A Unique Alternative Water Supply in the Central Florida Water Initiative Area: The Judge Farms Project

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Established in October 2003 by a special act of the Florida Legislature, Toho Water Authority (TWA) is the largest provider of water, wastewater, and reclaimed water services in Osceola County (county) and was established for the sole purpose of providing regional stewardship over its water resources. Currently, TWA serves approximately 106,000 water, 100,000 wastewater, and 18,000 reclaimed water customers in Kissimmee, Poinciana, and unincorporated areas of the county.

In the county, and throughout central Florida, the majority of public water supply needs have historically been met by fresh groundwater withdrawals from the Floridan aquifer. With significant future population growth expected in the region, however, traditional groundwater sources may be unable to satisfy all future needs without contributing to undesirable impacts to water resources and associated natural systems. As a regional utility provider, TWA seeks to diversify its supplies and to develop sustainable alternative sources of water.

Central Florida Water Initiative

Water supply in central Florida is regulated by three water management districts: St. Johns River Water Management District (SJRWMD), South Florida Water Management District (SFWMD), and Southwest Florida Water Management District (SWFWMD). These three districts worked in close collaboration, along with other agencies and key stakeholders, to prepare a regional water supply plan (RWSP) in 2015 for the Central Florida Water Initiative (CFWI) planning area. The planning area includes all of Orange, Osceola, Seminole, and Polk counties and southern Lake County. Seeking an integrated and consistent plan for water resources in the region, the goals of the CFWI process (SJRWMD, SFWMD, and SWFWMD, 2015a) include:

- Identifying sustainable quantities of traditional groundwater sources available for supply.
- Developing strategies to meet water demands that exceed the sustainable yield of existing traditional groundwater sources.
- Establishing consistent rules and regulations in the CFWI planning area.

The CFWI groundwater availability analysis determined that the continuing increased use of traditional groundwater for water supply in the central Florida region would not be sustainable without creating unacceptable impacts to natural systems. Total water use in the CFWI planning area was projected to increase from approximately 800 mil gal per day (mgd) in 2015 to about 1,100 mgd by 2035, while the yield analysis concluded that only approximately 850 mgd in traditional fresh groundwater supply would be sustainable (SJRWMD, SFWMD, and SWFWMD, 2015a). The CFWI 2015 RWSP also identified 150 alternative water supply (AWS) project options that could be developed to supplement traditional groundwater supplies and help satisfy future water demands. Prudent water suppliers in the region are already planning ahead to identify and develop new AWS sources.

Lake Tohopekaliga Restoration/ Alternative Water Supply Project (Judge Farms Project)

Various AWS project alternatives were investigated by TWA to diversify its future array of water supply sources. One unique project originally identified years ago by TWA, in collaboration with the county and other stakeholders, is the Lake Tohopekaliga (Toho) restoration/AWS reservoir project, also known as the Judge Farms Project, located at the former Judge Farms property on the northern shore of Lake Toho in the county. The Judge Farms reservoir project (hereinafter referred to as the "project") was one of the sustainable alternatives included in the CFWI 2015 RWSP (SJRWMD, SFWMD, and SWFWMD, 2015b).

The plan for the project involves diversion of a portion of the surface water from Mill Slough (a small creek channelized for stormwater drainage) and East City Ditch (a manmade drainage facility), along with collection of stormwater runoff from the county's NeoCity property development and surrounding area, into an approximately 470-mil-gal (MG) stormwater pond/AWS reservoir located on the former Judge Farms property. Due to its location, natural low topography, and significant size, the western half of the former Judge Farms property was considered highly suitable for use as a reservoir, while the higher-elevation eastern half of the property was identified for use by the county for commercial development. Once completed, the project will provide multiple benefits, including alternative water supply, regional flood control, stormwater treatment, nutrient reduction, and aesthetic and recreational benefits.

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Surface water from Mill Slough and East City Ditch, two tributaries of Lake Toho, will be captured during periods of high stage/flow and diverted into the planned reservoir, where this water will be commingled with stormwater collected from the site. The captured surface water/stormwater will be used as an AWS source for augmentation of TWA's nonpotable reuse system, reducing the future use of traditional groundwater for irrigation. In addition to reuse supplementation, water from the reservoir may be used by TWA to increase beneficial aquifer recharge via a series of rapid infiltration basins located along the Lake Wales Ridge in the northwestern part of the county. Additionally, by diverting stormwater before it enters Lake Toho, the reservoir and AWS use will help reduce pollutant (e.g., nutrient) loading into Lake Toho and downstream surface waterbodies.

After investigating various alternative layouts, TWA and its water resource consultants developed a preferred conceptual design for the various components of the AWS project. The conceptual layout of the project includes various key infrastructure components (Figure 1):

- Surface water intake pump stations on Mill Slough and East City Ditch, at 6,000 gal per minute (gpm) peak capacity each, with raw water delivery pipelines to the reservoir.
- Approximately 470-MG water storage reservoir, covering 130 acres on the project property, with excess stormwater outfalls to Lake Toho.
- Onsite TWA water treatment facility, providing filtration and disinfection of water withdrawn from the reservoir.
- Treated water storage tanks, high-service pump station, and distribution pipelines to store and deliver finished water to supplement TWA's nonpotable reuse system.

Figure 1. Lake Toho Restoration/AWS (Judge Farms) Project Conceptual Layout

Water Use Permitting Analysis

Based on the conceptual design, TWA applied to SFWMD for a new water use permit (WUP) for the project. The county, TWA's project collaborator, is managing land development on the project site and concurrently applied for an environmental resource permit (ERP). The water use permitting process for the project involved unique challenges. The SFWMD and U.S. Army Corps of Engineers have invested decades and roughly a billion dollars in the ongoing Kissimmee River Restoration (KRR) effort. The SFWMD and the Corps have made enormous strides to restore the Kissimmee River, which was channelized in the 1960s, into a more natural, meandering stream that better supports a healthy floodplain ecosystem. Improving the hydrology of the Upper Kissimmee Chain of Lakes, including Lake Toho, is a related component of the KRR project. It was critical to SFWMD that the new Judge Farms AWS project be compatible with the KRR project objectives.

As part of the WUP application review, TWA was required to demonstrate that the proposed AWS project will not cause harm to water resources or natural systems and will not interfere with existing legal uses of water. Based on decades of hydrologic and environmental studies, SFWMD intends to adopt a future water reservation rule to protect the restored Kissimmee system, limiting the amount and timing of water that may be available for additional consumptive use. Although a water reservation rule has not yet been adopted, in the spirit of cooperation and in line with its tradition of sustainable environmental stewardship, TWA adapted its proposed surface water withdrawal schedule for the Judge Farms project for consistency with SFWMD's KRR project goals. As described, various technical methods were used to provide reasonable assurance that the proposed TWA water diversion project will not cause unacceptable impacts to water resources, natural systems, or existing legal users.

System Operation Water Budget Modeling

Surface water and stormwater supplies available to fill the Judge Farms reservoir are expected to be greatest during periods of high rainfall. In contrast, TWA reuse system irrigation demands typically will peak during periods of low rainfall (e.g., in May). A mismatch in timing therefore exists between demand and supply. Due to this, a 26-year continuous simulation daily water budget model was created to study the long-term operation of the AWS system, including the diversion of surface water from the two Lake Toho tributaries and operation of the reservoir between assumed minimum and maximum design levels, while aiming to meet predicted TWA nonpotable demand needs. This system operation model was used to estimate, under long-term transient conditions, the potential daily variation of inflows, outflows, and water levels for the reservoir, and the estimated reliability of the reservoir in meeting projected TWA demands.

The system operation water budget model uses the basic continuity equation:

$$\Sigma \text{ Inflows} - \Sigma \text{ Outflows} = \Delta \text{ Storage}$$

Using this relationship, the model predicts the daily volume of supply available from the reservoir for reuse supplementation, after accounting for the different inflows and outflows to the reservoir for each simulation day. The model also calculates the change in reservoir storage volume for each simulation day and estimates the corresponding stage in the reservoir.

The inflows to the proposed reservoir include rainfall, diversions of surface water from adjacent tributaries Mill Slough and East City Ditch, and onsite stormwater runoff from the proposed county NeoCity property development and nearby contributing drainage area. Outflows from the proposed

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reservoir include evaporation, withdrawals to meet TWA reuse system supplementation needs, and overflows to Lake Toho. Surficial aquifer groundwater seepage is also included in the water budget continuity equation as either an inflow or outflow for the reservoir, depending on the relative difference between reservoir and Lake Toho water levels.

Surface Water Diversion Inflow

For the modeling analysis, two key constraints were placed on the potential daily diversion of water from the Lake Toho tributaries:

- Lake Toho stage must be above a protective water level schedule.
- Reservoir stage must be below its planned maximum operational level at 55 ft National Geodetic Vertical Datum (NGVD).

Through the project WUP negotiations, SFWMD staff members recommended a water level withdrawal schedule for Lake Toho (Figure 2) that they believed would be protective of water resources, and fish and wildlife species in the lake, consistent with KRR project goals. The withdrawal schedule sets a threshold water level for direct (lake) or indirect (tributary) withdrawals from the lake for each calendar day, consequently allowing diversions from Mill Slough and East City Ditch only on days when the stage of Lake Toho is above the daily scheduled water level.

In addition, diversions of surface water into the reservoir were assumed to occur only when the reservoir stage was below its maximum operating water level, to help minimize overflows from the reservoir back into Lake Toho. Based on agreement with the county, the planned active storage zone for the reservoir ranged from a minimum operating level of 43 ft NGVD to a maximum of 55 ft NGVD. On days when both the Lake Toho water level withdrawal schedule and reservoir maximum stage constraints are met, surface water was assumed to be diverted from the two tributaries at a planned combined intake pumping rate of 15 mgd.

Figure 2. Proposed Lake Toho Water Level Withdrawal Schedule

Table 1. Long-Term Average Flows Predicted by System Operation Water Budget Model

Water Budget Component	Average Daily Flow (mgd ADF)
Inflows	
Rainfall	0.6
Mill Slough Withdrawal	2.4
East City Ditch Withdrawal	2.4
Judge Property Stormwater Runoff	1.5
Net Seepage from Surficial Aquifer	0.2
Total Inflow	**7.2**
Outflows	
Evaporation	0.6
Withdrawal for Reuse Supplementation	6.0
Overflow to Lake Toho	0.6
Total Outflow	**7.2**

Stormwater Management Inflow

Daily inflow of stormwater collected on site—from the county's NeoCity development and surrounding areas—was also included in the water budget model. The daily amount of this stormwater inflow was estimated using a hydrologic and hydraulic (H&H) model developed for the contributing area based on the U.S. Environmental Protection Agency (EPA) Stormwater Management Model (SWMM) software (USEPA, 2015).

Toho Water Authority Reuse System Augmentation Withdrawal

A targeted daily withdrawal rate from the reservoir was assumed based on a seasonal analysis of TWA's future nonpotable water system demand deficits. The water budget model extracted this daily withdrawal amount from the reservoir whenever sufficient storage volume remained in the reservoir above the assumed minimum operating stage of 43 ft NGVD. The reservoir was predicted to be depleted during extended dry periods. The system water budget model was therefore used to estimate the reliability of the reservoir in being able to meet the targeted TWA daily demands.

Groundwater Seepage

A groundwater flow model using the U.S. Geological Survey MODFLOW code was developed for the project to simulate the operation of the reservoir. This groundwater model was used to quantify an estimated relationship between relative head difference (i.e., difference in water levels between the reservoir and Lake Toho) and predicted groundwater seepage into or out of the reservoir.

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Simulation Results

Long-term average flows predicted by the system operation model over a 26-year simulation period (1990-2015 climatic conditions) are summarized in Table 1. With the assumed withdrawal constraints, diversions from Mill Slough and East City Ditch were predicted to occur only approximately 32 percent of the time. This simulation also assumed that the county NeoCity property was fully developed and contributing a maximum future volume of stormwater inflow to the reservoir, at an estimated average of 1.5 mgd. On a long-term average, 6 mgd was simulated to be withdrawn from the reservoir for reuse system supplementation and daily targeted demands were predicted to be met with greater than 90 percent reliability.

The model also predicted the daily time series of reservoir water levels during the continuous simulation period (Figure 3). Constrained between the assumed minimum operating level of 43 ft NGVD and maximum of 55 ft NGVD, the long-term mean reservoir water level was estimated at approximately 51.8 ft NGVD during the assumed 26-year continuous simulation period.

Stormwater Management Model Hydraulic Modeling of Project Withdrawals

The proposed intakes for both Mill Slough and East City Ditch would be installed within the respective channel of each tributary at locations approximately 0.5 mi upstream of where each tributary discharges into Lake Toho (Figure 1). From these intake locations southward to the lake, the two tributaries flow past a large area of emergent wetlands, which may derive, in some part, water from the tributaries to maintain their hydroperiod. Some additional wetlands exist adjacent to Mill Slough farther upstream along its watercourse, primarily near its headwaters in Orange County. In the upstream direction, East City Ditch is an urban stormwater conveyance primarily surrounded by developed land. At the withdrawal locations, the two tributaries are heavily influenced by the water in Lake Toho and are essentially in a backwater condition; thus, the proposed withdrawals are not expected to significantly impact water levels in the two tributaries, as their stages will be sustained by the water in nearby Lake Toho.

In support of the WUP process, hydraulic modeling was used to demonstrate that the proposed withdrawals are not anticipated to cause impacts to stream or wetland water levels upstream along the two tributaries. This analysis was performed using the SWMM model developed for the project, which represented the hydrologic behavior of the Mill Slough, East City Ditch, and Judge Farms drainage areas, and the hydraulic behavior of the stream channels and existing and future stormwater management infrastructure.

Two scenarios were analyzed using the SWMM model, for a 26-year simulation period with daily time steps, to evaluate the potential for impact due to the proposed withdrawals:

- Existing-condition scenario, which simulated existing flows and stages in Mill Slough and East City Ditch.
- Withdrawal-condition scenario, which included a 7.5-mgd constant daily withdrawal applied to each tributary at the respective proposed intake locations.

The assumed withdrawal simulation was a very conservative (worst-case) assumption, as each 7.5-mgd withdrawal is only predicted to occur about one-third of the time. To determine the potential impact of the proposed tributary withdrawals, daily stages were simulated at all SWMM model nodes along both the Mill Slough and East City Ditch hydraulic channels for the 26-year simulation period for both scenarios. For each node in the two tributaries, the simulated daily stage from the withdrawal condition scenario was compared to the simulated daily stage from the existing condition (baseline) scenario.

Based on the SWMM hydraulic modeling results, the proposed peak withdrawals were predicted to have no significant effect on the stages in Mill Slough or East City Ditch for the entire lengths of the channels. The long-term average decline in modeled stages due to the proposed withdrawal was less than 0.002 ft for all nodes along Mill Slough and East City Ditch. The maximum simulated single-day stage difference, for any day in the 26-year simulation, was computed at 0.17 ft in Mill Slough and 0.05 ft in East City Ditch. As expected, because the proposed withdrawals are near the outfalls, the Lake Toho stage tends to control the water levels in the two channels at the points of withdrawal, and upstream nodes are therefore also not affected.

These SWMM model results indicated that the proposed withdrawals would have no measurable impact on the surface water stages of Mill Slough or East City Ditch. Consequently, wetlands adjacent to the two tributaries likewise should not be affected by the proposed surface water withdrawals.

Groundwater Modeling of Proposed Reservoir Operation

Numerical groundwater flow modeling was performed to simulate the operation of the reservoir and its predicted effects on groundwater levels at the Judge Farms site and in the surrounding area. The primary objective of the groundwater flow modeling was to provide reasonable assurance that the proposed operation of the reservoir would not cause unacceptable impacts to wetland systems near the proposed project site. As mentioned, the groundwater model was also used

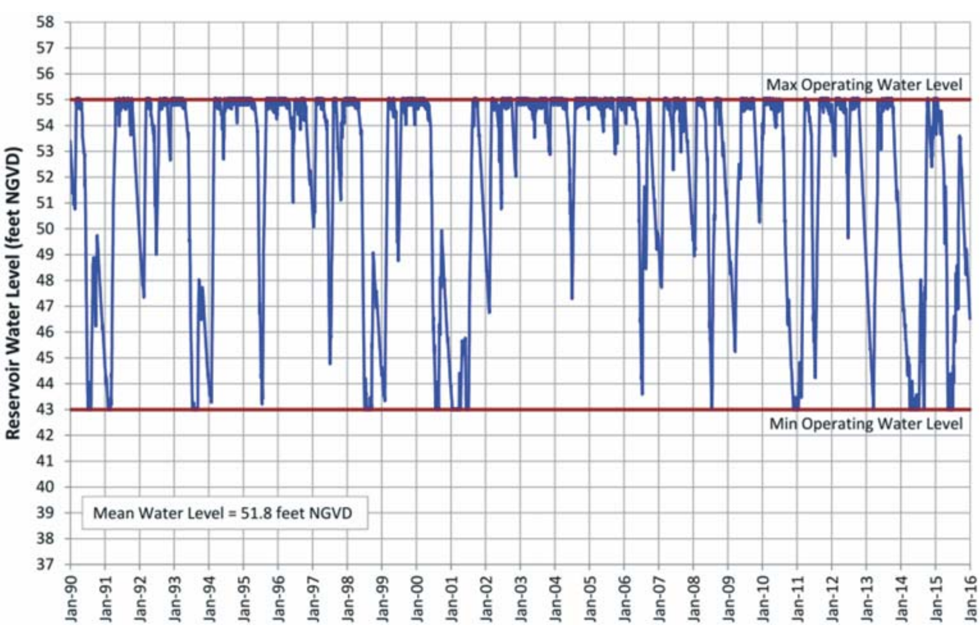

Figure 3. Daily Reservoir Stages Predicted by System Operation Water Budget Model

to develop estimates of groundwater seepage into and out of the Judge Farms reservoir, across a broad range of anticipated operating conditions, for use in the water budget modeling.

The groundwater model setup was based in part on information derived from the East Central Florida Transient (ECFT) groundwater model developed during the CFWI planning process (SFWMD, SJRWMD, and SWFWMD, 2015b). The new groundwater model was designed to actively represent the surficial aquifer system (SAS), which was subdivided into five horizontal layers for improved accuracy of simulation. The intermediate confining unit (ICU) was represented beneath the SAS in the model as a virtual layer, with assigned leakance values derived from the calibrated thickness and vertical hydraulic conductivity values in the ECFT model. The bottom layer of the model represented the Upper Floridan aquifer (UFA), assigned as a fixed-head boundary condition, with head values derived from SFWMD records.

A key input parameter expected to affect predicted model results was the hydraulic conductivity of the local SAS soils near the project site. Because some uncertainty existed regarding the most appropriate values, and due to the limited amount of field data available for calibration, the groundwater model was run with both high and low values of SAS hydraulic conductivity. This allowed for an assessment of the sensitivity of model results across a realistic expected range of hydraulic conductivity values. For a high hydraulic conductivity condition, the local site soils were assumed to have a horizontal hydraulic conductivity (K_h) of 20 ft per day (ft/day) and a vertical hydraulic conductivity (K_v) of 10 ft/day. For a low hydraulic conductivity condition, the local soils were assumed to have values of K_h = 2 ft/day and K_v = 1 ft/day.

For both assumed SAS hydraulic conductivity conditions (high and low), the groundwater flow model was used to simulate both the existing baseline condition and a predicted future condition when the project site is developed and the AWS reservoir is under active operation. The differences in predicted model heads from the two scenarios were then compared to estimate the change in groundwater levels due to the proposed project. The future project condition scenario was originally investigated for an anticipated long-term average reservoir stage of 52 ft NGVD, and then later re-analyzed at a more conservative assumed average reservoir stage of 51 ft NGVD. In both cases, the model-simulated changes in groundwater levels were determined to pose no significant risk of impact to wetlands near the project site. Also, the results were found to be not very sensitive to the assumption of high or low local SAS hydraulic conductivity.

Figure 4. Projected Average Drawdown in Wetland Water Levels for Alternative With Judge Farms Reservoir at 51 ft NGVD and Local Soils K_h = 2 ft/d

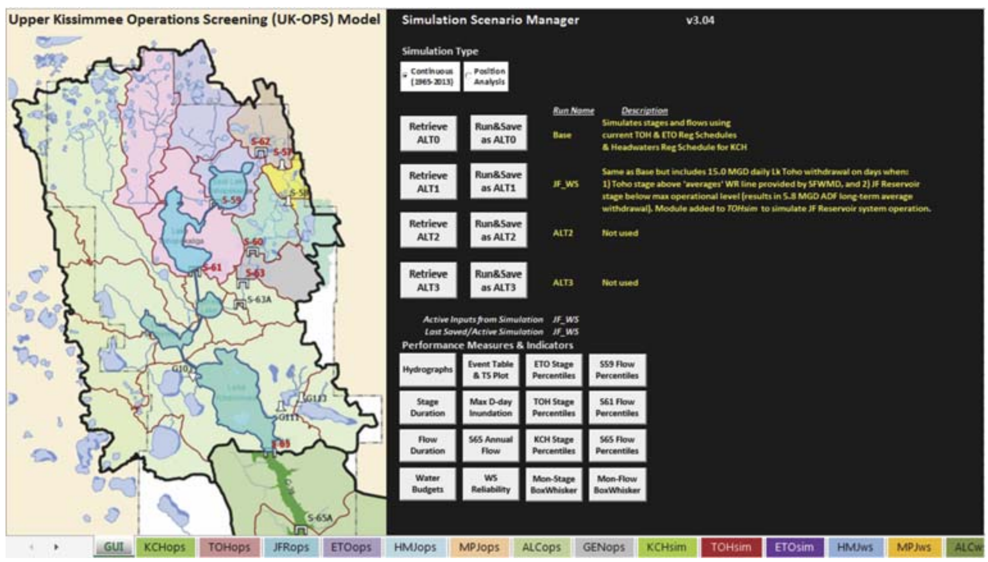

Figure 5. Upper Kissimmee Operations Screening Model Graphical User Interface

Figure 4 shows the predicted SAS water table head change results for the 51-ft-NGVD average reservoir stage condition using the more conservative low SAS hydraulic conductivity assumption. The western portion of the site shows predicted groundwater level drawdowns associated with future operation of the proposed reservoir. The central portion of the site shows a rebound/recovery (i.e., higher future water table elevations), because the average reservoir operating level is higher than the current water table elevations that have occurred with long-term dewatering operations from the Judge Farms pump station. In the eastern part of the Judge Farms prop-

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erty, an area of minor future drawdown is predicted, caused by the reduction of recharge rates that results from converting agricultural land to commercial land use.

Wetland areas shown in the National Wetlands Inventory (NWI) database are also displayed in Figure 4. The long-term average drawdown effects of the project reservoir on the wetlands surrounding the Judge Farms property appeared to be very minor, regardless of which SAS hydraulic conductivity values were assumed. Furthermore, wetlands located on the Judge Farms property are planned to be developed and any changes to those wetlands are already accounted for in the ERP issued for the project.

The model was also used to run a very conservative simulation estimating the predicted change in SAS and wetland water levels under a long-term steady-state condition when the reservoir stage is at its minimum operating level of 43 ft NGVD. Even in this extreme case, the predicted results did not appear to indicate areas of projected significant impacts to offsite wetlands.

Upper Kissimmee System Water Budget Modeling of Project Withdrawals

The WUP effort also required an analysis of the potential for impacts to water resources and existing legal users on Lake Toho or along additional downstream surface water systems due to the proposed surface water withdrawals. For this analysis, a modified version of SFWMD's Upper Kissimmee Operations Screening (UK-OPS) Model, version 3.04, was selected as an available and appropriate tool. The UK-OPS is a water budget model that represents Lake Toho and the other interconnected major surface waterbodies of the Upper Kissimmee Chain of Lakes via a 49-year, continuous daily simulation of system stages and flows (Figure 5).

An additional module was added to the UK-OPS model to explicitly represent the operation and water budget of the proposed Judge Farms reservoir. This module was based on the previous system operation water budget model developed for the project, integrated into the UK-OPS model, and applied across the 49-year UK-OPS simulation period.

The UK-OPS hydrologic continuous simulation modeling was used to:

- Analyze the expected effect that the proposed Judge Farms project withdrawals (with assumed constraints) would have on Lake Toho and Upper Kissimmee stages and flows.
- Estimate an appropriate peak annual allocation amount for the WUP.

Two scenarios were simulated with the UK-OPS model, and the stage and flow results from the two simulations were directly compared to estimate the potential net effect of the proposed project withdrawals on the water resource system:

- Baseline model scenario (ALT0), which simulated current operations for the Upper Kissimmee Basin.
- Project withdrawal model scenario (ALT1), which simulated a combined 15-mgd withdrawal from the Lake Toho tributaries on days when both the Lake Toho stage was above the recommended water level schedule and the Judge Farms reservoir was below its maximum operating level of 55 ft NGVD.

The results of the modeling showed that the proposed consumptive withdrawal of surface water was predicted to result in a long-term reduction of only 0.006 ft in the average stage of Lake Toho. Furthermore, the UK-OPS model predicted only minor reductions of 2.2 percent in the flow out of Structure S-61 at the southern outlet of Lake Toho, and 0.9 percent in the flow through Structure S-65 at the southern outlet of Lake Kissimmee, on average, for the proposed withdrawal scenario (ALT1). The predicted 0.9 percent flow reduction at Structure S-65 is much smaller than the 5 percent reduction threshold suggested by SFWMD staff as environmentally acceptable for the Kissimmee system. These predicted levels of change to system stages and flows were not expected to significantly impact downstream water resources or existing legal users.

With the assumed operational constraints, the results of the 49-year continuous daily modeling also indicated that surface water withdrawals from the tributaries would occur approximately 38 percent of the time, which was slightly greater than estimated by the previous 26-year water budget modeling. Also, the 49-year simulation predicted that the rolling annual average withdrawal from the surface water tributaries, when targeting a 6-mgd annual average daily flow (ADF) reuse water demand, may range from below 1 mgd ADF to above 8 mgd ADF under long-term variable climatic/ hydrologic conditions. Based on these simulation results, a maximum annual average allocation limit of 3,000 MG per year, or 8.22 mgd ADF, was proposed as an appropriate value for the WUP in order to most efficiently meet a reuse supplementation demand of 6 mgd ADF in any given year.

Conclusion

The Judge Farms project is a unique AWS initiative that will utilize surface water that's diverted only a limited portion of the time, combined with stormwater, for reservoir storage and subsequent beneficial use to supplement TWA's nonpotable reuse system. The water use permitting process for the project involved significant complexities, as TWA had to balance the various interests and requirements of project collaborators and regulators. Although a Kissimmee water reservation rule has not yet been adopted, in the spirit of cooperation and environmental stewardship, TWA adapted its proposed surface water withdrawal schedule for the Judge Farms project to be consistent with SFWMD's KRR project goals.

Following extended coordination with SFWMD staff, and based on the various supporting analyses described herein, TWA was issued a 30-year-duration WUP in October 2017 for a maximum annual allocation of 8.22 mgd of surface water diverted from the Lake Toho tributaries. The county also completed the ERP process in September 2017 and is proceeding with development of the former Judge Farms property, starting with active construction of the large onsite reservoir for stormwater management and future surface water AWS storage. Future project phases for TWA will involve the design and construction of the AWS facilities.

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