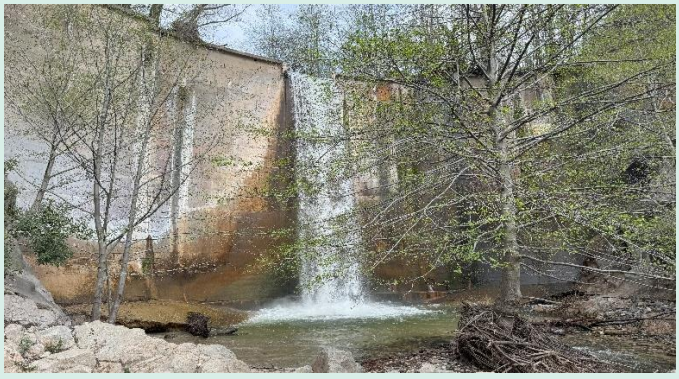
TECHNICAL REPORT ◦ JUNE 2024

Fish Passage Barrier Assessment in the Upper Arroyo Seco



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Cover photos (clockwise from top left): First crossing 1.71; Pasadena Water and Power diversion weir; *O. mykiss*, used with permission from Ian Shive, Nature in Focus; Brown Mountain Dam.

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Acronyms and Abbreviations

CDFW	California Department of Fish and Wildlife
DPS	Distinct Population Segment
ft	feet or foot
JPL	Jet Propulsion Laboratory
LAR	Los Angeles River
mm	millimeters
PAD	California Passage Assessment Database
PWP	Pasadena Water and Power
RM	river mile
SFEPAS	Stream Flow Enhancement Program for the Arroyo Seco
USGS	U.S. Geological Survey

1 INTRODUCTION

In 2022, the California Wildlife Conservation Board awarded a grant to the Arroyo Seco Foundation in the amount of $427,488 for the Stream Flow Enhancement Program for the Arroyo Seco (SFEPAS). The SFEPAS is a scientific study to map and analyze passage barriers, to improve stream flow, and prioritize additional stream flow enhancement projects on publicly owned land in the Upper Arroyo Seco Watershed within the City of Pasadena and the Angeles National Forest located in Los Angeles County, California. This report has been prepared by Stillwater Sciences in accordance with Task 3 of the Grant Agreement WC-2274EA between the California Wildlife Conservation Board and Arroyo Seco Foundation.

1.1 Background and Objectives

Headwaters to ocean watershed management is critical to the re-establishment of healthy watersheds and healthy communities. Barriers to free-flowing rivers and streams such as Brown Mountain Dam and others addressed in this report have been identified by National Marine Fisheries Service, California Department of Fish and Wildlife (CDFW), and Stillwater Sciences, among others as priorities for removal and/or treatment (CDFW 2023; Stillwater Sciences et al. 2022; Stillwater Sciences 2021, 2020; NMFS 2012).

The SFEPAS for the Arroyo Seco provides crucial next steps to improve stream flows and remove impediments for fish passage as well as assess physical habitat and flow conditions on the Arroyo Seco, a major tributary to the Los Angeles River (LAR). The barriers to fish passage are examined in this report while the instream flow and habitat assessment are presented in a separate report (Stillwater Sciences 2024). The Arroyo Seco historically provided essential habitat for steelhead (*Oncorhynchus mykiss*) that are part of the endangered Southern California Steelhead Distinct Population Segment (DPS). Urbanization during the past 100 years, including barrier construction, prevented the population of steelhead in the Arroyo Seco from accessing the ocean and expressing an anadromous life-history type. Above-barrier populations that no longer have access to the ocean are considered resident rainbow trout and are not under protected status by state or federal agencies. Herein, the general term *O. mykiss* is used to refer to the existing population of steelhead in the Arroyo Seco.

Despite extensive urbanization, a resident *O. mykiss* population persisted in the upper Arroyo Seco (defined as the Arroyo Seco upstream of Devil's Gate Dam) until the population was nearly extirpated following the 2009 Station Fire. Subsequently, in 2020, CDFW reintroduced *O. mykiss* from a rescued population in the San Gabriel watershed to the Arroyo Seco (Pareti 2020). Notably, this rescued population is primarily of native steelhead coastal ancestry with limited hatchery introgression (Abadía-Cardoso et al. 2016), meaning the existing population has descended from native steelhead and maintains genetics associated with anadromy. Because they maintain genetics associated with anadromy, some proportion of the existing population of *O. mykiss* in the Arroyo Seco likely attempt to migrate to the ocean but are blocked by Devil's Gate Dam. Any fish that failed to migrate downstream to the ocean would subsequently require upstream passage to reascend the Arroyo Seco to remain in the population.

In addition to major barriers that prevent expression of an anadromous life-history strategy, such as Devil's Gate Dam, numerous smaller fish passage barriers also occur within the upper Arroyo Seco. Smaller barriers can seasonally (or entirely) restrict *O. mykiss* access to and movements among habitats that are essential for fulfilling life-history requirements such as spawning and rearing. While many barriers have been identified in reports and databases, the objectives herein

were to compile this information into a single report to facilitate the identification and assessment of barriers in the field and then to use this information to prioritize barriers for removal, with the overall goal of providing *O. mykiss* with unimpeded movements to improve conditions for the population.

To prepare this report, Stillwater Sciences (Stillwater) consolidated existing information to identify barriers (e.g., natural waterfalls, high-gradient sections of the channel, weirs, bridge abutments, concrete aprons, dams, grade control structures, channelized concrete segments, and other natural and artificial structures in the channel) that could be impediments for fish passage. Stillwater also conducted a field assessment to survey and evaluate barriers and structures identified through the review of existing information. Collected data were analyzed to characterize the types of barriers (e.g., velocity barrier to upstream passage, height barrier to upstream passage, downstream passage barrier; passage impediments, and low flow barriers) and prioritize barriers for removal.

1.2 Study Area

The Arroyo Seco is a tributary to the LAR. The upper Arroyo Seco watershed includes the portion of the watershed upstream of Devil's Gate Dam, which drains an area of 23.6 square miles (Figure 1). For this report, the Study Area is defined as the approximate 4 miles of the stream from the Explorer Road bridge at the National Aeronautics and Space Administration's Jet Propulsion Laboratory (JPL) upstream to Brown Mountain Dam. For reference, Brown Mountain Dam is located between river mile (RM) 5.4 and RM 5.5 as counted upstream from Devil's Gate Dam (RM 0). The only surface flow diversion within the Study Area is the Pasadena Water and Power (PWP) diversion weir located at approximately RM 1.8. USGS Gage #11098000 is located about halfway up the Study Area at RM 3.4. Upstream of the USGS gage, the stream tends to have higher-quality fish habitat because it is perennially wetted with pools, boulders, good cover, and spawning habitat. Downstream of the USGS gage, the stream often dries up in the autumn, especially in drought years, and not as much cover for fish exists. *O. mykiss* have been observed throughout this reach of the Arroyo Seco, but the population predominantly exists within perennial habitat upstream of the USGS gage (CDFW 2023).

1.3 Steelhead Life-History Overview

Southern California steelhead is a species of trout that can migrate to the ocean (referred to as anadromous) or complete its life cycle entirely in fresh water (referred to as resident). Steelhead is the term used to describe the anadromous life-history type, whereas freshwater residents are generally referred to as rainbow trout or resident *O. mykiss*. The population of *O. mykiss* in the upper Arroyo Seco is considered resident *O. mykiss* because their access to the ocean is blocked by major barriers. *O. mykiss* located upstream of barriers to anadromy are not federally or state listed, but populations with access to the ocean are federally and state listed as endangered under the U.S. Endangered Species Act and California Endangered Species Act, respectively. The two life-history forms are capable of interbreeding and one life-history form can produce offspring that follows the alternate form (Donohoe et al. 2021).

Resident *O. mykiss* in southern California spawn from January to June. Following deposition in redd gravels in the winter and spring, southern California *O. mykiss* eggs incubate for 3 to 8 weeks before hatching; incubation time is related to water temperature (NOAA 2007). After hatching, alevins (or sac fry) remain in the redd gravels while undergoing further development and absorption of the yolk sac for another 2 to 6 weeks before emerging as fry (less than

50 millimeters [mm] standard length) (NOAA 2007). Based on expected spawning timing and the incubation period, developing southern California *O. mykiss* eggs or alevins may be present in spawning gravels from approximately February through July (Zimmerman and Reisenbichler 2002, Bush and Spina 2014).

Juvenile rearing may occur for 1 to 3 years before migrating to the ocean as smolts or remaining in the watershed (NMFS 2012). As mentioned, ocean access is blocked for *O. mykiss* in the upper Arroyo Seco because of major barriers downstream; however, anadromous potential is genetically maintained in above-barrier populations (Apgar et al. 2017, Pearse et al. 2019), and individuals may still exhibit this life-history strategy, albeit unsuccessfully. Resident *O. mykiss* can also exhibit dispersal in upstream or downstream directions for spawning or foraging opportunities, but dispersal patterns are not well understood.

Figure 1. Upper Arroyo Seco watershed from Devil's Gate Dam to Brown Mountain Dam.

O. mykiss historically occurred in the upper Arroyo Seco, even following the construction of major barriers. However, the population was nearly extirpated following the 2009 Station Fire that extensively burned the watershed. The existing population of *O. mykiss* in the upper Arroyo Seco is largely (or entirely) from a translocated population from the West Fork of the San Gabriel River and Bear Creek following the 2020 Bobcat Fire (Pareti 2020). Approximately 470 *O. mykiss* were released into the upper Arroyo Seco as part of this rescue/translocation (Pareti 2020).

2 FISH PASSAGE

Anthropogenic and natural in-stream barriers can impede movements of aquatic species. Barriers interfere with natural movement patterns of fish by limiting access to spawning and rearing habitat, thereby reducing the potential fish productivity in a stream system. Barriers can also cause increased energy expenditure and migration delay, potentially leading to reduced spawning success (CDFG 2004). Therefore, identifying and remediating fish passage barriers are important factors in the recovery and sustainability of productive fish populations.

Anthropogenic fish passage barriers occur in many forms. Transportation development due to urbanization often results in construction of human-made stream crossings, such as culverts, bridges, or fords, that either pass over or through a stream channel. Other potential barriers to migration include water diversions, dams, and grade control structures. Natural features, such as waterfalls or log jams, can also create fish passage barriers.

Anadromous species, such as steelhead, are particularly affected by passage barriers because they migrate through a stream network at multiple life stages (CDFG 2004). Generally, juvenile and adult salmonids, such as steelhead, attempt to pass barriers, such as road crossings, during elevated flow events, with adults attempting at higher flows than juveniles (Lang et al. 2004). Seasonally changing conditions, such as the height of the outlet and flow conditions in and adjacent to a crossing, can completely or partially prevent fish passage.

Barriers can be classified as temporal, which are impassable to all fish at certain flow conditions; partial, which are impassable to some fish species during some or all life stages at all flows; or total which are impassable to all fish at all flows (CDFG 2004). Although *O. mykiss* in the Arroyo Seco are not considered anadromous, passage barriers within the upper Arroyo Seco can still impact the population by impeding natural movement patterns associated with locating suitable refuge, dispersal, spawning, and foraging.

3 BARRIER ASSESSMENT METHODS

As described in Section 1.1, the objectives of this report were to identify and assess potential fish passage barriers within the upper Arroyo Seco from Devil's Gate Dam to Brown Mountain Dam and to prioritize barriers for replacement or removal to improve fish passage conditions.

3.1 Identification of Potential Barriers

Potential barriers within the Study Area were identified from available information in literature, previous site visits conducted by Stillwater engineers and biologists, personal communications with local experts, and the California Passage Assessment Database (PAD) (CDFW 2023). The

PAD is a periodically updated, map-based inventory of potential barriers to anadromous fish in California. While not comprehensive, the PAD contains most available information on potential fish passage barriers within the Study Area, including records of road crossings, diversions, and dams.

3.2 Field Survey

To assess barriers, a Stillwater field crew walked the stream from the JPL bridge upstream to Brown Mountain Dam on March 14 and 15, 2024. The Stillwater field crew was joined by a CDFW environmental scientist. During this survey, each potential barrier identified under Section 3.1 was located and assessed. Any additional potential barriers not previously identified were also documented and assessed. Measurements, including barrier height, pool depths, channel widths, and barrier length, were collected at each potential barrier using a stadia rod and transect tape, all potential barriers were photographed, and any other items of note (e.g., state of disrepair) were documented at each potential barrier. Potential barriers were categorized as either anthropogenic or natural, physical or velocity, partial or total barriers, and barriers for upstream and/or downstream movements.

4 BARRIER ASSESSMENT RESULTS AND DISCUSSION

4.1 Barrier Review Results

In reviewing literature, reports, and the PAD, a total of 13 potential barriers were identified throughout the upper Arroyo Seco at and below Brown Mountain Dam, of which only 6 are currently listed in the CDFW PAD (CDFW 2023). Of these 13 potential barriers, 11 are located within the Study Area, and two—Devil's Gate Dam and Brown Mountain Dam—are the boundaries of the Study Area and are known total barriers, so they were not further assessed herein (a separate report on Brown Mountain Dam removal feasibility is being developed as part of the Stream Flow Enhancement Program for the Arroyo Seco). The findings of this barriers assessment are summarized in Table A-1.

4.2 Field Survey Results

A total of 12 barriers within the Study Area were assessed during the field survey (Figures 2 and 3, Table 1). Ten of these barriers were identified in the desktop review of potential barriers, and two additional barriers were identified in the field. Two of the records from the desktop survey were found to represent the same barrier. Figures 2 and 3 show the locations of barriers within the downstream (Figure 2) and upstream (Figure 3) reaches of the Arroyo Seco within the Study Area. The preliminary assessment of the 12 potential fish passage barriers is presented hereafter.

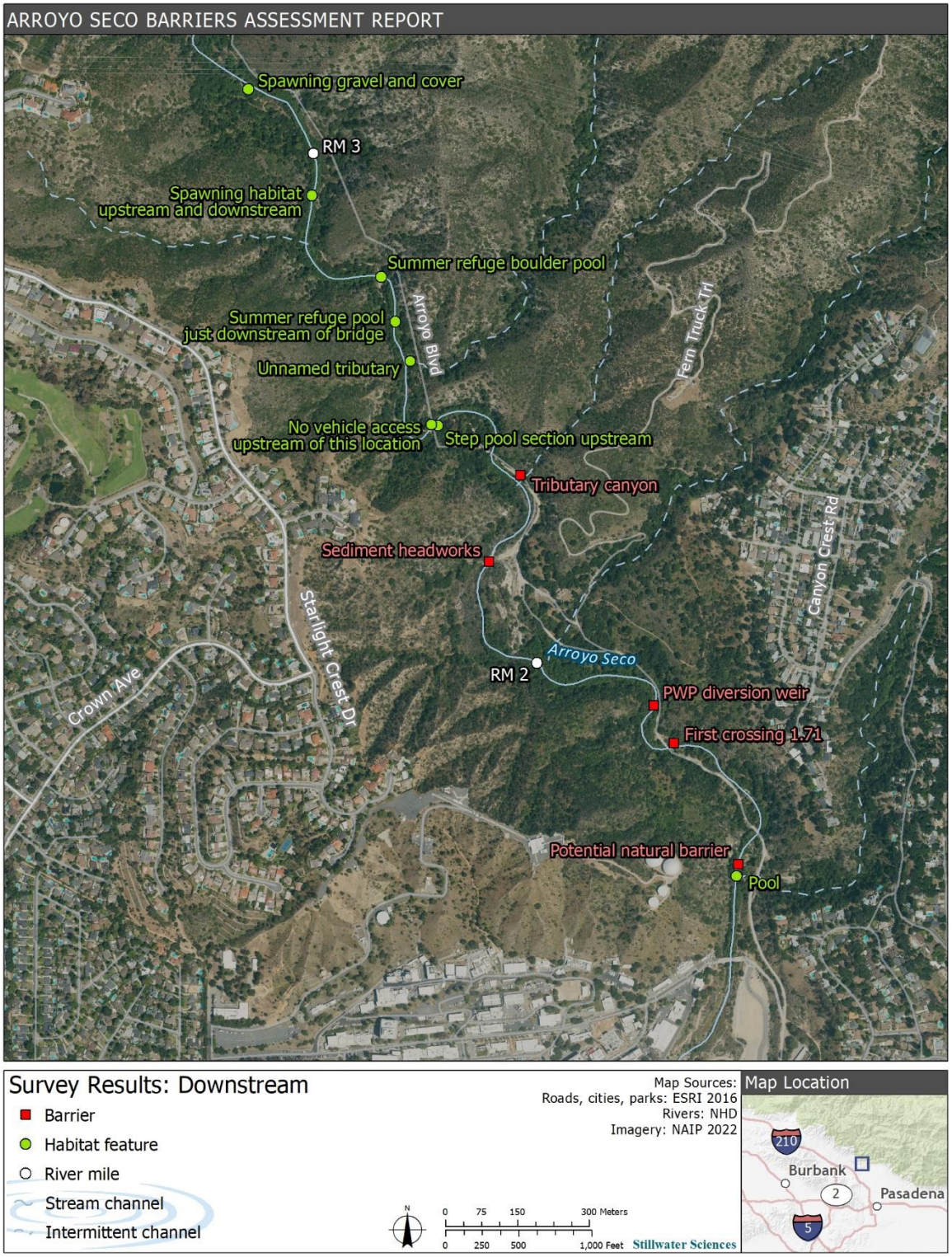

Figure 2. Barrier assessment survey results within the downstream reach of the Arroyo Seco, including significant habitat features also identified during the field survey.

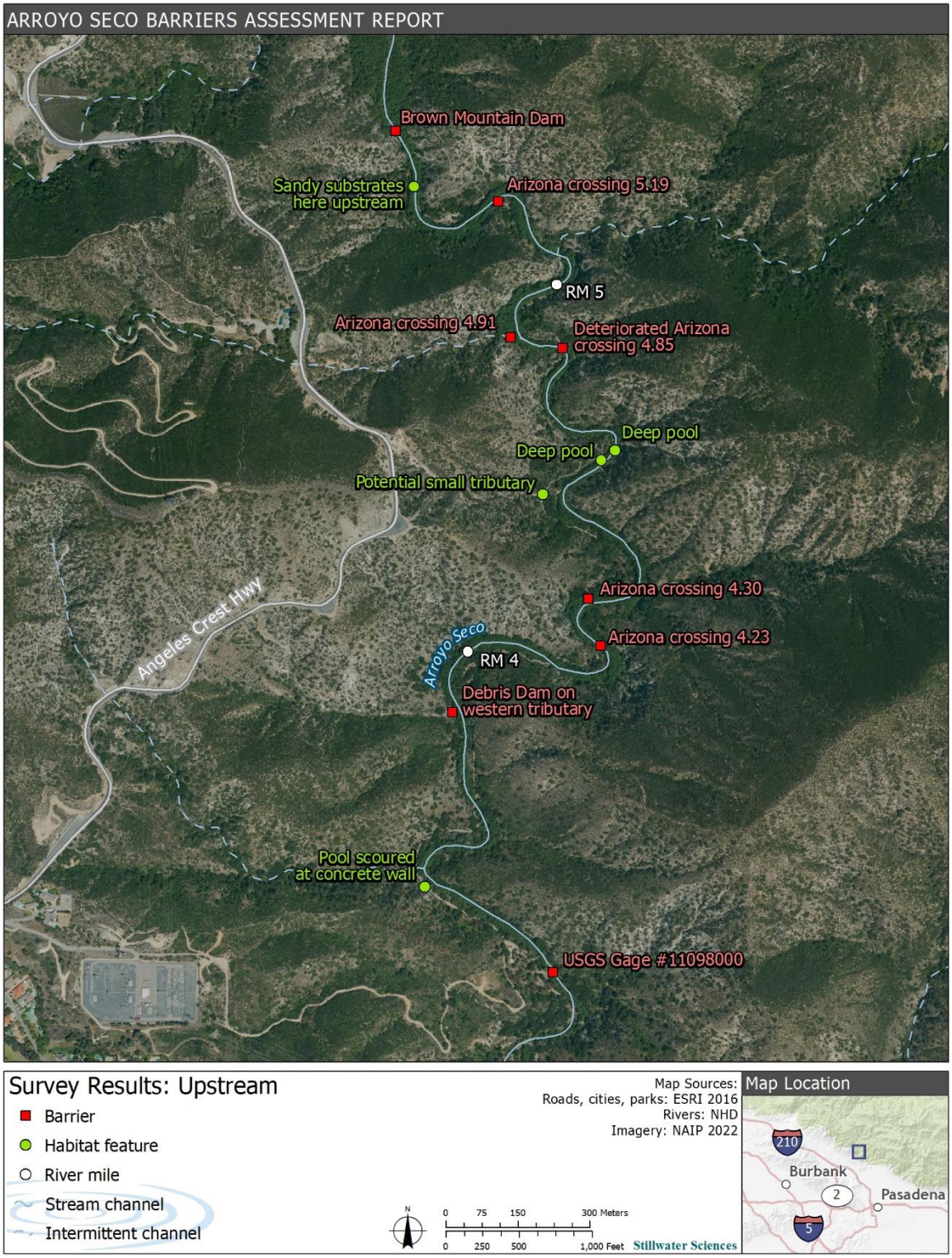

Figure 3. Barrier assessment survey results within the upstream reach of the Arroyo Seco.

4.2.1 Potential natural barrier (river mile 1.49)

The first potential barrier upstream of the JPL bridge is a small natural waterfall about 3 feet (ft) in height at RM 1.49. This is the only natural barrier of the 12 barriers assessed during this survey. The natural barrier could be a partial physical barrier to upstream migration, especially for smaller-sized juveniles or any life stage during periods of low flow.

Figure 4. Potential natural barrier at river mile 1.49.

4.2.2 First crossing (river mile 1.71)

The first crossing is a concrete apron under a bridge located at RM 1.71. The head height is about 4.5 ft, which is uniform for about 5 ft, and then there is a deep pocket near the concrete wing. The length of the barrier, measured from the downstream end to the upstream end of the structure, is a 34-ft run with some deep spots and a sand and gravel sediment bottom. This barrier is next to the road and has vehicle access. The first crossing barrier is likely a total physical barrier to upstream passage for most fish under most flows, but certainly for smaller fish and under low flows. Larger-sized fish may be able to pass under some flow conditions due to the deep pool depth downstream. The 34-ft run immediately upstream from the drop structure could also be a velocity barrier under high flows.

Figure 5. First crossing at river mile 1.71.

4.2.3 Pasadena Water and Power diversion weir (river mile 1.81)

The PWP diversion weir, located at RM 1.81, is a concrete wall with a 2.5-ft lip of concrete at the top and a natural bottom that becomes shallow upstream. There is a notched feature on the left bank (looking upstream). Very little cover exists in the pool downstream of the diversion. On March 13, 2024, an *O. mykiss* was observed attempting to jump over the barrier, but it was unsuccessful. Typically, the stream seasonally dries upstream of the diversion weir halfway to USGS Gage #11098000, especially in drought years (J. Stanovich, CDFW, pers. comm., March 14, 2024). The diversion is adjacent to the road with vehicle access. Overall, the PWP diversion weir is likely a total physical barrier to upstream movements of fish, regardless of flow and life stage.

Figure 6. Pasadena Water and Power diversion weir at river mile 1.81.

4.2.4 Sediment headworks (river mile 2.19)

The sediment headworks, located at RM 2.19, have a large concrete center block that splits the stream into two channels. The left bank has a drop caused by boulders on a diagonal, which could be passable by fish under certain flows. There are boulders, a bubble curtain, and a narrow channel downstream. The right bank does not have a drop, but vegetation is dense and chokes the river approximately 40 ft downstream. The two channels meet about 0.1 mile downstream of this barrier. Prior to surveys, the area downstream of the headworks in low-flow conditions was highly silty and had log jams and standing water (J. Stanovich, CDFW, pers. comm., March 14, 2024), and now the area has riffle habitat with rocks and non-uniform flow. The channel was rerouted by the City of Pasadena following heavy rains to maintain the adjacent road, and sediment berms were created on the right bank. The measurements in Table 1 (provided at the end of this section) are for the left bank. It is possible that the stream may reroute in the future. Water goes subsurface downstream of this barrier under low flow conditions. There is good vehicle access to this barrier on the adjacent road. Overall, the sediment headworks barrier is a partial physical barrier to upstream migration, especially for smaller-sized juveniles or during periods of low flow.

Figure 7. Sediment headworks at river mile 2.19.

4.2.5 Tributary canyon (river mile 2.32)

The tributary canyon barrier is located in a tributary to Arroyo Seco (the confluence is located at RM 2.32). The barrier's purpose is unknown. During the survey, the tributary was dry, and no suitable *O. mykiss* habitat was available upstream. There was some sediment in the downstream end, indicating that in the past water has flowed in this location. Because the tributary is assumed to be dry most of the time, it is concluded that the tributary canyon is not in fact a barrier to fish passage.

Figure 8. Tributary canyon at river mile 2.32.

4.2.6 USGS Gage #11098000 (river mile 3.43)

USGS Gage #11098000, located at RM 3.43, is a large concrete slab with a two-step face. During the survey, it had a few inches of water cascading over the top step and a log jam at the top of the barrier. A crack on the left bank has a deep undercut, and the deepest part of the downstream pool is inside the crack. Stillwater scientists observed *O. mykiss* at this location during site visits in 2022 (Stillwater unpubl. data) and the Arroyo Seco Foundation has consistently observed fish in this pool during surveys (The Arroyo Seco Foundation unpubl. data). The high-quality habitat upstream of this barrier makes it a good candidate for replacement or modification to improve fish passage. Vehicle access is available via the adjacent road and the nearby Gould Mesa Campground. The USGS gage is a partial physical barrier to upstream migration, and the sheet flow over the concrete could create a velocity barrier during high flows. The barrier is located adjacent to Gould Mesa Campground, which is accessible to vehicles via a private service road. All barriers upstream of USGS Gage #11098000 can be reached only on foot using a hiking trail (i.e., not accessible to vehicles), unless otherwise stated.

Figure 9. USGS Gage #11098000 at river mile 3.43.

4.2.7 Debris dam on western tributary (river mile 3.93)

The debris dam is a 40-ft high dam with rocks on a high-gradient tributary of the Arroyo Seco on the west side of the stream at RM 3.93. The tributary is assumed to be dry most of the time; therefore, it is concluded that the debris dam is not a barrier to fish passage.

Figure 10. Debris dam on western tributary at river mile 3.43.

4.2.8 Arizona crossing (river mile 4.23)

An Arizona crossing is a roadway that crosses a stream. The first and farthest downstream Arizona crossing within the Study Area is located at RM 4.23; it is scoured in the center and has major undercutting on either side. The scoured area was filled with sediment. Juvenile fish were observed in the scoured area and downstream of the barrier, likely *O. mykiss* because that is the only fish species known to be present within the Study Area (J. Stanovich, CDFW, pers. comm., March 15, 2024). Gravels were observed upstream, downstream, and inside the scoured portion of the barrier and could be used for spawning. This barrier no longer serves its intended purpose; it was built so that vehicles could cross the stream, but vehicle access to this area is no longer available. Furthermore, it could create public safety issues during high flows, and people crossing the stream at this location could disturb spawning habitat. Overall, this is a partial physical barrier to upstream migration and most likely prevents upstream migration during periods of low flows, especially for smaller-sized juveniles.

Figure 11. Arizona crossing at river mile 4.23.

4.2.9 Arizona crossing (river mile 4.30)

The second Arizona crossing, located at RM 4.30, is a low concrete slab that has started to scour in the center. The scouring was not obvious during CDFW surveys last year in 2023 (J. Stanovich, CDFW, pers. comm., March 15, 2024), so it may have started less than a year ago. The concrete slab can create a sheet flow that would create a partial velocity barrier to upstream fish passage during high flows. There was no pool on the downstream side. Some gravels were available nearby, but very little cover. This barrier is not as large as the downstream Arizona crossing, but they are located very close together, so it may be possible to remove both at the same time. Scour downstream could create a total barrier in the future.

Figure 12. Arizona crossing at river mile 4.30.

4.2.10 Deteriorated Arizona crossing (river mile 4.85)

The third Arizona crossing, located at RM 4.85, was not considered a barrier at the time of the survey because the concrete slab has deteriorated naturally. The remaining pieces are a 7-ft x 10-ft slab (left bank) and a 13-ft x 20-ft slab (right bank), which are somewhat choking the river, but fish can still pass through them. The concrete on the right bank is undercut, creating potential habitat for *O. mykiss*. During a previous site visit (September 5, 2018), Stillwater staff noted that if logs and debris were to become trapped in the concrete, they could potentially block fish passage.

Figure 13. Deteriorated Arizona crossing at river mile 4.85.

4.2.11 Arizona crossing (river mile 4.91)

The fourth Arizona crossing, located at RM 4.91, was not found during the initial desktop review of potential barriers but was observed during the field survey. It is a thick concrete slab that creates a total physical barrier to upstream passage to all life stages under all flows. At least six *O. mykiss* were observed in the pool downstream of this barrier during the field survey. This barrier would be difficult to remove logistically because it is not on a trail, it is located far from any areas with vehicle access, and vegetation surrounds the barrier. Possible solutions include notching the barrier or breaking up the concrete and leaving the pieces in the stream.

Figure 14. Arizona crossing at river mile 4.91.

4.2.12 Arizona crossing (river mile 5.19)

The fifth Arizona crossing, located at RM 5.19, is a concrete slab that is starting to deteriorate on top. This barrier is relatively low and may be low enough for larger-sized fish to jump but would be a physical barrier to upstream migration for smaller-sized juveniles. The sheet flow over the concrete slab could also be a velocity barrier under high flows. Additional scour downstream could create a total barrier in the future.

Figure 15. Arizona crossing at river mile 5.19.

Table 1. Summary of all barriers documented in the Upper Arroyo Seco watershed.

Name	Type of barrier[1]	Latitude	Longitude	River mile	Water depth (ft)[2]	Head height (ft)[3]	Width (ft)[4]	Length (ft)[5]	Land ownership
Potential natural barrier (RM 1.49)	Partial; physical; US	34.20477	-118.16632	1.49	> 3	3	–	–	–
First crossing (RM 1.71)	Partial; physical and velocity; US	34.20704	-118.16781	1.71	4	4.5	21.6	34	N/A
Pasadena Water and Power diversion weir (RM 1.81)	Total; physical; US	34.20774	-118.16828	1.81	3.4 to 4	3.7	35 (wetted width)	2.5	City of Pasadena Department of Water and Power
Sediment headworks (RM 2.19)	Partial; physical; US	34.21042	-118.17191	2.19	1	2.4	6-7	–	N/A
Tributary canyon (RM 2.32)	None	34.21204	-118.17135	2.32	–	–	30.3	40	N/A
USGS Gage #11098000 (RM 3.43)	Partial; physical and velocity; US	34.22195	-118.17777	3.43	4.5 in crack, 3 downstream	5	45.7	28	N/A
Debris dam on western tributary (RM 3.93)	None	34.22682	-118.18011	3.93	–	40	–	–	N/A
Arizona crossing (RM 4.23)	Partial; physical; US	34.22810	-118.17677	4.23	3.7 downstream, 2.5 middle (scoured)	2.6	79	26.2	U.S. Forest Service
Arizona crossing (RM 4.30)	Partial; velocity; US	34.22898	-118.17706	4.30	2 downstream, 0.6 over barrier	39	25.5	–	U.S. Forest Service
Deteriorated Arizona crossing (RM 4.85)	None	34.23368	-118.17771	4.85	–	–	–	–	U.S. Forest Service
Arizona crossing 4.91	Total; physical; US	34.23387	-118.17889	4.91	4	3.9	49	26	U.S. Forest Service
Arizona crossing (RM 5.19)	Partial; physical and velocity; US	34.23642	-118.17921	5.19	2	1.1	42.3	14	U.S. Forest Service

Note: RM = river mile; US = upstream

[1] All barriers are assumed to be anthropogenic, except when stated otherwise. Barriers are classified as partial or total, physical and/or velocity, and/or impacting upstream (US) and/or downstream (DS) movement.

[2] Depth of water at the deepest point immediately downstream of the barrier, unless otherwise stated.

[3] Measurement of surface water to the top of the barrier face.

[4] Measurement of the barrier face from the left bank to right bank, unless otherwise stated.

[5] Measurement of the length of the barrier from upstream to downstream.

4.3 Summary

Overall, 9 anthropogenic barriers within the upper Arroyo Seco impede the natural movement patterns of *O. mykiss*. Most barriers are considered partial barriers, and all of the barriers impede only upstream movement, especially during low flows. Early life stages of *O. mykiss* would be most impacted by these barriers, but movements of larger-sized juveniles and adults could also be impeded. On March 13, 2024, an *O. mykiss* was observed by Stillwater biologists in the pool downstream of the PWP diversion weir, possibly swept downstream from the higher-quality habitat upstream during winter storms. There were also sightings of *O. mykiss* trapped in the Devil's Gate Reservoir after these fish were swept down during winter storms, demonstrating the need for improved upstream passage throughout the upper Arroyo Seco.

5 BARRIER PRIORITIZATION

Prioritization of barriers for removal is presented in Table 2 and was based on two main factors: the type or severity of the barrier (velocity and/or physical and partial or total) and the need for connectivity based on quality of the habitat around the barrier. Two additional factors were taken into consideration: the accessibility of the barrier for purposes of removal, because barriers along the road would be easier to access and remove than barriers along the narrow trail that has no vehicle access; and the removal/replacement effort, which depends on both the accessibility and the physical nature of each barrier.

In general, the lower half of the Study Area has easier access to barriers but lower-quality habitat and fewer fish compared with the upstream half of the Study Area. The largest numbers of *O. mykiss* and the highest-quality habitat are located from the USGS gage upstream to Brown Mountain Dam. Compared with barrier removals in the lower half of the upper Arroyo Seco, removing high-priority barriers in the upper half would provide a greater benefit to the *O. mykiss* population by increasing habitat connectivity where the highest-quality habitat and the majority of the fish are located. The upper portion of the Study Area includes the five Arizona crossings, the majority of which the public uses to cross the stream on foot or by bicycle. These stream crossings can be a public safety concern during high flows, and foot traffic through the stream around difficult-to-cross barriers could disturb adjacent spawning habitat. Barriers within the upper reach of the Arroyo Seco are on National Forest System lands, which are now part of the San Gabriel Mountains National Monument, and all of these barriers can be accessed only by trail (no vehicle access) except for the Arizona crossing at RM 4.91, which is completely off-trail.

Table 2. Prioritization of removal of barriers in the Upper Arroyo Seco watershed.

Name	Type of barrier[1]	Habitat quality[2]	Access[3]	Proposed removal effort	Priority for removal
Potential natural barrier (RM 1.49)	Partial; physical; US	Low	Vehicle road (easy)	No removal necessary	Low
First crossing (RM 1.71)	Partial; physical and velocity; US	Low	Vehicle road (easy)	Modify or replace with a new structure for improved fish passage	Medium
Pasadena Water and Power diversion weir (RM 1.81)	Total; physical; US	Low	Vehicle road (easy)	Modify or replace with a new structure for improved fish passage	Medium
Sediment headworks (RM 2.19)	Partial; physical; US	Moderate	Vehicle road (easy)	Remove concrete blocks and sediment berms to naturalize reach	Low
Tributary canyon (RM 2.32)	None	Low	Vehicle road (easy)	–	Low
USGS Gage #11098000 (RM 3.43)	Partial; physical and velocity; US	High	Vehicle road (easy)	Modify or replace with a new structure for improved fish passage	High
Debris dam on western tributary (RM 3.93)	None	High	Foot trail (difficult)	–	Low
Arizona crossing (RM 4.23)	Partial; physical; US	High	Foot trail (difficult)	Remove Arizona crossing for improved fish passage	High
Arizona crossing (RM 4.30)	Partial; velocity; US	High	Foot trail (difficult)	Remove Arizona crossing for improved fish passage	Medium
Deteriorated Arizona crossing (RM 4.85)	None	High	Foot trail (difficult)	Remove concrete slabs to naturalize reach	Low
Arizona crossing (RM 4.91)	Total; physical; US	High	Off trail (very difficult)	Remove or notch Arizona crossing for improved fish passage	High
Arizona crossing (RM 5.19)	Partial; physical and velocity; US	High	Foot trail (difficult)	Remove Arizona crossing for improved fish passage	Medium

Notes: RM = river mile; US = upstream

[1] All barriers are assumed to be anthropogenic except when stated otherwise. Classified as partial or total, physical and/or velocity, and/or impacting upstream (US) and/or downstream (DS) movement.

[2] Quality of habitat that would be more easily accessible to fish if the barrier were removed.

[3] Accessibility of barrier for removal.

6 NEXT STEPS

6.1 Future Planning

The State of California is moving forward with implementation of biodiversity, connectivity, and access to nature policies that reinforce the importance of regional and local measures to remove barriers to wildlife connectivity. As part of this movement, the Arroyo Seco is poised to advance steelhead recovery actions to reconnect the headwaters to ocean fish migration and habitat needs to support the fishes' full lifecycle. Focused actions through the LA River fish passage, restoration, and flows program intentionally connect to the streamflow enhancement and barrier removals in the headwaters—the Arroyo Seco (Stillwater Sciences 2020, 2021; Stillwater Sciences et al. 2022; Katagi et al. 2022). Monitoring and management of fish populations, flows, and habitat are critical to recovery of the species and to implementation of statewide directives toward healthy connected watersheds.

These efforts are of particular importance to create resilient populations in the face of climate change. In southern California, the frequency and severity of droughts, wildfire, and debris flows are anticipated to increase under climate change predictions, which could further reduce population abundance, cause extirpations, and limit the effectiveness of recovery efforts. Removal of barriers is a key step towards increasing population resiliency by expanding access to refuge habitat (i.e., refuge from drought and high flows) and providing opportunities for *O. mykiss* to express diverse life history strategies.

6.2 Implementation of Barrier Removal

Next steps for addressing barriers include securing funding, acquiring permits, and implementing barrier removals. Early in this process (and throughout), agency and landowner coordination will be critical. Coordination is necessary with local (City of Pasadena, Los Angeles County), state (CDFW) and federal (i.e., U.S. Forest Service, U.S. Fish and Wildlife Service, USGS, U.S. Army Corp of Engineers) agencies, depending on the barrier location and the presence of other state or federal listed species. Barriers within the Arroyo Seco in locations on National Forest System lands will require specific U.S. Forest Service permits (such as Special Use Permits).

Engineering designs are a major part of many barrier removal projects, but most if not all of the priority barriers in this report would be considered removal projects (with restore to natural conditions) and may not require engineering designs or an extensive planning phase. However, determining how the barriers would be removed (i.e., with hand tools versus mechanical tools versus explosives) and how debris would be dealt with are key elements to the planning and permitting phases. Access may be one of the major challenges for implementation of barrier removals in the upper section of the Arroyo Seco, which is located on National Forest System lands.

7 REFERENCES

Abadía-Cardoso A., D. E. Pearse, S. Jacobson, J. Marshall, D. Dalrymple, G. Kawasaki F, Ruiz-Campos, and J. C. Garza. 2016. Population genetic structure and ancestry of steelhead/rainbow trout (*Oncorhynchus mykiss*) at the extreme southern edge of their range in North America. Conservation Genetics 17: 675–689.

Apgar, T. M., D. E. Pearse, and E. P. Palkovacs. 2017. Evolutionary restoration potential evaluated through the use of trait-linked genetic marker. Evolutionary Applications 10: 485–497.

Bush, R., and A. Spina. 2014. Spawning characteristics of sympatric steelhead and resident *O. mykiss* in the Ventura River.

CDFG (California Department of Fish and Wildlife). 2004. Recovery strategy for California coho salmon. Prepared by CDFG, Sacramento, California.

CDFW (California Department of Fish and Wildlife). 2023. Passage Assessment Database (PAD). Available at: https://nrm.dfg.ca.gov/PAD/.

Donohoe, C. J., D. E. Rundio, D. E. Pearse, and T. H. Williams. 2021. Straying and life history of adult steelhead in a small California coastal stream revealed by otolith natural tags and genetic stock identification. North American Journal of Fisheries Management 41: 711–723.

Katagi, W., N. Butler, A. Keith, S. Backlar, and B. Orr. 2022. Ecological restoration of the Los Angeles River provides natural and human benefits as part of a virtuous socioecological cycle. Frontiers in Ecology and Evolution 10: 932550.

Lang, M., M. Love, and W. Trush. 2004. Improving stream crossings for fish passage final report. National Marine Fisheries Service Contract No. 50ABNF800082.

NMFS (National Marine Fisheries Service). 2012. Southern California Steelhead Recovery Plan. Prepared by NMFS, Southwest Region, Protected Resources Division, Long Beach, California.

NOAA (National Oceanic and Atmospheric Administration). 2007. Draft biological opinion for the issuance of an Army Corps 404 Permit Authorization for the City of Ventura's Foster Park Well Facility Repairs Project (File No. 200501739-JWM). Prepared by NOAA, Ventura, California.

Pareti, J. 2020. Translocation of Rainbow Trout to the Arroyo Seco from the Bobcat Fire Burn Area. California Department of Fish and Wildlife.

Pearse, D. E., N. J. Barson, T. Nome, G. T. Gao, M. A. Campbell, A. Abadía-Cardoso, E. C. Anderson, D. E. Rundio, T. H. Williams, K. A. Naish, T. Moen, S. X. Liu, M. Kent, M. Moser, D. R. Minkley, E. B. Rondeau, M. S. O. Brieuc, S. R. Sandve, M. R. Miller, L. Cedillo, K. Baruch, A. G. Hernandez, G. Ben-Zvi, D. Shem-Tov, O. Barad, K. Kuzishchin, J. C. Garza, S. T. Lindley, B. Koop, G. H. Thorgaard, Y. Palti, and S. Lien. 2019. Sex-dependent dominance maintains migration supergene in rainbow trout. Nature Ecology and Evolution 3: 1,731–1,742.

Stillwater Sciences. 2020. Conceptual Ecological Model and Limiting Factors Analysis for Steelhead in the Los Angeles River Watershed. September 2020. Los Angeles, California.

Stillwater Sciences. 2021. Los Angeles River Fish Passage and Habitat Structure Design Project – CDFW Comment Letter on 2020 LA River Master Plan, Draft Program EIR – Brief. May 2021. Los Angeles, California.

Stillwater Sciences. 2024. Upper Arroyo Seco Instream Flow and Habitat Assessment. Prepared by Stillwater Sciences, Los Angeles, California, for the Arroyo Seco Foundation, Pasadena, California.

Stillwater Sciences, Northwest Hydraulic Consultants, TRC Engineers, Gannett Fleming, U.S. Department of the Interior Bureau of Reclamation. 2022. Los Angeles Fish Passage and Habitat Structures Design - 60% Basis of Design Report. May 2022. Los Angeles, California.

Zimmerman, C. E., and R. R. Reisenbichler. 2002. Rainbow trout and steelhead studies in the Matilija Creek/Ventura River basin: summary of activities. Prepared for U.S. Geological Survey, Western Fisheries Research Center, Seattle, Washington.

Appendix A

Summary of Potential Barriers Documented in the Upper Arroyo Seco

Table A-1. Summary of potential barriers documented in the upper Arroyo Seco. Coordinates may not be accurate when taken from databases; refer to field survey results for the most accurate coordinates.

Number	Name	Source	PAD ID	Type	Status	Latitude	Longitude	Owner	Assessed during field survey
1	Devil's Gate Dam	Passage Assessment Database	719040	Dam (debris, earth, rock, flashboard, drop structure, arch, weir, gravity, wing, gabion)	Total	34.18525826	-118.1750105	Los Angeles County Department of Public Works	No, outside Study Area
2	Drop structure at Road Crossing	Passage Assessment Database	765266	Dam (debris, earth, rock, flashboard, drop structure, arch, weir, gravity, wing, gabion)	Total	34.20649618	-118.1664242		Yes (same barrier as #3)
3	Drop structure downstream of bridge	Stillwater site visit 2/11/2023	–			34.206990	-118.167350		Yes (same barrier as #2)
4	Arroyo Seco diversion weir (Pasadena Water and Power diversion)	Passage Assessment Database	765265	Dam (debris, earth, rock, flashboard, drop structure, arch, weir, gravity, wing, gabion)	Temporal	34.20691468	-118.168079	City of Pasadena Department of Water and Power	Yes
5	Headworks sediment trap	Stillwater site visit 9/5/2018	–			34.210413	-118.172015		Yes
6	Spillway at tributary canyon with former gage	Stillwater site visit 2/11/2023	–			34.211974	-118.171341		Yes
7	USGS Gage #11098000	Stillwater site visit 9/5/2018	–			34.221838	-118.177918		Yes
8	Large debris dam on western tributary	Stillwater site visit 2/11/2023	–			34.226486	-118.179850		Yes
9	Abandoned road low-flow stream crossing	Passage Assessment Database	766487	Road crossing (culvert, bridge, low flow)	Temporal	34.22810275	-118.176760	U.S. Forest Service	Yes
10	Abandoned road low-flow stream crossing	Passage Assessment Database	766488	Road crossing (culvert, bridge, low flow)	Temporal	34.22883672	-118.1771031	U.S. Forest Service	Yes

Number	Name	Source	PAD ID	Type	Status	Latitude	Longitude	Owner	Assessed during field survey
11	deteriorated concrete (former road)	Stillwater site visit 9/5/2018	–			34.233343	-118.178021	U.S. Forest Service	Yes
12	Arizona crossing, small drop	Stillwater site visit 2/11/2023	–			34.236393	-118.179334	U.S. Forest Service	Yes
13	Brown Mountain Dam	Passage Assessment Database	715892	Dam (debris, earth, rock, flashboard, drop structure, arch, weir, gravity, wing, gabion)	Total	34.23860569	-118.1815421	U.S. Forest Service	No, outside Study Area