

Lagoon Seepage Testing Procedures for Central Facilities Area (CFA) Sewage Lagoons at Idaho National Laboratory Butte County, Idaho April 2014

May 2014



The INL is a U.S. Department of Energy National Laboratory
operated by Battelle Energy Alliance

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Facilities Area (CFA) Sewage Lagoons at Idaho
National Laboratory Butte County, Idaho April 2014**

J-U-B Engineers, Inc.

May 2014

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Idaho Falls, Idaho 83415**

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Lagoon Seepage Testing Procedures for Central Facilities Area (CFA) Sewage Lagoons

1. Introduction

Battelle Energy Alliance, LLC (BEA) operates the Central Facilities Area (CFA) located in Butte County, Idaho at Idaho National Laboratory (INL). The CFA has an existing wastewater system to collect and treat sanitary wastewater and non-contact cooling water from the facility. The existing treatment facility consists of three cells: Cell #1 has a surface area of 1.7 acres, Cell #2 has a surface area of 10.3 acres, and Cell #3 has a surface area of 0.5 acres. The three cells are lined with bentonite-treated soil and riprap. If flows exceed the evaporative capacity of the cells, wastewater is discharged to a 73.5 acre land application site that utilizes a center-pivot irrigation sprinkler system.

The lagoons were last tested for seepage in 2006. The Idaho Department of Environmental Quality (IDEQ), through the Wastewater Reuse Permit for the CFA Sewage Treatment Plant (LA-000141-03), is requiring that the seepage tests at CFA be repeated prior to August 31, 2014.

The layout of the lagoons, transfer structures, outlet structure, yard piping, and flow-control and isolation valves and gates are shown in **Figure 2**, **Figure 3**, and **Figure 4** in **Appendix A**.

The lagoons have the following characteristics:

Table 1-1: CFA Lagoons

Lagoon Cell #	Liner	Year Constructed	Maximum Water Depth (ft – Approximate) ^A	Freeboard above Max Water Depth (ft – Approximate)	Approximate Average Water Surface Area (acres)
1	Bentonite-treated soil with riprapped sides	1994	8	2	1.7
2	Bentonite-treated soil with riprapped sides	1994	8	2	10.3
3	Bentonite-treated soil with riprapped sides	1994	8	2	0.5

^A

Design depth. Typical maximum operating depth is approximately 7.5 feet

The lagoons will be tested to meet the requirements set forth in the Idaho Wastewater Rules (IDAPA 58.01.16). Since the lagoons were constructed prior to April 15, 2007, they will be tested to determine if the seepage rate is less than the allowable seepage rate of 0.25 inches per day.

2. Purpose

The lagoon seepage testing procedures are documented herein as required by the Wastewater Rules (IDAPA 58.01.16.493). The Wastewater Rules and Wastewater Reuse Permit LA-000141-03 require that the procedure used for performing a seepage test be approved by IDEQ prior to conducting the seepage test. The procedures described herein are based on a seepage testing plan that was developed by J-U-B ENGINEERS, Inc. (J-U-B) and has been accepted by several IDEQ offices for lagoons in Idaho.

3. Specific Issues

Per IDEQ's guidance, lagoons must be tested when groundwater depth is below the bottom of the lagoons. Groundwater data is collected on a monthly basis from monitoring well USGS-130, located less than a quarter of a mile west of the lagoons. The groundwater level measured in USGS-130 on April 8, 2014 was 484.91 feet below land surface. Data gathered from monitoring well USGS-130 shows that the groundwater level has been at least 480 feet below land surface for the past 10 years. The data can be viewed at the USGS Groundwater for USA website, <http://nwis.waterdata.usgs.gov>. Due to the extremely low groundwater in the area, it is assumed that the groundwater level will remain below the bottom of the lagoons during the lagoon seepage testing.

Each lagoon cell will be tested for seepage independently. Should insufficient valving or gating not allow a lagoon cell to be isolated to the degree necessary for seepage testing, the lagoon cell will be hydraulically connected to another cell. Once the water level in the connected lagoons equalizes, the seepage test will be performed for the connected lagoon cells, which will determine the seepage rate for both lagoons.

4. Personnel

Brett M. Converse, Ph.D./P.E., J-U-B, will be the Idaho Licensed Professional Engineer responsible for seepage testing of the lagoons. Dr. Converse will be assisted by Bridger Morrison, P.E., other J-U-B employees, and BEA employees during setup and to perform the daily inspections.

5. Equipment

The following equipment will be used for lagoon seepage testing:

1. **Precipitation Gauge** – A TE525-series tipping bucket rain gauge manufactured by Texas Electronics able to measure in 0.01-inch increments. The momentary switch closure is counted by the pulse-counting circuitry of Campbell Scientific data loggers.
2. **Air Temperature Sensor** – Campbell Scientific 107-L6 temperature sensor with 6-gill plate solar radiation shield.
3. **Water Temperature Sensor** – Campbell Scientific 107-L20 temperature sensor.
4. **Wind Speed and Direction** – Campbell Scientific 03002 Wind Sentry set with a 3-cup anemometer and wind vane.

5. **Liquid Level Sensor (2)** – GeoKon Model 4675LV, vibrating wire force transducer for water level monitoring with a full-scale sensor range from 0 to 6 inches and an accuracy of $\pm 0.1\%$ of full scale.
6. **Power Supply** – 12 V battery with 10 watt solar panel.
7. **Wooden Instrument Box and Supports**
8. **Data Logger** – Campbell Scientific CR 850 data logger and support software.
9. **Class A evaporation pan with pan stilling well**, situated on a level base constructed from wood. The evaporation pan will be a 4-foot-diameter stainless steel pan. The stilling well will be a 4-inch-diameter PVC tube attached to a galvanized steel tube with a triangular leveling base.

6. Procedures

The following testing and measuring methods will be used:

6.1 General Lagoon Preparation and Equipment Setup

The general preparation and equipment setup steps are as follows:

1. Isolate the sewage lagoon pond to be tested.
 - a. This step is unique to each lagoon. Refer to Section 6.3 for site-specific steps.
2. Fill the lagoon to be tested to the design operating depth, or the depth at which the lagoon is to be tested, prior to the start of the seepage test and wait for the lagoon to stabilize. If two to four weeks pass without reaching stabilization, the client will be consulted before testing will begin.
3. Identify a setup location.
4. Install a temporary fence and protective barrier around the setup location to protect the equipment from animals and guard against vandalism. This fence will likely consist of temporary construction fencing fabric attached to tubular markers or poles weighted sufficiently to hold the fence in place and protect the equipment. Prior to testing, fishing line will be suspended above the evaporation pan at approximately 12-inch spacing. The fishing line will likely be strung between the fencing used to enclose the equipment. Flagging or ribbon will be attached to the fishing line in locations where shadows will not be cast on the water.
5. Set up the evaporation pan on a level wood base and supported approximately 6 inches above the ground within the setup area. Fill to within 2 inches of the top with clean water. Check the levelness of the pan after filling with water to ensure the pan has not moved.
 - a. The evaporation pan will be located on a level area as close to the lagoon as possible but not near sun or wind blocks (building or trees).
 - b. The pan will be leveled using shims.
 - c. The pan stilling well will be anchored in the pan and not moved once the test period begins.
 - d. Initial water level in the pan will be approximately 2 inches below the lip.
 - e. Fresh water will be used to fill the pan and add water to the pan if necessary.
6. Set up the wooden instrument box and attach the following equipment:

- a. Solar panel
 - b. Rain gauge
 - c. Wind anemometer
 - d. Air temperature sensor and Gill shield
 - e. Air temperature sensor in the lagoon stilling well
 - f. Data logger weatherproof enclosure
7. Set up the liquid level sensor in the lagoon (must be mounted vertically). Refer to **Appendix B** for a general detail of mounting the liquid level sensor in a concrete transfer structure or control structure.
- a. This step is unique for each lagoon to be tested. Refer to Section 6.3 for site-specific steps.
 - b. Attach the liquid level sensor to the jack screw (length sufficient to reach 3 feet below the water surface).
 - c. Set two beams across the supporting structure. Check that the beams are level and secure; use shims to adjust them as needed.
 - d. Locate the jack screw plate between the two beams.
 - e. Submerge the liquid level sensor 5 inches below the water surface.
 - f. Turn the jack nut until it contacts the plate.
 - g. Turn the locking nut tight against the plate from the bottom.
 - h. Secure the plate to the beams with “C-clamps.”
 - i. Mark position of equipment so it can be relocated if accidentally moved.
 - i. If the level sensor support is accidentally moved or bumped, relocate the support in the original location.
 - ii. Make a note in the daily log of the time the support was bumped, moved, and/or relocated.
 - j. Verify that nothing is placed on top of the wire and that it is free of kinks and extreme bends during the test. This is necessary to protect the air tubes located inside the level sensor wires.
8. Set up the liquid level sensor within the 4-inch PVC stilling well in the evaporation pan (must be mounted vertically). Place stilling well so liquid level sensor is in the center of the evaporation pan.
- a. Verify that nothing is placed on top of the wire and that it is free of kinks and extreme bends during the test. This is necessary to protect the air tubes located inside the level sensor wires.
9. Set up the battery.
10. Set up the data logger.
11. Connect equipment to the data logger.
12. Record the setup with photographs.

6.2 Calibration

The liquid level sensors are comparatively calibrated at the beginning of each testing season and periodically during the testing season via a multi-day test. As an additional step to verify calibration, the sensors were factory calibrated in February 2014 and found to be operating within specifications.

6.3 Site-Specific Lagoon Preparation and Equipment Setup

The site specific lagoon preparation and equipment setups are as follows (see **Appendix A** for referenced figures):

1. Fill the lagoon to the test level, if necessary.
2. Isolate the lagoon cell to be tested. Note that the valve/gate operations described below are not listed in any particular order and should be coordinated and performed in the field by the Sewage Treatment Plant operator. Field modifications to the suggested plan may be needed to respond to site specific conditions.
 - a. To isolate and bypass Lagoon Cell #1 (see **Figure 2** and **Figure 3** in **Appendix A**):
 - i. Close valve 6INV-1 on inlet pipe
 - ii. Open valve 6INV-2 on inlet pipe
 - iii. At TRANSFER STRUCTURE-1:
 - a) Close gate 6INSLUICE-1
 - b) Close gate WEIR-1
 - c) Open gate 6INSLUICE-2
 - d) Close gate 6INSLUICE-3
 - e) Open gate 6INSLUICE-4
 - iv. At TRANSFER STRUCTURE-2:
 - a) Adjust valves/gates as desired to store and/or land apply wastewater.
 - v. At OUTLET STRUCTURE-1:
 - a) Adjust valves/gates as desired to store and/or land apply wastewater.
 - b. To isolate and bypass Lagoon Cell #2 while passing flow through Cell #1 and storing flow in Cell #3 or land applying (see **Figure 2** and **Figure 3** in **Appendix A**):
 - i. Open valve 6INV-1 on inlet pipe
 - ii. Close valve 6INV-2 on inlet pipe
 - iii. At TRANSFER STRUCTURE-1:
 - a) Close gate 6INSLUICE-1
 - b) Open gate WEIR-1
 - c) Close gate 6INSLUICE-2
 - d) Open gate 6INSLUICE-3
 - e) Close gate 6INSLUICE-4

- iv. At TRANSFER STRUCTURE-2:
 - a) Close gate WEIR-2
 - b) Close gate 6INSLUICE-5
 - c) Open gate 6INSLUICE-6
 - d) Close gate 7INSLUICE-7
 - e) Open gate 8INSLUICE-8
- v. At OUTLET STRUCTURE-1:
 - a) Adjust valves/gates as desired to store and/or land apply wastewater
- c. To isolate Lagoon Cell #3 while passing flow through Cell #1 and storing flow in Cell #2 (see **Figure 3** and **Figure 4** in **Appendix A**):
 - i. Open valve 6INV-1 on inlet pipe
 - ii. Close valve 6INV-2 on inlet pipe
 - iii. At TRANSFER STRUCTURE-1:
 - a) Close gate 6INSLUICE-1
 - b) Open gate WEIR-1
 - c) Close gate 6INSLUICE-2
 - d) Close gate 6INSLUICE-3
 - e) Open gate 6INSLUICE-4
 - iv. At TRANSFER STRUCTURE-2:
 - a) Close gate WEIR-2
 - b) Close gate 6INSLUICE-5
 - c) Close gate 6INSLUICE-6
 - d) Close gate 7INSLUICE-7
 - e) Open gate 8INSLUICE-8
 - v. At OUTLET STRUCTURE-1:
 - a) Close gate 6INSLUICE-9
 - b) Close gate 6INSLUICE -10
- 3. Equipment setup:
 - a. Set up the lagoon level sensor and support beams on the hydraulically connected transfer structure or manhole.
 - i. Cell #1: Mount level sensor in TRANSFER STRUCTURE-1 north of the downward opening weir gate, WEIR-1.
 - ii. Cell #2: Mount level sensor in TRANSFER STRUCTURE-2 north of the downward opening weir gate, WEIR-2.

- iii. Cell #3: Mount level sensor in TRANSFER STRUCTURE-2 south of the downward opening weir gate, WEIR-2.
- b. Follow the general setup steps above to finish installing the lagoon level sensor.
- c. Set up the remaining testing equipment nearby.

6.4 Test Procedure and Data Collection

1. In addition to the date and time, measurements from the following instruments will be recorded via the data logger every 4 to 5 minutes:
 - a. Rain gauge, inches of rain
 - b. Evaporation pan surface water temperature, degrees F
 - c. Evaporation pan water surface elevation, inches above level sensor
 - d. Lagoon water surface elevation
 - e. Air temperature, degrees F
 - f. Wind speed, mph
 - g. Wind direction, Azimuth degrees
2. Record measurements for approximately 120 hours, or less if consistency of data allows for a shorter duration.
3. Perform the following checks at approximately the same time each day¹ (refer to **Appendix C** for an example Daily Log Sheet):
 - a. Water level in the evaporation pan:
 - i. If the water level has dropped lower than 3 inches below the rim, add clean water to bring the liquid level up to 2 inches below the rim.
 - ii. Make a note in the log that water was added. The added water will be reflected in the subsequent level sensor readings.
 - iii. The change in liquid level sensor readings (inches) immediately after adding water will be subtracted from subsequent data recorded by the data logger to determine the overall change in pan surface elevation ($E_{\text{pan0}} - E_{\text{pan n}}$) at the end of the test.
 - b. Water level in lagoon:
 - i. If the water level has dropped more than 3 inches, rotate the jack-nut plate until the liquid level sensor is submerged approximately 5 inches.
 - ii. Make a note in the log that the liquid level sensor was lowered. The lowered liquid level sensor will be reflected in subsequent liquid level sensor readings.

¹ For Saturdays, Sundays, and holidays, it may not be possible to perform the field check of the equipment. For days when a field check is not performed, an automatic camera will be utilized to photograph the site numerous times throughout the day. Those photos will be reviewed, along with the data collected on the following day, to verify that the data collected is viable. Any discrepancies in the data or issues observed in the photos will be reported in the final report.

- iii. The change in liquid level sensor readings (inches) immediately after lowering the level sensor will be subtracted from subsequent data recorded by the data logger to determine the overall change in lagoon surface elevation ($E_{s0} - E_{sn}$) at the end of the test.
- c. Check all equipment for signs of disturbance.
- 4. Download data and review on the third day at the latest, but likely on a daily basis:
 - a. Adjust test if necessary.
- 5. Download data after 120 hours and review data to determine patterns:
 - a. Validate the test. If the test is valid, the test may end.
 - b. If time allows, additional measurements will be collected to provide extra data in case data has to be discarded due to unforeseen issues (wind, heavy rain, lightening, wildlife, failed isolation). If insufficient data is collected in the 120 hours to validate the test, the situation will be reviewed with the Owner and the Owner will decide whether to continue collecting additional data or end the test. Ending the test without sufficient data will result in a non-valid test.

7. Seepage Rate Calculations

The data will be entered into the IDEQ-provided Excel file that has been modified to accommodate J-U-B's data management scheme. The seepage rate will be calculated using the equations in the IDEQ spreadsheet.

8. Seepage Rate Calculation and Method Validation

J-U-B will use Visual Sample Plan software to calculate the number of discrete events needed to gain confidence in the dataset (95% confidence, alpha & beta=5%). If the number of sample events obtained is equal to or greater than the number needed to have confidence in the test, the results are valid and the seepage test can end. If additional sample events are needed, the test should be continued until the number of discrete events are reached. It is our understanding that DEQ will use a multi-metric approach to evaluate the seepage test as shown in the following **Table 8-1**.

Table 8-1: Validity Approach

Parameter	Type	Description and Objective
Compliance	Objective	Assess whether the anticipated average seepage rate exceeds the regulatory limit (0.125 or 0.25 inches per day) and screen to a first tier compliance category status (compliant/non-compliant).
Completeness	Objective	Determine if a sufficient number of calculated seepage rates exist to make a valid decision for compliance determination.
Category	Objective	Evaluate the impact of the errors/uncertainties on category assignment; make a determination whether the lagoon status is Category 1, 2, 3, or 4 (second tier)
Consistency	Quantitative with Arbitrary Limits	Determine if the most recent seepage rate conforms to the $\pm 20\%$ standard.
Comparability	Personal Judgment/ Subjective	Evaluate the degree to which levels in the lagoon and evaporative pan compare. Conclusion is based on the time series plot in the <u>DEQ</u> spreadsheet.
Data Sufficiency	Personal Judgment/ Subjective	Determine if the minimum number of data/measurements obtained during the course of the testing were obtained and Determine if sufficient hook gauge measurements were obtained.
Data Quality	Personal Judgment/ Subjective	Determine whether data were collected at the proper time/intervals and whether appropriate procedures and methods were employed.

This seepage testing procedure and methodology will provide DEQ with sufficient data to evaluate the seepage test results.

9. Written Report

A written report will be provided to IDEQ summarizing the data collected and the results.

10. Miscellaneous Procedural Notes

1. Data collected will be documented and provided to IDEQ in a written report.
2. Equipment manufacturer specification and calibration details will be provided to IDEQ upon request.
3. Photos will be taken of the setup and provided in the written report, including photos of the site before and after the test, evaporative pan set up, and protective measures.
4. Equipment will be protected from animals, recreational activities, and vandalism.
5. Where possible, liquid level sensors will be installed in existing lagoon transfer structures or manholes because the existing structure is more stable than a temporary stilling well structure in the center of the lagoon, and access to a transfer structure on the edge of the lagoon is safer than accessing a structure in the center of the lagoon, which would require a boat or raft.
6. By monitoring wind speed and direction, wind effects will be determined, and impacts the wind may have on the lagoon surface elevation will be correlated. If wind impacts are observed, data collected when the wind effects are apparent will not be used in the seepage analysis.

11. Schedule

Seepage testing of the sewage lagoons is anticipated to be completed within the following schedule (depending upon weather conditions and DEQ approval):

- Seepage testing in summer 2014

Appendices

Appendix A – Selected Drawings

Figure 1 – General Location

Figure 2 – Overall Lagoon Site Plan

Figure 3 – Transfer Structure Details

Figure 4 – Outlet Structure Details

Appendix B – Liquid Level Sensor Support Detail

Appendix C – Daily Log Sheet

Appendix A

Selected Drawings

Figure 1 – General Location

(Drawing from 2011 Operation and Maintenance Manual for the CFA Sewage Treatment Plant, INL/EXT-10-20704)

Figure 2 – Overall Lagoon Site Plan

(Drawing provided by Client - Record Drawing)

Figure 3 – Transfer Structure Details

(Drawing from 2011 Operation and Maintenance Manual for the CFA Sewage Treatment Plant, INL/EXT-10-20704)

Figure 4 – Outlet Structure Details

(Drawing provided by Client-Record Drawings)

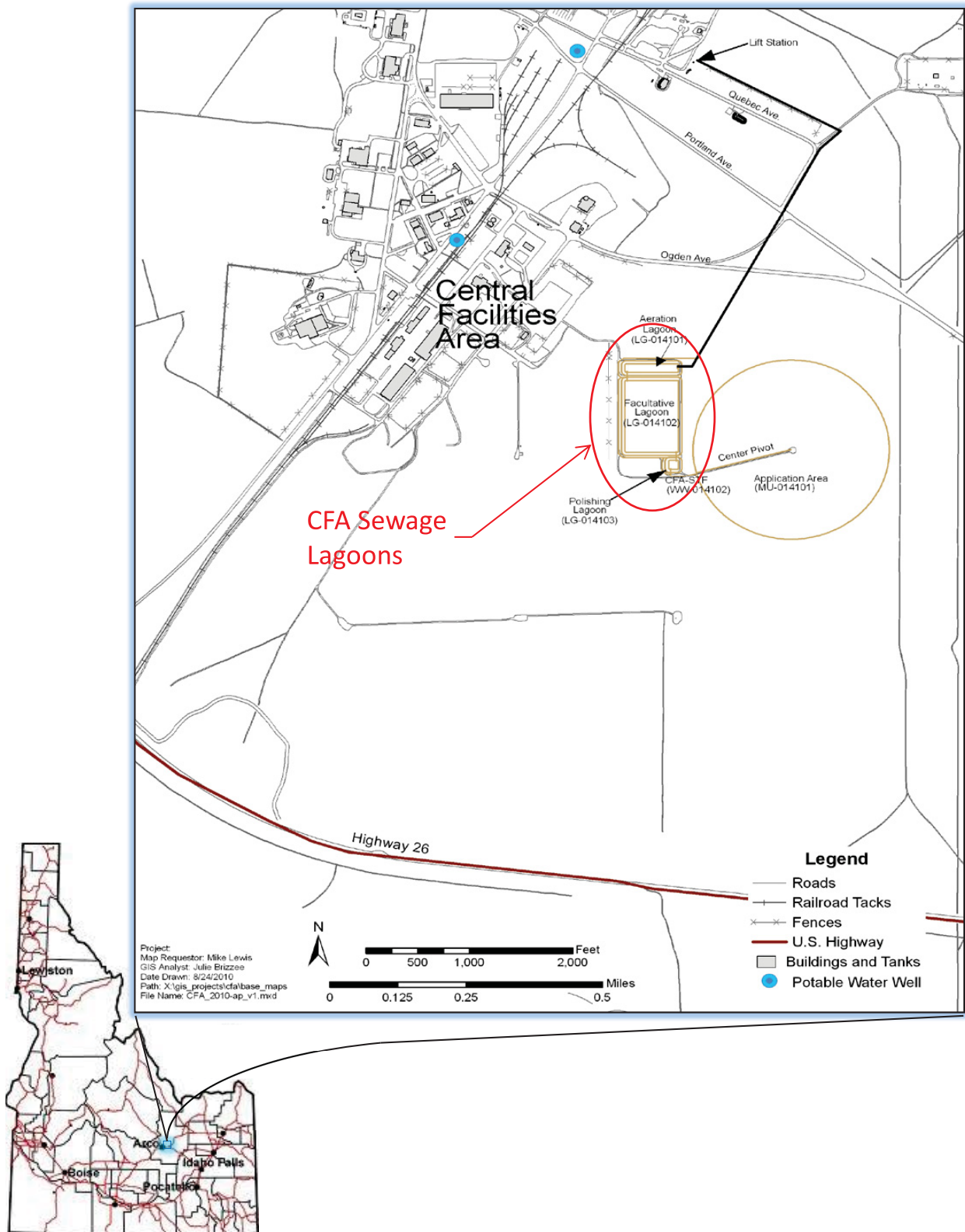


Figure 1 – General Location (Drawing from 2011 Operation and Maintenance Manual for the CFA Sewage Treatment Plant, INL/EXT-10-20704)

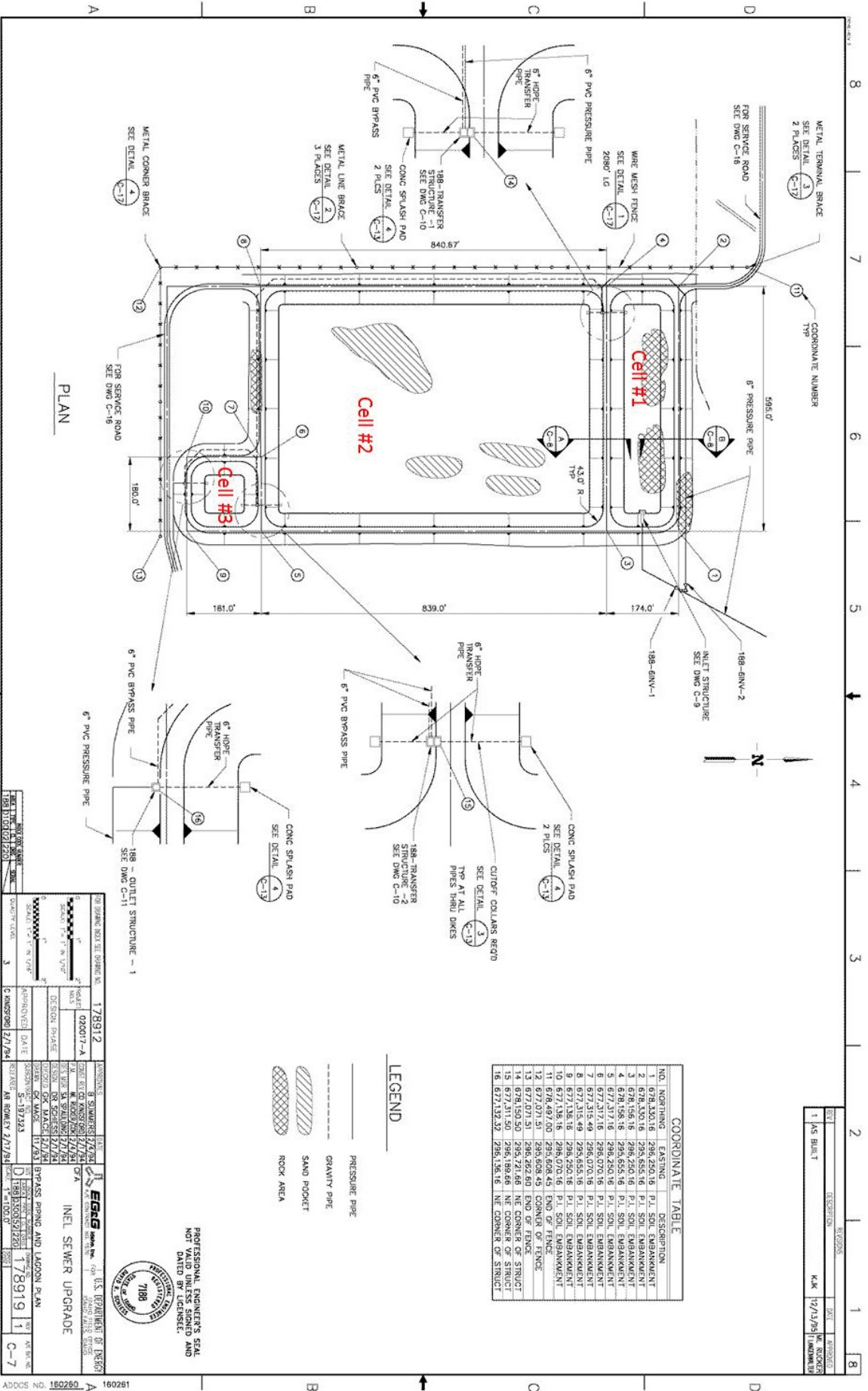


Figure 2 – Overall Lagoon Site Plan (Drawing provided by Client - Record Drawing)

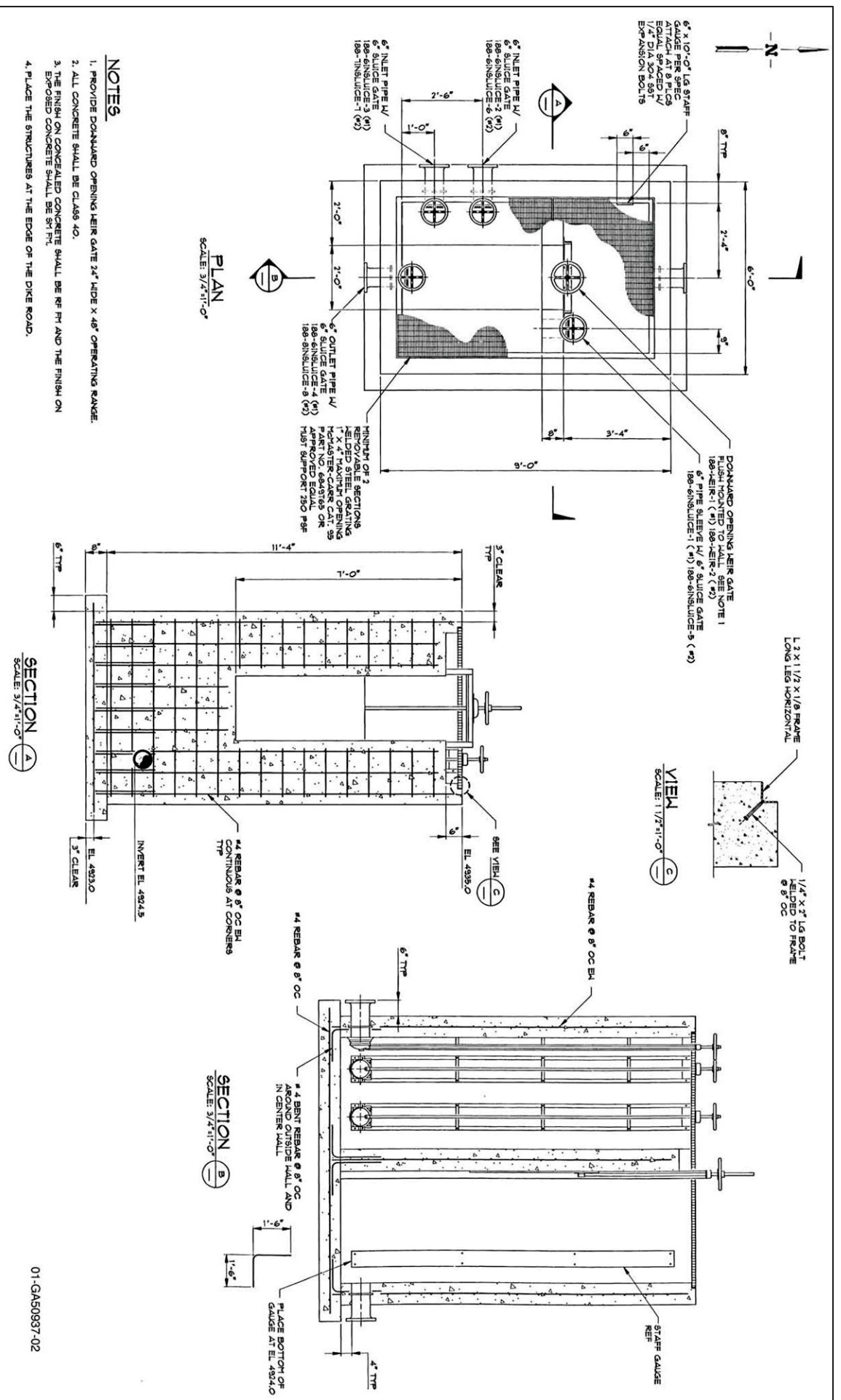
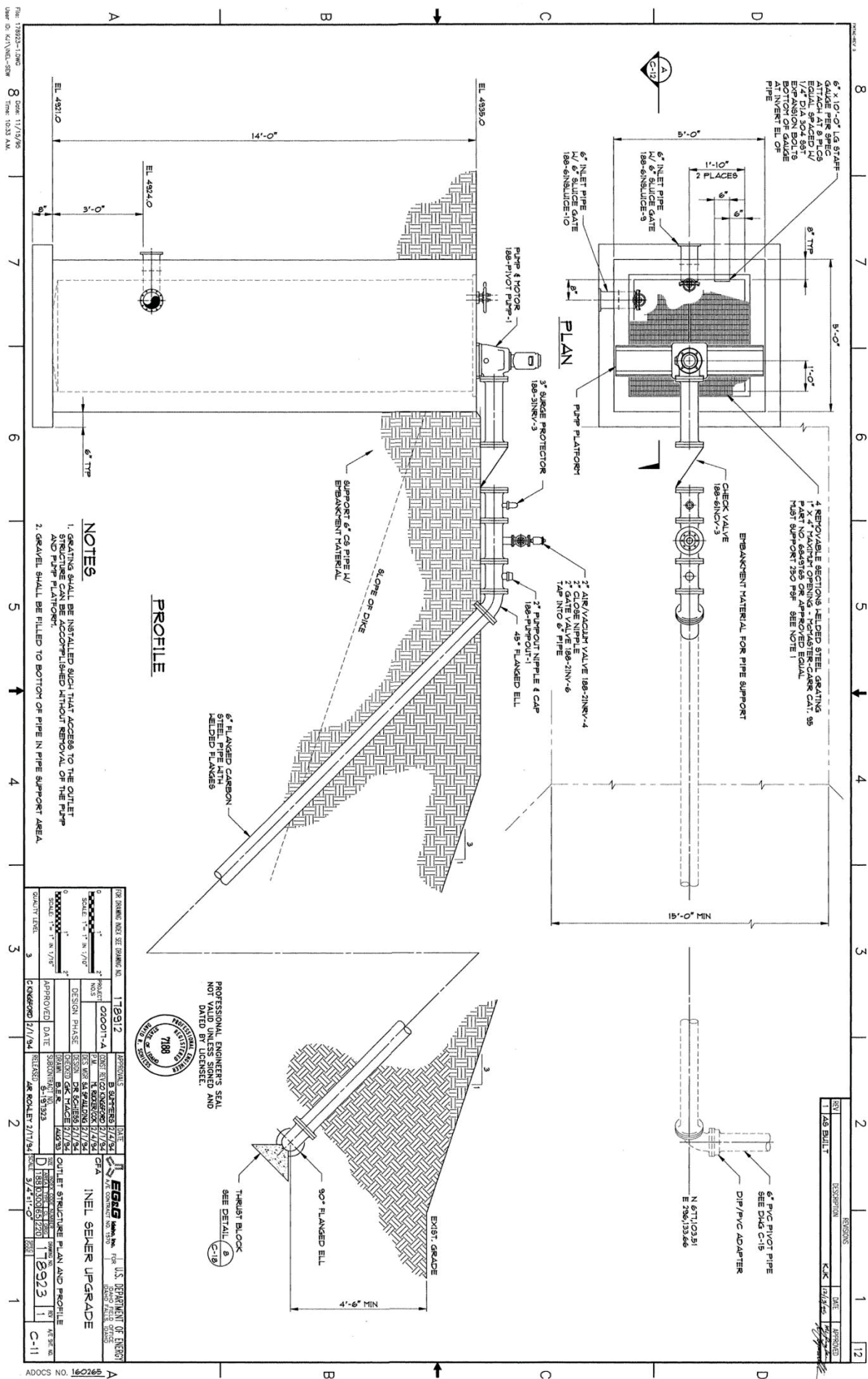


Figure 3 – Transfer Structure Details (Drawing from 2011 Operation and Maintenance Manual for the CFA Sewage Treatment Plant, INL/EXT-10-20704)



Appendix B

Liquid Level Sensor Support Detail

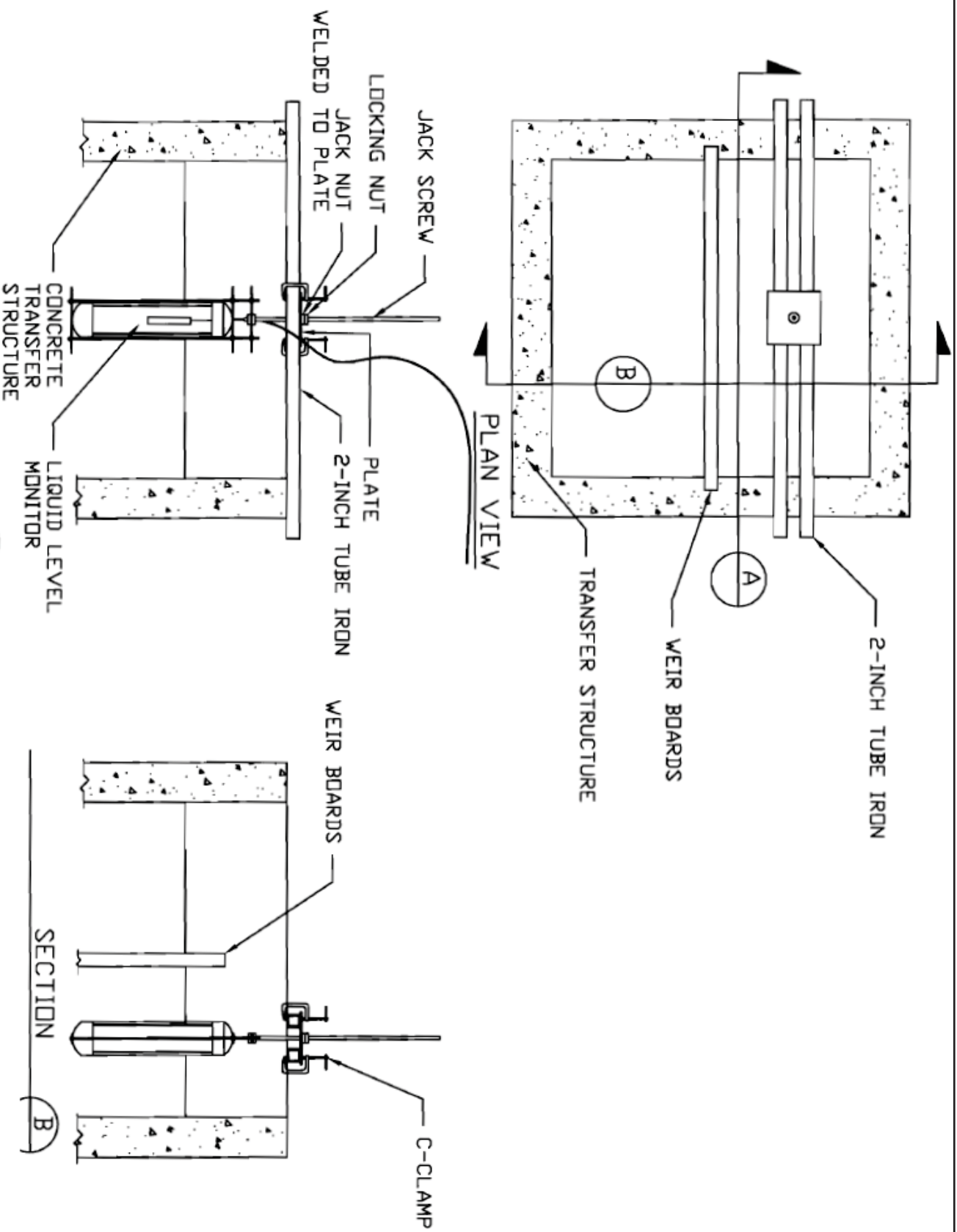


Figure 5 - Sensor Support

Appendix C

Daily Log Sheet

Daily Log Sheet

Lagoon _____

Day _____

Date _____

Time _____

1. Water surface in Pan

a. Is water surface within three inches from the top? _____

b. Was Water Added _____

i. Date _____

ii. Time _____

2. Water surface in Lagoon

a. Is liquid level within range of the buoy? _____

b. Was level sensor lowered _____

i. Date _____

ii. Time _____

3. Check Equipment

a. Fence _____

b. Wooden instrument box _____

c. Solar panel _____

d. Battery _____

e. Weather proof enclosure _____

f. Rain gauge _____

g. Wind anemometer _____

h. Wind vane _____

i. Air temperature sensor and gill shield _____

j. Air temperature sensor _____

k. Water temperature sensor _____

l. Lagoon liquid level sensor _____

m. Pan liquid level sensor _____

n. Check air pressure in inflatable plugs (if applicable) _____