PLACID (TP-4) SPILLGATE NO. 2 INSPECTION REPORT

BLACK & VEATCH PROJECT NO. 406598

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1.0 Introduction

The Guadalupe-Blanco River Authority (GBRA) owns and operates the Guadalupe Valley Hydroelectric System (GVHS) on the Guadalupe River near Seguin and Gonzales, Texas. The system consists of six dams put into services between 1928 and 1932. The six dams include a total of 15 spillgates each 12’-0” tall by 85’-0” to 98’-8” wide. The spillgates are original construction and are now approximately 90 years old.

On October 14, 2021 spillgate No. 2 failed at the Lake Placid dam (also referred to as TP-4). During a significant spill event the spillgate was being lowered by GBRA Operations staff. During operation, the gate was partially lowered and became nonresponsive and would lower no further. Sometime thereafter the gate dropped to the fully open position. Numerous attempts were made by the GBRA hydroelectric operations and engineering teams to raise the gate, but it would raise several feet at most and would not travel higher. As a result, the lake impoundment continued to drain through the lowered gates reducing the available upstream head pressure necessary to assist in raising the gate.

The spillgates on the dams that form the Guadalupe Valley Hydroelectric System have surpassed their useful life, as evidenced by spillgate failures at Lake Wood in 2016, Lake Dunlap in 2019, and Lake Gonzales in 2021. Each failure resulted in the sudden and uncontrolled discharge of water and the draining of the associated lake.

- During a flood event in 2016 Gate No. 1 at the Lake Wood Dam failed with a portion of the gate washing downstream.
- In May 2019 spillgate No. 2 at Lake Dunlap Dam catastrophically failed. The Dunlap failure was recorded by the dam’s security cameras. Within approximately 4 seconds the entire 85-foot-wide x 12-foot-tall gate dislodged and washed downstream.
- On August 3, 2021, spillgate No. 2 at the Lake Gonzales dam (also referred to as H-4) failed. Soon after being hit by a floating tree during a spill event the spillgate became non-responsive. The spillgate lowered and could not be brought back to its normal height of 12-feet despite multiple efforts to restore operation.

The failure of the spillgate at TP-4 has rendered the gate nonoperational. Unlike the failures at Lake Wood and Lake Dunlap, the failure at TP-4 did not result in destruction of the gate. This presents the possibility that the gate might again be made operational. However, multiple deficiencies of the gate were observed and are described herein.

GBRA requested Black & Veatch perform a site survey of the gate, visually investigate the exposed portions of the gate, and evaluate the condition of the system components. This Inspection Report documents the observed conditions of the gate.

2.0 TP-4 Spillgate No. 2 Visual Inspection & Data Assessment

On October 19, 2021 a visual inspection of the TP-4 spillway gates No. 1 & No. 2 was performed by Black & Veatch engineers Matt Richart and Kumar Samant. This inspection was supported by GBRA operations and engineering teams. The gates were in their lowered position and the water surface of the lake upstream of the gates had been lowered enough to prevent water from flowing over the top of the gates. Access to the gates was made from the left downstream spillway apron. All references to the right side or left side of gates are right or left as looking downstream.

Visual inspection was limited to the exterior of the gates with very limited ability to inspect the interior and underside of the gates through the hatch openings. The following primary items were noted during the inspection:

2.1 GATE BUOYANCY

It was observed that the hatch covers on the vertical leg of the upstream leaf of Gate 2 were missing, Figure 6-2. Additionally, one of the air operated gate vents was stuck in the open position. For the gate to raise, the water flow into the gate from the buoyancy chamber must be greater than any leakage through the gate. With these large openings passing flow this is likely the main reason operation of the gate was limited to only a few feet as water was escaping through these openings. Replacement of the covers would significantly improve buoyancy.

Other considerations regarding the reduction of the buoyant force available to raise the gate:

- Water flow into the gate was not observed during the inspection so the inspectors were unable to determine if additional locations of leakage existed.
- The roller timbers located at the interface between the upstream and downstream leaves of the gate along with the rollers in general appeared to be in visibly better shape than those at H-4 also recently inspected.
- The upstream leaf seal is partially missing on the south side along the powerhouse wall which likely contributes to leakage.

2.2 GATE OPERATIONAL FRICTION

Several items were observed that are creating friction which increases the force required to raise the gate.

- Both concrete structures on either side of Gate 2 show recent rubbing of the upstream leaf during gate rotation, Figure 6-3 and Figure 6-4. Rubbing on the powerhouse wall side was more significant and would account for the missing seal at this location. The gouging into the wall is relatively minimal and less than that observed on the recent failed gate at H-4. There was no observable rubbing of Gate 1 on the walls.
- The underside of the locking bars located on the upstream leaf of Gate 2 showed significant rubbing indicating these are contacting the curved beams on the downstream gate leaf during gate travel. These locking bars were replaced in 2018 and thus the damage is relatively recent. The observed damage included at a minimum missing paint but also grooving/gouging beginning to occur, Figure 6-8. All the locking bars showed some level of contact with those on the north end showing the most gouging. This friction would be a prime indicator for additional and unintended forces on the gate. This is also a possible cause for the gate getting stuck during the recent operation of attempting to lower the gate. It is apparent the gate leaves are making contact.

2.3 GATE LEAF DEFLECTION

During inspection, it was noted the north end of the Gate 2 upstream leaf showed a significant deflection over several beams spanning between the hinge and the crest point of the gate, Figure 2-1 and Figure 6-6. This area was visibly holding water. Additional observations were as follows:

- Based on survey information taken during the inspection, the 2nd through 5th beams from the middle pier all had deflection of greater than 1" in the middle of the span with the 3rd beam having deflection of 2.16", Figure 3-3. The gate was in the down position with no load thus the deflection observed is permanent.
- One of the timbers that spans between beams on the north end was visibly lower by an estimated 1-2 inches than the rest of the timbers as viewed from the underside of the gate. This beam was in the middle of the span between the hinge and the crest. It is unknown if the timber is permanently damaged or just significantly deflected but is an apparent weak point in the structure.
- The biofilm growth and zebra mussel attachments on the inside of the gate generally limited the visibility of any other damage or condition assessment.
- The observed deflection is likely partially affecting the contact between the two leaves of the gate, at least on the north end, Figure 2-2.
- In 2018 a survey was conducted inside of the gates while in the fully raised position. The CAD file of the survey points was provided to Black & Veatch for evaluation. Strategic points were surveyed from the underside of the gates including the hinge positions and bolt locations on the articulating tie bar that connects the two leaves, Figure 2-1. From the available data, there was an observable inward deflection at the bolt connection location on the upstream leaf for several beams in the same location as noted above with the most prevalent being specifically on the 3rd beam with approximately ½" of deflection. Similarly, the downstream leaf had outward deflection in the same location.

  It should be noted this connection is not in the middle of the beam span so the maximum deflection of the beam may have been more. Also, the points were taken on the bolt itself and it is unknown if there is wear within the bolt hole that would allow it to move. Further the gate was in the raised position when the survey was conducted. Therefore, the deflection measurements as taken from inside of the gate in the raised position provide relative information that deflection of these members has been present for at least three years but cannot be directly correlated with the current measurements taken on the outside of the gate later in the fully lowered position. Further, with only the current information, it cannot be determined if the deflection has increased over time.

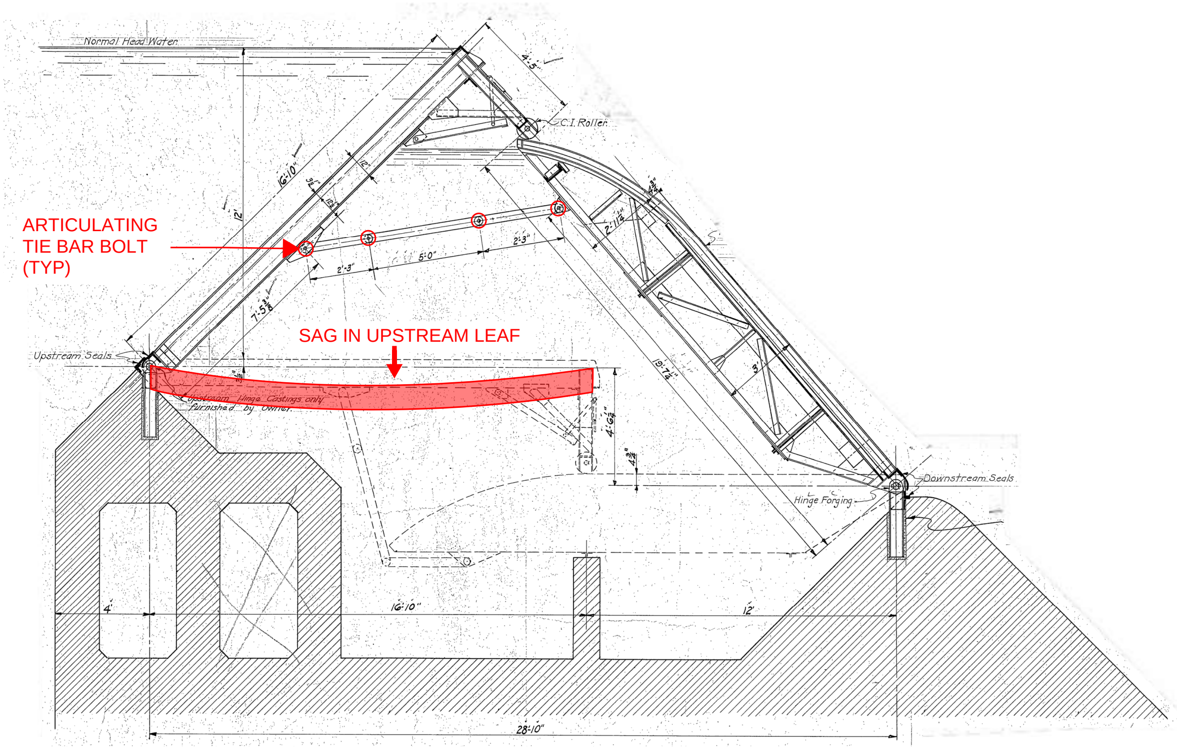

Figure 2-1 Gate Leaf Deflection

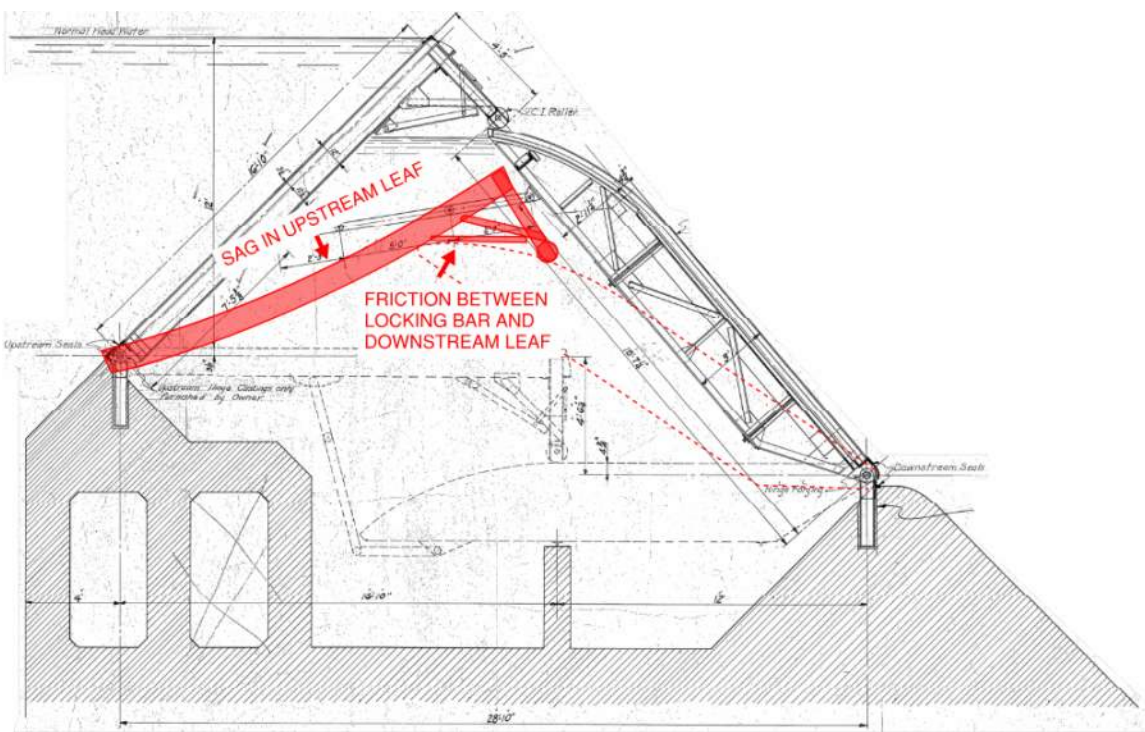

Figure 2-2 Gate Contact Between Locking Bar and Downstream Leaf in Upward Position

3.0 Site Survey

As part of the investigation on October 19, 2021, a site survey of both the TP-4 spillway gates No. 1 & No. 2 was performed by professionals from the survey firm Maestas and Associates Inc. under the direction of Black & Veatch. The data collected from the survey is presented in Table 3 1 and Table 3 2. The purpose of the survey was to determine elevations and alignment of various elements of the gate depicted in Figure 3-1 and Figure 3-2. Findings determined from the data collected during the survey include:

- Significant deflection of the Gate 2 upstream leaf structural beams near the north end as noted previously in this report, Figure 3-3.
- Gate 2 upstream leaf at the crest has a high point in the middle about 1" more than each of the north and south ends, Figure 3-3.
- Gate 1 upstream leaf at the crest sags about 1" from the south to the north end, Figure 3-4.

Table 3-1 Gate 1 Survey Elevations

GATE 1 SURVEY ELEVATION										
UPSTREAM LEAF							DOWNSTREAM LEAF			
LOCATION	NO.	HINGE POINT (EL.)	NO.	CENTER POINT (EL.)	NO.	CREST (EL.)	NO.	NEXT TO ROLLER (EL.)	NO.	HINGE POINT (EL.)
HINGE 1	75	486.21	46	486.16	45	486.11	16	481.68	15	481.78
HINGE 2	74	486.23	47	486.18	44	486.14	17	481.75	14	481.83
HINGE 3	73	486.23	48	486.21	43	486.19	18	481.76	13	481.83
HINGE 4	72	486.23	49	486.2	42	486.16	19	481.77	12	481.83
HINGE 5	71	486.23	50	486.21	41	486.17	20	481.77	11	481.83
HINGE 6	70	486.22	51	486.19	40	486.16	21	481.77	10	481.84
HINGE 7	69	486.22	52	486.2	39	486.19	22	481.81	9	481.85
HINGE 8	68	486.22	53	486.17	38	486.17	23	481.78	8	481.83
HINGE 9	67	486.23	54	486.25	37	486.17	24	481.78	7	481.84
HINGE 10	66	486.24	55	486.2	36	486.18	25	481.79	6	481.85
HINGE 11	65	486.22	56	486.2	35	486.18	26	481.79	5	481.85
HINGE 12	64	486.23	57	486.18	34	486.2	27	481.8	4	481.86
HINGE 13	63	486.21	58	486.2	33	486.2	28	481.8	3	481.85
HINGE 14	62	486.25	59	486.22	32	486.2	29	481.8	2	481.85
HINGE 15	61	486.23	60	486.2	31	486.2	30	481.77	1	481.86

Table 3-2 Gate 2 Survey Elevations

GATE 2 SURVEY ELEVATIONS										
UPSTREAM LEAF							DOWNSTREAM LEAF			
LOCATION	NO.	HINGE POINT (EL.)	NO.	CENTER POINT (EL.)	NO.	CREST (EL.)	NO.	NEXT TO ROLLER (EL.)	NO.	HINGE POINT (EL.)
HINGE 1	136	486.22	135	486.17	106	486.16	91	481.76	90	481.82
HINGE 2	137	486.19	134	486.06	107	486.17	92	481.78	89	481.83
HINGE 3	138	486.19	133	486.01	108	486.17	93	481.79	88	481.83
HINGE 4	139	486.2	132	486.05	109	486.15	94	481.76	87	481.83
HINGE 5	140	486.19	131	486.11	110	486.17	95	481.78	86	481.82
HINGE 6	141	486.2	130	486.16	111	486.18	96	481.79	85	481.84
HINGE 7	142	486.2	129	486.18	112	486.2	97	481.8	84	481.84
HINGE 8	143	486.22	128	486.21	113	486.21	98	481.82	83	481.82
HINGE 9	144	486.22	127	486.22	114	486.23	99	481.83	82	481.82
HINGE 10	145	486.2	126	486.22	115	486.24	100	481.85	81	481.84
HINGE 11	146	486.21	125	486.22	116	486.24	101	481.85	80	481.84
HINGE 12	147	486.21	124	486.22	117	486.24	102	481.84	79	481.82
HINGE 13	148	486.2	123	486.22	118	486.24	103	481.84	78	481.82
HINGE 14	149	486.2	122	486.19	119	486.21	104	481.8	77	481.84
HINGE 15	150	486.21	121	486.18	120	486.18	105	481.76	76	481.83

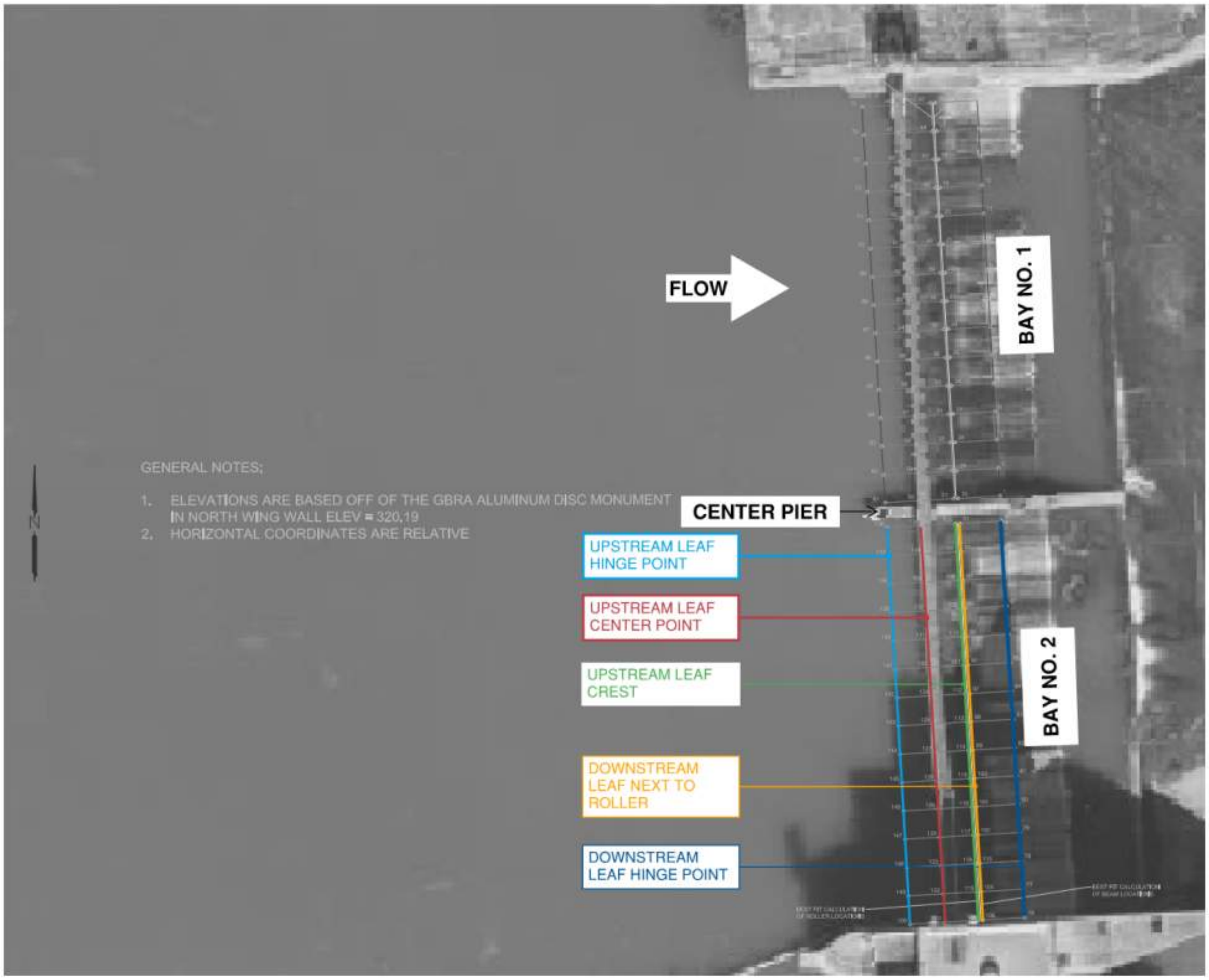

Figure 3-1 TP-4 Gate No. 2 Survey

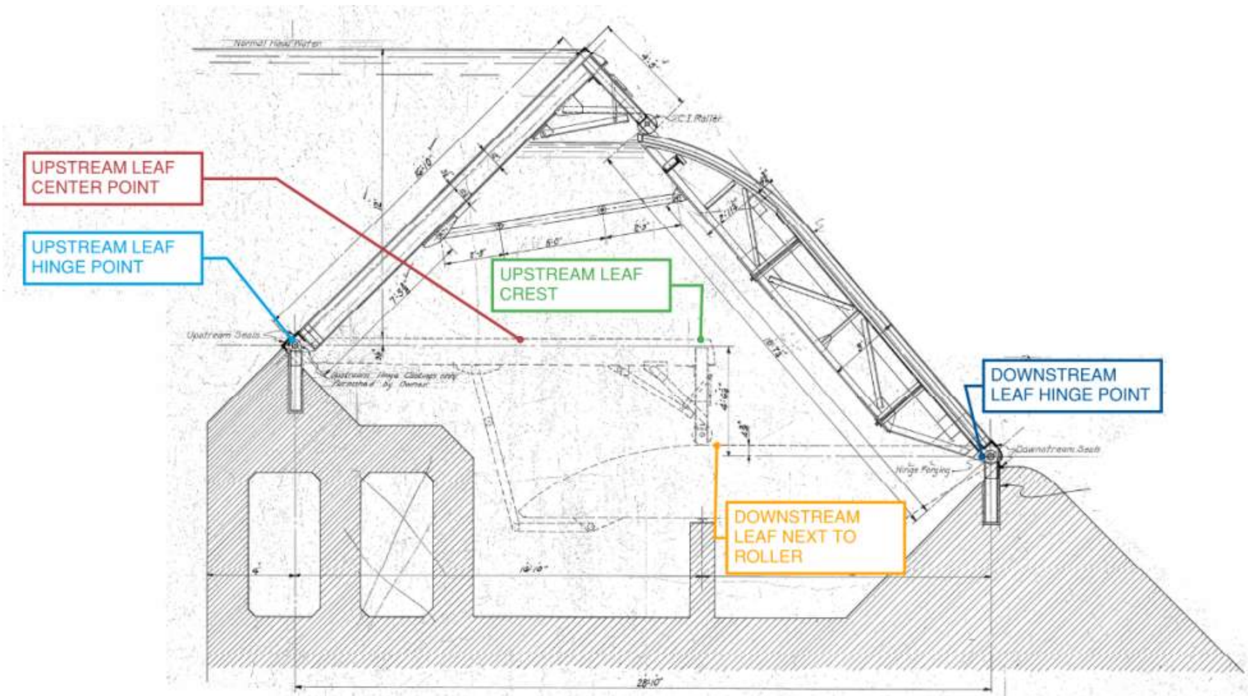

Figure 3-2 Gate Elevation Locations

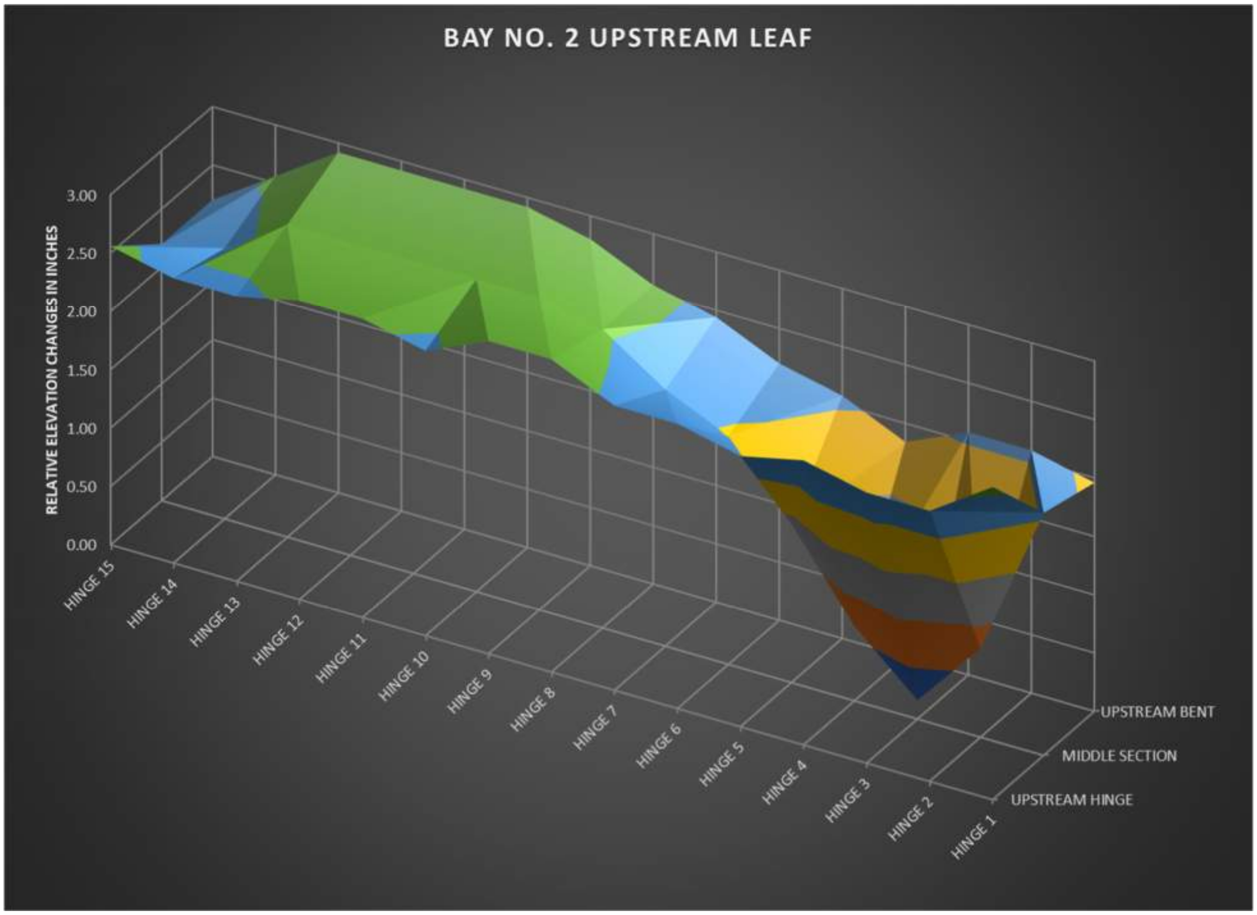

Figure 3-3 Gate No. 2 Upstream Leaf Relative Elevation

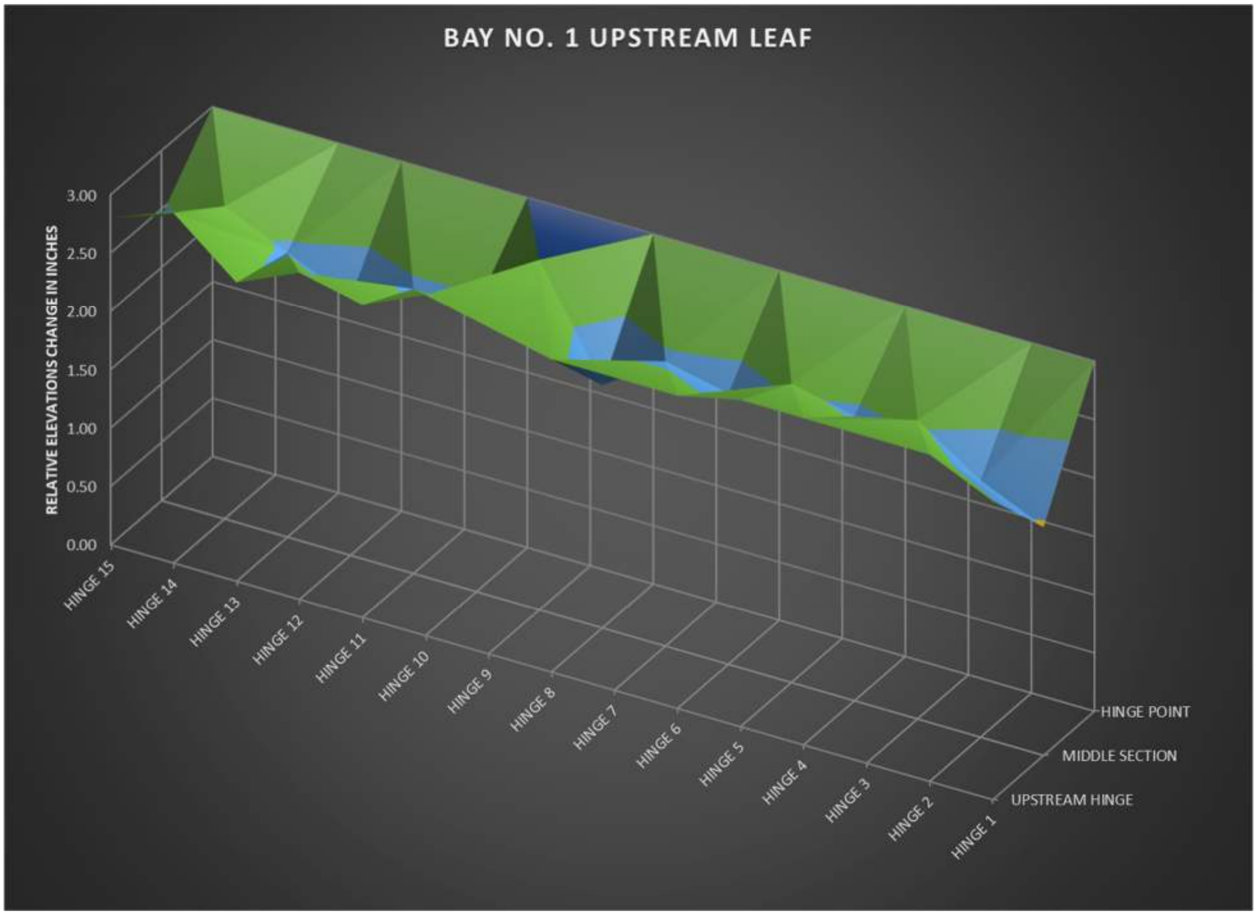

Figure 3-4 Gate No. 1 Upstream Leaf Relative Elevation

4.0 Condition Assessment & Possible Repairs

The following summarizes an assessment of the current condition of the gate, repairs, and possible risks associated with attempted operation of the gate in its current condition.

Figure 4-1 Typical Gate Components

4.1 LEAKAGE REPAIRS

The main cause of leakage which prevented the gate from rising appears to have been the missing hatch covers on the upstream leaf. The replacement of these hatches would likely reduce the majority of the leakage. During the inspection there was no attempt made to raise the gate to observe other leakage locations. However, it was noted that the seal conditions and gaps were notably better than the recently inspected H-4 gate. The main challenge if further leakage improvements were necessary is that typically these repairs would be done with the gate in the up position. It's unknown if these repairs have ever been done with a gate in the down position. With the gate in the down position there is little room in which to work below the gate. Because of the limited access for repairing a gate in the down position there could be much uncertainty in the estimated cost and schedule required to complete the repairs if it is determined such repairs are required.

4.2 GATE 2 UPSTREAM LEAF DEFLECTION & RUBBING

The north end of Gate 2 has a significant deflection in the upstream leaf. At least four of the beams show deflection without any load being applied; thus, indicating these beams were loaded past the yield point and are now permanently deformed. Normal water loading would not have caused this type of deformation and the load required to cause such deflection is on the order of five times normal maximum water pressure. It is unknown if this was due to debris impact load or another stress condition that may have occurred during previous gate operation.

The gate is binding during travel as noted by Operations staff and as physically observed by the scraping and gouging of the locking bars on the upstream leaf contacting the curved section of the downstream leaf. The scraping is observed on all the locking bars, however, is more apparent near the areas where the gate is deflected. Thus, it is apparent the deflection is contributing to the binding during travel.

The survey data taken indicates the gate has some misalignment/warping but not a consistent misalignment. The gate requires a very tight tolerance to operate correctly and there is no record of the original construction alignment measurements to compare with current conditions.

Several specific concerns are noted for operating the gate in the current condition even if other deficiencies regarding leakage are corrected:

- The deflection and contact issues of the gate leaves will not improve with continued operation and will likely only get worse with time.
- The locking bars are making contact with the downstream leaf and appear to be the cause of the gate binding during travel. When the binding occurs, this is placing abnormal loads and corresponding stresses on components of the gate members and hinges; risking further distortion or potential failure of gate members that are already compromised or at the end of their useful life.
- The gate is raised by filling the gate cavity from the upstream water level. If the gate is getting bound during travel while raising, this increases the buoyant force needed to lift the gate. Since the upstream water level is simultaneously controlled by the gate position, it is possible that it will not raise past the point it is binding. There is not an ability to apply additional force to raise the gate.
- As noted, the binding issue during gate travel is only likely to worsen. If the gate were able to be fully raised past the binding point, it is possible that during a high river flow event the gate may permanently bind at this point in travel while lowering, thus creating a potential increase in upstream flooding risk.
- A risk in potentially raising the gate with one end of the upstream leaf in its deflected condition is that it does not lift evenly. The gate alignment could become twisted during operation and cause the gate to bind between the concrete walls. This could be the cause of the concrete wall rubbing observed currently. However, the extent of the rubbing at least in the observed state would not be indicative of a significant risk for current operation.
- If the gate were to be raised and an upstream leaf timber(s) were to fully fail, water would enter the gate cavity from the upstream side. For the gate to be lowered during a flood event, the draining capacity out of the gate must exceed any inflow leakage to reduce the buoyancy of the downstream leaf. If this leakage was significant, the gate could not be lowered. If the gate could not be lowered, this would present a substantial risk to potential upstream flooding.

Repair of the structural members that are permanently deflected would be a complex effort. First, even under minimum flow conditions, water still passes over the gates and therefore some means would be necessary to isolate the gate area to complete the repairs. Replacement of the steel members would also require reinstallation of all the timbers that span between the beams and resealing these. The condition of these timbers is unknown and replacement could identify the need for additional replacements or modifications. The location of the gate in the downward position presents significant access challenges to the inside of the gate to make repairs. Additionally, the timing of preparing, procuring materials, and making any such repairs would likely roughly coincide with the timing for which the formal replacement project would begin anyway. Therefore, temporary repairs would not be prudent.

5.0 Conclusions

Placid Gate No. 2, like all others in the system, is at the end of its useful life and showing many signs of deterioration through leakage, deflection, misalignment and binding during operation. The ability to safely and successfully operate the gate in its current condition presents concerns and several additional risks, the most notably being the gate getting permanently bound partway through travel and unable to be fully lowered. This presents a significant risk to upstream flooding if this condition was to occur. For this reason, it is recommended the gates remain in the lowered position.

6.0 Photographs

Figure 6-1 Gate 1 In Lowered Position

Figure 6-2 Gate Leaf Access Hatches Missing

Figure 6-3 Gate 2 Powerhouse Wall (South) Upstream Leaf Wall Rubbing & Missing Side Seal

Figure 6-4 Gate 2 Upper Leaf Middle Pier (North) Wall Rubbing

Figure 6-5 Gate 1 Upper Leaf Abutment Wall (North) Missing Seal But No Rubbing

Figure 6-6 Gate 2 Upstream Leaf Deflection (North end)

Figure 6-7 Gate 2 Upstream Leaf Underside

Figure 6-8 Gate 2 Locking Bar Contact Gouging

Figure 6-9 Gate 2 Downstream Leaf Curved Edge & Articulating Tie Bars