SAN ANTONIO WATER SYSTEM

MITCHELL LAKE CONSTRUCTED WETLANDS

LAKE AND CONSTRUCTED WETLAND OPERATIONAL PLAN

SUBMITTED TO:

TEXAS COMMISSION ON ENVIRONMENTAL QUALITY

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PLUMMER

0535-012-01

Mitchell Lake – Lake and Constructed Wetland Operational Plan

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List of Abbreviations

ac-ft	acre-feet
ARC	antecedent runoff condition
BMP	best management practice
BOD	biochemical oxygen demand
°C	degrees Celsius
CFU	colony forming units
COSA	City of San Antonio
DO	dissolved oxygen
E. coli	*Escherichia coli*
EPA	Environmental Protection Agency
ft msl	feet above mean sea level
FWS	free water surface
in	inch
LCWRC	Leon Creek Water Recycling Center
mg/L	milligram per liter
ml	milliliters
MS4	Municipal Separate Storm Sewer System
Plummer	Plummer Associates, Inc.
SAWS	San Antonio Water System
s.u.	standard units
SWMP	Stormwater Management Program
TCEQ	Texas Commission on Environmental Quality
TPDES	Texas Pollutant Discharge Elimination System
TSS	total suspended solids
USEPA	United States Environmental Protection Agency

1 Introduction

This section describes the purpose for the report and the overall objectives associated with the Mitchell Lake and full-scale constructed wetland system ("lake/wetland system") Operational Plan.

1.1 PURPOSE OF REPORT

This report is intended to function as a preliminary description of operational protocols for Mitchell Lake and the full-scale constructed wetland system that will be used to polish discharges from the lake. This report has been prepared for the Texas Commission on Environmental Quality (TCEQ) to document how the Owner [San Antonio Water System (SAWS)] and the engineer [Plummer Associates, Inc., (Plummer)] are proposing the lake be operated in order to meet the project objectives. This is intended to function as a living document to be updated as new information is learned about the lake/wetland system.

1.2 PROJECT OBJECTIVES

The objectives associated with operation of the lake/wetland system are as follows:

1) Reduce the discharge of pollutants from Mitchell Lake into the downstream receiving water bodies.
2) Reduce the frequency and volume of unpolished water released over the Mitchell Lake dam spillway since this release does not enter the constructed wetland system.

2 Background

This section provides background on Mitchell Lake, including a description and history of the lake, a summary of its existing discharge permit and how it has historically been managed under this permit, the proposed transition of management of the system to a Municipal Separate Storm Sewer System (MS4) permit, and a description of the proposed lake/wetland system.

2.1 DESCRIPTION AND HISTORY OF MITCHELL LAKE

Mitchell Lake is located in south Bexar County, Texas. The lake, which is owned and operated by SAWS, is an on-channel impoundment comprised of an earthen dam and the main body of the lake. The earthen dam contains an existing spillway that has eight, 36-inch parallel pipes with invert elevations of 520.7 feet above mean sea level (ft msl). Although SAWS is authorized through its water rights permit (Certificate of Adjudication 19-2153) to impound up to 2,640 acre-feet (ac-ft) of water within the lake, the existing spillway only impounds approximately 2,086 acre-feet of water at a corresponding surface area of approximately 513 acres. The spillway, which is the only outlet from Mitchell Lake, discharges directly into Cottonmouth Creek, which is a tributary of the Medina River. The contributing watershed for the lake is approximately 8.7 square miles, excluding the area of the lake itself[1]. Refer to Figure 1 for an overview of the lake and Figure 2 for a photograph of the existing spillway.

The lake is a historic remnant of the City of San Antonio (COSA) sewage treatment operations. It was initially used as a receiving water body for temporarily storing raw or partially treated sewage prior to using the stored wastewater for crop irrigation. Disposal in the lake of wastewater and treatment process residuals ceased in 1987, and the lake now receives only stormwater runoff from its drainage basin and fully treated recycled water from the SAWS Leon Creek Water Recycling Center (LCWRC).

The lake is a designated bird refuge; and the Audubon Society maintains a Nature Center there, which was the first Audubon Nature Center established in Texas. The lake habitat and its location on the North American Central Flyway attracts hundreds of different bird species to the lake, including some species listed as threatened under the Endangered Species Act.

[1] Based on a lake surface area of 513 acres

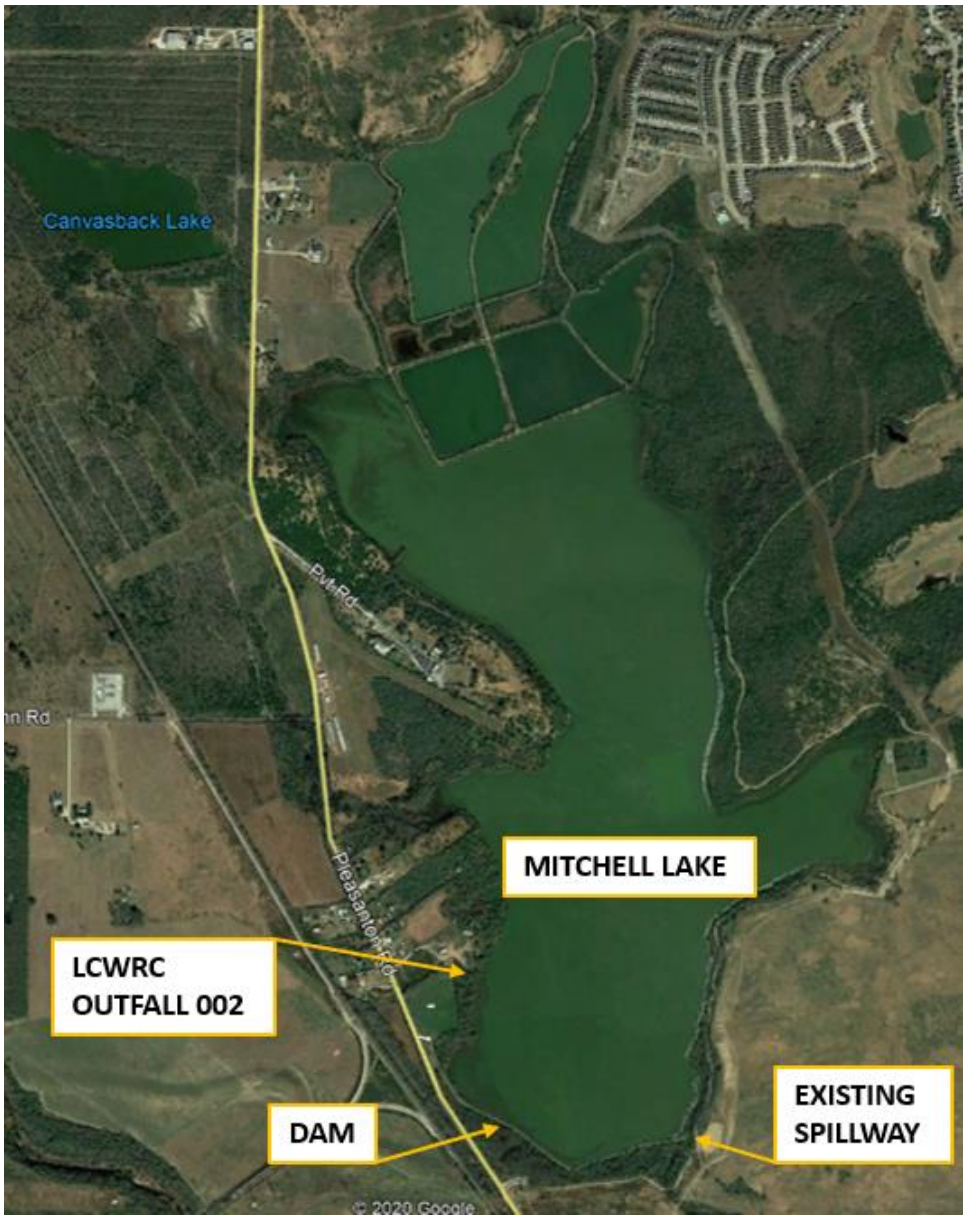

Figure 1
Mitchell Lake Layout

Figure 2
Mitchell Lake Existing Spillway

2.2 EXISTING MITCHELL LAKE PERMIT

Mitchell Lake is currently operated subject to its Texas Pollutant Discharge Elimination System (TPDES) permit (Permit No. WQ0010137004). The permit, which is issued to SAWS, designates the lake as an intermittent discharger with effluent quality limits assigned for five-day biochemical oxygen demand (BOD_5), total suspended solids (TSS), *Escherichia coli (E. coli)*, pH, and dissolved oxygen (DO). The limits are applicable whenever the lake is discharging to Cottonmouth Creek. The existing effluent quality limits and sampling/monitoring requirements are shown in Table 1.

Table 1
Existing Effluent Quality Limits for Mitchell Lake Discharges
(per TPDES Permit No. WQ0010137004)

Parameter	Daily Average	7-Day Average	Daily Max	Single Grab	Self-Monitoring Requirements
Flow	Report	-	Report	-	1/day, instantaneous
BOD_5	30 mg/L	45 mg/L	70 mg/L	100 mg/L	1/day, grab
TSS	90 mg/L	135 mg/L	-	-	1/day, grab
E. coli	126 CFU/100 mL		-	399 CFU/100 mL	1/month, grab
pH	-	-	-	6.0 to 9.0	1/month, grab
D.O.	-	-	-	≥ 4.0 mg/L	1/day, grab

Under the TPDES permit, Mitchell Lake is authorized to discharge intermittently. Flow and water quality are to be monitored during the periods of discharge and reported. Because of the high algal load present in the lake and the extensive bird life around the lake, SAWS has historically struggled to consistently meet effluent quality limits during the periods of discharge, particularly with respect to BOD_5, TSS, pH, and DO.

2.3 HISTORICAL MITCHELL LAKE OPERATIONS

Historically, Mitchell Lake has operated in a manner such that it rises and falls in response to precipitation gains and evaporative losses, and it discharges only in response to significant rain events. Three unique factors impact inflows into, and water levels within, Mitchell Lake:

1) As a result of the requirement that treatment units regulated by a TPDES permit for a wastewater treatment facility not receive surface runoff from stormwater, the Mitchell Lake watershed area has been designated by COSA as a mandatory detention area.[2] SAWS has required all new developments within the watershed to detain stormwater, which results in lower than typical runoff volumes from the watershed to the lake.
2) To maintain a suitable habitat for shorebirds and waterfowl, SAWS intermittently discharges treated LCWRC effluent to the lake in order to maintain desirable lake levels.

[2] COSA requires mandatory on-site detention of runoff originating from a 100-year, 24-hour storm event. In accordance with COSA's Storm Water Design Criteria Manual (January 2016), collected runoff is typically released from the detention ponds within 24 to 48 hours after the storm event.

3) An artesian well is located in the watershed upstream of Mitchell Lake.

2.4 RE-PERMITTING MITCHELL LAKE PERMIT UNDER AN MS4 PERMIT

After ongoing discussions, it has been jointly agreed upon by the United States Environmental Protection Agency (US EPA), TCEQ, and SAWS that Mitchell Lake will be re-permitted as part of COSA's MS4 permit rather than under a TPDES permit for wastewater treatment facilities. The primary justifications for this change are based on the facts that Mitchell Lake

1) is an on-channel reservoir constructed on a natural waterway;
2) receives significant stormwater inflows;
3) has previously been recognized as Surface Water in the State; and
4) is not, and does not function as, a treatment unit, since it receives only stormwater and fully treated effluent flows from LCWRC.

Under the MS4 permit, SAWS will be required to develop and implement a Stormwater Management Program (SWMP) for the lake to include, among other requirements, the following:

- Structural controls and pollution prevention measures to reduce the discharge of pollutants from the MS4 to the maximum extent practicable.

Pursuant to a Schedule of Activities outlined in USEPA Administrative Order CWA-06-2016-1770, SAWS is required to complete construction and place the lake/wetland system in operation by September 30, 2024. The constructed wetland that polishes discharges from Mitchell Lake will serve as the primary structural control and best management practice (BMP) for Mitchell Lake in the SWMP. It should be noted that the TCEQ specifically identifies the use of constructed wetlands as a structural control that acts "as a natural filter for inflows to a water body from a storm sewer system[3]."

2.5 PROOF OF CONCEPT – PILOT CONSTRUCTED WETLAND

Prior to constructing a full-scale constructed wetland to serve as the BMP for Mitchell Lake, USEPA Administrative Order CWA-06-2016-1770 required SAWS to evaluate the feasibility of the BMP using a small-scale pilot constructed wetland study. The purpose of the study is to determine the following:

[3] https://www.tceq.texas.gov/drinkingwater/SWAP/bmp.html

- Effectiveness of a constructed wetland for polishing eutrophic lake water that is especially high in algae and suspended solids, since relatively few existing constructed wetlands are used for this purpose;
- Most effective hydraulic loading rate and water depth through the constructed wetland; and
- Preferred vegetation type.

The pilot constructed wetland consists of 1.3 acres containing six individual cells arrayed within three parallel trains of two cells each. The pilot constructed wetland has been operational since August 2019. It will be operated through, at least, August 2020. The constructed wetland is a free-water-surface (FWS) wetland; i.e., one where water flows across the surface of the wetland, which is planted with native, emergent aquatic vegetation. Water from Mitchell Lake is supplied to the constructed wetland via a floating pump station, and the discharge from the pilot constructed wetland flows by gravity back into Mitchell Lake. The three trains are operated at differing hydraulic loading rates and varying depths to evaluate the effects of different flow regimes on discharge water quality. Water quality data are collected weekly to monitor the reduction of pollutants through the systems. Data from the study will be used to inform design and operation of the proposed full-scale constructed wetland. Data for the initial six months of operation have shown that the constructed wetland quantitatively reduces the concentrations of BOD_5 and TSS and the elevated pH present in the inflow water.

2.6 CONCEPTUAL DAM, SPILLWAY, AND FULL-SCALE CONSTRUCTED WETLAND DESIGN

This section presents the conceptual dam, spillway, and full-scale constructed wetland design. The final design will be modified, as appropriate, based on operational experience with the pilot constructed wetland.

2.6.1 Conceptual Dam and Spillway Improvements

The existing dam spillway will be modified so that the elevation is raised from approximately 520.7 ft msl to approximately 521.76 ft msl, and the length of the spillway will be increased. Spillway releases (water flowing over the top of the dam spillway) will occur whenever the lake elevation exceeds 521.76 ft msl. The rate of release will be solely a function of the water surface elevation in the lake. The increase in the spillway elevation will increase lake storage from approximately 2,086 ac-ft to approximately 2,640 ac-ft, which is the total impounded volume authorized by water

rights Certificate of Adjudication 19-2153. The conceptual design for the new spillway structure is an 840-ft fixed labyrinth weir.

A second system of outlet works will be constructed to preferentially route flow, by gravity, from Mitchell Lake to the constructed wetland system. Under most conditions, discharge will be continuous through these outlet works. Two outlet works structures are anticipated, one on each side of the dam spillway. Flow rates through the outlet works will be regulated such that increasing lake levels will discharge an increased flow rate to the constructed wetland. At this time, no conceptual design for the outlet works weirs has been prepared

2.6.2 Constructed Wetland

The full-scale constructed wetland of approximately 115 wetted acres will be sited downstream of Mitchell Lake. The conceptual layout is a FWS wetland that has two parallel trains, with a total of five cells. The two parallel trains will be located on opposite sides of Cottonmouth Creek. Flow rates into the two trains will be split in approximately the same relative proportions as the relative surface areas within each train. The constructed wetland will be planted with emergent aquatic vegetation. Water level control structures will control depths in the cells. Water will flow by gravity from cell to cell. The polished water will flow by gravity from each train into either Cottonmouth Creek or the Medina River through separate outfall structures.

Refer to Figure 3 for the conceptual layout of the full-scale constructed wetland.

PLUMMER

Mitchell Lake

PROPOSED SPILLWAY

LAKE OUTLET WORKS B (EAST)

DAM

LAKE OUTLET WORKS A (WEST)

EXISTING HIKE AND BIKE TRAIL

Pleasanton Road

MANHOLE (TYP)

ROAD

TRAIL HEAD

MANHOLE (TYP)

PIPE (TYP)

PIPE (TYP)

FENCE

DEEP WATER ZONE (TYP)

CELL 1 (WEST)

BERM (TYP)

ROAD

HEADWALL STRUCTURE

LAKE OUTFALL STRUCTURE A

FLOW

LAKE OUTFALL STRUCTURE B

FLOW

WATER LEVEL CONTROL STRUCTURE

WATER LEVEL CONTROL STRUCTURE

48" BOX CULVERT WITH HEADWALLS

WATER LEVEL CONTROL STRUCTURE

GATE

FENCE

BANK STABILIZATION AND EROSION CONTROL

DISTRIBUTION CANAL

SIPHON

CELL 5 OPTIONAL

OPEN WATER AREA

CELL 5 (EAST)

Utility Easement

FLOW

CELL 2 (CENTRAL)

CELL 4 (EAST)

Medina River

FLOW

Cottonmouth Creek

FLOW

SIPHON

WATER LEVEL CONTROL STRUCTURE

ALTERNATIVE WETLAND OUTFALL PIPES TO CREEK

HEADWALL STRUCTURE

CELL 3 (CENTRAL)

WATER LEVEL CONTROL STRUCTURE

FLOW

WETLAND OUTFALL PIPE TO RIVER

BANK STABILIZATION AND EROSION CONTROL

WATER LEVEL CONTROL STRUCTURE

WETLAND OUTFALL PIPE TO RIVER

Pleasanton Road

US Highway 281

N

300 150 0 300 600

GRAPHIC SCALE

SAN ANTONIO WATER SYSTEM
MITCHELL LAKE
DOWNSTREAM WETLANDS
CONCEPTUAL LAYOUT
1-29-2020

San Antonio Water System

3 Hydrologic Evaluation

This section describes the water balance developed for Mitchell Lake. The water balance was used to estimate the potential frequency and volume of spillway releases (i.e., flows over the dam spillway that do not go through the constructed wetlands) associated with a range of potential future operational scenarios of the lake/wetland system.

3.1 DEVELOPMENT OF MITCHELL LAKE WATER BALANCE

Following is a description of the assumptions and values used in the water balance model. The results of the model calibration using data from 2000 to 2018 are also presented.

3.1.1 Model Setup

A water balance model with daily time steps was developed by Plummer to evaluate the feasibility of utilizing the storage capacity of Mitchell Lake coupled with controlled discharges to the constructed wetland to manage stormwater flows within the Mitchell Lake watershed. The water balance model provides an estimation of the frequency and volume of spillway releases based on the volume and frequency of flows into and out of the lake under a range of conditions. Inflows consist of rainfall runoff, rainfall directly on the lake surface, discharges of treated effluent from LCWRC, and inflows from an artesian well in the watershed. Outflows consist of discharges to the constructed wetland, evaporation, and spillway releases. The model was calibrated using the following information for the period 2000-2018:

- Daily precipitation data from various rain gauges within and near the Mitchell Lake watershed. These data were obtained from the National Oceanic Atmospheric Administration (NOAA).
- Daily LCWRC discharge flows into Mitchell Lake, obtained from SAWS.
- Artesian well flow of 300 gallons per minute, based on State of Texas Well Report 280383 for Well No. W106-305.
- Monthly lake evaporation data for the quadrangle containing Mitchell Lake (Quad 809), obtained from the Texas Water Development Board (TWDB).

Model parameters were developed as follows:

- Land uses for existing and final buildout conditions are based on the 2011 National Land Cover Database and COSA zoning classifications. Runoff volumes based on land use and soil type are determined using weighted curve numbers for sub-watersheds within the

Mitchell Lake watershed. The curve numbers used are specific to the daily antecedent runoff condition (ARC).

- The relationships between lake elevation, volume, and surface area are based on a bathymetric survey conducted in 2018.

The daily water balance model was calibrated using the reported daily discharges from Mitchell Lake from 2000 through 2018. The model parameters that were adjusted to improve the consistency of the model predictions of release frequency and the historically observed release frequency were as follows:

- Ratio of initial abstraction to potential maximum retention after runoff begins (I_a/S) was increased from the default value of 0.20 to 0.65 inches. The higher value reflects the fact that developments within the watershed have historically been required to detain stormwater, in order to comply with regulations governing TPDES permits for wastewater treatment facilities.
- Duration of the antecedent rainfall for calculating ARC = 5 days; and
- Definition of ARC
    - ARC I: 0-inches ≤ antecedent rainfall < 0.5-inches
    - ARC II: 0.5-inches ≤ antecedent rainfall ≤ 0.9-inches
    - ARC III: 0.9-inches < antecedent rainfall.

3.1.2 Calibration Results

Results of the water balance calibration are shown in Figures 4 and 5. Figure 4 presents the actual and predicted spillway release events. Due to historical difficulties in precisely measuring the water surface elevation and limitations on the degree of accuracy achieved in estimating historical release flowrates, it is to be expected that there is a degree of variation between the historical flow rates and the predicted flow rates. For calibration purposes, the presence/duration of a release is assumed to be more reliable than the estimated release volume; therefore, number of release days was used to calibrate the model rather than volume.

Figure 5 represents the observed versus calculated lake water surface elevation. For the limited period when observed water surface elevations are available, the water balance model captures the trends in the water surface elevation and predicts the observed elevation within one foot.

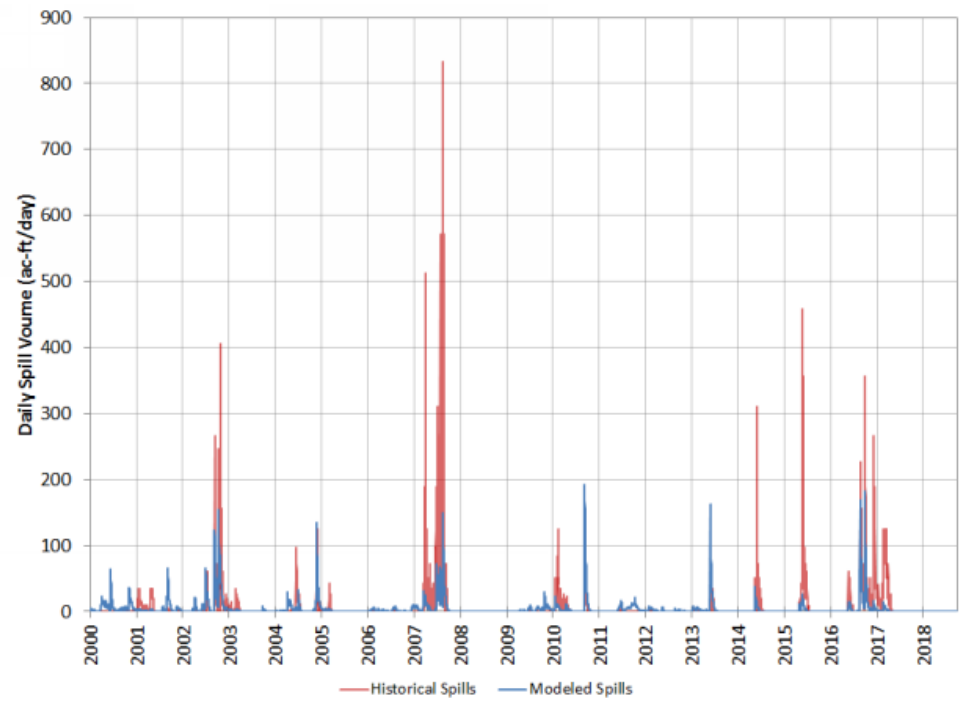

Figure 4
Mitchell Lake Water Balance – Calibration to Observed Release Frequencies and Peaks (2000-2018)

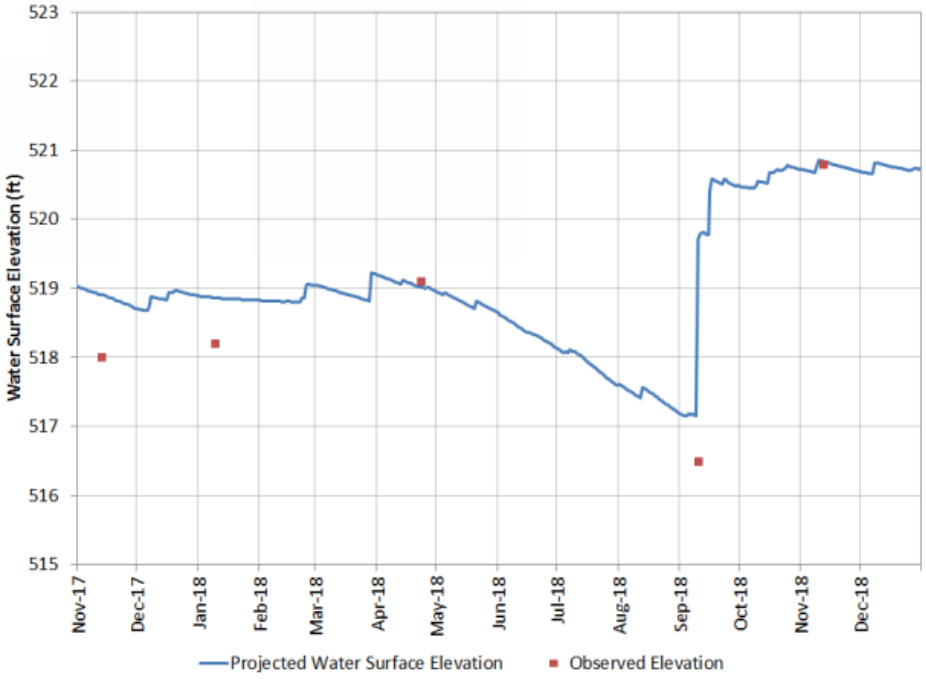

Figure 5
Mitchell Lake Water Balance – Calibration to Observed Mitchell Lake Water Surface Elevation (2017-2018)

3.2 PREDICTED NUMBER AND VOLUME OF SPILLWAY RELEASES FOR FUTURE OPERATING CONDITIONS

The calibrated model was used to predict the frequency and volume of future spillway releases for various operational strategies for the lake/wetland system. The potential frequency and volume of future releases is also compared to the frequency and volume of releases under the current operational program.

3.2.1 Conditions Modeled

The calibrated model was used to estimate the annual average frequency and volume of spillway releases for current conditions (designated "Existing Condition") and to predict the annual average frequency and volume of spillway releases for three potential, future operational scenarios (designated "Future Condition A," "Future Condition B," and "Future Condition C"). The model parameters used to represent the Existing Condition are as follows:

- The typical minimum operating water level in the lake is 517.5 ft msl.
- The spillway elevation is 520.7 ft msl.
- Inflow from the artesian well is included.
- The current land development pattern is estimated.

Future Condition A represents full buildout of the watershed, but with no improvements done to the dam spillway and without a discharge to the constructed wetland. The model parameter changed to represent this condition is as follows:

- Final buildout of the watershed assumes maximum possible development based on existing or projected zoning, and the curve numbers for estimating runoff are adjusted accordingly.

Future Condition B and Future Condition C both incorporate the proposed improvements to the dam spillway and proposed changes to the lake operating protocol, which involves preferential routing of flow through the constructed wetland system. Future Condition B assumes a continuous 2 MGD discharge to the wetland, while Future Condition C assumes a variable 2-to-7 MGD discharge to the wetland. (The intent of the variable discharge rate is that it will increase in proportion to the water level elevation increase when the lake elevation is above 518.5 ft msl.) The model parameters that were adjusted to represent these final two future conditions are as follows:

- The Mitchell Lake dam spillway elevation is raised from 520.7 ft msl to 521.76 ft msl to provide the maximum impoundment volume authorized in the water rights permit.
- The dam spillway is increased in length to 840-feet to match the conceptual labyrinth weir dimensions.
- The minimum operating water level in the lake is raised from 517.5 ft msl to 518.5 ft msl. This change is required in order to discharge water through the outlet works to the constructed wetland without having to conduct significant dredging within the lake, since the lake floor elevation in the vicinity of the dam is above 517.5 ft msl.
- Inflow from the artesian well is included.

Future Conditions B and C are expected to represent the actual range of operating conditions for the lake/wetland system, while Future Condition A is presented only for comparison purposes. The selection of 2 MGD and 7 MGD to represent the range of flow rates discharged to the constructed wetland is based on preliminary results from the pilot constructed wetland study. A flow rate of 7 MGD is, potentially, the upper limit of the flow rate that can be discharged to the constructed wetland that will produce measurable water quality improvements. The viable upper limit of the flow rate to the constructed wetland may be found to be either higher or lower than this value once actual operation of the full-scale constructed wetland begins. The viable upper flow limit may also vary according to water quality within the lake.

3.2.2 Model Results

The results of using the water balance model to estimate existing and future annual average frequencies and volumes of spillway releases are shown in Table 2. The following conclusions can be made regarding the frequency and volume of releases over the spillway based on the model results:

- Significantly more runoff will be produced with full development of the Mitchell Lake watershed. If the dam spillway remains unchanged and there is no constructed wetland, approximately twice the volume of water will be released over the spillway in the future (an annual average of approximately 1,260 ac-ft/yr versus the current annual average of approximately 598 ac-ft/yr). In addition, the lake will discharge more frequently (approximately 86 days versus 51 days as an annual average).
- Raising the spillway to the proposed 521.76 ft msl elevation, increasing the spillway length, and preferentially routing flow through the constructed wetland system will significantly reduce the volume of water released over the spillway and the frequency it is released.

With a continuous 2 MGD discharge to the constructed wetland, the release volume is calculated to be reduced to an annual average of 605 ac-ft/yr and the spill frequency to two days per year. With a variable 2-to-7 MGD discharge to the constructed wetland, the annual average release volume is calculated to be reduced to 330 ac-ft/yr and the spill frequency to one day per year. (The significant decrease in the frequency of spill days is due to the substantially longer spillway that will release most inflows above the spillway elevation on the same day they enter the lake, rather than the lake remaining surcharged above the spillway elevation for an extended period of time, as it currently operates.)

It should be noted that these values represent annual averages. There may be wet years when the number of spillway release days is greater, and there may be dry years when there is no spillway release. Additionally, it is likely that the actual number of spillway release days observed will be slightly higher than what the model calculates. This could be due to de minimis inputs such as groundwater inflow to the lake or from wind-driven waves overtopping the spillway weir. Neither of these items are accounted for in the model.

Table 2
Comparison of Mitchell Lake Dam Spillway Release Frequencies and Volumes for Existing and Future Conditions

Scenario	Watershed Development	Spillway Elevation (ft msl) & Length (ft)	Minimum Lake Level (ft msl)	Discharge to Wetland (MGD)	Annual Average Volume (ac-ft/yr) Released over Spillway	Annual Average Number of Release Days
1) Existing	Existing	520.7; 55	517.5	-	598	51
2) Future Condition A	Final Buildout	520.7; 55	517.5	-	1,260	86
3) Future Condition B	Final Buildout	521.76; 840	518.5	2	605	2
4) Future Condition C	Final Buildout	521.76; 840	518.5	2-to-7	330	1

4 Operational Protocol

This section presents a preliminary operational protocol for the lake/wetland system. It is important to note that the pilot constructed wetland study is still ongoing, and final results of the study may dictate that operational protocols different than those presented in this report are appropriate. Additionally, full-scale systems can perform somewhat differently than pilot systems. Additional changes to operational protocols may be required once the full-scale constructed wetland is functioning. Therefore, the following is intended to provide a preliminary and flexible operational protocol for managing the lake/wetland system.

4.1 MITCHELL LAKE PROPOSED OPERATIONS

The lake will be actively managed in a different manner than it has been managed historically. The primary differences are as follows:

- The existing dam spillway elevation will be raised to 521.76 ft msl.
- New outlet works will be added to preferentially route flow to the constructed wetland. The layout and elevation for the outlet works will be determined during detailed design, but the outlet works are intended to route a controlled volume of flow to the constructed wetland by gravity anytime the lake level is above approximately 518.5 ft msl.
- Supplemental LCWRC water will be pumped to Mitchell Lake only as needed to maintain a minimum lake elevation of approximately 518.5 ft msl for bird habitat and to provide sufficient water to maintain the constructed wetland.

When the lake level is above the outlet works elevation (approximately 518.5 ft msl), typically, the lake will discharge continuously to the constructed wetland via controlled discharges through the outlet works. The flow rate to the constructed wetland will vary based on the water elevation in the lake. A flow rate of approximately 2 MGD will be discharged when the lake level is just above the outlet works elevation, and a higher flow rate of up to 7 MGD will be discharged when the lake level is near or above the dam spillway. A design condition and operational protocol that specifically identifies how the outlet works discharge rate will be adjusted based on lake elevation will be developed based on the results of the pilot constructed wetland study. The operational protocol may be further adjusted as experience is gained with the performance of the full-scale constructed wetland. For example, operational experience may indicate that there will be periods when it is desirable not to have discharges from the constructed wetland.

4.2 CONSTRUCTED WETLAND PROPOSED OPERATIONS

The constructed wetland is expected to be operated with both trains and all cells online most of the time. Water depths are anticipated to remain between approximately 4 and 8 inches. There may be times when the constructed wetland is not operated in this manner due to either maintenance requirements (such as supplemental planting, repairing a water level structure, conducting a prescribed burn to reduce thatch cover, etc.) or performance optimization. Operational changes may include, but are not limited to, the following:

- It may be appropriate to take one or more cells offline temporarily and route all flow through the remaining cells.
- In some cases, future operational experience may indicate that, periodically, it is appropriate to reduce or restrict inflow to the constructed wetland below normal flow rates; to restrict discharge from the constructed wetland (by raising outflow water level structures); or to allow one or more cells to drain completely on a temporary basis..

5 Conclusion

Implementing a full-scale constructed wetland downstream of Mitchell Lake to treat most of the volume released from the lake is expected to meet the project objectives:

- The pilot constructed wetland study has demonstrated that the concentrations of BOD_5 and TSS in flows discharged from the constructed wetland are substantially less than those present in the waters of Mitchell Lake. In addition, the high pH is lowered.

- An operational protocol can be established, based on the anticipated performance of the constructed wetland, that reduces the frequency of untreated spillway releases.

The operational protocols are subject to adjustment as more data are obtained from the pilot constructed wetland and as experience is gained with the full-scale constructed wetland. However, results to date indicate that operational protocols are achievable that will provide improved discharge quality of Mitchell Lake waters and reduce untreated spillway releases.