AECOS No. 1463

Biological and water and sediment quality surveys in Mānoa Stream, Honolulu, Hawaiʻi

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Introduction

Hawai'i Department of Land and Natural Resources (HDLNR), Engineering Division proposes to conduct maintenance activities and implement modifications[1] to the channel of Mānoa Stream in the vicinity of Woodlawn Drive Bridge (herein the "Project"). The purpose of the Project is to restore and enhance flow capacity of Mānoa Stream and ease maintenance associated with routine dredging to maintain flow capacity.

Maintenance components include:

- vegetation removal along stream banks,
- maintenance dredging 40 ft upstream and 40 ft downstream of bridge,
- replacement of a portion of upstream bridge structure,
- replacement (and reconfiguration) of a portion of downstream bridge structure, and
- stabilizing banks with erosion control matting.

Proposed modifications to the stream channel include:

- dredging of an additional 940 lf downstream of bridge,
- lining banks and bottom with grouted rip-rap boulders for 400 lf downstream of bridge, and
- maintaining low flow channel with natural bottom and resting pools.

AECOS, Inc. is contracted by R. M. Towill Corporation[2] to conduct environmental surveys in support of the permitting process for the Project. Three biologists undertook surveys on January 27 and 29, 2016. Included were surveys of water quality, sediment quality, aquatic flora and fauna, riparian flora, and avian and mammalian resources at the Project site. This report details findings of those surveys.

Stream Description

Mānoa Stream arises at the head of a large amphitheater-headed valley drained by numerous small streams, including six that are named: 'Aihualama, Waihī, Lua'alaea, Naniuapo, Wa'aloa, and Waiakeakua (Figure 1). Most arise on the south face of Pu'u Konahuanui. Peaking at 946 m (3,105 ft), this is the highest

[1] Maintenance activities may be exempt from the Clean Water Act §404 program, but proposed modifications to the channel are likely to be regulated under the permit program. The U.S. Army Corps of Engineers will evaluate the proposed activities and resources and accept a permit application or issue a "no permit required" letter.

[2] Report prepared for R. M. Towill Corporation for environmental entitlements and will become part of the public record for the Project.

point on the Koʻolau mountain. The six tributaries converge at the upper end of the developed floor of Mānoa Valley. Annual rainfall in this upper part of Mānoa Valley is around 3900 mm (154 in; Giambelluca et al., 2013).

In a previous report of natural resources of the Ala Wai watershed (*AECOS*, 2010), we defined the reaches of Mānoa Stream as follows (illustrated in Fig. 1):

Upper stream reach – stream system tributaries above the confluence of Wahī and Luaʻalaea/Waiakeakua up to the tributary headwaters;
Middle stream reach – from the confluence (start of Mānoa Stream) down to the escarpment opposite Kanewai Field;
Lower stream reach – from the escarpment at Kanewai to the estuarine reach near Kaimuki High School;
Estuarine reach – Mānoa-Pālolo Drainage Canal from roughly midway between Kapiolani Blvd. viaduct and Date Street Bridge to the Ala Wai Canal.

As much as 60% of the middle and lower reaches of Mānoa Stream have been altered for flood control, mostly involving earthen- or concrete-shaped banks (Kido, 2007) and fully concrete-lined channels (*AECOS*, 2000). In addition to Mānoa Stream, Pālolo, and Makiki streams feed into the Ala Wai canal on leeward, south-central Oʻahu. The Ala Wai Canal discharges into the Ala Wai Boat Harbor and then Māmala Bay.

Woodlawn Drive Bridge crosses the middle reach of Mānoa Stream. The middle reach is classified in state water quality standards (Chapter 11-54 of the Hawaiʻi Administrative Rules [HAR]; HDOH, 2014a) as Class 2 inland waters. Beneficial uses of Class 2 waters are designated in HAR §11-54-03(b)(2) as follows:

> "The objective of class 2 waters is to protect their use for recreational purposes, the support and propagation of aquatic life, agricultural and industrial water supplies, shipping and navigation. The uses to be protected in this class of waters are all uses compatible with the protection and propagation of fish, shellfish, and wildlife, and with recreation on and in these waters. These waters shall not act as receiving waters for any discharge which has not received the best degree of treatment or control compatible with the criteria established for this class. No new treated sewage discharges shall be permitted within estuaries".

Specific water quality criteria have been promulgated in HAR Chapter 11-54, which, if met, are designed to allow the water bodies to achieve the beneficial uses described above. The Hawaiʻi Department of Health (HDOH) collects data from surface water bodies and compiles the information in periodic reports that describe the status of water quality and the extent to which the beneficial uses

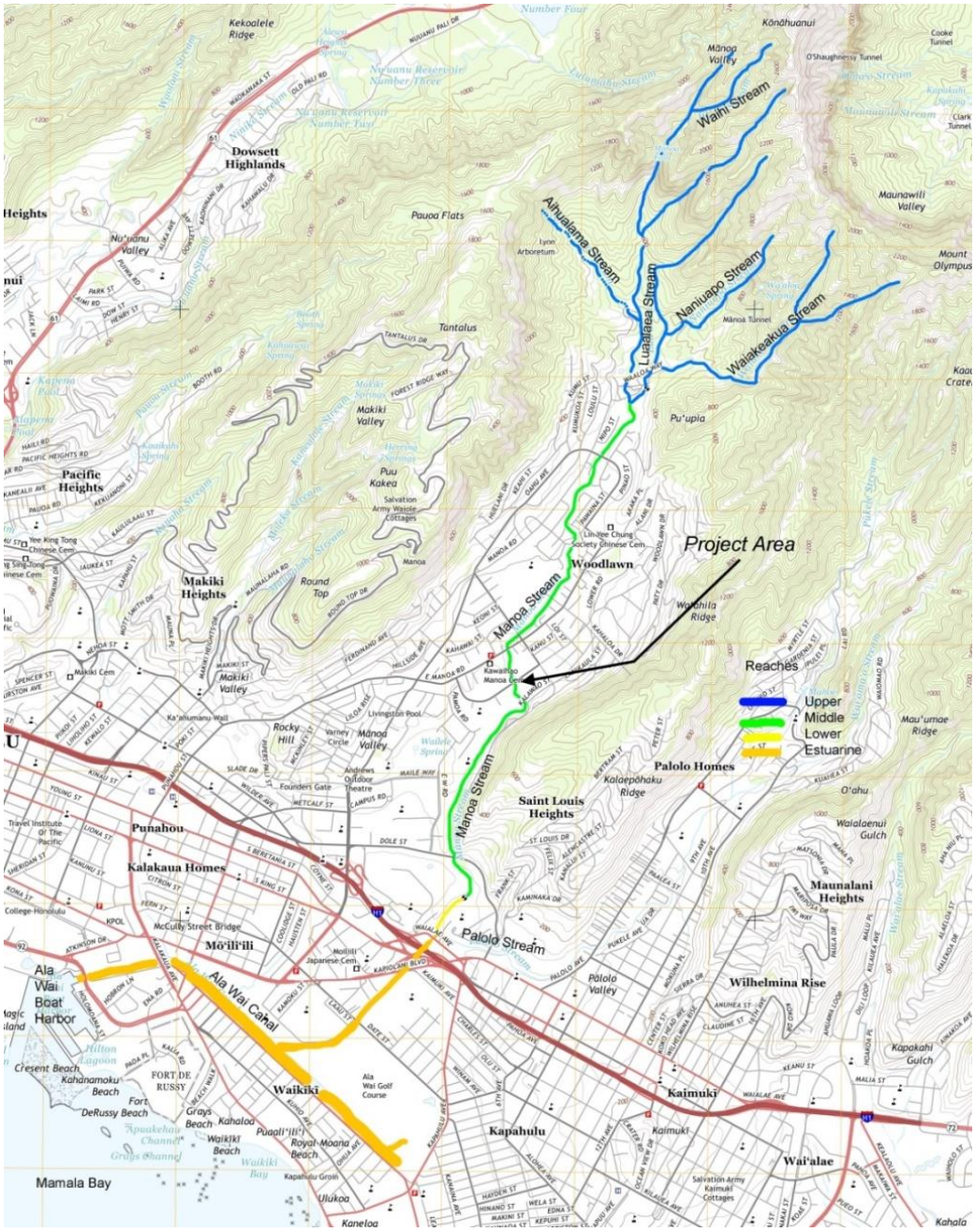

Figure 1. Location and extent of reaches of Mānoa Stream and Ala Wai Canal.

are being met. Water bodies that are "impaired" and not meeting their designated beneficial uses are placed on a list called the Clean Water Act (CWA) §303(d) list (or just §303(d) list).

Mānoa Stream is on the §303(d) list as described in the 2014 State of Hawai'i Water Quality Monitoring and Assessment Report (HDOH, 2014b). Mānoa Stream is listed as not meeting water quality standards for total nitrogen (TN), nitrate + nitrite (NO_3+NO_2), total phosphorus (TP), turbidity, total suspended solids (TSS), dieldrin, and chlordane. For each water body on the §303(d) list, a pollution budget or Total Maximum Daily Load (TMDL) must be developed to assist bringing that water body into compliance with water quality standards. Mānoa Stream is assigned a low priority ranking for TMDL development.

Dieldrin and chlordane are organochlorine pesticides that, until their use was banned in the U.S. in 1987 and 1988, respectively, were used to kill ground termites (ATSDR, 2002, 1994). Dieldrin was banned because of concerns about damage to the environment and potentially to human health (ATSDR, 2002) and chlordane was banned because of concerns over cancer risk, evidence of human exposure with build-up in body fat, persistence in the environment, and danger to wildlife (ATSDR, 1994). A U.S. Geological Survey (USGS) study found high levels of dieldrin and chlordane persistent in Mānoa Stream in 1998, at least 10 years after the chemicals were banned (Brasher and Anthony, 1998).

Survey Methods

Water Quality

The biologists measured field parameters and collected water samples at three stations in Mānoa Stream on January 27, 2016 (Figure 2). Samples were collected just below water surface. Temperature, pH, and dissolved oxygen (DO) were measured *in situ*. Water samples were collected, chilled, and returned to the *AECOS* laboratory for analyses (*AECOS* Log No. 31833). The following parameters were measured in the laboratory: conductivity, turbidity, total suspended solids (TSS), nitrate+nitrite (NO_3+NO_2), total nitrogen (TN), total phosphorus (TP), dieldrin, and chlordane. Table 1 lists the analytical methods used for field and laboratory analyses.

Sediment Quality

On January 29, 2016, *AECOS* biologists collected sediment samples from the Project area using a multi-incremental approach. Prior to collecting samples, we established three sampling "decision units", as shown in Figure 3. The methodology involved collecting a set of discrete samples from within each decision unit (DU), combining all the samples from each individual DU, compositing by thorough mixing the samples, and collecting a subsample for

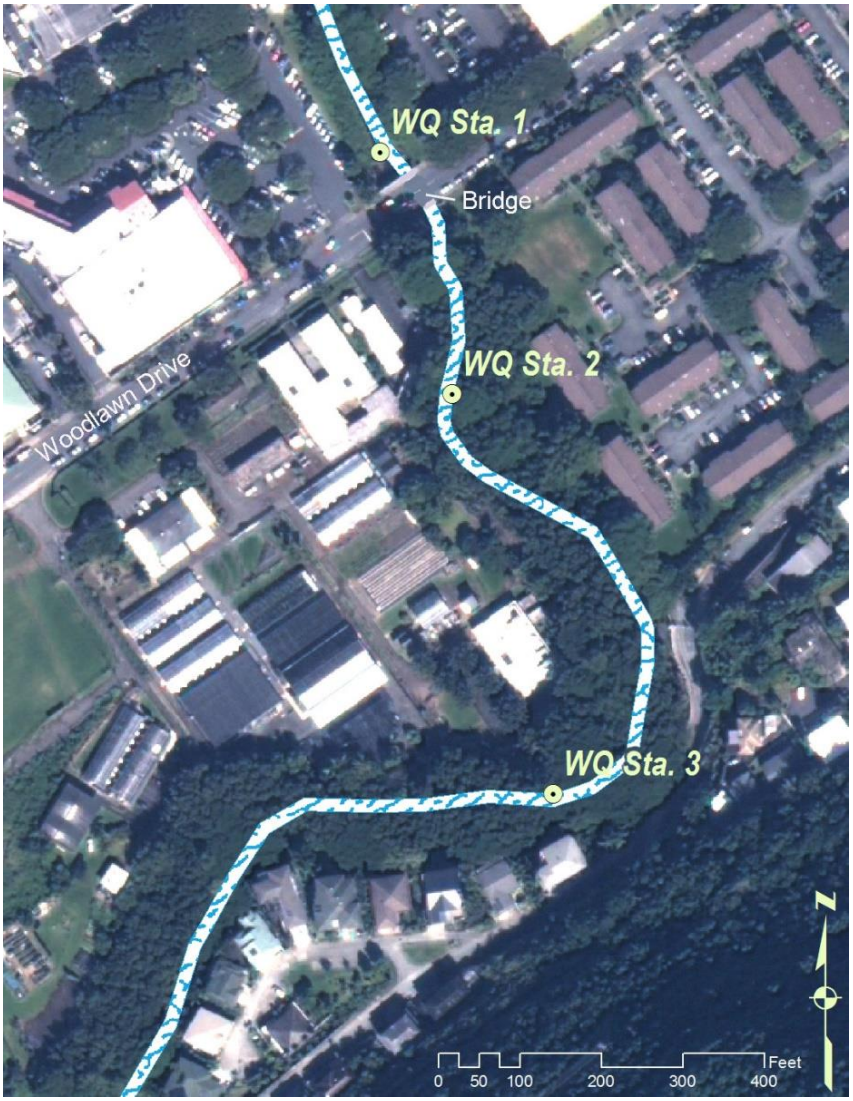

Figure 2. Location of water quality stations sampled on January 27, 2016.

analysis from the composited sample. Discrete samples were collected from 30 or more locations within each decision unit. Three replicates were collected from DU2. The samples were collected from the stream bed and lower banks in places that were accessible by wading and from places that were most likely contain contaminated sediments (e.g., depositional bars and benches, bottom of pools). Samples were collected from the upper layer (0 to 20 cm or 0 to 8 in).

Table 1. Analytical methods used in Mānoa Stream water quality sampling.

Analysis	Method	Reference
Temperature	SM 2550B	SM (1998)
Conductivity	SM 2510-B	SM (1998)
pH	SM 4500H+	SM (1998)
Dissolved Oxygen	SM 4500-O G	SM (1998)
Turbidity	EPA 180.1, Rev. 2.0	USEPA (1993a)
Total Suspended Solids	SM 2540D	SM (1998)
Nitrate + Nitrite	EPA 353.2, Rev. 2.0	USEPA (1993b)
Total Nitrogen	NCASI TNTP-W10900	NCASI (2011)
Total Phosphorus	365.3	USEPA (1978)
Dieldrin (water)	EPA 608	USEPA (1993c)
Chlordane (water)	EPA 608	USEPA (1993c)
Dieldrin (sediment)	EPA 8081A	USEPA (2007)
Chlordane (sediment)	EPA 8081A	USEPA (2007)

Aquatic Biology

An aquatic biologist made visual observations and captured aquatic organisms in nets within Mānoa Stream in the Project area. The biologist noted relative abundances (e.g., rare, common, abundant) of each species encountered as the survey progressed.

Terrestrial Biology

Plants — A botanist identified riparian plants within the Project area on January 27, 2016. The botanist noted the names and relative abundances of ferns, fern allies, gymnosperms, and flowering plants encountered along both banks in the survey area. Field notes were translated into a flora listing. For the most part, plant names given in the listing follow *Manual of the Flowering Plants of Hawai'i* (Wagner et al., 1990, 1999) for native and naturalized flowering plants, *Hawai'i's Ferns and Fern Allies* (Palmer, 2003) for ferns, and *A Tropical Garden Flora* (Staples and Herbst, 2005) for ornamental plants. Some names have been

updated to reflect more recent taxonomic or nomenclatural changes as presented in Imada (2012).

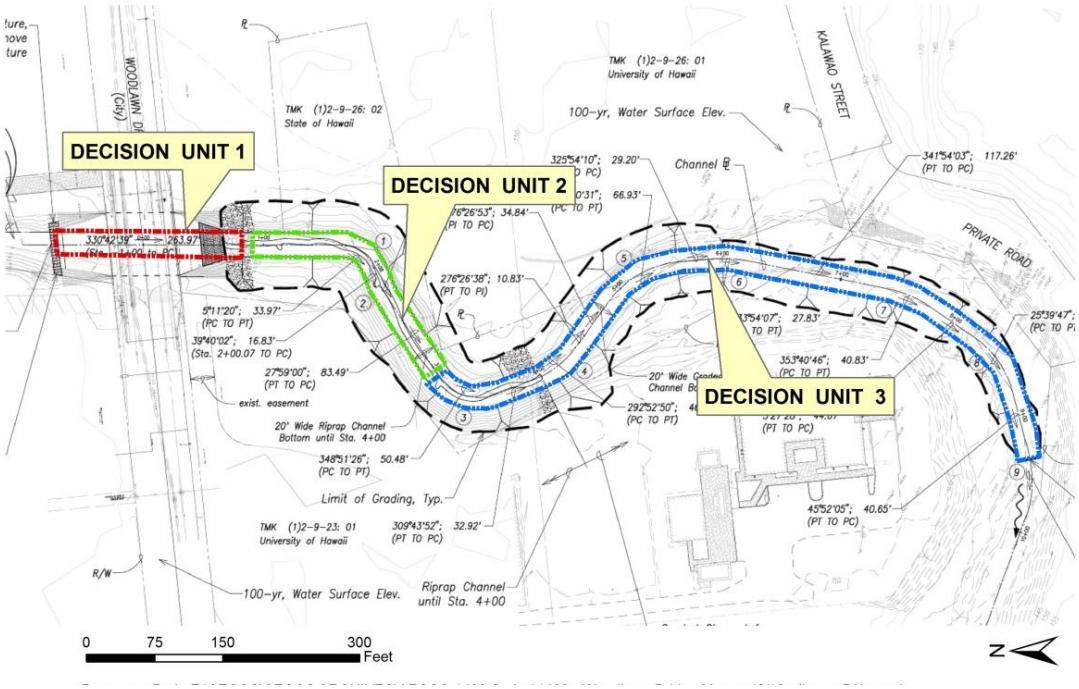

Figure 3. Location of sediment decision units sampled on January 29, 2016.

Birds — The avian survey included stationary point-counts at three stations in which all birds observed within a visible radius during an 8-minute period were recorded. One point-count station observed birds from Woodlawn Drive Bridge in the upstream direction, one observed birds from the bridge looking in the downstream direction, and one station was located at the downstream-end of the project near WQ Sta. 3. Any additional bird species observed during pedestrian investigation of all potential work areas were noted and a running tally kept.

Stationary point counts were conducted between 0730 and 0900 on January 29, 2016. Weather conditions during the survey were ideal, with no rain, unlimited visibility, and light winds. Species identifications were verified with *A Photographic Guide to the Birds of Hawaii: the Main Islands and Offshore Waters* (Denny, 2010). Taxonomy follows the *Checklist of North and Middle American Birds* by American Ornithologists' Union (AOU, 1998).

Mammals — A list of mammal species observed in the survey area was noted as biologists conducted botanical and avian surveys. Visual observation for tracks, scat, and other signs of mammalian use of the survey area were undertaken concurrently with the avian survey.

Survey Results

Water Quality

Water quality results are presented in Table 2. Temperature was highest at Sta. 1—an unshaded section of the stream channel; Stas. 2 and 3 are located under a closed canopy of mostly Java plum (*Syzygium cumini*) trees. Conductivity (reported as specific conductance) and pH were within the normal range and dissolved oxygen (DO) was high at all stations. Turbidity and total suspended solids (TSS) were relatively low in the Project area. Nutrients (nitrate-nitrite [NO_3+NO_2], total nitrogen [TN], and total phosphorus [TP]) were relatively low. Most (64 to 80%) of the nitrogen moieties present in the water is organic nitrogen. The highest TP level (19 µg P/l) was at Sta. 1, which also had the highest TSS level (4.2 mg/l). Neither chlordane nor dieldrin was detected in any of the water samples.

Sediment Quality

Results of sediment testing for dieldrin and chlordane are presented in Table 3. Dieldrin and chlordane appear to be evenly distributed in the stream bed sediment throughout the Project area.

Aquatic Biota

Table 4 is a listing of aquatic animals observed in Mānoa Stream by *AECOS* biologists (Project area only). Attachment 1 is a listing of species previously reported from throughout Mānoa Stream, including the Ala Wai estuary.

Armored catfishes, including bristle-mouth armored catfish (*Ancistrus* cf. *temminckii*) and suckermouth armored catfish (*Hypostomus* cf. *watwata* group), dominate the aquatic fauna in the Project area, nearly blanketing some segments of the streambed. Convict cichlids (*Archocentrus nigrofasciatus*) are conspicuous inhabitants of stream pools within the Project area—the black striped wild-type is most common, but white fish showing the leucistic coloration are also present. Smallmouth bass (*Micropterus dolomieu*) are

Table 2. Water quality results from January 27, 2016 sampling event.

Station	Time	Temp. (°C)	Spec. conduct. (µmhos/ cm)	pH	DO (mg/l)	DO % sat (%)	Turbidity (ntu)
Sta. 1	1352	24.2	166	7.59	8.57	102	2.94
Sta. 2	1332	23.9	169	7.26	8.30	98	2.53
Sta. 3	1227	22.1	177	7.07	8.62	99	2.78

	TSS (mg/l)	NO_3+ NO_2 (µg N/l)	TN (µg N/l)	TP (µg P/l)	Chlordane (µg/l)	Dieldrin (µg/l)
Sta. 1	4.2	66	330†	19	<0.96	<0.096
Sta. 2	3.1	62	<200	18	<0.96	<0.096
Sta. 3	3.4	83	230†	16	<0.96	<0.096

† Reported result is an estimated value

Table 3. Sediment testing results from January 29, 2016 sampling event.

Decision Unit	Dieldrin (µg/kg)†	Chlordane (µg/kg) †
DU 1	25	170
DU 2 Rep 1	23	170
DU 2 Rep 2	26	200
DU 2 Rep 3	25	200
DU 2 (mean and st. dev.)	24.7 ± 1.5	190.0 ± 17.3
DU 3	23	190

† Dry-weight of material.

present in the deeper pools and small poeciliids (*Poecilia* hybrid complex) are common in the shallows. We observed a single native fish, *ʻoʻopu nākea* (*Awaous guamensis*), which is the most often-reported native fish from the middle reach of Mānoa Stream (Kido, 2007; Englund & Arakaki, 2004; *AECOS*, 2000, 2002).

Table 4. List of aquatic species observed in Mānoa Stream in Project area on January 27 and 29, 2016.

PHYLUM, CLASS, ORDER, FAMILY *Genus species*	Common name	Status	Abundance
ALGAE			
RHODOPHYTA, FLORIDEOPHYCEAE, HILDENBRANDIALES, HILDENBRANDIACEAE			
Hildenbrandia angolensis Welwitsch ex West & G.S. West		ukw	O
ACROCHAETIALES, ACROCHAETIACEAE			
Audouinella sp.		ukw	O
INVERTEBRATES			
MOLLUSCA, GASTROPODA, NEOTAENIOGLOSSA, THIARIDAE			
Melanoides tuberculatus Muller	red-rim melania	Nat	O
MOLLUSCA, BIVALVIA VENEROIDA, CORBICULIDAE			
Corbicula fluminea O.F. Müller	Asiatic clam	Nat	R†
ARTHROPODA, MALACOSTRACA, DECAPODA CAMBARIDAE			
Procambarus clarkii Girard	American crayfish	Nat	R†
VERTEBRATES			
CHORDATA, ACTINOPTERYGII, PERCIFORMES, CICHLIDAE			
Archocentrus nigrofasciatus Günther	convict cichlid	Nat	C
CENTRARCHIDAE			
Micropterus dolomieu Lacapède	smallmouth bass	Nat	R
GOBIIDAE			
Awaous guamensis Valenciennes in Cuvier and Valenciennes	*ʻoʻopu nākea*	**Ind**	R

Table 4 (continued).

PHYLUM, CLASS, ORDER, FAMILY *Species*	Common name	Status	Abundance
SILURIFORMES, LORICARIIDAE			
Ancistrus cf. *temminckii* Valenciennes in Cuvier and Valenciennes	bristle-mouth armored catfish	Nat	A
Hypostomus cf. *watwata* group	suckermouth armored catfish	Nat	C
CYPRINODONTIFORMES, POECILIIDAE			
Poecilia hybrid complex	Liberty/Mexican molly	Nat	C
CHORDATA, AVES, ANSERIFORMES, ANATIDAE			
Anas platyrhynchos L.	mallard	Nat	R
PELECANIFORMES, ARDEIDAE			
Nycticorax nycticorax L.	black-crowned night-heron	**Ind**	R

Legend to Table 4

Status categories:

Nat – naturalized – a species introduced to Hawai'i intentionally or accidentally.

Ind – indigenous – a species native to Hawai'i and other places.

Abundance categories:

R – Rare – only one or two individuals observed.

O – Occasional – seen irregularly in small numbers

C – Common –observed everywhere, although generally not in large numbers.

A – Abundant – observed in large numbers and widely distributed.

† - shell or carapace only; not living.

Terrestrial biology

Vegetation — The land surrounding this part of Mānoa Stream is developed (urbanized), but the stream here is within a forested riparian zone (Figure 4) that begins at the Woodlawn Bridge and extends beyond the end of the Project area. Upstream from the bridge, the riparian zone is mostly open, with a few large trees along the left bank. In the latter area, the grassy right bank rises up to the parking lot at Manoa Market Place.

Figure 4. Most of the segment of Mānoa Stream in the Project area is shaded by numerous trees, some of considerable size.

Flora — A listing of all vascular plants observed in the survey area is presented as Table 5. A total of 84 flowering plants (four plant observations remain unidentified) and two ferns were recorded in our survey of the Project area. Of these 86 species, only 1 (1%)—*ʻihiʻai* (*Oxalis corniculatus*)—is possibly native to the Hawaiian Islands (may be an early Polynesian introduction) and four (5%) are regarded as early Polynesian introductions (so-called "canoe plants"): *kukui* (*Aleurites moluccana*), *hau* (*Hibiscus tiliaceus*), *ki* or ti plant (*Cordyline fruticosa*), and *niu* or coconut palm (*Cocos nucifera*). The remaining species are naturalized species (introduced species growing and spreading on their own; 81%), with a scattering of planted or escaped ornamentals (13%).

Table 5. List of plants found in the Mānoa Stream riparian zone in the Project area.

FAMILY SPECIES	Common Name	Status	Abund.	Notes
	PTERIDOPHYTES ~ FERNS			
POLYPODIACEAE				
Phymatosorus grossus (Langsd. & Fisch.) Brownlie	*laua'e*	Nat	C	<1>
THELYPTERIDACEAE				
Christella parasitica (L.) H. Lév	wood fern	Nat	R	
	FLOWERING PLANTS DICOTYLEDONE			
ACANTHACEAE				
Asystasia gangetica (L.) T. Anderson	Chinese violet	Nat	U	
Justicia betonica L.	white shrimp plant	Nat	Cc	
Odontonema cuspidatum (Nees) Kuntze	---	Nat	Oc	<1>
ANACARDIACEAE				
Mangifera indica L.	mango	Nat	R	<1>
ARALIACEAE				
*Schefflera actinophylla (*Endl.) Harms.	octopus tree	Nat	U	
ASTERACEAE				
Calyptocarpus vialis Less.	---	Nat	U	
Sphagneticola trilobata (L.) Pruski	wedelia	Nat	A	
Youngia japonica (L.) DC.	Oriental hawksbeard	Nat	U	<1>
BIGNONIACEAE				
Spathodea campanulata P. Beauv.	African tulip	Nat	R	
BUDDLEIACEAE				
Buddleia asiatica Lour.	dog tail	Nat	U	
BRASSICACEAE				
Lepidium virginicum L.	---	Nat	U	
COMBRETACEAE				
Terminalia catappa L.	tropical almond	Nat	R	
CONVOLVULACEAE				
Ipomoea obscura (L.) Sweet	field bindweed	Nat	U	
CUCURBITACEAE				
Coccina grandis (L.) Voigt	scarlet-fruited gourd	Nat	U	
ELAEOCARPACEAE				
Elaeocarpus angustifolius Blume	blue marble tree	Nat	R	<1, 2>
EUPHORBIACEAE				
Aleurites moluccana (L.) Willd.	*kukui*	**Pol**	R	<1>
Codiaeum variegatum (L.) Bl.	croton	Orn	R	<1>
Euphorbia prostrata Aiton	prostrate spurge	Nat	U	<1>

Table 5 (continued).

FAMILY SPECIES	Common Name	Status	Abund.	Notes
EUPHORBIACEAE (continued)				
Macaranga tanarius (L.) Müll. Arg.	---	Nat	R	
Phyllanthus debilis Klein ex Willd.	niuri	Nat	U	
FABACEAE				
Albizia saman Jacq.	monkeypod	Nat	R	<1>
Alysicarpus vaginalis (L.) DC.	Alyce clover	Nat	R	<1>
Falcataria moluccana (Miq.) Barneby & J.W. Grimes	Moluccan albizia	Nat	R	
Leucaena leucocephala (Lam.) deWit	*koa haole*	Nat	Uc	
Pithecellobium dulce (Roxb.) Benth.	*ʻopiuma,* mostly juv.	Nat	O	
LAURACEAE				
Cinnamomum burmannii (Nees) Blume	Padang cassia, juv.	Nat	R	<1,2>
MALVACEAE				
Hibiscus tiliaceus L.	*hau*	**Pol**	U	
MORACEAE				
Ficus microcarpa L. fil.	Chinese banyan	Nat	R	
MYRTACEAE				
Syzigium cumini (L.) Skeels	Java plum	Nat	Ca	
NYCTAGINACEAE				
Boerhavia coccinea Mill.	false *alena*	Nat	Uc	
OCHNACEAE				
Ochna kirkii Willd.	Mickey Mouse plant	Orn	R	
ONAGRACEAE				
Ludwigia octovalvis (Jacq.) Raven	primrose willow	Nat	U	
OXALIDACEAE				
Oxalis corniculata L.	*ʻihiʻai,* common wood sorrel	**Ind**	U	
Oxalis corymbosa DC.	pink wood sorrel	Nat	R	
PASSIFLORACEAE				
Passiflora suberosa L.	wild passionfruit	Nat	R	
PHYTOLACCACEAE				
Rivina humilis L.	coral berry	Nat	U	
RUBIACEAE				
Coffea arabica L.	Arabian coffee	Nat	U	
Paederia scandens (Lour.) Merr.	*maile pilau*	Nat	U	
RUTACEAE				
Citrus sp.	---	Nat	R	<1,2>
Murraya paniculata (L.) Jack	mock orange	Nat	R	
SAPINDACEAE				
Cardiospermum cf. *grandiflorum* Sw.	balloon vine	Nat	O	
Filicium decipiens (Wight & Arnott) Thwaites ex J.D. Hook.	fern tree	Nat	R	

Table 5 (continued).

FAMILY SPECIES	Common Name	Status	Abund.	Notes
SAPOTACEAE				
Chrysophyllum oliviforme (L.) Wettst.	satin leaf	Nat	U	
STERCULIACEAE				
Melochia umbellata (Houtt) Stapf	---	Nat	R	
ULMACEAE				
Trema orientalis (L.) Blume	gunpowder tree	Nat	Ru	
URTICACEAE				
Pilea microphylla (L.) Liebm.	artillery plant	Nat	Ra	
VERBENACEAE				
Citharexylum spinosum L.	fiddlewood	Nat	Oc	
	FLOWERING PLANTS MONOCOTYLEDONE			
AGAVACEAE				
Cordyline fruticosa (L.) A. Chev.	*ki*, ti	**Pol**	R	
Dracaena fragrans (L.) Ker Gawl.	"corn" plant	Orn	Ru	<1>
ARACEAE				
Alocasia cucullata (Lour.) Schott.	Chinese taro	Orn	R	
Epipremnum pinnatum (L.) Engl.	pothos	Nat	Oc	
Philodendron bipinnatifidum Endl.	selloum	Orn	Rc	<1>
Syngonium sp.	nephthys	Nat	Oa	
Xanthosoma robustum Schott	'ape	Nat	U	
ARECACEAE				
Dypsis lutescens (H. Wendl.) Beentje & J. Drans.	golden-fruited palm, mostly juv.	Nat	O	
Cocos nucifera L.	*niu*, coconut palm	**Pol**	R	<1>
Licuala grandis H. Wendl.	licuala palm	Orn	R	<1>
Veitchia merrillii (Beccari) H.E. Moore	Manila palm	Orn	R	<1>
BROMELIACEAE				
Aechmea sp.	---	Orn	R	<1,2>
Neoregelia carolinae (Beer) L.B. Smith	blushing bromeliad	Orn	Rc	<1>
COMMELINACEAE				
Commelina diffusa Burm. f.	day flower	Nat	Uu	
Tradescantia zebrina Bosse	wandering-jew	Orn	R	
CYPERACEAE				
Cyperus gracilis R. Br.	McCoy grass	Nat	Uc	
Cyperus involucratus Rottb.	umbrella sedge	Nat	O	
Kyllinga nemoralis (Forst.) Dandy ex Hutch. & Dalz.	*kili'o'opu*	Nat	R	
IRIDACEAE				
Watsonia sp.	bugle-lily	Orn	R	<2>

Table 5 (continued).

FAMILY SPECIES	Common Name	Status	Abund.	Notes
LILIACEAE				
Asparagus plumosus Baker	asparagus "fern"	Nat	R	<1>
POACEAE (GRAMINEAE)				
Axonopus compressa (Swartz) P. Beauv.	brd-lvd carpet grass	Nat	Uc	
Chloris barbata (L.) Sw.	swollen fingergrass	Nat	U	
Coix lachryma-jobi L.	Job's tears	Nat	Uc	
Eleusine indica (L.) Gartn.	wiregrass	Nat	U	
Eragrostis pectinacea (Michx.) Nees	Carolina lovegrass	Nat	R	
Megathyrsus maximus (Jacq.) B.K. Simon & W.L. Jacobs	Guinea grass	Nat	C	
Oplismenus compositus (L.) P. Beauv.	basket grass	Nat	Uc	<1>
Paspalum fimbriatum Kunth	Panama paspalum	Nat	R	<1>
Sporobolus cf. *indicus* (L.) R.Br.	Indian dropseed	Nat	U	<1,2>
Sporobolus sp.	dropseed	Nat	Ua	
Setaria parviflora (Poir.) Kerguélen	yellow foxtail	Nat	R	
Urochloa distachya (L.) T.Q. Nguyen	---	Nat	R	
Urochloa mutica (Forssk.) Nguyen	para or California grass	Nat	Uc	

Legend to Table 5

Status categories:

Ind – Indigenous; native to the Hawaiian Islands and elsewhere.

Nat – Naturalized; exotic, plant introduced to the Hawaiian Islands since the arrival of the Cook Expedition in 1778, and well-established outside of cultivation.

Orn – Ornamental; a cultivated plant; a species not thought to be naturalized (spreading on its own) in Hawai'i.

Pol – Early Polynesian introduction; canoe plant.

Abundance categories:

R – Rare – seen in only one or perhaps two locations.

U - Uncommon – seen at most in several locations.

O - Occasional – seen with some regularity.

C - Common – observed numerous times during the survey.

A - Abundant – found in large numbers; may be locally dominant.

Lower case letters following an occurrence rating indicate clusters within the survey area. In such cases, the ratings (R through A) should be considered as an estimate of the likelihood of encountering the species within the specified survey area. Then, the lower case letter suggests an abundance of the species where encountered as follows:

u – several plants present

c - many plants present

a – locally abundant

Notes:

<1> - Species recorded in riparian zone only from DU-3.

<2> - Species lacking flowers or fruit and therefore identification uncertain.

Avian point count — A total of 71 individual birds of 7 species, representing 7 separate families, was recorded during station counts (Table 6). An additional three species—*kōlea* or Pacific Golden-Plover (*Pluvialis fulva*), *ʻaukuʻu* or Black-crowned Night-Heron (*Nycticorax nyticorax*), and White-rumped Shama (*Copyschus malabaricus*)—were recorded as incidental observations in the general area by the biologists. *Kōlea* and *ʻaukuʻu* are the only two species detected that are native species.

Table 6. Avian species detected in the Project area on January 29, 2016.

Common Name	Scientific Name	STATUS	*RA*†
	ANSERIFORMES		
	ANATIDAE - Ducks, Geese & Swans		
	Anatinae - Ducks		
Mallard hybrid	*Anas* sp.	A	***1.7***
	PELECANIFORMES		
	ARDEIDAE - Herons, Bitterns & Allies		
Cattle Egret	*Bubulcus ibis*	A	***1.0***
	COLUMBIFORMES		
	COLUMBIDAE - Pigeons & Doves		
Spotted Dove	*Streptopelia chinensis*	A	***1.3***
	PASSERIFORMES		
	PYCNONOTIDAE - Bulbuls		
Red-vented Bulbul	*Pycnonotus cafer*	A	***2.3***
	ZOSTEROPIDAE - White-eyes		
Japanese White-eye	*Zosterops japonicus*	A	***12.7***
	STURNIDAE - Starlings		
Common Myna	*Acridotheres tristis*	A	***3.0***
	PSITTACIFORMES		
	PSITTACULIDAE - Parrots		
Rose-ringed Parakeet	*Psittacula krameri*	A	***1.7***

Legend to Table 6

Status categories:

A – Alien – species introduced to Hawaiʻi by humans intentionally or accidentally.

† Relative Abundance (*RA*) – Number of birds detected divided by the number of count stations (3).

Avian diversity and densities were relatively low, but in keeping with the highly disturbed habitat of the Project area. Japanese White-eye (*Zosterops japonicus*) accounted for over half (53%) of all birds recorded during station counts.

Mammalian survey — Domesticated animals are common in the Project area, which is adjacent to residences, a university of Hawai'i facility, and Manoa Market Place shopping center. During our survey, the biologists observed a dog (*Canis f. familiaris*) on a leash and a cat (*Felis catus*) being given a bath in the stream. Small Indian Mongooses (*Herpestes a. auropunctatus*) are common in the riparian forest of the Project area and adjacent open areas of the College of Tropical Agriculture and Human Resources research station. It is certainly possible that one or all of the four naturalized rodents (Family Muridae) in the Hawaiian Islands utilize the Project area.

Assessment

Water Quality

The water quality results from Mānoa Stream sampled on January 27, 2016 (Table 2) can be compared to certain water quality criteria established for streams (Table 7), as appropriate. Water quality criteria for nutrients and particulates require a set of samples collected from the same location over time for comparison to the criteria; therefore, our single-event results cannot be used to evaluate compliance. Numeric standards for toxic pollutants (dieldrin and chlordane) applicable to all waters are given in Table 8.

Criteria for DO saturation and specific conductance are not-to-exceed values and these criteria were met at all three sampling stations. pH values at all three stations were within the range specified for streams. The criteria for temperature (and also a second criterion for pH) are based on "deviations from ambient conditions"—these criteria essentially pertain to discharges that might cause deviations. The sampling results could be used as part of a larger data set to establish ambient conditions for various parameters in the future.

Particulates and nutrients were low and consistent at all three stations sampled on January 27, 2016. Storm water runoff is directed into Mānoa Stream at the upstream and downstream ends of the Project area (i.e., Stas. 1 and 3)—these two stations are likely to exhibit elevated particulate and nutrient levels during and after rain events. The January 27 sampling event is representative of baseflow conditions. Rainfall in January 2016 was influenced by an El Niño dry weather pattern—the Mānoa Lyon Arboretum rain gage received only 101 mm (3.96 in) of rain for January 2016, 34% of normal (NOAA-NWS, 2016), and it

Table 7. Water quality criteria applicable to streams (HDOH, 2014a).

Parameter	Geometric Mean value not to exceed this value	Value not to be exceeded more than 10% of the time	Value not to be exceeded more than 2% of the time
Total Nitrogen (µg N/L)	250.0* 180.0**	520.0* 380.0**	800.0* 600.0**
Nitrate+Nitrite (µg N/L)	70.0* 30.0**	180.0* 90.0**	300.0* 170.0**
Total Phosphorus (µg P/L)	50.0* 30.0**	100.0* 60.0**	150.0* 80.0**
Total Suspended Solids (µg/L)	20.0* 10.0**	50.0* 30.0**	80.0* 55.0**
Turbidity (NTU)	5.0* 2.0**	15.0* 5.5**	25.0* 10.0*

* Wet season – November 1 through April 30
** Dry season – May 1 through October 31
Other "standards":
- pH units are not to deviate more than 0.5 units from ambient and are to be neither lower than 5.5 nor higher than 8.0.
- Dissolved oxygen is not to decrease below 80% of saturation.
- Temperature is not to vary more than 1C° from ambient conditions.
- Specific conductance is to be less than 300 µmhos/cm.

Table 8. Numeric criteria (µg/L) for toxic pollutants applicable to all waters (HDOH, 2014a).

Pollutant	Freshwater	
	Acute	Chronic
Dieldrin	2.5	0.0019
Chlordane	2.4	0.0043

was not raining at the time of, or prior to, our site visit. A storm drain discharges runoff from Mānoa Shopping Center just upstream of Sta. 1 and a box culvert discharges upstream of Sta. 3. The box culvert directs flow coming from under Kalawao Street (Figure 5). Despite the lack of rain, water was flowing from the box culvert and the presence of iron bacteria indicates that groundwater, in addition to storm water, may contribute to flow from the culvert.

Figure 5. A box culvert discharges groundwater and storm water into Mānoa Stream in the Project area.

Chlordane and dieldrin were not detected in the water column at any of the stations. The laboratory detection limits were well above the chronic criteria for these compounds. However, chronic criteria are intended as limitations on long-term, low-level inputs of hazardous chemicals, as from an effluent discharge. Our measurements are intended only as background or baseline for potential acute inputs of these compounds resulting from disturbance of bottom sediments by dredging activity.

Water quality impacts generated by construction should be temporary and minimal if effective BMPs are employed. Construction plans should incorporate BMPs to prevent degradation of the water in Mānoa Stream. An Applicable Monitoring and Assessment Plan (AMAP) should be developed to monitor effectiveness of best management practices (BMPs) deployed during construction.

Clearing trees from the riparian zone and lining the stream bed with grouted rip-rap boulders will raise the ambient temperature of the water in the Project area. Project plans should leave a sufficient number of trees standing, such that the channel receives shade and water temperatures do not exceed 35 C° because the upper-lethal temperature limit for native aquatic species generally ranges from about 35 to 40 C° (Hathaway, 1978). A low-flow channel will maintain some cooler pools in the Project area.

Sediment Quality

Results of the analysis of contaminants in sediments collected from Mānoa Stream on January 29, 2016 cannot be compared directly to environmental action levels (EALs) established by Hawai'i Department of Health (HDOH, 2012) because the leaching models used to establish EALs assume the sampled soil is *not* in direct contact with groundwater or surface water. However, reference data established by National Oceanographic and Atmospheric Administration (NOAA) to identify potential impacts to costal resources and habitats (Buchman, 2008) are useful screening data to which the results can be compared. Appropriate values from the Screening Quick Reference Tables (SQuiRTs) for organics in freshwater sediment are provided in Table 8.

Table 8. Compounds found in Mānoa Stream bed sediments compared with screening levels for organics in freshwater sediment (NOAA, 2008).

	Mānoa Stream (range)	Lowest Effect Level (LEL) †	Severe Effect Level (SEL) ‡
Dieldrin (µg/kg)	23 - 26	2	910
Chlordane (µg/kg)	170-200	7	60

† LEL is a level of sediment contamination that can be tolerated by the majority of benthic organisms.

‡ SEL is a level of sediment contamination at which pronounced disturbance of the sediment-dwelling assemblage can be expected.

The concentrations of the two contaminants found in the samples were similar among the three decision units and among the three replicates within DU2, indicating the contaminants are well-distributed throughout the Project area. The amount of dieldrin found in the samples is well below the SEL in the SQuiRTs and, therefore, is not a concern. The amount of chlordane found in the samples is more than two times the SEL given in SQuiRTs. Chlordane adsorbs to sediment and, thus, if effective best management practices (BMPs) are in place that prevent dredged sediment from re-entering the stream as it is removed and dewatered, (and the sediment is ultimately disposed of properly), the amount of chlordane found in the sediments should not pose a problem to human health or the environment during construction. Removal of the contaminated sediments from the stream bed will lessen exposure of dieldrin and chlordane to aquatic life and reduce the risk of harm to the environment over the long-term.

Aquatic Resources

No aquatic species protected by State of Hawai'i Administrative Rules (HDLNR, 1989, 2014, 2015), nor proposed or listed as federally threatened or endangered or species as set forth in the Endangered Species Act of 1973, as amended (16 U.S.C. 1531-1543, USFWS, 2016a), were observed in Mānoa Stream within the Project area. State regulations (HDLNR, 1989) extend protection to species of *'o'opu* from net fishing activities.

No injurious aquatic species—animals known to be harmful to agriculture, aquaculture, indigenous wildlife or plants, or constitute a nuisance or health hazard (HDLNR, 2015)—were observed in Mānoa Stream within the Project area.

Mānoa Stream is populated by a diverse assemblage of native and naturalized species. Native stream macrofauna are diadromous: eggs are laid in the stream and the larvae that hatch from these eggs move downstream and into the ocean where they develop for a time before migrating back into freshwater to grow to maturity (Ford and Kinzie, 1982; Kinzie, 1988). We observed a native goby (*'o'opu nākea*) in the Project area and numerous stream studies have documented the presence of native fishes (*'o'opu nōpili* and *'o'opu nākea*) and crustaceans (*'opae kala'ole*) in the middle and upper reaches of Mānoa Stream (Timbol and Maciolek, 1978; Englund and Arakaki, 2004; Kido, 2007).

Best management practices (BMPs) developed and employed during construction to prevent degradation of water quality in Mānoa Stream will protect aquatic biota. Project BMPs should be monitored closely to ensure that native stream fauna are not adversely impacted by impairments to water

quality. Stream flow should be maintained at all times during construction and diversions should be temporary and not impede migration of native amphidromous species.

The low flow channel proposed to be constructed in the stream bed must be designed to maintain suitable microhabitats for resident *ʻoʻopu* and migrating *ʻoʻopu* and *ʻōpae*, particularly during low flow periods. As described in the Water Quality section above, clearing trees from the riparian zone and lining the stream bed with grouted rip-rap boulders will raise the ambient temperature of the water in the Project area. A sufficient number of trees should be left standing such that the channel receives shade and water temperatures do not exceed 35 C°. Armored catfishes appear to thrive in channels with concrete bottoms and shallow flow (Yamamoto and Tagawa, 2000). The proposed channel modifications will increase the amount of habitat acceptable to these introduced fishes.

Terrestrial Biology

Botanical Resources - No plants proposed, or listed as threatened or endangered species as set forth in the Endangered Species Act of 1973, as amended (16 U.S.C. 1531-1543; USFWS, 2016a; HDLNR, 1997), were seen in the Project area. For plants, state listing follows the federal listing. No native species of concern are present.

Mānoa Stream in the Project area flows through a moderately broad riparian forest. Although nearly bereft of native species, this mature, secondary forest is important to maintaining healthy conditions in the stream and adjacent environments (see *AECOS*, 2014). The shade provided by the mature trees reduces solar input, moderating water temperature and algal growth. The shade also tempers the growth of shrubs and grasses in the understory, easing pedestrian access along the stream banks and reducing potential for freshets to remove masses of vegetation to be carried downstream to clog lower reach segments. The forest and stream are a very visible natural feature winding through the urban setting, enhancing the environment for area residents and visitors. The mature trees of this forest have substantial value independent of the stream, reducing carbon emissions from the surrounding urban environment and moderating temperatures over a wide area. Mānoa Stream provides most of the maintenance service for this forest.

A majority of the trees lining this part of Mānoa Stream are Java plum. Most of the rest are a mix of many species. Short sections of the stream on both banks are lined with *hau* (*Hibiscus tiliaceus*), a species that can become problematic if

allowed to form a dense growth along waterways. The growth of *hau* here is kept in check by the mature trees. Both areas of *hau* occur where clearing of land has extended close to the stream. A more troublesome species—Moluccan albizia (*Falcataria moluccana*)—is present, but represented by two trees (one in DU-2 and one in DU-3). These trees should be removed.

Avian Resources – Naturalized, urban dwelling birds comprise the bulk of species encountered in the Project area. The Spotted Dove, Red-vented Bulbul, Japanese White-eye, Common Myna, and Rose-ringed Parakeet are all listed as injurious species—animals known to be harmful to agriculture, aquaculture, indigenous wildlife or plants, or constitute a nuisance or health hazard (HDLNR, 2015). No species listed as federally endangered or threatened species (USFWS, 2016a) are present. *ʻAukuʻu* or Black-crowned Night-heron is listed as "indigenous" under State of Hawaii, Administrative Rules (HDLNR, 2015) and thus is protected from hunting, capture, or export. The Project is not expected to adversely impact avian resources extant in the Project vicinity.

Mammalian Resources – The Small Indian Mongoose is listed as an injurious species—an animal known to be harmful to agriculture, aquaculture, indigenous wildlife or plants, or constitute a nuisance or health hazard (HDLNR, 2015). Other non-native mammals (rats and mice) likely occur throughout the Project area.

No mammalian species currently protected or proposed for protection under either the federal or State of Hawaiʻi endangered species programs were detected during the course of this survey (HDLNR, 2015; USFWS; 2016a). Hawaiian hoary bat or *ʻōpeʻapeʻa* (*Lasiurus cinereus semotus*) was not detected during the course of this survey (bats were not surveyed for, as detection requires special equipment deployed at night).

Trimming or removal of trees along the stream channel or in a staging area could pose an impact to bats, if present. Such action may temporarily displace individual bats roosting in trees. As bats use multiple roosts within their home territories, the disturbance resulting from the removal of vegetation would be minimal. However, during the pupping season between June 1 and September 15, females carrying pups may be less able to rapidly vacate a roost site if the tree is trimmed or felled. Adverse impacts from such disturbance can be avoided or minimized by not clearing woody vegetation taller than 4.6 m (15 ft) during the pupping season.

Critical Habitat

There is no federally delineated Critical Habitat for any species present on, adjacent, or in the vicinity of the Project area (USFWS, 2016b). Thus the modification of the habitat on all or any part of the site will not result in impacts to federally designated Critical Habitat. There is no equivalent statute under state law.

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Attachment 1. Checklist of aquatic biota reported in selected surveys from within Mānoa Stream and Ala Wai estuary

Species	**Common name**	Status	Reach	Notes
ALGAE				
ALGAE				
CYANOPHYTA (Cyanobacteria)	(blue-greens)			
OSCILLATORIACEAE				
Phormidium retzii		---	(L)	<7>
Phormidium sp.		---	(U)	<6>
			(M)	<6>
			(L)	
Symploca sp.			(L)	<7>
CHLOROPHYTA, CLADOPHORACEAE	(green algae)			
Cladophora spp.		---	(U)	<6>
			(M)	<6>
			(L)	<7>
Cloniophora cf. *plumosa*		---	(M)	<6>
			(L)	<7>
CHROMOPHYTA				
Hydrosera whamposensis		---	(L)	<7>
Misc. pennate diatoms		---	(M)	<6>
RHODOPHYTA	(red algae)			
HILDENBRANDIACEAE				
Hildenbrandia angolensis		---	(M)	<8>
ACROCHAETIACEAE				
Audouinella spp.		---	(U)	<6>
			(M)	<6>
			(L)	<7>
AQUATIC INVERTEBRATES				
PLATYHELMINTHES, TRICLADIDA	(flatworms)			
PLANARIIDAE				
Dugesia sp.			(M)	<4>
ANNELIDA, HIRUDINEA	(leeches)			
PISCICOLIDAE				
Myzobdella cf. *lugubris*		Nat	(U)	<6>
			(M)	<6>
			(L)	<7>

Attachment 1 (continued)

Species	**Common name**	Status	Reach	Notes
MOLLUSCA, GASTROPODA	(snails)			
NERITIDAE				
Neritina vespertina	*hapawai*	Nat	(L)	<4, 7>
THIARIDAE				
Melanoides tuberculata	melanid snail	Nat	(M)	<3, 4, 9>
			(L)	<4, 7>
Tareba granifera		Nat	(M)	<4>
			(L)	<4>
MOLLUSCA, BIVALVIA	(clams)			
Corbicula fluminea	Asiatic clam	Nat	(M)	<3, 4, 8>
			(L)	<3, 4, 7>
ARTHROPODA, CRUSTACEA	(crustaceans)			
AMPHIPODA, HYALELLIDAE	(clams)			
Hyalella azteca		Nat	(M)	<4>
CIRRIPEDIA, CHTHAMALIDAE				
Chthamalus proteus	Caribbean barnacle	Nat	(E)	<4>
DECAPODA, CAMBARIDAE				
Procambarus clarkii	American crayfish	Nat	(U)	<1, 4, 6, 9>
			(M)	<3, 4, 6, 8, 9>
			(L)	<1>
DECAPODA, ATYIIDAE				
Atyoida bisulcata	*ʻopae kalaʻole*	End	(U)	<1, 6>
Neocaridina denticulata sinensis	Taiwan blue shrimp	Nat	(U)	<4, 6>
			(M)	<3, 4, 6>
			(L)	<4>
DECAPODA, PALAEMONIDAE				
Macrobrachium grandimanus	*ʻopae ʻoehaʻa*	End	(L)	<2, 4, 7>
Macrobrachium lar	Pacific prawn	Nat	(U)	<6>
DECAPODA,				
Scylla serrata		Nat	(E)	<4>
ARTHROPODA, INSECTA	(insects)			
COLEOPTERA,				
Parathroscinus cf. *murphyi*		Nat	(L)	<4>
DIPTERA, CANACIDAE				
Procanace williamsi		End	(L)	<4>
DIPTERA, CERATOPOGONIDAE				
Forcypomyia sp.		---	(U)	<4>

Attachment 1 (continued)

Species	**Common name**	Status	Reach	Notes
DIPTERA, CHIRONOMIDAE				
Cricotopus bicinctus		Nat	(U)	<6>
			(M)	<4, 6>
			(L)	<7>
DIPTERA, DOLOCHOPODIDAE				
Chrysotus longipalpus		Nat	(M)	<4>
Pelastoneurus lugubris		Nat	(M)	<4>
Syntormon flexibile		Nat	(U)	<4>
			(M)	<4>
Thinophilus hardyi		Nat	(M)	<4>
DIPTERA, EMPIDIDAE				
Hemerodromia stellaris		Nat	(U)	<6>
			(M)	<6>
			(L)	<7>
DIPTERA, EPHYDRIDAE				
Discocerina mera		Nat	(L)	<4>
Scatella cilipes		End	(M)	<4>
Scatella hawaiiensis		End	(M)	<4>
Scatella stagnalis		Nat	(M)	<4>
			(L)	<4>
Scatella sp.		End	(M)	<4>
DIPTERA, TIPULIDAE				
Limonia advena		Nat	(M)	<4, 6>
Limonia sp.		---	(U)	<4>
LEPIDOPTERA, COSMOPTERIGIDAE				
Hyposmocoma sp.		End	(M)	<4>
ODONATA, COENAGRIONIDAE	(damselflies)			
Ischnura posita	fragile forktail	Nat	(M)	<3, 4>
Ischnura ramburi	Rambur's damselfly	Nat	(M)	<3>
			(L)	<3, 4, 9>
ODONATA, LIBELLULIDAE	(dragonflies)			
Crocothemis servilia		Nat	(M)	<3>
			(L)	<4>
Orthemis ferruginea	roseate skimmer	Nat	(L)	<4>
Pantala flavescens	skimmer	Ind	(M)	<3, 4>
			(L)	<4>

Attachment 1 (continued)

Species	Common name	Status	Reach	Notes
TRICOPTERA, HYDROPTILIDAE				
Hydroptila arctia		Nat	(U)	<6>
			(M)	<6>
			(L)	<7>
TRICOPTERA, HYDROPSYCHIDAE				
Cheumatopsyche analis		Nat	(U)	<4>
			(M)	<4>
Cheumatopsyche pettiti		Nat	(U)	<6>
			(L)	<7>
TRICOPTERA, HYDROPSYCHIDAE				
Cheumatopsyche analis		Nat	(U)	<4>
			(M)	<4>
Cheumatopsyche pettiti		Nat	(U)	<6>
			(L)	<7>
AQUATIC VERTEBRATES				
PISCES	(fishes)			
CALICHTHYIDAE				
Corydorus aenus	bronze catfish	Nat	(M)	<6, 8>
			(L)	<7, 9>
CICHLIDAE				
Aequidens rivulatus	green terror cichlid	†	(L)	<7>
Amphilophus citrinellum	red devil	†	(M)	<4, 8>
Archocentrus nigrofasciatus	convict cichlid		(M)	<3, 4, 6, 8>
			(L)	<4, 7>
Hemichromis elongates	jeweled cichlid		(M)	<9>
			(L)	<9>
Hypsophrys nicaraguaensis	Nicaragua cichlid	Nat	(L)	<4>
Sarotherodon melanotheron	blackchin tilapia	Nat	(M)	<3>
			(L)	<3, 4, 9>
Oreochromis/Sarotherodon	Mozambique tilapia and hybrids	Nat	(L)	<1, 7, 9>
			(E)	<4>
CENTRARCHIDAE				
Micropterus dolomieui	smallmouth bass	Nat	(M)	<4>
			(L)	<4>
CHANNIDAE				
Channa striata	snakehead, pongee	†	(L)	<1>

Attachment 1 (continued)

Species	**Common name**	Status	Reach	Notes
CLARIDAE				
Clarius fuscus	Chinese catfish	Nat	(U)	<1>
			(L)	<1>
COBITIDAE				
Misgurnus anguillicaudatus	dojo, weatherfish	Nat	(M)	<4, 8>
			(L)	<1>
CYPRINIDAE				
Cyprinus carpio	carp	†	(U)	<1>
			(M)	<4, 8>
ELEOTRIDAE				
Eleotris sandwicensis	*ʻoʻopu akupa*	**End**	(L)	<1, 3, 4, 7>
Awaous guamensis	*ʻoʻopu nakea*	**Ind**	(U)	<1, 6>
			(M)	<4, 6>
			(L)	<3, 4, 7>
Mugilogobius cavifrons	*mangrove goby*	**Nat**	(L)	<4>
GOBIIDAE				
Sicyopterus stimpsoni	*ʻoʻopu nōpili*	**End**	(M)	<6>
Stenogobius hawaiiensis	*ʻoʻopu naniha*	**End**	(L)	<1, 3, 4, 7>
KUHLIIDAE				
Kuhlia xenura	*āholehole*	**End**	(L)	<3, 7, 9>
LORICARIIDAE				
Ancistrus cf. *temminckii*	bristle-mouth	Nat	(U)	<4, 6, 9>
	armored catfish		(M)	<4, 6, 8, 9>
			(L)	<4, 7, 9>
Hypostomus cf. *watwata*	suckermouth	Nat	(U)	<6>
group	armored catfish		(M)	<4, 6, 8>
			(L)	<7, 9>
MUGILIDAE				
Mugil cephalus	*ʻamaʻama*		(L)	<4, 7>
POECILIIDAE				
Gambusia affinis	mosquitofish	Nat	(U)	<1, 6>
			(M)	<3, 6, 8, 9>
			(L)	<1, 2, 4>
			(E)	<4>
Poecilia mexicana	Mexican molly	Nat	(U)	<1, 4>
			(M)	<3, 4, 8, 9>
			(L)	<1, 7, 4, 9>
			(E)	<4>

Attachment 1 (continued)

Species	**Common name**	Status	Reach	Notes
POECILIIDAE (continued)				
Poecilia reticulata	rainbow fish, guppy	Nat	(U)	<1, 4, 9>
			(M)	<3, 4, 6, 8>
			(L)	<1,3>
Poecilia sphenops	short-fin molly, common molly	Nat	(M)	<6>
Xiphophorus helleri	swordtail	Nat	(U)	<1, 4, 6>
			(M)	<3, 4, 6>
			(L)	<1, 3>
SPHYRAENIDAE				
Sphyraena barracuda	barracuda*, kaku*	**Ind**	(E)	<4>
AMPHIBIA	(amphibians)			
BUFONIDAE				
Rhinella marina	giant neotropical toad	Nat	(U)	<9>
			(M)	<3, 4>
			(L)	<4>
Lithobates catesbeiana	American bullfrog	Nat	(U)	<9>
			(M)	<3, 8>
RANIDAE				
REPTILIA, TESTUDINES	(turtles)			
EMYDIDAE				
Chrysemys scripta elegans	red-eared slider	Nat	(M)	<4>
TRIONYCHIDAE				
Pelodiscus sinensis	Chinese softshell	Nat	(M)	<4>
	(birds)			
ANATIDAE				
Anas sp.	feral duck	†	(L)	<3, 9>
Anser sp.	feral goose	†	(L)	<3>
Cairina moschata	Muscovy duck	†	(L)	<3>
ARDEIDAE				
Nycticorax nycticorax hoactli	black-crowned night-heron	**Ind**	(L)	<3>

KEY TO SYMBOLS USED IN ATTACHMENT 1:

Status:

nat - naturalized. An introduced or exotic species.

ind - indigenous. A native species also found elsewhere in the Pacific.

end - endemic - A native species found naturally only in the Hawaiian Islands.

† - feral or introduced, not necessarily naturalized in these streams.

Attachment 1 (legend continued)

Specific reaches for each stream are defined in the text; general characteristics are:

U – upper reach (headwaters; 3rd order tributary streams).
M – middle reach (reach along the valley bottom.
L – lower reach (reach on coastal plain).
E – estuarine reach (reach subject to tidal and saline influences).

Notes:

<1> Timbol and Maciolek (1978)
<2> USGS (1999)
<3> *AECOS* (2000, 2002)
<4> Englund & Arakaki (2004)
<6> Kido (2007)
<7> Kido (2008); two stations from confluence of Mānoa/Pālolo assigned to (L)
<8> AECOS (2009a)
<9> *AECOS* (2013)

The aquatic species listing given in the *Atlas of Hawaiian Watersheds & Their Aquatic Resources. Ala Wai, O'ahu* (Parham et al., 2008) is not included because the *Atlas* listing is non-specific as to stream (that is, stream reaches for all streams in the Ala Wai watershed are lumped).