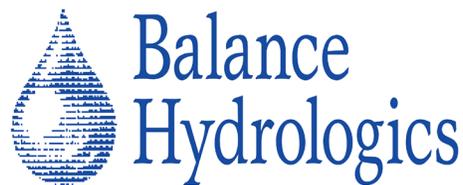




**JEWEL LAKE STUDY:  
RESTORATION AND PUBLIC  
ACCESS FEASIBILITY FOR  
WILDCAT CREEK'S  
JEWEL LAKE REACH**

**April 2025**



In collaboration with:



JEWEL LAKE STUDY: RESTORATION AND PUBLIC ACCESS FEASIBILITY  
FOR WILDCAT CREEK'S JEWEL LAKE REACH

April 2, 2025

**A TECHNICAL REPORT PREPARED FOR:**

**Scott Stoller, P.E.**

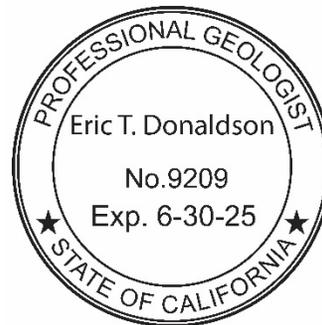
East Bay Regional Park District  
2950 Peralta Oaks Court  
Oakland, California 94605  
(888) 327-2757  
sstoller@ebparks.org

by:



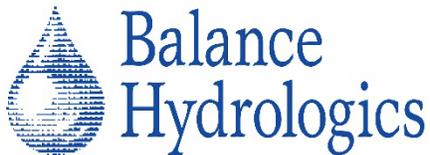
---

Eric Donaldson, P.G.  
Project Manager



---

Jonathan Owens  
Principal-in-charge



© 2025 Balance Hydrologics, Inc.  
Project Assignment: 220053

800 Bancroft Way, Suite 101 ~ Berkeley, California 94710-2251 ~ (510) 704-1000 ~ office@balancehydro.com

JEWEL LAKE STUDY: RESTORATION AND PUBLIC ACCESS FEASIBILITY  
FOR WILDCAT CREEK'S JEWEL LAKE REACH

**TABLE OF CONTENTS**

<b>EXECUTIVE SUMMARY</b>	<b>1</b>
<b>1 INTRODUCTION</b>	<b>2</b>
1.1 <i>Project Overview</i>	2
1.2 <i>Project Motivation</i>	3
1.3 <i>Project Goals and Objectives</i>	4
1.4 <i>Purpose of this Report</i>	6
1.4.1 <i>Evaluations Completed</i>	6
<b>2 PHYSICAL SETTING AND SITE CHARACTERISTICS</b>	<b>8</b>
2.1 <i>Project Location</i>	8
2.2 <i>Geology</i>	10
2.3 <i>Site History</i>	10
2.4 <i>Biological Resources</i>	11
2.5 <i>Hydrologic Summary</i>	12
2.5.1 <i>Rainfall</i>	12
2.5.2 <i>Hydrologic Observations, Water Years 2020 and 2021</i>	14
2.5.3 <i>Storm Flows and Daily Flow</i>	15
2.5.4 <i>Fish-Passage Flows</i>	19
2.5.5 <i>Evapotranspiration and Climate Change</i>	22
2.6 <i>Preliminary Hydraulic Model</i>	23
2.7 <i>Sediment Transport</i>	24
2.7.1 <i>Interpreting Sediment Processes: Sediment Basin and Jewel Lake Borings</i>	26
2.7.2 <i>Bathymetry and Dredging Volumes and Rates</i>	29
2.7.3 <i>Observations of Bank Height/Floodplain Transition along Channel</i>	30
2.7.4 <i>Sediment Transport Measurements</i>	31
2.7.5 <i>Scaling Sediment Rating Curves from Downstream to Jewel Lake reach</i>	33
<b>3 DESIGN CONSIDERATIONS</b>	<b>36</b>
3.1 <i>Project Opportunities and Constraints</i>	36
3.1.1 <i>Geology and Geomorphology Opportunities and Constraints</i>	36
3.1.2 <i>Hydrology Opportunities and Constraints</i>	37
3.1.3 <i>Infrastructure and Engineering Opportunities and Constraints</i>	38
3.1.4 <i>Biological Resources Opportunities and Constraints</i>	39
3.1.5 <i>Public Access and Recreation Opportunities and Constraints</i>	40

JEWEL LAKE STUDY: RESTORATION AND PUBLIC ACCESS FEASIBILITY  
FOR WILDCAT CREEK'S JEWEL LAKE REACH

3.1.6	Cultural Resources Opportunities and Constraints	41
3.2	<i>Summary of Design Criteria</i>	42
3.2.1	Hydraulic and Channel Design Criteria	42
3.2.2	Fish-Passage	44
3.2.3	Open-Water Resource Design Criteria	45
3.2.4	Access, Education and Recreation Criteria	45
<b>4</b>	<b>DESIGN CONCEPTS</b>	<b>47</b>
4.1	<i>Design Overview</i>	47
4.2	<i>Concept 1: No Project, Jewel Lake Fills In, Reinforce Bottom of Undermined Spillway</i>	47
4.2.1	Conceptual Design Narrative for Concept 1	47
4.2.2	Summary of Benefits and Drawbacks in the Context of Project Goals for Concept 1	48
4.3	<i>Concept 2: Dredge Lake Periodically, Construct Nature-Like Fishway</i>	49
4.3.1	Conceptual Design Narrative for Concept 2	49
4.3.2	Preliminary Phasing Notes for Concept 2	52
4.3.3	Summary of Benefits and Drawbacks in the Context of Project Goals for Concept 2	52
4.4	<i>Concept 3: Remove Dam and Lake, Restore Wildcat Creek</i>	54
4.4.1	Conceptual Design Narrative for Concept 3	54
4.4.2	Summary of Benefits and Drawbacks in the Context of Project Goals for Concept 3	56
4.5	<i>Concept 4: Modify Dam and Lake, Construct Channel for Fish Passage and Sediment Transport</i>	58
4.5.1	Conceptual Design Narrative for Concept 4	58
4.5.2	Sediment Analysis Related to Concept 4: Bypass Alternative	60
4.5.3	Sub-Concept 4: Bypass Channel on the East Side of Wildcat Canyon, Excavate	61
4.5.4	Summary of Benefits and Drawbacks in the Context of Project Goals for Concept 4	61
4.6	<i>Sediment Delivery to Lower Wildcat Canyon and Urbanized Downstream Reach</i>	62
4.7	<i>Trails, Recreation, and Education</i>	64
4.8	<i>Permitability</i>	64
4.9	<i>Concept Level Cost-Estimates</i>	64
4.10	<i>Design Elements Considered, But Not Selected</i>	64
<b>5</b>	<b>PUBLIC MEETINGS AND SELECTING PREFERRED CONCEPTS</b>	<b>66</b>

# JEWEL LAKE STUDY: RESTORATION AND PUBLIC ACCESS FEASIBILITY FOR WILDCAT CREEK'S JEWEL LAKE REACH

5.1	<i>Public Meetings</i>	66
5.2	<i>Preliminary, Informal Meeting with RWQCB staff</i>	67
<b>6</b>	<b>PREFERRED CONCEPTS</b>	<b>68</b>
<b>7</b>	<b>LIMITATIONS</b>	<b>71</b>
<b>8</b>	<b>REFERENCES</b>	<b>72</b>

## LIST OF TABLES

Table 2-1	Recurrence-interval flow table for Wildcat Creek and local tributaries.	18
Table 2-2	Recurrence flows calculated using three methods.	18
Table 2-3	CDFW Criteria for Hydraulic Design	21
Table 3-1	Recommended range of channel design slopes and maximum elevation drops for various roughened channel bedforms (modified from CDFW, 2009).	45

## LIST OF FIGURES

Figure 2-1	Jewel Lake and the upper Wildcat Creek watershed.	9
Figure 2-2	Cumulative daily precipitation, Vollmer Peak in Tilden Park, Contra Costa County, California, water years 2006 through 2024 (partial)	13
Figure 2-3	Jewel Lake, July 30, 2020.	14
Figure 2-4	Wildcat Creek tributaries in the vicinity of Jewel Lake.	15
Figure 2-5	Return periods of annual peak flows: Wildcat Creek at Jewel Lake, Contra Costa County, California.	17
Figure 2-6	Ranked Daily Mean Streamflow (water years 1976-1996 and 2006-2019): Wildcat Creek at Jewel Lake.	20
Figure 2-7	Maximum, Mean, Median and Minimum daily stream flows (Water Years 1976-1996 and 2006-2019): Wildcat Creek at Jewel Lake.	22
Figure 2-8	Sediment samples from the sediment basin located at the Little Farm (left) and in a distributary channel on the Jewel Lake delta (right).	26
Figure 2-9	Map of Jewel Lake delta hand-auger boreholes 2020-01, 2020-02, 2020-03.	27
Figure 2-10	Subsurface logs for Jewel Lake delta hand-auger boreholes 2020-01, 2020-02, 2020-03.	28

## JEWEL LAKE STUDY: RESTORATION AND PUBLIC ACCESS FEASIBILITY FOR WILDCAT CREEK'S JEWEL LAKE REACH

Figure 2-11	Measured sediment transport as a function of flow: Wildcat Creek at Vale Road. Suspended-sediment concentration and loading increases strongly as flow increases.	32
Figure 2-12	Measured bedload sediment transport as a function of flow: Wildcat Creek at Vale Road. Bedload transport can vary considerably from storm to storm and from the start to end of a storm.	33
Figure 3-1	Storm drain outfall emerging from underneath Wildcat Canyon Trail into the fringe of Jewel Lake (Looking North).	41
Figure 3-2	Headwall and culvert inlet at Jewel Creek where it crosses under Wildcat Canyon Trail (Looking west).	42
Figure 4-1	Example of a flow-control structure from Spanaway Creek bypass channel (Published in CDFW, 2009).	50

### **PLATES**

Plate 1	Project Site and Impairment Map
Plate 2	Concept 1 – Repair Bottom of Spillway and Eroded Slope

### **SHEETS**

Sheet 2.0	Concept 2 - Dredge Jewel Lake, Nature-Like Fishway
Sheet 3.0	Concept 3 - Restore Jewel Lake
Sheet 4.0	Concept 4 - Create Bypass Channel, Dredge Wildcat Creek

### **APPENDICES**

Appendix A	Revised Biological Resources Existing Conditions Report
Appendix B	Revised Aquatic Resources Delineation Report
Appendix C	Revised Geotechnical Report
Appendix D	Revised Trails Evaluation Report
Appendix E	Hydrologic Observers Log, Partial Year Water Year 2021
Appendix F	Preliminary Existing Conditions Hydraulic Modeling Results
Appendix G	Preliminary Sediment Transport Evaluation for Concept 4

## JEWEL LAKE STUDY: RESTORATION AND PUBLIC ACCESS FEASIBILITY FOR WILDCAT CREEK'S JEWEL LAKE REACH

Appendix H	Hydrologic Flow Sufficiency Comparison and Climate Change Evaluation Memorandum
Appendix I	Permitability Matrix
Appendix J	2021 Concept-level Cost Estimate Tables for Concepts 2, 3 and 4
Appendix K	Public Meeting Packet for October 21, 2020, Public Meeting
Appendix L	Public Meeting Packet for April 21, 2022, Public Meeting
Appendix M	Results of Informal Public Polling
Appendix N	Public Comments Received by East Bay Regional Parks

## EXECUTIVE SUMMARY

This report presents four conceptual approaches to manage the Jewel Lake reach of Wildcat Creek in the Tilden Nature Area in Contra Costa County, California. A dam constructed on Wildcat Creek in 1921 created Jewel Lake, which continues as a recreational amenity today. However, the dam restricts the natural passage of sediment down Wildcat Creek and is a complete barrier to upstream migration of rainbow trout and other fish.

Over time, sediment was trapped in the lake and reduced the area of open water. To maintain some open water, Jewel Lake was dredged in 1967 and 1991. The East Bay Regional Park District (Park District) commissioned this study to explore the feasibility of potential concepts proposed in the Wildcat Creek Watershed Erosion and Sediment Control Project (FlowWest, 2016) and aid in selecting a preferred concept which will help the Park District achieve the long-term goals for the recreational and ecological function of the Tilden Nature Area.

Presently, the lake is nearly filled with sediment and would need to be dredged to continue to provide open-water habitat and recreational benefits. The Park District is taking this opportunity to compare continued dredging with alternative approaches to managing habitat and public access.

The four project concepts are presented in **Section 1.1**, and include:

**Concept 1: No project, Jewel Lake fills in, repair deteriorating spillway.**

**Concept 2: Dredge lake periodically, construct nature-like fishway.**

**Concept 3: Remove the dam and lake, restore Wildcat Creek.**

**Concept 4: Modify dam and lake, construct bypass channel for fish passage and sediment transport.**

The Project goals are presented in **Section 1.3**.

Based on technical studies performed as part of this project, public input, and input from the Park District, Concept 3 and Concept 4 were selected as preferred options.

## 1 INTRODUCTION

### 1.1 Project Overview

The Long-term Management and Restoration Study for the Jewel Lake Reach of Wildcat Creek (Project) was conceived by the East Bay Regional Park District (Park District) to develop a plan of action to address the ongoing sedimentation of Jewel Lake, located in the Tilden Nature Area in Contra Costa County, California. A dam constructed on Wildcat Creek in 1921 created Jewel Lake, which continues to provide a recreational amenity today. The dam blocks the natural passage of sediment through the system and is a complete barrier to upstream migration of rainbow trout and other fish. Over time, sediment has been trapped in the lake which has reduced its depth and the area of open water.

The East Bay Regional Park District (Park District) has commissioned this study to explore the feasibility of potential concepts that were proposed in the previous Wildcat Creek Watershed Erosion and Sediment Control Project (FlowWest, 2016) and inform the selection of a preferred concept to help the Park District achieve long-term goals for the recreational and ecological function of the Tilden Nature Area.

This scope of work is focused on developing and evaluating four design concepts, which are summarized as:

**Concept 1: “No project” Jewel Lake fills in, repair deteriorating spillway.**

Allow sedimentation to continue, which will eventually convert Jewel Lake from open water to wet meadow, riparian woodland, and other habitat types. Conduct repairs to stabilize the spillway outfall to support long-term stability of the dam. Fish would still not be able to migrate upstream past the dam. Sediment that does not accumulate upstream of the dam would eventually pass over the spillway.

Although this is named the “no project” concept, at a minimum, repairs would be needed for the long-term stability of the spillway. Additionally, the sedimentation basin located near the Environmental Education Center (EEC) would become obsolete and could be decommissioned.

**Concept 2: Dredge lake periodically, construct nature-like fishway.** Periodically, dredge Jewel Lake to maintain open water habitat. Construct a nature-like fishway<sup>1</sup> to enable fish passage. Maintain sediment removal program from sediment detention basin located upstream at the EEC.

**Concept 3: Remove the dam and lake, restore Wildcat Creek.** Restore fish passage in Wildcat Creek by removing Jewel Dam and restoring the riparian corridor; construct a nature-based rock step-pool channel support fish passage. Decommission the sediment detention basin located upstream at the EEC.

**Concept 4: Modify dam and lake, construct a hydraulic bypass structure and channel for fish passage and sediment transport.** Construct a bypass stream channel on the west side of Wildcat Canyon to restore sediment continuity and fish passage. Dredge and modify Jewel Lake and Dam which will effectively take Jewel Lake “off-line” from Wildcat Creek. Construct a hydraulic structure to be operated to link the lake to Wildcat Creek. Decommission the sediment detention basin located upstream at the EEC.

Note that Concept 1 is the “no project” concept, even though it involves repairs and earthwork in the area around the downstream end of the spillway. We therefore refer to concepts 2-4 as the “active” concepts.

## 1.2 Project Motivation

Jewel Dam was constructed in 1921 for water supply. This action also converted habitat from riparian to lacustrine (lake), which changed ecological composition including colonization by non-native species. By damming Wildcat Creek, Jewel Lake also traps all bedload sediment, and a portion of the suspended sediment transported to the Project area. This sediment accumulation has caused a significant reduction in the area and depth of open water which are key features for retaining the aesthetic and recreational value of the historic use and enjoyment of the lake.

---

<sup>1</sup> A nature-like fishway is described in the fish passage literature as a boulder fish passage channel constructed with a large immobile framework of large rock mixed with smaller rock material (CDFW, 2009). We have adopted that terminology here.

## JEWEL LAKE STUDY: RESTORATION AND PUBLIC ACCESS FEASIBILITY FOR WILDCAT CREEK'S JEWEL LAKE REACH

The elimination of bedload sediment transport downstream of the dam has resulted in channel incision, which has degraded riparian and aquatic habitat value along Wildcat Creek downstream of the dam.

Jewel Dam is a complete passage-barrier to upstream migration for salmonids and is a near-complete barrier to downstream migration.

The Park District, the adjacent cities, and management agencies are investing heavily in actions to restore Wildcat Creek from the Bay to the headwaters with the ultimate goal to repopulate the creek with migratory Steelhead.

This project is motivated by the recognition that the management of Jewel Lake is at a crossroads since the lake is nearly filled with sediment. It is prudent at this juncture to evaluate options for the long-term future of this reach of Wildcat Creek.

### 1.3 Project Goals and Objectives

The Project goals listed below are intended to guide design development and preferred concept selection. Notably, some goals may be incompatible. Through the Park District's public engagement process, certain goals will be prioritized.

1. Maintain and improve habitat for existing native species including:
  - a. Species of special concern (e.g., western pond turtle and San Francisco dusky-footed woodrat);
  - b. riparian birds, bats, and riparian community (e.g., Wilson's warbler, warbling vireo);
  - c. rainbow trout.
2. Provide suitable conditions for salmonid passage through the Project reach.
3. Improve sediment transport and continuity through the Project reach to:
  - a. Limit the need for future dredging of Jewel Lake.

JEWEL LAKE STUDY: RESTORATION AND PUBLIC ACCESS FEASIBILITY  
FOR WILDCAT CREEK'S JEWEL LAKE REACH

- b. Benefit the downstream reaches of Wildcat Creek by replenishing eroded channel sediment.
- 4. Maintain and improve public access to key features in the Tilden Nature Area.
- 5. Maintain and/or create a “destination” for interpretive walks.
- 6. Maintain the Lake as open water.

The Project seeks to accomplish the above goals while also meeting the following objectives:

- 1. Minimize short- and long-term impacts to sensitive biological resources including:
  - a. Western pond turtle (California Species of Special Concern) nesting habitat;
  - b. aquatic resources, including wetlands;
  - c. riparian habitat (i.e., alder-willow woodland) immediately upstream of the open water area that is regionally important for several focal species in the California Riparian Bird Conservation Plan (RHJV, 2004);
  - d. San Francisco dusky-footed woodrat (California Species of Special Concern) habitat.
- 2. Minimize long-term maintenance of the system including:
  - a. Future dredging;
  - b. operations and maintenance of hydraulic and bypass infrastructure;
  - c. surrounding roads and trails.
- 3. Minimize disturbance to historical/archeological resources.
- 4. Effectively utilize available funds to meet the above-listed Project goals.

# JEWEL LAKE STUDY: RESTORATION AND PUBLIC ACCESS FEASIBILITY FOR WILDCAT CREEK'S JEWEL LAKE REACH

## 1.4 Purpose of this Report

The purpose of this document is to highlight the findings and results of the technical studies performed, and to provide rationale for the content in the preliminary conceptual designs. The technical studies contributed to developing the four project concepts and will be used to inform their evaluation using the Project goals and objectives stated above.

### 1.4.1 EVALUATIONS COMPLETED

The list below summarizes the technical evaluations completed to date:

- Kick-off and coordination meetings;
- review and integration of previous work and archival material;
- pre-design concept development to guide technical analyses;
- hydrologic and water quality evaluation, including field evaluations;
- supplemental topographic data collection surveys;
- geomorphic and soils evaluation around Jewel Lake and the Jewel Lake delta;
- existing conditions hydraulic modeling evaluation upstream of Jewel Dam;
- sediment transport evaluation to evaluate the feasibility of the flow split option in Concept 4;
- revised wetland delineation and biological resources evaluation (**Appendix A** and **Appendix B**);
- revised geotechnical evaluation (**Appendix C**);
- revised trails and interpretive resource evaluation (**Appendix D**);
- evaluation of evapotranspiration and climate change on water availability (**Appendix H**);
- public outreach meetings on October 20, 2021 and April 21, 2022;
- permitting considerations matrix (**Appendix I**);
- project cost estimates (**Appendix J**).

JEWEL LAKE STUDY: RESTORATION AND PUBLIC ACCESS FEASIBILITY  
FOR WILDCAT CREEK'S JEWEL LAKE REACH

For clarity and brevity, not all of the above work is addressed in depth here. Independent technical memoranda are included as appendices.

## 2 PHYSICAL SETTING AND SITE CHARACTERISTICS

### 2.1 Project Location

The Wildcat Creek watershed is located mainly in Contra Costa County, in the Berkeley Hills region (**Figure 2-1**). The Wildcat Creek watershed includes portions of the cities of Oakland, Berkeley, El Cerrito, San Pablo, and Richmond, and drains into San Pablo Bay. The lower portion of the watershed flows across the largely urbanized Wildcat Creek alluvial fan. Most of the Wildcat Creek watershed upstream of Jewel Lake is contained within Tilden Regional Park (**Figure 2-1**). Approximately 1.5 miles upstream of the project site, Charles Lee Tilden Dam impounds water and sediment to form Lake Anza.

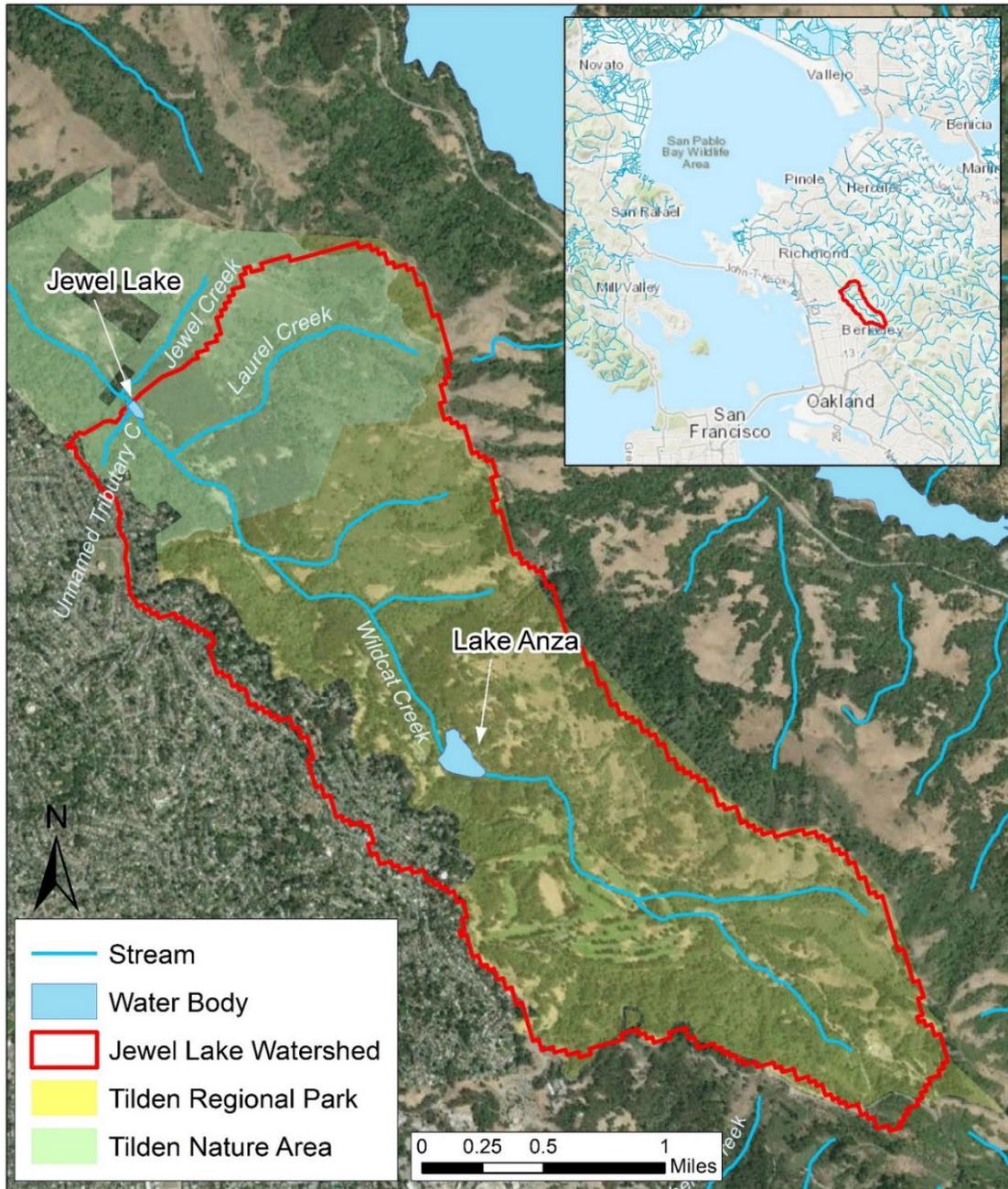
Jewel Lake is located in the Tilden Nature Area, which is in the upper canyon portion of the Wildcat Creek watershed, (**Figure 2-1**). Originally built in 1921 as a drinking water reservoir, it now serves as a resource for a variety of wildlife species and the thousands of visitors who come to the Tilden Nature Area annually. The Tilden Nature Area is a 740-acre preserve located at the north end of Tilden Regional Park. The Tilden Nature Area includes popular hiking trails, the historic Little Farm, and the Environmental Education Center, which is the headquarters for the area's interpretive program. Jewel Lake is an easy walk from the Environmental Education Center and provides a beautiful setting which provides excellent recreational and educational opportunities.

The Project site is roughly defined by the valley bottom along Wildcat Canyon, extending from approximately 2000 feet upstream of Jewel Dam to about 1000 feet downstream of Jewel Dam (See **Plate 1**).

There are several adjacent or nearby hydrologic features that influence Jewel Lake. Within the Project site there are many tributaries that join Wildcat Creek from smaller side canyons (**Plate 1**). The largest tributary is Laurel Canyon, which joins Wildcat Creek from the east along the Jewel Lake delta upstream of the dam. Jewel Creek, which runs from the east, passes through a culvert under Wildcat Canyon Trail before joining Wildcat Creek immediately downstream of the spillway. A smaller unnamed tributary is located directly west of the dam and drains to Wildcat Creek just downstream of Jewel Dam in the spillway plunge pool; this unnamed tributary has an alluvial/colluvial fan associated with it that forms a prominent slope to the west of Jewel Lake and has the potential to jump its bank and flow directly into Jewel Lake (**Plate 1**). We have labelled this unnamed

JEWEL LAKE STUDY: RESTORATION AND PUBLIC ACCESS FEASIBILITY  
FOR WILDCAT CREEK'S JEWEL LAKE REACH

Tributary C. Lake Anza is located 1.5 miles upstream and impacts both sediment and the streamflow to Jewel Lake.



**Figure 2-1 Jewel Lake and the upper Wildcat Creek watershed.** Note that a majority of the watershed upstream of Jewel Lake is within the Tilden Nature Area and Tilden Regional Park.

## 2.2 Geology

We are using geology and soils information to plan for future site evolution, and to create designs that are resilient to possible earth movement, bank slumps, and expected sediment carried by tributaries.

Rockridge Geotechnical conducted a preliminary field investigation and prepared a technical memorandum which is presented in **Appendix C**.

The geology of the Jewel Lake site is dominated by rocks of the Orinda Formation, a Tertiary age (10 to 12 million years old) series of sedimentary rocks (See Project Geotechnical Memorandum, **Appendix C, Figure 1**). Wildcat Creek has cut a prominent canyon just east of the frontal flanks of the Berkeley Hills along the trace of the Wildcat Fault. The active Hayward fault lies on the western side of the Berkeley Hills and trends northwest, similar to the older suspected dormant Wildcat fault. This complex geology and the highly erodible and poorly lithified nature of the Orinda Formation rocks play a large role in the sediment production and delivery to Wildcat Creek. Several prominent fans and landslide deposits are found where tributaries enter Wildcat Creek.

Underlying the Orinda Formation, Older Franciscan Complex bedrock is exposed as outcrops in the site vicinity and are probably composed of mélangé units characteristic of most of the fault zones in the Bay Area.

## 2.3 Site History

Historical photographs captured during Jewel Lake construction and in the years following, as well as a detailed summary of the site history as it relates to the proposed concept designs, will be presented in the Feasibility Report.

A number of historic structures assumed to be constructed under the Works Progress Administration (c. 1936 to 1942) are located in the vicinity of the project. These include the Wildcat Canyon Trail bridge that crosses Wildcat Creek near the Little Farm, the headwall on the Wildcat Canyon Trail where it crosses Jewel Creek, the Jewel Lake restroom building and a small stormwater outfall directly adjacent to the Jewel Lake restrooms and Jewel Lake.

## JEWEL LAKE STUDY: RESTORATION AND PUBLIC ACCESS FEASIBILITY FOR WILDCAT CREEK'S JEWEL LAKE REACH

Nguyen (1991) estimated that Jewel Lake had a capacity of approximately 45,000 cubic yards when constructed and has been partially dredged twice since construction necessitated the reservoir trapping much of the sediment transported into the lake from upstream.

The first dredging procedure occurred during the fall of 1967. In 1967, prior to dredging, the remaining lake capacity was reported to be approximately 9,450 cubic yards (FlowWest, 2016). Dredging in 1967 was accomplished with a crane and trucks and removed approximately 6,000 to 8,000 cubic yards (Pitchford and Pitchford, 1990) of wet sediment which was transported to a spoils site approximately 2,000 feet north of Jewel Lake.

As a preventative measure after dredging, an upstream sediment-trapping/removal pond was built in 1969 (at its current location) (Pitchford and Pitchford, 1990).

In 1991, prior to dredging, Jewel Lake had about 1 acre of open water surface area. Hydraulic dredging methods were used to pump approximately 9,900 cubic yards (Nguyen, 1991) to a constructed settling lagoon at the same spoils site that was used in 1967. 1991 dredging expanded the lake to approximately 1.4 acres (Nguyen, 1991).

Currently (2021), Jewel Lake has a surface area of approximately 0.8 acres, during the winter, when the lake is just spilling over the spillway. The sediment accumulation zone extends substantially upstream and laterally from the original Jewel Lake footprint.

### 2.4 Biological Resources

Jewel Lake, Wildcat Creek and its adjacent woodlands support many biological resources of local, regional, and statewide sensitivity. Despite its artificial origin and alteration of Wildcat Creek hydrology and vegetation dynamics in the early 20<sup>th</sup> century, Jewel Lake is currently a natural environment that attracts a large number of visitors, many of whom travel to the area specifically to view wildlife at the lake and riparian boardwalk area. Much of the study area is composed of vegetation communities or aquatic resources that are regulated under federal and state law. Although it is not expected to support any species listed under the Federal Endangered Species Act (FESA) or California Endangered Species Act (CESA), it supports several California Species of Special Concern (e.g., Western Pond Turtle, San Francisco dusky-footed woodrat) and a diverse community of riparian birds. In addition, the site provides roosting habitat for two

## JEWEL LAKE STUDY: RESTORATION AND PUBLIC ACCESS FEASIBILITY FOR WILDCAT CREEK'S JEWEL LAKE REACH

special-status bat species. Future environmental documentation and permitting for the Project will need to address these topics in detail. That said, with proper planning and incorporation of regional conservation planning guidelines and principles for the affected resources (RHJV, 2004, BAOSC, 2019), the goal is that the Project will result in an overall long-term benefit for the Wildcat Creek watershed and ecosystem. The existing biological resources are described in more detail in **Appendix A**.

The Team has prepared the Project aquatic resources delineation, which is included as **Appendix B** in this report to facilitate evaluation of impacts and comparison of the proposed concepts during subsequent phases of the Project.

### 2.5 Hydrologic Summary

Wildcat Creek is located in the San Francisco Bay Area, which is characterized by a Mediterranean climate with cool, wet winters and warm, dry summers. Average annual rainfall at Jewel Lake is approximately 26 inches (PRISM, 2015).

Historic and ongoing land uses within the watershed, including cattle grazing, timber harvesting, road and trail construction, golfing, and suburban housing have increased runoff amounts and rates compared to pre-development conditions. Increased runoff results in higher peak flows and greater erosive power. It is assumed that the development and added impervious areas associated with the Regional Park and Lake Anza has not substantially altered the hydrology at the site because Lake Anza is relatively small, and that water is generally passed through the reservoir during most conditions. Sediment accumulation within Lake Anza has likely changed sediment transport and the geomorphology of the creek channel between Lake Anza and Jewel Lake.

#### 2.5.1 RAINFALL

**Figure 2-2** presents cumulative annual rainfall data between water year<sup>2</sup> 2006 and September 2024 from Contra Costa County's "Tilden Park Gage" downloaded from the California Data Exchange Center (CDEC) which is located at Vollmer Peak, the highest point in the Wildcat Creek watershed. The recent mean annual precipitation *for that*

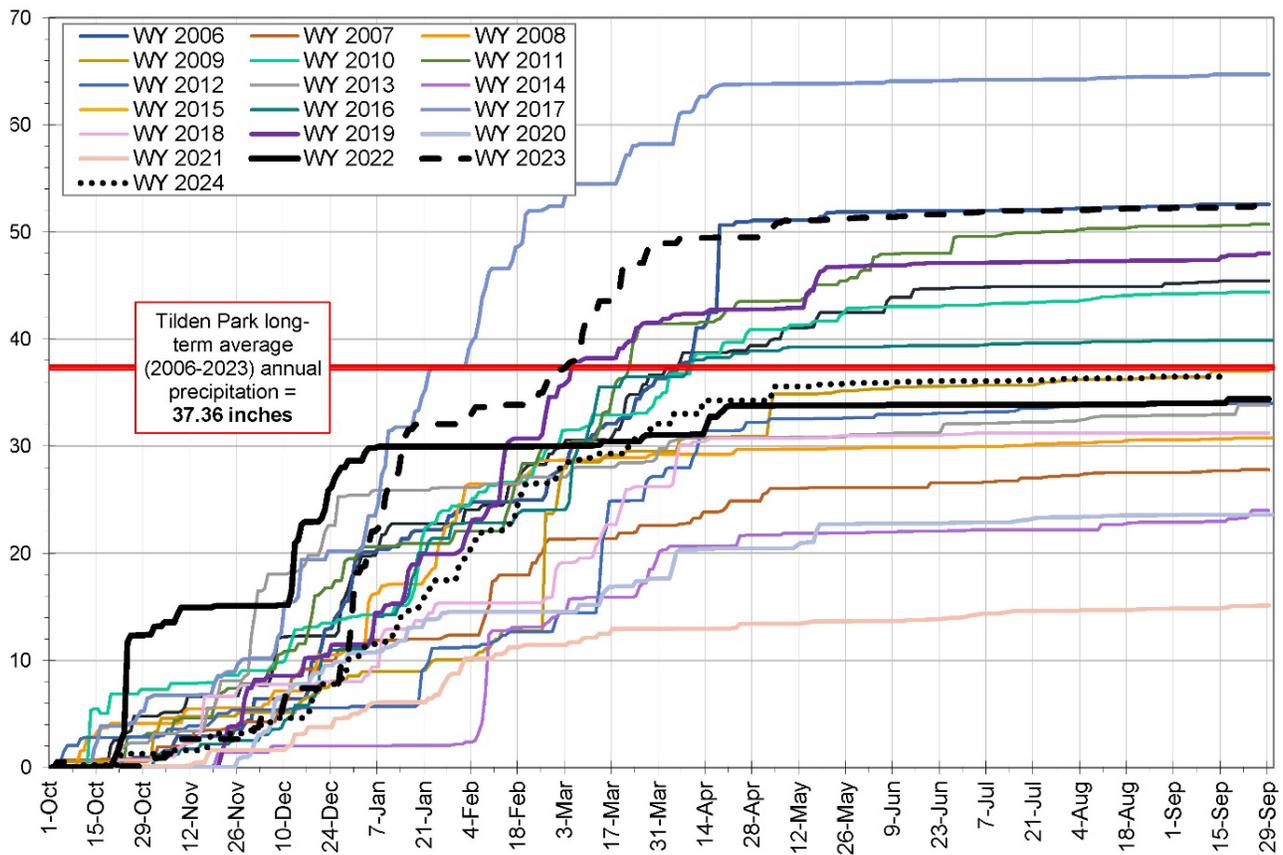
---

<sup>2</sup> A water year describes a hydrologic year which extends from October 1 to September 30 and is named according to the year in which it ends. For example, water year 2020 described the water year between October 1, 2019, and September 30, 2020.

JEWEL LAKE STUDY: RESTORATION AND PUBLIC ACCESS FEASIBILITY  
FOR WILDCAT CREEK'S JEWEL LAKE REACH

period of record is approximately 37 inches at the high point of the watershed. Contra Costa County Department of public works estimates the *long-term* mean annual rainfall at Vollmer Peak to be about 32.5 inches (highest in the county) for the period between 1879 and 1973 (Boucher, 2011).

When compared to the *recent* period of record for rainfall at Vollmer Peak, water year 2020 was the second driest water year with only 23.6 inches of rainfall. Water year 2021 was the driest year on record with only 15.2 inches of rainfall; water year 2022 experienced near-average rainfall of 34.4 inches; water year 2023 experienced the third highest rainfall with 52.4 inches, and water year 2024 (through middle of September 2024) experienced near-average rainfall of 36.5 inches.



**Figure 2-2** Cumulative daily precipitation, Vollmer Peak in Tilden Park, Contra Costa County, California, water years 2006 through 2024 (partial)

## JEWEL LAKE STUDY: RESTORATION AND PUBLIC ACCESS FEASIBILITY FOR WILDCAT CREEK'S JEWEL LAKE REACH

### 2.5.2 HYDROLOGIC OBSERVATIONS, WATER YEARS 2020 AND 2021

Sections of Wildcat Creek go dry during the late summer and fall months during most years. Jewel Lake rarely dries out *completely* (even if there is no inflow and spilling has stopped). Prior to release of water from Lake Anza in October 2020<sup>3</sup>, the surface area of Jewel Lake was very small. **Figure 2-3** presents a photograph taken of Jewel Lake on July 30, 2020.

Balance staff visited the site during the water year 2021 wet season. Balance staff visited the site during October, November, and December as part of the site assessment. Our hydrologic observation log is presented in **Appendix E**. **Figure 2-4** presents a map of the site and relevant tributaries for the hydrologic study.

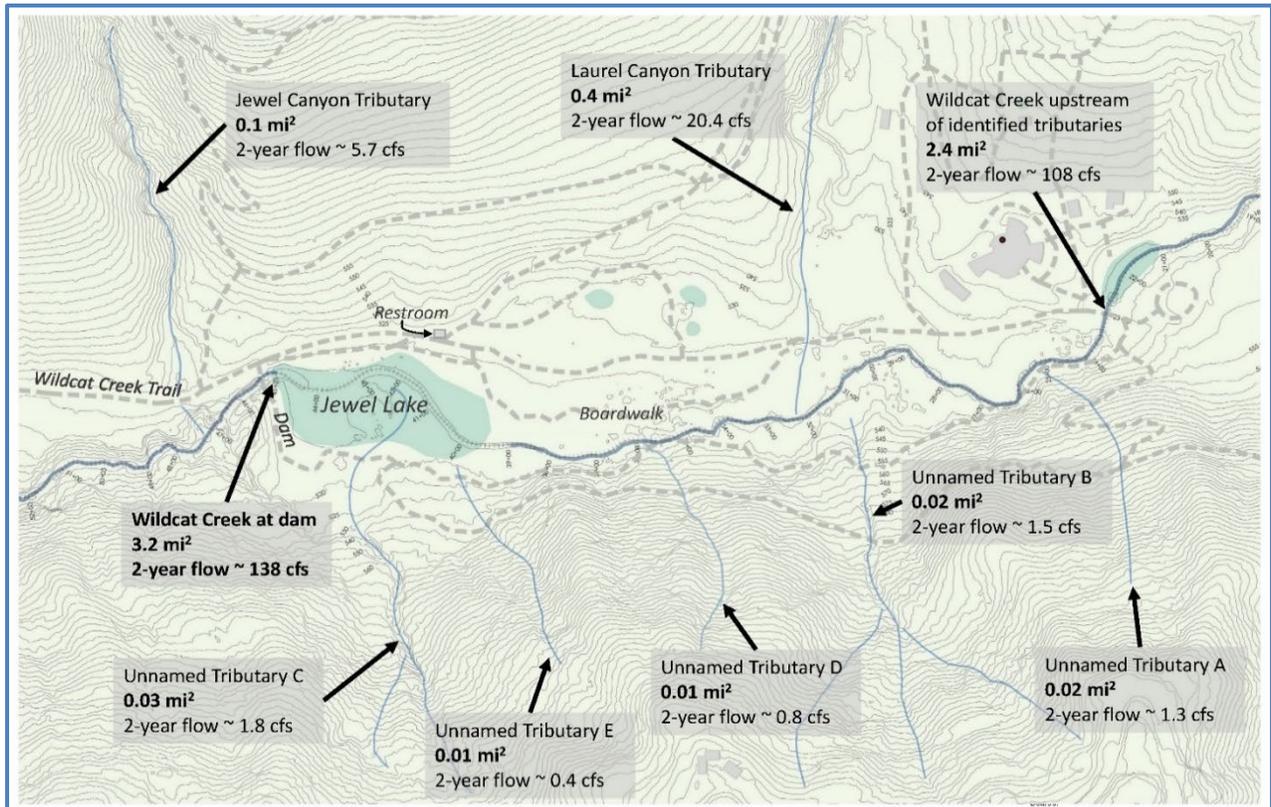


**Figure 2-3** Jewel Lake, July 30, 2020. Low lake levels after a very dry water year 2020.

---

<sup>3</sup> We understand that water is released from Lake Anza in the fall for maintenance purposes.

JEWEL LAKE STUDY: RESTORATION AND PUBLIC ACCESS FEASIBILITY  
FOR WILDCAT CREEK'S JEWEL LAKE REACH



**Figure 2-4 Wildcat Creek tributaries in the vicinity of Jewel Lake.** Jewel Lake, shown schematically (the green area includes riparian and open-water area). The 2-year flow estimates are based on USGS StreamStats (<https://streamstats.usgs.gov>)

Additional observations taken during a more normal rainfall year would help evaluate the hydrology of Wildcat and the relevant tributaries at the Project site, however these preliminary observations suggest that water supplied to the site from tributaries is limited and may not be a reliable source for perennial wetland features, however they may still support constructed seasonal wetland features.

### 2.5.3 STORM FLOWS AND DAILY FLOW

Because there is no site-specific flow data for this section of Wildcat Creek, we used adjusted data from downstream, to estimate flow for storms, fish-passage, and sediment transport.

## JEWEL LAKE STUDY: RESTORATION AND PUBLIC ACCESS FEASIBILITY FOR WILDCAT CREEK'S JEWEL LAKE REACH

Streamflow on Wildcat Creek has been measured downstream of the Project in Richmond, CA at two locations and over three time periods:

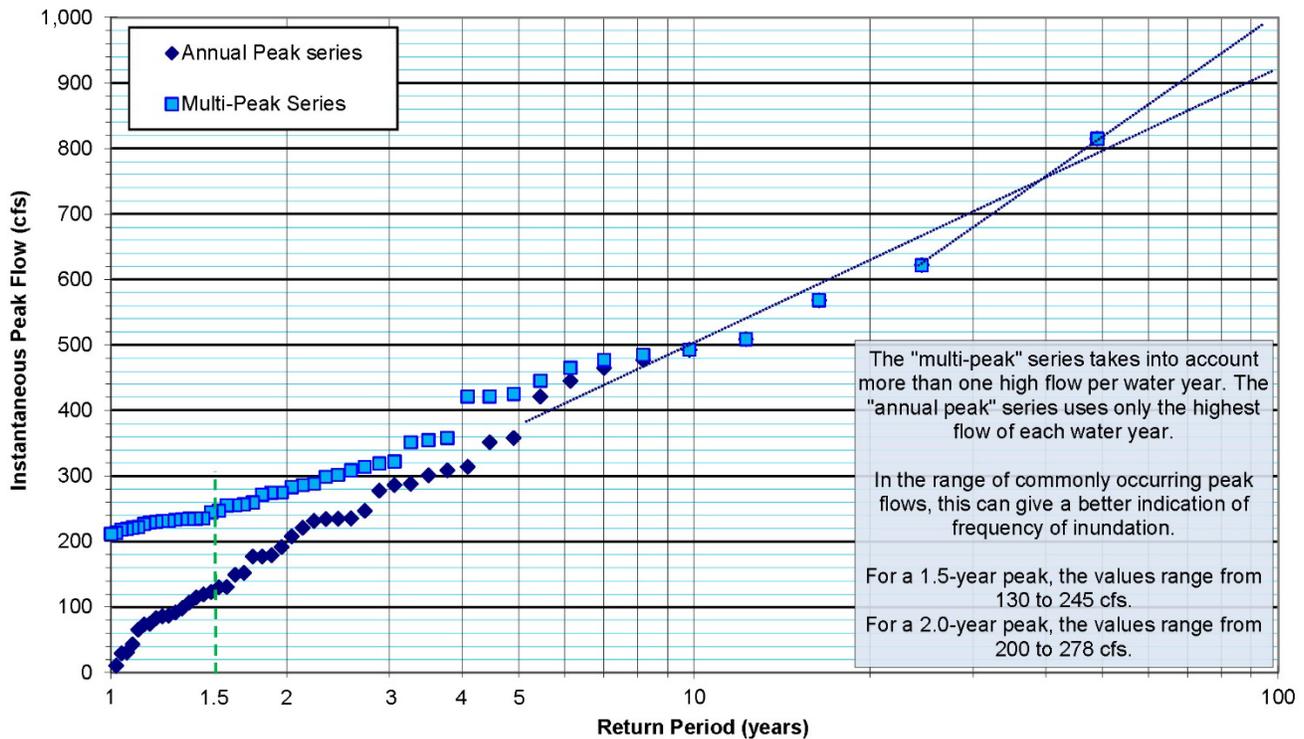
- by USGS near the Southern Pacific rail tracks -1965 – 1975 (ID# 11181400);
- by USGS at Vale Road - 1976 – 1996 (ID# 11181390);
- by Balance Hydrologics at Vale Road - 2006 to present.

Return periods of annual peak flows for Wildcat Creek at Jewel Lake were estimated by scaling the downstream Wildcat Creek flow data by watershed area. The Jewel Lake watershed is less than half the size of the Vale watershed. These return periods, in the form of annual-peak series and "multi-peak" series<sup>4</sup>, can be seen in **Figure 2-5**.

---

<sup>4</sup> Multi-peak series is sometimes called a partial-duration series. Multi-peak series include multiple peak storm flows per year. Multi-peak is used here because of its descriptiveness. Including multiple peaks per year demonstrates that annual peak series often underestimate the frequency of lower magnitude events. In other words, multi-peak series help visualize that during wet years when we typically see larger flows, we also typically see more moderate events that perform geomorphic "work". The difference between multi-peak series and annual peak series becomes inconsequential above approximately the 5-year recurrence flow (Langbein, 1949).

JEWEL LAKE STUDY: RESTORATION AND PUBLIC ACCESS FEASIBILITY  
FOR WILDCAT CREEK'S JEWEL LAKE REACH



**Figure 2-5** Return periods of annual peak flows: Wildcat Creek at Jewel Lake, Contra Costa County, California. The annual peak flows that have occurred over the period of gaging are ranked and then plotted based on their calculated return period (a measure of how frequently a peak flow of that size is likely to recur).

Peak-flow recurrence was also estimated for Wildcat Creek and tributaries in the vicinity of Jewel Lake (**Figure 2-4**) by using USGS regional regression equations developed for the North Coast (Region 1) of California by the USGS (Gotvald, et al, 2012). Using calculated watershed areas and mean annual precipitation data, 2-, 5-, 10-, 25-, 50-, and 100-year recurrence flows were calculated for identified tributaries (**Table 2-1**). **Table 2-2** presents the flow recurrence estimates derived using Gotvald (2012), estimates scaled by drainage area from the stream gage at Vale Road for both the annual-peak and multi-peak flow estimates<sup>5</sup>.

<sup>5</sup> The drainage area at Vale Road is approximately 7.4 square miles and the drainage area at Jewel Lake is approximately 3.2 square miles, therefore a scaling ratio of 0.40 was used.

JEWEL LAKE STUDY: RESTORATION AND PUBLIC ACCESS FEASIBILITY  
FOR WILDCAT CREEK'S JEWEL LAKE REACH

**Table 2-1 Recurrence-interval flow table for Wildcat Creek and local tributaries.**  
We are comparing these flow values to channel features we see at the site and to design Project features, to resist erosion at high flow. We use the 1.5 and 2-year peak flows as reference points from which to design over-bank features and floodplains.

<b>USGS Regional Regression Equations</b>									
Estimated using USGS Regional Regression equations developed for North Coast (Region 1) of California by the USGS (Gotvald, et al, 2012)									
	<i>upstream</i>							<i>downstream</i>	
	Wildcat Creek upstream of identified tributaries	Laurel Canyon tributary	Unnamed tributary (A)	Unnamed tributary (B)	Unnamed tributary (D)	Unnamed tributary (E)	Unnamed tributary (C)	Wildcat Creek at Jewel Lake Dam	Jewel Canyon tributary
Drainage Area (mi <sup>2</sup> ) =	2.4	0.4	0.02	0.02	0.01	0.01	0.03	3.2	0.1
Mean Annual Precipitation (in/yr) =	28.4	27.2	27.2	27.2	27.2	27.2	27.2	28	26.7
<b>North Coast (Region 1)</b>									
2 Year Peak Flow (cfs)	108	20	1	2	1	0	2	138	6
5 Year Peak Flow (cfs)	233	46	3	4	2	1	4	298	13
10 Year Peak Flow (cfs)	328	66	5	5	3	2	6	419	19
25 Year Peak Flow (cfs)	455	93	7	8	4	2	9	580	28
50 Year Peak Flow (cfs)	558	114	8	9	5	3	11	711	34
100 Year Peak Flow (cfs)	665	138	10	11	6	4	14	847	41
<b>2 Year Peak Flow (cfs) =</b>	<b>108</b>	<b>20.4</b>	<b>1.3</b>	<b>1.5</b>	<b>0.8</b>	<b>0.4</b>	<b>1.8</b>	<b>138</b>	<b>5.7</b>

**Table 2-2 Recurrence flows calculated using three methods.** Because site-specific flow data are not available, we present a range of flow values to be used to inform the design based on USGS regression equations (Gotvald, 2012) and annual and multi-peak recurrence flow data scaled from Wildcat Creek at Vale Road. Multi-peak series are shown for more frequent flows to more accurately represent the possible range of expected flows.

<i>Wildcat Creek at Jewel Lake Dam Peak Flows</i>			
	Using USGS North Coast regional regression equations	Using WC creek at Vale data scaled to Jewel Lake (Annual peak series)	Using WC creek at Vale data scaled to Jewel Lake (Multi-peak series)
2-Year Peak Flow (cfs)	138	200	279
5-Year Peak Flow (cfs)	298	360	429
10-Year Peak Flow (cfs)	419	490	494
25-Year Peak Flow (cfs)	580	622	n/a
50-Year Peak Flow (cfs)	711	815	n/a
100-Year Peak Flow (cfs)	847	1,000	n/a

#### 2.5.4 FISH-PASSAGE FLOWS

Steelhead trout (*O. mykiss*) are the anadromous (sea-run) form of rainbow trout believed to have been extirpated from the Wildcat Creek watershed sometime after 1915 (Leidy and others, 2005). Winter-run steelhead are at or near sexual maturity at 2 to 3 years of age, when they return to freshwater during late fall and winter, and spawn from late December through April, with the peak between January and March (Leidy and others, 2005).

Resident (non-anadromous) trout occupies most reaches of Wildcat Creek, though their populations are more robust in the upper reaches of the main stem, within Wildcat Canyon (Urban Creeks Council, 2010).

To assess the relevant stream flows for fish-passage considerations, we ranked daily mean streamflow values from water years 1976-1996 and 2006-2019 according to defined fish-passage flows for various species and life stages (**Figure 2-6**). Similar to recurrence flows, we scaled data from Wildcat Creek at Vale to Jewel Lake by watershed area before use in the fish-passage analysis.

Fish-passage flows for Wildcat Creek based on criteria established in the California Department of Fish and Wildlife (CDFW) Design Manual (CDFW, 2009) are illustrated in **Figure 2-6** and summarized in **Table 2-3**.

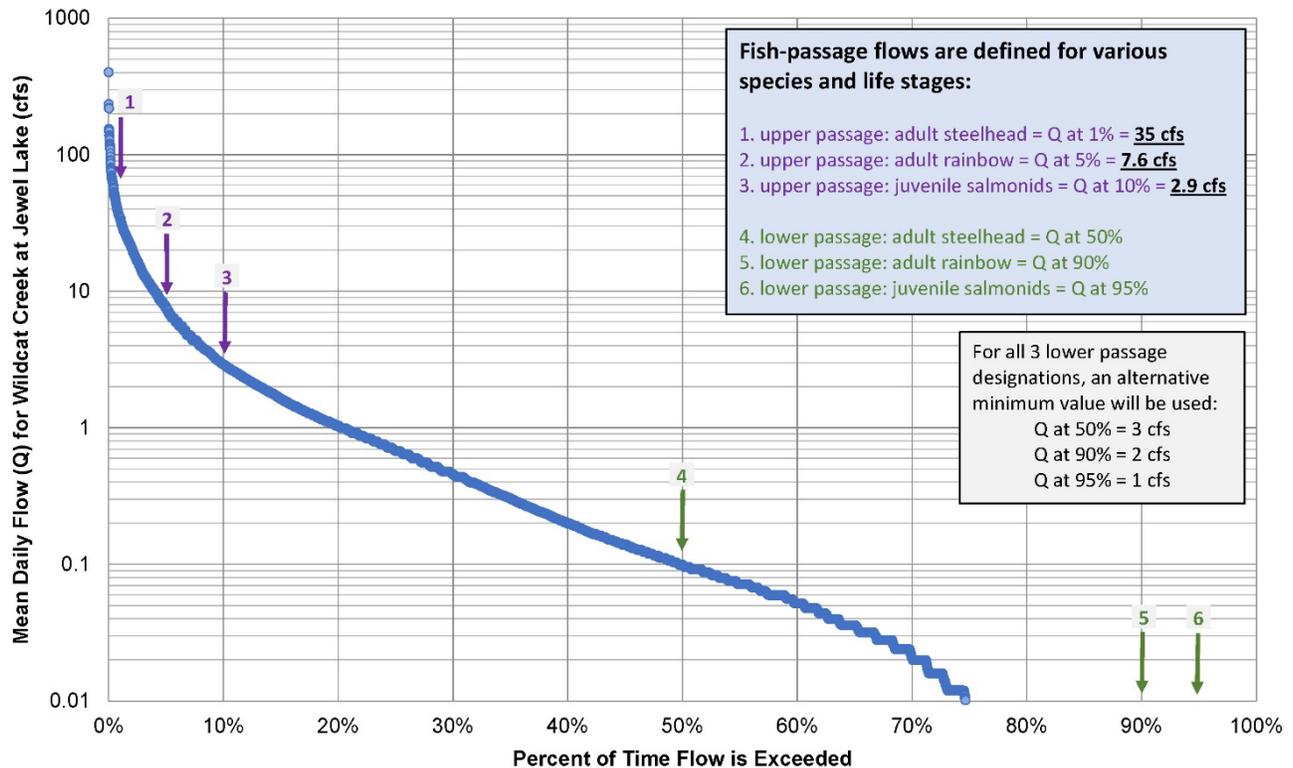
CDFW recommends application of upper and lower fish passage flows to estimate the upper and lower migration flows for analysis of designed channels. When calculated lower passage flow ( $Q_{lp}$ ) for juveniles and adults are below threshold values, the CDFW recommends that alternative minimum discharges of 1 cfs and 3 cfs, respectively, be used to evaluate passage, as shown in **Table 2-3**.

For Wildcat Creek, the calculated lower passage flows (adult and juvenile) fall under the minimum passage thresholds, as is typical for streams of this size, so use of alternative minimum values will likely be required for fish passage analysis.

Based on the CDFW fish passage criteria, the preferred concept should target unimpeded fish passage between approximately 1 cfs and 35 cfs.

JEWEL LAKE STUDY: RESTORATION AND PUBLIC ACCESS FEASIBILITY  
FOR WILDCAT CREEK'S JEWEL LAKE REACH

It should be noted that the Wildcat Creek at Vale is located on the alluvial fan downstream of the mouth of Wildcat Canyon, and that base flow at Vale Road likely infiltrates into the creek bed differently than at the Project site and therefore flow correlations from Vale Road likely underestimate flows in Wildcat Creek in the vicinity of Jewel Lake at lower flows. Direct flow measurements at the Project site could improve the correlation of low flows between Wildcat Creek at Vale and the Project site.



**Figure 2-6** Ranked Daily Mean Streamflow (water years 1976-1996 and 2006-2019): Wildcat Creek at Jewel Lake. This plot graphically shows how percentile flows are ranked, and then calculated. 13,150 days of data were used. These flow values aid in designing fish-passage features, as well as conceptualizing time-of-year operations for the bypass-channel concept.

**Table 2-3 CDFW Criteria for Hydraulic Design**

<b>Adult Steelhead/Rainbow</b>	<b>CDFW Recommended Criteria and Site-specific Flows</b>	
(1) Upper Passage Flow - Steelhead	35 cfs	(Q at 1%) <sup>6</sup>
(2) Upper Passage - Rainbow Trout	7.6 cfs	(Q at 5%)
(4) Lower Passage Flow (Q <sub>lp</sub> )	3 cfs	(Q at 50% or 3 cfs min.)
(5) Lower Passage Flow – Rainbow Trout	2 cfs	(Q at 90% or 2 cfs min.)
Minimum Adult Water Depth	1.00 ft	
Maximum Adult Water Velocity	5.00 ft/s	
Maximum Adult Outlet Drop	1.00 ft	
<b>Juvenile Salmonids</b>		
(3) Upper Passage Flow	2.9 cfs	Q at 10%
(6) Lower Passage Flow	1 cfs	(Q at 95% or 1 cfs min.)
Minimum Juvenile Water Depth	0.50 ft	
Maximum Water Velocity	1.00 ft/s	
Maximum Outlet Drop	0.50 ft	

Note: Numbering refers to arrows in **Figure 2-6**

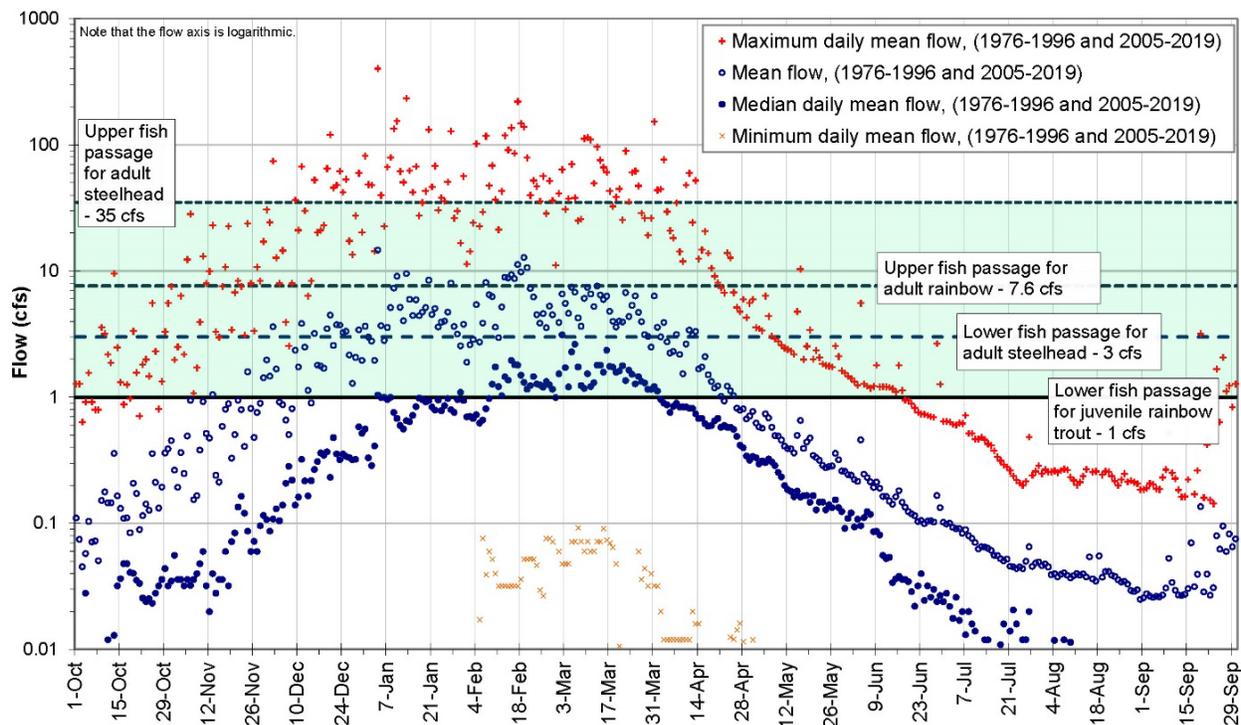
Maximum, mean, minimum and median daily flows scaled for Jewel Lake from the Vale Road record for the 1976-1997 and 2005-2019 records is presented in **Figure 2-7**. Based on the Vale Road correlated data, median flow, which is a reasonable approximation for typical baseflow, suggests that flow in Wildcat Creek at Jewel Lake typically exceeds 1 cfs (Lower Fish Passage flow for steelhead) from approximately mid-February to early April, but that baseflow rarely exceeds 2 cfs (Lower Fish flow for adult rainbow trout) and 3 cfs (Lower Fish Passage flow for steelhead, shown in **Figure 2-7**).

The minimum flow data presented in **Figure 2-7** should be noted; dry years may have much lower creek flow than the median or average.

---

<sup>6</sup> Q-% is defined by the discharge (Q) that is exceeded for a certain percentage of the time, i.e., Q-50% represents a discharge that is exceeded 50 percent of the time.

## JEWEL LAKE STUDY: RESTORATION AND PUBLIC ACCESS FEASIBILITY FOR WILDCAT CREEK'S JEWEL LAKE REACH



**Figure 2-7** Maximum, Mean, Median and Minimum daily stream flows (Water Years 1976-1996 and 2006-2019): Wildcat Creek at Jewel Lake. Upper and lower fish passage flows are shown on the plot and show the approximate range of flows for which fish passage should not be impeded. Data are scaled from the Vale Road gaging station.

### 2.5.5 EVAPOTRANSPIRATION AND CLIMATE CHANGE

After publication of the Draft Feasibility Memorandum in July 2021, Balance was asked to evaluate the potential changes to evapotranspiration between the four proposed concepts and evaluate whether climate change could be a differentiating factor in selecting a preferred alternative (**Appendix H**). Findings of that analysis are summarized below:

- The four different concepts affect overall availability of water to Wildcat Creek to varying degrees
- Concept 3 would likely reduce evapotranspiration water loss and could extend baseflow to the channel downstream of the site by approximately five days to two weeks, when compared to the other concepts.

- Concept 3 is expected to reduce the stream's temperature of Wildcat Creek, downstream of Jewel Lake reach, compared to current conditions and the other concepts.
- The expected differences in evapotranspiration between the concepts would be more important during drought years and drought years are expected to be more common in the future.
- Because uncertainty associated with climate change surrounding evapotranspiration and rainfall remains, climate-change factors appear to be low-order differentiators between the four concepts.

## 2.6 Preliminary Hydraulic Model

Balance developed a preliminary 2-dimensional hydraulic model using HEC-RAS software v5.07 to illustrate potential existing conditions flow paths, velocities and inundation areas for a range of flows in Wildcat Creek. The model was built using the 2019 LiDAR surface supplemented with estimated lake bathymetry<sup>7</sup>. The model uses peak flow data scaled from the Vale Road gage and is not explicitly calibrated due to the lack of local flow data and ambiguity associated with high water marks observed at the site. Flow data were not adapted to evaluate climate change scenarios. Those results highlighted a number of hydraulic characteristics, as listed below, that influence restoration design and feasibility. Screen captures of the model output are shown in **Appendix F**. Model output indicates the following:

- During 2-year flows, the floodplain is likely engaged in lower areas, particularly within the area of the proposed project. Field site visits during the fall of 2020 suggest the model reasonably portrays lowland inundation areas and existing side channels.
- During 10-year flows, much of the valley bottom is inundated. Velocities in Jewel Lake range from approximately 0.2 to 4 feet/sec and floodplain flow velocities range from approximately 0 to 1 feet/sec.

---

<sup>7</sup> Model was built prior to receiving 2014 Jewel Lake bathymetric data, but bathymetric data has little impact on hydraulic model results when the lake is full and spilling.

## JEWEL LAKE STUDY: RESTORATION AND PUBLIC ACCESS FEASIBILITY FOR WILDCAT CREEK'S JEWEL LAKE REACH

- During 25-year flows, velocities in Jewel Lake range from approximately 0.2 to 4 feet/sec and floodplain flow velocities range from 1 to 2 feet/sec.
- During 100-year flows, velocities in Jewel Lake range from approximately 1 to 6 feet/sec and floodplain flow velocities range from 1 to 3 feet/sec. Wildcat Canyon Trail does not appear to become inundated at the 100-year flow.

### 2.7 Sediment Transport

We used a multi-prong approach to investigate sediment-transport processes and rates. Because sediment transport rates vary greatly depending on the amount of flow in Wildcat Creek, different proposed concepts will interact with creek sediment in different ways, and different types (sizes) of sediment behave differently within the concept options. Some questions that we wanted to be able to answer about sediment transport are:

- How quickly does Wildcat Creek bring sediment to Jewel Lake?
- For Concept 4, the bypass-channel option, how much sediment would be bypassed vs. how much sediment could end up in the lake?
- How will sediment carried downstream of Jewel Lake be affected by different options?

The three functional types/classes of sediment that we considered are:

- Bedload sediment – gravel and coarse sand – which slides and hops along the creek bed.
- Coarse suspended sediment – sand -- greater than 63 microns – which is suspended in the water column at high flow but settles out quickly when water slows.
- Fine suspended sediment – less than 63 microns - silt and clay – which is suspended in the water column and moves at the velocity of creek flow, settles out slowly.

## JEWEL LAKE STUDY: RESTORATION AND PUBLIC ACCESS FEASIBILITY FOR WILDCAT CREEK'S JEWEL LAKE REACH

We looked at these types of sediment in conjunction with their associated processes, and historical flow data. Processes vary along the Jewel Lake section of Wildcat Creek, largely as flow changes over time and as velocity, depth, and width change along the creek, through the delta area, and into the open-water section of lake.

In order to quantify estimates of sediment rates, we considered sediment processes at several spatial and temporal scales:

- small spatial scale – sediment basin and boring locations;
- continuum channel scale – bank height changes and floodplain inundation changes from upstream to downstream through Jewel Lake reach;
- medium to long time scale – lake-filling rates from dredging and bathymetry records;
- downstream sediment data – USGS and Balance Hydrologics sediment transport measurements at Vale Road;
- timescales of water years based on creek gaging records, integrating high and low flows over wet and dry years.

In general, it appears that:

- Almost all sand and gravel sediment brought to Jewel Lake settles out in the lake.
- Silt and clay settle out in areas of slow or ponded water, such as the riparian floodplain near the boardwalk area, but much of the silt- and clay-sized sediment washes over the spillway without settling (particularly during high flow).
- The channel bank height/floodplain height is higher upstream than close to the lake, and seems to be gradually increasing; thus, the rate of sediment being delivered to the lake may be increasing slowly as the floodplain is inundated less frequently.
- Under current conditions, the small, dredged area of Jewel Lake has taken approximately 24 to 30 years (following dredging) to become mostly refilled with sediment (possibly being partially offset by sediment removal at the Little Farm sediment basin).

## JEWEL LAKE STUDY: RESTORATION AND PUBLIC ACCESS FEASIBILITY FOR WILDCAT CREEK'S JEWEL LAKE REACH

### 2.7.1 INTERPRETING SEDIMENT PROCESSES: SEDIMENT BASIN AND JEWEL LAKE BORINGS

Balance collected shallow hand-auger samples to inspect the character of sediment deposited at:

- The sediment basin (just prior to the Fall 2020 sediment removal operation);
- the Jewel Lake delta within the distributary channel system (to evaluate the character of the active bedload); and
- out of the channel on floodplain areas (to evaluate overbank deposition).

A photo of representative material from within the sediment basin is presented in **Figure 2-8**. A map of the borehole locations is presented in **Figure 2-9**, and borehole logs are presented in **Figure 2-10**.



**Figure 2-8** Sediment samples from the sediment basin located at the Little Farm (left) and in a distributary channel on the Jewel Lake delta (right). These samples suggest that the dominant active bedload consists of sands and gravels.

JEWEL LAKE STUDY: RESTORATION AND PUBLIC ACCESS FEASIBILITY  
FOR WILDCAT CREEK'S JEWEL LAKE REACH

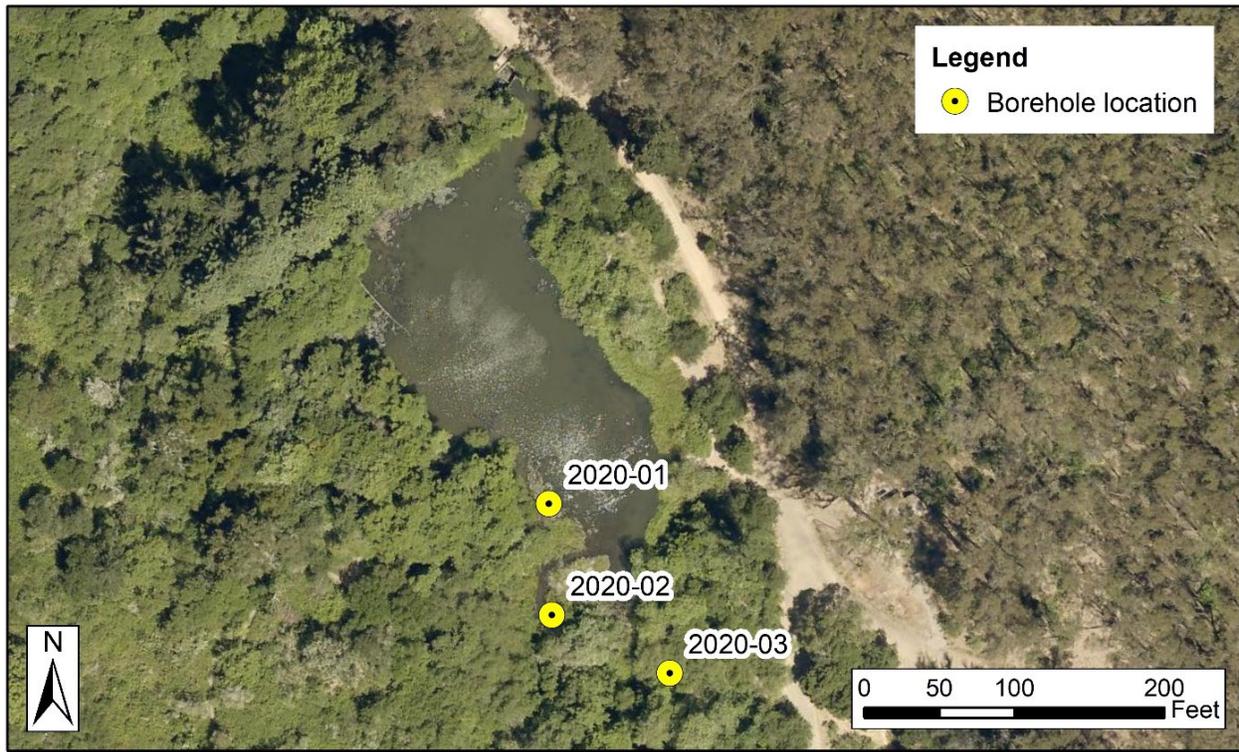


Figure 2-9 Map of Jewel Lake delta hand-auger boreholes 2020-01, 2020-02, 2020-03.

JEWEL LAKE STUDY: RESTORATION AND PUBLIC ACCESS FEASIBILITY  
FOR WILDCAT CREEK'S JEWEL LAKE REACH

Depth bgs. (ft):	2020-01	2020-02	2020-03
	Near lake margins, middle of delta	Gravel bar next to historic channel	Low area/wetland, eastern margin of delta
	Approx ground elevation (NAVD88):		
	515.5 ft	516.0 ft	515.5 ft
0- 1	Silty clay; brown	Predominantly gravel and sand; hit water at 18"; similar material as found in the sediment basin.	Clayey-silts, no sand; grayish brown; hit water at 10-12"
1- 2	Interbedded silty clays and silty sands; brown		Clayey-silts; grayish brown; lots of rusty mottling (root staining)
2- 3			
3- 4	Silty sands; blue/gray		Clayey-silts; grayish; anaerobic shell
4- 5		Clayey-silts; darker gray; pieces of wood and organic material	
5- 6	Alternating silty sands and sandy silts; blue/gray		
6- 7			Silty sands; poorly graded medium sized
7- 8	finer towards bottom; some clay; blue/gray		
8- 8.5			

notes:

1. bgs = below ground surface, ft. = feet
2. Subsurface conditions have been simplified for presentation, field logs available upon request

**Figure 2-10 Subsurface logs for Jewel Lake delta hand-auger boreholes 2020-01, 2020-02, 2020-03.** Borehole data suggests that the *channel* transports primarily gravel and sand, but on the overbank floodplain areas, deposition of sands, silts and clays appear to be the dominant process as the lake fills and the Wildcat Creek delta aggrades.

## JEWEL LAKE STUDY: RESTORATION AND PUBLIC ACCESS FEASIBILITY FOR WILDCAT CREEK'S JEWEL LAKE REACH

Material that we sampled in the Little Farm sediment basin consisted primarily of gravely sands and sandy gravels; however, we found silt-dominated material in slow-water zones within the basin.

In the Jewel Lake delta, borehole number 2020-02 sampled a break-out delta channel, where we observed gravel and sand, similar to what was sampled in the sediment basin upstream. Boreholes 2020-01 and 2020-03 were taken in overbank areas near the margin of Jewel Lake and on the riparian overbank. Both 2020-01 and 2020-03 consisted of clays, silts and sands. At the depths and locations of 2020-01 and 2020-03, gravels were absent.

From the hand-auger borehole data we infer that the channel is transporting primarily sands and gravels as bedload, and floodplain deposition occurs through settling of finer sands, silts and clays on the floodplains where velocity is slower during periods of high flow.

Deeper silty and clayey layers also seem to coincide with areas of former open water when the water was deeper (easier for fine material to settle and be deposited).

Overall, the general mix of sediment sizes found in the borings seem to be split to be approximately evenly between sand and coarser vs. silt and finer.

### 2.7.2 BATHYMETRY AND DREDGING VOLUMES AND RATES

Jewel Lake serves as an efficient sediment trap for Wildcat Creek sediment. Collins et. al. (2001) and FlowWest (2016) compiled information on lake volume and the dredged material removed at various points over the lake's history. There are many volumetric time periods to compare to estimate sedimentation rates (including prior to Lake Anza in 1938). Based on comparing volumes and years from the FlowWest (2016) Table 7, lake filling rates apparently can range between 137 and 903 cubic yards per year. Because sediment processes are evolving over time, such as the height of the riparian floodplain and the amount of suspended sediment passing over the spillway, we think that the modern period since 1991 is the period that is most representative of current conditions.

## JEWEL LAKE STUDY: RESTORATION AND PUBLIC ACCESS FEASIBILITY FOR WILDCAT CREEK'S JEWEL LAKE REACH

When we compare the lake volume after 1991 dredging to the lake volume in 2013, or an estimated volume in 2021, we calculate modern, average, multi-year filling rates of approximately 300 to 400 yd<sup>3</sup>/yr<sup>8</sup>. While bathymetry comparisons can inform us about the filling of the open water area, this volumetric rate does not include sediment that is deposited on the floodplain upstream of the dam nor suspended sediment passing over the spillway. Thus, these calculated lake-filling rates are generally going to be somewhat lower than total sediment-transport rates by Wildcat Creek.

### 2.7.3 OBSERVATIONS OF BANK HEIGHT/FLOODPLAIN TRANSITION ALONG CHANNEL

As a simplification, we assume that sediment carried by Wildcat Creek goes to 4 general locations:

- Little Farm sediment basin – some sediment is trapped here – amount depends on maintenance;
- floodplain - sediment can build up on the wide, flat, wooded floodplain next to the creek channel;
- Jewel lake – sediment can settle out in the lake;
- downstream – fine sediment that does not settle out on the floodplain or in the lake would stay in the creek flow over the spillway.

We visited the site to test a theory; in an aggrading evolving delta we expected to find a deeper channel near the upstream end with the channel banks becoming gradually shallower downstream. This would mean the upper portion of the delta area is inundated less frequently and the lower end (closer to the lake) would be inundated more frequently. This theory was borne out by LiDAR data and the hydraulic modeling that used LiDAR base elevations (**Section 2.6** and **Appendix F**).

---

<sup>8</sup> These values are not meant to represent expected sediment trapping in any given year, but instead represent a 20- to 30-year long average. Wet years with large storms would likely have much higher values and dry years with no large storms would have much lower values.

In the field we observed:

- relatively fresh deposition of sediment on the floodplain surface;
- infrastructure that is slowly being buried;
- culverts that need to be ditched;
- trenches for drainage, and;
- apparent excavation around the boardwalk.

Based on these observations and data, we concluded that the sediment deposit is gradually evolving, with the floodplain gradually growing higher, which means that sediment transport to lower parts of the delta may be becoming more efficient. Thus, Jewel Lake may be filling up slightly faster over time. However, this gradual increase may be offset or partially offset by occasional/regular emptying of the Little Farm sediment basin.

#### 2.7.4 SEDIMENT TRANSPORT MEASUREMENTS

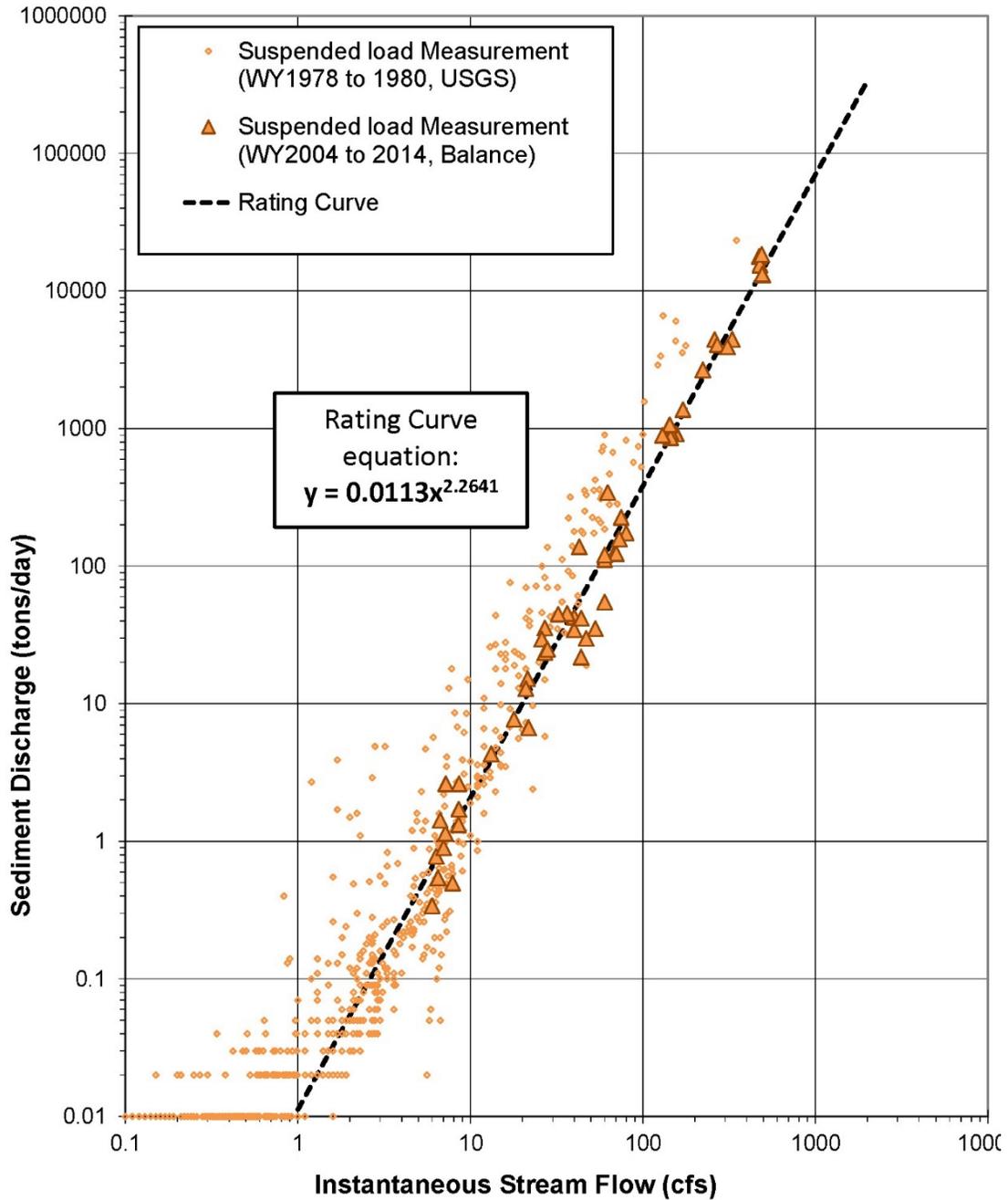
A Jewel Lake site-specific sediment transport measurement program has not been performed, but fortunately, sediment transport has been measured on Wildcat Creek downstream at Vale Road along the Richmond/San Pablo boundary.

Suspended- and bedload-sediment transport data have been collected downstream at the Vale Road gage. The USGS collected suspended sediment data for 3 to 4 years, from 1977 to 1980. Earlier data collected farther downstream by the USGS is also relevant (1965 through 1975). Balance collected bedload data between 2004 and 2012. Those data were used to compile suspended- and bedload-sediment transport "rating curves" which correlate flow rate to sediment transport rate at the Vale Road station. The Vale Road suspended-sediment rating curve is presented in **Figure 2-11** and the bedload-sediment rating curve is presented in **Figure 2-12**.

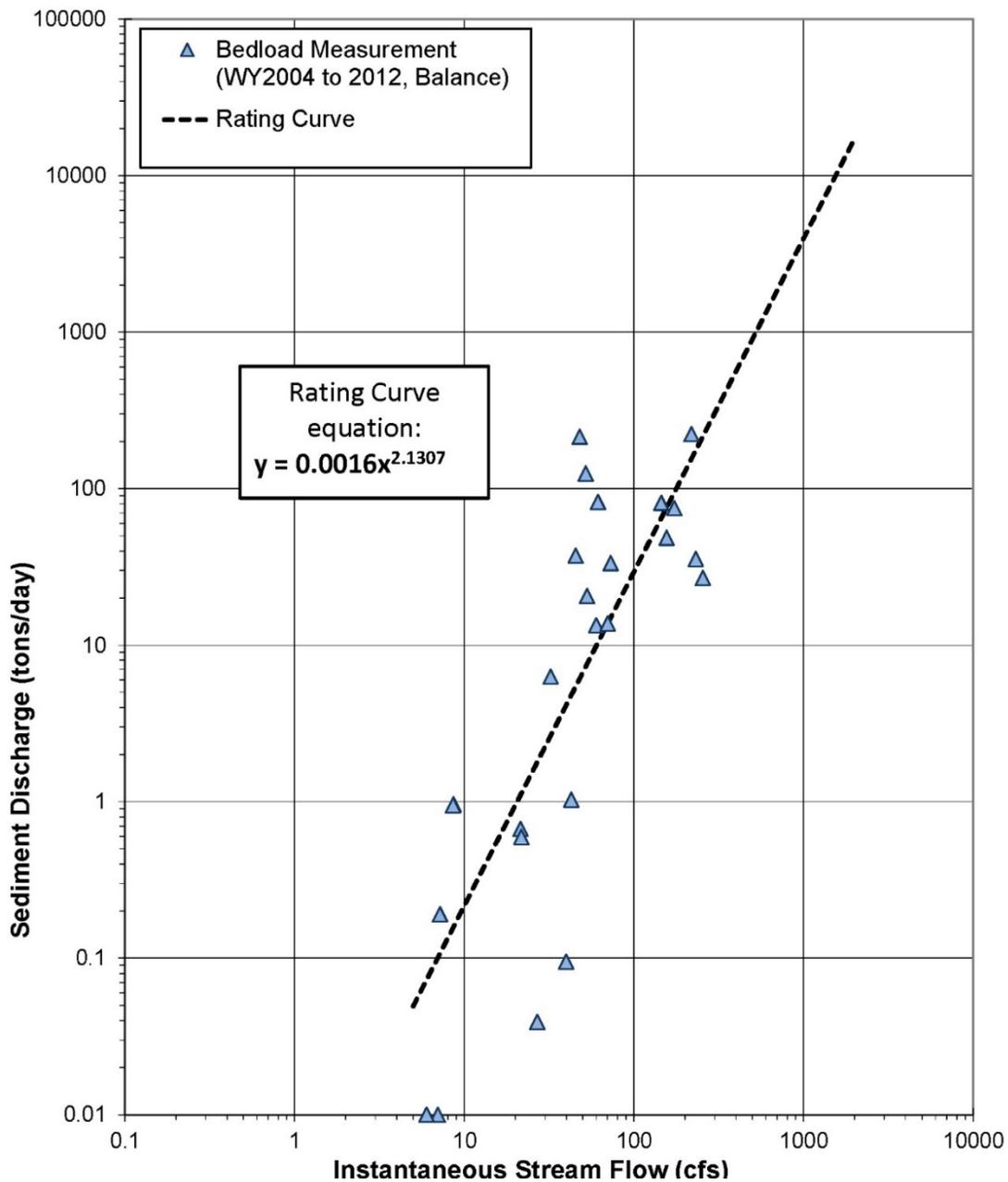
Suspended-sediment samples are sent to a laboratory for analysis of sediment concentration, typically in milligrams per liter. The concentration is measured in two tiers, larger and smaller than 63 microns; this breakdown corresponds to the size difference between silt and sand and provides additional information about how suspended sediment may behave in slow-water areas (coarser material will settle faster). This fraction

JEWEL LAKE STUDY: RESTORATION AND PUBLIC ACCESS FEASIBILITY  
FOR WILDCAT CREEK'S JEWEL LAKE REACH

varies with flow rate and therefore total sediment concentration (**Appendix G**); we used this correlation to calculate the coarse and fine portions of suspended sediment.



**Figure 2-11 Measured sediment transport as a function of flow: Wildcat Creek at Vale Road.** Suspended-sediment concentration and loading increases strongly as flow increases.



**Figure 2-12 Measured bedload sediment transport as a function of flow: Wildcat Creek at Vale Road.** Bedload transport can vary considerably from storm to storm and from the start to end of a storm.

### 2.7.5 SCALING SEDIMENT RATING CURVES FROM DOWNSTREAM TO JEWEL LAKE REACH

Based on the he data and observations presented above, we scaled suspended- and bedload-sediment transport rating curves for Wildcat Creek at Jewel Lake based on the bathymetry filling rates for Jewel Lake from 1992 through 2013 (FlowWest, 2016). Based on

## JEWEL LAKE STUDY: RESTORATION AND PUBLIC ACCESS FEASIBILITY FOR WILDCAT CREEK'S JEWEL LAKE REACH

FlowWest's historic bathymetry summary, we estimated a recent multi-year lake-refilling rate of 300 yd<sup>3</sup>/year between 1992 and 2013. If we use the period from 1967 to 2013, we estimate a lake-filling rate of 338 yd<sup>3</sup>/year. We hypothesize that this filling rate largely represents bedload and the coarser fraction of suspended sediment. Because some sediment were contemporaneously deposited on the floodplain upstream of the Jewel Lake and some fine sediment went over the spillway, which was not accounted for in their analysis, additional assumptions need to be made to account for those processes. Operation of the Little Farm sediment basin could also affect the interpretation of lake filling rates.

We started by applying the sediment rating curves to a multi-year set of 15-minute flow data (scaled to Jewel Lake location for water years 2006 through 2018); from this 13-year period we used flow statistics similar to the bathymetry period of water years 1992 through 2013.

We used results from hydraulic modeling (**Appendix F**) as a guide for water velocity in order to estimate the sediment processes for the coarse and fine fractions of suspended sediment. We also qualitatively compared these estimates to observations of the mix of fine and coarse sediment in the boreholes and floodplain sediment deposition that we observed.

Based on these multiple lines of evidence, *for the purpose of a rough sediment budget*, we made the following approximations for:

- bedload; none deposits on floodplain; all gets to the lake; none goes over spillway;
- coarse portion of suspended sediment; 25 percent deposits on floodplain ~ 75 percent trapped in lake; none goes over spillway;
- fine portion of suspended sediment; 25 percent deposits on floodplain; 25 percent trapped in lake; 50 percent goes over spillway.

We applied these estimates to multi-year sediment transport calculations and adjusted the scaling of the sediment rating curves to approximately match lake-filling rates from bathymetry data. We did not include sediment trapped on the floodplain in this comparison. If we use a lake-filling rate of 300 yd<sup>3</sup>/year, that equates to a scaling factor

JEWEL LAKE STUDY: RESTORATION AND PUBLIC ACCESS FEASIBILITY  
FOR WILDCAT CREEK'S JEWEL LAKE REACH

of 0.62; if we use a lake-filling rate of 400 yd<sup>3</sup>/year, that equates to a scaling factor of approximately 0.82.

If we use a filling rate of 300 yd<sup>3</sup>/year, that equates to an incoming sediment load of approximately 700 yd<sup>3</sup>/year; if we use a filling rate of 400 yd<sup>3</sup>/year, that equates to a scaling factor of approximately 930 yd<sup>3</sup>/year.

Based on our assumptions and estimates, the amount of trapped sediment comprises approximately 65 percent of the incoming sediment load to Jewel Lake (for both scaling factors).

Scaled sediment rates for suspended and bedload sediment are used to evaluate the feasibility of splitting flows in Concept 4 (See **Appendix G**).

### 3 DESIGN CONSIDERATIONS

The Team approached the four conceptual design concepts by evaluating site conditions to understand the opportunities and constraints. We then considered the goals and objectives in light of the opportunities and constraints and worked to harmonize those within the preferred Park District concepts. In this section we also articulate design criteria that can help to prioritize Project goals. This report is intended to accompany the conceptual design sheets (**Sheets 2.0, 3.0 and 4.0**).

#### 3.1 Project Opportunities and Constraints

**Plate 1** presents a geographic overview of the Project site and site impairments that could be restored.

The purpose of the opportunities and constraints section of this document is to give a clear picture of how the site encourages or inhibits achievement of the Park District's goals and objectives in the context of the information presented in **Section 1** and **Section 2**. The opportunities and constraints consider the following resources:

- Geology and Geomorphology
- Hydrology
- Infrastructure and Engineering
- Biological Resources
- Public Access and Recreation
- Cultural Resources

Opportunities are site characteristics that may encourage certain actions or types of use, while constraints are those characteristics that might limit certain actions or types of use.

##### 3.1.1 GEOLOGY AND GEOMORPHOLOGY OPPORTUNITIES AND CONSTRAINTS

###### *Opportunities*

Rubble in Wildcat Creek downstream of dam: Construction of the San Pablo Reservoir water tunnel resulted in large cobbles, boulders, and debris deposited in the creek

channel. Many of the boulders appear to resist erosion and would make a good place to conform the restored channel downstream of the dam. Selecting this location as the downstream conform may also reduce the amount of earthwork. At later phases, overall cut and fill balancing should be further analyzed as the design is refined. The Park District may want to consider opportunistically removing tunneling-era debris (e.g., pipes and mining car pieces). Removing the debris would improve riparian recruitment and aquatic habitat function in this reach

### *Constraints*

**Sediment transport:** Abundant sediment loading from upstream, combined with limited sediment-transport capacity (through the lake) means that the existing Wildcat Creek delta upstream of Jewel Lake would continue to tend toward aggradation.

**Valley width:** The confined nature of Wildcat Canyon places natural limits on the Project width.

**Mapped landslide to the west of the site:** Geologic mapping of the site highlights the extensive landslide deposits on the west side of the Lake in Wildcat Canyon. Boring logs show interlayered debris landslide and alluvial fan series sediments and suggest the basal landslide plane west of the dam (**Appendix C**) is at least 45 feet below the ground surface. This landslide material is characterized by wet and weak materials which make excavation and grading more difficult. In their geotechnical investigation (**Appendix C**) Rockridge Geotechnical found that because the landsliding is composed of many coalescing debris slides and localized slumps extending to the hiking path near the top of the ridge, it is unlikely that constructing a new creek channel along the west side of the lake would destabilize the entire landslide mass. Localized overbank flow and debris flows emanating from the Tributary C should also be addressed within project designs to handle those episodic events.

## 3.1.2 HYDROLOGY OPPORTUNITIES AND CONSTRAINTS

### *Opportunities*

**The watershed is largely in a protected, open space:** The Wildcat Creek watershed upstream from Jewel Lake is largely within East Bay Regional Parks jurisdiction (approximately 90 percent) and largely undeveloped (3 percent) (FlowWest, 2016).

## JEWEL LAKE STUDY: RESTORATION AND PUBLIC ACCESS FEASIBILITY FOR WILDCAT CREEK'S JEWEL LAKE REACH

Thus, the hydrology at the Project site, while moderately impacted by Lake Anza, roads, and other infrastructure, has not been substantially altered.

**Tributaries:** Numerous tributary channels enter the site from side canyons and may be useful for supplementing flow to the designed lake, creek, and wetland features.

**Flow duration and temperature:** Because Concept 3 has no open-water component, it is likely to increase flow duration by approximately 5 days to 2 weeks (in drier years, when creek flow is more likely to cease) and decrease stream temperature downstream of the Project site because it minimizes streamflow losses due to evapotranspiration.

### *Constraints*

**Lake Water Quality:** For Concept 4, flows would be split between the creek channel and lake. A flow split is an unnatural circumstance, therefore it may be challenging to maintain lake water quality, because less flow will be available to circulate through the lake. Decreasing flow through lakes tends to: increase temperature, decrease dissolved oxygen, reduce mixing, and foster algae growth.

### 3.1.3 INFRASTRUCTURE AND ENGINEERING OPPORTUNITIES AND CONSTRAINTS

#### *Opportunities*

**Sediment detention basin:** The existing sediment detention basin on Wildcat Creek, located upstream of the site (**Plate 1**) at the Environmental Education Center, is operational and reduces the amount of sediment delivered to the Jewel Lake reach of Wildcat Creek.

There is an opportunity to decommission the sediment detention basin under Concepts 1, 3 and 4. This would reduce operations and maintenance costs and improve habitat connectivity by removing the small dam which is a partial barrier to fish passage. Discontinuing sediment removal and/or removing the sediment detention basin as part of Concept 1 would accelerate the process of filling Jewel Lake.

#### *Constraints*

**Aging dam infrastructure:** The Jewel Dam spillway is approximately 100 years old. The downstream end of the spillway is severely undercut, the eastern wall of the spillway

appears to be leaning slightly toward the spillway, and the spillway weir at the upstream end of the spillway appears to have been added to or repaired multiple times. Jewel Dam does not fall within the jurisdiction of the Division of Dam Safety and the risks associated with possible failure of Jewel Dam are not severe due to attenuation of flow and sediment through Wildcat Canyon (Greene, 1991). The project should take measures to reinforce the spillway if the intent is to keep it in use as a feature.

**Historic restroom facilities and the storm drain outfalls to the east of the Jewel Lake reach of Wildcat Creek:** Preserving the unique history of the Tilden Nature Area by preserving the historic buildings and historic stonework infrastructure should be considered. In the vicinity of Jewel Lake, this includes the restroom to the east of the lake, a stonework culvert outfall to the east of the lake, and the stonework face of the Wildcat Canyon Trail crossing over Jewel Creek. All of these structures were constructed through the Works Progress Administration (WPA) in the 1930's.

**Wildcat Canyon Trail:** Wildcat Canyon Trail crosses Wildcat Creek at the Little Farm and Jewel Canyon just downstream of Jewel Dam. In addition, we assume that The Park District requires emergency and maintenance vehicle access along Wildcat Canyon Trail. We considered locations of footpaths as minor constraints; we also re-discovered locations of older abandoned trail alignments. We expect that some bridges may be added to trails as well as some trail re-routes.

**Repair and restore the spillway plunge pool:** For the concepts that preserve the dam in place (Concepts 1, 2, and 4) the spillway plunge pool at the downstream end of the spillway would need to be stabilized and/or reconstructed to reduce the likelihood of spillway and dam failure.

**Elevation Drop across Jewel Dam:** Proposed solutions to restore channel function, fish passage and sediment transport need to account for approximately 34 feet of elevation across the dam.

### 3.1.4 BIOLOGICAL RESOURCES OPPORTUNITIES AND CONSTRAINTS

#### *Opportunities*

**Fish Passage:** Currently, rainbow trout cannot migrate past Jewel Dam. Downstream of Jewel Lake, fish-passage impediments such as the San Pablo Avenue and I-80 culverts,

## JEWEL LAKE STUDY: RESTORATION AND PUBLIC ACCESS FEASIBILITY FOR WILDCAT CREEK'S JEWEL LAKE REACH

limit access for steelhead. Removing or reducing fish-passage barriers in Wildcat Creek presents an opportunity to restore anadromy (Urban Creeks Council, 2010). Plans are currently underway to retrofit these barriers.

**Existing riparian habitat upstream and downstream of the dam:** The existing riparian habitat is thriving and provides valuable for many birds and other species and would support the biodiversity of the completed project; thus, the Project should strive to minimize the impacts to these resources and improve these resources over the long-term.

### *Constraints*

**Existing riparian habitat upstream of the dam:** The Project should strive to minimize the impacts to existing riparian habitat resources over the long-term. Please note that prior to the construction of Jewel Dam, the riparian woodland likely would not have been as extensive nor as moist, which would have been reflected in different species abundance.

### 3.1.5 PUBLIC ACCESS AND RECREATION OPPORTUNITIES AND CONSTRAINTS

#### *Opportunities*

**Popular Destination:** The Jewel Lake area is a popular recreation and educational destination. All of the concepts developed in this study present opportunities to enhance recreation, provide an ecological focal point, or focal points, and educate a wide audience about the art, science, and engineering of ecological restoration and management.

**Interpretive Ponds:** The recently completed interpretive ponds would help offset the loss of potential habitat for WPT, and other aquatic species, if the dam is removed and Jewel Lake is replaced by a riparian environment that does not include ponds.

#### *Constraints*

**Changes to the existing trails and circulation pattern should be minimized:** Maintaining key features within the Tilden Nature Area is a project goal. The existing trails, including the boardwalk trail, should be preserved to the extent possible.

### 3.1.6 CULTURAL RESOURCES OPPORTUNITIES AND CONSTRAINTS

#### *Opportunities*

**Rich Park History:** The Tilden Nature Area has a rich history which is supported by a strong interpretive program. Regardless of which concept is selected there are ample opportunities to build upon the Tilden Nature Area's mission and engage users with thoughtful interpretive resources about the park's natural and human history, and the role this project plays in that history.

#### *Constraints*

**Close proximity to Works Project Administration-era structures:** The project may require removal of historic Works Project Administration-era works including a stonework storm drain outfall emanating from under Wildcat Canyon Trail (**Figure 3-1**), and a stonework culvert headwall at Jewel Creek (**Figure 3-2**). Additional historical structures, including the Jewel Lake restroom to the east of the Lake, and the Wildcat Canyon Trail bridge over Wildcat Creek near the EEC are not likely to be impacted by the project.



**Figure 3-1** Storm drain outfall emerging from underneath Wildcat Canyon Trail into the fringe of Jewel Lake (Looking North).



**Figure 3-2** Headwall and culvert inlet at Jewel Creek where it crosses under Wildcat Canyon Trail (Looking west). No stonework was used on the western side of Wildcat Canyon Trail because the canal formerly bordered the trail.

## 3.2 Summary of Design Criteria

### 3.2.1 HYDRAULIC AND CHANNEL DESIGN CRITERIA

The methods we used to inform channel designs for the proposed concepts are summarized in this section. Our geomorphic reconnaissance and topographic surveys included data collection at a reference reach of Wildcat Creek. Where possible, we used multiple lines of evidence to establish the basis of design. The design criteria which apply to all concepts are presented below, and followed by criteria specific to each of the Concepts:

JEWEL LAKE STUDY: RESTORATION AND PUBLIC ACCESS FEASIBILITY  
FOR WILDCAT CREEK'S JEWEL LAKE REACH

- Rock-sizing should be estimated based on the 100-year recurrence event and refined in future phases of work as the design develops.
- Floodplain and flood bench height and width and side-slopes so as to reduce the erosive forces applied to the channel.
- Channel sizing and meander geometry should be similar to the channel sizing and meander geometry of the reference reach.

**Additional Criteria for Concept 1 – Repair spillway and allow Jewel Lake to fill in.**

- Consideration should be given to spillway maintenance needs as a result of abrasion after the lake completely fills and bedload-sediment transport commences down the spillway.

**Additional Criteria for Concept 2 – Dredge the lake periodically and construct a nature-like fishway.**

- Rock sizing for the nature-like fishway element should be estimated based on the maximum flow through the flow control structure.
- The size the fishway and fishway flow-control structure should be optimized to the range of fish-passage flows and will route most of the high flows to the existing spillway to reduce the risk of damage to the fishway.
- Design downstream confluence of nature-like fishway and Wildcat Creek to attract fish to the fishway by locating the confluence close to the bottom of the spillway and routing fish-passage flows through fishway.

**Additional Criteria for Concept 3 – Remove dam and lake, restore Wildcat Creek**

No additional criteria at this time.

**Additional Criteria for Concept 4 – Modify dam and lake and construct channel for fish passage and sediment transport**

- The timing of bypass gate operation schedule should be set up based on fish life-cycle timing based on fish-passage flow range criteria. A simple way for the bypass to operate could be based on seasonal dates and/or flow thresholds. An automated gate with a flow or depth sensor could be used to respond more

## JEWEL LAKE STUDY: RESTORATION AND PUBLIC ACCESS FEASIBILITY FOR WILDCAT CREEK'S JEWEL LAKE REACH

dynamically to bypass storms and medium flows that carry sediment and fish, while allowing some amount of baseflow to flow through the lake.

- Flow bypass structure and berm should be designed to keep sediment-laden storm flows out of the lake to minimize sedimentation in the lake. The connection from the bypass gate to the lake would be screened to keep migrating fish out.
- Maintaining circulation through a lake feature could be challenging. Potential options to route water to the lake during winter bypass periods when creek flow will otherwise be bypassed around the lake include:
  - Routing flows to lake after storm-peaks have subsided;
  - Routing tributary flow to the lake;
  - directing subsurface baseflow to the lake;
  - or creating a separate intake. Such an intake could be placed at the current location of the sediment detention basin, for example, which will be decommissioned as part of this project.

### 3.2.2 FISH-PASSAGE

CDFW fish-passage criteria for salmonids are considered in developing conceptual designs for Concepts 2-4. For this phase, these criteria were used to estimate channel sizing. A detailed analysis of fish-passage velocities and jump-heights should be evaluated as part of future work to refine the selected design. We note that NOAA-NMFS (2019) has modified their maximum step-height recommendation for juvenile salmonids from 0.5-feet (CDFW recommendation) to 1 foot for most streams, based on recent research. We anticipate that the 1-foot maximum step height criteria will apply to this project and may reduce the complexity and cost associated with channel construction for Concepts 2, 3 and 4.

To overcome the vertical height of the dam and minimize the impacts upstream and downstream of the dam, a 3- to 5-percent channel slope will be required. For all concepts, it is likely that a step-pool, roughened channel, or similar approach will be required as described in the California Department of Fish and Wildlife (CDFW) Manual (CDFW, 2009).

### *Nature-Like Fishway Design*

CDFW (2009) provides guidance on nature-like fishway design. After repairing the bottom of the spillway (and raising the grade in the downstream channel), the fishway must accommodate approximately 21 feet of vertical drop. Of the recommended approaches (See **Table 3-1**), a step-pool design which includes periodic longer energy dissipation pools, is considered most appropriate for the site.

**Table 3-1 Recommended range of channel design slopes and maximum elevation drops for various roughened channel bedforms (modified from CDFW, 2009).**

<b>Bedform</b>	<b>Overall Roughened Channel Slope</b>	<b>Recommended Maximum Elevation Drop Across Roughened Channel</b>
Rock Ramps	≤4.0%	5 feet <sup>1</sup>
Chutes and Pools	≤4.0%	2 feet per Sequence
Step-Pools	3.0-5%	5 feet per Sequence <sup>2</sup>
Cascade and Pool	4.0-6.5%	5 feet per Sequence

<sup>1</sup> Larger drops across the roughened channel require breaking up the reach with large pools.

<sup>2</sup> A step-pool sequence may include multiple steps; four or five steps per sequence are common. Multiple sequences of step pools are often used.

### 3.2.3 OPEN-WATER RESOURCE DESIGN CRITERIA

- Restore Jewel Lake to a maximum 12-foot depth below spillway crest, based on past dredging activities.
- Incorporate shallow side-slopes to the extent practicable, to minimize the likelihood of sloughing and sliding of incompetent lake sediments, with slopes at 3:1 or shallower.
- Habitat requirements and enhancements for Western Pond Turtles and emergent wetland vegetation.

### 3.2.4 ACCESS, EDUCATION AND RECREATION CRITERIA

- Create focal points with rich educational opportunities.

## JEWEL LAKE STUDY: RESTORATION AND PUBLIC ACCESS FEASIBILITY FOR WILDCAT CREEK'S JEWEL LAKE REACH

- Maintain a loop trail for enhanced user experience; increase trail opportunities where appropriate.
- Connect to the existing trail network, to the extent practicable.
- Vehicular access should be planned for maintenance and repair activities where appropriate and new design elements are installed.

## 4 DESIGN CONCEPTS

### 4.1 Design Overview

Concept 1 is presented in **Plate 2**. Concept 2 is presented on **Sheet 2.0**. Concept 3 is presented on **Sheet 3.0**. Concept 4 is presented on **Sheet 4.0**. Grading presented is preliminary and based on LiDAR-based topography supplemented with topographic surveys performed as part of this project. Bathymetric data were not collected as part of this project, however bathymetric data collected by FlowWest in 2014 has been incorporated into the base maps where no LiDAR data were collected (below the water line at the time of survey). It should be noted that, while the FlowWest data is the best available, it likely does not represent the current bathymetry because it was collected in 2014, and subsequent high flows have delivered sediment to Jewel Lake.

For each concept, we highlight benefits and drawbacks. Each benefit or drawback listed is preceded by the correlated project goal or objective category.

### 4.2 Concept 1: No Project, Jewel Lake Fills In, Reinforce Bottom of Undermined Spillway

#### 4.2.1 CONCEPTUAL DESIGN NARRATIVE FOR CONCEPT 1

Concept 1 involves repairing and reinforcing the downstream end of the Jewel Dam spillway and an adjacent slope to the east. Under Concept 1, the natural process of sediment delivery to Jewel Lake would continue and the lake would convert from open water to riparian woodland, and/or other high value habitat. Under this concept, the spillway outfall and plunge pool, adjacent slopes and adjacent channel would be repaired to support the long-term functioning of the cantilevered downstream section of the spillway collapsing. This is the “no project” concept.

Our sediment transport estimates suggest that the lake may fill in completely over the course of a few decades if the dredging is not performed. Even if some sediment is captured in the existing sediment basin, nearly all suspended sediment and some bedload sediment would continue to make it through the basin and would be trapped in the Jewel Lake area until full. After Jewel Lake becomes completely filled with sediment, bedload sediment transport would occur over the dam and begin to replenish the supply of gravel and cobble downstream of the dam.

## JEWEL LAKE STUDY: RESTORATION AND PUBLIC ACCESS FEASIBILITY FOR WILDCAT CREEK'S JEWEL LAKE REACH

Additionally, sediment removal from the sediment detention basin could be discontinued and/or the basin could be abandoned or decommissioned, which would accelerate filling of Jewel Lake.

The erosion at the spillway outfall would likely be addressed by removing the overhanging portion of the existing spillway and installing a steep riprap apron in the existing plunge pool and armoring the pool with rock to prevent erosion. Concept 1 would also include placement of fill and rock slope protection to address erosion between the plunge pool and Wildcat Canyon Trail. The spillway would need to be monitored for signs of abrasion once the lake fills in and sediment regularly passes over the spillway.

### 4.2.2 SUMMARY OF BENEFITS AND DRAWBACKS IN THE CONTEXT OF PROJECT GOALS FOR CONCEPT 1

Below, we highlight the benefits and drawbacks for Concept 1. Each benefit or drawback is paired to the relevant project goal or objective (bold). Note that drawbacks are juxtaposed against the goal or objective the concept does not address.

#### **Benefits:**

- **Minimize long-term maintenance:** Concept 1 addresses the most pressing structural concern regarding undermining of the spillway. With this concept there is “no project” to maintain, aside from monitoring the dam periodically for safety. Decommissioning the sediment detention basin would further reduce maintenance and accelerate the rate of filling in Jewel Lake.
- **Maintain/Improve habitat for existing native species:** As a result of implementing Concept 1, riparian woodland would likely expand, increasing wood rat and bird habitat.

The spillway plunge pool will be reduced in size but maintained to provide resting pool for fish.

- **Minimize short- and long-term impacts:** Concept 1 allows for a reduced construction footprint downstream of the dam and thus fewer impacts and lower cost, relative to the other concepts. Though a greenhouse gas emissions study was not performed as part of this feasibility study, it is likely that Concept 1 would have the smallest carbon footprint because of the reduced level-of-effort for

construction and because the wet meadow would likely support more carbon sequestration than the other concepts.

- **Minimizing use of funds:** If the District is weighing how to allocate limited funds for competing projects, adopting Concept 1 would minimize implementation and maintenance costs. Note that the aging spillway may need repair/replacement in the future.

#### **Drawbacks:**

- **Fish Passage:** Concept 1 does not support upstream fish passage.
- **Maintain/Improve habitat for existing native species:** As a result of implementing Concept 1, Jewel Lake would eventually disappear.

### 4.3 Concept 2: Dredge Lake Periodically, Construct Nature-Like Fishway

#### 4.3.1 CONCEPTUAL DESIGN NARRATIVE FOR CONCEPT 2

Under this proposed concept, Jewel Lake would be dredged to return the open-water area to a size and depth similar to the 1991 dredging project (approximately 12 feet deep, 1.2 acres). This concept also includes constructing a nature-like fishway which would enable passage for native trout and anadromous fish around the dam. A nature-like fishway is a channel constructed out of boulders, cobbles, and gravels, which may or may not be grouted or have a sealed foundation to prevent leakage and undermining. A flow-control structure would be constructed at the upstream end adjacent to the spillway, likely a concrete headwall with an opening that could be tastefully embellished. **Figure 4-1** presents a photo of such a feature published in the CDFW Design Manual (CDFW, 2009).



**Figure 4-1** Example of a flow-control structure from Spanaway Creek bypass channel (Published in CDFW, 2009). A similar flow-control structure could be installed at the top end of the fishway to partition flow between the fishway and the existing Jewel Lake spillway. Low flow would all go down the fishway, while higher flows are split between the two paths.

After considering fishway locations on either the east or west side, the Team recommends an eastern alignment because the natural topography of Jewel Creek allows for a channel with a 5-percent gradient, within the acceptable slopes for nature-like fishways. Lower gradients are correlated with more successful passage of fish, especially when fishways must overcome tall vertical barriers, such as Jewel Dam, because they allow for fewer hydraulic jumps and larger resting pools (CDFW, 2009). In addition, the east side alignment presented in Concept 2 is likely to reduce the overall impact on native vegetation and simplify maintenance access and effort. The final channel alignment and slope would be refined in a future design phase.

## JEWEL LAKE STUDY: RESTORATION AND PUBLIC ACCESS FEASIBILITY FOR WILDCAT CREEK'S JEWEL LAKE REACH

The existing spillway would continue to convey most of the storm flows since the fishway would capture only low flows. The downstream end of the spillway is severely undermined and would need to be repaired/reinforced. The design would raise the channel grade downstream of the dam and backfill underneath and around the undermined spillway. Alternatively, the undermined section (approximately 12 feet) could be structurally stabilized or removed entirely. In either case, large rock would be strategically placed in the downstream end of the spillway to dissipate energy. In addition, a redesigned plunge pool would mimic the functions of the existing plunge pool, to the extent practicable, though the plunge height and associated scour potential would be reduced.

Recognizing the value of this deep-pool habitat to salmonids, the proposed design includes resting pools, accompanied by buried flow retention sills. Large wood structures have also been shown schematically, to encourage scour and improve cover. Flow retention sills may consist of clay-filled trenches or similar sub-surface hydraulic barrier and would extend deep enough and wide enough prevent piping and premature draining of habitat pools. Proper gradation selection, compaction and water jetting of placed fill and engineered streambed mix would be crucial to maintain ponding in habitat pools. We recommend a softer approach, avoiding sheet-piles and/or concrete; as the designed channel evolves, clay plugs are less likely to interfere with channel function.

The conform to the existing channel is approximately 390 feet downstream of the spillway at an elevation of 375 feet. The rehabilitated channel slope (between the downstream end of the new nature-like fishway and the conform to existing grade) is approximately 4 percent. This tie-in location was selected because it is at the top of a steep section of creek consisting of boulders and debris field that resulted from the construction of the water tunnel<sup>9</sup>. In addition, an apparent old road surface/terrace along the left creek bank (approximately 300 to 375 feet downstream of the dam), could become an activated floodplain with this approach. Due to incision, the channel banks in this reach are steep with numerous scarps, slumps, and/or debris flow swales that are mapped on both sides of the creek. Channel fill at this location would serve to improve bank stability.

---

<sup>9</sup> Downstream of this location, the channel steepens to more than 6 percent for approximately 150 feet. If the restored channel extended further downstream, it would result in substantially more impacts without much improvement in channel passability for fish.

## JEWEL LAKE STUDY: RESTORATION AND PUBLIC ACCESS FEASIBILITY FOR WILDCAT CREEK'S JEWEL LAKE REACH

We recommend placement of sediment removed from the sediment basin in the channel directly downstream of the dam, as opposed to a spoils pile. Doing so would support sediment continuity in the decades prior to filling of the lake and natural sediment bypass.

Under Concept 2, the design maintains the existing alignment for Tributary C and adds a guide berm to direct flows past the downstream of the dam. Field evidence suggests that under existing conditions, high flows and debris flows coming down Tributary C may leave the channel upstream of Jewel Dam and flow toward Jewel Lake.

### 4.3.2 PRELIMINARY PHASING NOTES FOR CONCEPT 2

Construction would likely require staggered timing over approximately one calendar year. Clearing vegetation that has encroached on the lake would likely happen in the winter, outside of bird nesting season. Dredging the lake and fishway construction would occur during the following summer. A second season might be required if dewatering/drying of the dredged material is necessary to facilitate re-use at the site. Note that construction activities for lake dredging and fishway construction are independent and could be phased depending on the Park District's priorities and available construction funds.

### 4.3.3 SUMMARY OF BENEFITS AND DRAWBACKS IN THE CONTEXT OF PROJECT GOALS FOR CONCEPT 2

Below, we highlight the benefits and drawbacks for Concept 2. Each benefit or drawback is paired to the relevant project goal or objective (**bold**). Note that drawbacks are juxtaposed against the goal or objective the concept does not address.

#### **Benefits:**

- **Maintain and improve habitat for existing native species:**
  - Concept 2 has a smaller footprint than other active concepts and therefore fewer short-term impacts to surrounding riparian vegetation and riparian-dependent species – grading work around Jewel Lake would be largely limited to areas dominated by eucalyptus that generally have a lower ecological value.
  - Concept 2 provides high quality habitat for Western Pond Turtles.

- **Fish passage:** Concept 2 improves fish passage over existing conditions.
- **Maintain and improve public access to key features in the Tilden Nature Area:** Maintains an open water focal point for visitors; larger area of open water compared to other concepts.
- **Minimize short- and long-term impacts to sensitive biological resources:** Concept 2 requires a smaller construction footprint within sensitive riparian.

#### Drawbacks:

- **Improve sediment transport:** Jewel Lake would not pass more sediment than it currently does, which would result in continued degradation to fish habitat downstream of Jewel Lake. Although it may be possible to use the gravel portion of dredged sediment to perform gravel augmentation downstream of the dam.
- **Improve Fish Passage:**
  - A fishway, nature-like or otherwise, is less effective at encouraging fish passage than channel restoration (CDFW, 2009) but would be better than existing conditions.
  - Fish that use the fishway would still have to pass through the lake, where they are more likely to be predated<sup>10</sup>.
- **Minimize disturbance to historic/archeological resources:** Concept 2 would require that the historic headwall on the east side of Wildcat Canyon Trail at Jewel Canyon be removed. Stonework could be incorporated and featured in the design of the new trails or interpretive locations.

---

<sup>10</sup> The Team did not find any information on fish species in Jewel Lake other than occasional trout and mosquitofish since the Sacramento perch population was relocated in 2014. However, based on available information on Lake Anza, it appears that largemouth bass, bluegill, green sunfish, and channel catfish are present, and it is possible that during high flow periods some of these fish could be washed over the dam and move downstream into Jewel Lake and potentially further downstream. Park District staff also note that the lake and reach of Wildcat Creek upstream of Lake Anza support more trout compared to downstream reaches, which suggests that Lake Anza may support the trout population. Under the existing conditions in Jewel Lake, it is likely too shallow to support these species, but it is likely that they would be able to survive in Jewel Lake, once dredged, however it is unclear how dredging will impact the populations of rainbow trout with respect to predation.

## JEWEL LAKE STUDY: RESTORATION AND PUBLIC ACCESS FEASIBILITY FOR WILDCAT CREEK'S JEWEL LAKE REACH

- **Effective use of funds:** Concept 2 requires building near the existing 100-year-old dam and spillway. The need for structural reinforcement of the dam and spillway walls should be evaluated during future phases if this concept is selected.
- **Minimize both short- and long-term impacts to sensitive biological resources:** Jewel Lake would continue to fill in after dredging and would continue to have a long-term impact.
- **Minimize long-term maintenance:**
  - Jewel Lake would continue to fill with sediment, and dredging would be needed into the future, impairing the overall habitat value of Jewel Lake.
  - A nature-like fishway at Jewel Dam would have to overcome approximately 20-23 vertical feet over approximately 580 feet long, with 40-46 half-foot, step-pool sequences (maximum step height for juvenile passage). Fish-passage success criteria are likely to be more onerous than for Concept 3, thus, even with flow control at the upstream end, a nature-like fishway will likely require periodic adaptive maintenance to manage for fish passage.

### 4.4 Concept 3: Remove Dam and Lake, Restore Wildcat Creek

#### 4.4.1 CONCEPTUAL DESIGN NARRATIVE FOR CONCEPT 3

For this proposed concept, the Jewel Lake reach of Wildcat Creek would be restored by removing Jewel Dam and creating a dynamically stable and geomorphically appropriate channel. The proposed concept places a priority on minimizing impacts to the riparian ecosystem immediately upstream of the lake while improving sediment transport and fish passage. This concept includes the creation of floodplain wetland areas. To the extent possible, the channel geometry is based on the reference reach upstream of the site adjacent to the Indian Camp Picnic Area, however sinuosity has been minimized to reduce the amount of earthwork and impacts to adjacent vegetation.

In order to reduce the upstream footprint of the project, we have proposed a channel longitudinal profile that would require 10 to 12 feet of fill at the large plunge pool at the bottom of the spillway, which has been recognized as an important resource for salmonids. The proposed design includes resting pools, accompanied by buried flow

## JEWEL LAKE STUDY: RESTORATION AND PUBLIC ACCESS FEASIBILITY FOR WILDCAT CREEK'S JEWEL LAKE REACH

retention sills and large wood structures to encourage scour downstream of the dam to increase water retention in the designed resting pools. Flow retention sills may consist of clay-filled trenches or similar sub-surface hydraulic barrier and would extend deep enough and wide enough to prevent piping and pre-mature draining of habitat pools. Proper gradation selection, compaction and water jetting of placed fill and engineered streambed mix would be crucial to maintain ponding in habitat pools. We recommend a softer approach, avoiding sheet-piles and/or concrete; as the designed channel evolves, clay plugs are less likely to interfere with channel function.

During initial design planning meetings, a priority was placed on preserving the dense riparian community upstream of the dam. The Team considered the potential benefits and drawbacks of various approaches, including complete restoration of the valley bottom to pre-dam conditions. Overall, the impacts to thriving, existing, ecosystems present at the site do not justify potential improvements. Therefore, an approach was taken that limits the upstream and downstream extent of the restored channel by increasing the slope of the restored channel and does not include as much channel sinuosity as observed in the reference reach. Sufficient large rock material will be used to stabilize the channel, to allow the channel to adjust over time, but protect against meander formation which could undermine the design.

Alluvial deltas, such as the one on Wildcat Creek as it enters Jewel Lake, are inherently dynamic environments where the stream course frequently relocates as velocities slow at the lake margin and deposition occurs. If the channel upstream does not pass sediment effectively, the channel could change course and potentially circumvent portions of the designed channel and cause unwanted changes to the designed channel. Rather than impact the channel and riparian corridor upstream of the dam all the way up to the Wildcat Creek Trail crossing, the team has located the connection to the existing channel downstream of the boardwalk to the extent practicable. Bank heights at the upstream extent of the delta near Wildcat Canyon Trail are approximately 6 feet, and the channel appears to be generally stable. Based on observations of breakout channels along the Jewel Lake delta, it appears that the channel is more dynamic with bank heights approaching 2-3 feet. We have selected to pick up the channel where the bank heights are approximately 3-4 feet. The design channel then meanders to the east side of the canyon to form a "catch" meander with grade control at the downstream end. The intent of this feature is to allow natural channel migration and dynamics to take place upstream of the project and also protect the restoration from deleterious erosion.

## JEWEL LAKE STUDY: RESTORATION AND PUBLIC ACCESS FEASIBILITY FOR WILDCAT CREEK'S JEWEL LAKE REACH

Based on historic photo evidence, we note that the historic channel likely traveled down the east side of the canyon along the distal edge of the debris fan emanating from the west side of the canyon, just upstream of the dam. This concept seeks to restore this alignment through the Jewel Lake reach of Wildcat Creek.

The preliminary concept presents a new channel to carry flow from Tributary C across the debris fan and into a created floodplain pond along a lower slope (1 percent) reach of Wildcat Creek. Field evidence suggests Tributary C periodically produces debris flows. The pond depicted in Concept 3, in-line with Tributary C would likely eventually fill with sediment, and success criteria established for such a feature should accommodate such changes.

If the impacts of creating a new channel to connect Tributary C to the channel upstream of the dam are considered too great, the Tributary C channel could be improved and allowed to continue past the dam along its current alignment to enter Wildcat Creek downstream of the dam.

As part of this Concept 3, the eroded slope adjacent to the Wildcat Canyon Trail, the historic canal, and the Jewel Dam spillway would be removed and re-graded, a new culvert would be installed under Wildcat Canyon Trail, and a short reach of Jewel Creek would be restored near the confluence with Wildcat Creek.

### 4.4.2 SUMMARY OF BENEFITS AND DRAWBACKS IN THE CONTEXT OF PROJECT GOALS FOR CONCEPT 3

Below, we highlight benefits and drawbacks for Concept 3. Each benefit or drawback is paired to the relevant project goal or objective (bold). Note that drawbacks are juxtaposed against the goal or objective the concept does not address.

#### **Benefits:**

- **Improve fish passage:** Concept 3 provides the best fish habitat and fish passage improvements. Flows are not “split” between the stream channel and an open-water lake feature in this option, making more water available to facilitate fish passage and fish habitat through the restored reach. In addition, this concept is anticipated to have the lowest evapotranspiration demand and is

likely to extend summer baseflows for approximately five days to two weeks during drier years (See **Appendix H**).

- **Improve sediment transport and continuity:** Concept 3 would restore bedload sediment transport, which would improve fish habitat downstream of the Jewel Lake reach of Wildcat Creek.
- **Maintain and improve public access to key features in the Tilden Nature Area:** Concept 3 provides an opportunity to educate park users about ecological restoration, dam removal, and engineering.
- **Maintain and improve habitat for existing native species:** Concept 3 would increase shading along Wildcat Creek eliminate the warming that occurs as water is retained and heated in Jewel Lake, thereby reducing downstream water temperature and improving the quality of aquatic habitat downstream.
- **Minimize long-term maintenance:** Concept 3 creates a natural channel that is less complicated than other concepts, and likely to require less management and maintenance.

#### **Drawbacks:**

- **Minimize short- and long-term impacts to sensitive biological species:**
  - Concept 3 would require earthwork up and downstream of the dam, resulting in short- and long-term impacts to the existing riparian corridor.
  - Excavating the new stream channel would lower the groundwater table along portions of the valley bottom upstream of the dam, which may result in conversion to more xeric, upland riparian vegetation in the vicinity of the Project upstream of Jewel Dam.
  - Concept 3 would remove open water and emergent habitat types and eliminate Western Pond Turtle habitat at this location.
- **Maintain and improve public access to key features in the Tilden Nature Area:**
  - Concept 3 would remove the “open water” user experience.

## 4.5 Concept 4: Modify Dam and Lake, Construct Channel for Fish Passage and Sediment Transport

### 4.5.1 CONCEPTUAL DESIGN NARRATIVE FOR CONCEPT 4

Concept 4 splits flows from Wildcat Creek between a newly recreated Jewel Lake and a restored dynamically stable and geomorphically appropriate bypass channel. Jewel Lake would be modified and separated from Wildcat Creek by a berm. Under Concept 4, the recreated lake could be sized between approximately 0.8 acres (as presented herein) and approximately 1.2 acres. Future design phases could explore ways of increasing lake size, which include narrowing the width of the berm separating the lake and the restored channel or extending the lake to the south or to the east and mitigating impacts to the existing trail and boardwalk.

Under this proposed concept, the Jewel Lake reach of Wildcat Creek would be re-created as a dynamically stable step-pool channel, similar to Concept 3. To the extent possible the channel geometry is based on the reference reach upstream of the site adjacent to the Indian Camp Picnic Area, however sinuosity would be minimized to reduce the amount of earthwork and impacts.

The results of the geotechnical investigations (**Appendix C**) suggest that there is no single deep-seated landslide sliding plane in the vicinity of the west edge of the lake to a depth of 45 feet. Instead, there is evidence of interlayered shallow debris slides and flows and alluvial fan deposits emanating from the swale on the western side of the canyon. Thus, it appears that locating the Wildcat Creek bypass channel along the west side of the canyon, at the bottom of Tributary C, is feasible. The proposed approach will likely require additional bank stabilization measures above and beyond those typical for creek restoration projects (e.g., geotechnical keyway at the toe of slope, ballast and/or engineered drainage) along 300 to 400 feet of the west side (left bank) of the restored bypass section of Wildcat Creek that traverses the bottom of Tributary C.

Substantial geotechnical design and slope stability features will also be needed between the lake and the creek channel.

Sediment observed in borehole B-1, which was located approximately on the proposed berm appears to be clay-rich, however removal of native fill and replacement with engineered and compacted fill, or potentially other strategies to limit the risks associated with flow through the berm, may be necessary (**Appendix C**). Further investigations during

## JEWEL LAKE STUDY: RESTORATION AND PUBLIC ACCESS FEASIBILITY FOR WILDCAT CREEK'S JEWEL LAKE REACH

design refinement would be needed to determine what measures are necessary to construct the proposed berm between Jewel Lake and the restored bypass channel.

The Concept 4 design includes a guide berm along Tributary C to guide flow and sediment into the bypass Wildcat Creek channel.

A primary objective for this concept is to keep sediment out of the newly off-lined Jewel Lake. The design shows a flow-splitting berm to be constructed to separate flows in Wildcat Creek from the lake. The berm should be tall enough to limit flows of less than approximately the 25- to 50-year event, and the height has been selected accordingly. To drive water from the flow-split to the lake, some elevation change is necessary. We propose lowering the spillway 1 foot to elevation 513 feet to impart a steeper hydraulic slope and drive flow toward the lake.

At the flow-split, water can be directed to either the lake to support water levels and water quality or to the restored section of Wildcat Creek to allow fish and sediment to pass through the reach. The primary design element is a hardscape flow-split structure, likely a concrete flashboard notch/weir in the berm which divides the lake from the stream channel; boards, or a similar valve can be added during the winter to prevent storm flow from entering the lake and boards can be removed during summer months to route flow through the lake and over the spillway or operated using real-time water level monitoring. To improve winter water quality, it seems prudent to actively manage the flow split in the winter to allow water to enter the lake when there is sufficient flow, but not when high flows are transporting a substantial amount of sediment.

The conceptual plan sheets assume an actively managed flow split structure. Other flow-split concepts, such as an infiltration gallery upstream of the reach, or a leaky berm section can be value engineered during subsequent design phases, if deemed necessary.

The proposed step-pool channel through and downstream of the dam has a 4 percent slope. A plunge pool would be designed to replace the existing plunge pool – which provides deep water cover for salmonids. Because large, scouring flows would not regularly occur, we have designed a sharp ninety-degree bend in the channel to encourage scour. Additionally, the Jewel Creek confluence should be designed with a cascade into the pool to help scour the pool. Pulse flows may aid in scouring the designed pool. This may require flashboards to be outfitted on the current spillway weir.

## JEWEL LAKE STUDY: RESTORATION AND PUBLIC ACCESS FEASIBILITY FOR WILDCAT CREEK'S JEWEL LAKE REACH

The proposed step-pool channel design incorporates numerous resting pools. The proposed design includes resting pools, accompanied by buried flow retention sills and large wood structures to encourage scour downstream of the dam to increase water retention in the designed resting pools. Flow retention sills may consist of clay-filled trenches or similar sub-surface hydraulic barrier and would extend deep enough and wide enough to prevent piping and pre-mature draining of habitat pools. Proper gradation selection, compaction and water jetting of placed fill and engineered streambed mix would be crucial to maintain ponding in habitat pools. We recommend a softer approach, avoiding sheet-piles and/or concrete; as the designed channel evolves, clay plugs are less likely to interfere with channel function.

### 4.5.2 SEDIMENT ANALYSIS RELATED TO CONCEPT 4: BYPASS ALTERNATIVE

Under Concept 4, the most likely operation scenario during the steelhead migration season would route all flows from Wildcat Creek down the bypass channel during flows below about 4 cfs. We assume that all summer flows would be routed through the lake as part of this Concept, so the challenge is optimizing water quality during winter months through opportunistic diversions. We performed a sediment transport evaluation to gain a better understanding of the feasibility of allowing flows into the lake which potentially contain suspended sediment. This analysis is presented in more detail in **Appendix G**.

Based on Balance Hydrologics' and the USGS's scaled flow and sediment transport data from the Wildcat Creek at the Vale Road stream gage, we performed a series of computations to evaluate a variety of bypass flow scenarios that attempt to simulate a range of winter diversion scenarios that could be accomplished with common diversion tools and techniques.

The Team evaluated sediment loading (rate of lake infill) and the number of lake exchanges (proxy for water quality) that would occur in each of these scenarios from December 1 – April 30 for a range of year-types. This spreadsheet-based tool can be implemented and refined during ongoing and later phases to evaluate scenarios.

Through an iterative process of bracketing potential bypass scenarios over the modeled near-normal and below-normal year types, loading of sediment into the lake is greatly reduced. We estimate that over a spectrum of feasible bypass scenarios, sediment loading will be reduced to 10 to 25 percent of year-round sediment loading to the lake (current condition). Over the same range of feasible scenarios, we note that 20 to 33

percent of wet season flows can be routed during the lake. Overall, the evaluation suggests that winter diversions to the lake are feasible.

#### 4.5.3 SUB-CONCEPT 4: BYPASS CHANNEL ON THE EAST SIDE OF WILDCAT CANYON, EXCAVATE

An additional sub-concept is likely feasible wherein the restored channel would be excavated on the east side of the Jewel Dam spillway and along the course of Jewel Canyon, in a similar alignment to the nature-like fishway proposed under Concept 2. Under this concept, earthwork would take place east of the dam, and the dam would remain in place. The restored bypass channel would be required to convey storm flows up to the 50- to 100-year event, the channel dimensions would be larger than the nature-like fishway presented in Concept 2. In order to avoid large areas of cut into the hillside to the East, we anticipate retaining walls would be needed, likely in close proximity to the channel.

We chose the presented concept for Concept 4 (over this sub-concept) because a) the added complexity associated with disturbance to the east side of the canyon, Jewel Creek and Wildcat Canyon Trail are likely to impose additional risk and cost, and b) that retaining walls should be minimized to align with the aesthetic of the Tilden Nature Area. This version of Concept 4 could be explored as part of a value engineering review during subsequent design development phases if Concept 4 is selected as the preferred approach.

#### 4.5.4 SUMMARY OF BENEFITS AND DRAWBACKS IN THE CONTEXT OF PROJECT GOALS FOR CONCEPT 4

Below, we highlight the benefits and drawbacks for Concept 4. Each benefit or drawback is paired to the relevant project goal or objective (bold). Note that drawbacks are juxtaposed against the goal or objective the concept does not address.

##### **Benefits:**

- **Provide fish passage:** Improves fish passage over the existing condition and Concept 2.
- **Improve sediment transport and continuity:** Restores bedload sediment transport, which would improve fish habitat downstream of the Jewel Lake reach of Wildcat Creek.

## JEWEL LAKE STUDY: RESTORATION AND PUBLIC ACCESS FEASIBILITY FOR WILDCAT CREEK'S JEWEL LAKE REACH

- **Maintain and improve public access to key features in the Tilden Nature Area:** Concept 4 provides opportunity to educate park users about ecological restoration, dam removal, and engineering.
- **Maintain and/or create a destination for interpretive walks:** Concept 4 maintains an open-water focal point.
- **Maintain and improve habitat for existing native species:** Concept 4 is likely to provide Western Pond Turtle habitat.

### Drawbacks:

- **Minimize long-term maintenance:** Concept 4 is more complicated, and thus increased management and maintenance would be required. Wildcat Creek flows are finite and would be split to accomplish open water habitat and stream habitat goals would need to be more closely monitored and managed, thus the Park District would need to monitor and operate the flow-split in perpetuity.
- **Minimize short- and long-term impacts to sensitive biological resources:** Concept 4 would require earthwork upstream and downstream of the dam, resulting in short- and long-term impacts to existing riparian vegetation habitat.

### 4.6 Sediment Delivery to Lower Wildcat Canyon and Urbanized Downstream Reach

Since construction of Jewel Dam, bedload and a proportion of suspended load from upstream has deposited upstream of the dam. Periodic dredging has removed some of that sediment from the system, while some remains in place in the floodplain/delta that has formed upstream of Jewel Dam.

Restoring sediment transport through the Project would affect sediment dynamics to stream reaches downstream of Jewel Lake. At the mouth of Wildcat Canyon, approximately 4.5 miles downstream of Jewel Lake, the slope of Wildcat Canyon Creek reduces from a reach average slope in the Lower Canyon reach of 1.55 percent to 0.56 percent (Urban Creeks Council, 2010), and the sediment-transport capacity of the stream is reduced. We anticipate that concepts which allow sediment to pass through the Project site will improve bed conditions by depositing gravel in lower Wildcat Canyon, thereby limiting the changes in bedload sediment yields to reaches downstream of Wildcat Canyon for some time. We expect suspended sediment yields to increase more quickly. During this intermediate period, we anticipate possible occasional channel

## JEWEL LAKE STUDY: RESTORATION AND PUBLIC ACCESS FEASIBILITY FOR WILDCAT CREEK'S JEWEL LAKE REACH

widening and continued bank erosion, a major source area for sediment in the lower Wildcat Canyon Reach (Collins, 2001; FlowWest, 2016). After the period of bed aggradation, we anticipate a new pseudo-steady-state channel profile will develop and sediment transport rates will increase to reaches downstream of the canyon. In time, concepts which allow sediment to pass through the Project site will likely require increased sediment-removal maintenance to maintain channel capacity downstream of Wildcat Canyon.

The four concepts will affect sediment delivery to stream reaches downstream of Jewel Lake in different ways. We have estimated that approximately 60 percent of the sediment contributing area at the mouth of Wildcat Canyon is downstream of Jewel Dam, so concepts that restore sediment transport will proportionally impact sediment yields at the mouth of Wildcat Canyon.

Concept 1 would eventually restore bedload sediment supply to downstream reaches, once Jewel Lake completely fills in. Currently, a substantial portion of suspended sediment already passes through Jewel Lake.

Concept 2 would maintain a similar reduced sediment supply condition to downstream reaches.

Concepts 3 and 4 restore sediment transport immediately upon implementation. Concept 3 would restore sediment passing through the site. In addition, Concept 3 reduces the accessible floodplain area upstream of the site to a greater degree than Concept 4. Concept 4 will pass most sediment, however Concept 4 will leave considerable floodplain available upstream of the site, and a portion of sediment, likely 10-20 percent, will end up in the new version of Jewel Lake, therefore less sediment will be transported downstream past the site (than Concept 3).

Compared to current conditions (and Concept 2) we estimate Concept 3 will increase sediment yield at the mouth of Wildcat Creek by a factor of 1.4, based on comparisons with sediment transport data from the Vale Road stream gage. Compared to current conditions we estimate Concept 4 will increase the sediment yield at the mouth of Wildcat Creek by a similar factor, even though some sediment, mainly suspended sediment, will end up in the new lake.

#### 4.7 Trails, Recreation, and Education

The concepts for trails are presented on Concepts 2 through 4 on **Sheet 2.0**, **Sheet 3.0** and **Sheet 4.0** respectively. A discussion of the existing trails, and the preliminary trail layout is discussed in **Appendix D**. Concept 1 does not incorporate additional trails or recreational features.

#### 4.8 Permitability

The Team has prepared a summary matrix of permitting issues which would be evaluated after the initial round of review and feedback from The Park District. The summary matrix of permitting issues is included as **Appendix I**).

#### 4.9 Concept Level Cost-Estimates

Balance developed concept-level cost estimates in 2021 for concepts 2, 3 and 4, with construction projected to occur in 2026 (**Appendix J**). Actual costs are likely to be substantially higher because construction costs have risen much faster than the 4 percent CPI originally used to estimate costs and construction of concepts 2, 3 or 4 will likely take place after 2026.

#### 4.10 Design Elements Considered, But Not Selected

The Team considered a number of ideas during early phases of the Project with the intent of proposing feasible possibilities for consideration. This section presents some ideas that were discussed and were ultimately eliminated or integrated into concept development for the four concepts.

For Concept 2, Dredge Jewel Lake and create a nature-like fishway, the Team considered sluicing sediment through a modified section of the spillway weir on Jewel Dam. However, Western Pond Turtles likely overwinter in the lake, and drawing down water each winter would disturb the nesting population.

For Concept 2, Dredge Jewel Lake and create a nature-like fishway, the Team considered a hardscape (i.e., concrete and steel) fishway alternative as a potentially more cost-effective concept to pass fish around the dam. However, The Park District emphasized a priority on naturalizing new infrastructure, to the extent possible.

## JEWEL LAKE STUDY: RESTORATION AND PUBLIC ACCESS FEASIBILITY FOR WILDCAT CREEK'S JEWEL LAKE REACH

For Concepts 3 and 4, The Park District and the Team are in favor of minimizing disturbance of the alluvial wetland that is currently occupying the Wildcat Creek delta as it enters the lake. The area has become well known for the diversity of birds it hosts and as an excellent woodrat habitat. Thus, for Concepts 3 and 4, restoration to pre-dam conditions is not advised. The Project reference reach upstream of the site is sinuous, occupies a 70- to 90-foot-wide meander corridor and has approximately a 1 percent slope; a project that mimics the valley bottom meander corridor width and slope would likely require removal of nearly all the sediment that has deposited in the delta upstream of Jewel Dam, and removal of the majority vegetation within the riparian corridor between Jewel Dam and the Wildcat Canyon Trail crossing, adjacent to the Tilden Little Farm.

## 5 PUBLIC MEETINGS AND SELECTING PREFERRED CONCEPTS

### 5.1 Public Meetings

Following completion of the Draft Feasibility Memorandum for the Restoration and Public Access Feasibility for Wildcat Creek's Jewel Lake Reach in July 2021 (Donaldson and Owens, 2021), The Park District held a virtual public meeting on October 20, 2021, in which all four concepts were presented. The presentation Packet for the October 20, 2021, public meeting, is presented in **Appendix K**. Seventy members of the public participated and 42 gave feedback through an online survey. The survey highlighted a few main points. Survey participants:

- Overwhelmingly supported prioritizing fish passage and habitat enhancement for *native species*;
- slightly favored the notion that the proposed project should provide a "destination" for visitors;
- slightly favored restoring wildcat creek to historic conditions;
- slightly disfavored prioritizing and open water lake area.

Following the October 2021 public meeting, Park District staff integrated public feedback, consultant findings and Park District staff evaluations and selected Concept 3 and Concept 4 as the preferred concepts. The Park District staff made a presentation to the Park District Board Executive Committee on March 11, 2022, where they discussed the benefits and drawbacks of the concepts and recommended advancing Concepts 3 and 4 for the next public meeting and further study.

Park District staff convened a second public meeting on April 21, 2022, where they presented a more detailed overview of Concepts 3 and 4. The presentation packet for the April 21, 2022, public meeting is presented in **Appendix L**. The workshop included informal public polling that was made available for six weeks. Results of the informal public polling are included in **Appendix M**.

Parks assembled written comments from the public. The comments are compiled in **Appendix N**.

## 5.2 Preliminary, Informal Meeting with RWQCB staff

A preliminary, informal meeting was held February 3, 2022, with RWQCB (Regional Water Quality Control Board) staff to introduce the concepts and solicit informal feedback and discuss potential permitting challenges. The RWQCB prepared a comment letter dated April 19, 2022 (**Appendix N**)

## 6 PREFERRED CONCEPTS

After reviewing and considering the findings of the study to date, along with feedback from cross-divisional Park District staff, agency stakeholders, and community feedback, the Board Executive Committee determined that Concepts 3 (Restore Wildcat Creek) and 4 (Modify Lake and Bypass Channel) showed the most promise for meeting multiple project goals, including fish passage and sediment transport. These concepts are summarized as follows:

- **Concept 3:** Remove Jewel Dam and Lake and restore Wildcat Creek to optimize fish passage, and
- **Concept 4:** Modify Dam and Lake, construct a hydraulic bypass structure and channel for fish passage and sediment transport, add flow-split structure to route flow to either a smaller lake or fish-passable channel.

**Table 6-1** provides a comparison of Concepts 3 and 4 using the following evaluation metrics established by Park District staff:

- Impact on Rainbow Trout habitat;
- Amount of open water;
- Likelihood of success;
- Impact on operations and maintenance activities;
- Climate change resiliency;
- Impact on riparian alluvial woodland upstream of Jewel Lake;
- Cost (including maintenance).

Design of complex restoration and enhancement projects is iterative in nature, and the final preferred concept may borrow elements from the other concepts, or it may include new design elements that are conceived during subsequent engineering design and permitting phases.

Concept 3 (Restore Wildcat Creek) prioritizes restoring naturally self-sustaining watershed processes with minimal operations and maintenance needs, offers the best opportunity

## JEWEL LAKE STUDY: RESTORATION AND PUBLIC ACCESS FEASIBILITY FOR WILDCAT CREEK'S JEWEL LAKE REACH

for fish passage and has the highest likelihood of success. There are numerous grant funding opportunities that align with these priorities.

Concept 4 (Modify Lake and Bypass Channel) prioritizes restoring open water and engineering a hydraulic structure that will allow fish passage and sediment transport requiring ongoing operations and maintenance inputs and would need to overcome a number of technical challenges to be successful. There are fewer grant funding opportunities for reconstruction of reservoirs for recreational use with engineered fish passage.

The Park District is continually evaluating, and prioritizing capital improvement needs in the parks. Improvements at Jewel Lake are not currently identified for implementation at this time. Findings from this study will provide the technical foundation and understanding for the development of any future capital project improvements at Jewel Lake. Recognizing that design of complex restoration and enhancement projects is iterative in nature, at such time that a project at Jewel Lake is advanced into design development and permitting, the design may evolve to borrow elements from the concepts developed in this study or include new design elements that are conceived during subsequent engineering design and permitting. Design adjustments may also be needed to respond to changed circumstances or evolving functions and needs of the park.

**Table 6-1. Comparison of Concepts 3 and 4**

<b>Metric</b>	<b>Concept 3</b>	<b>Concept 4</b>
<b>Impact on Rainbow Trout habitat</b>	Reliable fish passage and fish habitat	Intermittent fish passage and fish habitat that is dependent on operation of the proposed hydraulic diversion structure
<b>Amount of open water</b>	No open water reduces predation of trout	Open water provides aesthetic amenity/preserves open water habitat
<b>Likelihood of success</b>	The concept has a high likelihood of success; Concept 3 presents a simpler, more straightforward dam removal project; there are many recent examples of successful projects.	The concept faces more technical challenges in order to succeed: Concept 4 relies on close monitoring and maintenance of proposed diversion in order to meet the concept goals. The design is complex and there are uncertainties about water quality issues (e.g., dissolved oxygen and algae) that may arise from splitting surface flows in Wildcat Creek between the creek channel and the lake feature. Substantial geotechnical and stability structures may be needed between the lake and creek channel.
<b>Impact on operations and maintenance activities</b>	The concept, once constructed, would largely be self-sustaining, natural process is restored. Maintenance would be similar to other natural reaches of Wildcat Creek within the Tilden/Wildcat parks.	Relies on the close monitoring of water levels and sediment concentrations. Monitoring and clearing accumulated sediment and debris. Mechanical and electrical maintenance of the hydraulic structure.
<b>Climate change resiliency</b>	The concept is highly climate-resilient because it restores the creek corridor to a near-natural state. The concept places the least demand on surface water and ground water at the site (lower evapotranspiration).	The concept is less climate-resilient because warmer weather will tend to exacerbate water-quality challenges in the lake, and there will be less flow in Wildcat Creek.
<b>Impact on riparian alluvial woodland upstream of Jewel Lake</b>	For both concepts 3 and 4, efforts have been made to preserve the alluvial woodland upstream of the current dam and lake, to the extent possible and to a similar degree.	
<b>Cost (based on conceptual cost estimates for construction in 2026 based on 2021 dollars)</b>	<b>\$8.8 to 11.3MM</b> High Grant Competitiveness	<b>\$13 to 16.6MM</b> Low Grant Competitiveness

## 7 LIMITATIONS

The design plans (**Sheet 2.0** through **Sheet 4.0**) are suitable for presentation to and discussion among interested parties; however, this report should always accompany the proposed conceptual design elements when the designs are distributed. Concept 1 as presented in **Plate 2** is presented for interpretative purposes.

Please note that future design iterations may change based on feedback from the resource agencies and other interested parties.

This work was executed to the standard of care in Northern California for aquatic habitat design. It is important to note that aquatic habitat design science is inherently inexact. Realistically, the design concepts reflect a range of values that may be anticipated following design completion. Qualitative and quantitative analyses of pre- and post-restorations have revealed what many people also intuitively know: that the nature of creeks and rivers is not strictly predictable – they are dynamic systems. Adjustments may be warranted in the future as more becomes known about the likely response of channels draining such areas to episodic events.

# JEWEL LAKE STUDY: RESTORATION AND PUBLIC ACCESS FEASIBILITY FOR WILDCAT CREEK'S JEWEL LAKE REACH

## 8 REFERENCES

- BAOSC (Bay Area Open Space Council). 2019. Conservation Lands Network 2.0 Accessed February 4, 2021. <https://www.bayarealands.org/wp-content/uploads/2019/10/CLN%202.0%20Final%20Report.Web.pdf>
- Boucher, M., 2009. Mean Seasonal Precipitation Raster from Drawing B-166. 13p + figures
- CDFG, 2009, California Salmonid Stream Habitat Restoration Manual third edition, Part XII Fish passage design and implementation. 139 p. + appendices.
- Collins L.M., Grossinger R.M., McKee L.J., Riley A., Collins J.N. 2001. Wildcat Creek Watershed: A Scientific Study of Physical Processes and Land Use Effects. Richmond, CA: San Francisco Estuary Institute. Available from: <http://www.sfei.org/wildcatcreeklandscapehistory>
- Donaldson, E., and Owens, J. 2021. Revised Memorandum: Jewel Lake Study: Restoration and Access Feasibility for Wildcat Creek's Jewel Lake Reach. A report prepared for East Bay Regional Park District. 67 p. + plates, sheets, and appendices.
- FlowWest, 2016, Wildcat Creek Watershed Erosion and Sediment Control Project: FlowWest consulting report prepared for East Bay Regional Park District, 73 p.
- Gotvald, A.J., Barth, N.A., Veilleux, A.G. and Parrett, C. 2012. Methods for determining magnitude and frequency of floods in California, based on data through water year 2006. US Geological Survey Scientific Investigations Report, 5113, p.38.
- Greene, R. K. 1991. Preliminary engineering study Jewel Lake and Dam, Tilden Park, California. A consulting memorandum prepared by Woodward-Clyde Consultants for the East Bay Regional Park District. 6 p.
- Hassler, T. [2002?], Land Use and Water Quality at Wildcat Creek, CA, 16 p.
- Langbein, W.B., 1949. Annual floods and the partial-duration flood series. Eos, Transactions American Geophysical Union, 30(6), pp.879-881.
- Leidy, R. A., Becker, G. S., and Harvey, B. N. (2005). Historical distribution and current status of steelhead/rainbow trout (*Oncorhynchus mykiss*) in streams of the San Francisco Estuary, California. Oakland, CA: Center for Ecosystem Management and Restoration. 275 p.
- Nguyen, B., 1991. Jewel Lake dredging data. East Bay Regional Park District inter-departmental correspondence. 7 p.
- NOAA-NMFS, 2019. Guidelines for salmonid passage at stream crossings for applications in California at engineered stream crossings to facilitate passage of anadromous salmonids – August 30, 2019, addendum. 15 p.
- OCM Partners, 2020: 2018 - 2019 USGS LiDAR: Northern California Wildfire - QL2 from 2010-06-15 to 2010-08-15. NOAA National Centers for Environmental Information, <https://www.fisheries.noaa.gov/inport/item/58957>

JEWEL LAKE STUDY: RESTORATION AND PUBLIC ACCESS FEASIBILITY  
FOR WILDCAT CREEK'S JEWEL LAKE REACH

Pitchford, N. H. and Pitchford, D. N., 1990. Construction in the East Bay Regional Park District (1962-1983) – Jewel Lake, Tilden Regional Park. A memorandum prepared for the East Bay Regional Park District. 10 p.

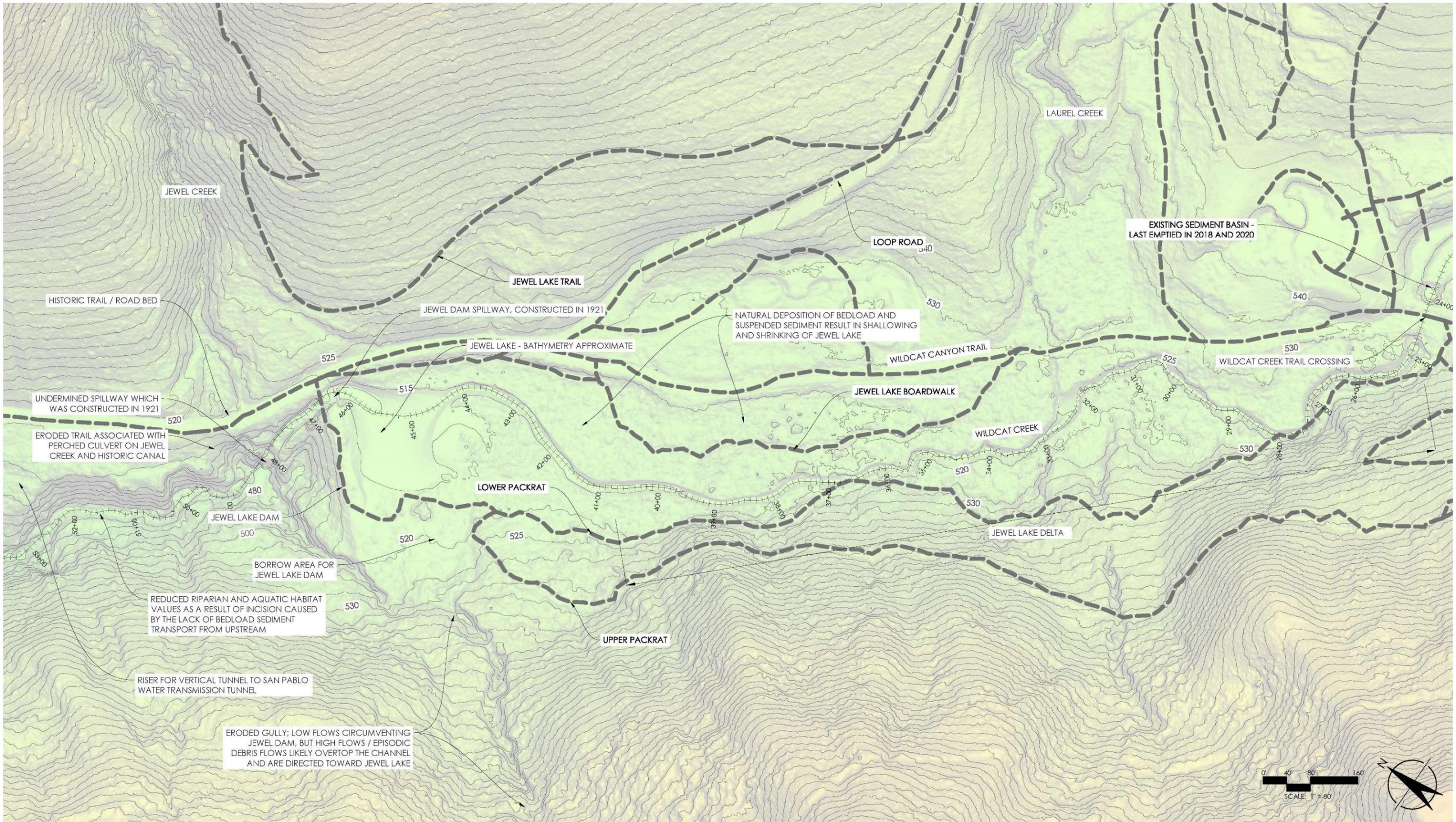
PRISM Climate Group, 2015. 30-year normals. Oregon State University,  
<http://prism.oregonstate.edu>

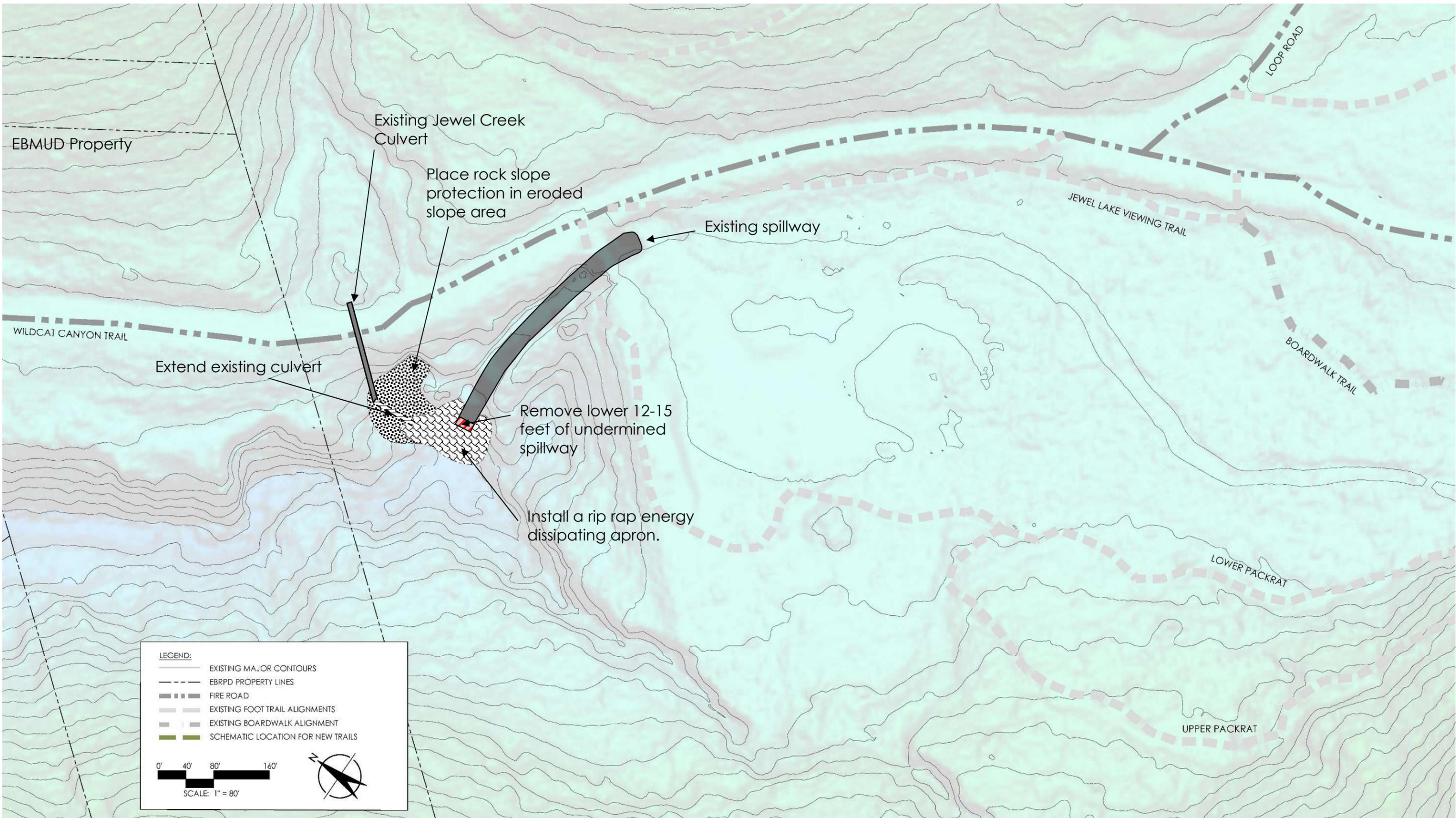
RHJV (Riparian Habitat Joint Venture). 2004. The Riparian Bird conservation Plan: a strategy for reversing the decline of riparian associated birds in California. California Partners in Flight. Accessed February 1, 2021. [http://www.prbo.org/calpif/pdfs/riparian\\_v-2.pdf](http://www.prbo.org/calpif/pdfs/riparian_v-2.pdf)

Urban Creeks Council. 2010. Wildcat Creek Restoration Action Plan. A report prepared for the Wildcat-San Pablo Watershed Council and adopted by the City of San Pablo. 73 p.

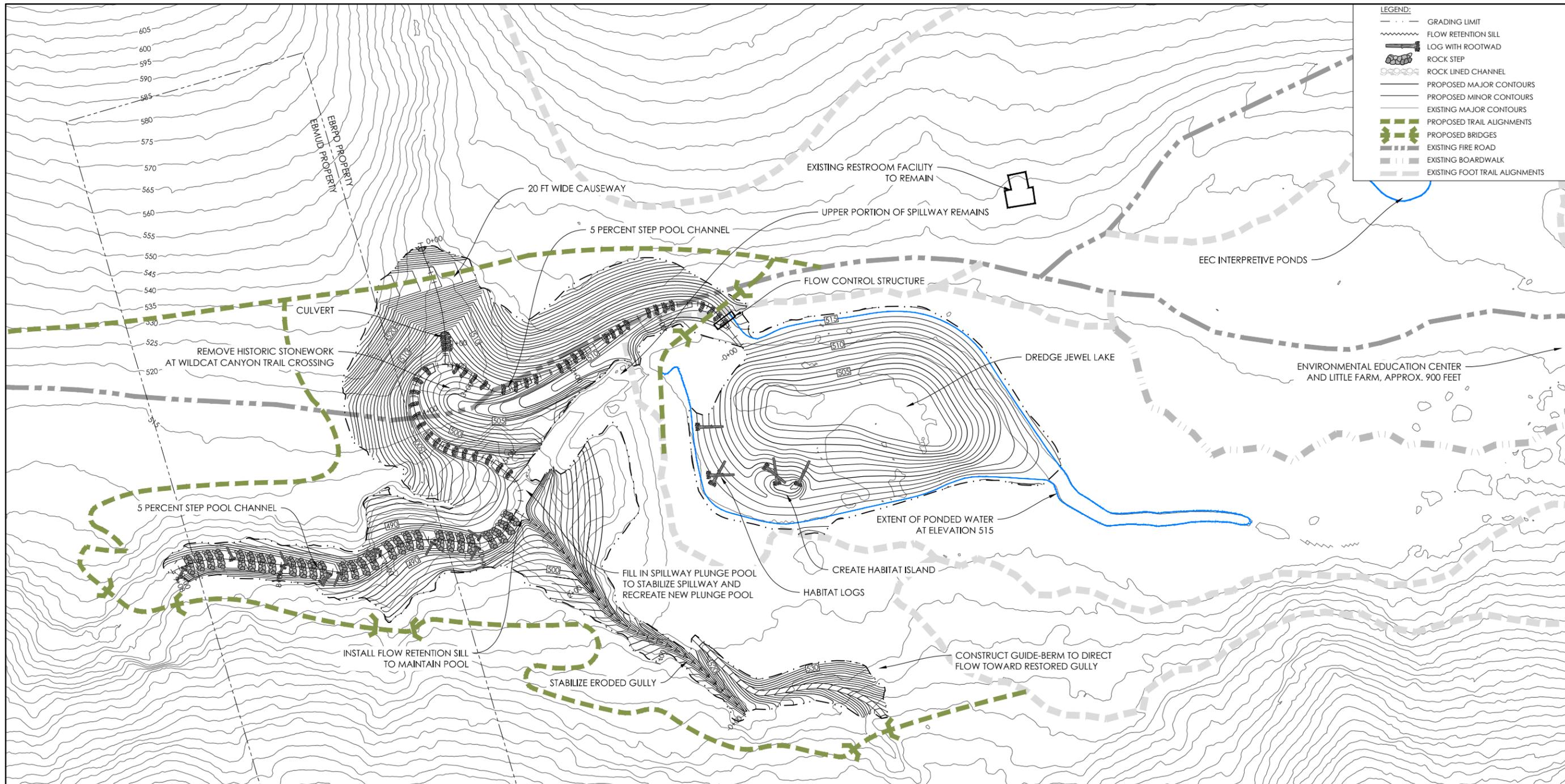
USGS, 2018. 3D Elevation Program 1-Meter Resolution Digital Elevation Model.

## PLATES





**SHEETS**



**Balance Hydrologics, Inc.**  
 800 Bancroft Way · Suite 101  
 Berkeley, CA 94710  
 tel: (510) 704-1000 · fax: (510) 704-1001  
 www.balancehydro.com

SUBMITTALS / REVISIONS	
BY	DATE

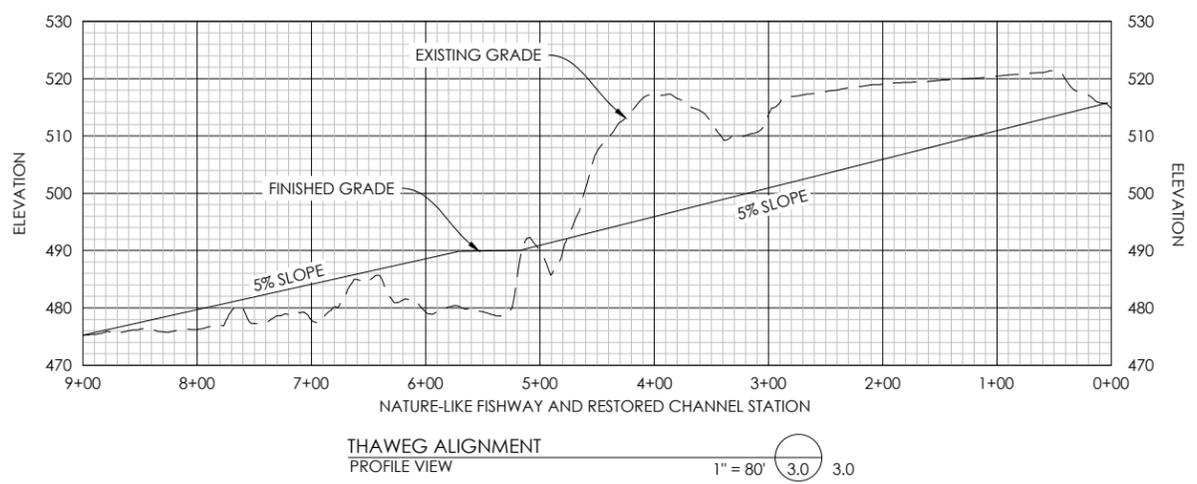
NOT FOR CONSTRUCTION

**CONCEPT 2**  
 DREDGE JEWEL LAKE,  
 NATURE-LIKE FISHWAY  
 LONG-TERM MANAGEMENT AND RESTORATION STUDY  
 FOR THE JEWEL LAKE REACH OF WILDCAT CREEK  
 EAST BAY REGIONAL PARK DISTRICT

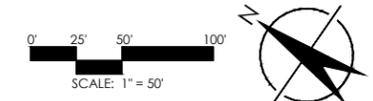
PROJECT NUMBER  
220053

SCALE  
AS NOTED

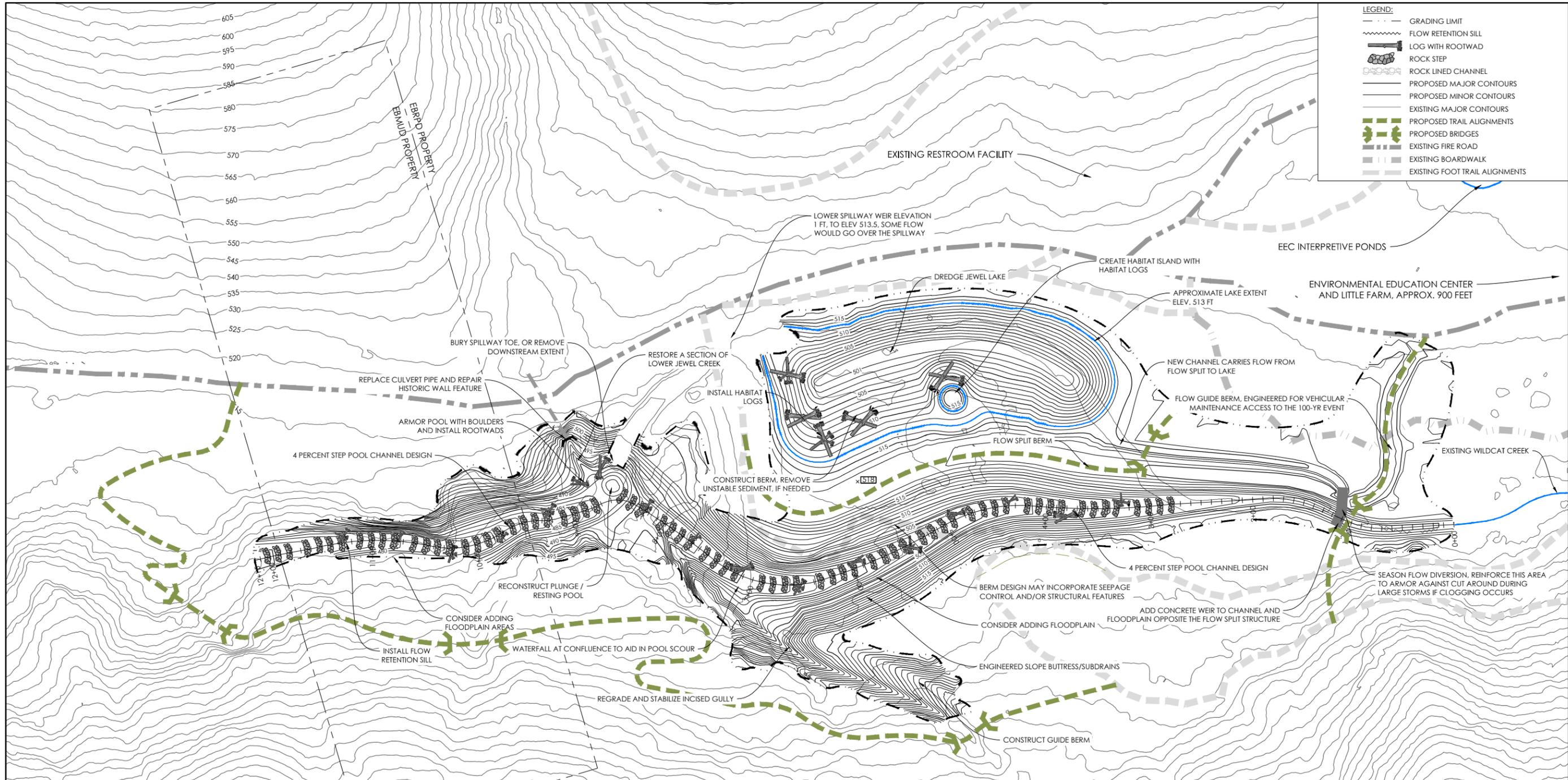
FIGURE  
**2.0**



THAWEG ALIGNMENT  
 PROFILE VIEW  
 1" = 80' 3.0 3.0







- LEGEND:**
- GRADING LIMIT
  - FLOW RETENTION SILL
  - LOG WITH ROOTWAD
  - ROCK STEP
  - ROCK LINED CHANNEL
  - PROPOSED MAJOR CONTOURS
  - PROPOSED MINOR CONTOURS
  - EXISTING MAJOR CONTOURS
  - PROPOSED TRAIL ALIGNMENTS
  - PROPOSED BRIDGES
  - EXISTING FIRE ROAD
  - EXISTING BOARDWALK
  - EXISTING FOOT TRAIL ALIGNMENTS

**Balance Hydrologics, Inc.**  
 800 Bancroft Way · Suite 101  
 Berkeley, CA 94710  
 tel (510) 704-1000 · fax (510) 704-1001  
 www.balancehydro.com

SUBMITTALS / REVISIONS	
BY	DATE

DESIGNED BY	DRAWN BY	CHECKED BY	IN CHARGE	DATE

NOT FOR CONSTRUCTION

**CONCEPT 4**  
 CREATE BYPASS CHANNEL,  
 DREDGE WILDCAT CREEK  
 LONG-TERM MANAGEMENT AND RESTORATION STUDY  
 FOR THE JEWEL LAKE REACH OF WILDCAT CREEK  
 EAST BAY REGIONAL PARK DISTRICT

PROJECT NUMBER  
220053

SCALE  
AS NOTED

FIGURE  
**4.0**

