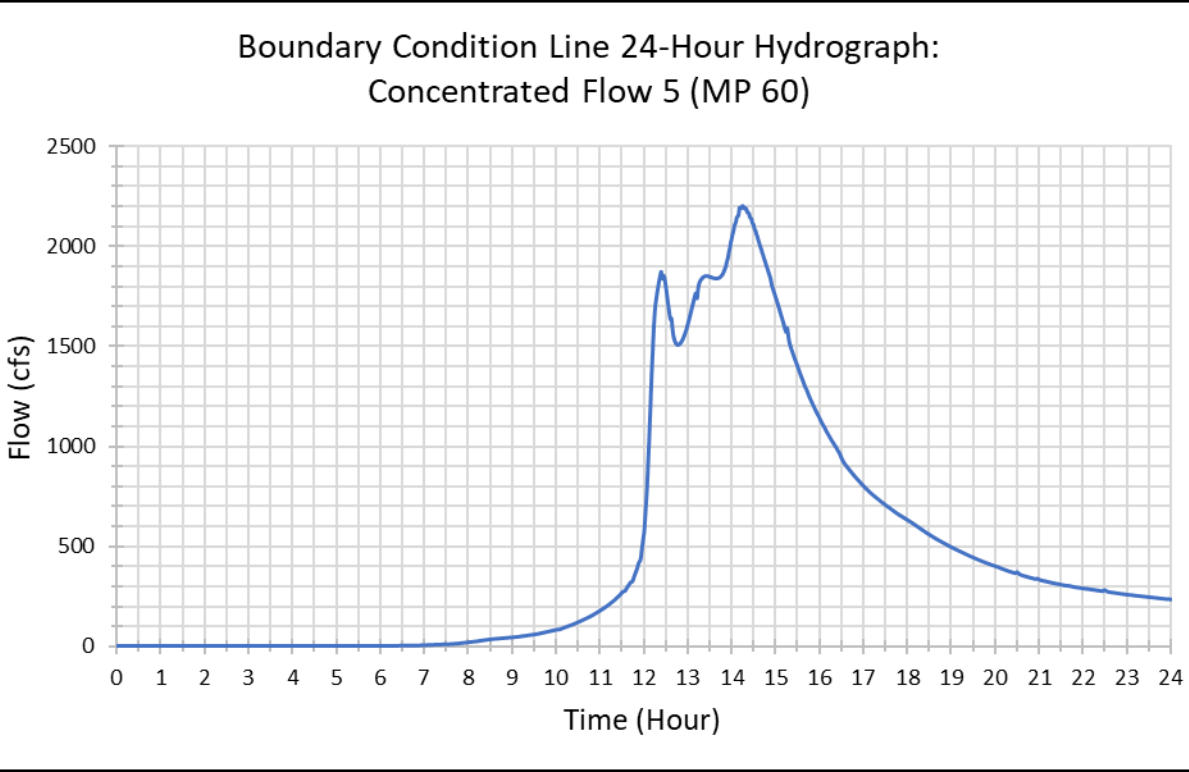

Boundary Condition Line 24-Hour Hydrograph:
Ineffective Flow 2 (MP 60)
Flow (cfs)
1
0.9
0.8
0.7
0.6
0.5
0.4
0.3
0.2
0.1
0
0 1 2 3 4 5 6 7 8 9 10 11 12 13 14 15 16 17 18 19 20 21 22 23 24
Time (Hour)

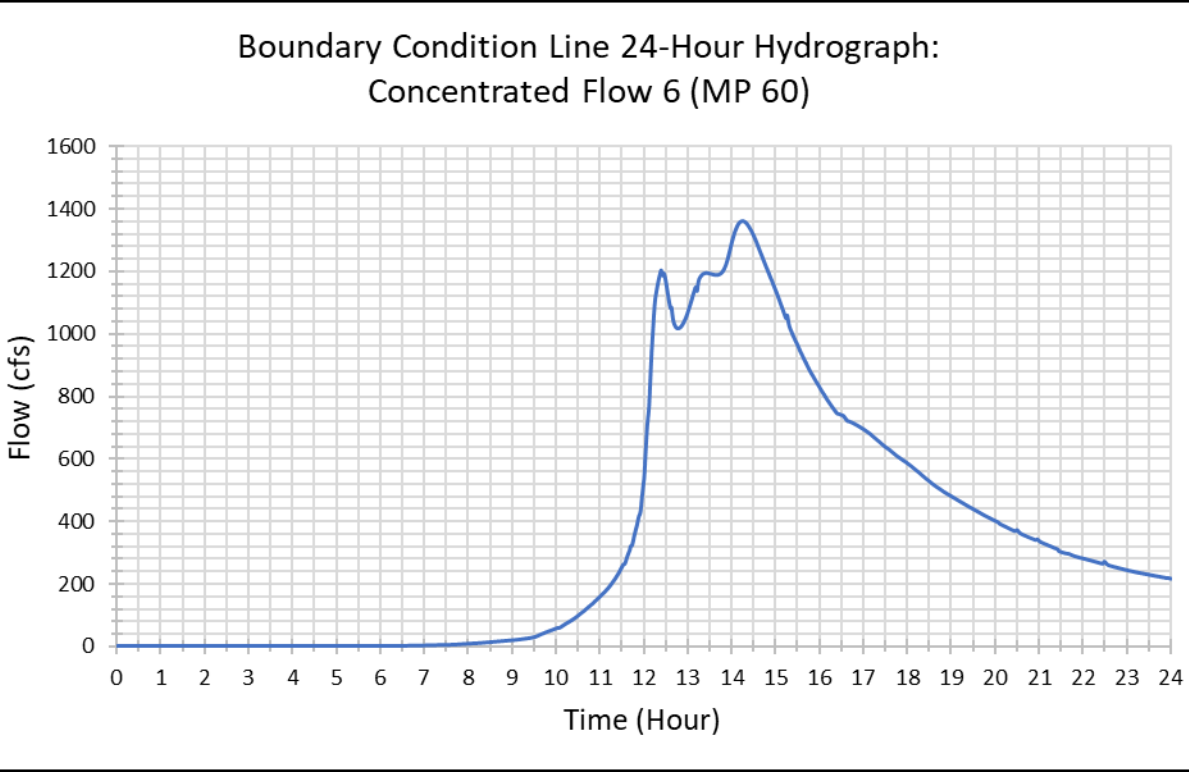

Boundary Condition Line 24-Hour Hydrograph:
Shallow Flow 1 (MP 60)
Flow (cfs)
120
100
80
60
40
20
0
0 1 2 3 4 5 6 7 8 9 10 11 12 13 14 15 16 17 18 19 20 21 22 23 24
Time (Hour)

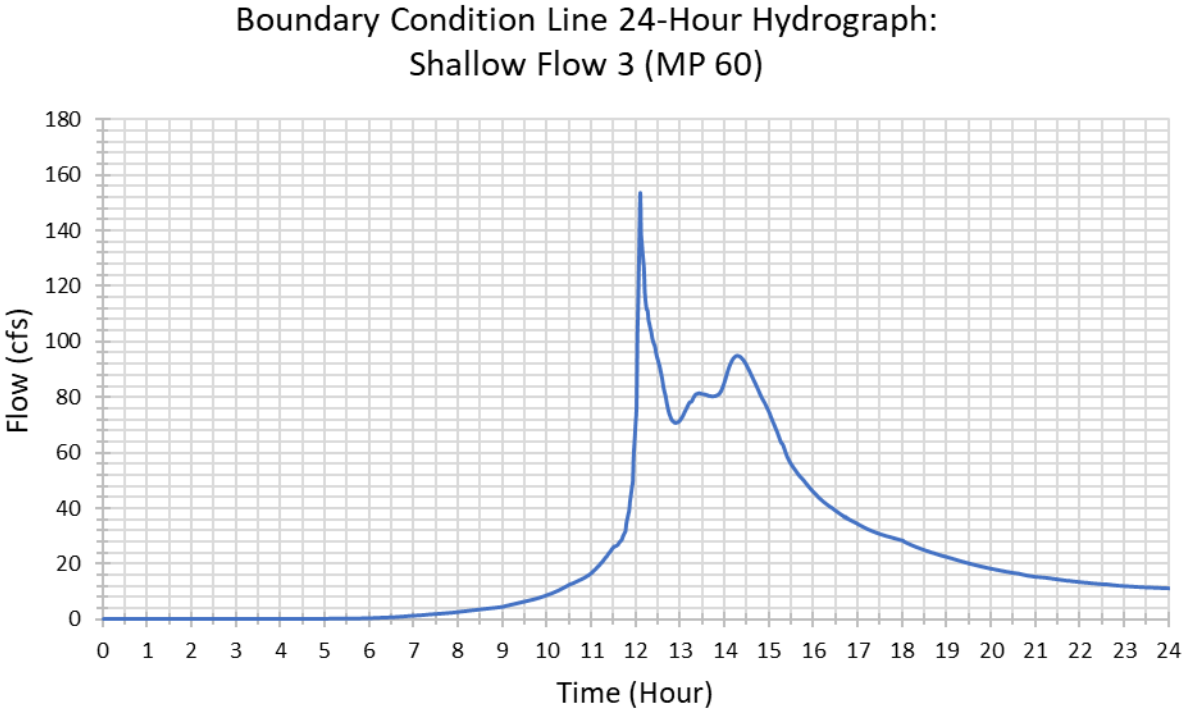

Boundary Condition Line 24-Hour Hydrograph:
Concentrated Flow 3 (MP 60)
Flow (cfs)
8000
7000
6000
5000
4000
3000
2000
1000
0
0 1 2 3 4 5 6 7 8 9 10 11 12 13 14 15 16 17 18 19 20 21 22 23 24
Time (Hour)

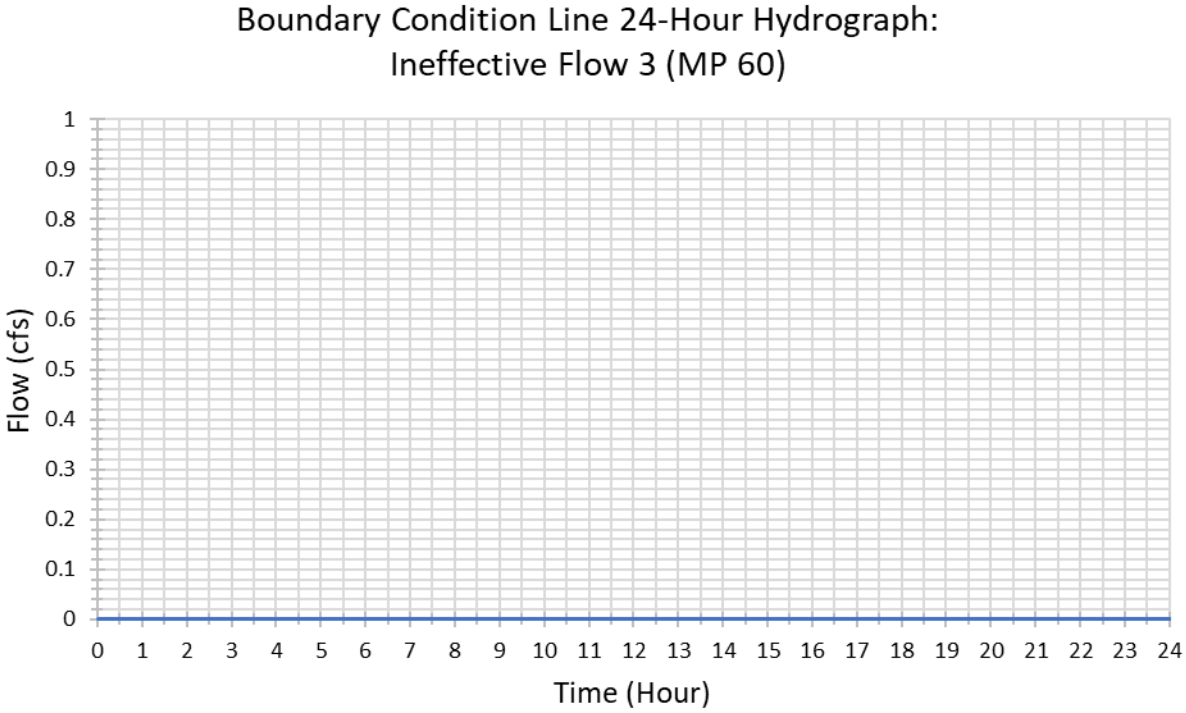

Boundary Condition Line 24-Hour Hydrograph:
Shallow Flow 2 (MP 60)
Flow (cfs)
90
80
70
60
50
40
30
20
10
0
0 1 2 3 4 5 6 7 8 9 10 11 12 13 14 15 16 17 18 19 20 21 22 23 24
Time (Hour)

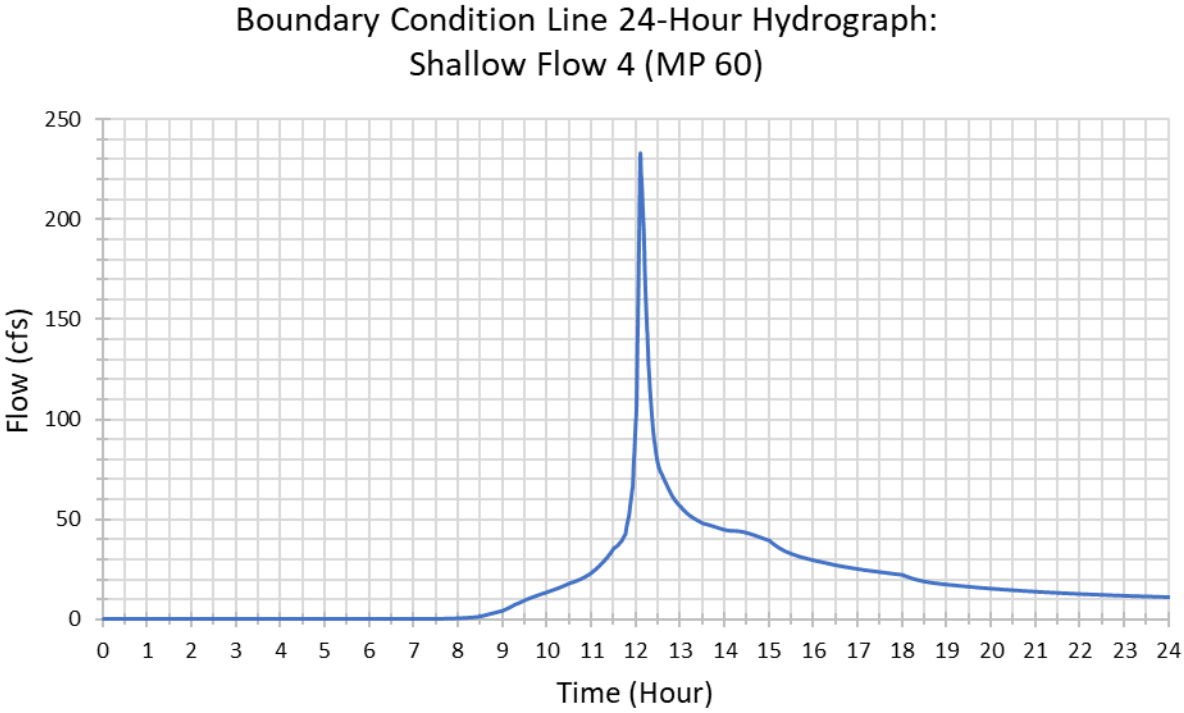

Boundary Condition Line 24-Hour Hydrograph:
Concentrated Flow 4 (MP 60)
Flow (cfs)
400
350
300
250
200
150
100
50
0
0 1 2 3 4 5 6 7 8 9 10 11 12 13 14 15 16 17 18 19 20 21 22 23 24
Time (Hour)

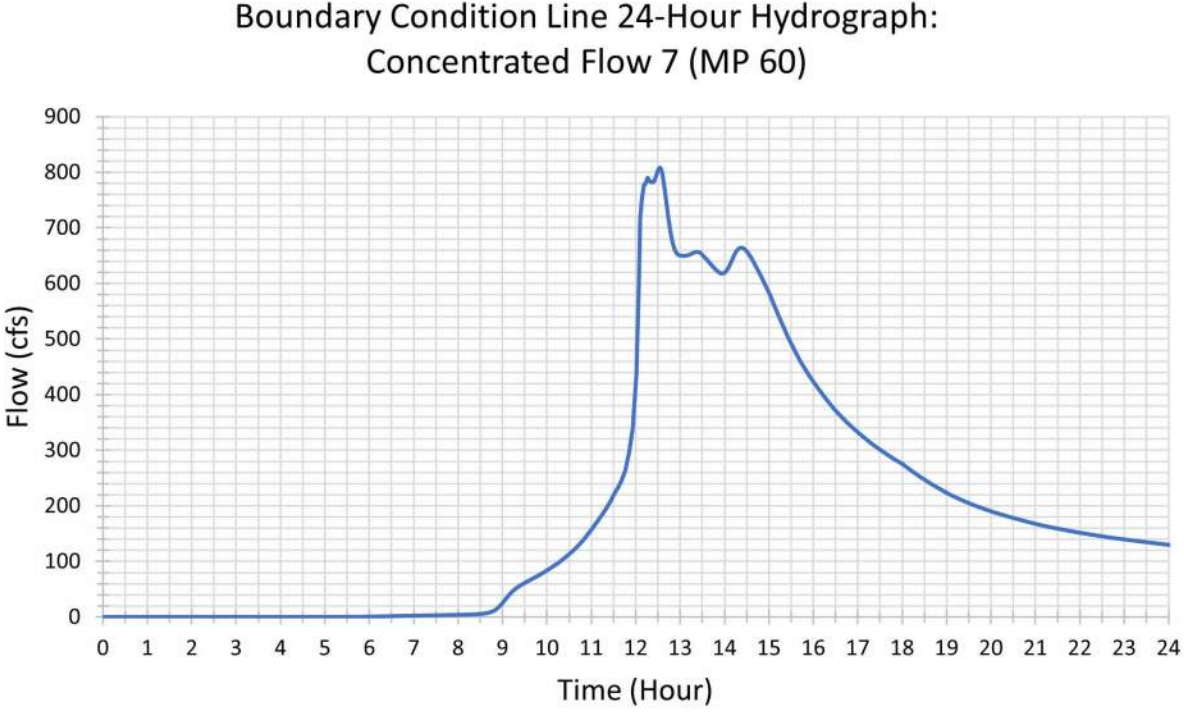

Boundary Condition Line 24-Hour Hydrograph:
Concentrated Flow 5 (MP 60)
Flow (cfs)
2500
2000
1500
1000
500
0
0 1 2 3 4 5 6 7 8 9 10 11 12 13 14 15 16 17 18 19 20 21 22 23 24
Time (Hour)

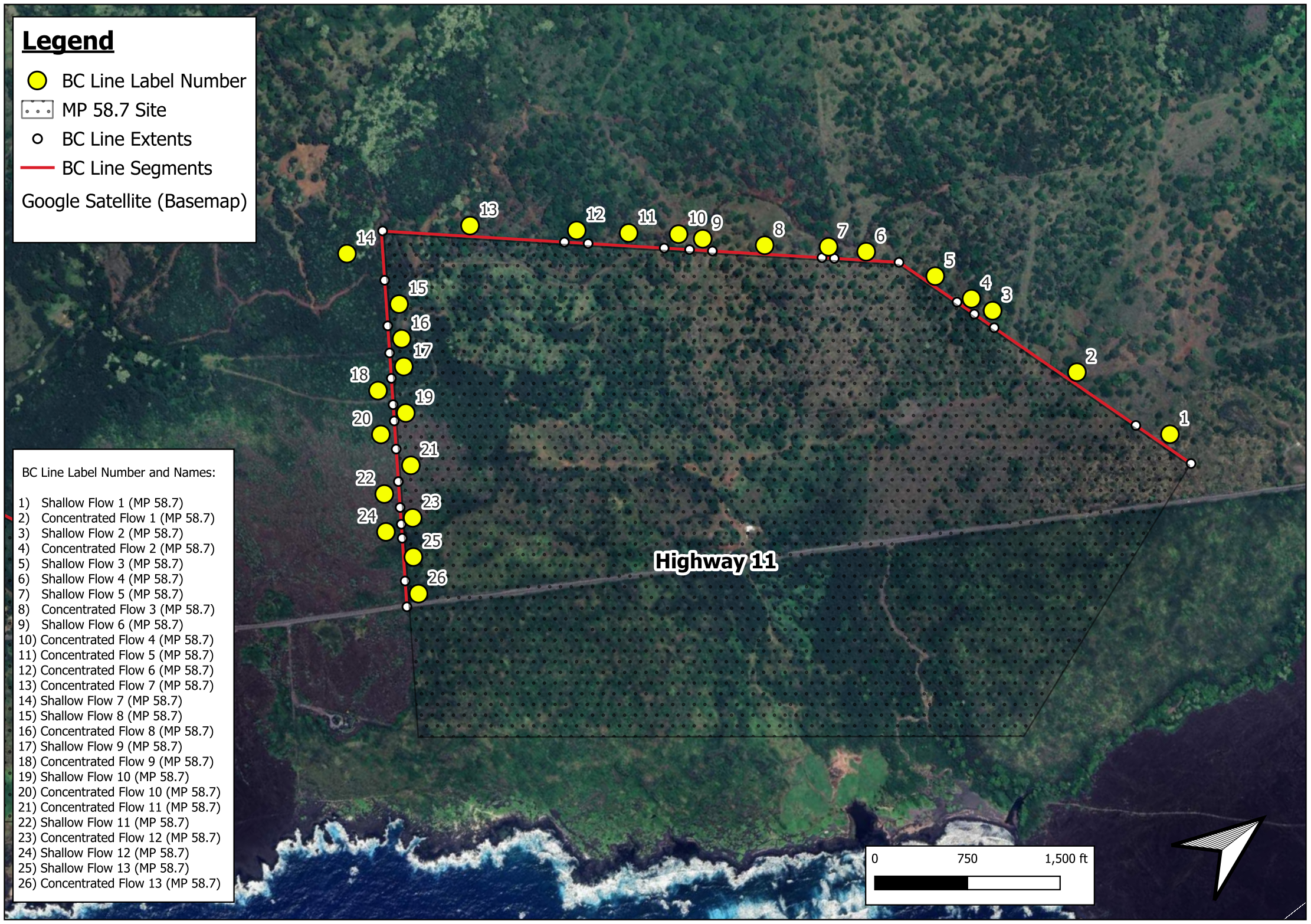

Boundary Condition Line 24-Hour Hydrograph:
Concentrated Flow 6 (MP 60)
Flow (cfs)
1600
1400
1200
1000
800
600
400
200
0
0 1 2 3 4 5 6 7 8 9 10 11 12 13 14 15 16 17 18 19 20 21 22 23 24
Time (Hour)

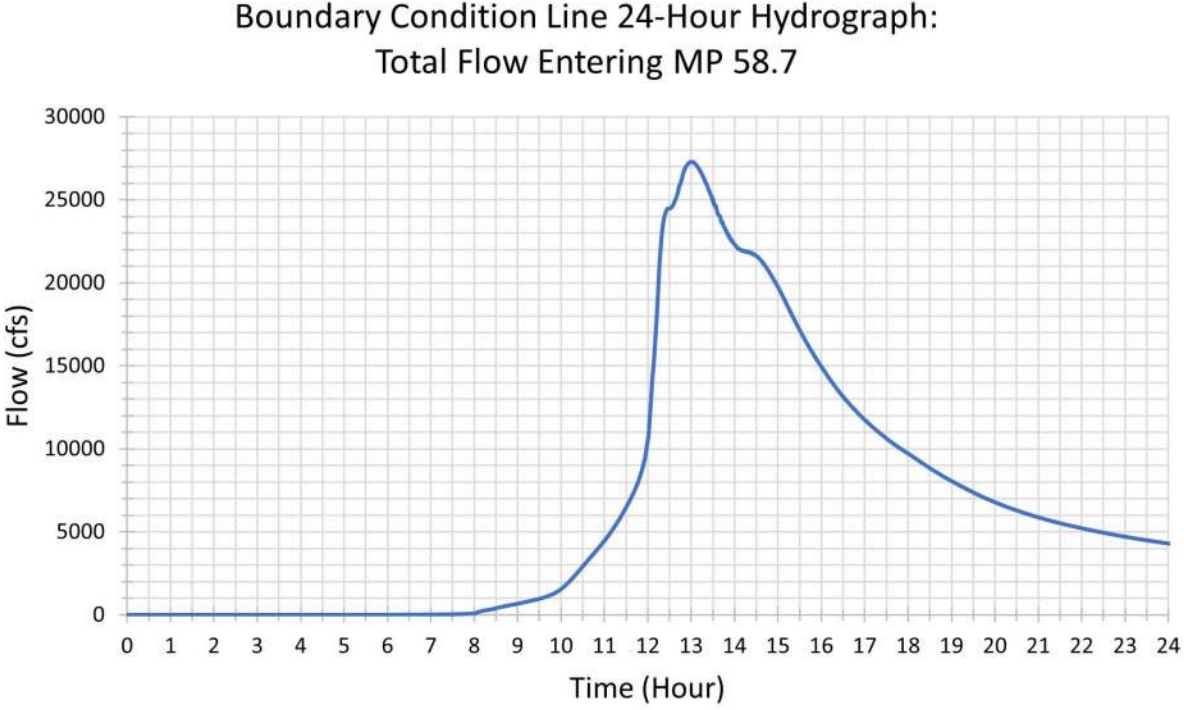

Boundary Condition Line 24-Hour Hydrograph:
Shallow Flow 3 (MP 60)
Flow (cfs)
180
160
140
120
100
80
60
40
20
0
0 1 2 3 4 5 6 7 8 9 10 11 12 13 14 15 16 17 18 19 20 21 22 23 24
Time (Hour)

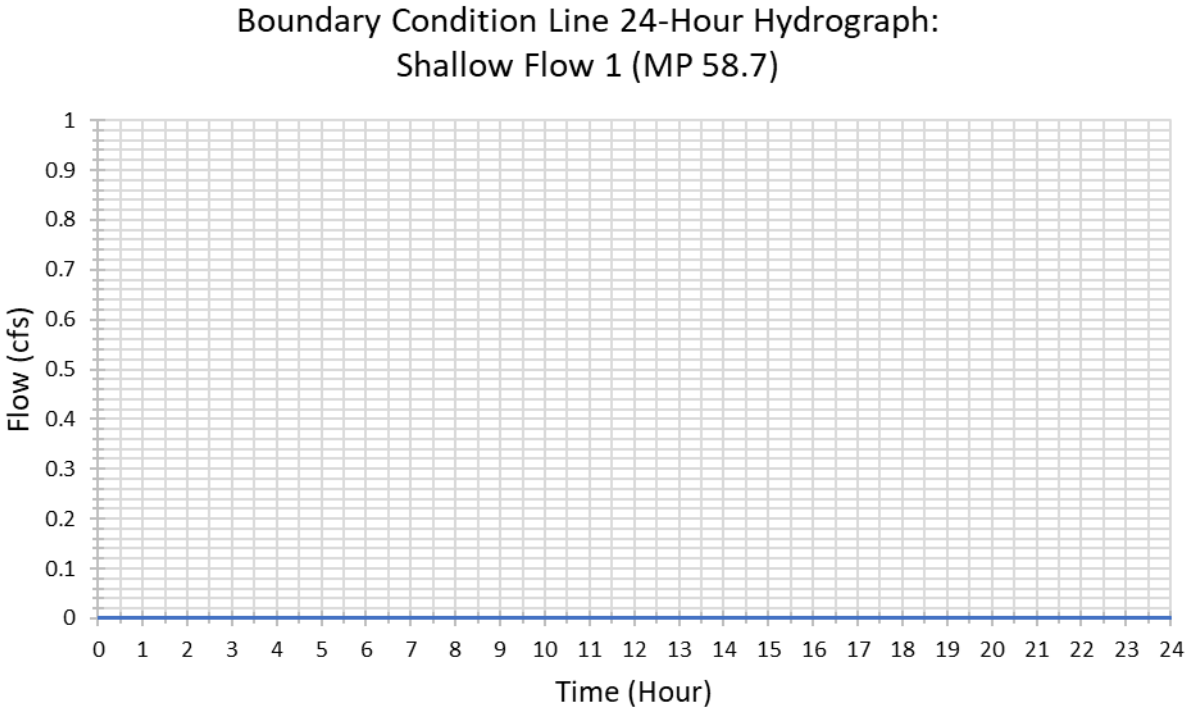

Boundary Condition Line 24-Hour Hydrograph:
Ineffective Flow 3 (MP 60)
Flow (cfs)
1
0.9
0.8
0.7
0.6
0.5
0.4
0.3
0.2
0.1
0
0 1 2 3 4 5 6 7 8 9 10 11 12 13 14 15 16 17 18 19 20 21 22 23 24
Time (Hour)

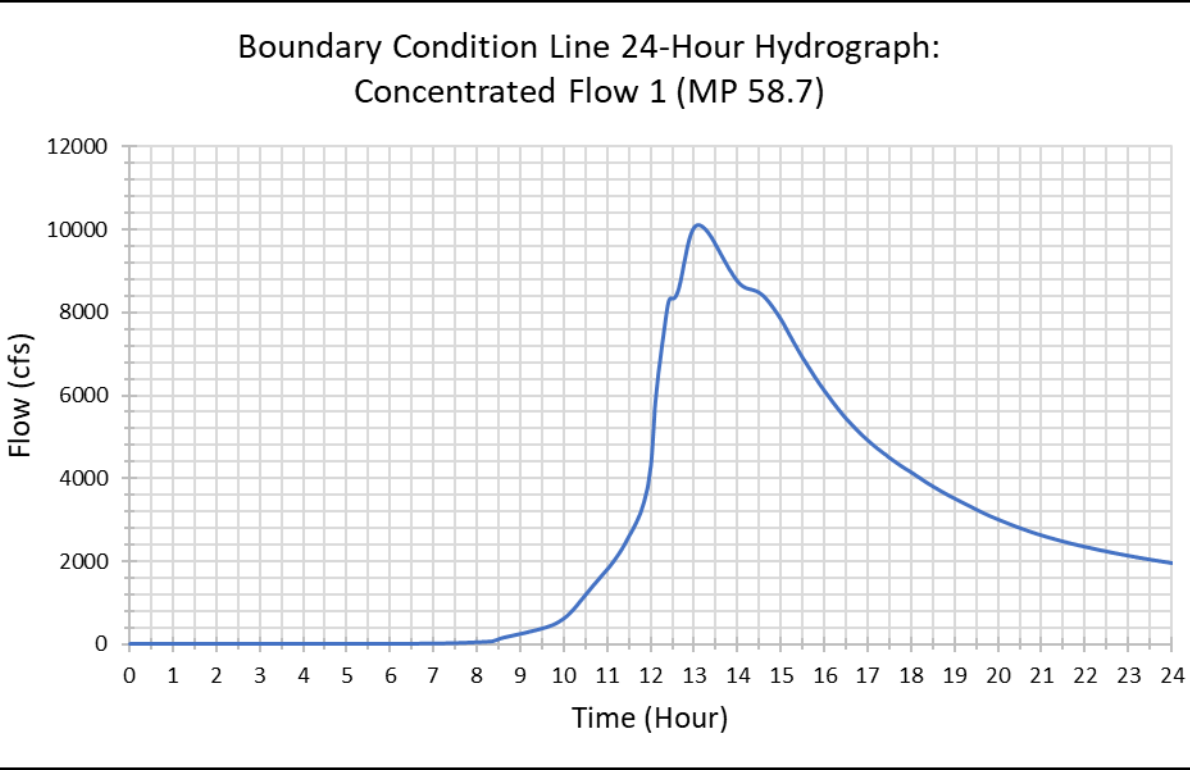

Boundary Condition Line 24-Hour Hydrograph:
Shallow Flow 4 (MP 60)
Flow (cfs)
250
200
150
100
50
0
0 1 2 3 4 5 6 7 8 9 10 11 12 13 14 15 16 17 18 19 20 21 22 23 24
Time (Hour)


Boundary Condition Line 24-Hour Hydrograph:
Concentrated Flow 7 (MP 60)
Flow (cfs)
900
800
700
600
500
400
300
200
100
0
0 1 2 3 4 5 6 7 8 9 10 11 12 13 14 15 16 17 18 19 20 21 22 23 24
Time (Hour)

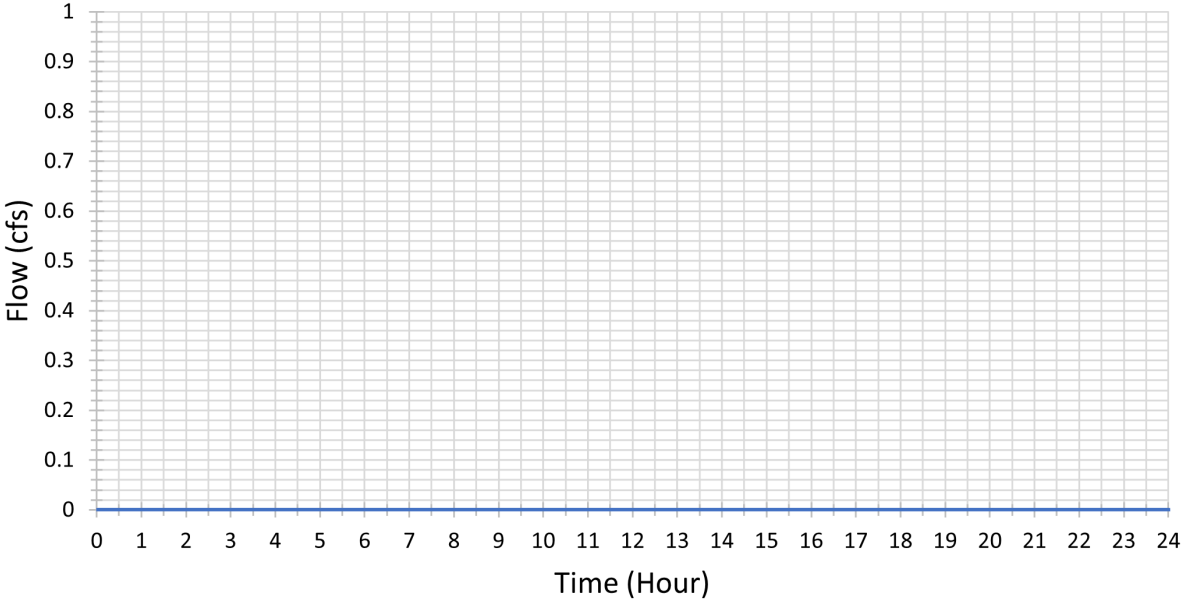

Legend
BC Line Label Number
MP 58.7 Site
BC Line Extents
BC Line Segments
Google Satellite (Basemap)
BC Line Label Number and Names:
1) Shallow Flow 1 (MP 58.7)
2) Concentrated Flow 1 (MP 58.7)
3) Shallow Flow 2 (MP 58.7)
4) Concentrated Flow 2 (MP 58.7)
5) Shallow Flow 3 (MP 58.7)
6) Shallow Flow 4 (MP 58.7)
7) Shallow Flow 5 (MP 58.7)
8) Concentrated Flow 3 (MP 58.7)
9) Shallow Flow 6 (MP 58.7)
10) Concentrated Flow 4 (MP 58.7)
11) Concentrated Flow 5 (MP 58.7)
12) Concentrated Flow 6 (MP 58.7)
13) Concentrated Flow 7 (MP 58.7)
14) Shallow Flow 7 (MP 58.7)
15) Shallow Flow 8 (MP 58.7)
16) Concentrated Flow 8 (MP 58.7)
17) Shallow Flow 9 (MP 58.7)
18) Concentrated Flow 9 (MP 58.7)
19) Shallow Flow 10 (MP 58.7)
20) Concentrated Flow 10 (MP 58.7)
21) Concentrated Flow 11 (MP 58.7)
22) Shallow Flow 11 (MP 58.7)
23) Concentrated Flow 12 (MP 58.7)
24) Shallow Flow 12 (MP 58.7)
25) Shallow Flow 13 (MP 58.7)
26) Concentrated Flow 13 (MP 58.7)
Highway 11
0
750
1,500 ft

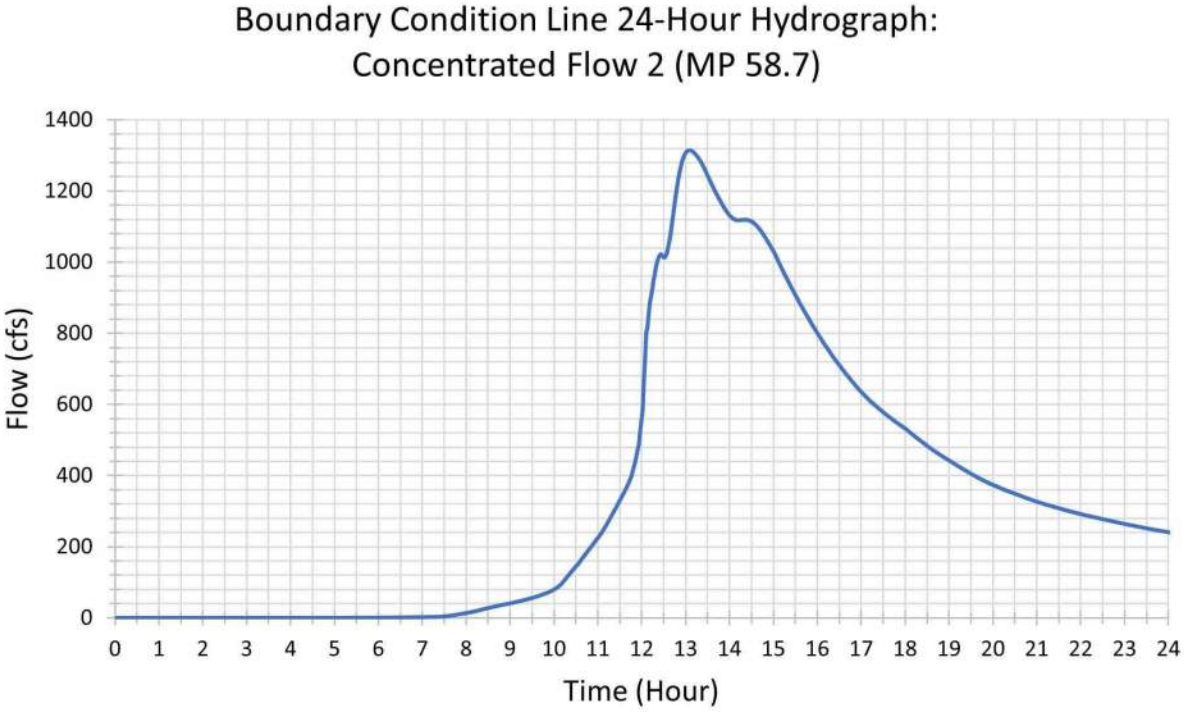

Boundary Condition Line 24-Hour Hydrograph:
Total Flow Entering MP 58.7
Flow (cfs)
30000
25000
20000
15000
10000
5000
0
0 1 2 3 4 5 6 7 8 9 10 11 12 13 14 15 16 17 18 19 20 21 22 23 24
Time (Hour)

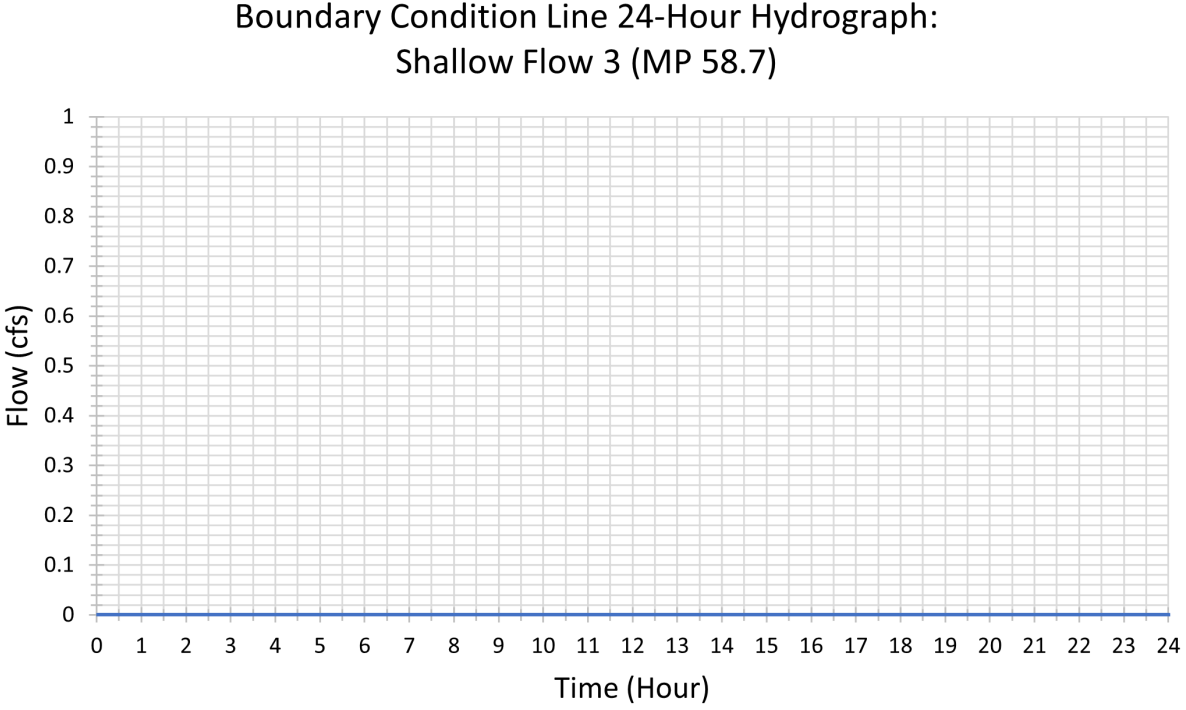

Boundary Condition Line 24-Hour Hydrograph:
Shallow Flow 1 (MP 58.7)
Flow (cfs)
1
0.9
0.8
0.7
0.6
0.5
0.4
0.3
0.2
0.1
0
0 1 2 3 4 5 6 7 8 9 10 11 12 13 14 15 16 17 18 19 20 21 22 23 24
Time (Hour)

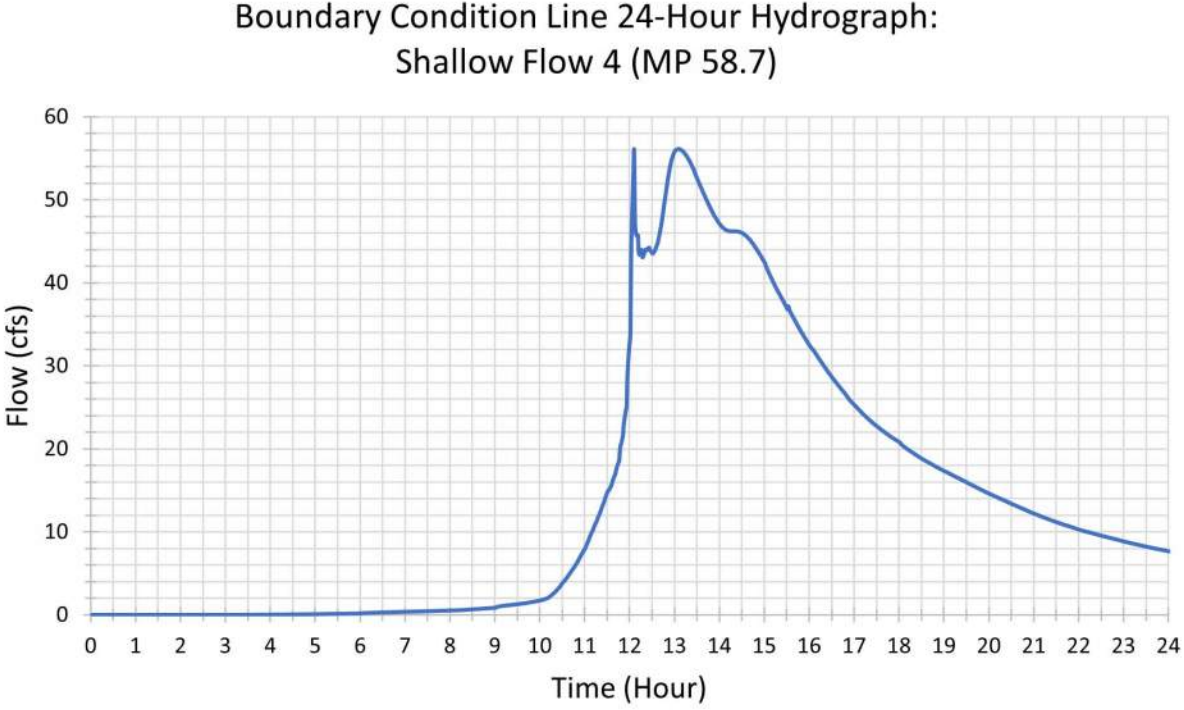

Boundary Condition Line 24-Hour Hydrograph:
Concentrated Flow 1 (MP 58.7)
Flow (cfs)
12000
10000
8000
6000
4000
2000
0
0 1 2 3 4 5 6 7 8 9 10 11 12 13 14 15 16 17 18 19 20 21 22 23 24
Time (Hour)

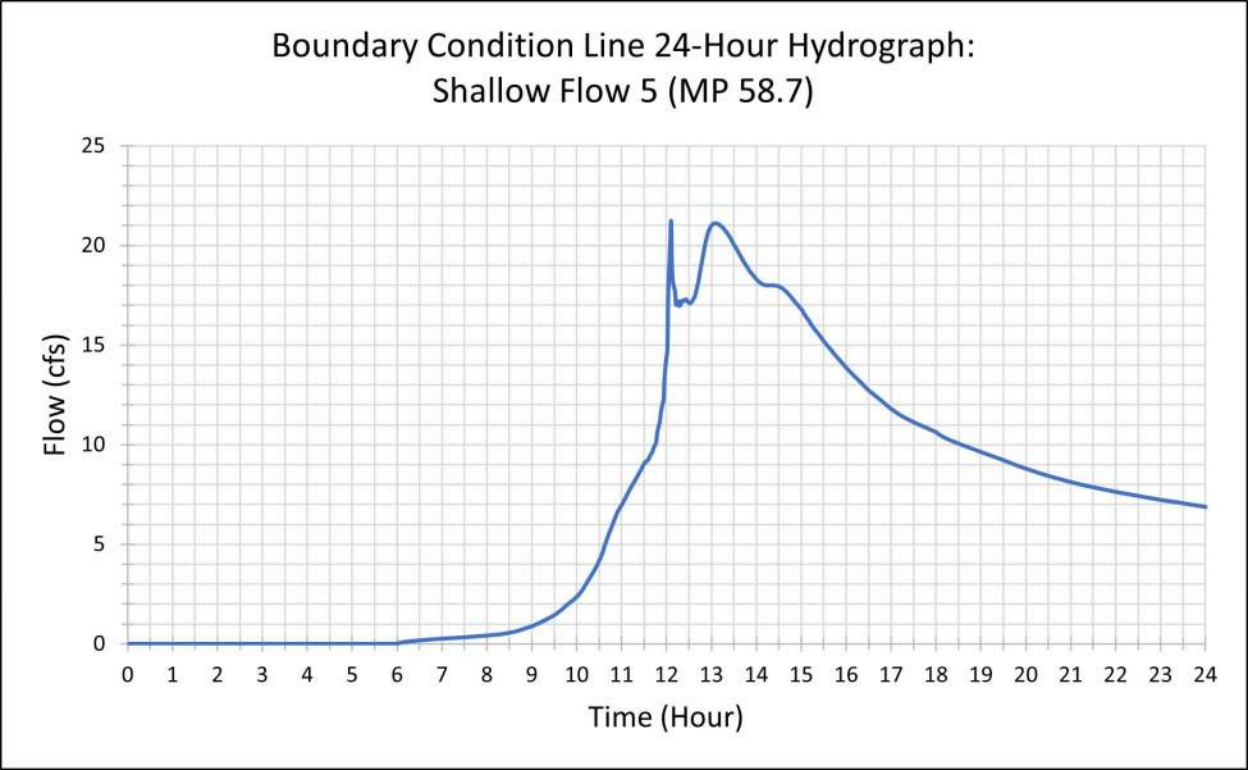
Boundary Condition Line 24-Hour Hydrograph: Shallow Flow 2 (MP 58.7)



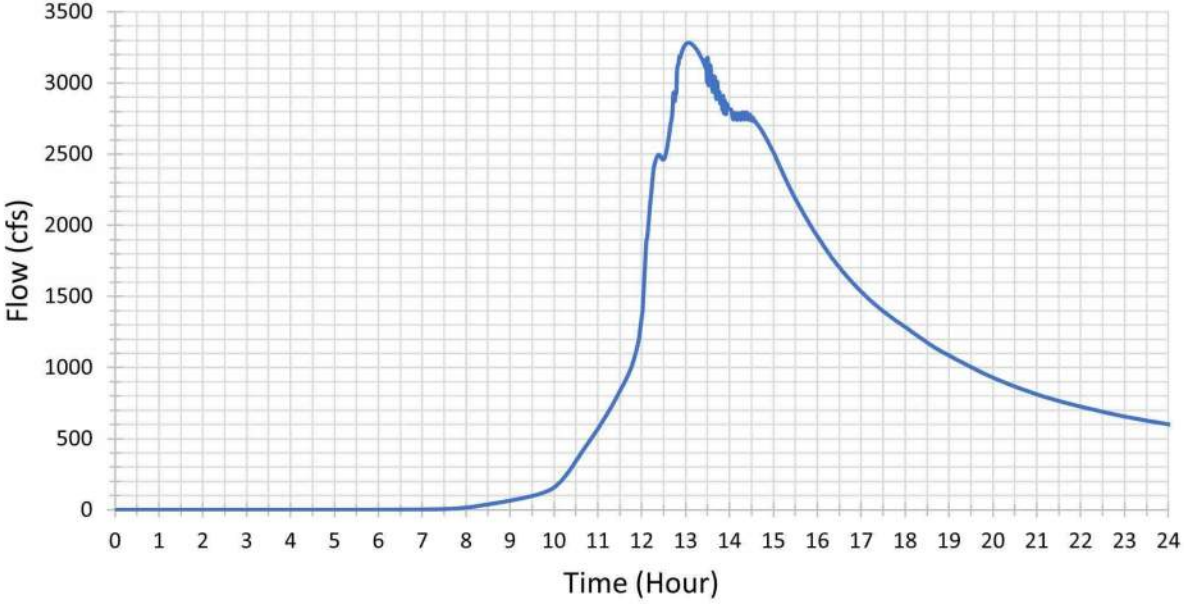

Boundary Condition Line 24-Hour Hydrograph:
Concentrated Flow 2 (MP 58.7)
Flow (cfs)
1400
1200
1000
800
600
400
200
0
0 1 2 3 4 5 6 7 8 9 10 11 12 13 14 15 16 17 18 19 20 21 22 23 24
Time (Hour)

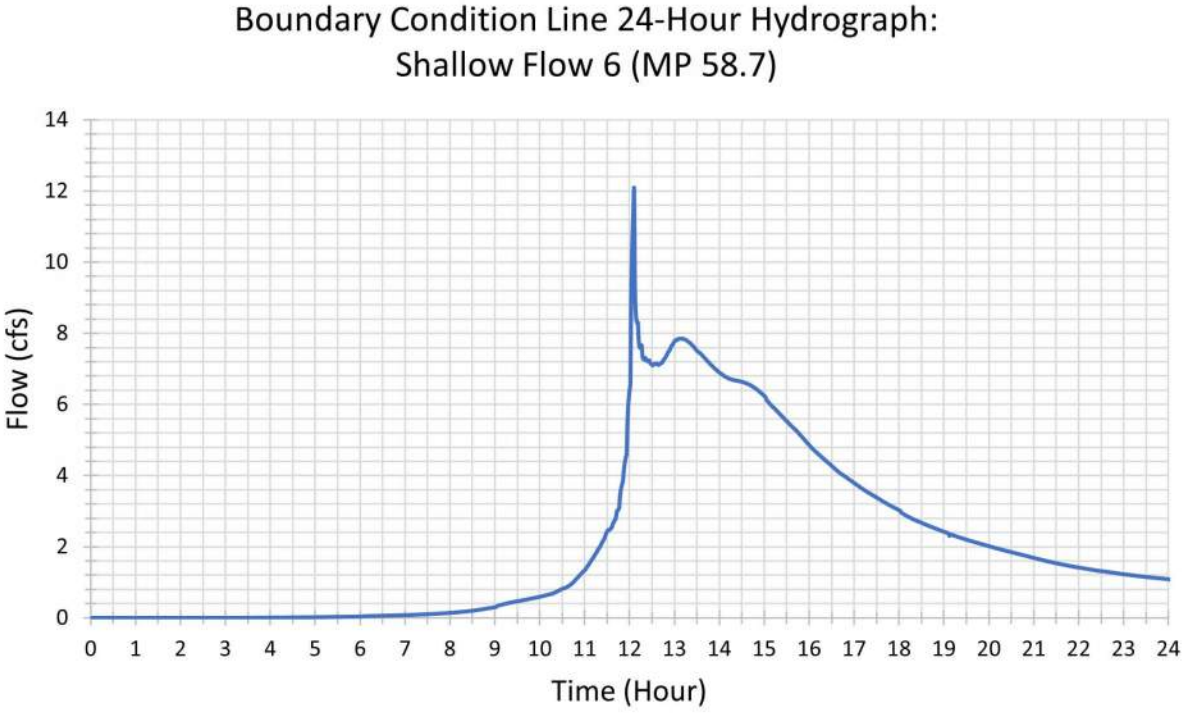

Boundary Condition Line 24-Hour Hydrograph:
Shallow Flow 3 (MP 58.7)
Flow (cfs)
1
0.9
0.8
0.7
0.6
0.5
0.4
0.3
0.2
0.1
0
0 1 2 3 4 5 6 7 8 9 10 11 12 13 14 15 16 17 18 19 20 21 22 23 24
Time (Hour)

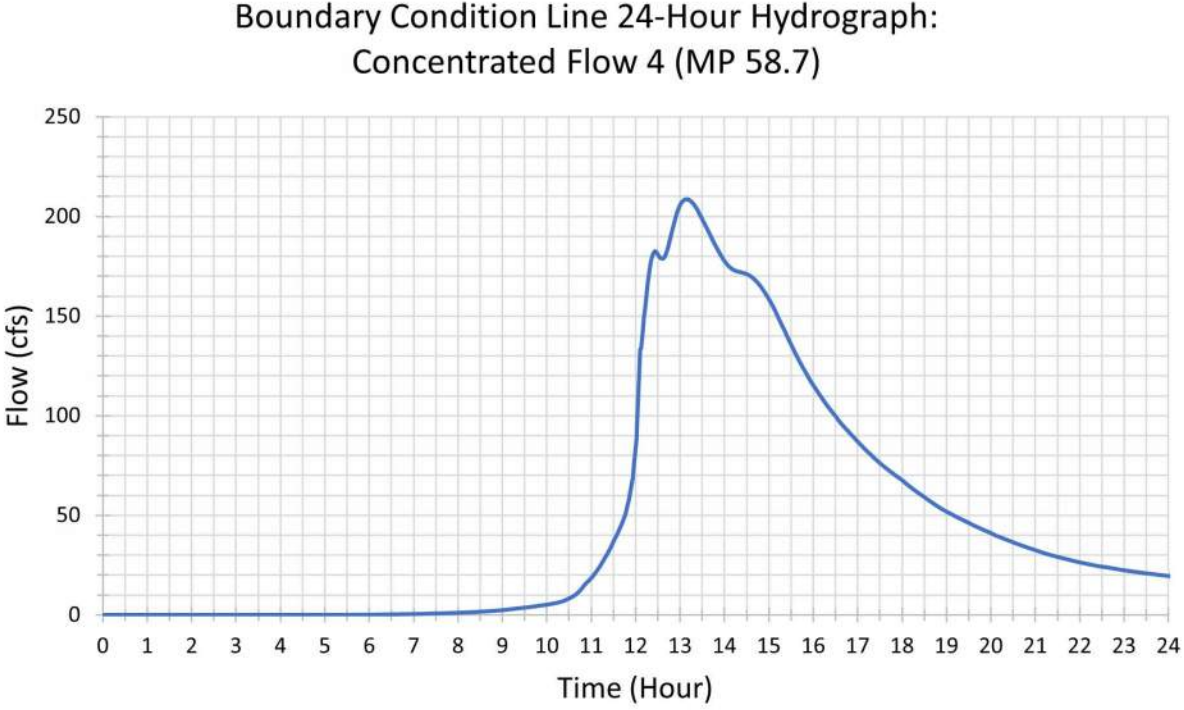

Boundary Condition Line 24-Hour Hydrograph:
Shallow Flow 4 (MP 58.7)
Flow (cfs)
60
50
40
30
20
10
0
0 1 2 3 4 5 6 7 8 9 10 11 12 13 14 15 16 17 18 19 20 21 22 23 24
Time (Hour)

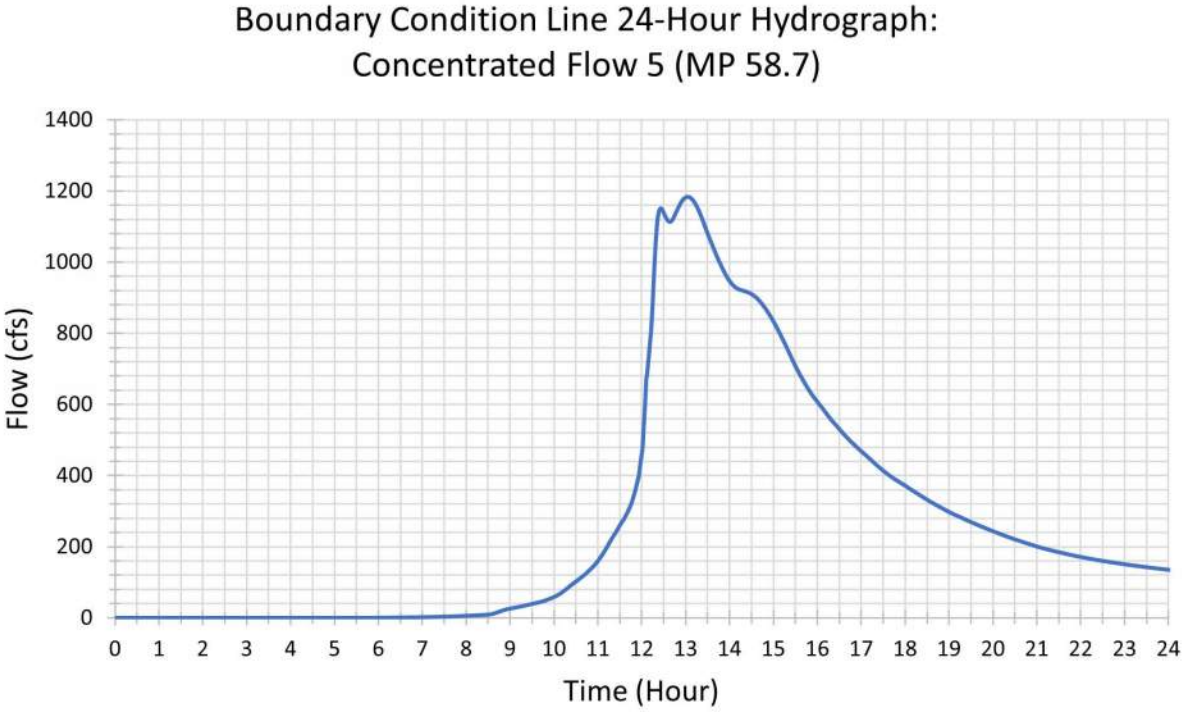

Boundary Condition Line 24-Hour Hydrograph:
Shallow Flow 5 (MP 58.7)
Flow (cfs)
0
5
10
15
20
25
0 1 2 3 4 5 6 7 8 9 10 11 12 13 14 15 16 17 18 19 20 21 22 23 24
Time (Hour)

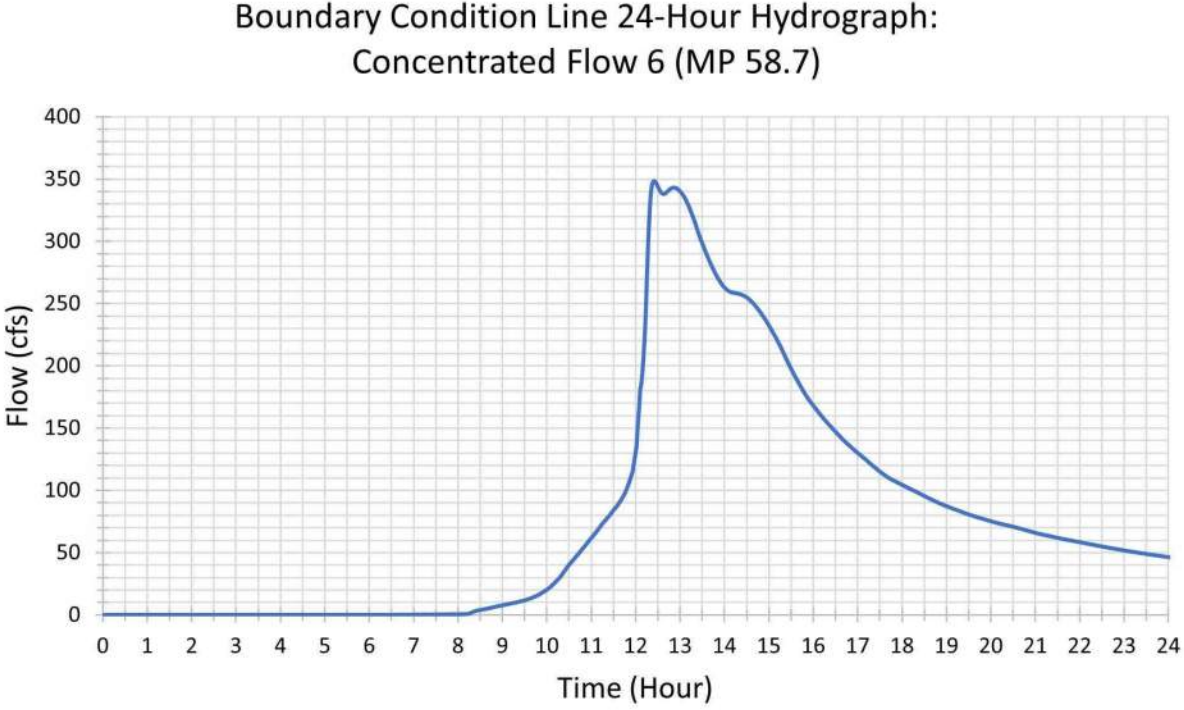
Boundary Condition Line 24-Hour Hydrograph: Concentrated Flow 3 (MP 58.7)

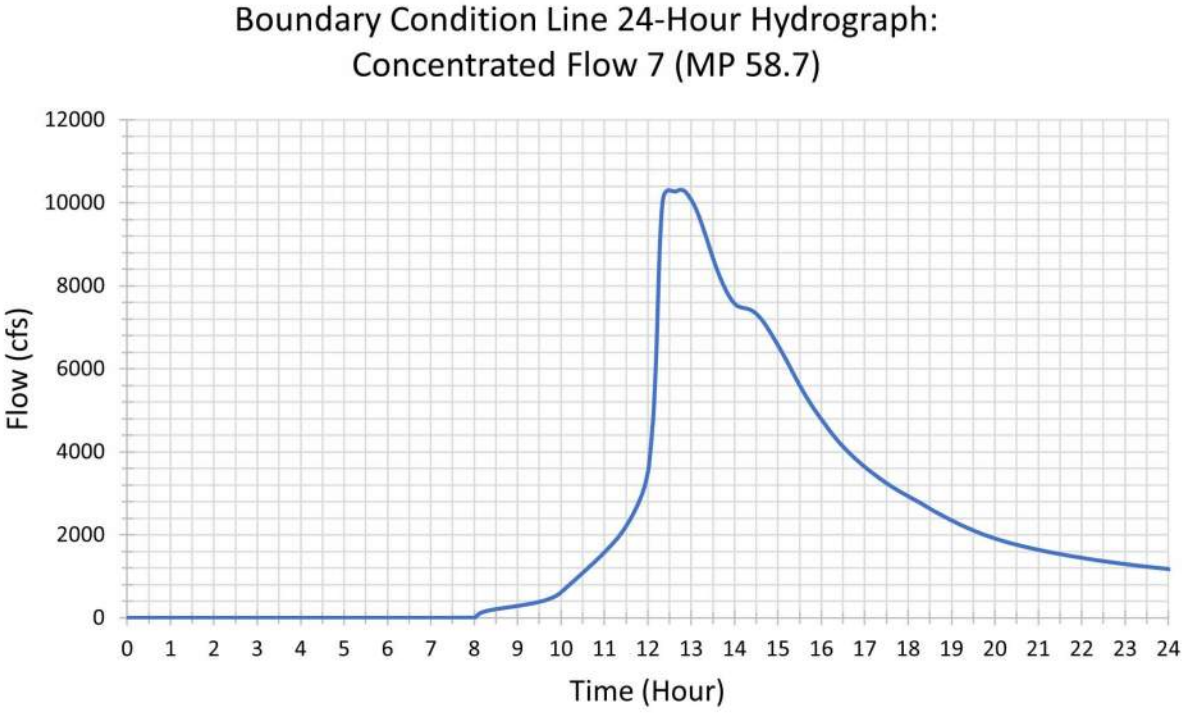


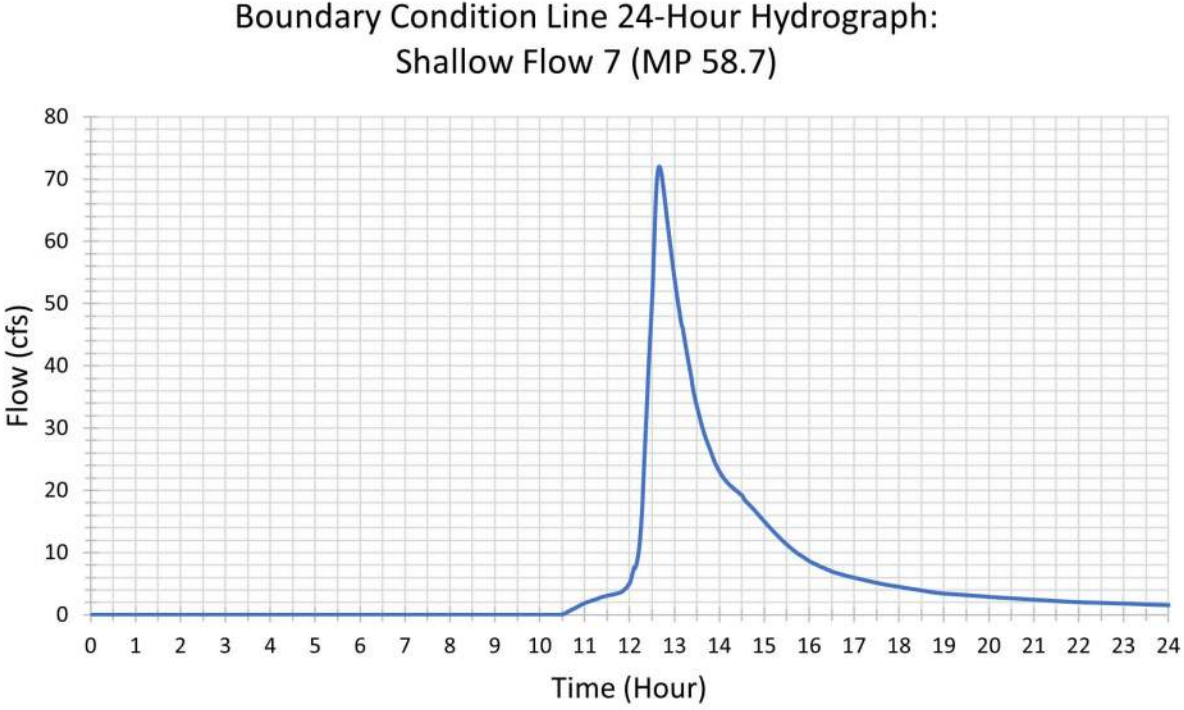

Boundary Condition Line 24-Hour Hydrograph:
Shallow Flow 6 (MP 58.7)
Flow (cfs)
0
2
4
6
8
10
12
14
Time (Hour)
0 1 2 3 4 5 6 7 8 9 10 11 12 13 14 15 16 17 18 19 20 21 22 23 24


Boundary Condition Line 24-Hour Hydrograph:
Concentrated Flow 4 (MP 58.7)
Flow (cfs)
250
200
150
100
50
0
0 1 2 3 4 5 6 7 8 9 10 11 12 13 14 15 16 17 18 19 20 21 22 23 24
Time (Hour)

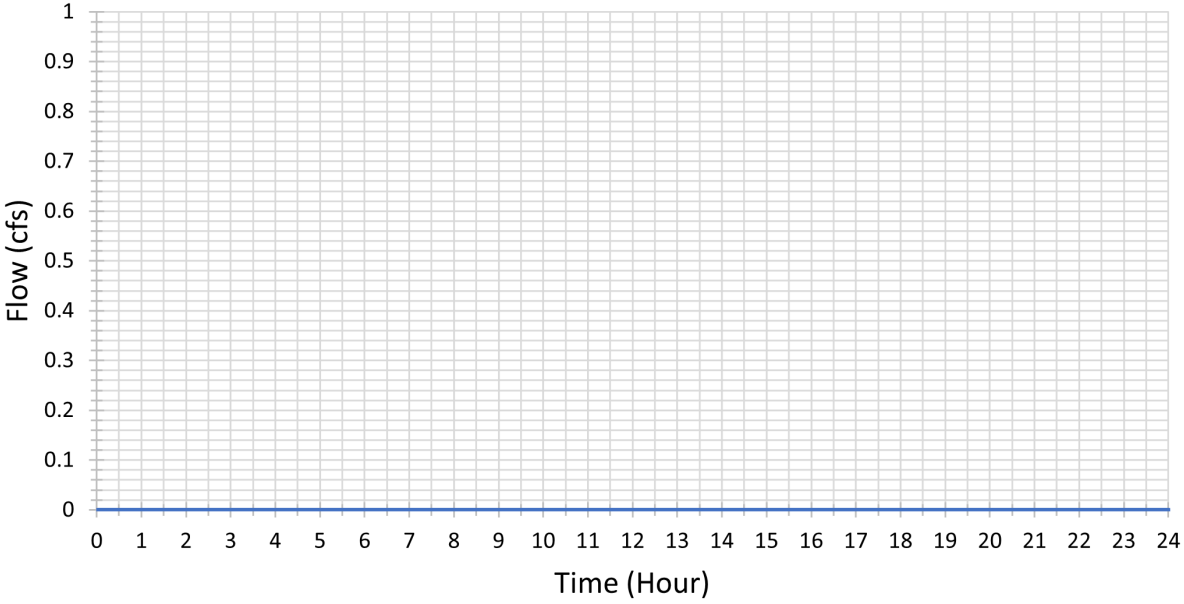

Boundary Condition Line 24-Hour Hydrograph:
Concentrated Flow 5 (MP 58.7)
Flow (cfs)
1400
1200
1000
800
600
400
200
0
0 1 2 3 4 5 6 7 8 9 10 11 12 13 14 15 16 17 18 19 20 21 22 23 24
Time (Hour)


Boundary Condition Line 24-Hour Hydrograph:
Concentrated Flow 6 (MP 58.7)
Flow (cfs)
400
350
300
250
200
150
100
50
0
0 1 2 3 4 5 6 7 8 9 10 11 12 13 14 15 16 17 18 19 20 21 22 23 24
Time (Hour)

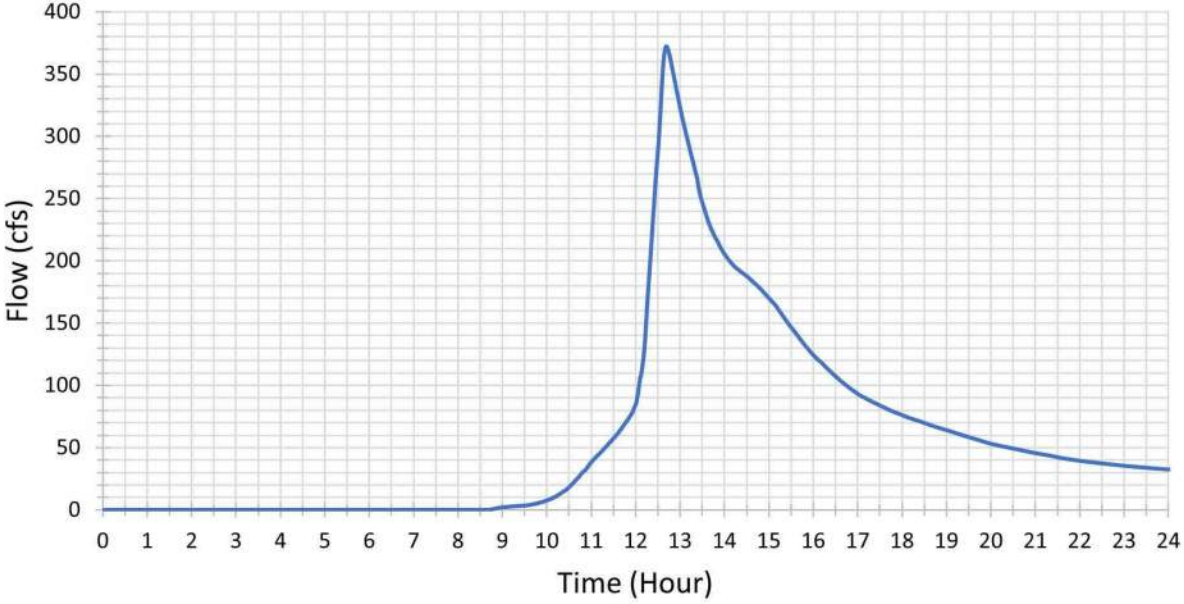

Boundary Condition Line 24-Hour Hydrograph:
Concentrated Flow 7 (MP 58.7)
Flow (cfs)
12000
10000
8000
6000
4000
2000
0
0 1 2 3 4 5 6 7 8 9 10 11 12 13 14 15 16 17 18 19 20 21 22 23 24
Time (Hour)


Boundary Condition Line 24-Hour Hydrograph:
Shallow Flow 7 (MP 58.7)
Flow (cfs)
80
70
60
50
40
30
20
10
0
0 1 2 3 4 5 6 7 8 9 10 11 12 13 14 15 16 17 18 19 20 21 22 23 24
Time (Hour)

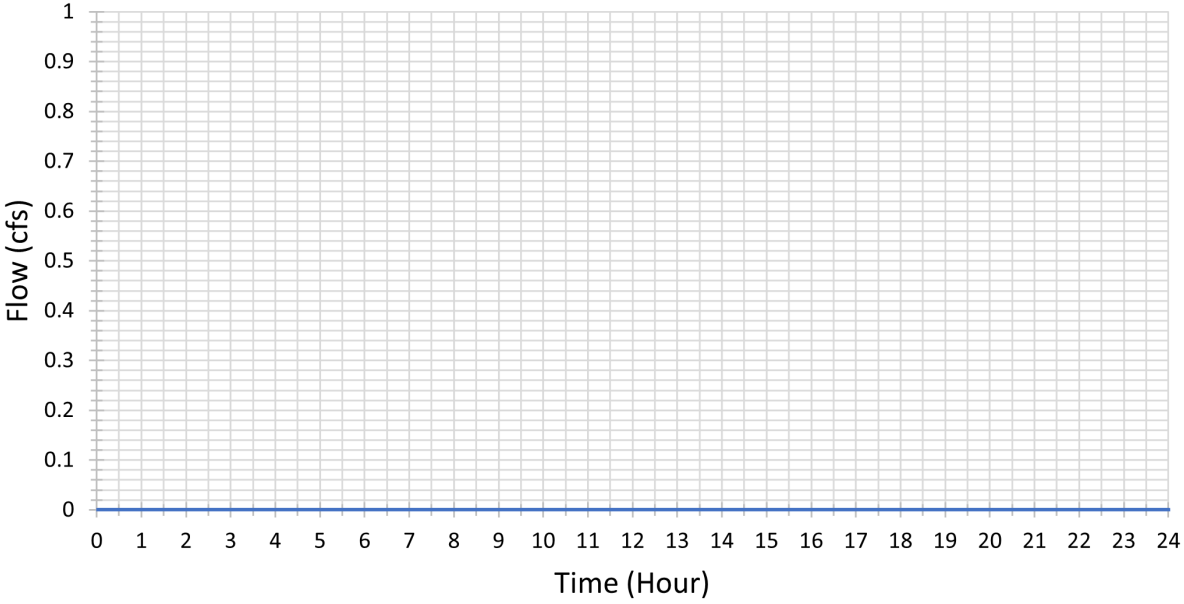
Boundary Condition Line 24-Hour Hydrograph: Shallow Flow 8 (MP 58.7)



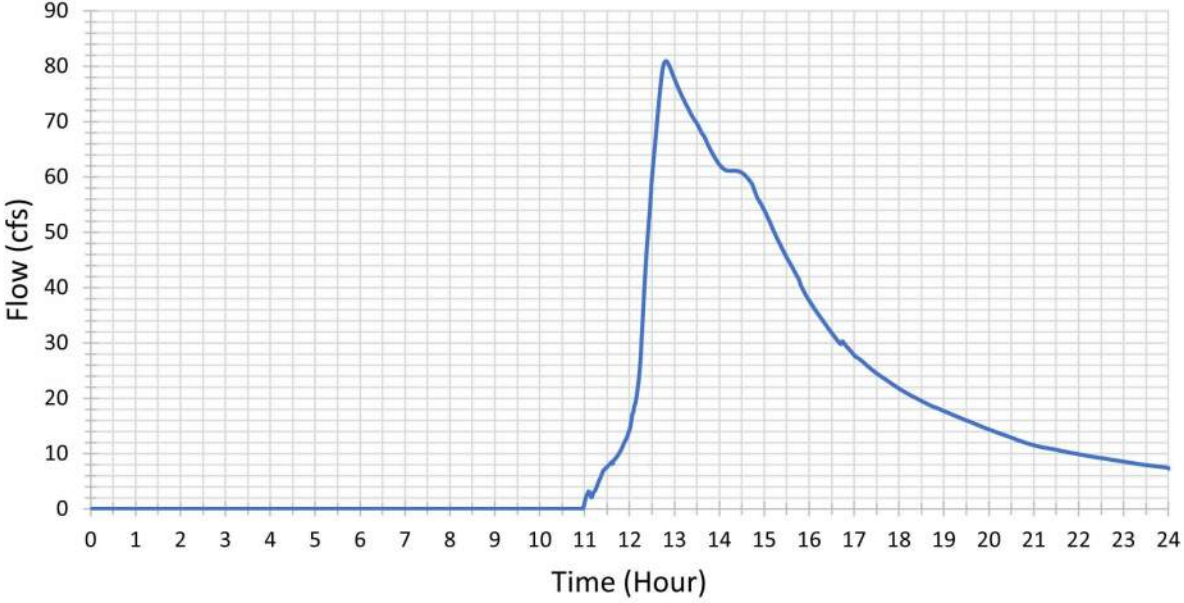
Boundary Condition Line 24-Hour Hydrograph: Concentrated Flow 8 (MP 58.7)



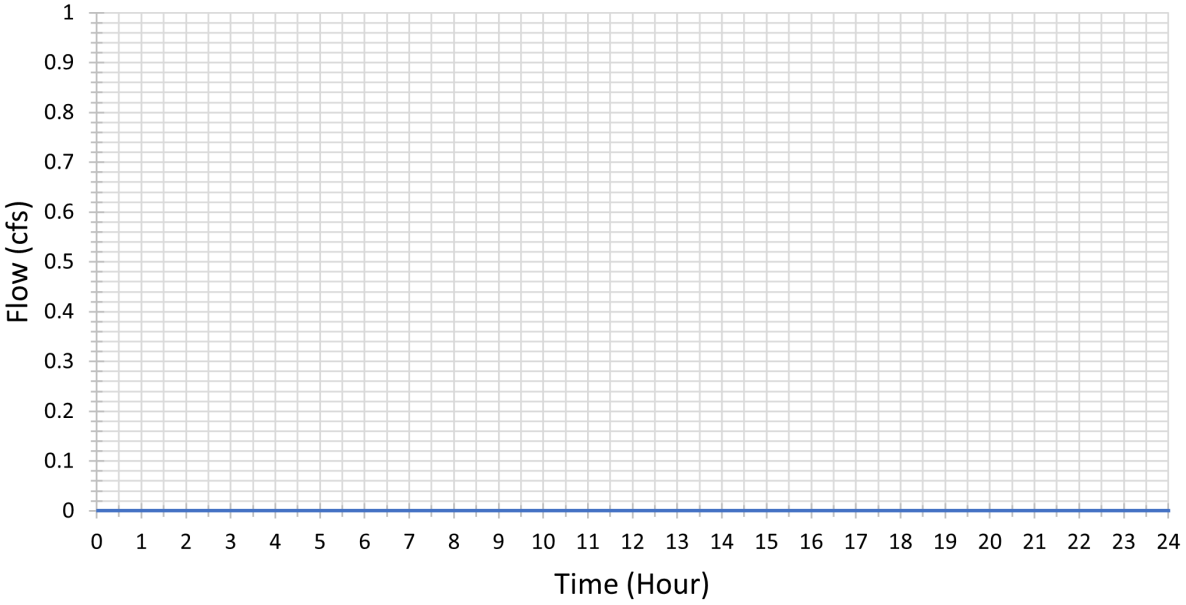
Boundary Condition Line 24-Hour Hydrograph: Shallow Flow 9 (MP 58.7)

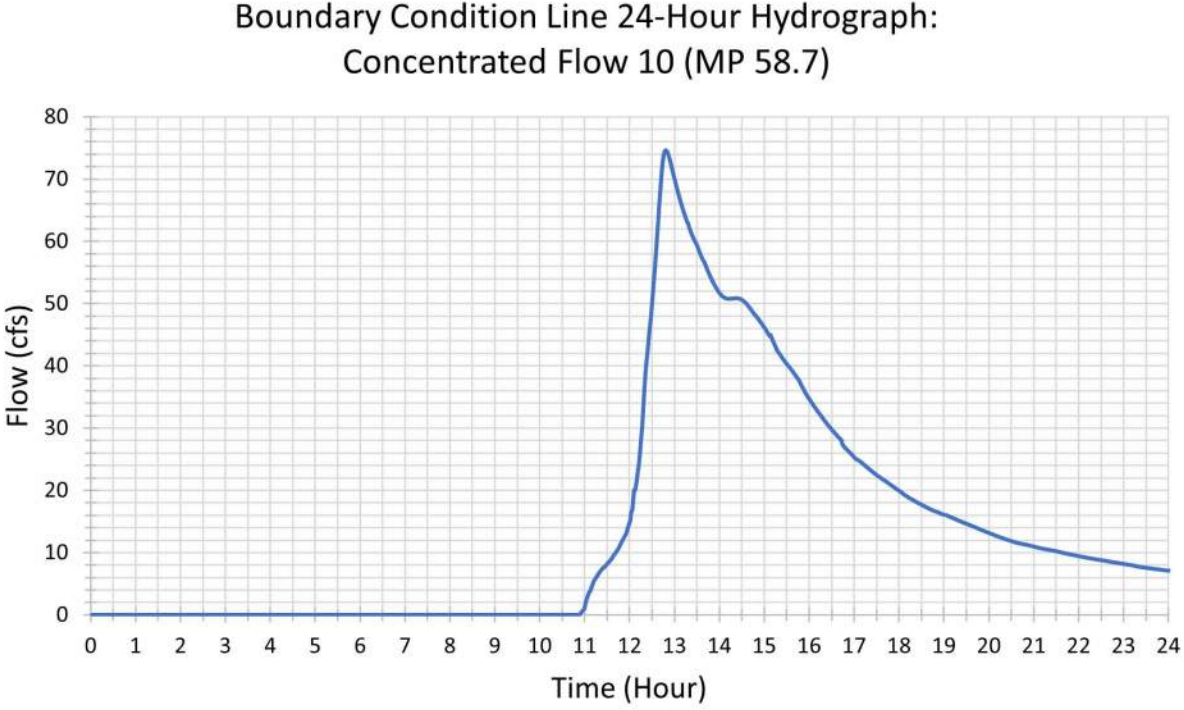


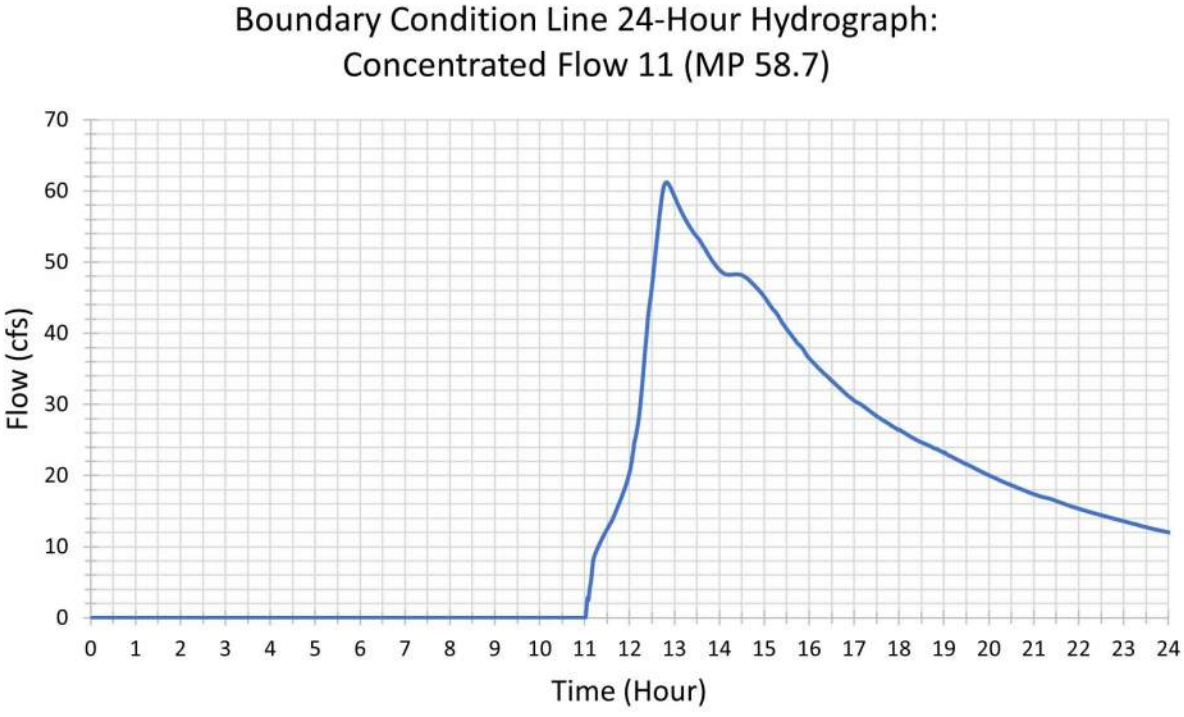
Boundary Condition Line 24-Hour Hydrograph: Concentrated Flow 9 (MP 58.7)



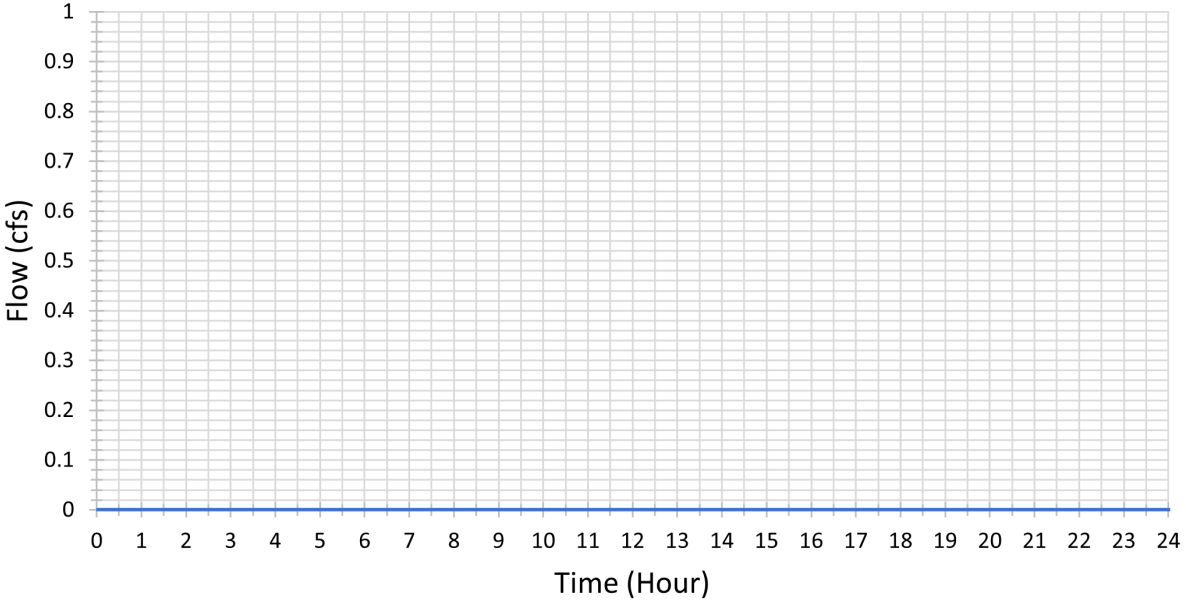
Boundary Condition Line 24-Hour Hydrograph: Shallow Flow 10 (MP 58.7)

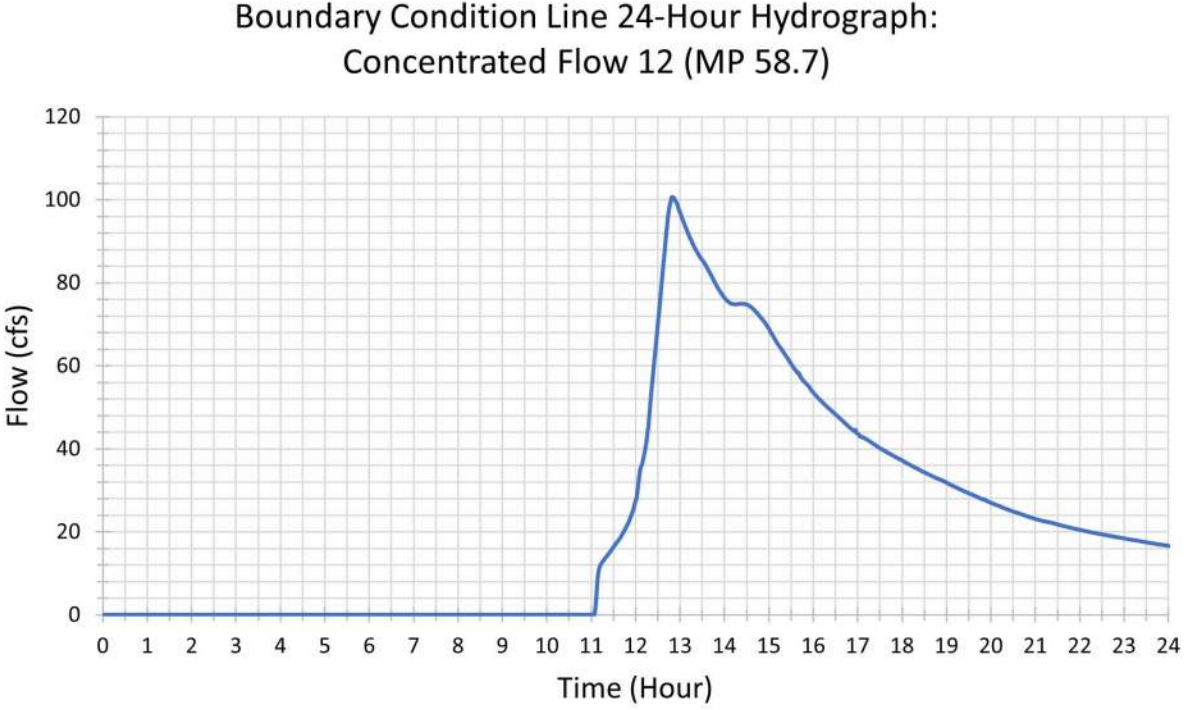


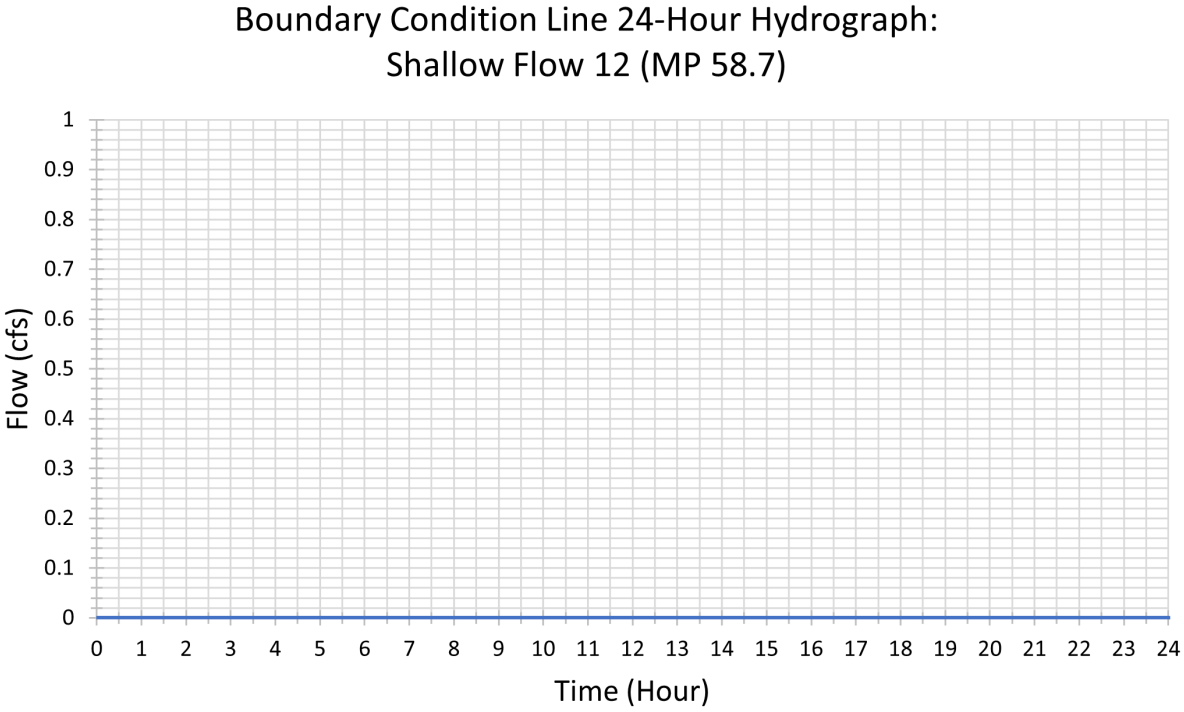

Boundary Condition Line 24-Hour Hydrograph:
Concentrated Flow 10 (MP 58.7)
Flow (cfs)
80
70
60
50
40
30
20
10
0
0 1 2 3 4 5 6 7 8 9 10 11 12 13 14 15 16 17 18 19 20 21 22 23 24
Time (Hour)

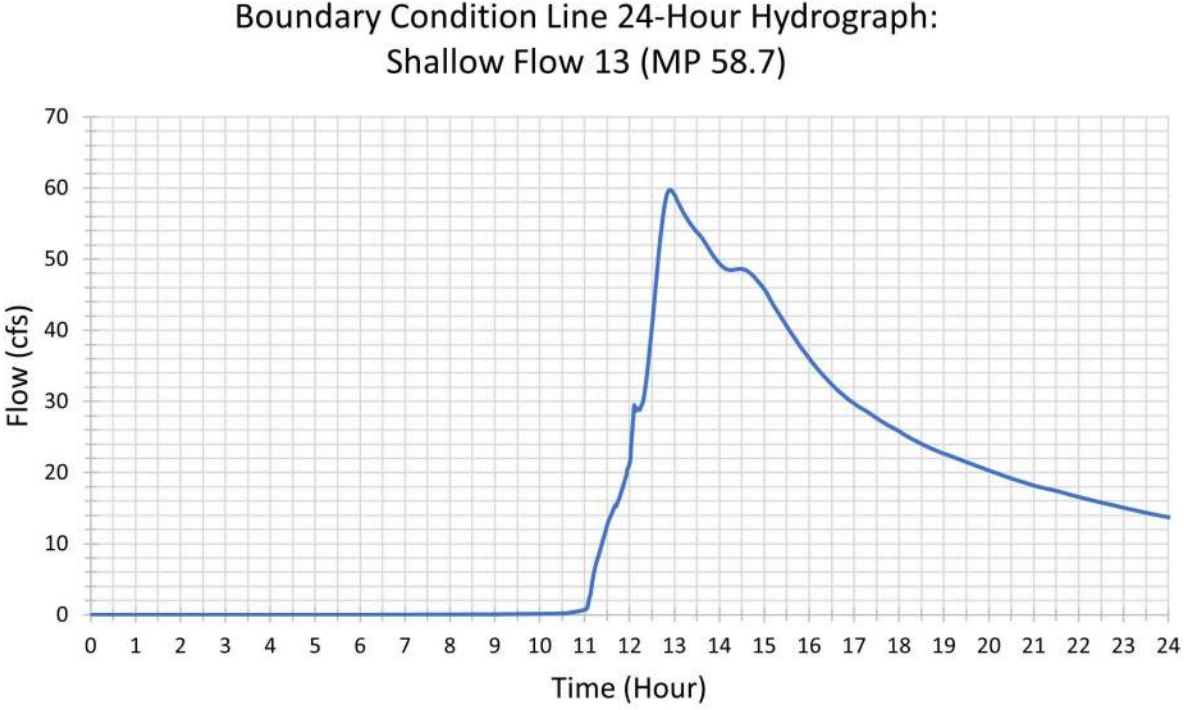

Boundary Condition Line 24-Hour Hydrograph:
Concentrated Flow 11 (MP 58.7)
Flow (cfs)
70
60
50
40
30
20
10
0
0 1 2 3 4 5 6 7 8 9 10 11 12 13 14 15 16 17 18 19 20 21 22 23 24
Time (Hour)

Boundary Condition Line 24-Hour Hydrograph: Shallow Flow 11 (MP 58.7)




Boundary Condition Line 24-Hour Hydrograph:
Concentrated Flow 12 (MP 58.7)
Flow (cfs)
120
100
80
60
40
20
0
0 1 2 3 4 5 6 7 8 9 10 11 12 13 14 15 16 17 18 19 20 21 22 23 24
Time (Hour)


Boundary Condition Line 24-Hour Hydrograph:
Shallow Flow 12 (MP 58.7)
Flow (cfs)
1
0.9
0.8
0.7
0.6
0.5
0.4
0.3
0.2
0.1
0
0 1 2 3 4 5 6 7 8 9 10 11 12 13 14 15 16 17 18 19 20 21 22 23 24
Time (Hour)


Boundary Condition Line 24-Hour Hydrograph:
Shallow Flow 13 (MP 58.7)
Flow (cfs)
70
60
50
40
30
20
10
0
0 1 2 3 4 5 6 7 8 9 10 11 12 13 14 15 16 17 18 19 20 21 22 23 24
Time (Hour)

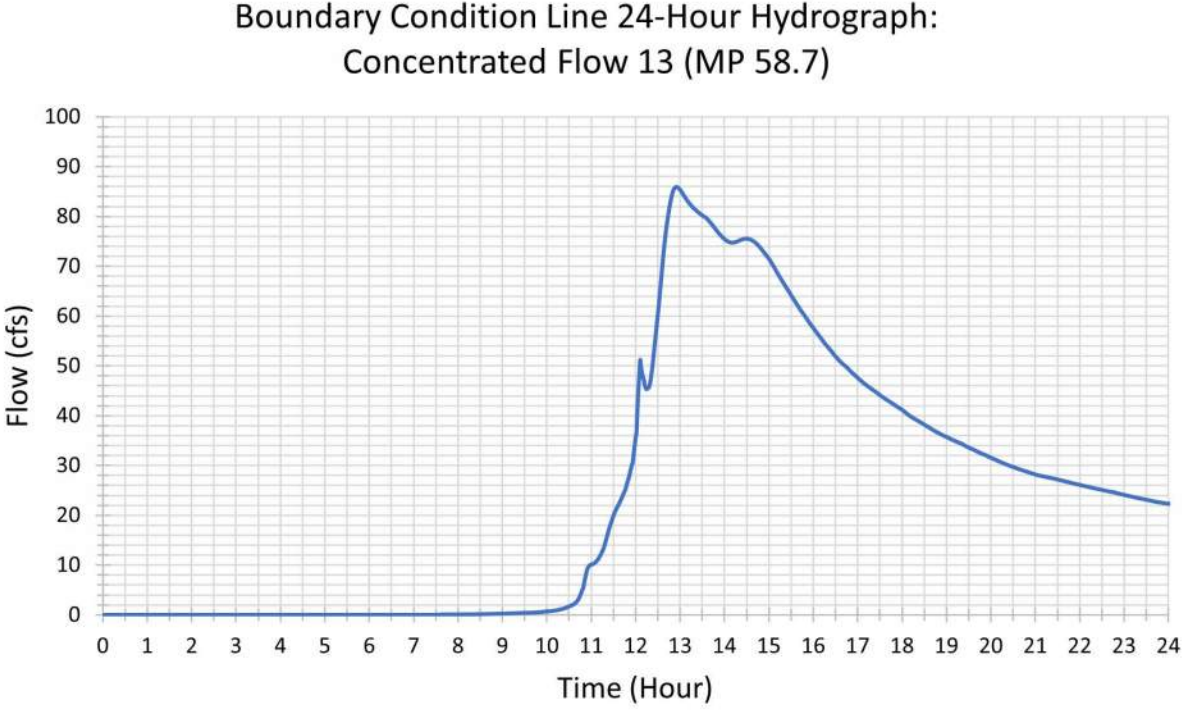

Boundary Condition Line 24-Hour Hydrograph:
Concentrated Flow 13 (MP 58.7)
Flow (cfs)
100
90
80
70
60
50
40
30
20
10
0
0 1 2 3 4 5 6 7 8 9 10 11 12 13 14 15 16 17 18 19 20 21 22 23 24
Time (Hour)

Exhibit 12

HEC-RAS - River Analysis System

Project File: C:\Users\jgriffiths\Desktop\Hwy 11\BigIslandHwy11RO.prj

Project Name: Big Island Hwy11 ROG

Plan Name: 50-yr-Hydraulics Only-FM

Short ID: 50-yr-Hydraulics Only-FM

Starting Time: 31May2022 2400

Ending Time: 01Jun2022 1800

```
################################################
#                                              #
#                                              #
#       1D and 2D Unsteady Flow Module         #
#                                              #
#                                              #
#          HEC-RAS 6.5 February 2024           #
#                                              #
#             08DEC24 at 20:41:37              #
#                                              #
################################################
```

US Inflow	DS Outflow	Lat Hydro	SA Hydro	Groundwater	Diversions	Precip Excess
*********	**********	*********	********	**********	**********	**********

Start 1D Reach	Final 1D Reach	Starting SA's	Final SA's
**********	**********	**********	**********

*** Volume Accounting for 2D Flow Area in Acre Feet ***

2D Area	Starting Vol	Ending Vol	Cum Inflow	Cum Outflow	Error	Percent Error
*******	**********	**********	**********	**********	*****	**********
Hwy58.7-60		641.7	14969.	14328.	1.268	0.008471

*** Total Volume Accounting (for the entire model) in Acre Feet ***

Total Boundary Flux of Water In	14969.
Total Boundary Flux of Water Out	14328.
Starting Volume	0.0000000000
Ending Volume	641.7

Error	Percent Error
*****	**********
1.268	0.008471

HEC-RAS - River Analysis System

Project File: C:\Users\jgriffiths\Desktop\Hwy 11\BigIslandHwy11RO.prj

Project Name: Big Island Hwy11 ROG

Plan Name: 50-yr-Hydraulics Only-FM_Altern 1

Short ID: 50-yr-Hydraulics Only-FM_Altern 1

Starting Time: 31May2022 2400

Ending Time: 01Jun2022 1800

```
################################################
#                                              #
#                                              #
#       1D and 2D Unsteady Flow Module         #
#                                              #
#                                              #
#          HEC-RAS 6.5 February 2024           #
#                                              #
#             10DEC24 at 16:41:11              #
#                                              #
################################################
```

US Inflow	DS Outflow	Lat Hydro	SA Hydro	Groundwater	Diversions	Precip Excess
*********	**********	*********	********	**********	**********	**********

Start 1D Reach	Final 1D Reach	Starting SA's	Final SA's
**********	**********	**********	**********

*** Volume Accounting for 2D Flow Area in Acre Feet ***

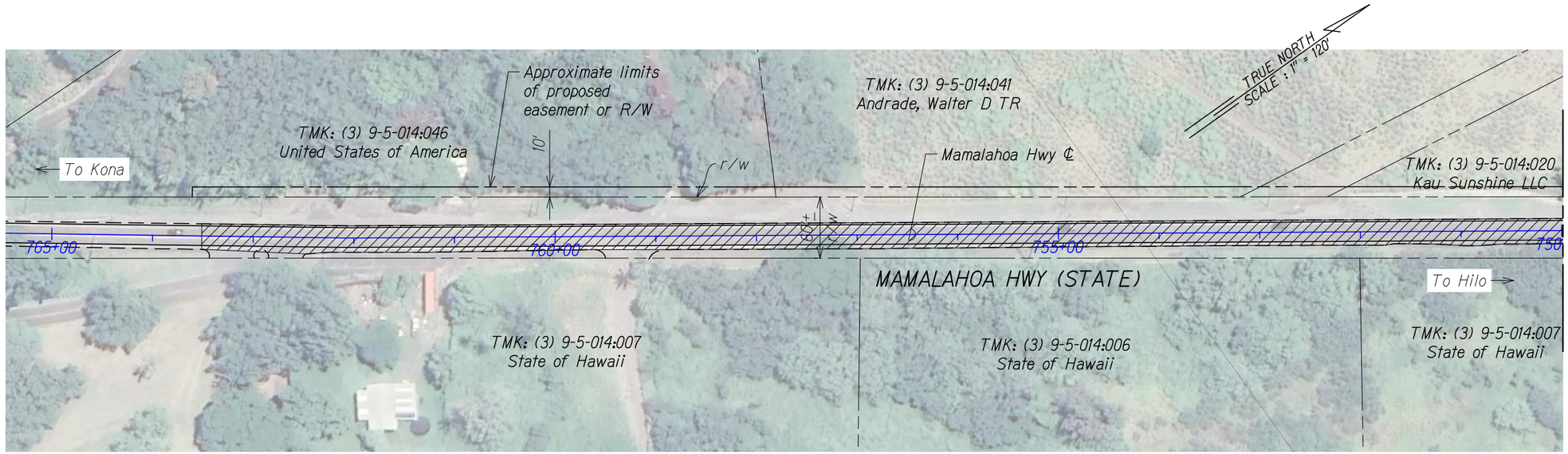
2D Area	Starting Vol	Ending Vol	Cum Inflow	Cum Outflow	Error	Percent Error
*******	**********	**********	**********	**********	*****	**********
Hwy58.7-60		662.2	14969.	14309.	2.490	0.01664

*** Total Volume Accounting (for the entire model) in Acre Feet ***

Total Boundary Flux of Water In	14969.
Total Boundary Flux of Water Out	14309.
Starting Volume	0.0000000000
Ending Volume	662.2

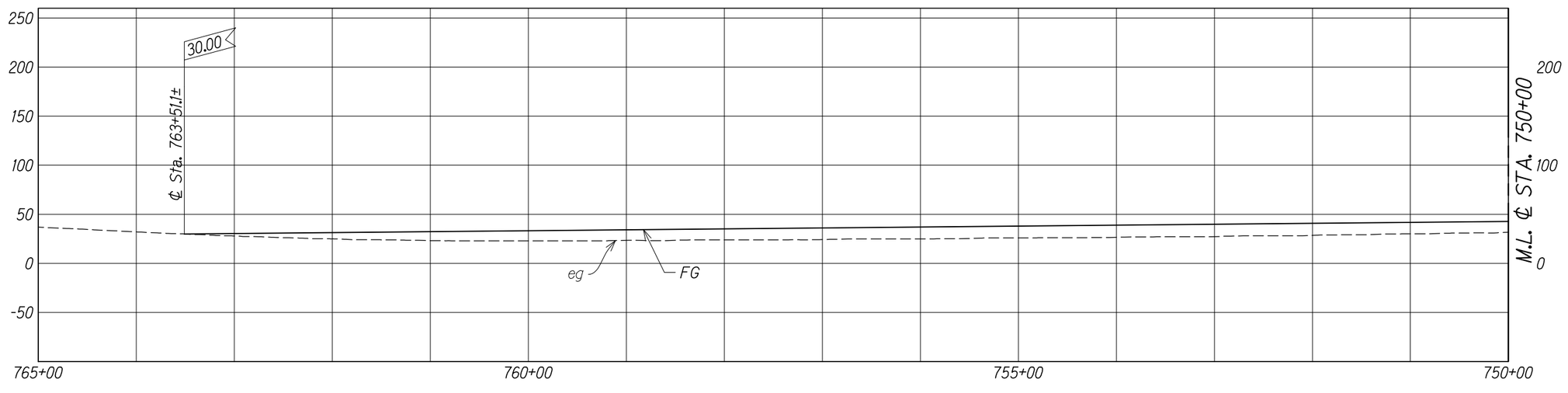
Error	Percent Error
*****	**********
2.490	0.01664


WEST
CONSULTANTS
WATER | ENVIRONMENTAL | SEDIMENTATION | TECHNOLOGY



PLAN - MP 60

SCALE: 1" = 120'



PROFILE - MP 60

SCALE: 1" = 120'

LEGEND:

Approx. limits of raised road

EARTHWORKS:

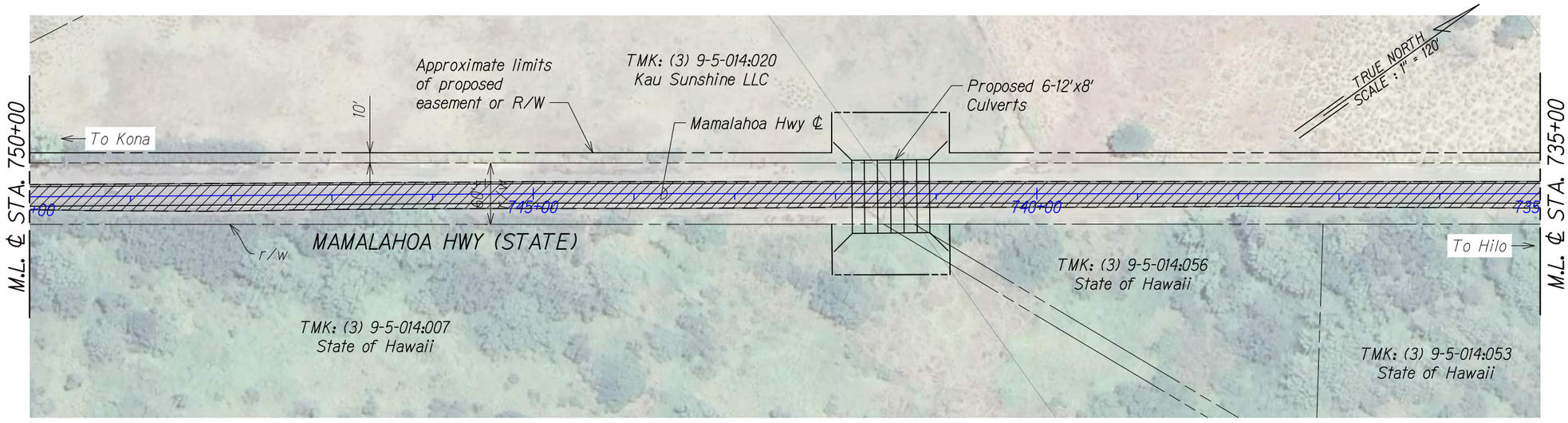
Total Area: 4.77 ac

Embankment:	43,657 Cy (Fill)
Excavation:	6,712 Cy (Cut)
Net:	36,945 Cy (Fill)

GRAPHIC SCALE:

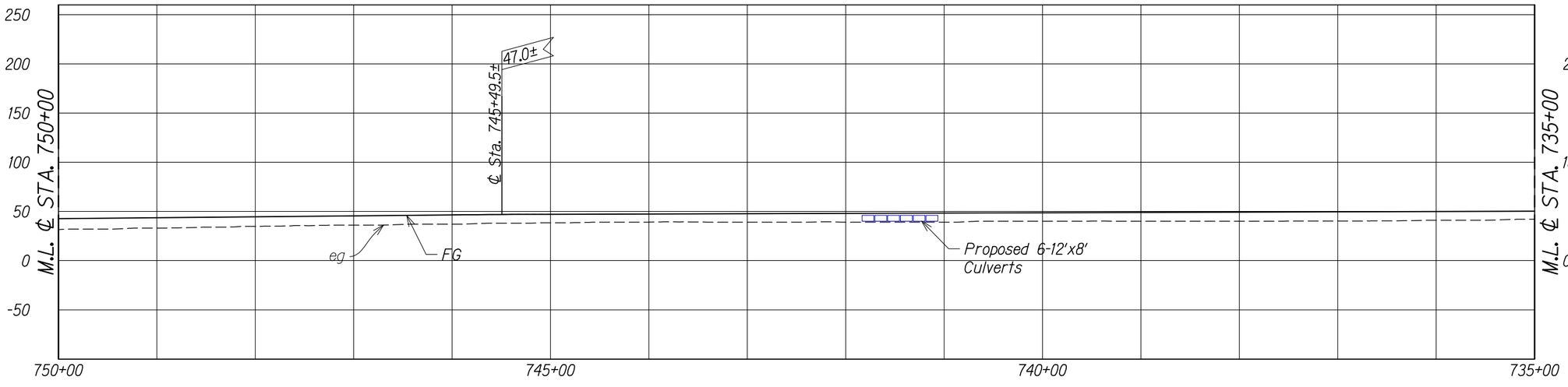
60' 30' 0 60' 120'

Scale: 1" = 120'



PLAN - MP 60

SCALE: 1" = 120'



PROFILE - MP 60

SCALE: 1" = 120'

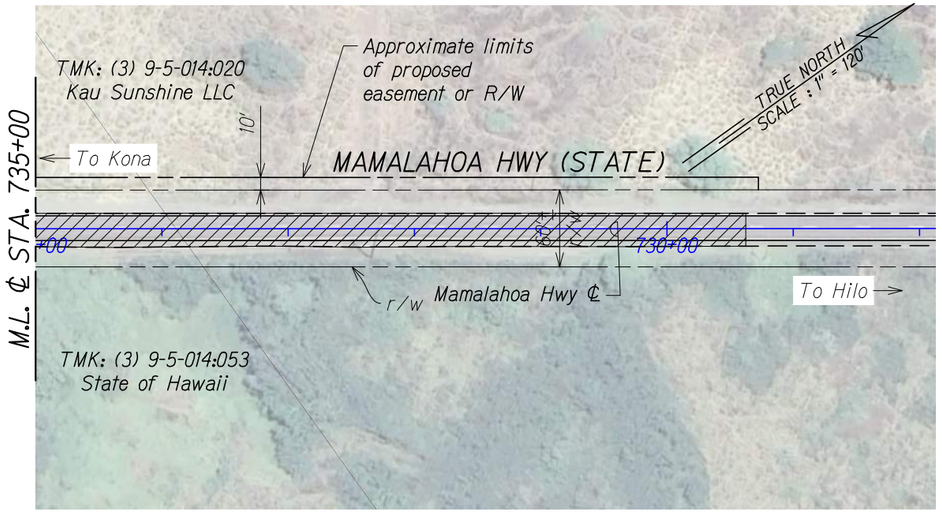
LEGEND:

Approx. limits of raised road

GRAPHIC SCALE:

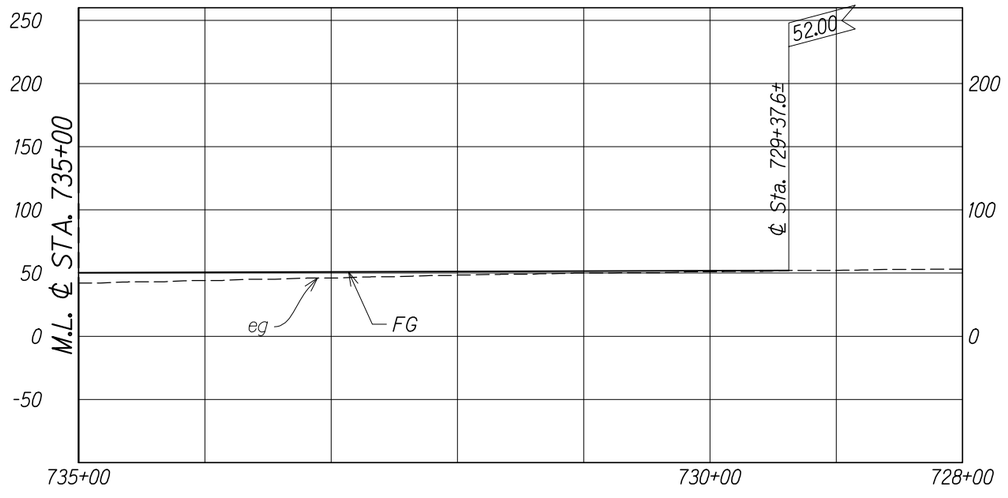
60' 30' 0 60' 120'

Scale: 1" = 120'



PLAN - MP 60

SCALE: 1" = 120'



PROFILE - MP 60

SCALE: 1" = 120'

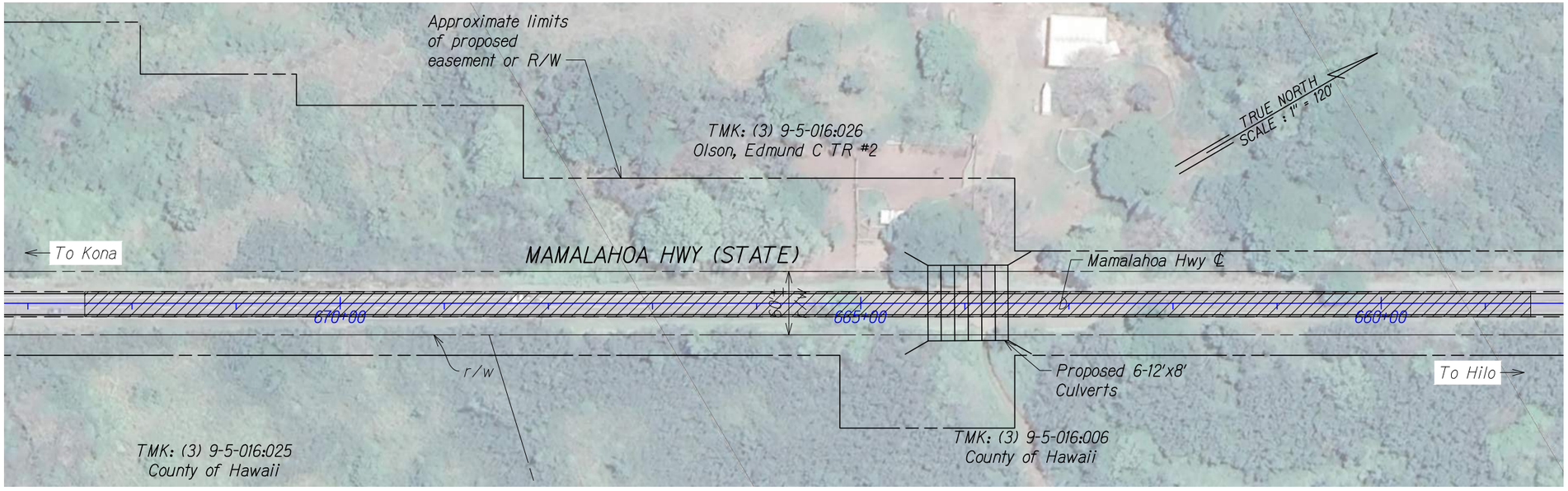
LEGEND:

Approx. limits of raised road

GRAPHIC SCALE:

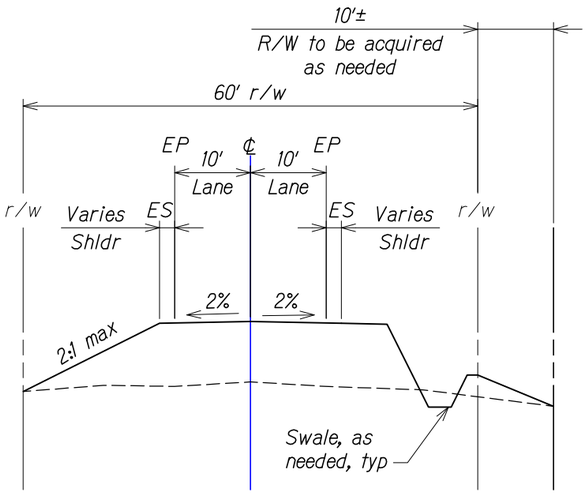
60' 30' 0 60' 120'

Scale: 1" = 120'



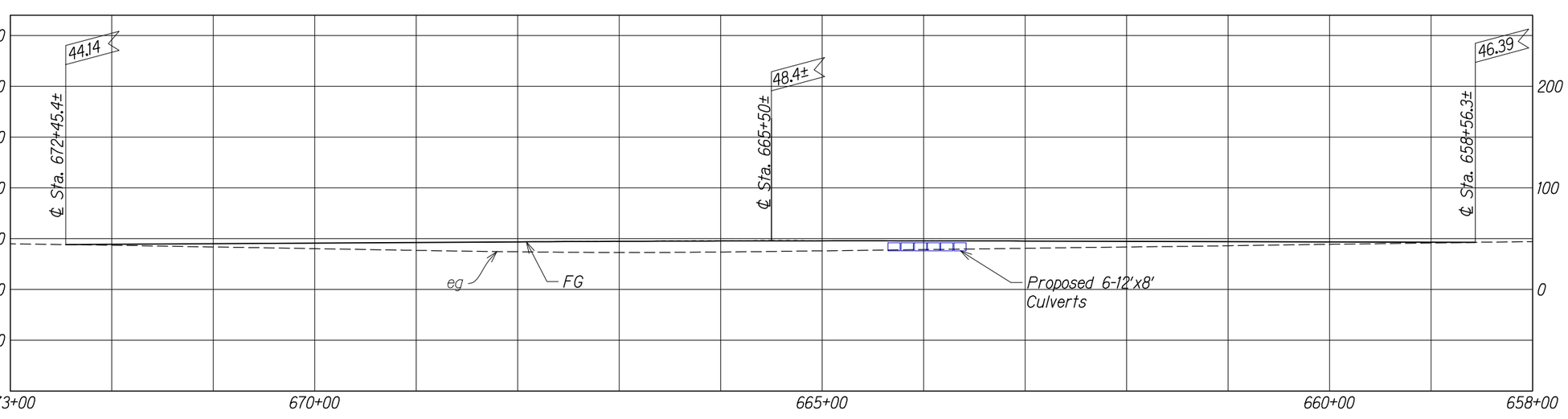
PLAN - MP 58.7

SCALE: 1" = 120'



Typical Section - MP58.7 and MP60

Not to Scale



PROFILE - MP 58.7

SCALE: 1" = 120'

LEGEND:

Approx. limits of raised road

EARTHWORKS:

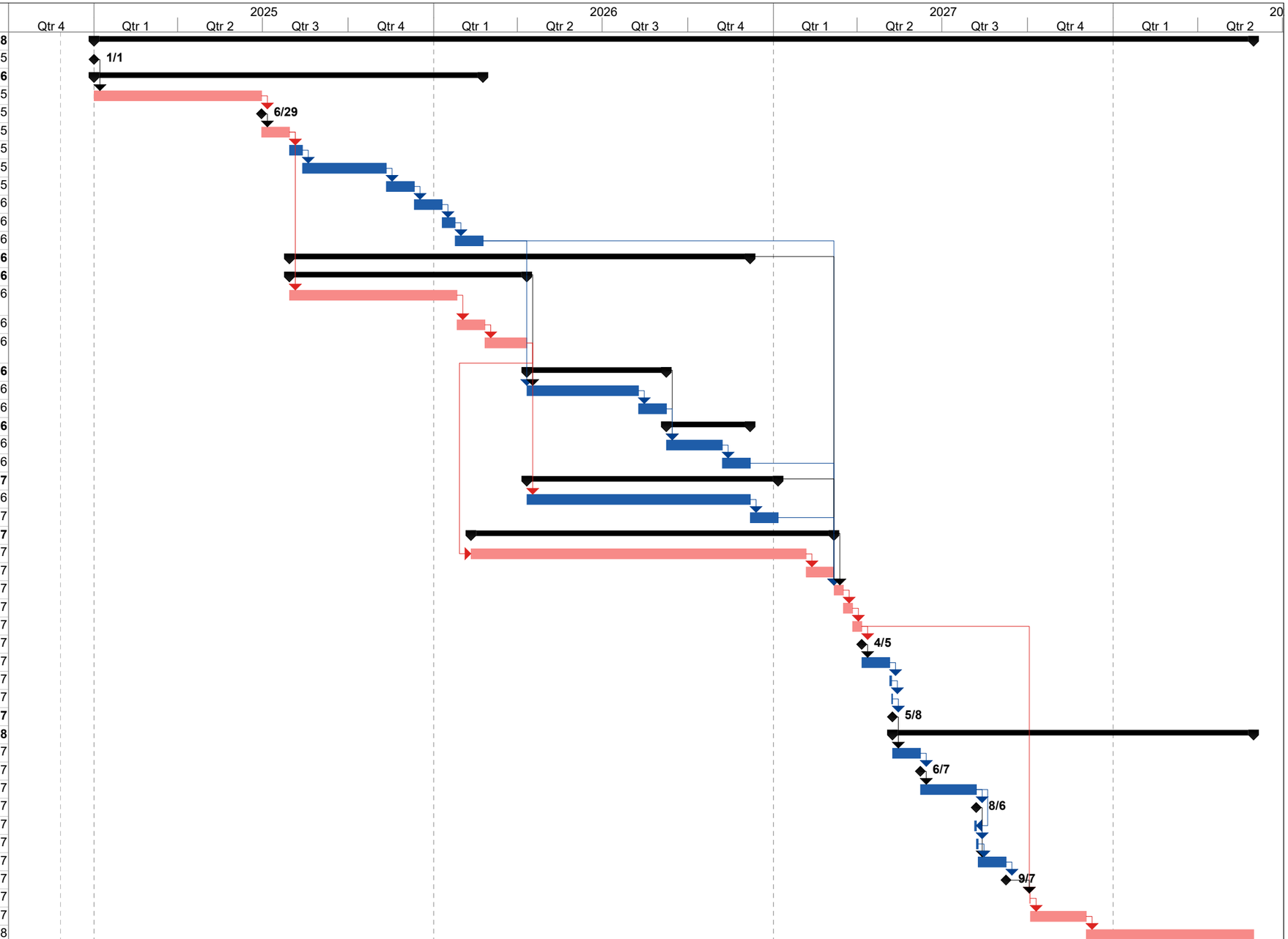
Total Area: 1.89 ac

Embankment: 17,237 Cy (Fill)
Excavation: 2,848 Cy (Cut)
Net: 14,389 Cy (Fill)

GRAPHIC SCALE:

60' 30' 0 60' 120'
Scale: 1" = 120'

ID	Task Name	Duration	Start	Finish
1	**Highway 11 Kau Drainage Improvements**	**1246 days**	**Wed 1/1/25**	**Tue 5/30/28**
2	NTP	0 days	Wed 1/1/25	Wed 1/1/25
3	**Environmental Assessment**	**418 days**	**Wed 1/1/25**	**Sun 2/22/26**
4	Draft EA, Studies and Concept Design	180 days	Wed 1/1/25	Sun 6/29/25
5	Draft EA to HDOT	0 days	Sun 6/29/25	Sun 6/29/25
6	HDOT Review of Draft EA	30 days	Mon 6/30/25	Tue 7/29/25
7	Finalize Draft EA	14 days	Wed 7/30/25	Tue 8/12/25
8	Agency coorindation including AMP and DF	90 days	Wed 8/13/25	Mon 11/10/25
9	Draft Final EA	30 days	Tue 11/11/25	Wed 12/10/25
10	HDOT Review of Final EA	30 days	Thu 12/11/25	Fri 1/9/26
11	Finalize Final EA	14 days	Sat 1/10/26	Fri 1/23/26
12	Anticipated FONSI	30 days	Sat 1/24/26	Sun 2/22/26
13	**Design**	**495 days**	**Wed 7/30/25**	**Sun 12/6/26**
14	**60% PS&E**	**255 days**	**Wed 7/30/25**	**Fri 4/10/26**
15	Preliminary Drawings, Drainage Report, Geotech, Survey, etc.	180 days	Wed 7/30/25	Sun 1/25/26
16	HDOT Review	30 days	Mon 1/26/26	Tue 2/24/26
17	Construction Easements, ROW exhibits and Utility Relocation Exhibits	45 days	Wed 2/25/26	Fri 4/10/26
18	**90% PS&E**	**150 days**	**Sat 4/11/26**	**Mon 9/7/26**
19	Revise drawings, drainage report, etc.	120 days	Sat 4/11/26	Sat 8/8/26
20	HDOT Review	30 days	Sun 8/9/26	Mon 9/7/26
21	**100% PS&E**	**90 days**	**Tue 9/8/26**	**Sun 12/6/26**
22	Revise drawings, drainage report, etc.	60 days	Tue 9/8/26	Fri 11/6/26
23	HDOT Review	30 days	Sat 11/7/26	Sun 12/6/26
24	**Utility Relocation**	**270 days**	**Sat 4/11/26**	**Tue 1/5/27**
25	Coordination with HELCO, etc.	240 days	Sat 4/11/26	Sun 12/6/26
26	Finalize UA's, MOUs	30 days	Mon 12/7/26	Tue 1/5/27
27	**ROW Acquisition**	**390 days**	**Tue 2/10/26**	**Sat 3/6/27**
28	Coordination with property owners	360 days	Tue 2/10/26	Thu 2/4/27
29	Finalize ROW	30 days	Fri 2/5/27	Sat 3/6/27
30	Approval of Final PS&E Memo to District	10 days	Sun 3/7/27	Tue 3/16/27
31	Request for Construction Funds	10 days	Wed 3/17/27	Fri 3/26/27
32	PS&E Approval Authorization to Advertise	10 days	Sat 3/27/27	Mon 4/5/27
33	Obligation	0 days	Mon 4/5/27	Mon 4/5/27
34	Title Sheet Signatures	30 days	Tue 4/6/27	Wed 5/5/27
35	Preparation of Bid Set	2 days	Thu 5/6/27	Fri 5/7/27
36	Submittal of Bid Set to Contracts Section	1 day	Sat 5/8/27	Sat 5/8/27
37	**Ready to advertise**	**0 days**	**Sat 5/8/27**	**Sat 5/8/27**
38	**Advertising and Bidding**	**388 days**	**Sun 5/9/27**	**Tue 5/30/28**
39	HDOT to print/advertise bid documents	30 days	Sun 5/9/27	Mon 6/7/27
40	Advertise	0 days	Mon 6/7/27	Mon 6/7/27
41	Bidding Period	60 days	Tue 6/8/27	Fri 8/6/27
42	Bid Opening	0 days	Fri 8/6/27	Fri 8/6/27
43	Submit bid tabulations to HDOT, if necessa	2 days	Thu 8/5/27	Fri 8/6/27
44	Submit Detailed Estimate on low bid to HD	2 days	Sat 8/7/27	Sun 8/8/27
45	HDOT Review	30 days	Mon 8/9/27	Tue 9/7/27
46	Award	0 days	Tue 9/7/27	Tue 9/7/27
47	HDOT to notify selected contractor	1 day	Sun 10/3/27	Sun 10/3/27
48	Contract Execution	60 days	Mon 10/4/27	Thu 12/2/27
49	Construction NTP	180 days	Fri 12/3/27	Tue 5/30/28



Project: Kawa Flats Drainage Improve
Date: Tue 11/26/24

Task	Project Summary	Inactive Milestone	Manual Summary Rollup	Critical	
Split	External Tasks	Inactive Summary	Manual Summary	Critical Split	
Milestone	External Milestone	Manual Task	Start-only	Progress	
Summary	Inactive Task	Duration-only	Finish-only	Deadline	