INVESTIGATION OF FISH ATTRACTION TO LA GRANGE POWERHOUSE DRAFT TUBES STUDY REPORT

LA GRANGE HYDROELECTRIC PROJECT FERC NO. 14581

Prepared for:
Turlock Irrigation District – Turlock, California
Modesto Irrigation District – Modesto, California

Prepared by:
FISHBIO and LGL Alaska Research Associates
September 2017

TABLE OF CONTENTS

List of Figures

List of Tables

List of Attachments

List of Acronyms and Abbreviations

ac-ft	acre-foot
BLM	Bureau of Land Management
BOR	Bureau of Reclamation
CCSF	City and County of San Francisco
CDFG	California Department of Fish and Game, now CDFW
CDFW	California Department of Fish and Wildlife
cfs	cubic feet per second
CG	Conservation Groups
Districts	Turlock Irrigation District and Modesto Irrigation District
FERC	Federal Energy Regulatory Commission
FLA	Final License Application
FPA	Federal Power Act
GIS	geographic information system
ILP	Integrated Licensing Process
ISR	Initial Study Report
LGDD	La Grange Diversion Dam
LPs	licensing participants
M&I	municipal and industrial
MID	Modesto Irrigation District
NMFS	National Marine Fisheries Service
NPS	National Park Service
O&M	operation and maintenance
PAD	Pre-Application Document
PSP	Proposed Study Plan
QA/QC	quality assurance/quality control
RM	river mile
RSP	Revised Study Plan
SD2	Scoping Document 2
SPD	Study Plan Determination
TAF	thousand acre-feet
TID	Turlock Irrigation District
TM	technical memorandum
USFWS	United States Fish and Wildlife Service
USGS	United States Geological Survey
USR	Updated Study Report

1.0 INTRODUCTION

1.1 Background

The Turlock Irrigation District (TID) and Modesto Irrigation District (MID) (collectively, the Districts) jointly own the La Grange Diversion Dam (LGDD) located on the Tuolumne River in Stanislaus County, California (Figures 1.1-1 and 1.1-2). LGDD is 131 feet high and is located at river mile (RM) 52.2 at the exit of a narrow canyon, the walls of which contain the headpond formed by the diversion dam. Under normal river flows, the headpond formed by the diversion dam extends for approximately two miles upstream. When not in spill mode, the water level upstream of the diversion dam is between elevation 294 feet and 296 feet approximately 90 percent of the time. Within this 2-foot range, the headpond storage is estimated to be less than 100 acre-feet of water.

The drainage area of the Tuolumne River upstream of LGDD is approximately 1,550 square miles. Tuolumne River flows upstream of LGDD are regulated by four reservoirs: Hetch Hetchy, Lake Eleanor, Cherry Lake (also known as Lake Lloyd), and Don Pedro. The Don Pedro Hydroelectric Project (Federal Energy Regulatory Commission [the Commission or FERC] No. 2299) is owned jointly by the Districts, and the other three dams are owned by the City and County of San Francisco (CCSF) and operated by the San Francisco Public Utilities Commission. Inflow to the La Grange headpond is the sum of releases from the Don Pedro Project, located 2.3 miles upstream, and very minor contributions from two small intermittent drainageways downstream of Don Pedro Dam.

LGDD was constructed from 1891 to 1893 displacing Wheaton Dam, which was built by other parties in the early 1870s. LGDD raised the level of the Tuolumne River to permit the diversion and delivery of water by gravity to irrigation systems owned by TID and MID. The Districts' irrigation systems currently provide water to over 200,000 acres of prime Central Valley farmland and drinking water to the City of Modesto. Built in 1924, the La Grange hydroelectric plant is located approximately 0.2 miles downstream of LGDD on the east (left) bank of the Tuolumne River and is owned and operated by TID. The powerhouse has a capacity of 4.7 megawatts (MW). The La Grange Hydroelectric Project (Project; FERC No. 14581) operates in run-of-river mode. The LGDD provides no flood control benefits, and there are no existing recreation facilities associated with the Project or the La Grange headpond.

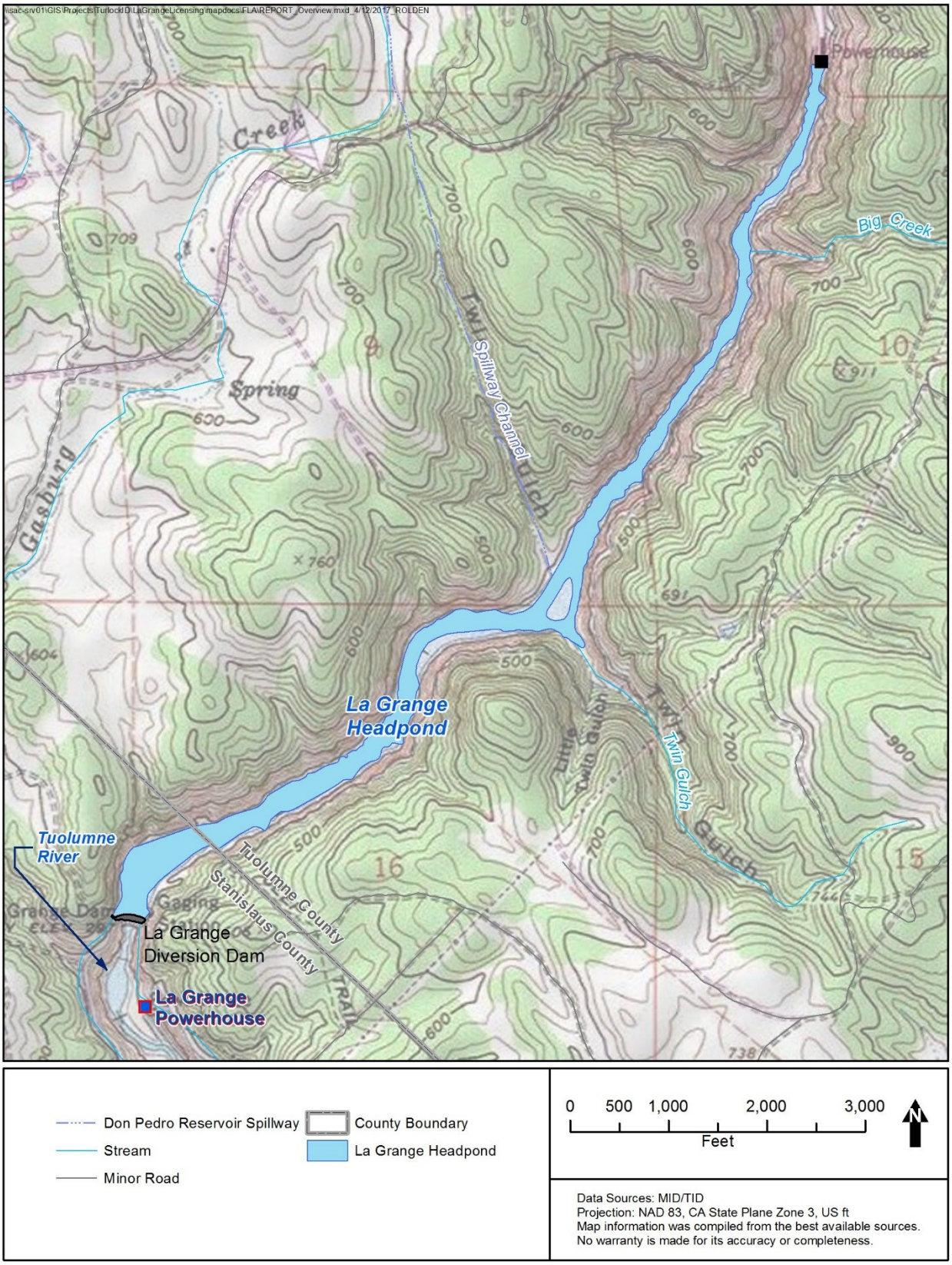

Figure 1.1-1. La Grange Hydroelectric Project location map.

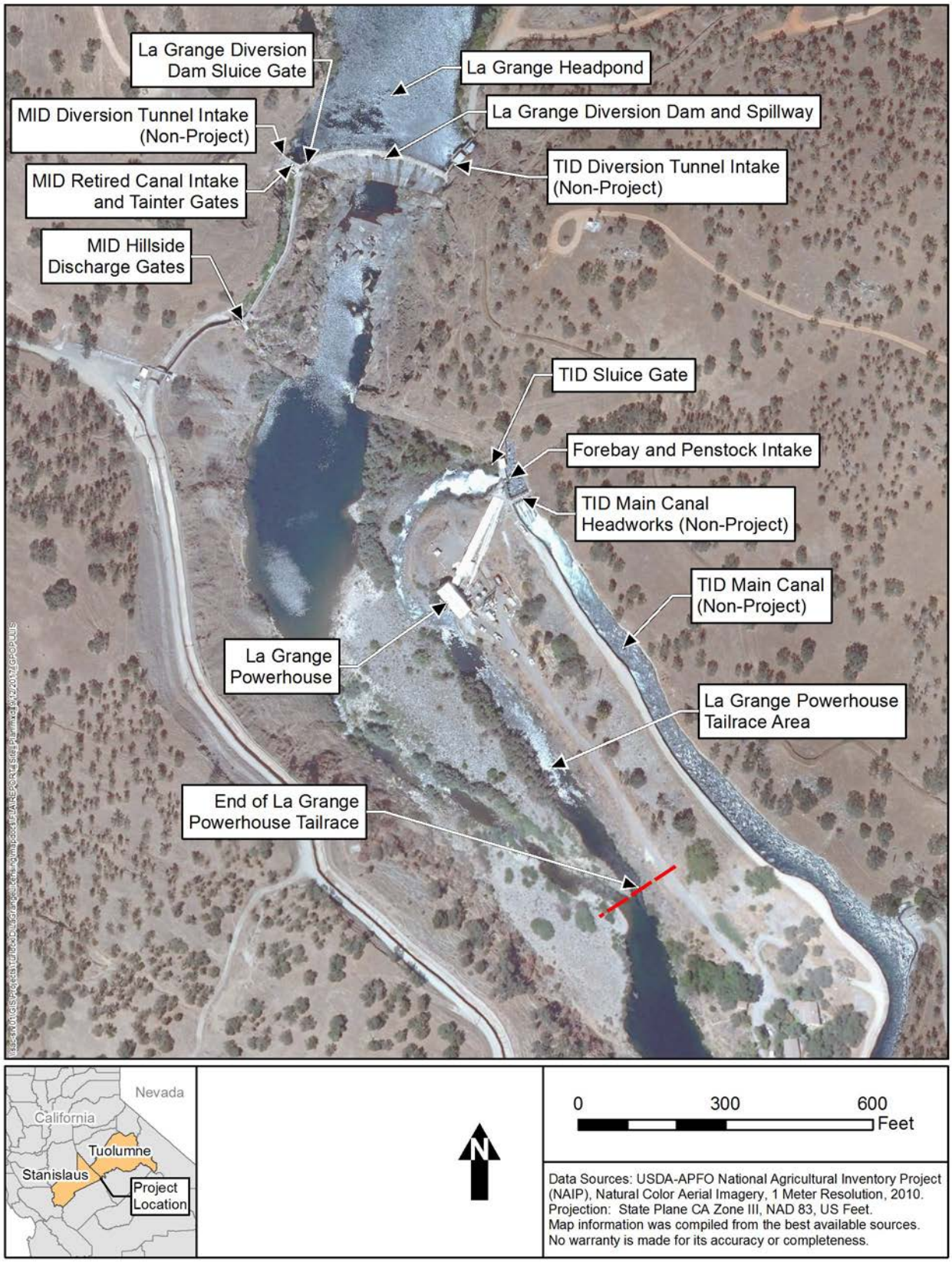

Figure 1.1-2. La Grange Hydroelectric Project site plan.

1.2 Licensing Process

In 2014, the Districts commenced the pre-filing process for the licensing of the La Grange Project by filing a Pre-Application Document with FERC[1]. On September 5, 2014, the Districts filed their Proposed Study Plan to assess Project effects on fish and aquatic resources, recreation, and cultural resources in support of their intent to license the Project. On January 5, 2015, in response to comments from licensing participants, the Districts filed their Revised Study Plan (RSP) containing three study plans: (1) Cultural Resources Study Plan; (2) Recreation Access and Safety Assessment Study Plan; and (3) Fish Passage Assessment Study Plan[2].

On February 2, 2015, FERC issued the Study Plan Determination (SPD), approving or approving with modifications six studies (Table 1.2-1). Of those six studies, five had been proposed by the Districts in the RSP. The Districts note that although FERC's SPD identified the Fish Passage Barrier Assessment, Fish Passage Facilities Alternatives Assessment, and Fish Habitat and Stranding Assessment below La Grange Diversion Dam as three separate studies, all three assessments are elements of the larger Fish Passage Assessment as described in the RSP. The sixth study approved by FERC, Effects of the Project and Related Activities on the Losses of Marine-Derived Nutrients in the Tuolumne River, was requested by the National Marine Fisheries Service (NMFS) in its July 22, 2014 comment letter.

Table 1.2-1. Studies approved or approved with modifications in FERC's Study Plan Determination.

No.	Study	Approved by FERC in SPD without Modifications	Approved by FERC in SPD with Modifications
1	Recreation Access and Safety Assessment		X
2	Cultural Resources Study		X
3	Fish Passage Barrier Assessment		X[1]
4	Fish Passage Facilities Alternatives Assessment		X
5	Fish Habitat and Stranding Assessment below La Grange Dam		X
6	Effects of the Project and Related Activities on the Losses of Marine-Derived Nutrients in the Tuolumne River	X[2]	

[1] Page A-1 of Appendix A of FERC's SPD states that FERC approved with modifications the Fish Passage Barrier Assessment. However, the Districts found no modifications to this study plan in the SPD and page B-7 of the SPD states that "no modifications to the study plan are recommended."

[2] FERC directed the Districts to conduct the study plan as proposed by NMFS.

In the SPD, FERC recommended that, as part of the Fish Passage Facilities Alternatives Assessment, the Districts evaluate the technical and biological feasibility of the movement of anadromous salmonids through La Grange and Don Pedro project reservoirs if the results from

[1] On December 19, 2012, Commission staff issued an order finding that the La Grange Hydroelectric Project is required to be licensed under Section 23(b)(1) of the Federal Power Act. Turlock Irrigation District and Modesto Irrigation District, 141 FERC ¶ 62,211 (2012), aff'd Turlock Irrigation District and Modesto Irrigation District, 144 FERC ¶ 61,051 (2013). On May 15, 2015, the U.S. Court of Appeals for the District of Columbia Circuit denied the Districts' appeal and affirmed the Commission's finding that the La Grange Hydroelectric Project requires licensing. Turlock Irrigation District, et al., v. FERC, et al., No. 13-1250 (D.C. Cir. May 15, 2015).

[2] The Fish Passage Assessment Study Plan contained a number of individual, but related, study elements.

Phase 1 of that study indicate that the most feasible concept for fish passage would involve fish passage through Don Pedro Reservoir or La Grange headpond. On September 16, 2016, the Districts filed the final study plan with FERC. On November 17, 2016, the Districts filed a letter with FERC after consulting with fish management agencies (i.e., NMFS and the California Department of Fish and Wildlife [CDFW]) regarding the availability of test fish and a determination that no fish would be available to support conducting this study in 2017. On January 12, 2017, the Districts filed a letter with FERC stating that with FERC's approval, they intend to conduct the study in 2018 if the results from the Fish Passage Facilities Alternatives Assessment indicate that upstream or downstream fish passage at La Grange and Don Pedro projects would require anadromous fish transit through one or both reservoirs.

In addition to the six studies noted in Table 1.2-1, the SPD required the Districts to develop a plan to monitor anadromous fish movement in the vicinity of the Project's powerhouse draft tubes to determine the potential for injury or mortality from contact with the turbine runners. The Districts filed the Investigation of Fish Attraction to La Grange Powerhouse Draft Tubes study plan with FERC on June 11, 2015, and on August 12, 2015, FERC approved the study plan as filed.

On February 2, 2016, the Districts filed the Initial Study Report (ISR) for the La Grange Hydroelectric Project. The Districts held an ISR meeting on February 25, 2016, and on March 3, 2016, filed a meeting summary. Comments on the meeting summary and requests for new studies and study modifications were to be submitted to FERC by Monday, April 4, 2016. One new study request was submitted; NMFS requested a new study entitled Effects of La Grange Hydroelectric Project Under Changing Climate (Climate Change Study). On May 2, 2016, the Districts filed with FERC a response to comments received from licensing participants and proposed modifications to the Fish Passage Facilities Alternatives Assessment and the La Grange Project Fish Barrier Assessment, and a revised pre-filing schedule. On May 27, 2016, FERC filed a determination on requests for study modifications and new study. The May 27, 2016 determination approved the Districts' proposed modifications and did not approve the NMFS Climate Change Study, and accepted the Districts' revised pre-filing schedule.

On February 1, 2017, the Districts filed the Updated Study Report (USR) for the La Grange Hydroelectric Project. The Districts held a USR meeting on February 16, 2017, and on March 3, 2017, filed a meeting summary. Comments on the meeting summary and requests for new studies and study modifications were to be submitted to FERC by Monday, April 3, 2017. Comments on the USR were received from the Central Sierra Environmental Resource Center on February 27, 2017, from NMFS on April 3, 2017, and from CDFW on April 13, 2017. On May 2, 2017, the Districts filed with FERC a response to comments received from licensing participants.

On April 24, 2017, the Districts filed the Draft License Application for the La Grange Hydroelectric Project. Comments on the Draft License Application were received from NMFS on May 12, 2017, from FERC on July 18, 2017, and from CDFW on August 18, 2017. The Districts' response to these comments is included in the La Grange Hydroelectric Project Final License Application (FLA). The FLA was filed with FERC on October 11, 2017, in accordance with the Districts' Request for Extension of Time granted by FERC on September 1, 2017.

On February 1, 2017, the Districts filed the Investigation of Fish Attraction to La Grange Powerhouse Draft Tubes Study Report in the Updated Study Report (USR). Comments on the USR were due to FERC by Monday, April 3. In response to a comment received, the Districts have revised the final bullet point in Section 6.1 to state that the risk of fish entering the draft tubes is extremely low.

This study report describes the objectives, methods, and final results of the Investigation of Fish Attraction to La Grange Powerhouse Draft Tubes, which is one of five study components of the Fish Habitat and Stranding Assessment below La Grange Diversion Dam being implemented by the Districts in accordance with FERC's SPD. Documents relating to the Project licensing are publicly available on the Districts' licensing website at www.lagrange-licensing.com/.

1.3 Study Plan

FERC's Scoping Document 2 (SD2) issued on September 5, 2014 identified potential for Project effects on upstream migration of anadromous fish.

FERC's SPD approved with modifications the Districts' proposed Fish Habitat and Stranding Assessment below La Grange Diversion Dam. In its SPD, FERC ordered the Districts: (1) to continue monitoring of existing flow conduits where flow monitoring is already occurring, conduct two years of flow monitoring at flow conduits not currently monitored (i.e., the Modesto hillside discharge and La Grange dam sluice gate), develop estimates of historical flows, data permitting, for each of the five flow conduits at the Project, and based on existing information, to the extent available, characterize the magnitude and rate of flow and stage changes when Project conduits are shut down, (2) collect topographic, depth, and habitat data downstream, and in the vicinity of, the Project, (3) assess fish presence and the potential for stranding, and (4) in consultation with NMFS and other interested parties, develop and implement a plan for monitoring anadromous fish movement into the powerhouse draft tubes.

As noted in FERC's SPD, the Districts' January 5, 2015, RSP did not include "protocols for monitoring anadromous fish movement into the powerhouse tailrace and the potential for injury or mortality by contact with the turbine runners." FERC therefore directed the Districts to develop a study plan to address a fourth directive of the Fish Habitat and Stranding Assessment below La Grange Diversion Dam to monitor anadromous fish movement into the powerhouse draft tubes. The plan was to be developed in consultation with NMFS and other interested stakeholders and implemented beginning in 2015 for the anadromous fish migration. On May 4, 2015 the Districts provided a draft study plan to licensing participants for 30-day review. No comments were received and on June 11, 2015, the Districts filed the study plan with FERC. On August 12, 2015, FERC approved the study plan as filed.

The Investigation of Fish Attraction to La Grange Powerhouse Draft Tubes Study Report summarizes the implementation of the FERC-approved study plan consistent with Item (4) described above.

2.0 STUDY GOALS AND OBJECTIVES

The goal of this study (hereinafter referred to as the Draft Tube Study) is to evaluate the potential impact of certain La Grange powerhouse facilities on adult fall-run Chinook salmon (*Oncorhynchus tshawytscha*) and rainbow trout (*Oncorhynchus mykiss).* Specific information obtained by this study will be used to:

- document adult resident *O. mykiss* and adult anadromous salmonid behavior in the vicinity of the La Grange powerhouse discharge during the fall 2015 (fall-run Chinook) to spring 2016 (*O. mykiss)* migration season;
- identify anadromous fish reaching the La Grange powerhouse;
- describe behavioral activities of fish in relation to La Grange powerhouse operations; and
- determine if fish are moving into the draft tube of operating units.

3.0 STUDY AREA

The study area includes the immediate vicinity of the discharge from La Grange powerhouse and the operating units (see previous Figure 1.1-2).

4.0 METHODOLOGY

4.1 Imaging Sonar Deployment and Monitoring

An imaging sonar unit (ARIS Explorer 1800, Sound Metrics) was installed at the outlet from the La Grange powerhouse on September 1, 2015 for operation during the 2015/2016 migration season to determine if fish were attempting to access the La Grange powerhouse or enter the powerhouse draft tubes, and to assess their behavior in relation to powerhouse operations. The Unit 1 draft tube was the focus of the evaluation given water availability and that the projected generation schedule anticipated the operation of only this unit during the study period.

The imaging sonar system consisted of a sonar head, data transmission cable, sonar control box, ethernet cable and laptop computer loaded with imaging sonar data acquisition software (ArisScope, Sound Metrics). Electronic components were housed in a ventilated box for protection from rain and heat. The system was powered with 110 VAC, and also had a surge-protected uninterruptable power supply to prevent loss of data during power surges or short-term power outages.

Imaging sonar resolution and quality can be affected by entrained air and turbulence created during power generation. Prior to deployment, feasibility testing of the imaging sonar system was conducted to identify deployment configurations and assess the issue of turbulence as a potential limitation for sonar sampling. With a discharge of 150 cfs at Unit 1 (Unit 2 was not operational during the field tests and was not expected to be operational during the proposed sampling periods), turbulence was noted to be fairly minor. Therefore, it was likely that sonar imagery would not be significantly degraded during similar operational conditions within the proposed sampling periods.

The imaging sonar unit was deployed approximately five feet outside of the pit and eight feet below the water surface, and was aimed with a positive 9.5 tilt angle to allow for imaging the bottom edges of the draft tube and the water volume below the Unit 1 draft tube (Figure 4.1-1). With this deployment, fish presence and behavior were assessed at the pit entrance and within the pit including directly below the draft tube.

The sampling design reasonably permitted the observation of fish that may enter the draft tube pit and the draft tube. The water volume directly below the draft tube was ensonified and any fish that entered that volume was detected (Figure 4.1-2). Any fish detected within the volume directly below the draft tube that swim up into the draft tube was shown to disappear from the field of view. Given that the water volume directly below the draft tube entrance was also ensonified, fish that exited the field of view without moving beyond the circumference of the bottom of the tube were assumed to have moved up into the draft tube.

Continuous data collection began on September 4, 2015 and continued through May 5, 2016. Data were ported directly to external hard drives, and backed up and archived daily to additional hard drives to ensure no data were lost.

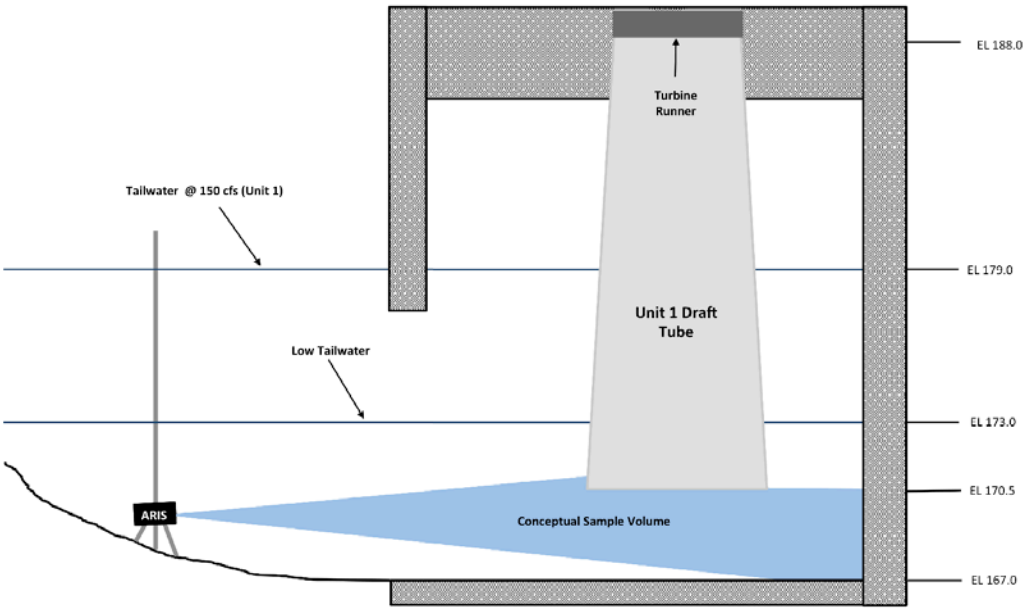

Figure 4.1-1. **Conceptual depiction of an imaging sonar deployment used to assess fish presence and behavior in the vicinity of and directly below the La Grange Unit 1 draft tube. Note that drawing is not to scale.**

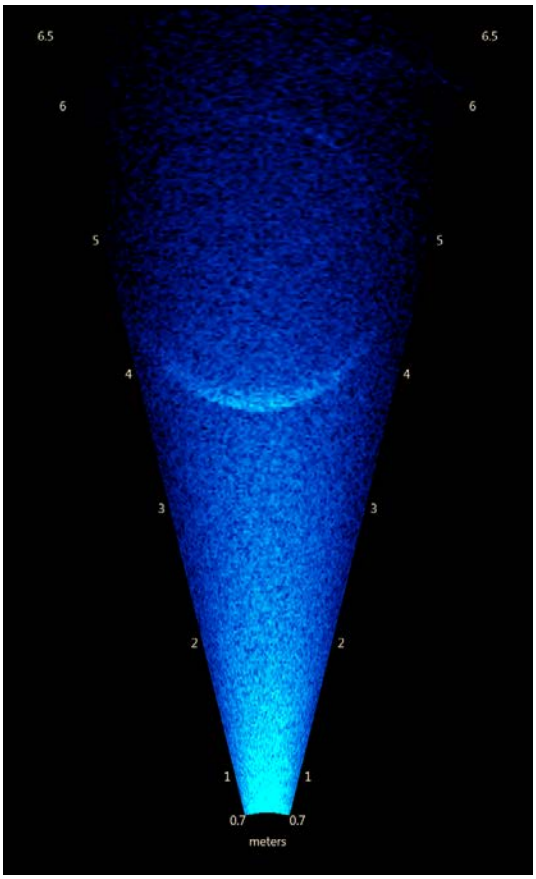

Figure 4.1-2. **Image of the field of view from the ARIS showing the entire circumference of the Unit 1 draft tube during operation of Unit 1.**

4.2 Data Processing and Analysis

The Districts processed and analyzed subsets of the imagery data to encompass periods during the fall-run Chinook salmon migration/spawning period (October through mid-December) and during the period after the fall-run Chinook salmon season (mid-December through May). Consistent with the FERC approved study plan, sub-sampled time periods were chosen based on observations of fish passing the tailrace monitoring weir (the Districts deployed a counting weir just downstream of the La Grange powerhouse in accordance with the La Grange Fish Barrier Assessment (TID/MID 2017a) concurrent in time with the Draft Tube Study). Weir count data from the Fish Barrier Assessment were reviewed to optimize the timing of the sonar imaging analysis (i.e., to determine when peak counts of fish are in the vicinity of the powerhouse). The sonar imaging monitoring periods chosen to be processed and analyzed were as follows: the consecutive five-week period from November 15 through December 19, 2015; and five three-day periods between December 20, 2015 and February 2016 (December 20 through 22, December 26 through 28, January 10 through 12, January 21 through 23, and February 24 through 26).

Initially, raw data were to be processed using a Convolved-Samples-Over-Threshold (CSOT) algorithm to filter out data that do not contain moving targets (i.e., all static imagery will be removed, resulting in a much smaller dataset to be manually processed). However, given that turbulence and debris were observed to confound the motion-sensing features of the CSOT algorithm, it was necessary to manually review all data files. Manual processing entailed reviewing the data files using playback software (ARISFish) that presents the data in both echogram and sonar display formats. When potential fish traces were observed in the echogram a short excerpt of data around the trace was then reviewed in sonar format to confirm whether or not the trace was a fish (the sonar format presents the data as a streaming view that allows for recognition of fish based on swimming movements and morphological features). Observed fish were then measured using the software's sizing tool. For all adult-sized (>30 cm) fish detected, the following data were documented: date, time, estimated total length, fish location relative to edge of draft tube (whether or not fish were observed to be within 0.6 m of the draft tube), whether or not the fish occupied the area below the draft tube or entered into and/or exited Unit 1 draft tube. If a fish were partially observed (i.e. its entire body was not in the field of view), but the portion of the body observed was > 30 cm, then the estimated total length assigned for the fish included a '+' sign to indicate that the length was a partial estimate. For example, if a fish was observed along the edge of the field of view and the portion of the body of the fish that was visible was 41 cm, then the fish was assigned an estimated total length of 41+ cm.

Imaging sonar is a passive method for sampling fish, as this technique relies on operational frequencies above the known hearing range of all species of fish (Fay and Simmons 1999). Imaging sonar is an accepted fisheries science data collection method and has been used for both fish passage investigations at hydropower dams (Johnson et al. 2013) and for estimating salmonid escapement in large rivers (Burwen et al. 2014). An important limitation of imaging sonar is that fish cannot be identified to species when similar species are present at the same time. In the context of this study this limitation is relevant since it was not possible to separate observations of Chinook salmon from observations of *O. mykiss* and other adult-sized fish (e.g., striped bass and Sacramento pikeminnow) based on imaging sonar data alone as those species are all generally similar in body shape (as opposed to for example lamprey or sturgeon which

have distinctly different body shapes and as a result can be identified using imagery sonar). All adult-sized fish (including Chinook salmon and *O. mykiss)* observed in the ARIS system field of view during the sampling period were included in the analysis and overall fish observations are inclusive of both Chinook salmon and *O. mykiss* as well as other adult fish of other species that may have been present during the sampling periods. Another important note is that an individual fish cannot be identified and tracked from the imaging sonar. This is relevant to the study results since total observations identified does not necessarily equal numbers of fish present in the vicinity of the draft tube (i.e., one fish may be responsible for multiple observations).

All entered data were reviewed for quality assurance purposes. Finalized datasheets were entered into a Microsoft Excel database and then independently reviewed for accuracy. Database quality assurance and quality control consisted of a comparison of entered data to the original datasheet information to affirm appropriate database entry.

5.0 RESULTS

5.1 Sampling Effort and Operational Conditions

The ARIS system was configured to collect data continuously throughout the study period but on a few occasions data collection was interrupted due to technical difficulties and system malfunction. As a result some portions of the study period were not monitored. For the consecutive five-week sub-sampled period (November 15 through December 19) sampling effort was 87 percent (of 840 hours, 728 hours were sampled and processed; Attachment A). For the five three-day periods, the sampling effort was 94 percent (of 360 hours, 339 hours were sampled and processed; Attachment B)

Operation of Unit 1 was not consistent throughout the study periods (Attachment A and Attachment B). Throughout a large portion of the month of November, Unit 1 was not operational, due to maintenance issues. For the five-week sub-sampled period, Unit 1 was operational for 60 percent of all hours. Across all five three-day sub-sampled periods, Unit 1 was operational for 80 percent of all hours.

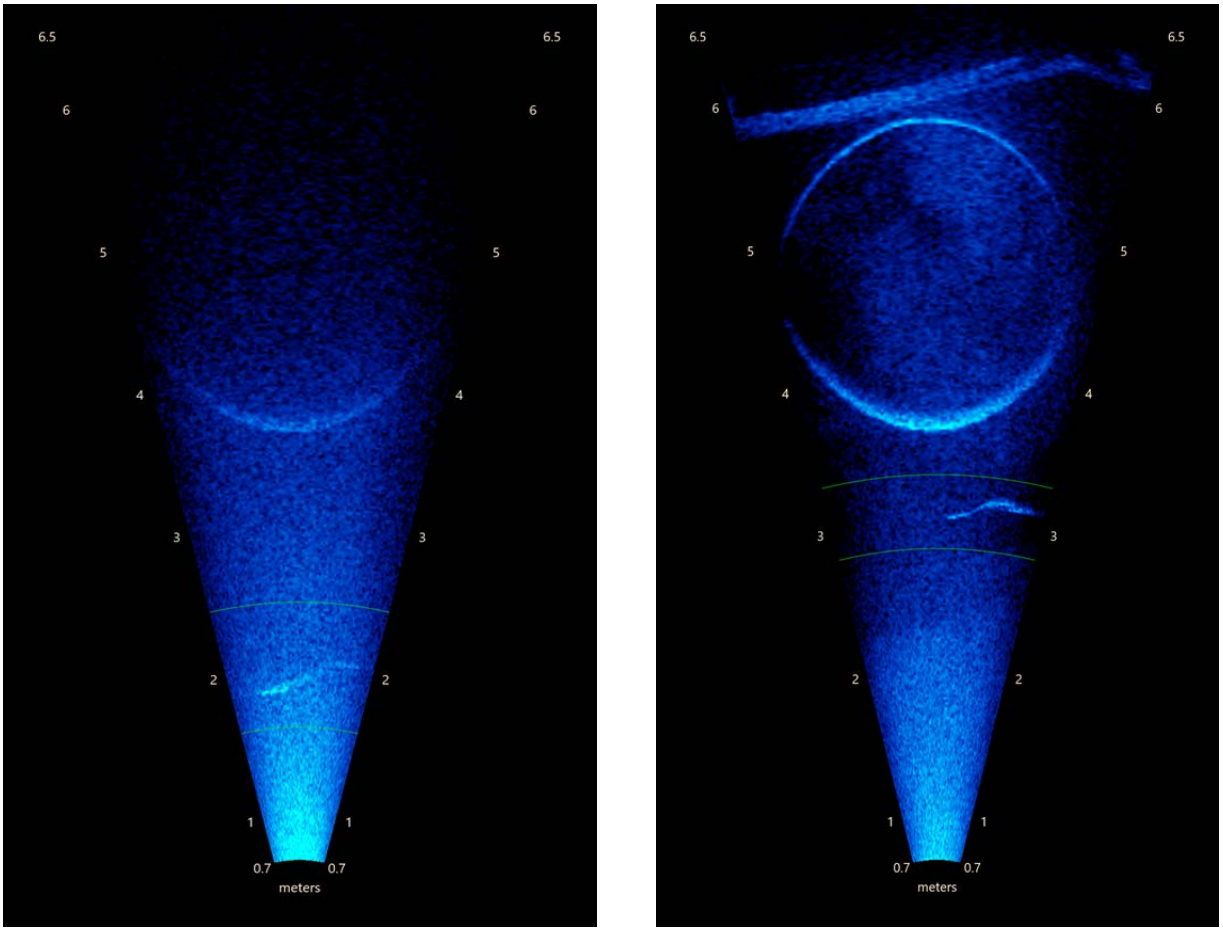

Figure 5.1-1. Still images from ARIS data with adult fish showing the differences in image quality during Unit 1 in operation (left panel) and Unit 1 not in operation (right panel).

5.1.1 Image Quality

The quality and clarity of ARIS imagery was not consistent across Unit 1 operational conditions (Figure 5.1-1, above). When Unit 1 was operational the imagery was characterized with less visible structural features in the field of view and lower resolution of fish images as compared with data collected when Unit 1 was off. When the unit was not operational the walls of the draft tube pit were visible and the entire circumference of the bottom of the draft tube could be clearly seen.

5.1.2 Adult Fish Observations

5.1.2.1 Overall Counts and Temporal Patterns

A total of 883 observations of adult fish were detected with ARIS during the consecutive five-week sampling period in 2015 (Figure 5.1-2). As noted above, these observation events do not represent individual fish, as an individual fish could pass through the ARIS field of view multiple times. Weir monitoring in the tailrace channel just downstream (~50 meters) of the ARIS monitoring location detected a total of 1,988 adult fish (>30 cm) passage events (1,016 upstream, 972 downstream) during this five-week period (Table 5.1-1). During this period, weir monitoring determined that 60 Chinook salmon were present in the vicinity of La Grange powerhouse, accounting for 67.3 percent of total weir passages (TID/MID 2017a).

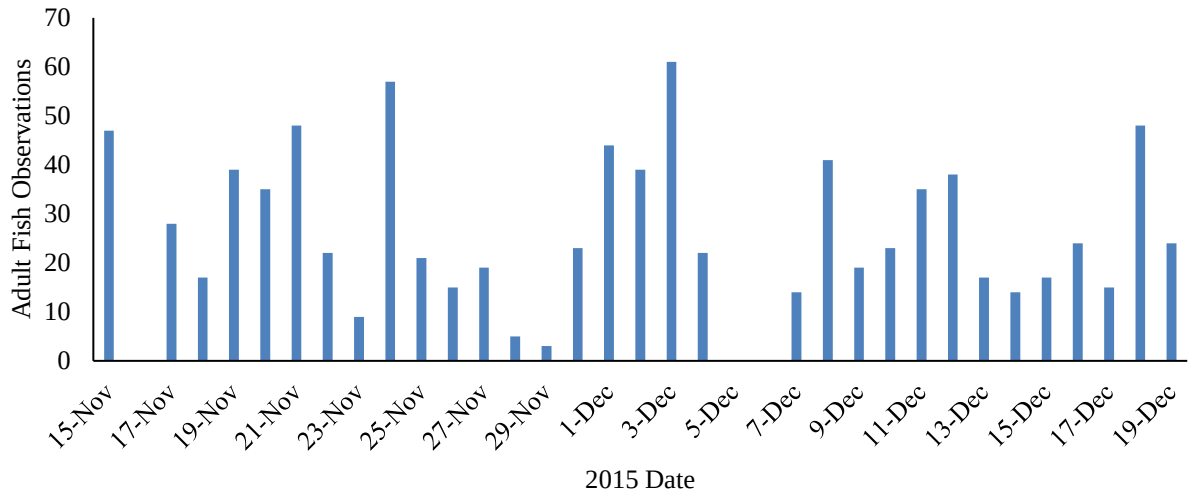

Figure 5.1-2. Number of adult fish observations detected with ARIS by date throughout the five-week sampling period (November 15 through December 19, 2015). Dates with missing bars were days in which sampling did not occur.

During the five three-day periods in 2015/2016 a total of 300 adult fish observations were detected (Figure 5.1-3). These periods (December 20 through 22, December 26 through 28, January 10 through 12, January 21 through 23, and February 24 through 26) were selected based on increase adult *O. mykiss* detections at the tailrace weir (TID/MID 2017a). During the five three-day periods, 630 adult fish (>30 cm) passage events (305 upstream, 325 downstream) were detected at the tailrace weir location. Striped bass accounted for 43.2 percent of the total

passages during these periods, with Chinook salmon and *O. mykiss* accounting for 35.2 percent and 7.8 percent, respectively (Table 5.1-1). It was estimated that the numbers of salmon present during these five periods were 12, 2, 1, 3, and 0, respectively.

Table 5.1-1. Adult fish (>30 cm) weir passage events in the tailrace channel just downstream of the ARIS monitoring location.

Species	Weir Passage Events		Percent of Total Passage
	Up	Down	
Consecutive Five-week Period			
Chinook	662	676	67.3
O. mykiss	19	13	1.6
Striped Bass	228	241	23.6
Sacramento Pikeminnow	57	65	6.1
Unidentified	6	21	1.4
Five Three-day Periods			
Chinook	112	110	35.2
O. mykiss	22	27	7.8
Striped Bass	135	137	43.2
Sacramento Pikeminnow	16	22	6.0
Carp/Goldfish	14	12	4.1
Unidentified/Other[1]	6	17	3.7

[1] Passages classified as other included bass (two down passages) and Sacramento sucker (one up passage).

All adult fish observations detected during the study periods are listed in Attachments C and D. Assessing fish observations by hour indicates an increase of activity during the late morning and early afternoon hours throughout the five-week sampling period during both Unit 1 on and off conditions (Figure 5.1-4). The hourly pattern was less consistent throughout the five three-day sampling periods with generally more activity from 0600 to 1200 hours when Unit 1 was operating (Figure 5.1-5).

5.1.2.2 Size Estimates

Proportional distributions of fish observations by size class indicated that the majority of fish were between 30-39 cm and 40-49 cm in estimated total length (Figure 5.1-6). Fish within the 50-59 cm size class were also frequently observed.

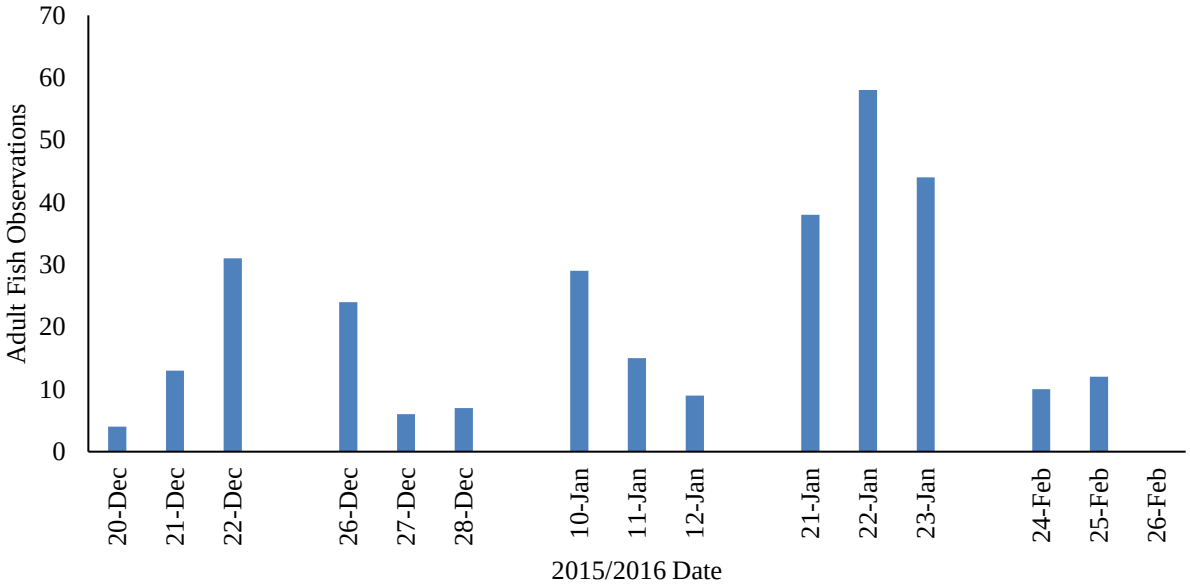

Figure 5.1-3. **Number of adult fish observations detected with ARIS by date throughout the five three-day sampling periods (December 20 through December 22, 2015; December 26 through December 28, 2015; January 10 through January 12, 2016; January 21 through January 23, 2016; and February 24 through February 26, 2016). The missing bar for February 26 indicates that no fish were observed that day.**

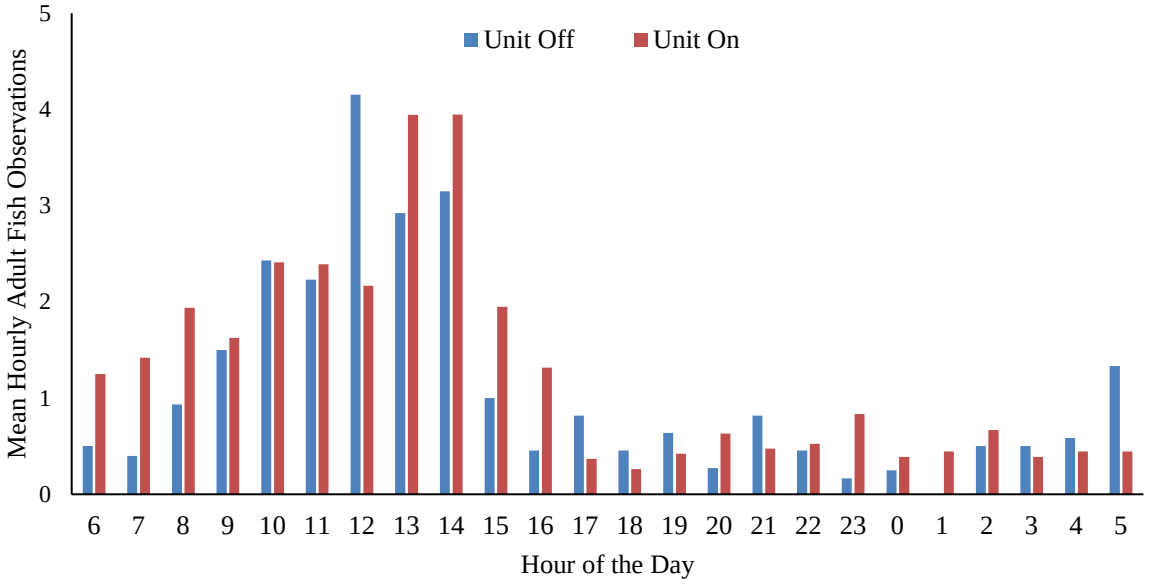

Figure 5.1-4. **Mean hourly adult fish observations detected with ARIS throughout the five week sampling period (November 15 through December 19, 2015) during Unit 1 on and off conditions. Mean hourly counts are standardized by sampling effort. The missing bar for hour 1 indicates no fish were observed during that hour when Unit 1 was off.**

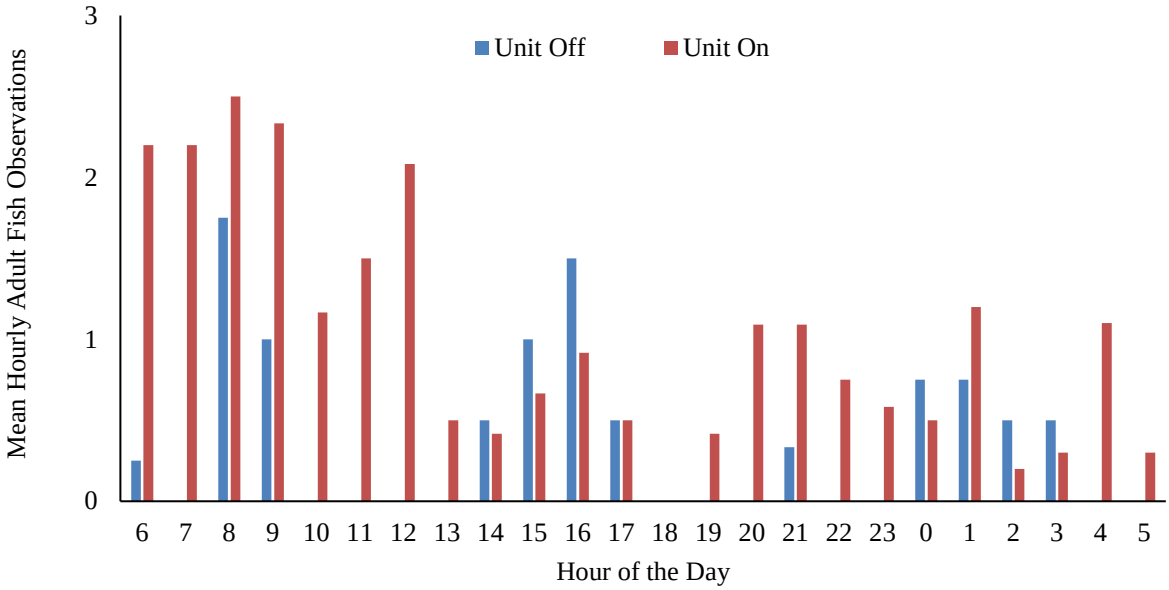

Figure 5.1-5. **Mean hourly adult fish observations detected with ARIS throughout the five 3-day sampling periods (December 20 through December 22, 2015; December 26 through December 28, 2015; January 10 through January 12, 2016; January 21 through January 23, 2016; and February 24 through February 26, 2016) during Unit 1 on and off conditions. Mean hourly counts are standardized by sampling effort. Hours with missing bars indicate that no fish were observed during those hours. Unit 1 on and off conditions occurred to some extent during each hour of the day through the five three-day study periods (see Figure 5.1-2).**

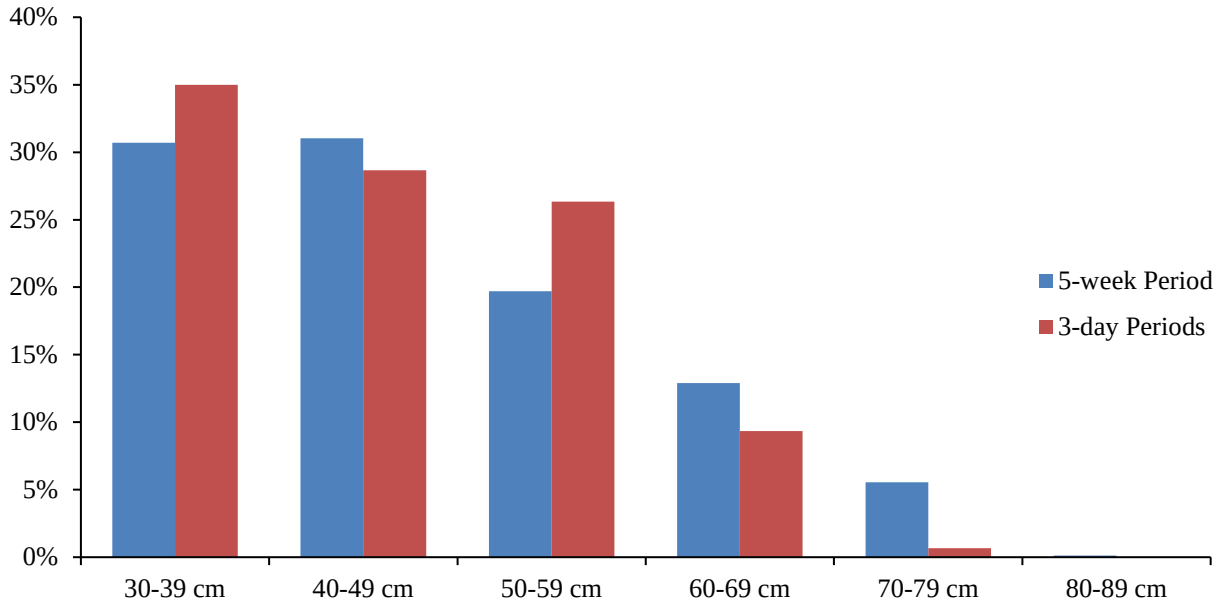

Figure 5.1-6. **Proportional distributions of adult fish observations by size classification for the consecutive five-week (left) and five three-day (right) sampling periods. Note there was one observation (0.11 percent) of a fish within the 80-89 cm size class (estimated total length 83 cm) during the consecutive five-week period and no fish observed in that size class during the five three-day periods.**

5.1.2.3 Observations and Unit Operations

During the consecutive five-week sample period 62 percent of all observations occurred when Unit 1 was operational (Table 5.1-2). Ninety percent of all observations occurred when Unit 1 was operational during the five three-day sample periods.

Table 5.1-2. Number and percentage of adult fish observations detected during Unit 1 On and Off conditions in the five-week and five three-day sample periods. Numbers and percentages are also shown for observations that occurred near (within 0.6 m) and under the draft tube.

	Five-week Period			Five Three-day Periods		
	Total Observations	**Near Draft Tube (>0.6m)**	**Under Draft Tube**	**Total Observations**	**Near Draft Tube (>0.6m)**	**Under Draft Tube**
Unit 1 ON	546 (62%)	39 (7%)	0	271 (90%)	75 (28%)	0
Unit 1 OFF	337 (38%)	53 (16 %)	5 (1%)	29 (10%)	6 (21%)	0

The majority of observations throughout all sample periods and across operational conditions were of fish detected beyond 0.6 m from the edge of the draft tube. When Unit 1 was operational seven percent of observations were of fish detected near (within 0.6 m) the draft tube during the five-week study period and 28 percent during the five three-day sample periods (Table 5.1-2). No adult fish were detected under the draft tube when Unit 1 was on. When Unit 1 was off 16 percent and 21 percent of observations were of fish near the draft tube for the five-week and the five three-day sample periods, respectively. A total of five observations (one percent) were of adult fish detected below the draft tube when Unit 1 was off during the five-week sample period (e.g. Figure 5.1-7).

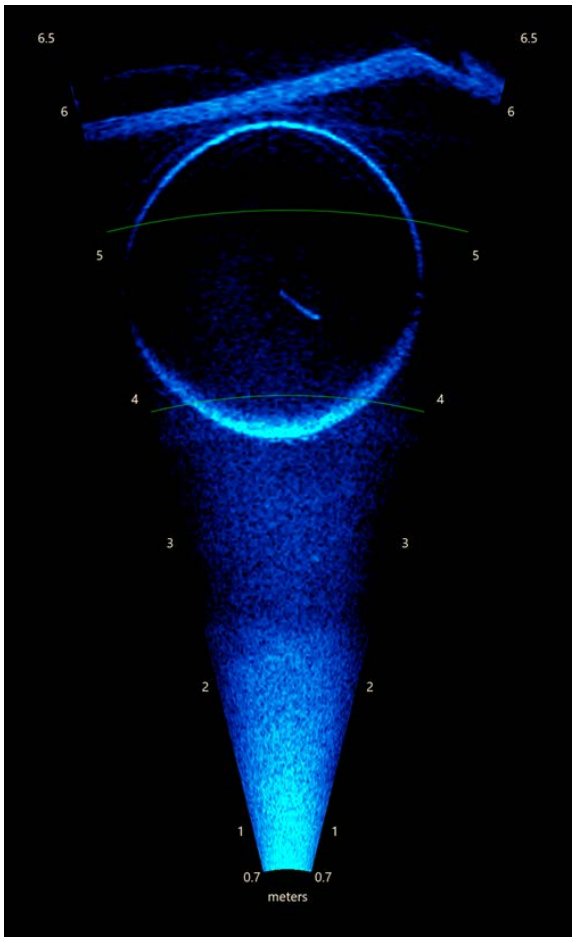

Figure 5.1-7. **Still image of ARIS data showing an adult fish (estimated total length 35 cm) below the Unit 1 draft tube. This observation occurred at 0630 on November 19, 2015 (Unit 1 was not operating).**

6.0 DISCUSSION AND FINDINGS

The quality of the ARIS imagery differed between periods when Unit 1 was operating and when Unit 1 was not operating. During non-operational conditions the ensonified volume was clear throughout the field of view which allowed for more defined and higher resolution images of fish as compared to when the unit was in operation. During operational conditions the ensonified volume was less clear due to turbulence associated with unit operation, which resulted in less defined and lower resolution images of fish as compared to non-operational conditions. However, despite the lower resolution imagery during operational conditions the quality was high enough to sufficiently assess adult fish presence throughout the field of view when the unit was operating.

Results from ARIS sampling out front of the La Grange Diversion Dam powerhouse indicated that the area in the vicinity of the draft tube pit was occupied frequently by adult fish. Weir counts from the Fish Barrier Assessment indicated that the majority of observations at the tailrace weir were of adult salmonids, although striped bass, Sacramento pikeminnow, common carp and goldfish were also observed (TID/MID 2017a). Therefore, it is likely that the observations based on ARIS sampling included individuals from each of these species that were observed passing up through the weir. It is also important to note that the observations of adult fish in the vicinity of the draft tube pit do not reflect the observation of separate individual fish but instead indicate the movement of individual fish continuously entering and exiting the ARIS field of view.

The frequent presence of adult fish in the vicinity of the La Grange powerhouse was observed during the fall-run Chinook 2015 migration period and the winter 2015/2016 migration season for *O. mykiss*. Adult fish observations during these periods often exceeded 30 per day. Weir count information (from the Fish Barrier Assessment) analyzed for this study's monitoring period indicate that a variety of fish species, including fall-run Chinook and *O. mykiss*, were present in the vicinity of the La Grange powerhouse. Though fish presence in the vicinity of the La Grange powerhouse was evident, they were detected most frequently in the foreground of the field of view and not close to the draft tube. It appears that adult fish often occupy the area in front of the powerhouse but do not approach the draft tube. This result was evident during both Unit 1 On and Unit 1 Off conditions. Adult fish were not observed to occupy the area under the draft tube when Unit 1 was operational. Furthermore, fish were rarely observed occupying the area under the draft tube when Unit 1 was not operational. The study results indicate that there is an extremely low risk of fish entering the draft tube and furthermore, swimming vertically up the draft tube and leaping into and being injured as a result of being in contact with the turbine runners in Unit 1 while it is in operation. Given that both units at La Grange Diversion Dam are vertically oriented Francis units with conical, straight-drop draft tubes (not elbow draft tubes) and the low steel of the turbine runner is significantly above tailwater elevation during normal operation, it is likely that the study results apply to both units. These results are also corroborated in the field where crews were on site daily (Fish Presence and Stranding Assessment [TID/MID 2017b]) throughout the study period and reported no observations of injuries or mortalities of adult fish that would have indicated evidence of fish being struck by turbine blades. The lack of adult fish observations below the draft tube when Unit 1 was operational and the absence of direct evidence of blade strike injuries support the notion that

considering the vertical orientation of the draft tube (of both units) and the distance between the turbine runner and the tailwater elevation (Figure 4.1-1), there is a very low likelihood of fish entering the draft tube and leaping up towards a turbine runner while units are operating.

6.1 Summary of Findings

The following is a summary of study findings.

- Adult fish, including fall-run Chinook salmon and *O. mykiss* (as determined by weir counts), were frequently observed in the vicinity of the La Grange powerhouse (883 observations during the consecutive five-week study period; 300 observations during the five three-day study period). Note that these observation events do not represent individual fish. For example, weir monitoring in the tailrace channel just downstream of the ARIS monitoring location estimated 60 adult salmon present during the five-week study period (TID/MID 2017a).
- Mean hourly observations showed an increase of activity during the late morning and early afternoon hours throughout the five-week sampling period, and this pattern was consistent whether or not Unit 1 was operating. The hourly pattern was less consistent throughout the five three-day sampling periods with generally more activity from 0600 to 1200 hours, especially when Unit 1 was operating.
- Proportional distributions of fish observations by size class indicated that the majority of fish were between 30-39 cm and 40-49 cm in estimated total length through all sample periods. Fish within the 50-59 cm size class were also observed.
- The majority of observations occurred when Unit 1 was operational (62 percent during the consecutive five-week sample period and 90 percent during the five three-day sample periods).
- The majority of observations throughout all sample periods and across operational condition were of fish detected beyond 0.6 m from the edge of the draft tube.
- Five observations (one percent) of adult fish were detected below the draft tube when Unit 1 was off during the five-week sample period and no observations were detected below the draft tube when Unit 1 was off during the five three-day sample periods.
- No adult fish were observed under the draft tube when Unit 1 was operational throughout all sample periods.
- Study results (also corroborated by daily field observations from the Fish Presence and Stranding Assessment [TID/MID 2017b]) indicate that the risk of fish entering unit draft tubes while in operation and being injured by the turbine runners is extremely low.

7.0 STUDY VARIANCES AND MODIFICATIONS

There was a single variance to this study. The study plan identified January through April as the period for five additional three-day sampling events after the fall-run Chinook season. Review of weir data in the tailrace immediately downstream of the ARIS monitoring location identified an increase in *O. mykiss* passages starting in mid-December. In order to better evaluate potential interactions of *O. mykiss* near the draft tubes, this monitoring period was shifted to mid-December through February, and three-day periods corresponded with peaks in *O. mykiss* passage.

8.0 REFERENCES

Burwen, D. L., J. A. Miller, S. Fleischman and J. Huang. 2014. Kenai River Chinook salmon sonar assessment. Alaska Department of Fish and Game, Regional Operational Plan ROP.SF2A.2014.06, Anchorage, AK.

Fay R.R. and A.M. Simmonds. 1999. The sense of hearing in fishes and amphibians. In *Comparative hearing: fishes and amphibians*. R. R. Fay, A. N. Popper (eds). Springer-Verlag: New York; 269-318.

Johnson, E. L., T. S. Clabough, M. L. Keefer, C. C. Caudill, P. N. Johnson, M. A. Kirk and M. A. Jepson. 2013. Evaluation of dual-frequency identification sonar (DIDSON) for monitoring Pacific lamprey passage behaviour at fishways of Bonneville and John Day Dams, 2012. Final technical report for U.S Army Corps of Engineers, Portland District.

Turlock Irrigation District and Modesto Irrigation District (TID/MID). 2017a. La Grange Project Fish Barrier Assessment Study Report. Prepared by FISHBIO. September 2017.

_____. 2017b. Fish Presence and Stranding Assessment Technical Memorandum. Prepared by FISHBIO. September 2017.

INVESTIGATION OF FISH ATTRACTION TO LA GRANGE POWERHOUSE DRAFT TUBES STUDY REPORT

ATTACHMENT A

SAMPLING EFFORT AND UNIT 1 OPERATION FOR THE FIVE-WEEK PERIOD NOVEMBER 15 THROUGH DECEMBER 19, 2015

Table A-1. **Sampling effort and Unit 1 operation for the five-week period November 15 through December 19, 2015. Hourly sampling effort is shown using values 0 to 1 with 0 indicating that the hour was not sampled and 1 indicated that the full hour was sampled. Fractional values indicate the proportion of the hour that was sampled. Blue shaded hours denote when Unit 1 was off and yellow shaded hours denote when Unit 1 was on.**

Hr of Day	11/15	11/16	11/17	11/18	11/19	11/20	11/21	11/22	11/23	11/24	11/25	11/26	11/27	11/28	11/29	11/30	12/1	12/2
0	1	0	0	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1
1	1	0	0	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1
2	1	0	0	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1
3	1	0	0	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1
4	1	0	0	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1
5	1	0	0	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1
6	1	0	0	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1
7	1	0	0	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1
8	1	0	0	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1
9	1	0	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1
10	1	0	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1
11	1	0	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1
12	1	0	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1
13	1	0	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1
14	0.75	0	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1
15	0	0	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1
16	0	0	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1
17	0	0	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1
18	0	0	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1
19	0	0	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1
20	0	0	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1
21	0	0	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1
22	0	0	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1
23	0	0	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1

Table A-1. (cont.)

Hour of Day	12/3	12/4	12/5	12/6	12/7	12/8	12/9	12/10	12/11	12/12	12/13	12/14	12/15	12/16	12/17	12/18	12/19
0	1	1	0	0	0	1	1	1	1	1	1	1	1	1	1	1	1
1	1	1	0	0	0	1	1	1	1	1	1	1	1	1	1	1	1
2	1	1	0	0	0	1	1	1	1	1	1	1	1	1	1	1	1
3	1	1	0	0	0	1	1	1	1	1	1	1	1	1	1	1	1
4	1	1	0	0	0	1	1	1	1	1	1	1	1	1	1	1	1
5	1	1	0	0	0	1	1	1	1	1	1	1	1	1	1	1	1
6	1	1	0	0	0	1	1	1	1	1	1	1	1	1	1	1	1
7	1	1	0	0	0.5	1	1	1	1	1	1	1	1	1	1	1	1
8	1	1	0	0	1	1	1	1	1	1	1	1	1	1	1	1	1
9	1	1	0	0	1	1	1	1	1	1	1	1	1	1	1	1	1
10	1	0	0	0	1	1	1	1	1	1	1	1	1	1	1	1	1
11	1	0	0	0	1	1	1	1	1	1	1	1	1	1	1	1	1
12	1	0	0	0	1	1	1	1	1	1	1	1	1	1	1	1	1
13	1	0	0	0	1	1	1	1	1	1	1	1	1	1	1	1	1
14	1	0	0	0	1	1	1	1	1	1	1	1	1	1	1	1	1
15	1	0	0	0	1	1	1	1	1	1	1	1	1	1	1	1	1
16	1	0	0	0	1	1	1	1	1	1	1	1	1	1	1	1	1
17	1	0	0	0	1	1	1	1	1	1	1	1	1	1	1	1	1
18	1	0	0	0	1	1	1	1	1	1	1	1	1	1	1	1	1
19	1	0	0	0	1	1	1	1	1	1	1	1	1	1	1	1	1
20	1	0	0	0	1	1	1	1	1	1	1	1	1	1	1	1	1
21	1	0	0	0	1	1	1	1	1	1	1	1	1	1	1	1	1
22	1	0	0	0	1	1	1	1	1	1	1	1	1	1	1	1	1
23	1	0	0	0	1	1	1	1	1	1	1	1	1	1	1	1	1

INVESTIGATION OF FISH ATTRACTION TO LA GRANGE POWERHOUSE DRAFT TUBES STUDY REPORT

ATTACHMENT B

SAMPLING EFFORT AND UNIT 1 OPERATION FOR THE FIVE THREE-DAY SUB-SAMPLED PERIODS

Table B-1. **Sampling effort and Unit 1 operation for the five three-day sub-sampled periods. Hourly sampling effort is shown using values 0 to 1 with 0 indicating that the hour was not sampled and 1 indicated that the full hour was sampled. Blue shaded hours denote when Unit 1 was off and yellow shaded hours denote when Unit 1 was on.**

	Period 1			Period 2			Period 3			Period 4			Period 5		
Hour of Day	12/20	12/21	12/22	12/26	12/27	12/28	1/10	1/11	1/12	1/21	1/22	1/23	2/24	2/25	2/26
0	1	1	1	1	1	1	1	1	1	0	1	1	1	1	1
1	1	1	1	1	1	1	1	1	1	0	1	1	1	1	1
2	1	1	1	1	1	1	1	1	1	0	1	1	1	1	1
3	1	1	1	1	1	1	1	1	1	0	1	1	1	1	1
4	1	1	1	1	1	1	1	1	1	0	1	1	1	1	1
5	1	1	1	1	1	1	1	1	1	0	1	1	1	1	1
6	1	1	1	1	1	1	1	1	1	0	1	1	1	1	1
7	1	1	1	1	1	1	1	1	1	0	1	1	1	1	1
8	1	1	1	1	1	1	1	1	1	0	1	1	1	1	1
9	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1
10	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1
11	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1
12	1	1	1	0	1	1	1	1	1	1	1	1	1	1	1
13	1	1	1	0	1	1	1	1	1	1	1	1	1	1	1
14	1	1	1	0	1	1	1	1	1	1	1	1	1	1	1
15	1	1	1	0	1	1	1	1	1	1	1	1	1	1	1
16	1	1	1	0	1	1	1	1	1	1	1	1	1	1	1
17	1	1	1	0	1	1	1	1	1	1	1	1	1	1	1
18	1	1	1	0	1	1	1	1	1	1	1	1	1	1	1
19	1	1	1	0	1	1	1	1	1	1	1	1	1	1	1
20	1	1	1	0	1	1	1	1	1	1	1	1	1	1	1
21	1	1	1	0	1	1	1	1	1	1	1	1	1	1	1
22	1	1	1	0	1	1	1	1	1	1	1	1	1	1	1
23	1	1	1	0	1	1	1	1	1	1	1	1	1	1	1

INVESTIGATION OF FISH ATTRACTION TO LA GRANGE POWERHOUSE DRAFT TUBES STUDY REPORT

ATTACHMENT C

DAILY COUNTS OF ADULT FISH OBSERVATIONS DURING THE FIVE-WEEK SAMPLE PERIOD NOVEMBER 15 THROUGH DECEMBER 19, 2015

Table C-1. Daily counts of adult fish observations during the five-week sample period November 15 through December 19, 2015.

Date	Fish Observations		Estimated Size Range (cm)
	Away From Draft Tube (>0.6 m)	Near Draft Tube (<0.6 m)	
15-Nov	44	3	30-76
16-Nov	0	0	--
17-Nov	25	3	35-75
18-Nov	16	1	30-75
19-Nov	29	10	30-77
20-Nov	32	3	32-78
21-Nov	42	6	31-83
22-Nov	19	3	30-70
23-Nov	3	6	36-70
24-Nov	51	6	30-67
25-Nov	21	0	32-64
26-Nov	8	7	32-71
27-Nov	17	2	30-66
28-Nov	3	2	35-44
29-Nov	3	0	37-49
30-Nov	20	3	31-59
1-Dec	40	4	32-70
2-Dec	34	5	31-76
3-Dec	56	5	30-64
4-Dec	20	2	32-73
5-Dec	0	0	--
6-Dec	0	0	--
7-Dec	11	3	39-68
8-Dec	40	1	33-77
9-Dec	18	1	31-75
10-Dec	23	0	31-59
11-Dec	34	1	31-68
12-Dec	33	5	32-59
13-Dec	15	2	30-60
14-Dec	14	0	32-66
15-Dec	15	2	32-57
16-Dec	22	2	32-56
17-Dec	13	2	31-71
18-Dec	47	1	30-67
19-Dec	23	1	31-59

INVESTIGATION OF FISH ATTRACTION TO LA GRANGE POWERHOUSE DRAFT TUBES STUDY REPORT

ATTACHMENT D

DAILY COUNTS OF ADULT FISH OBSERVATIONS DURING THE FIVE THREE-DAY SUB-SAMPLED PERIODS

Table D-1. Daily counts of adult fish observations during the five three-day sub-sampled periods.

Date	Fish Observations		Estimated Size Range (cm)
	Away From Draft Tube (>0.6m)	Near Draft Tube (<0.6 m)	
20-Dec	2	2	35-47
21-Dec	6	7	29-55
22-Dec	29	2	32-61
26-Dec	21	3	30-56
27-Dec	5	1	32-50
28-Dec	7	0	32-47
10-Jan	23	6	30-57
11-Jan	15	0	30-53
12-Jan	7	2	34-47
21-Jan	26	12	31-67
22-Jan	36	22	31-71
23-Jan	24	20	34-73
24-Feb	9	1	32-61
25-Feb	9	3	31-52
26-Feb	0	0	--