Minimum Flows for Gum Slough Spring Run Addendum

October 2016

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Southwest Florida Water Management District
Brooksville, Florida

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Minimum Flows for Gum Slough Spring Run
Addendum

October 2016

The geological evaluation and interpretation contained in the report entitled *Minimum Flows for Gum Slough Spring Run Addendum* has been prepared by or approved by a Certified Professional Geologist in the State of Florida, in accordance with Chapter 492, Florida Statutes.

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Executive Summary

A Peer Review Draft of the Proposed Minimum Flows and Levels for the Gum Slough Spring Run report was completed on May 26, 2011. The Peer Review Panel completed their review of the draft report in September 2011, and the draft report was revised in October 2011 based on Panel comments and stakeholder input. Since that time, additional data have become available that have changed the results of the analyses used to develop the proposed minimum flows. Because the methodology included in the original, peer-reviewed report has not changed, this addendum was created to serve as a companion to the revised 2011 report and appendices. This addendum includes updated results of the analyses contained in the revised 2011 report, as well as updated minimum flow recommendations for Gum Slough Spring Run.

In the revised 2011 report, the mean daily discharge of Gum Slough Spring Run, including both overland flow and base flow, was reported as 98 cubic feet per second (cfs), based on discharge data from October 2003 through September 2010. With the inclusion of additional discharge data from October 2010 through September 2013, increasing the period of record from October 2003 through September 2013, the updated, period-of-record mean daily discharge rate was 88 cfs.

Results of a water budget for the Gum Springs group springshed in which all consumptively-used water was conservatively estimated to result in equivalent reductions in springflow indicate that the current groundwater withdrawn within the contributing area results in about a 2.5 percent decline in springflow. In the revised 2011 report, the 2008 version of the Northern District Model (NDM), a groundwater flow model, was used to simulate the impact on flow due to groundwater withdrawals in 2005. The predicted streamflow decline for Gum Slough Spring Run (Gum Springs near Holder station) under those pumping conditions was determined to be approximately four percent. For this addendum, the latest version of the NDM (Version 4.0) was used to simulate the flow change at the Gum Springs group due to groundwater withdrawals in 2010. Similar to the model results included in the revised 2011 report, the updated model results indicate that predicted drawdown within the Upper Floridan aquifer near Gum Springs is less than 0.25 feet. The updated model results indicate that the predicted streamflow decline for Gum Slough Spring Run (Gum Springs near Holder station) under recent pumping conditions is approximately 3.4 percent.

The minimum flows recommended in the revised 2011 report would allow up to a nine percent reduction in natural flow, e.g., flows corrected for withdrawal impacts, and would be applicable the entire year. The allowable percent-of-flow reduction included in the revised 2011 report was based on Physical Habitat Simulation (PHABSIM) modeling that predicted a 15 percent decrease of available habitat for the shallow-slow fish guild and benthic macroinvertebrates. However, after revising the PHABSIM modeling to include updated, withdrawal-corrected flow records collected from October 2010 through September 2013, the maximum allowable flow reduction was calculated to be six percent, based on a 15 percent decrease of available habitat for adult spotted sunfish. This updated information was used to revise minimum flow recommendations for Gum Slough Spring Run to allow up to a six percent reduction in natural flows.

In the 2011 revised report, the recommended minimum flows also included a low-flow threshold, defined to be a flow that serves to limit surface water withdrawals, of 35 cfs, using the Hydrologic Engineering Centers River Analysis System (HEC-RAS) model to characterize flows and based on flows associated with fish passage and the inundation of the stream channel. After revising the HEC-RAS modeling to include the updated, withdrawal-corrected flow record, the low-flow threshold was updated to 43 cfs.

Updated minimum flow recommendations for Gum Slough Spring Run were approved by the District Governing Board on March 29, 2016, adopted into the District's Minimum Flows and Levels and Rates of Flow Rules (Chapter 40D-8, F.A.C) on May 31, 2016, and became effective on June 20, 2016. The minimum flow rules for Gum Slough Spring Run are protective of all relevant environmental values identified for consideration in the Water Resource Implementation Rule when establishing minimum flows and levels. Because updated groundwater modeling indicates that the predicted streamflow decline for Gum Slough Spring Run under current pumping conditions is approximately 3.4 percent, the proposed minimum flows are being met, and a recovery strategy is not currently required.

As specified in the adopted/effective rules, the District will re-evaluate the adopted minimum flow for Gum Slough Spring Run within ten years. In addition, annual status assessments of the spring run will be conducted to determine whether the adopted minimum flows continue to be met.

CHAPTER 1 – INTRODUCTION

The District completed the “Proposed Minimum Flows and Levels for the Gum Slough Spring Run – Peer Review Draft” report on May 26, 2011. A Peer Review Panel completed their review of the draft minimum flows and levels (MFLs) report in September 2011, and based on Panel findings summarized by Dahm et al. (2011), the District completed a revised 2011 version of the draft report in October 2011. The revised 2011 report also included some changes made in response to input from several stakeholders, but the originally recommended minimum flows for Gum Slough Spring Run included in the May 2011 report were not modified.

Since October 2011, additional information has become available, and analyses based on these data have indicated that the originally proposed minimum flows should be updated. This addendum summarizes those data and analyses and includes updates to information contained in the revised 2011 report, including updated minimum flow recommendations. As such, this addendum serves as a companion document for the revised 2011 draft report.

The District met with several stakeholders and held a public workshop during February and March 2016 to present the updated proposed minimum flows for Gum Slough Spring Run. Comments received from stakeholders during February and March 2016 are included in Appendix 1 of this document, and this addendum was revised in response to comments received from several stakeholders.

The updated proposed minimum flows were presented to the Governing Board on March 29, 2016, and the Board approved initiation of rulemaking to adopt minimum flows for Gum Slough Spring Run. The minimum flows for Gum Slough Spring Run were adopted into the District’s Minimum Flows and Levels and Rates of Flow Rules (Chapter 40D-8, F.A.C) on May 31, 2016, and became effective on June 20, 2016.

CHAPTER 2 – ENVIRONMENTAL VALUES ASSOCIATED WITH MINIMUM FLOWS AND LEVELS DEVELOPMENT

Section 1.1 of the revised 2011 report identified environmental values associated with coastal, estuarine, riverine, spring, aquatic, and wetlands ecology that should be considered when developing minimum flows and levels (MFLs); however, details regarding the applicability of these environmental values to Gum Slough Spring Run were not provided. The originally proposed minimum flows for Gum Slough Spring Run are protective of all relevant environmental values identified for consideration in the Water Resource Implementation Rule when establishing MFLs (see Rule 62-40.473, F.A.C.). In the paragraphs that follow, details regarding the environmental values that were considered in the development of minimum flows for Gum Slough Spring Run are summarized.

Recreation in and on the Water: This environmental value is considered relevant to Gum Slough Spring Run. The Outstanding Florida Water (OFW) designation of this system is, in part, based on its recreational significance. The maintenance of minimum water depths for recreational use was addressed by the minimum flows analysis through assessment of low-flow threshold criteria associated with fish passage and recreational use.

Fish and Wildlife Habitats and the Passage of Fish: This environmental value is relevant to the development of minimum flows for Gum Slough Spring Run. The minimum flows analyses included assessment of minimum water depths in the spring run for fish passage, maintenance of water depths above inflection points in the wetted perimeter of the channel to maximize aquatic habitat for fish and wildlife with the least amount of flow, and protection of wetland and in-channel habitat, including woody habitats and exposed roots, for fish, invertebrates, and wildlife.

Estuarine Resources: This environmental value was not considered relevant for development of minimum flow recommendations for Gum Slough Spring Run based on the landscape position of the system upstream of the impounded section of the Withlacoochee River that drains to the Gulf of Mexico.

Transfer of Detrital Material: This environmental value is considered relevant to the minimum flows analysis. Since the District's approach is largely habitat based and addresses the maintenance of minimum water depths in the spring run for fish passage and protection of wetland and in-channel habitat, this ecological function is expected to be addressed by the proposed minimum flows.

Maintenance of Freshwater Storage and Supply: Consideration of this environmental value for development of minimum flow recommendations was based on the evaluation of the effects of existing and permitted water use that affect flows in Gum Slough Spring Run. This environmental value is expected to be protected through implementation of the District's Water Use Permitting Program based on the inclusion of permit conditions that stipulate permitted withdrawals will not lead to violation of adopted MFLs. An alternative definition of this environmental value, preferred by the Florida Department of Environmental Protection (DEP), is the protection of an adequate amount of freshwater for non-consumptive uses and environmental values associated with coastal, estuarine, riverine, spring, aquatic, and wetlands ecology. This environmental value is expected to be protected by the proposed minimum flows, which are protective of all environmental values.

Aesthetic and Scenic Attributes: Although aesthetic and scenic attributes are considered relevant to the establishment of minimum flows for the spring run, there are no available data specifically associating this environmental value with flow. This environmental value is, however, closely linked with the “Recreation in and on the Water” value associated with Gum Slough Spring Run and its designation as an OFW. Ensuring sufficient flows for protection of this and other relevant environmental values, including fish and wildlife habitats and the passage of fish, transfer of detrital material, filtration and absorption of nutrients, water quality, and navigation is expected to be protective of aesthetic and scenic attributes.

Filtration and Absorption of Nutrients and Other Pollutants: This environmental value is expected to be addressed because the District’s approach to minimum flows development for Gum Slough Spring Run is primarily habitat based. For example, maintaining an acceptable level of ecological integrity for wetlands associated with the spring run ecosystem is expected to be protective of this ecological function.

Sediment Loads: Since approximately 28 percent of the discharge in Gum Slough Spring Run consists of surface water runoff, this environmental value is considered relevant for minimum flows development for the system. Because the District’s approach is largely habitat based and addresses the maintenance of minimum water depths in the spring run for the protection of wetland and in-channel habitat, this ecological function is expected to be protected by the proposed minimum flows.

Water Quality: Similar to many springs’ systems in Florida, Gum Slough Spring Run is experiencing rising nutrient concentrations due to urban and agricultural land-uses in its springshed (WRI 2011). Water quality criteria are designed to protect a water body’s designated use. Florida’s anti-degradation policy is designed to prevent worsening of water quality from specified activities unless it is found to be in the public interest and does not apply to water quantity decisions, such as MFLs. An OFW designation is part of Florida’s anti-degradation policy, and Gum Slough Spring Run is a designated OFW. While flow can affect water quality, the proposed minimum flow criteria are not expected to negatively affect water quality in Gum Slough Spring Run or impair the water body’s designated use.

Navigation: This environmental value is considered applicable to maintenance of water depths and channel widths suitable for passage of watercraft. Protection of this value was addressed through consideration of criteria associated with recreational watercraft (e.g., canoes, kayaks).

CHAPTER 3 – HYDROLOGY

Since the revised 2011 report was completed, additional hydrologic information has become available, and analyses based on these data were used to investigate whether the originally proposed minimum flows for Gum Slough Spring Run should be updated. In addition, the model used for the analyses has been revised and improved. The information presented in this section updates the results included in the Hydrology Section (Section 4) of the revised 2011 report.

3.1 Gum Slough Spring Run Discharge History

In the revised 2011 report, the Gum Slough Spring Run discharge history for the United States Geological Survey (USGS) Gum Springs near Holder gage site was described in Section 4.2.2.2 using flow data from October 2003 through September 2010. With the inclusion of five additional years of flow records (October 2010 through August 2015), expanding the record from seven to 12 years, the descriptive statistics have been revised.

The average daily flow from October 2003 through August 2015 was 90 cubic feet per second (cfs), equivalent to 59 million gallons per day (mgd). For the same period of record, the median daily flow was 84 cfs (which is the same median daily flow calculated for the seven-year period of record used in the original report). The maximum and minimum daily recorded flows were 520 cfs (336 mgd) and five cfs (3.3 mgd), respectively (Figure 3-1), compared to 520 and 24 cfs, respectively, in the revised 2011 report. The lowest recorded discharge of five cfs was measured following a prolonged drought during May 2012.

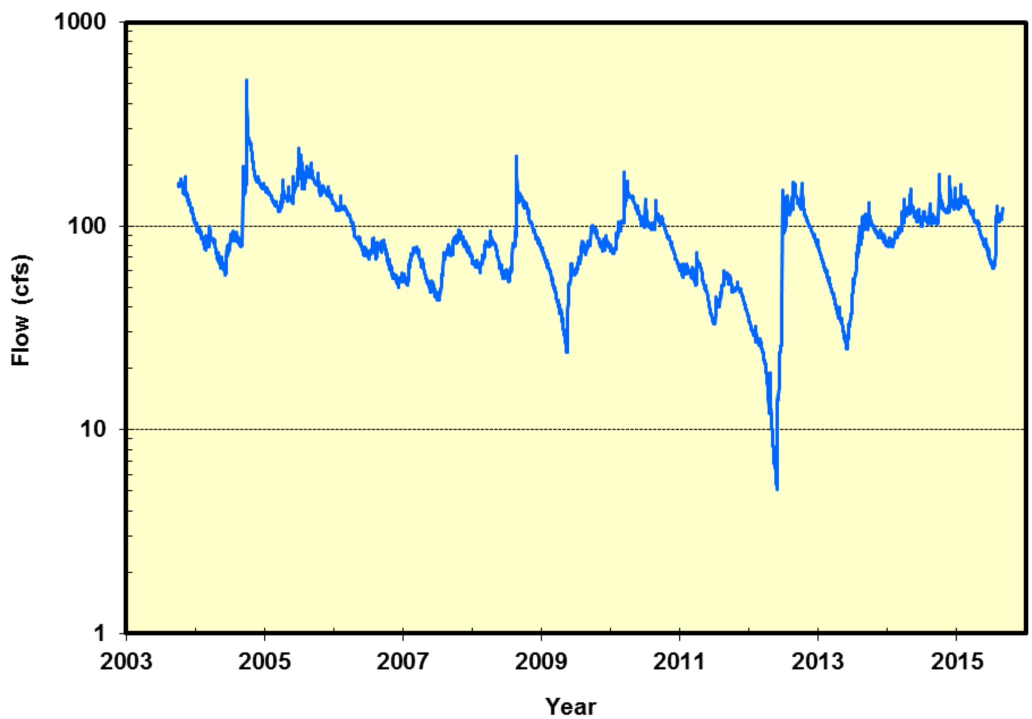


Figure 3-1. Flow history at the USGS Gum Springs near Holder station (October 2003 – August 2015). This figure is an update of Figure 4-5 included in the revised 2011 report.

3.2 Gum Slough Spring Run Base Flow Separation

The base flow separation process, described in Section 4.2.2.3 of the revised 2011 report, was repeated using additional discharge data available from the USGS[1] for October 2010 through September 2013, increasing the available period-of-record discharge data for updated minimum flows analysis from October 2003 through September 2013. Note that this period of record is shorter than the record used for the discharge history description presented in the previous section of this addendum, but it represents the period-of-record flow data that were available when analyses were completed for the re-evaluation of minimum flow recommendations.

Results from the base flow separation process indicated the average streamflow was 88 cfs, with a base flow contribution of 63 cfs, for the period of record from October 2003 through September 2013 (Figure 3-2). This compares to an average streamflow of 98 cfs, with a base flow contribution of 73 cfs, for the period of record from October 2003 through July 2010 that was identified in the revised 2011 report. For Gum Slough Spring Run, base flow contributes approximately 72 percent of streamflow volume as measured at the Gum Springs near Holder gage.

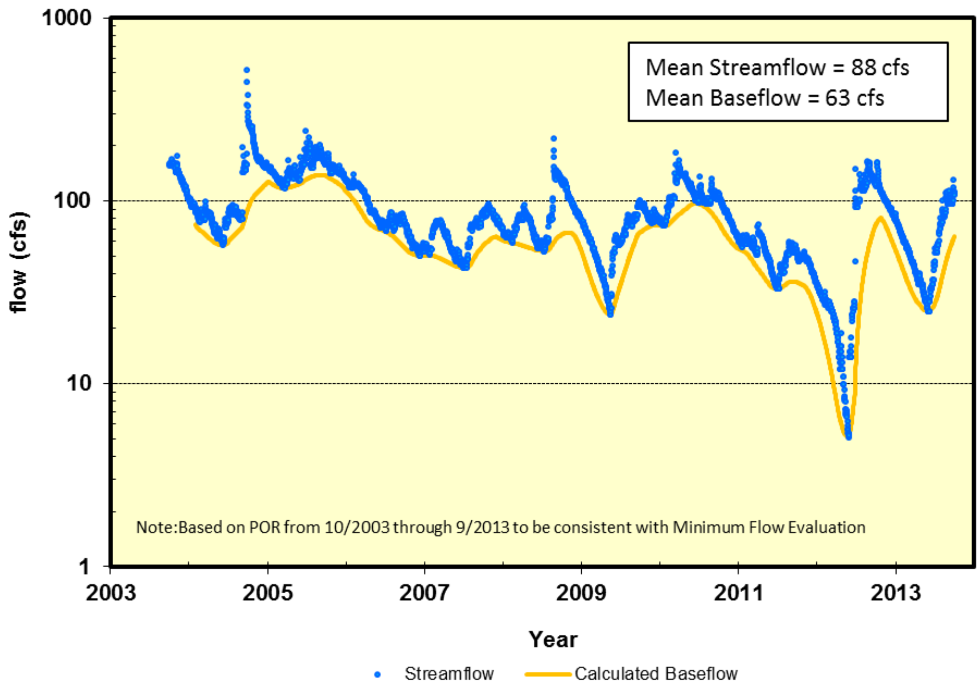


Figure 3-2. Streamflow and estimated base flow at the Gum Springs near Holder station for the updated period of record used for the minimum flow re-evaluation. This figure is an update of Figure 4-6 included in the revised 2011 report.

[1]Reported by USGS as *02312764 GUM SPRINGS NEAR HOLDER FL*.

3.3 Long-Term Rainfall Changes

In the revised 2011 report, the long-term rainfall history for the area was described in Section 4.2.2.4 using rainfall data from 1930 through 2008. With the inclusion of six additional years of rainfall data (2009 through 2015), the descriptive statistics have been revised.

Similar to the revised 2011 report, the analysis of rainfall averaged from the Brooksville, Inverness, and Ocala National Oceanic and Atmospheric Administration (NOAA) stations from 1930 through 2014 showed a declining trend after 1970, especially pronounced after 1989. The cumulative departure from mean annual rainfall from 1970 to 2014 was approximately -70 inches. In contrast, the cumulative departure from mean rainfall from 1931 through 1969 was +74 inches (Figure 3-3). An analysis of the annual departure in mean rainfall demonstrated that below average rainfall since 1970 was recorded for 31 out of 45 years (Figure 3-4). In both 2012 and 2014, however, rainfall was above average.

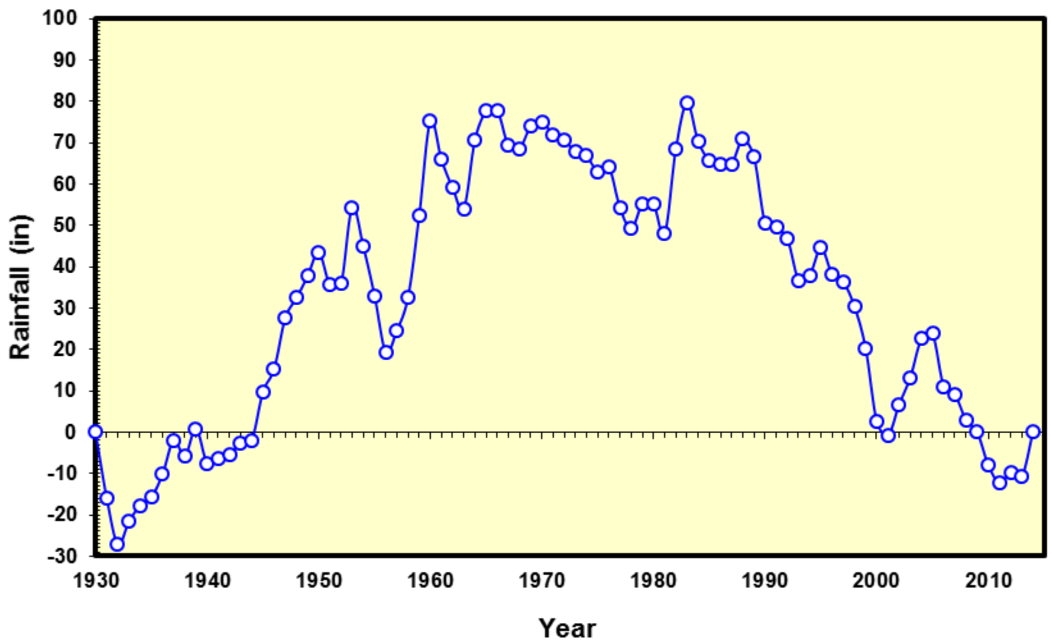


Figure 3-3. Cumulative departure in mean annual rainfall from 1930 through 2014 based on average rainfall values for the Inverness, Ocala, and Brooksville NOAA rainfall stations (Note: 2012-2014 data from nearby SWFWMD rainfall stations). This figure is an update of Figure 4-7 included in the revised 2011 report.

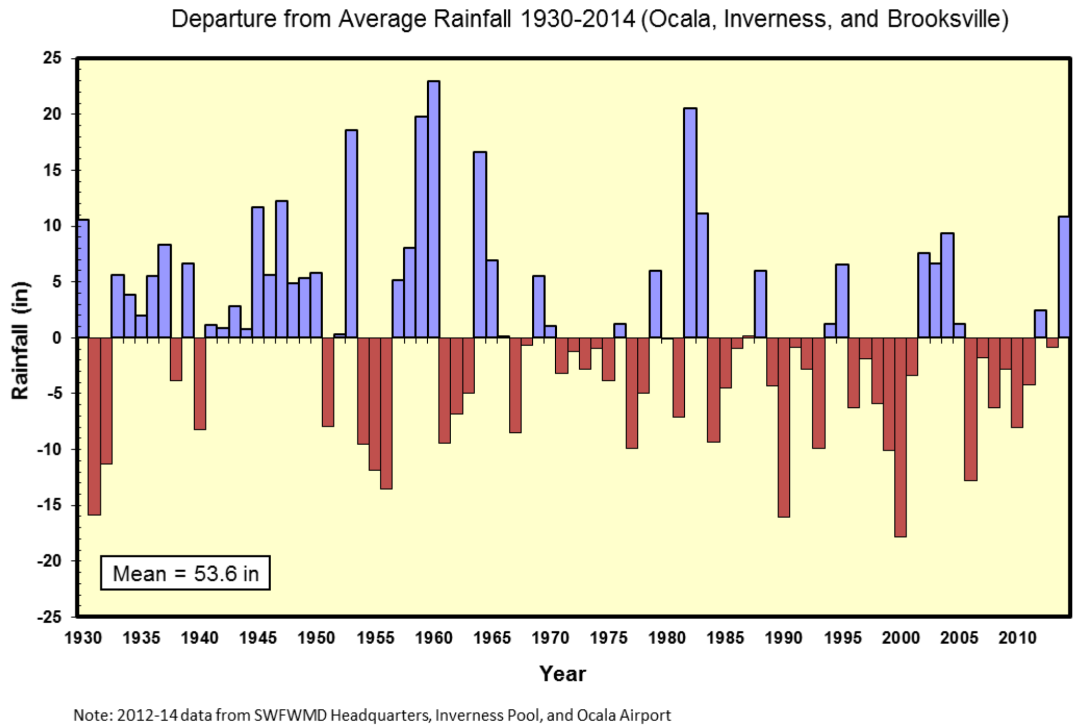
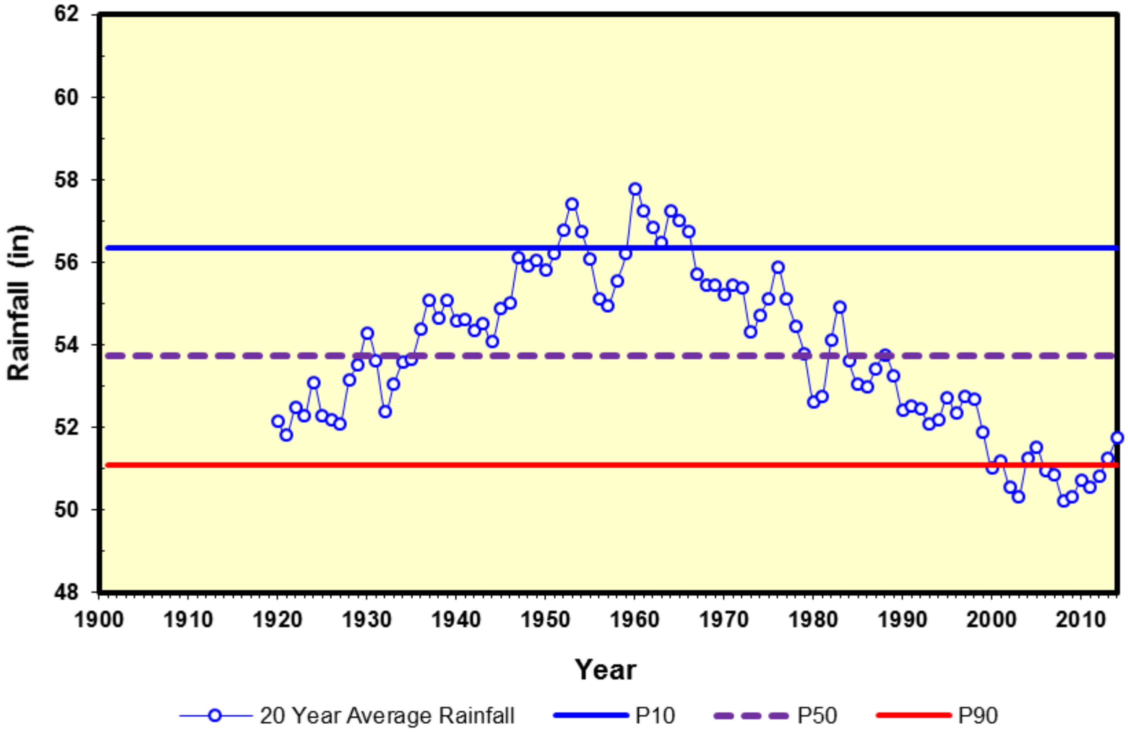


Figure 3-4. Annual departure in mean rainfall from 1930 through 2014 based on rainfall averaged from the Inverness, Ocala, and Brooksville NOAA rainfall stations (Note: 2012-2014 data from nearby SWFWMD rainfall stations). This figure is an update of Figure 4-8 included in the revised 2011 report.

While analyses of three-, six-, and ten-year moving averages of rainfall accumulated from the Ocala, Inverness, and Brooksville stations were presented in the revised 2011 report, long-term rainfall patterns can perhaps be better shown using a 20-year moving average of accumulated annual rainfall at the stations. The 20-year rainfall data for the period from 1930 through 2014 showed an increasing trend up until the mid-1960s and then a declining trend thereafter (Figure 3-5). This is consistent with multi-decadal cycles associated with the Atlantic Multidecadal Oscillation (AMO) (Kelly and Gore 2008). The 20-year moving average was below the bottom 10th percentile (P90) for most of the averages post-2000 (Figure 3-5). Recent 20-year periods (1994-2013 and 1995-2014) have increased and lie between the P90 and P50 percentiles.



Note: 2012-14 data from SWFWMD Headquarters, Inverness Pool, and Ocala Airport

Figure 3-5. Twenty-year moving average rainfall compared to the P10, P50, and P90 percentiles (1901-2014). Average rainfall based on records for the Inverness, Ocala, and Brooksville NOAA rainfall stations.

3.4 Water Budget

A water budget for the Gum Springs group was developed using the period-of-record mean base flow from Gum Slough Spring Run based on no change in storage for the period from October 2003 through August 2015. Base flow represents the total groundwater contribution for all springs in the group. Assuming that spring discharge is equivalent to recharge within the springshed, the estimated recharge to the Upper Floridan aquifer (UFA) would equal 44 mgd or 8.9 inches per year. Groundwater withdrawals in 2012 were estimated at 2.4 mgd (0.5 inches per year) and constituted about 5.6 percent of average recharge. These withdrawals were relatively small and dispersed throughout the springshed (Figure 3-6). The USGS estimates that, on average, only 45 percent of the groundwater withdrawn is consumptively-used due to septic tank leakage, return flows from irrigation, and reclaimed water disposal (Marella 2008). Applying this factor to the total groundwater withdrawn in the springshed, and conservatively assuming every gallon of consumptively-used water results in a gallon decline in springflow, this would equate to a flow decline of 2.5 percent due to withdrawals in the springshed. This is a conservative assumption, however, since water from the aquifer can come from changes in storage (water level decline), induced leakage from lakes and wetlands, reductions in evapotranspiration (ET), runoff, and groundwater seepage to lakes and rivers. For example, just a little over a one percent reduction in annual ET would account for all the water withdrawn from the springshed.

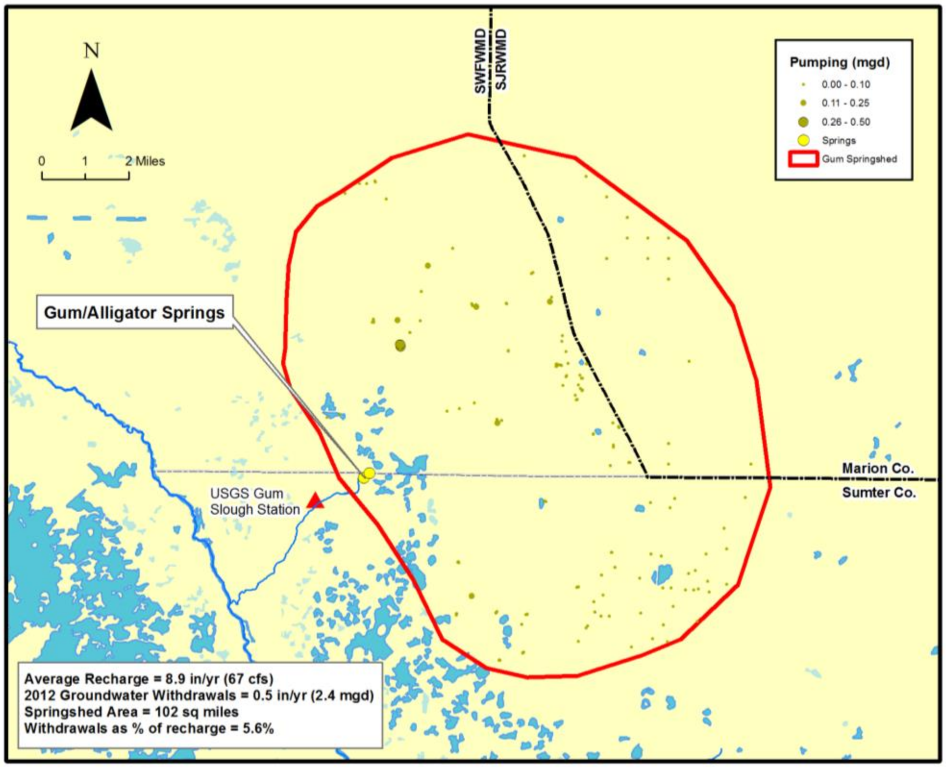


Figure 3-6. Water budget of Gum Springs contributing area (springshed) and distribution of groundwater withdrawals during 2012.

3.5 Numerical Model Results

This section is an update of Section 4.2.3 in the revised 2011 report. An updated numerical model was used to estimate drawdown in the aquifer and subsequently reduction in springflow due to groundwater withdrawals. The model estimated a three cfs average flow reduction at the slough measuring station or a 3.4 percent reduction in mean flow based on the period from 2003 through 2013.

3.5.1 Northern District Model Updates

The Northern District groundwater flow model (NDM) was developed in 2008 by the consulting firm HydroGeoLogic, Inc. (HGL 2008), and this model was used for the revised 2011 report. Since that time, there have been several refinements to the original model, including Version 2.0 in 2010 (HGL 2010), Version 3.0 in 2011 (HGL 2011a, 2011b), and Version 4.0 in 2013 (HGL 2013). Version 4.0 includes an expanded model grid that was extended northward and eastward. Development of this latest version of the model was a cooperative effort between the St. Johns River Water Management District (SJRWMD), SWFWMD, Marion County, and the Withlacoochee River Regional Water Supply Authority. The domain of the NDM includes portions of the SWFWMD, the SJRWMD, and the Suwannee River Water Management District (SRWMD). The model encompasses the entire Central West-Central Florida Groundwater Basin (CWCFGWB) and the Northern West-Central Florida Groundwater Basin (NWCFGWB) and also includes portions of the Northern East-Central Florida Groundwater Basin (SWFWMD 1987). The eastern boundary of the regional groundwater flow model extends to the St. Johns River. The western boundary of the model domain extends approximately five miles offshore of the Gulf of Mexico (Figure 3-7).

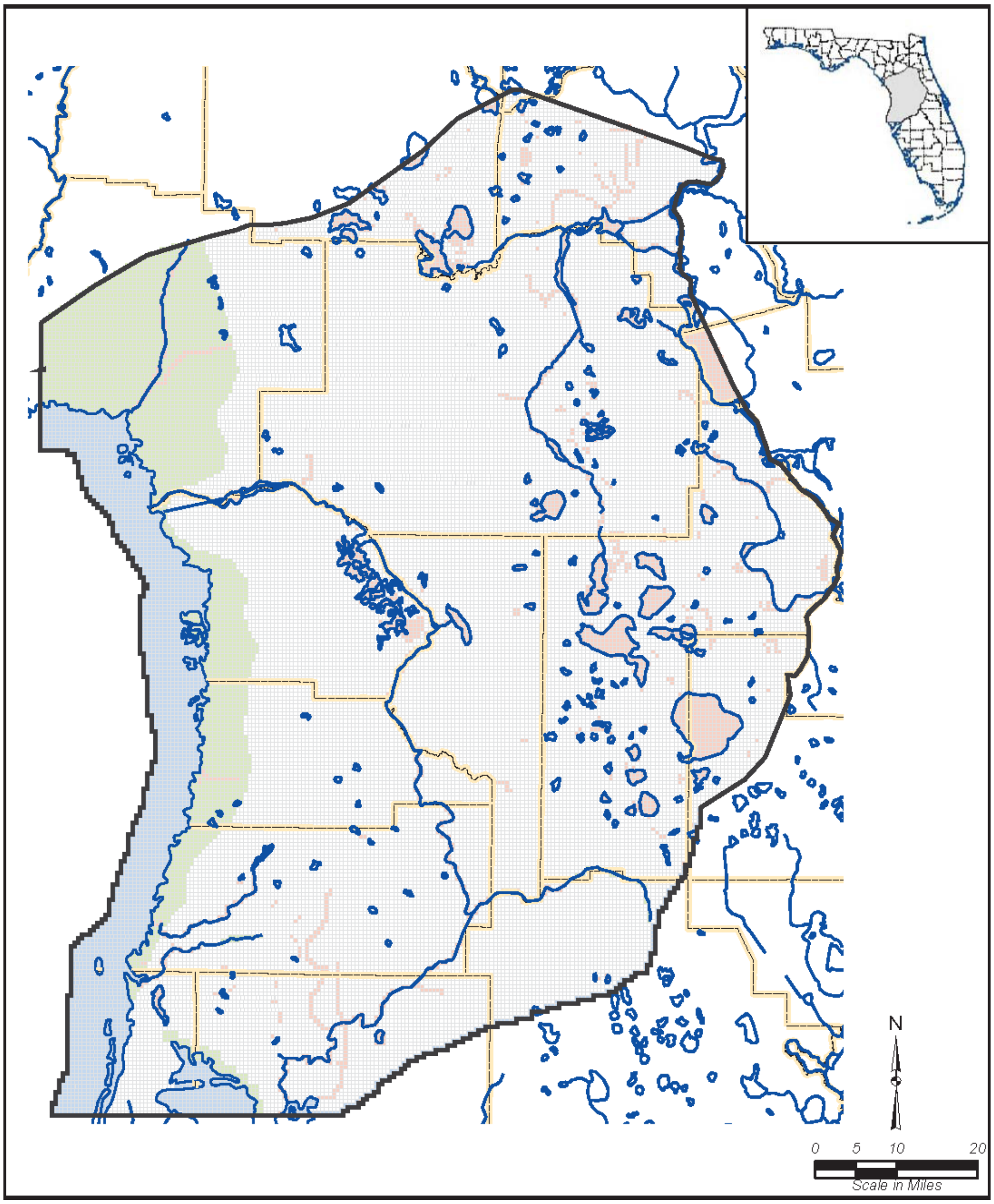


Figure 3-7. Groundwater grid in the Northern District Model (Version 4.0). This figure is an update of Figure 4-12 included in the revised 2011 report.

3.5.2 NDM Scenario

In the revised 2011 report, 2005 groundwater withdrawals were simulated in the NDM to determine drawdown in the UFA and potential impacts to the flow in Gum Slough Spring Run. In the update discussed below, 2010 groundwater withdrawals were simulated in the NDM.

To determine potential impacts to Gum Slough Spring Run flow, 2010 groundwater withdrawals were simulated in the NDM under long-term transient conditions (five years) and compared to pre-pumping conditions (zero withdrawals) by running the model one year under transient conditions. Heads in the UFA and springflows generated at the end of the 2010 simulation were subtracted from UFA heads and springflows at the end of the pre-pumping simulation to determine aquifer drawdown and flow changes. A total of 461 mgd of groundwater withdrawals occurred within the 10,000-square-mile NDM domain in 2010. The magnitude and spatial distribution of 2010 withdrawals based on District data and water use estimated from the SJRWMD in the NDM are shown in Figure 3-8.

Gum Springs discharge is represented in the NDM as the total of Gum Main Spring and Alligator Spring. Other springs of the Gum Slough Group were not simulated in the NDM. Similar to the 2005 conditions described in the revised 2011 report, the model predicts UFA drawdown of less than 0.25 feet from pre-pumping to 2010 conditions at Gum and Alligator Springs. The predicted reduction in the combined flow of Gum and Alligator Springs was 4.8 percent, compared to the 5.2 percent flow reduction reported previously based on 2005 conditions. Recent water use estimates suggest that current groundwater withdrawals are less than they were in 2010. For example, in Marion and Sumter Counties, the total amount of groundwater withdrawn declined from 105.5 mgd in 2010 to 98.6 mgd in 2013, the most recent year with available estimated and metered water use.

The mean base flow based on observed period-of-record data for Gum Slough from October 2003 through September 2013 was 63 cfs; therefore, a 4.8 percent flow reduction due to groundwater withdrawals would equal three cfs (Table 3-1). The mean observed streamflow, e.g., the combination of base flow and overland flow, for Gum Slough was 88 cfs for the period from October 2003 through September 2013. A three cfs reduction in Gum Slough discharge would, therefore, equate to a 3.4 percent reduction in streamflow for the period through September 2013 at the Gum Springs near Holder USGS gaging station. This 3.4 percent withdrawal-related flow reduction is similar but slightly less than the four percent impact on flows at the gage station that was estimated based on data for the period from 2003 through 2010 and was previously used to support development of the minimum flow recommendations included in the revised 2011 report.

Table 3-1. Summary of model results for the updated period 2003-2013.

Variable	Value
NDM Drawdown (feet)	<0.25
Average Base Flow Reduction (Percent)	4.8
Average Base Flow (cfs)	63
Stream Flow Reduction (cfs)	3
Average Total Stream Flow (cfs)	88
Average Total Flow Reduction (Percent)	3.4

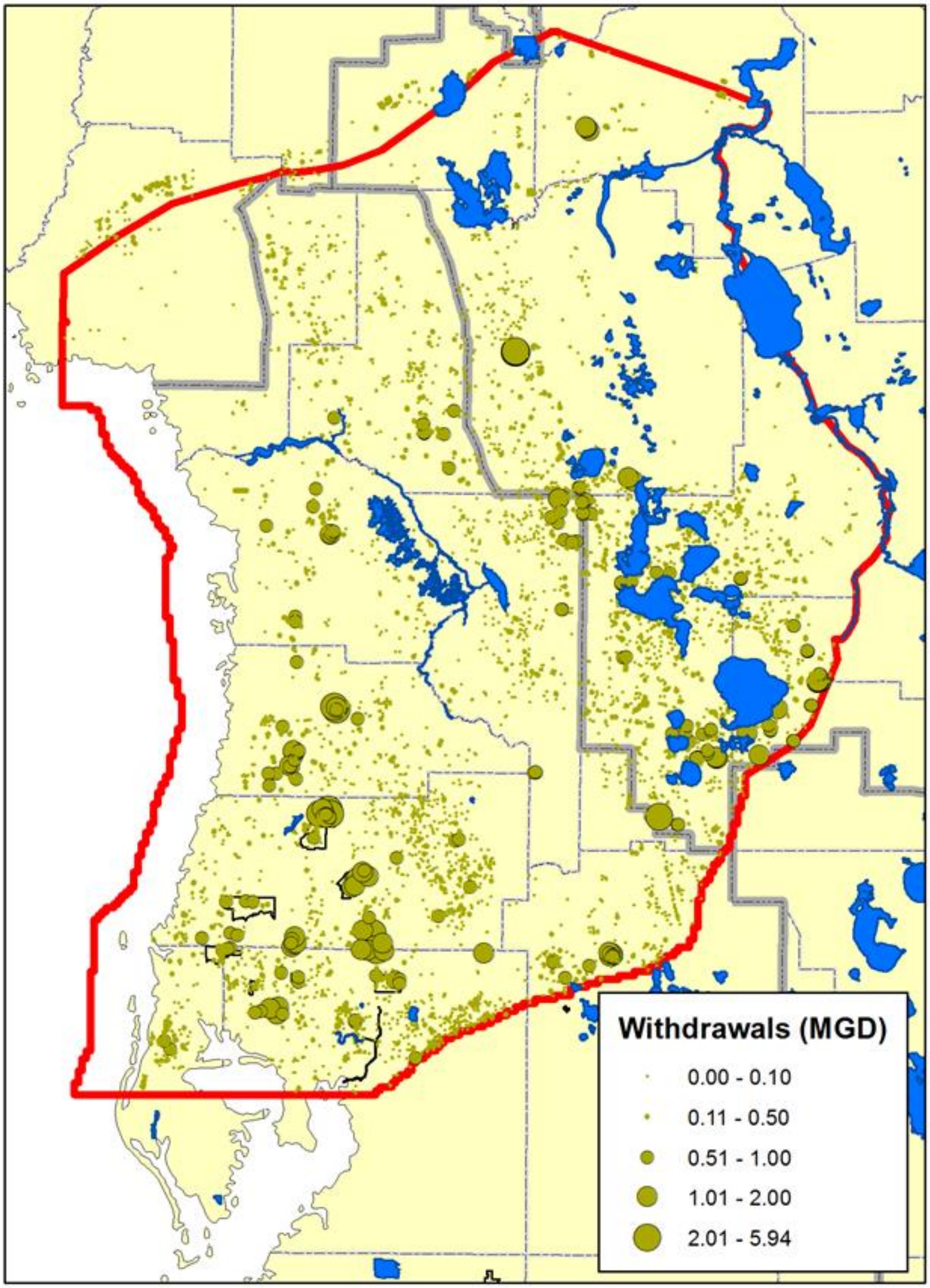


Figure 3-8. Magnitude and distribution of groundwater withdrawals in the UFA in 2010 within the Northern District Model (Version 4) domain. This figure updates Figures 4-3 and 4-13 included in the revised 2011 report.

CHAPTER 4 – WATER QUALITY

As mentioned in Chapter 2 of this document, nutrient levels, specifically nitrite and nitrate nitrogen (NO_x-N), have been increasing in many springs systems within the District in recent years, including Gum Slough Spring Run. The source has been attributed mostly to the application of inorganic fertilizer (Phelps 2004). In addition to the increases in NO_x-N concentrations, the discharge of many Florida springs systems has been declining since the 1960s (Heyl 2012). While water quality issues typically do not apply to water quantity decisions, such as MFLs, this issue has received considerable attention. Therefore, the relationship between NO_x-N levels and minimum flows has been investigated in several springs systems within the District, including Gum Slough Spring Run, since the revised 2011 report was completed (Heyl 2012).

Because of the importance of this issue, the analysis of the relationship between flow and NO_x-N levels for the Gum Slough Springs group is briefly summarized in this section. Water quality data for Gum Springs (Vents 1, 2, 3, 4, and Main) from the District's Water Management Information System (WMIS) database and discharge data from the USGS Gum Springs near Holder gage from October 2003 through January 2012 was used for this analysis. Temporal trends in discharge and NO_x-N concentration for Gum Slough Springs Run for that time period are shown in Figure 4-1.

To evaluate the relationships and changes in spring flow and NO_x-N concentrations for the Gum Slough Springs group, each trend was evaluated in the context of the other (Heyl 2012). For this analysis, the influence of one predictor variable was systematically removed before testing the other predictor variable. First, NO_x-N was specified as the response variable, discharge was selected as the predictor variable, and a LOWESS (Locally Weighted Scatterplot Smoothing) (see Helsel and Hirsch 1992) was calculated. The output included observed NO_X-N values, the LOWESS-predicted NO_X-N values, and the differences, termed "residuals." The residuals represent the concentration of NO_X-N that cannot be explained by flow; in other words, the "effect" of flow was removed from the time series of NO_X-N values. The residuals were then plotted against time (Figure 4-2, left panel) and were determined to be significantly related to time, indicating that the NO_X-N concentration that cannot be explained by flow increased with time. Time was then selected as the predictor variable, and the evaluation was repeated. In that case, the variation in NO_X-N that can be explained by time was removed and the residuals tested for a significant relationship with flow. The results (Figure 4-2, right panel) indicate that once the time effect has been removed, the relationship between NO_X-N concentration and flow was not significant.

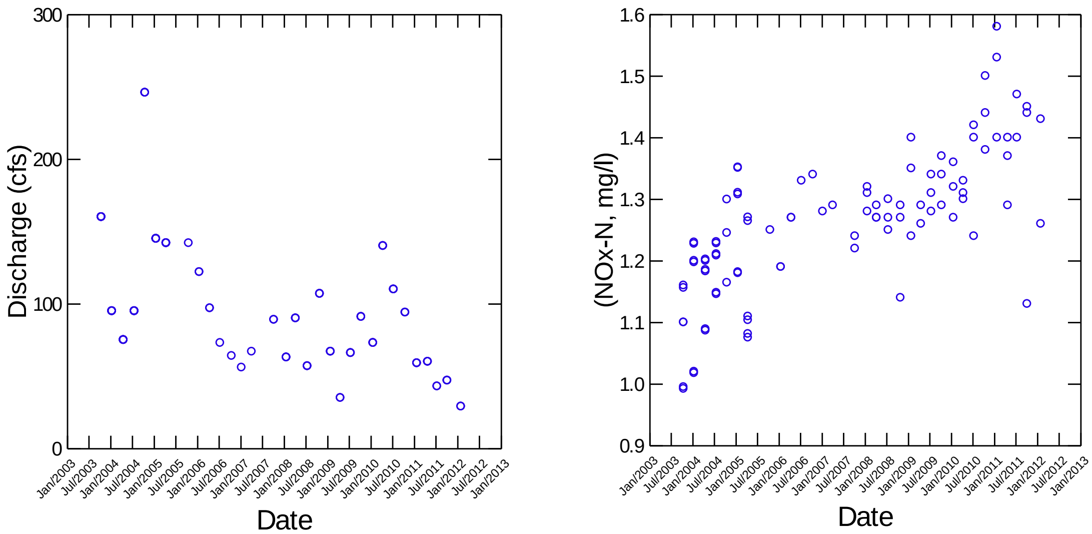


Figure 4-1. Discharge (left panel) and NOx-N concentration (right panel) for Gum Slough Springs Run as a function of date (reproduced from Heyl 2012).

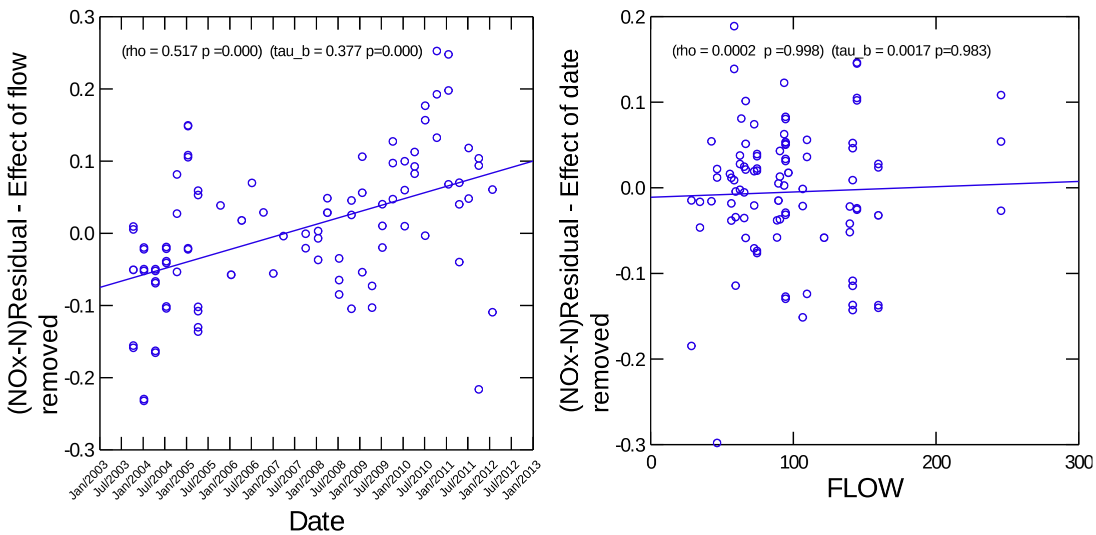


Figure 4-2. Residual plots for Gum Slough Springs Run. NOx-N concentration unaccounted for by flow is significantly related to date (left panel), while NOx-N concentration unaccounted for by date is not significantly related to flow (right panel) (reproduced from Heyl 2012).

CHAPTER 5 – TECHNICAL APPROACH FOR ESTBALISHING MINIMUM FLOWS FOR GUM SLOUGH SPRING RUN

The same technical approach for establishing proposed minimum flows for Gum Slough Spring Run described in the revised 2011 report was used to support the development of revised minimum flow recommendations that are presented in this report addendum. The revised minimum flow recommendations were, however, developed using an updated flow record for the period from October 2003 through September 2013. This updated flow record includes three additional years of data (October 2010 through September 2013) as compared to the previously used record.

As was the case for the minimum flow analyses described in the revised 2011 report, the updated flow record was based on observed flows at the USGS Gum Springs near Holder gage station that were modified to account for groundwater withdrawal effects. Although the updated hydrological modeling indicated that withdrawals resulted in an average 3.4 percent reduction in streamflow at the gaging station for the period from 2003 through 2013 (compared to a four percent reduction included in the revised 2011 report), in order to take a conservative approach, the original four percent impact value was used for updating the PHABSIM modeling, as described in the following section of this addendum.

The updated flow record, along with the original four percent impact value, was also used to conduct updated simulations of the Hydrologic Engineering Centers River Analysis System (HEC-RAS) model. The updated model results revised the flows associated with maintaining fish passage along the spring run, the inundation of the stream channel, and the long-term inundation of instream woody habitats; the revised results are described in this chapter.

Data collected during a synoptic study of Gum Slough Spring Run conducted since the revised 2011 report was completed (Wetland Solutions, Inc. 2011) provided information for an additional criterion to support the development of minimum flows. This additional criterion examines the effect of changes in flow of the Gum Slough Springs Run on the ecosystem metabolism, an estimate of the overall biological function, of the system and is described in the last section of this chapter.

5.1 Evaluation of Instream Habitat for Fish and Macroinvertebrates Using the Physical Habitat Simulation Model

In their review of the District's minimum flow methods, Gore et al. (2002) suggested the use of procedures that link biological preferences for hydraulic habitats with hydrological and physical data. Specifically, Gore et al. (2002) endorsed use of the PHABSIM model, a component of the Instream Flow Incremental Methodology (Bovee et al. 1998), and its associated software for determining changes in habitat availability associated with changes in flow. Following this recommendation, the PHABSIM model has been used for development of minimum flows for numerous District rivers and was used to support development of minimum flow recommendations for Gum Springs Slough Run.

This section includes revisions to the PHABSIM site and cross-section selection and modeling methodology that were described in the revised 2011 report in Sections 7.2.1 and 7.6.2, and the PHABSIM appendix.

5.1.1 PHABSIM Cross-Sections

For PHABSIM modeling, cross-sections were established at four representative sites to quantify specific habitats for fish and macroinvertebrates within Gum Spring Slough Run at differing flow conditions. Based on the geomorphology of the spring run channel and to ensure adequate representation of the river corridor, the selected PHABSIM sites included runs, shoals, and a pool. Shoals were included because these features represent relatively slower velocity but turbulent flow zones, and loss or reduction of hydraulic connection at these locations during low-flow periods may also present barriers to fish migration or hamper recreational use. Field reconnaissance of shoals within the entire study reach was conducted to aid in the selection of PHABSIM sites. Pools and runs were included in the PHABSIM sites based on their common occurrence in the spring run.

Since the locations of the four PHABSIM sites were not presented in the revised 2011 report, they are shown in Figure 5-1 and described as follows. Three of the PHABSIM sites were co-located at cross-section sites used for characterization of floodplain vegetation/soils/hydrologic indicators and instream woody habitats. The Headspring site is a shoal that is co-located with the Vegetation 1 cross-section (see Figures 7-2 and 7-3 in the revised 2011 report). The Shoal site is a shoal co-located with the Vegetation 6 cross-section, and the USGS site is a pool co-located with the Vegetation 8 cross-section. The Springhole site is a run located about 150’ upstream from the Shoal site (Figure 5-1).

The PHABSIM analyses required acquisition of field data concerning channel habitat composition and hydraulics. At each PHABSIM site, tag lines were used to establish up to three cross-sections corresponding to shoal, run, and pool habitats, as applicable, across the channel to the top of bank on either side of the spring run. At each cross-section, stream depth, substrate type, and habitat/cover were recorded, and water velocity was measured with a StreamPro Acoustic Doppler Current Profiler and/or a Sontek Flow Tracker Handheld Acoustic Doppler Velocimeter at intervals determined based on cross-section width. Interval selection was based on collecting a minimum of 20 sets of measurements per cross section. Other hydraulic descriptors measured included channel geometry (river bottom-ground elevations), water surface elevations across the channel, and water surface slope determined from points upstream and downstream of the cross-sections. Elevation data were collected relative to temporary bench marks that were subsequently surveyed by District surveyors to establish absolute elevations, relative to the North American Vertical Datum of 1988 (NAVD 88). Data were collected under a range of flow conditions (low, medium, and high flows) to provide information needed to run the PHABSIM models for each site.

5.1.2 PHABSIM Modeling

Hydraulic modeling for the PHABSIM analysis was conducted using the hydraulic and physical data described in the preceding section (Section 5.1.1) of this addendum and the IFG4 component of the suite of PHABSIM models to predict changes in velocity in individual cells of the channel cross-sections as water surface elevation changes. Predicted velocity values were then used with the Habitat Suitability Curves described in the next section of this addendum in an additional PHABSIM routine (HABTAT) to determine cell-by-cell the amount of weighted usable area (WUA) or habitat available for various organisms and habitat-base guilds as a function of discharge (refer to Figure 7-4 in the revised 2011 report).

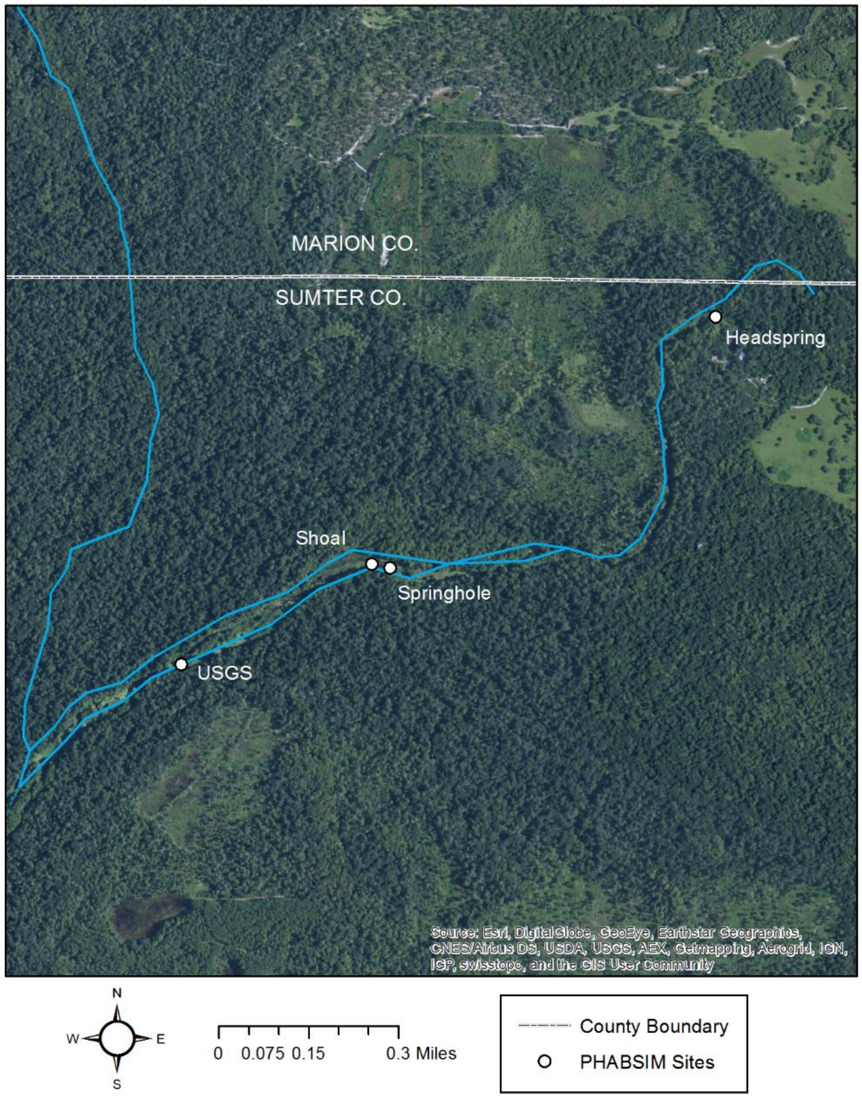


Figure 5-1. Location of the four PHABSIM transect sites in Gum Slough Spring Run.

The relationships between hydraulic conditions and WUA were then used to evaluate potential flow-related habitat losses and gains relative to the WUA values associated with the updated, modified October 2003 through September 2013 flow record. This assessment was accomplished using the Time Series Library time series analysis routine (Milhous et al. 1990), the updated flow records, and flow records corresponding to 10, 20, 30, and 40 percent reductions to the updated record. Figure 7-5 in the revised 2011 report shows an example of potential habitat gains and losses, e.g., changes in WUA relative to flow reductions of 10, 20, 30, and 40 percent for a specific habitat-based fish guild.

The PHABSIM suite of models do not specifically identify acceptable amounts of habitat loss or gain for any given species, taxonomic group, or other criterion. Rather, given hydrologic data and habitat preferences, the model system can be used for minimum flow purposed to establish relationships between hydrology and WUA for target species or other criteria, and allows examination of habitat availability in terms of the historic, e.g., non-withdrawal impacted, and altered flow regimes. The amount of potential habitat loss, or deviation from the optimum, that a water body is capable of withstanding that is determined from these data is based on professional judgment. Gore et al. (2002) provided guidance regarding this issue, suggesting that "[*i]n general, instream flow analysts consider a loss of more than 15 percent habitat, as compared to undisturbed or current conditions, to be a significant impact on that population or assemblage.*" For purposes of minimum flows development, the District has defined withdrawal related percent-of-flow reductions that result in greater than a 15 percent reduction in available habitat from historic or non-withdrawal impacted conditions as limiting factors that can be used for developing minimum flows. The appendices to the revised 2011 report include additional information concerning simulation of hydraulic conditions for the river that were used with Habitat Suitability Curves and discharge data to evaluate changes in WUA associated with changes in flow for various organisms and habitat-based guilds.

5.1.2.1 Development of Habitat Suitability Curves

Habitat suitability criteria used the 18 functional and taxonomic groups assessed using PHABSIM modeling included continuous variable or univariate curves designed to encompass the expected range of suitable conditions for water depth, water velocity, and substrate/cover type and proximity. Habitat suitability curves are generally classified into three categories based on the types of data and data summarization approaches used for their development (Waddle 2012).

Type I curves are not dependent upon acquisition of additional field-data but are, instead, based on personal experience and professional judgment. Informal development of Type I curves typically involves a roundtable discussion (Scheele 1975); stakeholders and experts meet to discuss habitat suitability information to be used for prediction of habitat availability for specific target organisms. A more formal process, known as the Delphi technique (Zuboy 1981), involves submission of a questionnaire to a large respondent group of experts. Results from this survey process are summarized by presenting a median and interquartile range for each variable. Several iterations of this process must be used in order to stabilize the responses, with each expert being asked to justify why his/her answer may be outside the median or interquartile range when presented the results of the survey. The Delphi system lacks the rapid feedback of a roundtable discussion, but does remove the potential biases of a roundtable discussion by creating anonymity of expert opinion. The Delphi system does assume that experts are familiar with the creation of habitat suitability criteria and can respond with sufficient detail to allow development of appropriate mathematical models of habitat use.

Type II curves are based upon frequency distributions for use of certain variables (e.g., flow), which are measured at locations utilized by the target species. Curves for numerous species have been published by the United States Fish and Wildlife Service (USFWS) or the USGS and are commonly referred to as "blue book" criteria.

Type III curves are derived from direct observation of the utilization and/or preference of target organisms for a range of environmental variables (Manly et al. 1993). These curves are weighted by actual distribution of available environmental conditions in the stream (Bovee et al. 1998). Type III curves assume that the optimal conditions will be "preferred" over all others if individuals are presented equal proportions of less favorable conditions (Johnson 1980).

Based on the abundance and distribution of the spotted sunfish (*Lepomis punctatus*) in rivers within the District, including Gum Slough Spring Run, modified Type III habitat suitability curves were created for adult, juvenile, spawning, and fry life stages of this species and used for evaluating habitat availability at the Gum Slough Spring Run PHABSIM sites. Development of these curves involved the initial creation of Type I curves that were subsequently modified based on field sampling efforts. Initially, since most of the regional experts in fish ecology that were consulted were unfamiliar with development of habitat suitability criteria, a hybrid of the roundtable and Delphi techniques was used to develop Type I curves for the species. For this effort, a proposed working model of habitat suitability criteria was provided to 14 experts for evaluation. The proposed suitability curves were based on flow criteria reported by Aho and Terrell (1986) for another member of the Family Centrarchidae, the redbreast sunfish (*Lepomis auritus*), that were modified according to published literature on the biology of spotted sunfish. Respondents were given approximately 30 days to review the proposed habitat suitability criteria and to suggest modifications. Six of the 14 experts provided comments. In accordance with Delphi techniques, the suggested modifications were incorporated into the proposed Type I curves. Suggested modifications that fell outside of the median and 25% interquartile range of responses were not considered unless suitable justification could be provided. The resulting Type I curves were later modified following fish sampling conducted on the Peace River. Data obtained from these field collections were considered sufficient to classify the modified curves as Type II to Type III curves.

Modified Type II habitat suitability criteria for adult, juvenile, spawning, and fry life stages of largemouth bass (*Micropterus salmoides)* and bluegill (*Lepomis macrochirus*), two other common fish species in Gum Slough Spring Run (Wetland Solutions, Inc. 2011), were established using USFWS/USGS “blue book” criteria (Stuber et al. 1982). Curves for these species have been widely used in PHABSIM model applications and were used for the Gum Slough Spring Run PHABSIM analyses.

Type III habitat suitability criteria for macroinvertebrate community diversity were established based on suitability curves published by Gore et al. (2001). Modified substrate and cover codes used for criteria development were established through consultation with District and Florida Fish and Wildlife Conservation Commission staff. For this effort, emphasis was placed on invertebrate preference for macrophytes, inundated woody snags and exposed root habitats common in Gum Slough Spring Run and other Florida streams.

A Type II habitat suitability curve for combined adult life stages of minnows (the Family Cyprinidae) was developed based on electrofishing conducted at several Florida Rivers. The sampling involved quantification of all cyprinid minnows, without segregation by species, in association with observed flow velocities, water depth, and substrate types. The curve is, therefore, based on total occurrence of cyprinids in the sampled Florida systems. It may be considered a generalized curve applicable for all Cyprinidae and could certainly be refined for individual taxa or for specific water bodies based on data availability. This generalized curve was considered suitable for use in the PHABSIM analyses for Gum Spring Slough Run.

Type III curves developed for a suite of habitat guilds representative of fish habitat diversity were also used for the PHABSIM analyses for Gum Slough Spring Run. The habitat guild curves include shallow-slow, shallow-fast, deep-slow, and deep-fast guilds and serve as generalized indicators of habitat diversity associated with ranges of flow velocity, water depth, and substrate type. They are used to improve understanding of results based on taxon-specific curves and to address potential habitat changes for taxa currently lacking specific life-history stage curves. The habitat guild criteria are based on information developed by Leonard and Orth (1988) for a suite of fish and habitat types occurring in a number of streams in Virginia. Their use for Gum Slough Spring

Run and other Florida systems is considered appropriate as they specify habitat characteristics that are expected to be populated by local fish fauna.

5.2 Updated PHABSIM Modeling Results

Inclusion of the three additional years of flow records (2010-2013) in the PHABSIM model runs yielded modeled gains and losses in habitat availability for 18 functional and taxonomic groups associated with changes in discharge from the non-withdrawal impacted, historical conditions that differed from those reported in the revised 2011 report. Tables 5.1 and 5.2 include the revised modeling results and replace Figure 7-5 included in Section 7.6.2 of the revised 2011 report, as well as the graphics presented in the PHABSIM Appendix.

For all PHABSIM sites combined, the decrease of available, suitable habitat as a result of flow reductions in Gum Slough Spring Run was greatest for adult spotted sunfish. For example, the largest decrease of available habitat for adult spotted sunfish as a result of a 10 percent reduction in flow (almost 24 percent) occurred in July (Table 5.2).

A study characterizing the ecosystem of Gum Slough Spring Run conducted since the revised 2011 report was completed demonstrates that the guilds and species selected for the PHABSIM modeling were appropriate (Wetland Solutions, Inc. 2011). For example, sunfish, including largemouth bass, bluegill, and spotted sunfish, and minnows were typically the species most often observed during fish surveys of the spring run from October 2010 through September 2011.

Table 5-1. PHABSIM modeling results (habitat for all sites combined) of habitat gains/losses for the shallow-slow, shallow-fast, deep-slow, and deep-fast habitat guilds; adult, juvenile, spawning, and fry largemouth bass; and adult bluegill for Gum Slough Spring Run based on 10, 20, 30, and 40 percent reductions in flow from 2003 through 2013 corrected for withdrawal impacts. This table is an update of the information presented in Figure 7-5 included in the revised 2011 report, as well as the graphics presented in the PHABSIM Appendix.

Flow Reduction (Percent)	Percent Change in Habitat Availability								
	Shallow-Slow Habitat Guild	Shallow-Fast Habitat Guild	Deep-Slow Habitat Guild	Deep-Fast Habitat Guild	Adult Largemouth Bass	Juvenile Largemouth Bass	Spawning Largemouth Bass	Largemouth Bass Fry	Adult Bluegill
January									
10	13.7	5.1	-2.6	-4.2	-2.9	1.2	-5.9	-7.4	-4.0
20	21.6	7.9	-5.8	-8.9	-5.9	2.8	-13.0	-18.2	-8.8
30	26.1	9.9	-9.6	-14.8	-9.5	4.3	-21.5	-33.2	-15.0
40	48.7	10.7	-13.8	-22.9	-12.9	5.2	-30.0	-46.3	-21.6
February									
10	13.1	4.2	-2.8	-3.9	-2.9	1.4	-6.4	-8.7	-4.1
20	11.5	6.1	-6.2	-8.6	-5.9	3.0	-14.1	-22.1	-9.0
30	17.6	6.7	-10.2	-15.6	-10.0	4.2	-23.6	-38.2	-16.6
40	34.1	8.6	-13.7	-24.1	-13.0	5.2	-32.4	-53.0	-22.9
March									
10	2.1	3.6	-2.6	-3.2	-2.9	1.6	-6.2	-8.9	-4.1
20	2.5	7.3	-5.2	-8.7	-6.5	2.8	-14.9	-24.1	-10.3
30	14.4	9.1	-8.3	-15.3	-9.8	4.3	-23.7	-40.4	-16.3
40	29.4	9.3	-13.6	-23.9	-12.9	4.9	-31.0	-49.3	-22.4
April									
10	6.2	4.2	-2.7	-3.8	-3.4	1.5	-7.1	-11.0	-5.5
20	9.2	6.7	-5.7	-8.8	-6.2	3.4	-14.8	-24.9	-9.8
30	20.6	7.9	-9.6	-15.3	-9.4	4.8	-22.4	-36.6	-15.2
40	42.3	9.8	-14.7	-24.5	-12.3	4.9	-29.3	-43.7	-21.2

Flow Reduction (Percent)	Percent Change in Habitat Availability								
	Shallow-Slow Habitat Guild	Shallow-Fast Habitat Guild	Deep-Slow Habitat Guild	Deep-Fast Habitat Guild	Adult Largemouth Bass	Juvenile Largemouth Bass	Spawning Largemouth Bass	Largemouth Bass Fry	Adult Bluegill
May									
10	5.9	2.7	-2.8	-4.2	-3.1	1.3	-7.1	-11.4	-4.5
20	12.6	4.6	-6.1	-9.2	-5.9	2.7	-14.3	-23.4	-9.1
30	22.6	6.6	-6.5	-16.3	-9.2	3.3	-21.7	-33.8	-15.0
40	37.5	6.8	-11.4	-25.5	-12.9	3.2	-28.9	-43.8	-22.1
June									
10	3.7	2.3	-2.9	-3.9	-3.3	1.3	-7.0	-11.9	-5.1
20	13.4	4.4	-4.6	-9.6	-6.3	2.4	-14.8	-25.2	-10.1
30	21.8	5.9	-9.2	-16.4	-9.3	3.1	-21.9	-36.2	-15.6
40	38.8	6.3	-13.1	-26.1	-13.3	2.7	-29.4	-45.1	-23.5
July									
10	8.4	3.9	-2.7	-3.5	-2.7	1.7	-6.5	-11.6	-3.7
20	13.8	6.3	-4.2	-7.9	-6.0	3.1	-14.1	-23.5	-9.1
30	23.8	8.1	-8.5	-14.9	-9.3	4.2	-22.6	-37.7	-15.1
40	40.9	10.3	-13.9	-23.8	-12.9	4.5	-30.4	-48.6	-22.2
August									
10	13.8	5.2	-2.3	-3.5	-2.9	1.7	-6.1	-8.1	-3.5
20	31.3	9.2	-5.4	-7.8	-5.8	3.4	-12.8	-18.5	-7.6
30	42.9	12.8	-9.3	-13.7	-9.2	4.8	-20.8	-30.8	-13.5
40	56.0	14.3	-14.2	-21.8	-13.2	5.9	-30.1	-45.8	-21.4
September									
10	16.8	7.3	-1.4	-1.9	-2.6	2.5	-5.1	-6.0	-2.2
20	35.9	14.2	-3.9	-5.7	-5.0	4.6	-10.8	-13.4	-4.6
30	56.0	20.6	-7.2	-10.4	-8.7	6.3	-17.5	-21.9	-9.9
40	78.1	27.0	-11.8	-17.3	-12.4	7.9	-26.2	-35.5	-16.6

Flow Reduction (Percent)	Percent Change in Habitat Availability								
	Shallow-Slow Habitat Guild	Shallow-Fast Habitat Guild	Deep-Slow Habitat Guild	Deep-Fast Habitat Guild	Adult Largemouth Bass	Juvenile Largemouth Bass	Spawning Largemouth Bass	Largemouth Bass Fry	Adult Bluegill
October									
10	17.5	8.3	-1.4	-1.4	-2.3	2.7	-4.9	-6.9	-1.3
20	36.8	16.9	-3.7	-4.2	-5.1	4.9	-10.5	-13.9	-4.2
30	49.1	23.2	-6.9	-9.1	-8.5	6.7	-17.4	-22.4	-9.2
40	54.6	23.9	-10.8	-15.4	-12.7	8.8	-26.5	-37.8	-16.1
November									
10	18.9	6.8	-1.7	-2.1	-2.8	2.2	-5.1	-6.3	-2.7
20	43.5	14.0	-4.3	-5.9	-5.3	3.9	-10.9	-13.1	-5.4
30	54.1	19.2	-7.7	-10.8	-8.8	5.7	-17.7	-23.2	-10.8
40	72.29	21.8	-12.4	-18.3	-12.9	6.9	-27.1	-38.6	-18.1
December									
10	14.9	5.7	-2.3	-3.1	-2.5	1.7	-5.3	-6.8	-2.9
20	27.2	10.4	-5.2	-7.4	-5.5	3.3	-11.8	-15.7	-7.3
30	33.1	12.9	-8.9	-13.3	-9.0	4.8	-19.9	-28.9	-13.2
40	55.6	14.6	-13.8	-20.9	-12.9	5.9	-28.9	-43.9	-20.5

Table 5-2. PHABSIM modeling results (habitat for all sites combined) of habitat gains/losses for juvenile, spawning, and fry bluegill; adult, juvenile, spawning, and fry spotted sunfish; benthic macroinvertebrates; and Cyprinidae for Gum Slough Spring Run based on 10, 20, 30, and 40 percent reductions in flow from 2003 through 2013 corrected for withdrawal impacts. This table is an update of the information presented in Figure 7-5 included in the revised 2011 report, as well as the graphics presented in the PHABSIM Appendix.

Flow Reduction (Percent)	Percent Change in Habitat Availability								
	Juvenile Bluegill	Spawning Bluegill	Bluegill Fry	Adult Spotted Sunfish	Juvenile Spotted Sunfish	Spawning Spotted Sunfish	Spotted Sunfish Fry	Benthic Macroinvertebrates	Cyprinidae
January									
10	5.9	3.7	-0.9	-10.7	5.9	6.5	6.4	21.9	5.6
20	11.1	6.2	-3.9	-25.3	12.9	13.9	14.2	40.5	10.9
30	16.0	9.4	-7.2	-38.5	20.7	21.9	22.9	62.0	16.3
40	20.9	10.8	-12.9	-49.9	28.5	30.1	32.7	96.7	22.8
February									
10	4.8	2.6	-2.7	1.5	6.3	6.5	6.7	16.7	5.0
20	8.9	5.6	-4.8	-28.7	13.5	13.9	14.3	28.6	9.6
30	12.9	7.9	-10.2	-38.7	21.0	21.8	23.3	50.7	14.7
40	17.2	9.9	-16.0	-54.3	28.6	29.7	32.8	84.9	21.1
March									
10	4.4	2.4	-0.8	-7.0	6.4	6.6	6.2	8.7	4.4
20	8.6	5.2	-4.4	-23.9	12.9	13.5	13.7	25.3	9.4
30	12.9	8.6	-10.6	-41.3	21.1	21.9	23.1	47.4	14.9
40	17.2	11.2	-14.6	-59.9	27.6	28.9	31.6	78.8	21.0
April									
10	4.7	3.3	-2.8	-10.8	6.5	7.0	6.9	15.2	4.8
20	9.7	6.8	-5.5	-27.7	14.3	15.2	15.6	30.5	10.2
30	15.1	10.1	-10.0	-43.4	21.4	23.0	24.2	55.9	15.9
40	20.7	11.0	-12.6	-50.4	26.7	29.2	31.8	100.2	22.8
	Percent Change in Habitat Availability								

Flow Reduction (Percent)	Juvenile Bluegill	Spawning Bluegill	Bluegill Fry	Adult Spotted Sunfish	Juvenile Spotted Sunfish	Spawning Spotted Sunfish	Spotted Sunfish Fry	Benthic Macroinvertebrates	Cyprinidae
May									
10	4.1	2.9	-3.6	-1.6	6.0	6.5	6.5	12.8	4.4
20	8.7	4.8	-4.8	-20.5	12.7	13.4	13.7	26.9	8.9
30	13.1	7.0	-9.5	-41.8	18.3	19.6	20.5	49.9	14.1
40	17.3	9.2	-12.5	-54.9	23.2	24.9	27.6	80.8	19.4
June									
10	3.9	3.1	-1.9	-4.9	5.9	6.1	6.1	9.5	3.7
20	8.2	5.4	-5.2	-13.0	12.4	12.7	13.3	25.3	8.4
30	11.9	6.9	-9.4	-38.6	18.1	18.6	20.2	43.3	13.1
40	15.6	8.8	-13.3	-46.2	22.4	23.3	26.9	72.6	18.4
July									
10	5.1	2.9	-1.6	-23.6	6.9	7.1	6.9	12.5	4.8
20	9.6	5.9	-4.5	-22.6	14.1	14.4	14.4	25.2	9.3
30	14.2	7.9	-9.1	-45.3	21.2	21.7	22.8	46.8	14.8
40	17.9	9.6	-14.1	-50.5	27.3	27.8	31.2	75.7	20.8
August									
10	6.8	3.7	-1.6	-15.1	6.9	7.6	7.3	21.9	5.9
20	12.9	6.5	-3.9	-21.5	14.9	15.9	15.6	46.2	11.9
30	18.3	9.9	-6.7	-31.2	22.7	23.9	24.2	74.5	18.1
40	22.7	12.0	-12.7	-43.4	30.8	32.3	34.4	108.9	24.6
September									
10	9.1	4.9	0.1	-6.9	8.9	10.0	8.6	21.9	7.1
20	17.9	9.3	-0.5	-22.7	17.5	19.6	17.3	56.8	14.9
30	25.9	12.9	-2.2	-24.9	26.1	28.9	26.5	93.8	22.1
40	33.1	16.4	-6.5	-45.3	36.1	39.5	37.9	137.7	29.9

Flow Reduction (Percent)	Percent Change in Habitat Availability								
	Juvenile Bluegill	**Spawning Bluegill**	**Bluegill Fry**	**Adult Spotted Sunfish**	**Juvenile Spotted Sunfish**	**Spawning Spotted Sunfish**	**Spotted Sunfish Fry**	**Benthic Macroinvertebrates**	**Cyprinidae**
October									
10	8.5	4.9	-0.6	-15.6	9.7	10.6	8.9	18.3	7.4
20	16.9	9.7	0.4	-26.4	18.7	20.5	17.3	46.8	14.9
30	24.8	13.7	-0.9	-32.8	27.9	30.5	27.2	77.5	22.5
40	32.4	17.8	-5.5	-49.4	38.7	42.1	39.6	112.4	30.0
November									
10	8.2	4.7	0.1	-1.8	8.1	8.9	7.7	22.6	6.4
20	16.5	8.1	-0.3	-10.9	16.3	17.9	16.1	54.3	13.9
30	23.5	11.5	-2.4	-29.1	24.5	26.5	24.9	81.2	20.4
40	29.9	15.1	-7.6	-33.9	34.0	36.4	36.3	120.8	27.6
December									
10	6.6	3.7	0.6	-1.7	6.9	7.5	6.9	20.7	5.9
20	13.0	7.2	-1.0	-17.9	14.2	15.3	14.7	43.3	11.8
30	18.7	10.3	-4.4	-32.6	22.1	23.5	23.8	66.9	17.8
40	24.1	12.6	-10.3	-45.5	30.7	32.3	34.2	102.7	24.3

5.2.1 Summary of Updated PHABSIM Model Results

The updated percent flow reduction resulting in a 15 percent decrease of available habitat calculated for each functional/taxonomic group as a result of the updated PHABSIM modeling is presented in Table 5-3. While the shallow-slow fish habitat guild and benthic macroinvertebrates were the most restrictive criteria in the previous analysis using the available flow record from 2003 through 2010 resulting in an allowable flow reduction of nine percent for the Gum Springs near Holder gage, adult spotted sunfish were the most restrictive in the updated analyses using the flow record from 2003 through 2013, resulting in an allowable flow reduction of six percent for the gage site.

Table 5-3. PHABSIM percent flow reduction calculations. This table is an update of Table 8-1 included in the revised 2011 report.

Taxonomic Group	Allowable Flow Reduction (Percent)
Adult Spotted Sunfish	6
Largemouth Bass Fry	12
Spawning Largemouth Bass	19
Deep-Fast Habitat Guild	27
Adult Bluegill	27
Bluegill Fry	37
Shallow-Slow Habitat Guild	40
Deep-Slow Fish Guild	40
Shallow-Fast Habitat Guild	40
Adult Largemouth Bass	40
Juvenile Largemouth Bass	40
Juvenile Bluegill	40
Spawning Bluegill	40
Juvenile Spotted Sunfish	40
Spawning Spotted Sunfish	40
Spotted Sunfish Fry	40
Benthic Macroinvertebrates	40
Cyprinidae	40

5.3 <u>Updated HEC-RAS Modeling Results</u>

Results of additional HEC-RAS model simulations are described in a technical memorandum (Intera, Inc. 2014) included in Appendix 2 of this document; this technical memorandum updates the HEC-RAS Modeling Appendix included with the 2011 revised report. The additional model simulations included a simulation using flow records from the USGS Gum Springs near Holder gage station from October 2003 through September 2013 that were modified to account for the estimated four percent withdrawal impact on flows. Results from this simulation were used to assess flows associated with the inundation of the stream channel (e.g., the wetted perimeter) and flows necessary for maintaining fish passage along the spring run. The results were also used for updated analysis of the inundation of woody habitats in Gum Slough Spring Run.

A second simulation used results of a statistical model developed between the USGS Gum Springs near Holder gage and the Rainbow Springs group gage in order to estimate long-term flow at Gum Springs. A linear regression was developed to compare the measured flows with the flows calculated by the statistical model from October 2003 through September 2013. Because the linear regression did not adequately estimate high flows, the flows calculated by the statistical model were not used for any of the analyses.

5.3.1 Summary of Updated Low-Flow Threshold Evaluation Results

The updated low-flow threshold was established at the higher of two flow criteria, which were based on maintaining fish passage and maximizing wetted perimeter for the least amount of flow in the spring run.

5.3.1.1 Fish Passage Evaluation

The flows necessary at the USGS Gum Springs near Holder gage site to maintain a minimum water depth of 0.6 foot to allow for fish passage at each cross-section in the HEC-RAS model are shown in Figure 5-2. Based on these results, a flow of 22 cfs at the USGS gage site was used to define the fish passage criterion.

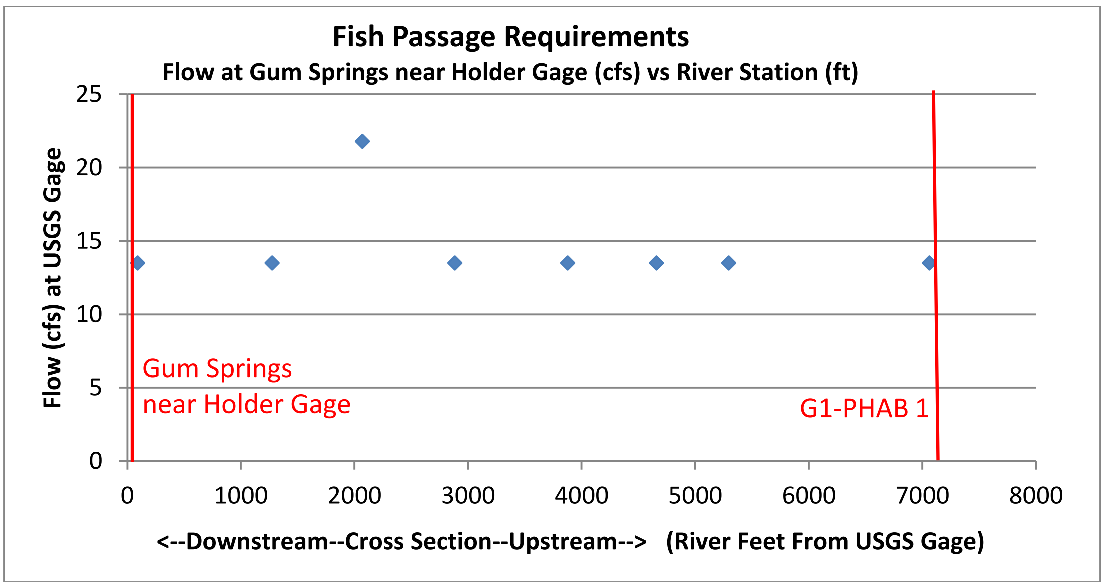


Figure 5-2. Flow required at the Gum Springs near Holder USGS gage site to inundate the deepest part of the channel at HEC-RAS model cross-sections in Gum Slough Spring Run to a depth of 0.6 feet. This figure is an update of Figure 8-1 included in the revised 2011 report.

5.3.1.2 Instream Habitat Quantity Evaluation

Output from the updated HEC-RAS model simulation was used to create wetted perimeter versus discharge plots for each of the HEC-RAS cross-sections of Gum Slough Spring Run. To assist in the identification of potential wetted perimeter inflection points, only the low end of the modeled flows were plotted. These updated plots are presented below and replace Figure 7-6 included in

Section 7.7.1 of the revised 2011 report, as well as the plots included in the Wetted Perimeter Appendix.

There was no apparent lowest perimeter inflection point (LWPIP) for the four most upstream cross-sections (G1-PHAB 1, G2, G3, or G4) (Figures 5-3 through 5-6); however, LWPIPs were noted at the four most downstream cross-sections; all corresponded with a flow of 43 cfs at the USGS gage (Figures 5-7 through 5-10).

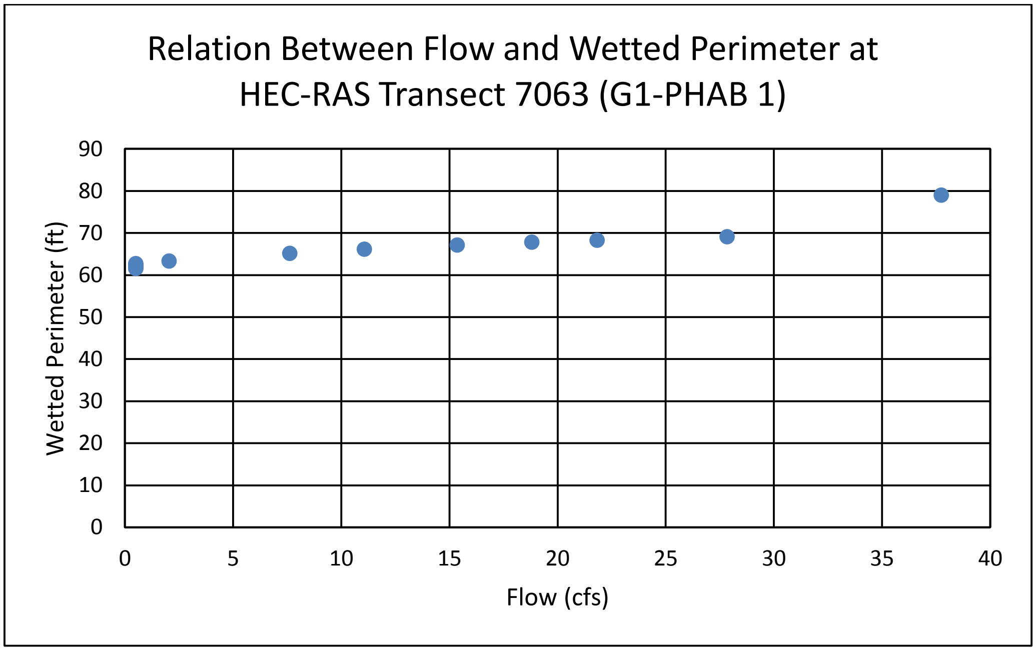


Figure 5-3. Wetted perimeter versus discharge at HEC-RAS model station number 7063 (G1-PHAB 1) in Gum Slough Spring Run. This figure is an update of Figure 7-6 included in the revised 2011 report.

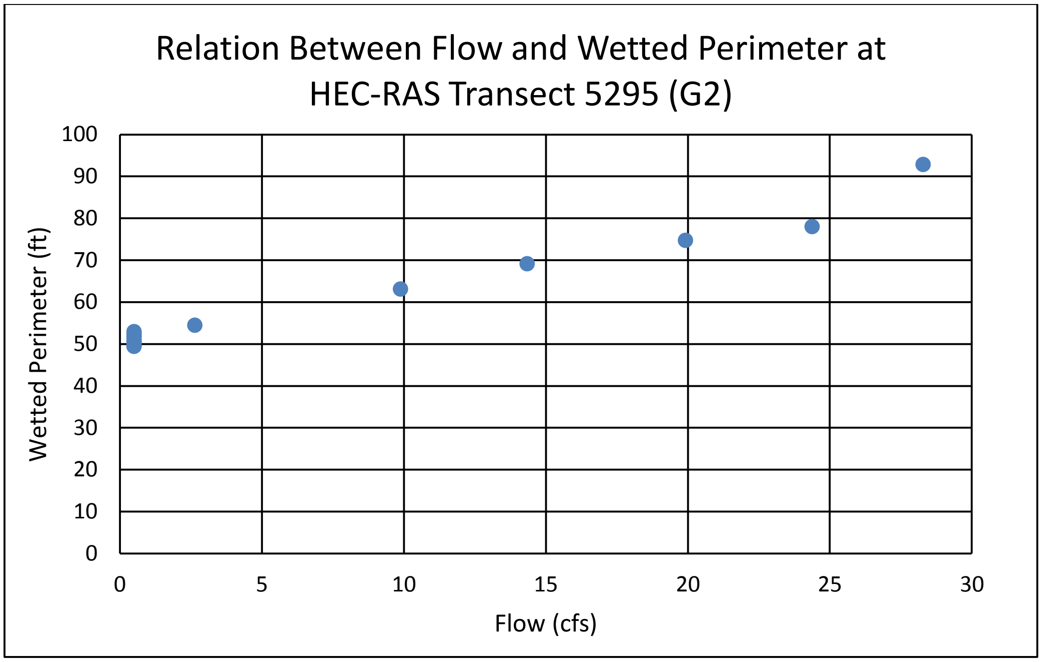


Figure 5-4. Wetted perimeter versus discharge at HEC-RAS model station number 5295 (G2) in Gum Slough Spring Run. This figure is an update of the figures included in the Wetted Perimeter Appendix of the revised 2011 report.

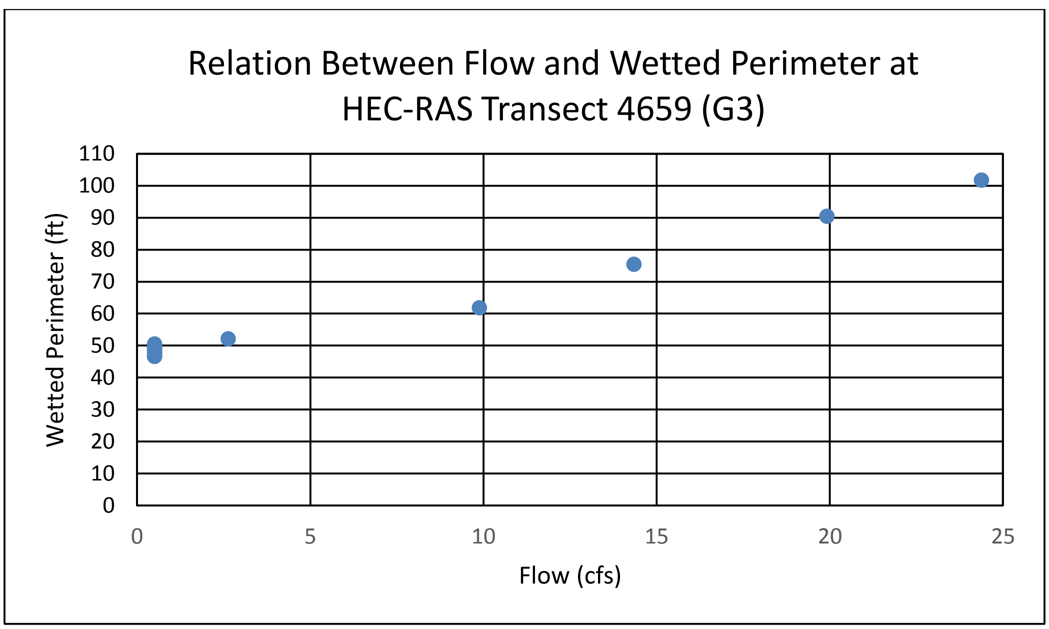


Figure 5-5. Wetted perimeter versus discharge at HEC-RAS model station number 4659 (G3) in Gum Slough Spring Run. This figure is an update of the figures included in the Wetted Perimeter Appendix of the revised 2011 report.

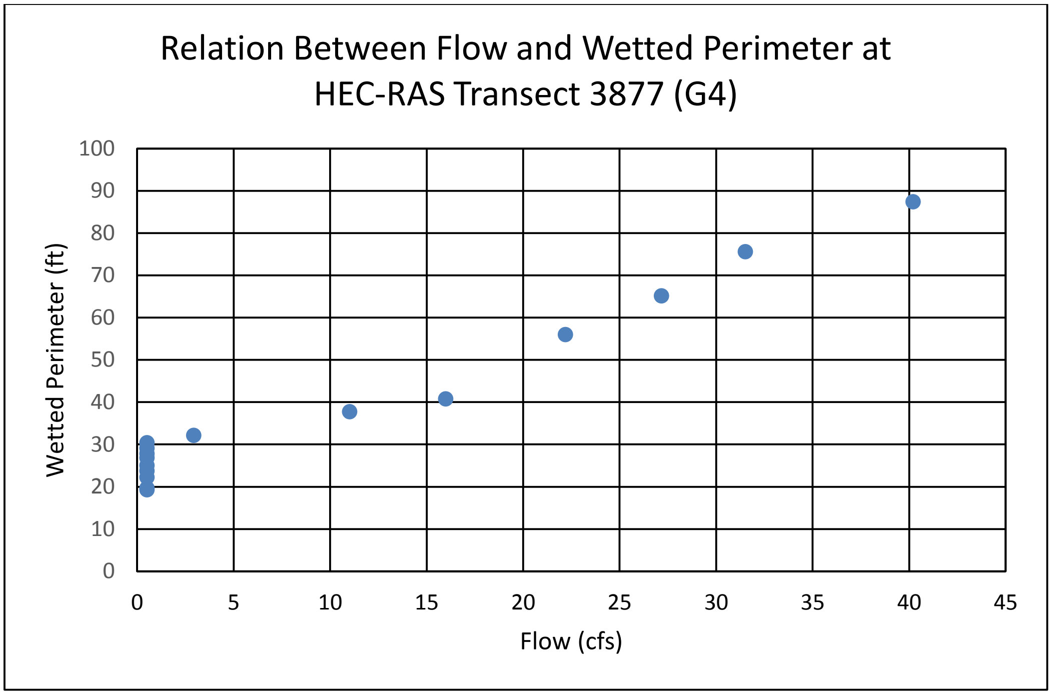


Figure 5-6. Wetted perimeter versus discharge at HEC-RAS model station number 3877 (G4) in Gum Slough Spring Run. This figure is an update of the figures included in the Wetted Perimeter Appendix of the revised 2011 report.

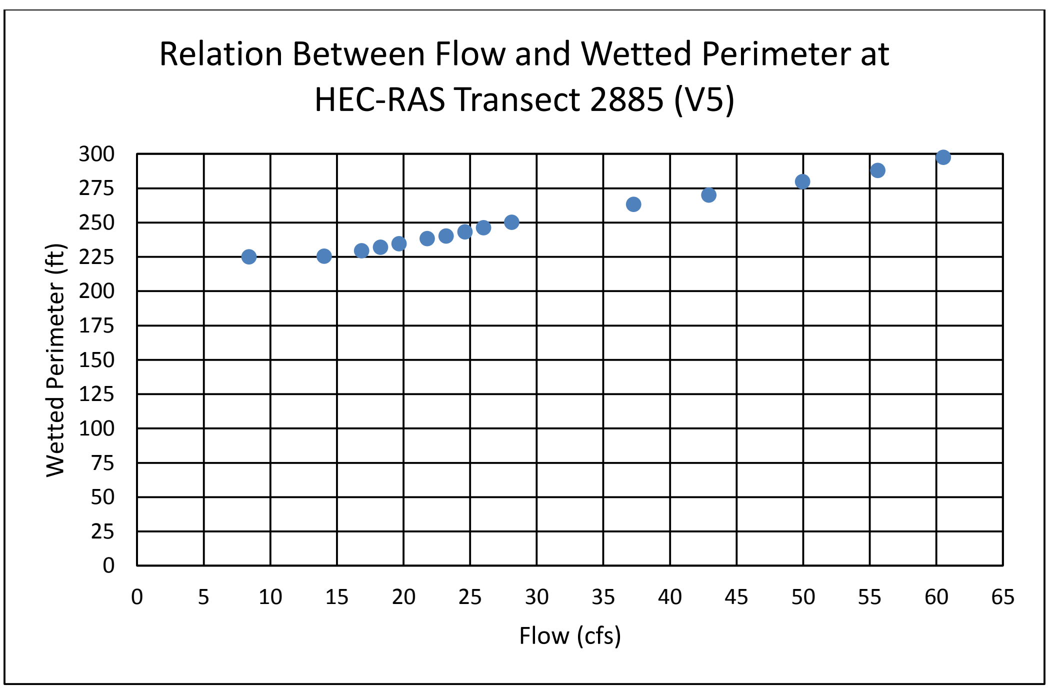


Figure 5-7. Wetted perimeter versus discharge at HEC-RAS model station number 2885 (V5) in Gum Slough Spring Run. This figure is an update of the figures included in the Wetted Perimeter Appendix of the revised 2011 report.

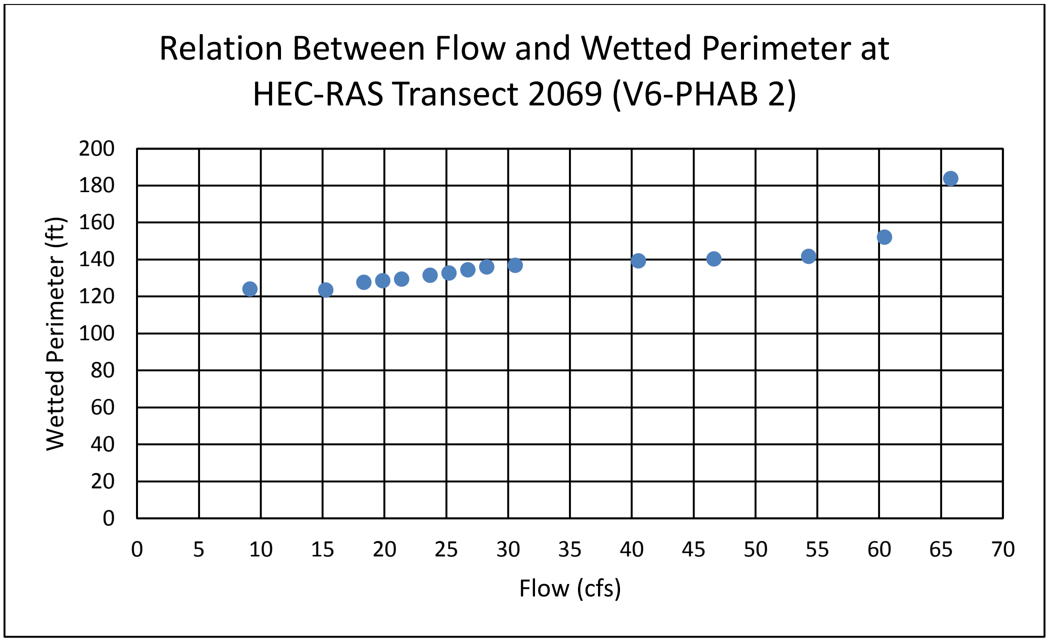


Figure 5-8. Wetted perimeter versus discharge at HEC-RAS model station number 2069 (V6-PHAB 2) in Gum Slough Spring Run. This figure is an update of the figures included in the Wetted Perimeter Appendix of the revised 2011 report.

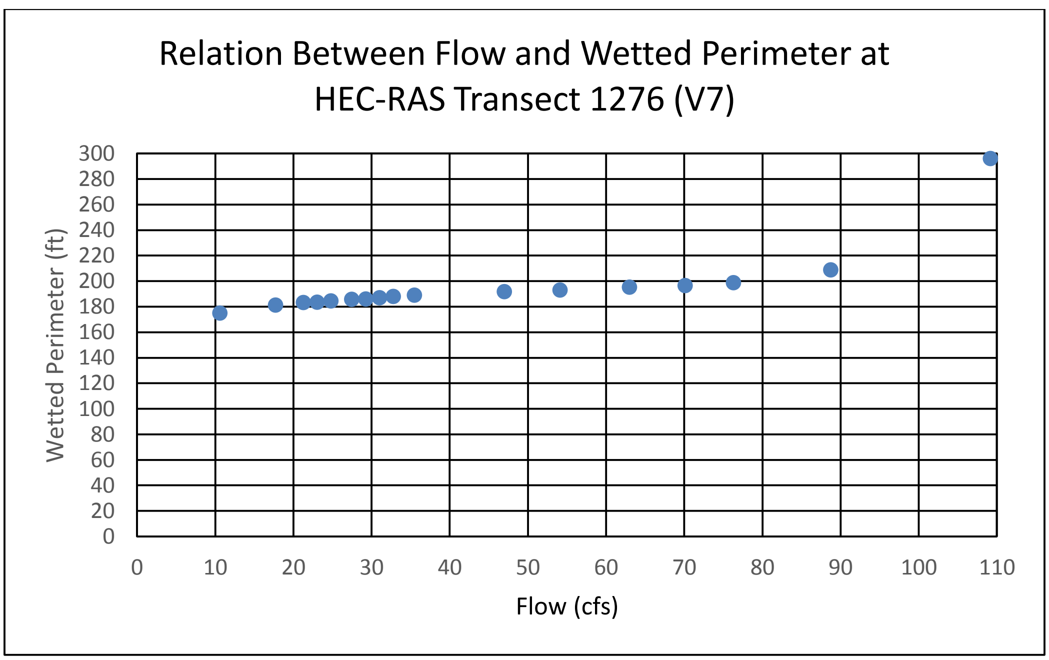


Figure 5-9. Wetted perimeter versus discharge at HEC-RAS model station number 1276 (V7) in Gum Slough Spring Run. This figure is an update of the figures included in the Wetted Perimeter Appendix of the revised 2011 report.

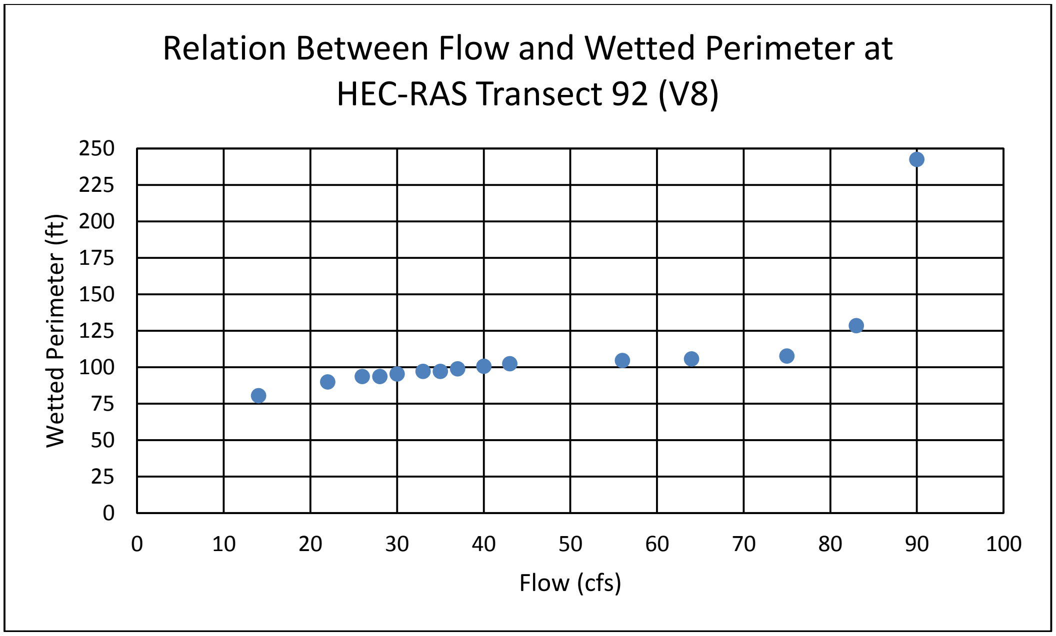


Figure 5-10. Wetted perimeter versus discharge at HEC-RAS model station number 92 (V8-USGS GAGE) in Gum Slough Spring Run. This figure is an update of the figures included in the Wetted Perimeter Appendix of the revised 2011 report.

Figure 5-11 shows the flows necessary at the USGS Gum Springs near Holder gage site to inundate the lowest wetted perimeter inflection point at each cross-section in the HEC-RAS model. A flow of 43 cfs at the USGS near Holder gage was used to define the LWPIP criterion.

The low-flow threshold was established at the higher of the fish passage and wetted perimeter criteria and is, therefore, expected to provide protection for ecological and cultural values associated with both criteria. Therefore, the low-flow threshold was set at 43 cfs at the Holder gage. Although flows in the spring run may be expected to drop naturally below the low-flow threshold, this threshold is defined to be a flow that serves to limit surface water withdrawals.

5.3.2 Summary of Updated Woody Habitat Inundation Analyses

Using the updated HEC-RAS model simulation results, the updated allowable percent withdrawal for exposed roots and snags for each cross-section was updated from the values presented in the original 2011 report (Table 5-4). However, to be more representative of the entire spring run, a median value was calculated for these criteria (versus mean values calculated in the original 2011 report). Therefore, the updated revised allowable percent withdrawals for exposed roots and snags are seven and 23 percent at the Gum Springs near Holder gage, respectively. The woody habitat inundation criterion is, therefore, defined as the more conservative value of seven percent maximum allowable flow reduction.

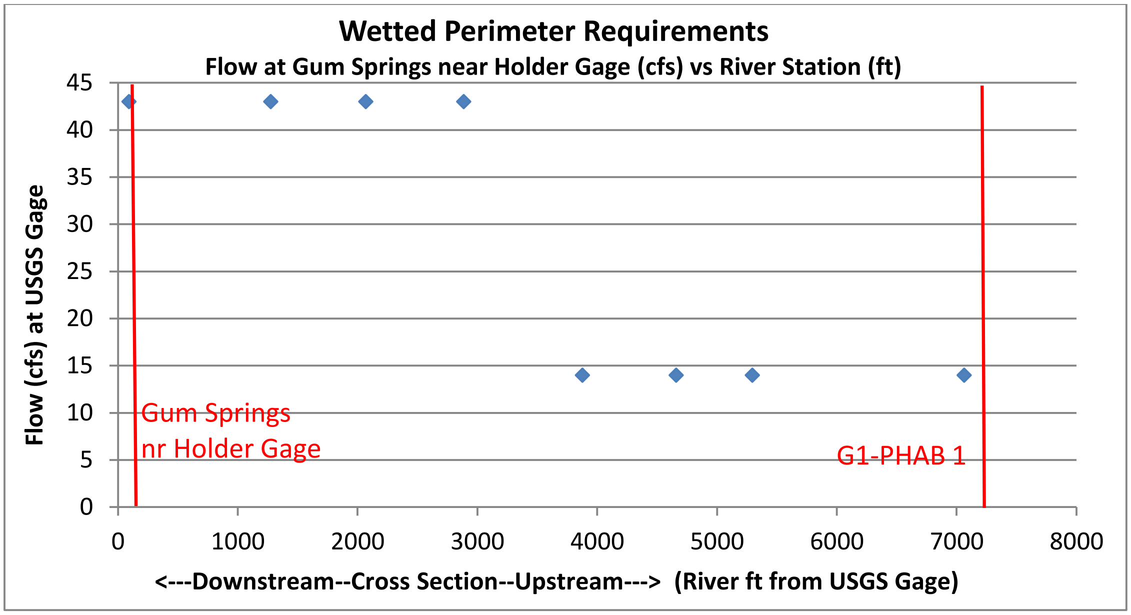


Figure 5-11. Flow required at the Gum Springs near Holder USGS gage site to inundate the lowest wetted perimeter inflection point at HEC-RAS model cross-sections in Gum Slough Spring Run. This figure is an update of Figure 8-2 included in the revised 2011 report.

Table 5-4. Mean elevation of instream woody habitats (exposed roots and snags) at various instream habitat sites, corresponding flows at the Gum Springs near Holder USGS gage required for inundation of the mean elevations, and maximum percent-of-flow reductions associated with less than a 15% reduction in the number of days flow sufficient to inundate the mean habitat elevations. This table is an update of Table 8-6 included in the revised 2011 report.

Habitat	Site	Mean Elevation (ft. NAVD)	S.D.	Flow (cfs) at Gum Springs @ Holder Gage Required for Inundation	Allowable Percent of Flow Reduction
Exposed Roots	Veg 1	37.98	1.06	14	73
Exposed Roots	Veg 2	41.66	0.97	87	6
Exposed Roots	Veg 3	42.15	0.74	113	9
Exposed Roots	Veg 4	41.42	1.18	127	6
Exposed Roots	Veg 5	41.28	1.93	123	5
Exposed Roots	Veg 6	40.47	1.73	76	8
Exposed Roots	Veg 7	39.96	1.10	59	14
Exposed Roots	Veg 8	40.12	1.19	84	6
Mean					**16**
Median					**7**
Snags	Veg 1	37.93	1.01	14	73
Snags	Veg 2	40.57	1.46	59	14
Snags	Veg 3	40.73	1.63	59	14
Snags	Veg 4	41.21	1.31	112	10
Snags	Veg 5	40.03	2.61	45	24
Snags	Veg 6	40.00	1.68	47	22
Snags	Veg 7	39.71	1.19	44	25
Snags	Veg 8	38.89	2.12	22	57
Mean					**30**
Median					**23**

5.4 Additional Criterion – Ecosystem Metabolism

Ecosystem metabolism, which is an estimate of the overall biological function of an aquatic system, was evaluated in the synoptic study of Gum Slough Spring Run conducted from October 2010 through September 2011 (Wetland Solutions, Inc. 2011). Data were collected during the study to determine the relationship between photosynthetic efficiency, an important ecosystem function, and total discharge of the Gum Slough Springs Group. The equation developed for this relationship from the study is as follows:

$$\text{Average Photosynthetic Efficiency (\%)} = 0.0904[\text{Flow (cfs)}]^{0.6861}$$

Using the equation listed above, a 15 percent loss in photosynthetic efficiency is equal to a 21 percent loss in flow.

CHAPTER 6 – UPDATED MINIMUM FLOW RECOMMENDATIONS FOR GUM SLOUGH SPRING RUN

Previously proposed minimum flows for Gum Slough Spring Run are presented in Section 8.6 of the revised 2011 report; however, they have been updated based on the updated analyses presented in this addendum. Table 6-1 summarizes the updated minimum flows criteria based on the updated PHABSIM analyses, analyses based on the updated HEC-RAS model simulations, and the addition of a new criterion. The minimum flows criteria include flow rates that were considered for development of a low-flow threshold for flows at the USGS Gum Springs near Holder gage and allowable percent-of-flow reductions for withdrawal-corrected flows at the gage site.

Table 6-1. Flow threshold or allowable flow reduction recommendations for each analysis/ criterion. This table is an update of Table 8-7 included in the revised 2011 report.

Criterion	Measure/Goal	Flow Threshold (cfs) or Maximum Allowable Flow Reduction (percent)
Fish Passage	Maintain depth of 0.6 feet across shoals	22 cfs
Instream Habitat Quantity	Maximize inundated area in the river channel	43 cfs
Fish and Benthic Macroinvertebrate Instream Habitat	Avoid reductions >15 percent of available habitat for 18 functional and taxonomic groups	6 percent
Instream Snag Habitat	Avoid reductions >15 percent in snag habitat availability	23 percent
Instream Exposed Roots Habitat	Avoid reductions >15 percent in exposed root habitat availability	7 percent
Ecosystem Metabolism	Avoid reductions >15 percent in photosynthetic efficiency	21 percent

Based on the most restrictive allowable flow reduction and low-flow threshold criteria, and using the term “natural flows” to correspond with historic flows that are corrected for groundwater withdrawal impacts, the following minimum flow recommendations for Gum Slough Spring Run were approved by the District Governing Board on March 29, 2016, adopted into the District’s Minimum Flows and Levels and Rates of Flow Rules (Chapter 40D-8, F.A.C.) on May 31, 2016, and became effective on June 20, 2016.

(a) *For purposes of this rule, Gum Slough Spring Run includes the watercourse from the Gum Slough Springs Group headspring to the Withlacoochee River, including all named and unnamed springs that discharge to the spring run.*
(b) *The Minimum Flow for Gum Slough Spring Run is 94% of the natural flow as measured at the United States Geological Survey Gum Springs near Holder, FL Gage (Gage No. 02312764), or as measured at any point downstream from this Gage. Natural flow is defined for the purpose of this rule as the flow that would exist in the absence of withdrawal impacts.*
(c) *The Minimum Flow for Gum Slough Spring Run also includes a flow-based Minimum Low Flow Threshold of 43 cfs at this Gage. No surface water withdrawal shall be permitted that*

would individually or cumulatively cause the natural flow to be reduced below the Minimum Low Flow Threshold of 43 cfs.

(d) The District will re-evaluate the Minimum Flow within ten years of adoption of this rule.

Figure 6-1 illustrates the historical flows at the USGS Gum Springs near Holder gage site on an annual basis corrected for withdrawal impacts along with flows that could result from maximum withdrawal impacts that would be allowed based on the updated minimum flow recommendations for the system. The recommended Low-Flow Threshold is also depicted in the figure.

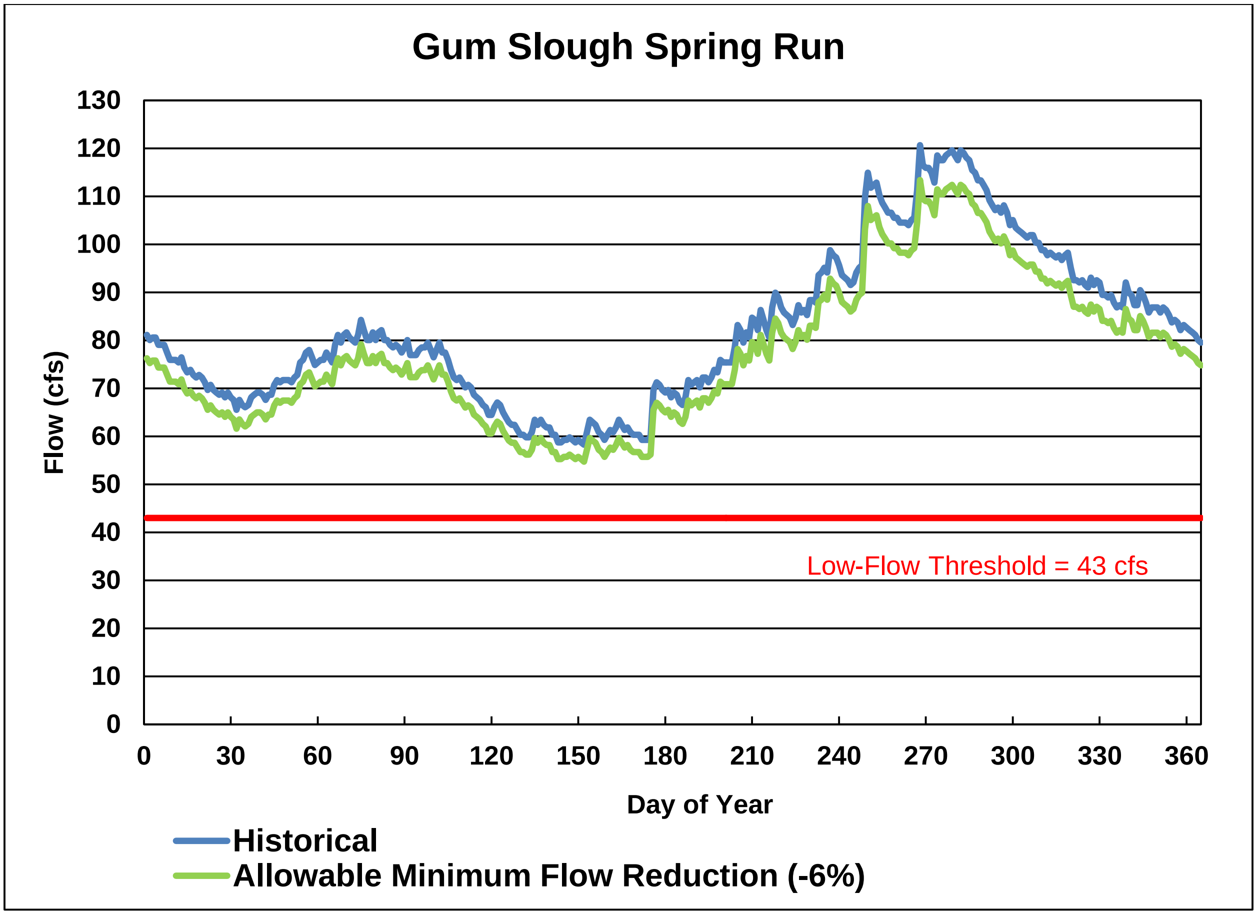


Figure 6-1. Median historical daily flows (corrected for withdrawal impacts) at the Gum Springs near Holder USGS gage site from October 2003 through September 2013, and flows corresponding to historical flows reduced by six percent. This figure is an update of Figure 8-9 included in the revised 2011 report.

The updated minimum flow recommendations for Gum Slough Spring Run are protective of all relevant environmental values identified for consideration in the Water Resource Implementation Rule when establishing minimum flows and levels (see Rule 62-40.473, F.A.C.). The methods used for their development are largely habitat based and includes the maintenance of minimum water depths in the spring run for fish passage, maintenance of water depths above inflection points in the wetted perimeter of the channel to maximize aquatic habitat for fish and wildlife with the least amount of flow, and protection of wetland and in-channel habitat, including woody habitats and exposed roots, for fish, invertebrates, and wildlife. The recommended minimum flows are protective of several environmental values identified in the Water Resource Implementation

Rule, including recreation in and on the water, fish and wildlife habitats and the passage of fish, transfer of detrital material, aesthetic and scenic attributes, filtration and absorption of nutrients and other pollutants, sediment loads, and water quality. In addition, the environmental value, maintenance of freshwater storage and supply, is expected to be protected by the proposed minimum flows based on inclusion of conditions in water use permits that stipulate that permitted withdrawals will not lead to violation of adopted minimum flows and levels; using the DEP's definition, this environmental value is also expected to be protected by the proposed minimum flows, which are protective of all environmental values.

One environmental value identified in the Water Resource Implementation Rule, was not considered relevant to development of proposed minimum flows for Gum Slough Spring Run. Estuarine resources were not considered relevant for the spring run based on its hydrologic isolation from the estuarine reaches of the downstream Withlacoochee River.

As specified in the adopted/effective minimum flow rules for Gum Slough Spring Run, the District will re-evaluate the adopted minimum flows within ten years. In addition, annual status assessments of the spring run will be conducted to determine whether the adopted minimum flows continue to be met.

CHAPTER 7 – CONCLUSION

Because the original minimum flows analyses for Gum Slough Spring Run described in a 2011 revised report were based on a relatively short flow record, a decision was made to gather more information to support more robust minimum flow recommendations for the system. The flow record was increased from seven to ten years, and the previously peer-reviewed analyses used for the original minimum flows determination were repeated.

Results of the new analyses yielded an updated minimum flow recommendation that would allow up to a six percent reduction in flows due to water withdrawals, based on a potential 15 percent decrease of available habitat for adult spotted sunfish in the spring run. The updated minimum flow recommendation also includes the recommended stipulation that surface water withdrawals are prohibited from depressing flows below 43 cfs. The adopted minimum flow will be re-evaluated within ten years.

Updated groundwater modeling results indicated that the predicted streamflow decline for Gum Slough Spring Run at the USGS Gum Springs near Holder gage site under current pumping conditions is approximately 3.4 percent. Based on this information, a recovery strategy is not required for the proposed minimum flows.

CHAPTER 8 – LITERATURE CITED

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Appendix 1

Public Workshop Information and Stakeholder Comments Received in February and March 2016

From: Kym Holzwart
To: Sonny Hall
Cc: Andrew Sutherland; Doug Leeper
Subject: RE: SWFWMD Proposed MFLs for Gum Slough Spring Run in Marion and Sumter Counties
Date: Wednesday, February 24, 2016 7:31:43 AM
Attachments: image001.png
image002.png

Hi Sonny,
Thanks so much for taking time out of your busy schedule to review the addendum and appreciate any comments that you may have on the 2011 report.
Best regards and looking forward to working with you and Andrew on future minimum flows projects (including Rainbow),
Thanks again,
Kym

From: Sonny Hall [mailto:shall@sjrwmd.com]
Sent: Tuesday, February 23, 2016 10:59 AM
To: Kym Holzwart <Kym.Holzwart@swfwmd.state.fl.us>
Cc: Andrew Sutherland <asutherl@sjrwmd.com>
Subject: RE: SWFWMD Proposed MFLs for Gum Slough Spring Run in Marion and Sumter Counties

Hi Kym,

I have attached a copy of the Gum_Spring_Final_Draft_Addendum_2016.pdf which contains comments for your review. I hope to spend the next several days looking a the revised 2011 report and will try to give you any comments by Friday, February 26. I would suspect they would be similar to those in the 2016 Addendum. The 2016 Addendum looks good. We believe your minimum flow is protective and well supported. Please call if you have any questions regarding our comments.

Best regards,

G.B. "Sonny" Hall, Ph.D.
Technical Program Coordinator
Bureau of Resource Evaluation and Modeling
St. Johns River Water Management District
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Office: (386) 329-4368
Email: shall@sjrwmd.com
Website: floridaswater.com
Connect with us: Newsletter, Facebook, Twitter, YouTube

From: Kym Holzwart [mailto:Kym.Holzwart@swfwmd.state.fl.us]
Sent: Monday, February 22, 2016 8:33 AM
To: Llewellyn, Janet; Eric Nagid; Sonny Hall; Andrew Sutherland; Kathleen.Greenwood@dep.state.fl.us; Hoehn, Ted; Stasey.Whichel@MyFWC.com; Eric.Sutton@myFWC.com; Linda.Clemens@dep.state.fl.us; Jack.Furney@dep.state.fl.us; david.trimble@dep.state.fl.us
Cc: Doug Leeper; Ron Basso; Nathan Johnson; Jerry Mallams; Veronica Craw
Subject: RE: SWFWMD Proposed MFLs for Gum Slough Spring Run in Marion and Sumter Counties

Good morning everyone,

I wanted to inform you that a revised final draft addendum has been posted on our website. It includes a revised low-flow threshold of 43 cfs and a few minor editorial corrections, including some changes to the draft rule language presented in the document. Please let me know if you have any questions.

Best regards,

Kym

Kym Rouse Holzwart, M.S.
Certified Senior Ecologist
Senior Environmental Scientist
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2379 Broad Street
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352-796-7211, ext. 4295
1-800-423-1476, ext. 4295
Cell: 813-482-4028
Kym.Holzwart@swfwmd.state.fl.us

From: Kym Holzwart
Sent: Monday, February 08, 2016 3:10 PM
To: 'Llewellyn, Janet' <Janet.Llewellyn@dep.state.fl.us>; 'Eric Nagid' <eric.nagid@MyFWC.com>; 'SHall@sjrwmd.com' <SHall@sjrwmd.com>; 'asutherland@sjrwmd.com' <asutherland@sjrwmd.com>; 'Kathleen.Greenwood@dep.state.fl.us' <Kathleen.Greenwood@dep.state.fl.us>; 'Hoehn, Ted' <ted.hoehn@MyFWC.com>; 'Stasey.Whichel@MyFWC.com' <Stasey.Whichel@MyFWC.com>; 'Eric.Sutton@myFWC.com' <Eric.Sutton@myFWC.com>; 'Linda.Clemens@dep.state.fl.us' <Linda.Clemens@dep.state.fl.us>; 'Jack.Furney@dep.state.fl.us' <Jack.Furney@dep.state.fl.us>; 'david.trimble@dep.state.fl.us' <david.trimble@dep.state.fl.us>
Cc: Doug Leeper <Doug.Leeper@swfwmd.state.fl.us>; Ron Basso <Ron.Basso@swfwmd.state.fl.us>; Nathan Johnson <Nathan.Johnson@swfwmd.state.fl.us>; Jerry Mallams <Jerry.Mallams@swfwmd.state.fl.us>; Veronica Craw <Veronica.Craw@swfwmd.state.fl.us>
Subject: SWFWMD Proposed MFLs for Gum Slough Spring Run in Marion and Sumter Counties

Good afternoon,

The Southwest Florida Water Management District has developed proposed minimum flows for Gum Slough Spring Run and has scheduled a public workshop for discussion of the proposed minimum flows. Public comment received during and following the workshop will be used to modify the proposed flows, as appropriate, and summarized for the District Governing Board. Staff will present a summary of public comments and rule amendments associated with the proposed minimum flows to the Governing Board for consideration at the March 29, 2016 meeting.

Draft reports on the proposed flows are posted on the District's internet site at: http://www.swfwmd.state.fl.us/projects/mfl/mfl_reports.php

Information regarding the workshop is listed below:

What: Gum Slough Spring Run Proposed Minimum Flows Public Workshop

When: Thursday, February 25, 2016; 4:00 PM - 6:00 PM (meeting set-up to begin at 3:00 PM)

Where: Marion Oaks Community Center, 294 Marion Oaks Lane, Ocala, Florida 34473

Draft MFLs Report and planned schedule: A final draft addendum and final report on the proposed minimum flows for Gum Slough Spring Run is available and has replaced the draft 2011 report for the spring run that was posted on the District's Minimum Flows and Levels (Environmental Flows) Documents and Reports web page. Comments received during and subsequent to the workshop will be summarized for consideration by the Governing Board. Staff anticipate seeking Board approval for rulemaking concerning the proposed levels at the March 29, 2016 Board meeting.

Please feel free to contact me by email or telephone (numbers listed below) if you have any questions or comments regarding the workshop or the proposed minimum flows. It would be great if you could send me any comments that you may have by the end of the month so that they can be considered.

Best regards,

Kym

Kym Rouse Holzwart, M.S.
Certified Senior Ecologist
Senior Environmental Scientist
Springs & Environmental Flows
Natural Systems & Restoration Bureau

Southwest Florida Water Management District
2379 Broad Street
Brooksville, FL 34609
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Cell: 813-482-4028
Kym.Holzwart@swfwmd.state.fl.us

We value your opinion. Please take a few minutes to share your comments on the service you received from the District by clicking this link

Proposed Minimum Flows and Levels for Gum Slough Spring Run Addendum FINAL DRAFT

February 2016

Kym Rouse Holzwart, Nathan Johnson, Doug Leeper, Ron Basso
Southwest Florida Water Management District
Brooksville, Florida

Summary of Comments on 384.1 Gum_Spring_Final_Draft_Addendum_2016_SHall_A_Sutherland_Comments_FEB_23_2016.pdf

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Proposed Minimum Flows and Levels for Gum Slough Spring Run Addendum FINAL DRAFT

February 2016

Kym Rouse Holzwart, Nathan Johnson, Doug Leeper, Ron Basso
Southwest Florida Water Management District
Brooksville, Florida

The Southwest Florida Water Management District (District) does not discriminate on the basis of disability. This nondiscrimination policy involves every aspect of the District's functions, including access to and participation in the District's programs and activities. Anyone requiring reasonable accommodation as provided for in the Americans with Disabilities Act should contact the District's Human Resources Bureau Chief, 2379 Broad St., Brooksville, FL 34604-6899; telephone (352) 796-7211 or 1-800-423-1476 (FL only), ext. 4703; or email ADACoordinator@WaterMatters.org. If you are hearing or speech impaired, please contact the agency using the Florida Relay Service, 1(800)955-8771 (TDD) or 1(800)955-8770 (Voice).

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We recommend that throughout this document you add text to briefly describe the importance of a particular threshold or parameter, define what they mean, and describe how they were calculated or developed. We have pointed out several instances of this but there are more others. Referencing the 2011 revised report is good but many readers will probably not read and study that document.

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Executive Summary

A Peer Review Draft of the Proposed Minimum Flows and Levels for the Gum Slough Spring Run report was completed on May 26, 2011. The Peer Review Panel completed their review of the draft report in September 2011, and the draft report was revised in October 2011 based on Panel comments and stakeholder input. Since that time, additional data has become available that has changed the results of the analyses used to develop the proposed minimum flows. Because the methodology included in the original, peer-reviewed report has not changed, this addendum was created to serve as a companion to the revised 2011 report and appendices. This addendum includes updated results of the analyses contained in the revised 2011 report, as well as updated minimum flow recommendations for Gum Slough Spring Run.

In the revised 2011 report, the mean daily discharge of Gum Slough Spring Run, including both overland flow and base flow, was reported as 98 cubic feet per second (cfs), based on discharge data from October 2003 through September 2010. With the inclusion of additional discharge data from October 2010 through August 2015, increasing the period of record from October 2003 through August 2015, the updated, period-of-record mean daily discharge rate was 88 cfs.

Results of a water budget for the Gum Springs group springshed in which all consumptively-used water was conservatively estimated to result in equivalent reductions in springflow indicate that the current groundwater withdrawn within the contributing area results in about a 2.5 percent decline in springflow. In the revised 2011 report, the 2008 version of the Northern District Model (NDM), a groundwater flow model, was used to simulate the impact on flow due to groundwater withdrawals in 2005. The predicted streamflow decline for Gum Slough Spring Run (Gum Springs near Holder station) under those pumping conditions was determined to be approximately four percent. For this addendum, the latest version of the NDM (Version 4.0) was used to simulate the flow change at the Gum Springs group due to groundwater withdrawals in 2010. Similar to the model results included in the revised 2011 report, the updated model results indicate that predicted drawdown within the Upper Floridan aquifer near Gum Springs is less than 0.25 feet. The updated model results indicate that the predicted streamflow decline for Gum Slough Spring Run (Gum Springs near Holder station) under recent pumping conditions is approximately 3.4 percent.

The minimum flows recommended in the revised 2011 report would allow up to a nine percent reduction in natural flow, e.g., flows corrected for withdrawal impacts, and would be applicable the entire year. The allowable percent-of-flow reduction included in the revised 2011 report was based on Physical Habitat Simulation (PHABSIM) modeling that predicted a 15 percent loss of habitat for the shallow-slow fish guild and benthic macroinvertebrates. However, after revising the PHABSIM modeling to include updated, withdrawal-corrected flow records collected from October 2010 through September 2013, the maximum allowable flow reduction was calculated to be six percent, based on a 15 percent loss of habitat for adult spotted sunfish. This updated information was used to revise minimum flow recommendations for Gum Slough Spring Run to allow up to a six percent reduction in natural flows.

In the 2011 revised report, the recommended minimum flows also included a low-flow threshold, defined to be a flow that serves to limit surface water withdrawals, of 35 cfs, using the Hydrologic Engineering Centers River Analysis System (HEC-RAS) model to characterize flows and based on flows associated with fish passage and the inundation of the stream channel. After revising the HEC-RAS modeling to include the updated, withdrawal-corrected flow record, the low-flow threshold was updated to 14 cfs.

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Number: 2 Author: Shall Subject: Sticky Note Date: 2/23/2016 8:46:56 AM
...additional data have (plural). Has vs. have.

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Number: 10 Author: Shall Subject: Sticky Note Date: 2/23/2016 10:18:57 AM
Would be helpful, for those who don't read the 2011 report, to include the species that constitute the shallow-slow fish guild.

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Number: 13 Author: Shall Subject: Sticky Note Date: 2/23/2016 8:49:08 AM
SJRWMD agrees with the statements by the SWFWMD Gum Spring Slough peer review panel. "The selection of the 15% threshold to indicate significant harm has stood up to past peer reviews, and represents a defensible value. Ultimately, experimental studies that examine the effects of a variety of percentage losses of habitat on multiple species of interest would test the assumption that 15% is protective, but until such research is completed the current value in use has merit." Experimental studies and/or biomonitoring data collection and analyses are required to "prove up" this 15% threshold. Such work may indicate that a "one-size fits all" threshold is inappropriate. In the mean time, the 15% significant harm threshold used by SWFWMD does not seem unreasonable, and it should be stressed, as you have done, that the threshold is based upon professional judgment.

Number: 14 Author: Shall Subject: Sticky Note Date: 2/23/2016 10:28:48 AM
The "low-flow threshold" should be defined more clearly here. Tell the reader briefly what it is base upon (how developed) and what it is used for - "no surface water withdrawals from the system will be permitted that would cumulatively cause the natural flow to be reduced below the minimum low-flow threshold of 14 cfs."

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The updated minimum flow recommendations for Gum Slough Spring Run are protective of all relevant environmental values identified for consideration in the Water Resource Implementation Rule when establishing minimum flows and levels. Because updated groundwater modeling indicates that the predicted streamflow decline for Gum Slough Spring Run under current pumping conditions is approximately 3.4 percent, the proposed minimum flows are being met, and a recovery strategy is not currently required.

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CHAPTER 1 – INTRODUCTION

The District completed the “Proposed Minimum Flows and Levels for the Gum Slough Spring Run – Peer Review Draft” report on May 26, 2011. A Peer Review Panel completed their review of the draft minimum flows and levels (MFLs) report in September 2011, and based on Panel findings summarized by Dahm et al. (2011), the District completed a revised 2011 version of the draft report in October 2011. The revised 2011 report also included some changes made in response to input from several stakeholders, but the originally recommended minimum flows for Gum Slough Spring Run included in the May 2011 report were not modified.

Since October 2011, additional information has become available, and analyses based on these data have indicated that the originally proposed minimum flows should be updated. This addendum summarizes those data and analyses and includes updates to information contained in the revised 2011 report, including updated minimum flow recommendations. As such, this addendum serves as a companion document for the revised 2011 draft report.

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CHAPTER 2 – ENVIRONMENTAL VALUES ASSOCIATED WITH MINIMUM FLOWS AND LEVELS DEVELOPMENT

Section 1.1 of the revised 2011 report identified environmental values associated with coastal, estuarine, riverine, spring, aquatic, and wetlands ecology that should be considered when developing minimum flows and levels (MFLs); however, details regarding the applicability of these environmental values to Gum Slough Spring Run were not provided. The originally proposed minimum flows for Gum Slough Spring Run are protective of all relevant environmental values identified for consideration in the Water Resource Implementation Rule when establishing MFLs (see Rule 62-40.473, F.A.C.). In the paragraphs that follow, details regarding the environmental values that were considered in the development of minimum flows for Gum Slough Spring Run are summarized.

Recreation in and on the Water: This environmental value is considered relevant to Gum Slough Spring Run. The Outstanding Florida Water (OFW) designation of this system is, in part, based on its recreational significance. The maintenance of minimum water depths for recreational use was addressed by the minimum flows analysis through assessment of low-flow threshold criteria associated with fish passage and recreational use.

Fish and Wildlife Habitats and the Passage of Fish: This environmental value is relevant to the development of minimum flows for Gum Slough Spring Run. The minimum flows analyses included assessment of minimum water depths in the spring run for fish passage, maintenance of water depths above inflection points in the wetted perimeter of the channel to maximize aquatic habitat for fish and wildlife with the least amount of flow, and protection of wetland and in-channel habitat, including woody habitats and exposed roots, for fish, invertebrates, and wildlife.

Estuarine Resources: This environmental value was not considered relevant for development of minimum flow recommendations for Gum Slough Spring Run based on the landscape position of the system upstream of the impounded section of the Withlacoochee River that drains to the Gulf of Mexico.

Transfer of Detrital Material: This environmental value is considered relevant to the minimum flows analysis. Since the District's approach is largely habitat based and addresses the maintenance of minimum water depths in the spring run for fish passage and protection of wetland and in-channel habitat, it is assumed that this ecological function is addressed by the proposed minimum flows.

Maintenance of Freshwater Storage and Supply: [1] Consideration of this environmental value for development of minimum flow recommendations was based on the evaluation of the effects of existing and permitted water use that affect flows in Gum Slough Spring Run. This environmental value is expected to be protected through implementation of the District's Water Use Permitting Program based on the inclusion of permit conditions that stipulate permitted withdrawals will not lead to violation of adopted MFLs. [2]

Aesthetic and Scenic Attributes: Although aesthetic and scenic attributes are considered relevant to the establishment of minimum flows for the spring run, there are no available data specifically associating this environmental value with flow. This environmental value is, however, closely linked with the "Recreation in and on the Water" value associated with Gum Slough Spring Run and its designation as an OFW. Ensuring sufficient flows for protection of this and other relevant environmental values, including fish and wildlife habitats and the passage of fish, transfer

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Our legal staff has communicated with Janet Llewellyn (FDEP) who was involved with the development of 62-40.473, FAC. Janet disagreed with SJRWMD's original definition of "Maintenance of Freshwater Storage and Supply". SJRWMD's original definition was: "The protection of an amount of freshwater supply for permitted users at the time of MFLs determinations." We assessed protection of this WRV through implementation of the CUP program and inclusion of existing water uses in the models for the particular basin (essentially accounting for the water uses in the MFLs compliance evaluations).

Janet's recommended definition is: "The protection of an adequate amount of freshwater for non-consumptive uses and environmental values associated with coastal, estuarine, riverine, spring, aquatic, and wetlands ecology."

Essentially, all the other WRV values are encompassed in this one WRV. Conclusion, if the other WRVs are protected, then this WRV is protected. We prefer our original definition but at our legal staff's and Janet's request, now apply the updated definition.

of detrital material, filtration and absorption of nutrients, water quality, and navigation is expected to be protective of aesthetic and scenic attributes.

Filtration and Absorption of Nutrients and Other Pollutants: It is assumed that this environmental value is addressed because the District's approach to minimum flows development for Gum Slough Spring Run is primarily habitat based. For example, maintaining an acceptable level of ecological integrity for wetlands associated with the spring run ecosystem is assumed to be protective of this ecological function.

Sediment Loads: Since discharge in Gum Slough Spring Run is dominated by springflow rather than surface water runoff, this environmental value was not considered relevant for minimum flows development for the system.

Water Quality: Similar to many springs' systems in Florida, Gum Slough Spring Run is experiencing rising nutrient concentrations due to urban and agricultural land-uses in its springshed (WRI 2011). Water quality criteria are designed to protect a water body's designated use. Florida's anti-degradation policy is designed to prevent worsening of water quality from specified activities unless it is found to be in the public interest and does not apply to water quantity decisions, such as MFLs. An OFW designation is part of Florida's anti-degradation policy, and Gum Slough Spring Run is a designated OFW. While flow can affect water quality, the proposed minimum flow criteria are not expected to negatively affect water quality in Gum Slough Spring Run or impair the water body's designated use.

Navigation: This environmental value is considered applicable to maintenance of water depths and channel widths suitable for passage of watercraft. Protection of this value was addressed through consideration of criteria associated with recreational watercraft (e.g., canoes, kayaks).

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Sediment loads would seem to be important in this spring run. Movement of sediment, particularly finer sediment (detritus) would seem to be very important for the microbial foodweb which supports downstream foodwebs (macroinvertebrates and fish). We do not agree that sediment loads would be irrelevant in this spring run. The rationale presented here is very weak.

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CHAPTER 3 – HYDROLOGY

Since the revised 2011 report was completed, additional hydrologic information has become available, and analyses based on these data were used to investigate whether the originally proposed minimum flows for Gum Slough Spring Run should be updated. In addition, the models used for the analyses has been revised and improved. The information presented in this section updates the results included in the Hydrology Section (Section 4) of the revised 2011 report.

3.1 Gum Slough Spring Run Discharge History

In the revised 2011 report, the Gum Slough Spring Run discharge history for the United States Geological Survey (USGS) Gum Springs near Holder gage site was described in Section 4.2.2.2 using flow data from October 2003 through September 2010. With the inclusion of five additional years of flow records (October 2010 through August 2015), expanding the record from seven to 12 years, the descriptive statistics have been revised.

The average daily flow from October 2003 through August 2015 was 90 cubic feet per second (cfs), equivalent to 59 million gallons per day (mgd). For the same period of record, the median daily flow was 84 cfs (which is the same median daily flow calculated for the seven-year period of record used in the original report). The maximum and minimum daily recorded flows were 520 cfs (336 mgd) and five cfs (3.3 mgd), respectively (Figure 3-1), compared to 520 and 24 cfs, respectively, in the revised 2011 report. The lowest recorded discharge of five cfs was measured following a prolonged drought during May 2012.

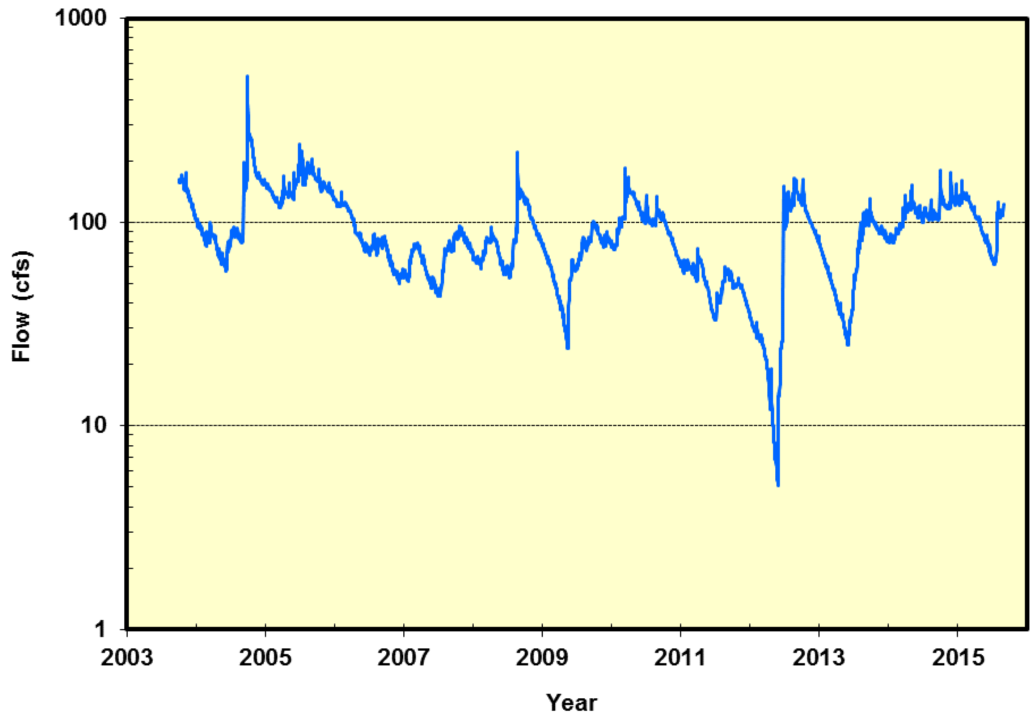

Figure 3-1. Flow history at the USGS Gum Springs near Holder station (October 2003 – August 2015). This figure is an update of Figure 4-5 included in the revised 2011 report.

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3.2 Gum Slough Spring Run Base Flow Separation

The base flow separation process, described in Section 4.2.2.3 of the revised 2011 report, was repeated using additional discharge data available from the USGS[1] for October 2010 through September 2013, increasing the available period-of-record discharge data for updated minimum flows analysis from October 2003 through September 2013. Note that this period of record is shorter than the record used for the discharge history description presented in the previous section of this addendum, but it represents the period-of-record flow data that were available when analyses were completed for the re-evaluation of minimum flow recommendations.

Results from the base flow separation process indicated the average streamflow was 88 cfs, with a base flow contribution of 63 cfs, for the period of record from October 2003 through 2013 (Figure 3-2). This compares to an average streamflow of 98 cfs, with a base flow contribution of 73 cfs, for the period of record from October 2003 through July 2010 that was identified in the revised 2011 report. For Gum Slough Spring Run, base flow contributes approximately 72 percent of streamflow volume as measured at the Gum Springs near Holder gage.

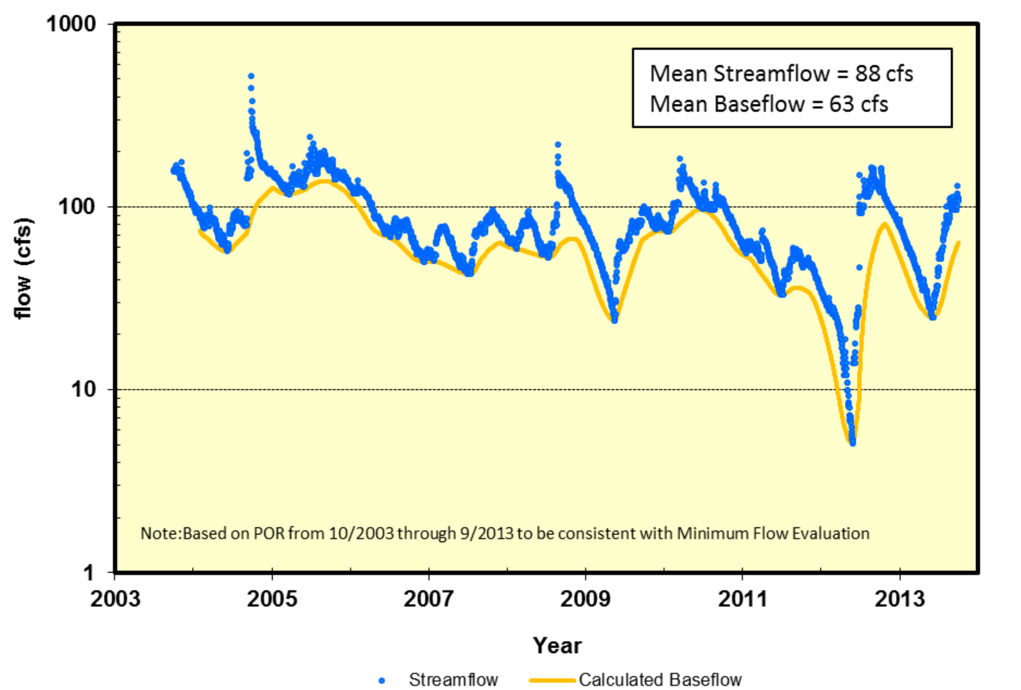

Figure 3-2. Streamflow and estimated base flow at the Gum Springs near Holder station for the updated period of record used for the minimum flow re-evaluation. This figure is an update of Figure 4-6 included in the revised 2011 report.

[1]Reported by USGS as *02312764 GUM SPRINGS NEAR HOLDER FL*.

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Is the method for calculation of the baseflow contribution explained somewhere in the report? Might want to reference that report section or explain it briefly here to help the reader's understanding.

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3.3 Long-Term Rainfall Changes

In the revised 2011 report, the long-term rainfall history for the area was described in Section 4.2.2.4 using rainfall data from 1930 through 2008. With the inclusion of six additional years of rainfall data (2009 through 2015), the descriptive statistics have been revised.

Similar to the revised 2011 report, the analysis of rainfall averaged from the Brooksville, Inverness, and Ocala National Oceanic and Atmospheric Administration (NOAA) stations from 1930 through 2014 showed a declining trend after 1970, especially pronounced after 1989. The cumulative departure from mean annual rainfall from 1970 to 2014 was approximately -70 inches. In contrast, the cumulative departure from mean rainfall from 1931 through 1969 was +74 inches (Figure 3-3). An analysis of the annual departure in mean rainfall demonstrated that below average rainfall since 1970 was recorded for 30 out of 45 years (Figure 3-4). In both 2012 and 2014, however, rainfall was above average.

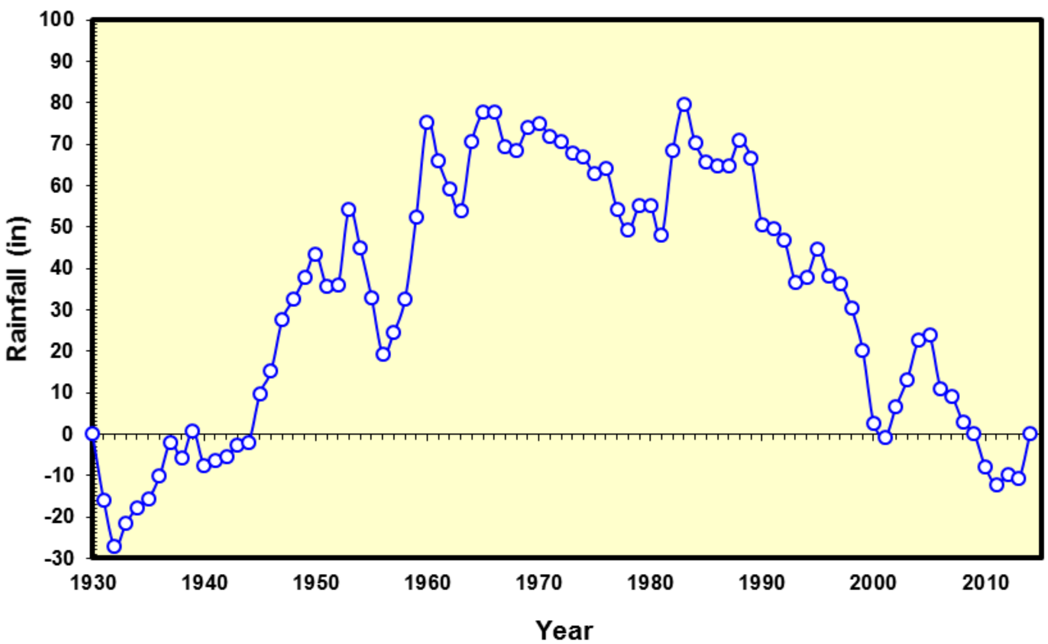

Figure 3-3. Cumulative departure in mean annual rainfall from 1930 through 2014 based on average rainfall values for the Inverness, Ocala, and Brooksville NOAA rainfall stations (Note: 2012-2014 data from nearby SWFWMD rainfall stations). This figure is an update of Figure 4-7 included in the revised 2011 report.

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I get 30 out of 44 years.

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May want to make the major tick marks larger to help the reader (here and on other figures).

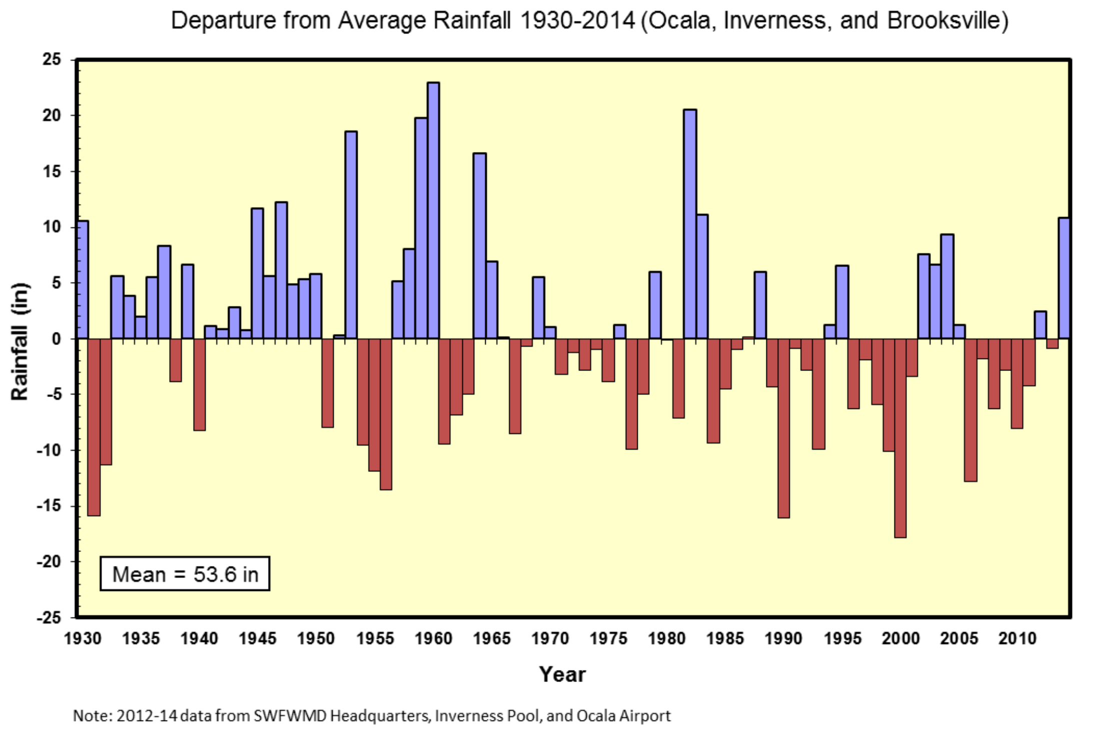

Figure 3-4. Annual departure in mean rainfall from 1930 through 2014 based on rainfall averaged from the Inverness, Ocala, and Brooksville NOAA rainfall stations (Note: 2012-2014 data from nearby SWFWMD rainfall stations). This figure is an update of Figure 4-8 included in the revised 2011 report.

While analyses of three-, six-, and ten-year moving averages of rainfall accumulated from the Ocala, Inverness, and Brooksville stations were presented in the revised 2011 report, long-term rainfall patterns can perhaps be better shown using a 20-year moving average of accumulated annual rainfall at the stations. The 20-year rainfall data for the period from 1930 through 2014 showed an increasing trend up until the mid-1960s and then a declining trend thereafter (Figure 3-5). This is consistent with multi-decadal cycles associated with the Atlantic Multidecadal Oscillation (AMO) (Kelly and Gore 2008). The 20-year moving average was below the bottom 10th percentile (P90) for most of the averages post-2000 (Figure 3-5). Recent 20-year periods (1994-2013 and 1995-2014) have increased and lie between the P90 and P50 percentiles.

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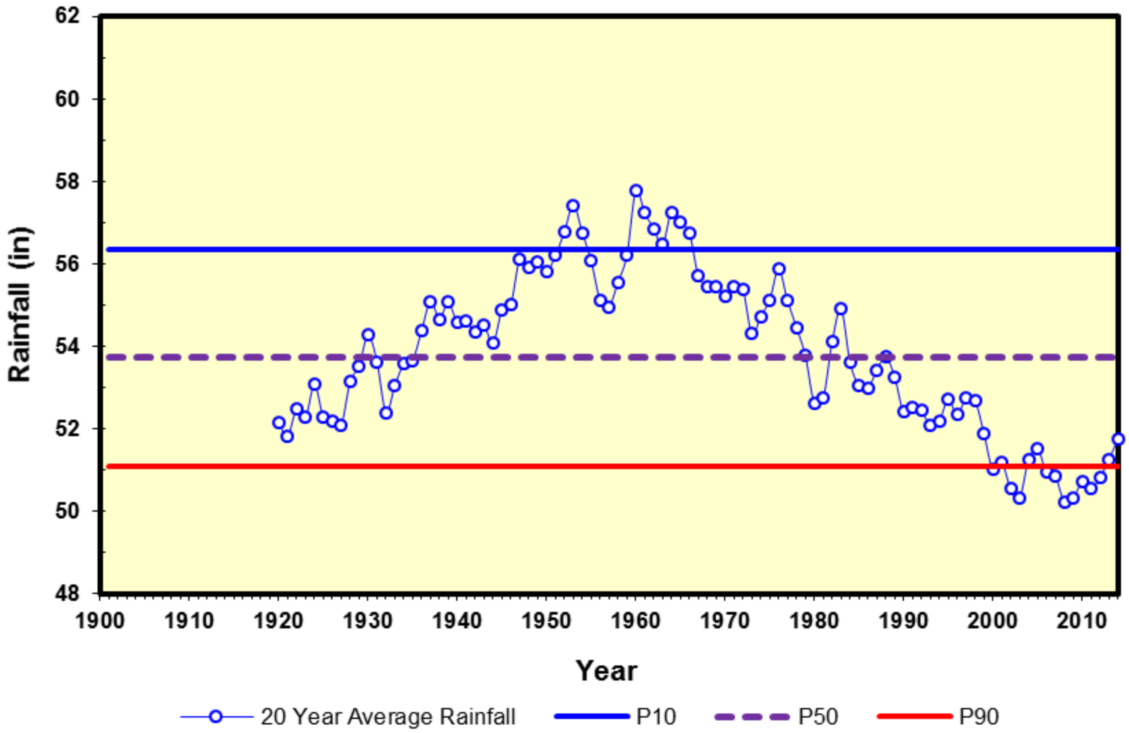

Note: 2012-14 data from SWFWMD Headquarters, Inverness Pool, and Ocala Airport

Figure 3-5. Twenty-year moving average rainfall compared to the P10, P50, and P90 percentiles (1901-2014). Average rainfall based on records for the Inverness, Ocala, and Brooksville NOAA rainfall stations.

3.4 Water Budget

A water budget for the Gum Springs group was developed using the period-of-record mean base flow from Gum Slough Spring Run based on no change in storage for the period from October 2003 through August 2015. Base flow represents the total groundwater contribution for all springs in the group. Assuming that spring discharge is equivalent to recharge within the springshed, the estimated recharge to the Upper Floridan aquifer (UFA) would equal 44 mgd or 8.9 inches per year. Groundwater withdrawals in 2012 were estimated at 2.4 mgd (0.5 inches per year) and constituted about 5.6 percent of average recharge. These withdrawals were relatively small and dispersed throughout the springshed (Figure 3-6). The USGS estimates that, on average, only 45 percent of the groundwater withdrawn is consumptively-used due to septic tank leakage, return flows from irrigation, and reclaimed water disposal (Marella 2008). Applying this factor to the total groundwater withdrawn in the springshed, and conservatively assuming every gallon of consumptively-used water results in a gallon decline in springflow, this would equate to a flow decline of 2.5 percent due to withdrawals in the springshed. This is a conservative assumption, however, since water from the aquifer can come from changes in storage (water level decline), induced leakage from lakes and wetlands, reductions in evapotranspiration (ET), runoff, and groundwater seepage to lakes and rivers. For example, just a little over a one percent reduction in annual ET would account for all the water withdrawn from the springshed.

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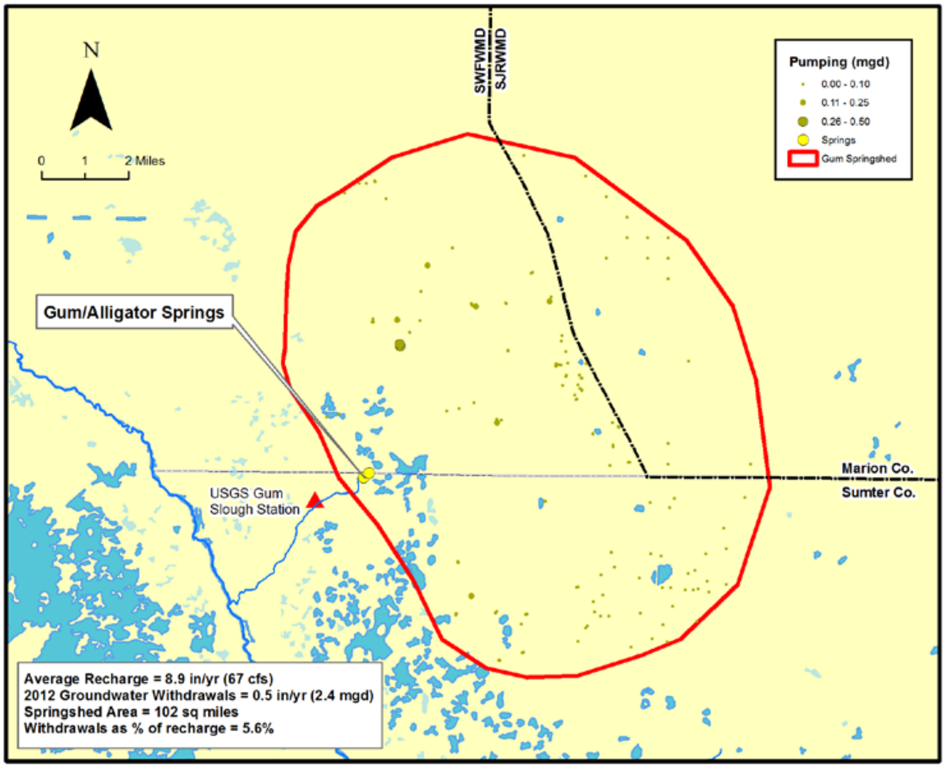

Figure 3-6. Water budget of Gum Springs contributing area (springshed) and distribution of groundwater withdrawals during 2012.

3.5 <u>Numerical Model Results</u>

This section is an update of Section 4.2.3 in the revised 2011 report. An updated numerical model was used to estimate drawdown in the aquifer and subsequently reduction in springflow due to groundwater withdrawals. The model estimated a three cfs average flow reduction at the slough measuring station or a 3.4 percent reduction in mean flow based on the period from 2003 through 2013.

3.5.1 Northern District Model Updates

The Northern District groundwater flow model (NDM) was developed in 2008 by the consulting firm HydroGeoLogic, Inc. (HGL 2008), and this model was used for the revised 2011 report. Since that time, there have been several refinements to the original model, including Version 2.0 in 2010 (HGL 2010), Version 3.0 in 2011 (HGL 2011a, 2011b), and Version 4.0 in 2013 (HGL 2013). Version 4.0 includes an expanded model grid that was extended northward and eastward. Development of this latest version of the model was a cooperative effort between the St. Johns River Water Management District (SJRWMD), SWFWMD, Marion County, and the Withlacoochee River Regional Water Supply Authority. The domain of the NDM includes portions of the SWFWMD, the SJRWMD, and the Suwannee River Water Management District (SRWMD). The model encompasses the entire Central West-Central Florida Groundwater Basin (CWCFGWB) and the Northern West-Central Florida Groundwater Basin (NWCFGWB) and also includes portions of the Northern East-Central Florida Groundwater Basin (SWFWMD 1987). The eastern

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boundary of the regional groundwater flow model extends to the St. Johns River. The western boundary of the model domain extends approximately five miles offshore of the Gulf of Mexico (Figure 3-7).

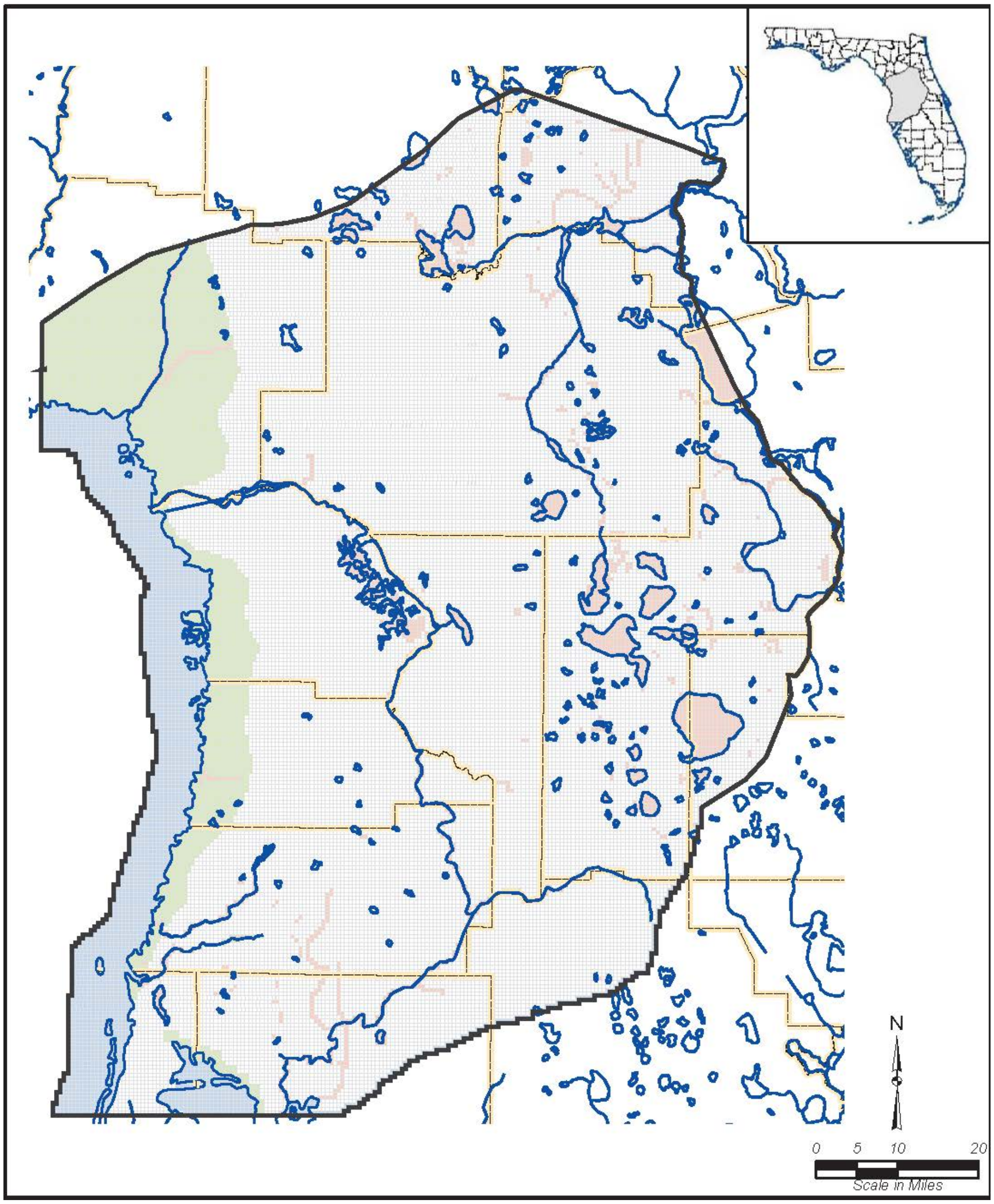

Figure 3-7. Groundwater grid in the Northern District Model (Version 4.0). This figure is an update of Figure 4-12 included in the revised 2011 report.

3.5.2 NDM Scenario

In the revised 2011 report, 2005 groundwater withdrawals were simulated in the NDM to determine drawdown in the UFA and potential impacts to the flow in Gum Slough Spring Run. In the update discussed below, 2010 groundwater withdrawals were simulated in the NDM.

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To determine potential impacts to Gum Slough Spring Run flow, 2010 groundwater withdrawals were simulated in the NDM under long-term transient conditions (five years) and compared to pre-pumping conditions (zero withdrawals) by running the model one year under transient conditions. Heads in the UFA and springflows generated at the end of the 2010 simulation were subtracted from UFA heads and springflows at the end of the pre-pumping simulation to determine aquifer drawdown and flow changes. A total of 461 mgd of groundwater withdrawals occurred within the 10,000-square-mile NDM domain in 2010. The magnitude and spatial distribution of 2010 withdrawals based on District data and water use estimated from the SJRWMD in the NDM are shown in Figure 3-8.

Gum Springs discharge is represented in the NDM as the total of Gum Main Spring and Alligator Spring. Other springs of the Gum Slough Group were not simulated in the NDM. Similar to the 2005 conditions described in the revised 2011 report, the model predicts UFA drawdown of less than 0.25 feet from pre-pumping to 2010 conditions at Gum and Alligator Springs. The predicted reduction in the combined flow of Gum and Alligator Springs was 4.8 percent, compared to the 5.2 percent flow reduction reported previously based on 2005 conditions. Recent water use estimates suggest that current groundwater withdrawals are less than they were in 2010. For example, in Marion and Sumter Counties, the total amount of groundwater withdrawn declined from 105.5 mgd in 2010 to 98.6 mgd in 2013, the most recent year with available estimated and metered water use.

The mean base flow based on observed period-of-record data for Gum Slough from October 2003 through September 2013 was 63 cfs; therefore, a 4.8 percent flow reduction due to groundwater withdrawals would equal three cfs. The mean observed streamflow, e.g., the combination of base flow and overland flow, for Gum Slough was 88 cfs for the period from October 2003 through September 2013. A three cfs reduction in Gum Slough discharge would, therefore, equate to a 3.4 percent reduction in streamflow for the period through September 2013 at the Gum Springs near Holder USGS gaging station. This 3.4 percent withdrawal-related flow reduction is similar but slightly less than the four percent impact on flows at the gage station that was estimated based on data for the period from 2003 through 2010 and was previously used to support development of the minimum flow recommendations included in the revised 2011 report.

Table 3-1. Summary of model results for the updated period 2003-2013.

Variable	Value
NDM Drawdown (feet)	<0.25
Average Base Flow Reduction (Percent)	4.8
Average Base Flow (cfs)	63
Stream Flow Reduction (cfs)	3
Average Total Stream Flow (cfs)	88
Average Total Flow Reduction (Percent)	3.4

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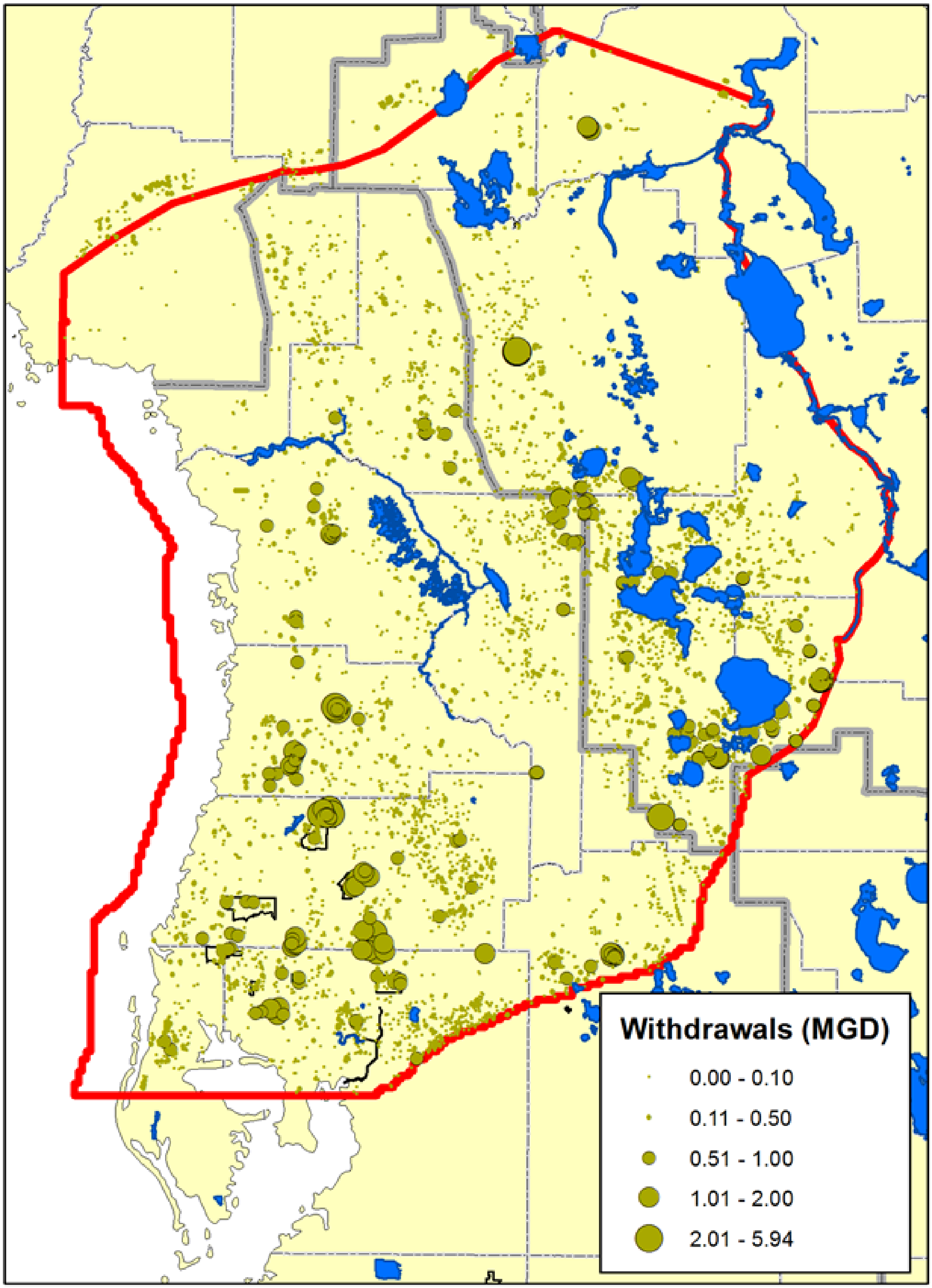

Figure 3-8. Magnitude and distribution of groundwater withdrawals in the UFA in 2010 within the Northern District Model (Version 4) domain. This figure updates Figures 4-3 and 4-13 included in the revised 2011 report.

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CHAPTER 4 – WATER QUALITY

As mentioned in Chapter 2 of this document, nutrient levels, specifically nitrite and nitrate nitrogen (NO_x-N), have been increasing in many springs systems within the District in recent years, including Gum Slough Spring Run. The source has been attributed mostly to the application of inorganic fertilizer (Phelps 2004). In addition to the increases in NO_x-N concentrations, the discharge of many Florida springs systems has been declining since the 1960s (Heyl 2012). While water quality issues typically do not apply to water quantity decisions, such as MFLs, this issue has received considerable attention. Therefore, the relationship between NO_x-N levels and minimum flows has been investigated in several springs systems within the District, including Gum Slough Spring Run, since the revised 2011 report was completed (Heyl 2012).

Because of the importance of this issue, the analysis of the relationship between flow and NO_x-N levels for the Gum Slough Springs group is briefly summarized in this section. Water quality data for Gum Springs (Vents 1, 2, 3, 4, and Main) from the District's Water Management Information System (WMIS) database and discharge data from the USGS Gum Springs near Holder gage from October 2003 through January 2012 was used for this analysis. Temporal trends in discharge and NO_x-N concentration for Gum Slough Springs Run for that time period are shown in Figure 4-1.

To evaluate the relationships and changes in spring flow and NO_x-N concentrations for the Gum Slough Springs group, each trend was evaluated in the context of the other (Heyl 2012). For this analysis, the influence of one predictor variable was systematically removed before testing the other predictor variable. First, NO_x-N was specified as the response variable, discharge was selected as the predictor variable, and a LOWESS (Locally Weighted Scatterplot Smoothing) (see Helsel and Hirsch 1992) was calculated. The output included observed NO_X-N values, the LOWESS-predicted NO_X-N values, and the differences, termed "residuals." The residuals represent the concentration of NO_X-N that cannot be explained by flow; in other words, the "effect" of flow was removed from the time series of NO_X-N values. The residuals were then plotted against time (Figure 4-2, left panel) and were determined to be significantly related to time, indicating that the NO_X-N concentration that cannot be explained by flow increased with time. Time was then selected as the predictor variable, and the evaluation was repeated. In that case, the variation in NO_X-N that can be explained by time was removed and the residuals tested for a significant relationship with flow. The results (Figure 4-2, right panel) indicate that once the time effect has been removed, the relationship between NO_X-N concentration and flow was not significant.

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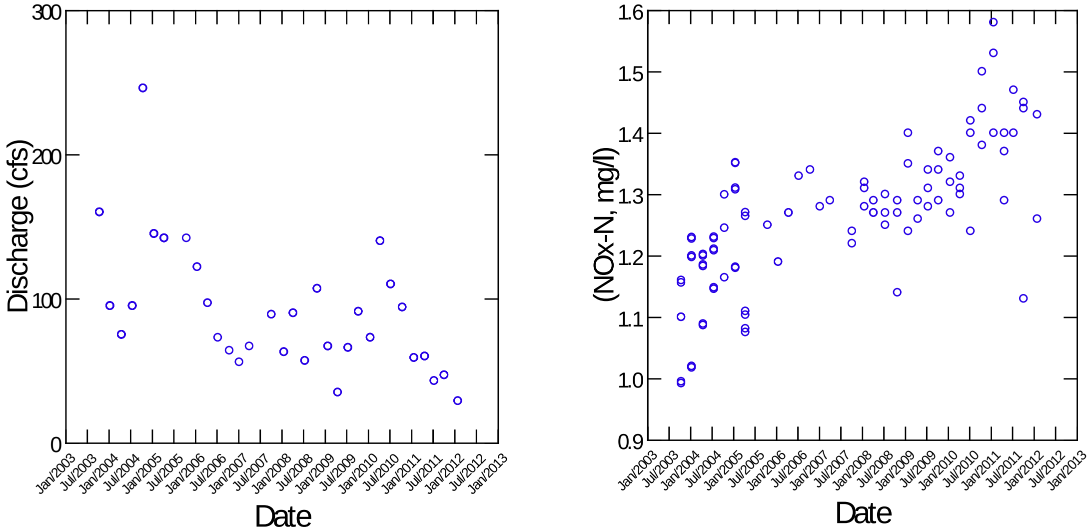

Figure 4-1. Discharge (left panel) and NOx-N concentration (right panel) for Gum Slough Springs Run as a function of date (reproduced from Heyl 2012).

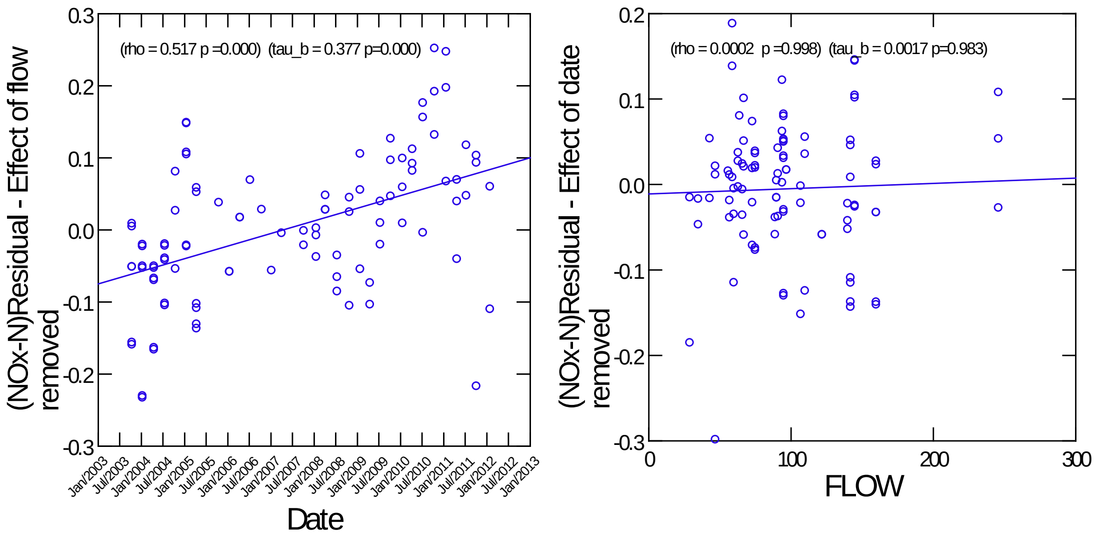

Figure 4-2. Residual plots for Gum Slough Springs Run. NOx-N concentration unaccounted for by flow is significantly related to date (left panel), while NOx-N concentration unaccounted for by date is not significantly related to flow (right panel) (reproduced from Heyl 2012).

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CHAPTER 5 – TECHNICAL APPROACH FOR ESTBALISHING MINIMUM FLOWS FOR GUM SLOUGH SPRING RUN

The same technical approach for establishing proposed minimum flows for Gum Slough Spring Run described in the revised 2011 report was used to support the development of revised minimum flow recommendations that are presented in this report addendum. The revised minimum flow recommendations were, however, developed using an updated flow record for the period from October 2003 through September 2013. This updated flow record includes three additional years of data (October 2010 through September 2013) as compared to the previously used record.

As was the case for the minimum flow analyses described in the revised 2011 report, the updated flow record was based on observed flows at the USGS Gum Springs near Holder gage station that were modified to account for groundwater withdrawal effects. Although the updated hydrological modeling indicated that withdrawals resulted in an average 3.4 percent reduction in streamflow at the gaging station for the period from 2003 through 2013 (compared to a four percent reduction included in the revised 2011 report), in order to take a conservative approach, the original four percent impact value was used for updating the PHABSIM modeling, as described in the following section of this addendum.

The updated flow record, along with the original four percent impact value, was also used to conduct updated simulations of the Hydrologic Engineering Centers River Analysis System (HEC-RAS) model. The updated model results revised the flows associated with maintaining fish passage along the spring run, the inundation of the stream channel, and the long-term inundation of instream woody habitats; the revised results are described in this chapter.

Data collected during a synoptic study of Gum Slough Spring Run conducted since the revised 2011 report was completed (Wetland Solutions, Inc. 2011) provided information for an additional criterion to support the development of minimum flows. This additional criterion examines the effect of changes in flow of the Gum Slough Springs Run on the ecosystem metabolism, an estimate of the overall biological function, of the system and is described in the last section of this chapter.

5.1 PHABSIM Cross-Sections and Modeling Methodology

This section includes revisions to the PHABSIM site and cross-section selection and modeling methodology that were described in the revised 2011 report in Sections 7.2.1 and 7.6.2, and the PHABSIM appendix.

5.1.1 PHABSIM Cross-Sections

For PHABSIM modeling, cross-sections were established at four representative sites to quantify specific habitats for fish and macroinvertebrates within Gum Spring Slough Run at differing flow conditions. Based on the geomorphology of the spring run channel and to ensure adequate representation of the river corridor, the selected PHABSIM sites included runs, shoals, and a pool. Shoals were included because these features represent relatively slower velocity but turbulent flow zones, and loss or reduction of hydraulic connection at these locations during low-flow periods may also present barriers to fish migration or hamper recreational use. Field

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reconnaissance of shoals within the entire study reach was conducted to aid in the selection of PHABSIM sites. Pools and runs were included in the PHABSIM sites based on their common occurrence in the spring run.

Since the locations of the four PHABSIM sites were not presented in the revised 2011 report, they are shown in Figure 5-1 and described as follows. Three of the PHABSIM sites were co-located at cross-section sites used for characterization of floodplain vegetation/soils/hydrologic indicators and instream woody habitats. The Headspring site is a shoal that is co-located with the Vegetation 1 cross-section (see Figures 7-2 and 7-3 in the revised 2011 report). The Shoal site is a shoal co-located with the Vegetation 6 cross-section, and the USGS site is a pool co-located with the Vegetation 8 cross-section. The Springhole site is a run located about 150’ upstream from the Shoal site (Figure 5-1).

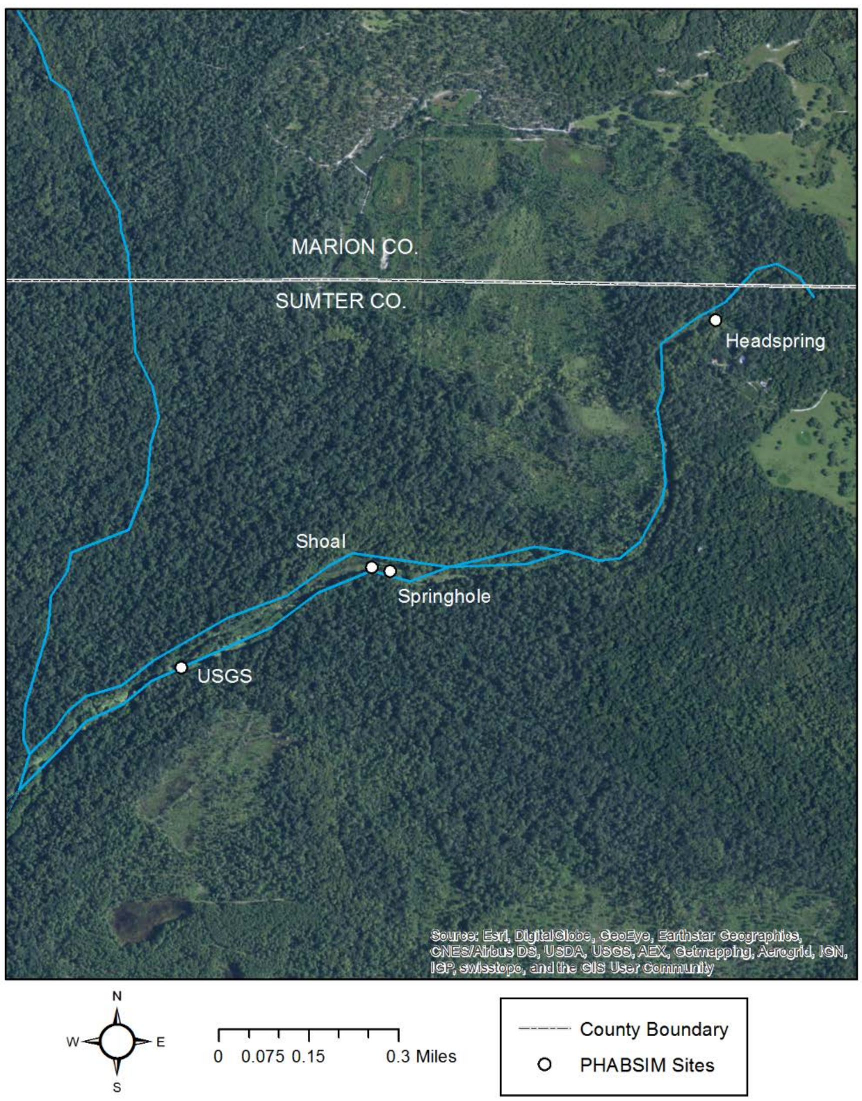

Figure 5-1. Location of the four PHABSIM transect sites in Gum Slough Spring Run.

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The PHABSIM analyses required acquisition of field data concerning channel habitat composition and hydraulics. At each PHABSIM site, tag lines were used to establish up to three cross-sections corresponding to shoal, run, and pool habitats, as applicable, across the channel to the top of bank on either side of the spring run. At each cross-section, stream depth, substrate type, and habitat/cover were recorded, and water velocity was measured with a StreamPro Acoustic Doppler Current Profiler and/or a Sontek Flow Tracker Handheld Acoustic Doppler Velocimeter at intervals determined based on cross-section width. Interval selection was based on collecting a minimum of 20 sets of measurements per cross section. Other hydraulic descriptors measured included channel geometry (river bottom-ground elevations), water surface elevations across the channel, and water surface slope determined from points upstream and downstream of the cross-sections. Elevation data were collected relative to temporary bench marks that were subsequently surveyed by District surveyors to establish absolute elevations, relative to the North American Vertical Datum of 1988 (NAVD 88). Data were collected under a range of flow conditions (low, medium, and high flows) to provide information needed to run the PHABSIM models for each site.

5.1.2 PHABSIM Modeling

In their review of the District's minimum flow methods, Gore et al. (2002) suggested the use of procedures that link biological preferences for hydraulic habitats with hydrological and physical data. Specifically, Gore et al. (2002) endorsed use of the PHABSIM model, a component of the Instream Flow Incremental Methodology (Bovee et al. 1998), and its associated software for determining changes in habitat availability associated with changes in flow. Following this recommendation, the PHABSIM model has been used for development of minimum flows for numerous District rivers and was used to support development of minimum flow recommendations for Gum Springs Slough Run.

Hydraulic modeling for the PHABSIM analysis was conducted using the hydraulic and physical data described in the preceding section (Section 5.1.1) of this addendum and the IFG4 component of the suite of PHABSIM models to predict changes in velocity in individual cells of the channel cross-sections as water surface elevation changes. Predicted velocity values were then used with the Habitat Suitability Curves described in the next section of this addendum in an additional PHABSIM routine (HABTAT) to determine cell-by-cell the amount of weighted usable area (WUA) or habitat available for various organisms and habitat-base guilds as a function of discharge (refer to Figure 7-4 in the revised 2011 report).

The relationships between hydraulic conditions and WUA were then used to evaluate potential flow-related habitat losses and gains relative to the WUA values associated with the updated, modified October 2003 through September 2013 flow record. This assessment was accomplished using the Time Series Library time series analysis routine (Milhous et al. 1990), the updated flow records, and flow records corresponding to 10, 20, 30, and 40 percent reductions to the updated record. Figure 7-5 in the revised 2011 report shows an example of potential habitat gains and losses, e.g., changes in WUA relative to flow reductions of 10, 20, 30, and 40 percent for a specific habitat-based fish guild.

The PHABSIM suite of models do not specifically identify acceptable amounts of habitat loss or gain for any given species, taxonomic group, or other criterion. Rather, given hydrologic data and habitat preferences, the model system can be used for minimum flow purposed to establish relationships between hydrology and WUA for target species or other criteria, and allows examination of habitat availability in terms of the historic, e.g., non-withdrawal impacted, and

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altered flow regimes. The amount of potential habitat loss, or deviation from the optimum, that a water body is capable of withstanding that is determined from these data is based on professional judgment. Gore et al. (2002) provided guidance regarding this issue, suggesting that "[*i*]*n general, instream flow analysts consider a loss of more than 15 percent habitat, as compared to undisturbed or current conditions, to be a significant impact on that population or assemblage.*" For purposes of minimum flows development, the District has defined withdrawal related percent-of-flow reductions that result in greater than a 15 percent reduction in available habitat from historic or non-withdrawal impacted conditions as limiting factors that can be used for developing minimum flows. The appendices to the revised 2011 report include additional information concerning simulation of hydraulic conditions for the river that were used with Habitat Suitability Curves and discharge data to evaluate changes in WUA associated with changes in flow for various organisms and habitat-based guilds.

5.1.2.1 Development of Habitat Suitability Curves

Habitat suitability criteria used for PHABSIM modeling included continuous variable or univariate curves designed to encompass the expected range of suitable conditions for water depth, water velocity, and substrate/cover type and proximity. Habitat suitability curves are generally classified into three categories based on the types of data and data summarization approaches used for their development (Waddle 2012).

Type I curves are not dependent upon acquisition of additional field-data but are, instead, based on personal experience and professional judgment. Informal development of Type I curves typically involves a roundtable discussion (Scheele 1975); stakeholders and experts meet to discuss habitat suitability information to be used for prediction of habitat availability for specific target organisms. A more formal process, known as the Delphi technique (Zuboy 1981), involves submission of a questionnaire to a large respondent group of experts. Results from this survey process are summarized by presenting a median and interquartile range for each variable. Several iterations of this process must be used in order to stabilize the responses, with each expert being asked to justify why his/her answer may be outside the median or interquartile range when presented the results of the survey. The Delphi system lacks the rapid feedback of a roundtable discussion, but does remove the potential biases of a roundtable discussion by creating anonymity of expert opinion. The Delphi system does assume that experts are familiar with the creation of habitat suitability criteria and can respond with sufficient detail to allow development of appropriate mathematical models of habitat use.

Type II curves are based upon frequency distributions for use of certain variables (e.g., flow), which are measured at locations utilized by the target species. Curves for numerous species have been published by the United States Fish and Wildlife Service (USFWS) or the USGS and are commonly referred to as "blue book" criteria.

Type III curves are derived from direct observation of the utilization and/or preference of target organisms for a range of environmental variables (Manly et al. 1993). These curves are weighted by actual distribution of available environmental conditions in the stream (Bovee et al. 1998). Type III curves assume that the optimal conditions will be "preferred" over all others if individuals are presented equal proportions of less favorable conditions (Johnson 1980).

Based on the abundance and distribution of the spotted sunfish (*Lepomis punctatus*) in rivers within the District, including Gum Slough Spring Run, modified Type III habitat suitability curves

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SJRWMD agrees with the statements by the SWFWMD Gum Spring Slough peer review panel. "The selection of the 15% threshold to indicate significant harm has stood up to past peer reviews, and represents a defensible value. Ultimately, experimental studies that examine the effects of a variety of percentage losses of habitat on multiple species of interest would test the assumption that 15% is protective, but until such research is completed the current value in use has merit." Experimental studies and/or biomonitoring data collection and analyses are required to "prove up" this 15% threshold. Such work may indicate that a one-size fits all threshold is inappropriate. In the mean time, the 15% significant harm threshold used by SWFWMD does not seem unreasonable. You have stressed that this 15% threshold is based upon professional judgment.

Number: 2 Author: Shall Subject: Highlight Date: 2/19/2016 2:37:04 PM

were created for adult, juvenile, spawning, and fry life stages of this species and used for evaluating habitat availability at the Gum Slough Spring Run PHABSIM sites. Development of these curves involved the initial creation of Type I curves that were subsequently modified based on field sampling efforts. Initially, since most of the regional experts in fish ecology that were consulted were unfamiliar with development of habitat suitability criteria, a hybrid of the roundtable and Delphi techniques was used to develop Type I curves for the species. For this effort, a proposed working model of habitat suitability criteria was provided to 14 experts for evaluation. The proposed suitability curves were based on flow criteria reported by Aho and Terrell (1986) for another member of the Family Centrachidae, the redbreast sunfish (*Lepomis auritus*), that were modified according to published literature on the biology of spotted sunfish. Respondents were given approximately 30 days to review the proposed habitat suitability criteria and to suggest modifications. Six of the 14 experts provided comments. In accordance with Delphi techniques, the suggested modifications were incorporated into the proposed Type I curves. Suggested modifications that fell outside of the median and 25% interquartile range of responses were not considered unless suitable justification could be provided. The resulting Type I curves were later modified following fish sampling conducted on the Peace River. Data obtained from these field collections were considered sufficient to classify the modified curves as Type II to Type III curves.

Modified Type II habitat suitability criteria for adult, juvenile, spawning, and fry life stages of largemouth bass (*Micropterus salmoides)* and bluegill (*Lepomis macrochirus*), two other common fish species in Gum Slough Spring Run (Wetland Solutions, Inc. 2011), were established using USFWS/USGS “blue book” criteria (Stuber et al. 1982). Curves for these species have been widely used in PHABSIM model applications and were used for the Gum Slough Spring Run PHABSIM analyses.

Type III habitat suitability criteria for macroinvertebrate community diversity were established based on suitability curves published by Gore et al. (2001). Modified substrate and cover codes used for criteria development were established through consultation with District and Florida Fish and Wildlife Conservation Commission staff. For this effort, emphasis was placed on invertebrate preference for macrophytes, inundated woody snags and exposed root habitats common in Gum Slough Spring Run and other Florida streams.

A Type II habitat suitability curve for combined adult life stages of minnows (the Family Cyprinidae) was developed based on electrofishing conducted at several Florida Rivers. The sampling involved quantification of all cyprinid minnows, without segregation by species, in association with observed flow velocities, water depth, and substrate types. The curve is, therefore, based on total occurrence of cyprinids in the sampled Florida systems. It may be considered a generalized curve applicable for all Cyprinidae and could certainly be refined for individual taxa or for specific water bodies based on data availability. This generalized curve was considered suitable for use in the PHABSIM analyses for Gum Spring Slough Run.

Type III curves developed for a suite of habitat guilds representative of fish habitat diversity were also used for the PHABSIM analyses for Gum Slough Spring Run. The habitat guild curves include shallow-slow, shallow-fast, deep-slow, and deep-fast guilds and serve as generalized indicators of habitat diversity associated with ranges of flow velocity, water depth, and substrate type. They are used to improve understanding of results based on taxon-specific curves and to address potential habitat changes for taxa currently lacking specific life-history stage curves. The habitat guild criteria are based on information developed by Leonard and Orth (1988) for a suite of fish and habitat types occurring in a number of streams in Virginia. Their use for Gum Slough Spring Run and other Florida systems is considered appropriate as they specify habitat characteristics that are expected to be populated by local fish fauna.

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5.2 Updated PHABSIM Modeling Results

Inclusion of the three additional years of flow records (2010-2013) in the PHABSIM model runs yielded modeled gains and losses in habitat availability associated with changes in discharge from the non-withdrawal impacted, historical conditions that differed from those reported in the revised 2011 report. Tables 5.1 and 5.2 include the revised modeling results and replace Figure 7-5 included in Section 7.6.2 of the revised 2011 report, as well as the graphics presented in the PHABSIM Appendix.

For all PHABSIM sites combined, the loss of available, suitable habitat as a result of flow reductions in Gum Slough Spring Run was greatest for adult spotted sunfish. For example, the largest loss of available habitat for adult spotted sunfish as a result of a 10 percent reduction in flow (almost 24 percent) occurred in July (Table 5.2).

A study characterizing the ecosystem of Gum Slough Spring Run conducted since the revised 2011 report was completed demonstrates that the guilds and species selected for the PHABSIM modeling were appropriate (Wetland Solutions, Inc. 2011). For example, sunfish, including largemouth bass, bluegill, and spotted sunfish, and minnows were typically the species most often observed during fish surveys of the spring run from October 2010 through September 2011.

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Table 5-1. PHABSIM modeling results (habitat for all sites combined) of habitat gains/losses for the shallow-slow, shallow-fast, deep-slow, and deep-fast habitat guilds; adult, juvenile, spawning, and fry largemouth bass; and adult bluegill for Gum Slough Spring Run based on 10, 20, 30, and 40 percent reductions in flow from 2003 through 2013 corrected for withdrawal impacts. This table is an update of the information presented in Figure 7-5 included in the revised 2011 report, as well as the graphics presented in the PHABSIM Appendix.

Flow Reduction (Percent)	Percent Change in Habitat Availability								
	Shallow-Slow Habitat Guild	Shallow-Fast Habitat Guild	Deep-Slow Habitat Guild	Deep-Fast Habitat Guild	Adult Largemouth Bass	Juvenile Largemouth Bass	Spawning Largemouth Bass	Largemouth Bass Fry	Adult Bluegill
January									
10	13.7	5.1	-2.6	-4.2	-2.9	1.2	-5.9	-7.4	-4.0
20	21.6	7.9	-5.8	-8.9	-5.9	2.8	-13.0	-18.2	-8.8
30	26.1	9.9	-9.6	-14.8	-9.5	4.3	-21.5	-33.2	-15.0
40	48.7	10.7	-13.8	-22.9	-12.9	5.2	-30.0	-46.3	-21.6
February									
10	13.1	4.2	-2.8	-3.9	-2.9	1.4	-6.4	-8.7	-4.1
20	11.5	6.1	-6.2	-8.6	-5.9	3.0	-14.1	-22.1	-9.0
30	17.6	6.7	-10.2	-15.6	-10.0	4.2	-23.6	-38.2	-16.6
40	34.1	8.6	-13.7	-24.1	-13.0	5.2	-32.4	-53.0	-22.9
March									
10	2.1	3.6	-2.6	-3.2	-2.9	1.6	-6.2	-8.9	-4.1
20	2.5	7.3	-5.2	-8.7	-6.5	2.8	-14.9	-24.1	-10.3
30	14.4	9.1	-8.3	-15.3	-9.8	4.3	-23.7	-40.4	-16.3
40	29.4	9.3	-13.6	-23.9	-12.9	4.9	-31.0	-49.3	-22.4
April									
10	6.2	4.2	-2.7	-3.8	-3.4	1.5	-7.1	-11.0	-5.5
20	9.2	6.7	-5.7	-8.8	-6.2	3.4	-14.8	-24.9	-9.8
30	20.6	7.9	-9.6	-15.3	-9.4	4.8	-22.4	-36.6	-15.2
40	42.3	9.8	-14.7	-24.5	-12.3	4.9	-29.3	-43.7	-21.2

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Flow Reduction (Percent)	Percent Change in Habitat Availability								
	Shallow-Slow Habitat Guild	**Shallow-Fast Habitat Guild**	**Deep-Slow Habitat Guild**	**Deep-Fast Habitat Guild**	**Adult Largemouth Bass**	**Juvenile Largemouth Bass**	**Spawning Largemouth Bass**	**Largemouth Bass Fry**	**Adult Bluegill**
May									
10	5.9	2.7	-2.8	-4.2	-3.1	1.3	-7.1	-11.4	-4.5
20	12.6	4.6	-6.1	-9.2	-5.9	2.7	-14.3	-23.4	-9.1
30	22.6	6.6	-6.5	-16.3	-9.2	3.3	-21.7	-33.8	-15.0
40	37.5	6.8	-11.4	-25.5	-12.9	3.2	-28.9	-43.8	-22.1
June									
10	3.7	2.3	-2.9	-3.9	-3.3	1.3	-7.0	-11.9	-5.1
20	13.4	4.4	-4.6	-9.6	-6.3	2.4	-14.8	-25.2	-10.1
30	21.8	5.9	-9.2	-16.4	-9.3	3.1	-21.9	-36.2	-15.6
40	38.8	6.3	-13.1	-26.1	-13.3	2.7	-29.4	-45.1	-23.5
July									
10	8.4	3.9	-2.7	-3.5	-2.7	1.7	-6.5	-11.6	-3.7
20	13.8	6.3	-4.2	-7.9	-6.0	3.1	-14.1	-23.5	-9.1
30	23.8	8.1	-8.5	-14.9	-9.3	4.2	-22.6	-37.7	-15.1
40	40.9	10.3	-13.9	-23.8	-12.9	4.5	-30.4	-48.6	-22.2
August									
10	13.8	5.2	-2.3	-3.5	-2.9	1.7	-6.1	-8.1	-3.5
20	31.3	9.2	-5.4	-7.8	-5.8	3.4	-12.8	-18.5	-7.6
30	42.9	12.8	-9.3	-13.7	-9.2	4.8	-20.8	-30.8	-13.5
40	56.0	14.3	-14.2	-21.8	-13.2	5.9	-30.1	-45.8	-21.4
September									
10	16.8	7.3	-1.4	-1.9	-2.6	2.5	-5.1	-6.0	-2.2
20	35.9	14.2	-3.9	-5.7	-5.0	4.6	-10.8	-13.4	-4.6
30	56.0	20.6	-7.2	-10.4	-8.7	6.3	-17.5	-21.9	-9.9
40	78.1	27.0	-11.8	-17.3	-12.4	7.9	-26.2	-35.5	-16.6

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Flow Reduction (Percent)	Percent Change in Habitat Availability								
	Shallow-Slow Habitat Guild	**Shallow-Fast Habitat Guild**	**Deep-Slow Habitat Guild**	**Deep-Fast Habitat Guild**	**Adult Largemouth Bass**	**Juvenile Largemouth Bass**	**Spawning Largemouth Bass**	**Largemouth Bass Fry**	**Adult Bluegill**
October									
10	17.5	8.3	-1.4	-1.4	-2.3	2.7	-4.9	-6.9	-1.3
20	36.8	16.9	-3.7	-4.2	-5.1	4.9	-10.5	-13.9	-4.2
30	49.1	23.2	-6.9	-9.1	-8.5	6.7	-17.4	-22.4	-9.2
40	54.6	23.9	-10.8	-15.4	-12.7	8.8	-26.5	-37.8	-16.1
November									
10	18.9	6.8	-1.7	-2.1	-2.8	2.2	-5.1	-6.3	-2.7
20	43.5	14.0	-4.3	-5.9	-5.3	3.9	-10.9	-13.1	-5.4
30	54.1	19.2	-7.7	-10.8	-8.8	5.7	-17.7	-23.2	-10.8
40	72.29	21.8	-12.4	-18.3	-12.9	6.9	-27.1	-38.6	-18.1
December									
10	14.9	5.7	-2.3	-3.1	-2.5	1.7	-5.3	-6.8	-2.9
20	27.2	10.4	-5.2	-7.4	-5.5	3.3	-11.8	-15.7	-7.3
30	33.1	12.9	-8.9	-13.3	-9.0	4.8	-19.9	-28.9	-13.2
40	55.6	14.6	-13.8	-20.9	-12.9	5.9	-28.9	-43.9	-20.5

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Table 5-2. PHABSIM modeling results (habitat for all sites combined) of habitat gains/losses for juvenile, spawning, and fry bluegill; adult, juvenile, spawning, and fry spotted sunfish; benthic macroinvertebrates; and Cyprinidae for Gum Slough Spring Run based on 10, 20, 30, and 40 percent reductions in flow from 2003 through 2013 corrected for withdrawal impacts. This table is an update of the information presented in Figure 7-5 included in the revised 2011 report, as well as the graphics presented in the PHABSIM Appendix.

Flow Reduction (Percent)	Percent Change in Habitat Availability								
	Juvenile Bluegill	Spawning Bluegill	Bluegill Fry	Adult Spotted Sunfish	Juvenile Spotted Sunfish	Spawning Spotted Sunfish	Spotted Sunfish Fry	Benthic Macroinvertebrates	Cyprinidae
January									
10	5.9	3.7	-0.9	-10.7	5.9	6.5	6.4	21.9	5.6
20	11.1	6.2	-3.9	-25.3	12.9	13.9	14.2	40.5	10.9
30	16.0	9.4	-7.2	-38.5	20.7	21.9	22.9	62.0	16.3
40	20.9	10.8	-12.9	-49.9	28.5	30.1	32.7	96.7	22.8
February									
10	4.8	2.6	-2.7	1.5	6.3	6.5	6.7	16.7	5.0
20	8.9	5.6	-4.8	-28.7	13.5	13.9	14.3	28.6	9.6
30	12.9	7.9	-10.2	-38.7	21.0	21.8	23.3	50.7	14.7
40	17.2	9.9	-16.0	-54.3	28.6	29.7	32.8	84.9	21.1
March									
10	4.4	2.4	-0.8	-7.0	6.4	6.6	6.2	8.7	4.4
20	8.6	5.2	-4.4	-23.9	12.9	13.5	13.7	25.3	9.4
30	12.9	8.6	-10.6	-41.3	21.1	21.9	23.1	47.4	14.9
40	17.2	11.2	-14.6	-59.9	27.6	28.9	31.6	78.8	21.0
April									
10	4.7	3.3	-2.8	-10.8	6.5	7.0	6.9	15.2	4.8
20	9.7	6.8	-5.5	-27.7	14.3	15.2	15.6	30.5	10.2
30	15.1	10.1	-10.0	-43.4	21.4	23.0	24.2	55.9	15.9
40	20.7	11.0	-12.6	-50.4	26.7	29.2	31.8	100.2	22.8

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Flow Reduction (Percent)	Percent Change in Habitat Availability								
	Juvenile Bluegill	**Spawning Bluegill**	**Bluegill Fry**	**Adult Spotted Sunfish**	**Juvenile Spotted Sunfish**	**Spawning Spotted Sunfish**	**Spotted Sunfish Fry**	**Benthic Macroinvertebrates**	**Cyprinidae**
May									
10	4.1	2.9	-3.6	-1.6	6.0	6.5	6.5	12.8	4.4
20	8.7	4.8	-4.8	-20.5	12.7	13.4	13.7	26.9	8.9
30	13.1	7.0	-9.5	-41.8	18.3	19.6	20.5	49.9	14.1
40	17.3	9.2	-12.5	-54.9	23.2	24.9	27.6	80.8	19.4
June									
10	3.9	3.1	-1.9	-4.9	5.9	6.1	6.1	9.5	3.7
20	8.2	5.4	-5.2	-13.0	12.4	12.7	13.3	25.3	8.4
30	11.9	6.9	-9.4	-38.6	18.1	18.6	20.2	43.3	13.1
40	15.6	8.8	-13.3	-46.2	22.4	23.3	26.9	72.6	18.4
July									
10	5.1	2.9	-1.6	-23.6	6.9	7.1	6.9	12.5	4.8
20	9.6	5.9	-4.5	-22.6	14.1	14.4	14.4	25.2	9.3
30	14.2	7.9	-9.1	-45.3	21.2	21.7	22.8	46.8	14.8
40	17.9	9.6	-14.1	-50.5	27.3	27.8	31.2	75.7	20.8
August									
10	6.8	3.7	-1.6	-15.1	6.9	7.6	7.3	21.9	5.9
20	12.9	6.5	-3.9	-21.5	14.9	15.9	15.6	46.2	11.9
30	18.3	9.9	-6.7	-31.2	22.7	23.9	24.2	74.5	18.1
40	22.7	12.0	-12.7	-43.4	30.8	32.3	34.4	108.9	24.6
September									
10	9.1	4.9	0.1	-6.9	8.9	10.0	8.6	21.9	7.1
20	17.9	9.3	-0.5	-22.7	17.5	19.6	17.3	56.8	14.9
30	25.9	12.9	-2.2	-24.9	26.1	28.9	26.5	93.8	22.1
40	33.1	16.4	-6.5	-45.3	36.1	39.5	37.9	137.7	29.9

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Flow Reduction (Percent)	Percent Change in Habitat Availability								
	Juvenile Bluegill	**Spawning Bluegill**	**Bluegill Fry**	**Adult Spotted Sunfish**	**Juvenile Spotted Sunfish**	**Spawning Spotted Sunfish**	**Spotted Sunfish Fry**	**Benthic Macroinvertebrates**	**Cyprinidae**
October									
10	8.5	4.9	-0.6	-15.6	9.7	10.6	8.9	18.3	7.4
20	16.9	9.7	0.4	-26.4	18.7	20.5	17.3	46.8	14.9
30	24.8	13.7	-0.9	-32.8	27.9	30.5	27.2	77.5	22.5
40	32.4	17.8	-5.5	-49.4	38.7	42.1	39.6	112.4	30.0
November									
10	8.2	4.7	0.1	-1.8	8.1	8.9	7.7	22.6	6.4
20	16.5	8.1	-0.3	-10.9	16.3	17.9	16.1	54.3	13.9
30	23.5	11.5	-2.4	-29.1	24.5	26.5	24.9	81.2	20.4
40	29.9	15.1	-7.6	-33.9	34.0	36.4	36.3	120.8	27.6
December									
10	6.6	3.7	0.6	-1.7	6.9	7.5	6.9	20.7	5.9
20	13.0	7.2	-1.0	-17.9	14.2	15.3	14.7	43.3	11.8
30	18.7	10.3	-4.4	-32.6	22.1	23.5	23.8	66.9	17.8
40	24.1	12.6	-10.3	-45.5	30.7	32.3	34.2	102.7	24.3

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5.2.1 Summary of Updated PHABSIM Model Results

The updated percent flow reduction resulting in a 15 percent loss of available habitat calculated for each taxonomic group as a result of the updated PHABSIM modeling is presented in Table 5-3. While the shallow-slow fish habitat guild and benthic macroinvertebrates were the most restrictive criteria in the previous analysis resulting in an allowable flow reduction of nine percent for the Gum Springs near Holder gage, adult spotted sunfish were the most restrictive in the updated analyses, resulting in an allowable flow reduction of six percent for the gage site.

Table 5-3. PHABSIM percent flow reduction calculations. This table is an update of Table 8-1 included in the revised 2011 report.

Taxonomic Group	Allowable Flow Reduction (Percent)
Adult Spotted Sunfish	6
Largemouth Bass Fry	12
Spawning Largemouth Bass	19
Deep-Fast Habitat Guild	27
Adult Bluegill	27
Bluegill Fry	37
Shallow-Slow Habitat Guild	40
Deep-Slow Fish Guild	40
Shallow-Fast Habitat Guild	40
Adult Largemouth Bass	40
Juvenile Largemouth Bass	40
Juvenile Bluegill	40
Spawning Bluegill	40
Juvenile Spotted Sunfish	40
Spawning Spotted Sunfish	40
Spotted Sunfish Fry	40
Benthic Macroinvertebrates	40
Cyprinidae	40

5.3 Updated HEC-RAS Modeling Results

Results of additional HEC-RAS model simulations are described in a technical memorandum (Intera, Inc. 2014) included as an appendix to this document; this technical memorandum updates the HEC-RAS Modeling Appendix included with the 2011 revised report. The additional model simulations included a simulation using flow records from the USGS Gum Springs near Holder gage station from October 2003 through September 2013 that were modified to account for the estimated four percent withdrawal impact on flows. Results from this simulation were used to assess flows associated with the inundation of the stream channel (e.g., the wetted perimeter) and flows necessary for maintaining fish passage along the spring run. The results were also used for updated analysis of the inundation of woody habitats in Gum Slough Spring Run. A second simulation used results of a model developed for predicting modified flows at the Gum

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The change in allowable flow reduction from 9% to 40% seems like a huge change with the addition of only three years of additional flow record. What accounts for this? It makes the method seem very sensitive to the length and/or quality (large range of flow fluctuation vs. small range of flow fluctuation) of the flow record. Is that the case? And is this a problem? Would you get a significantly different outcome if the POR flow data was much larger?

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Springs near Holder gage based on flows at the Rainbow Springs Group gage; however, because the relationship was not strong, results from this simulation were not used for additional analyses.

5.3.1 Summary of Updated Low-Flow Threshold Results

The updated low-flow threshold was established at the higher of two flow criteria, which were based on maintaining fish passage and maximizing wetted perimeter for the least amount of flow in the spring run.

5.3.1.1 Fish Passage

[1]The flows necessary at the USGS Gum Springs near Holder gage site to maintain a minimum water depth of 0.6 foot to allow for fish passage at each cross-section in the HEC-RAS model are shown in Figure 5-2. [2]Based on these results, a flow of 14 cfs at the USGS gage site was used to define the fish passage criterion.

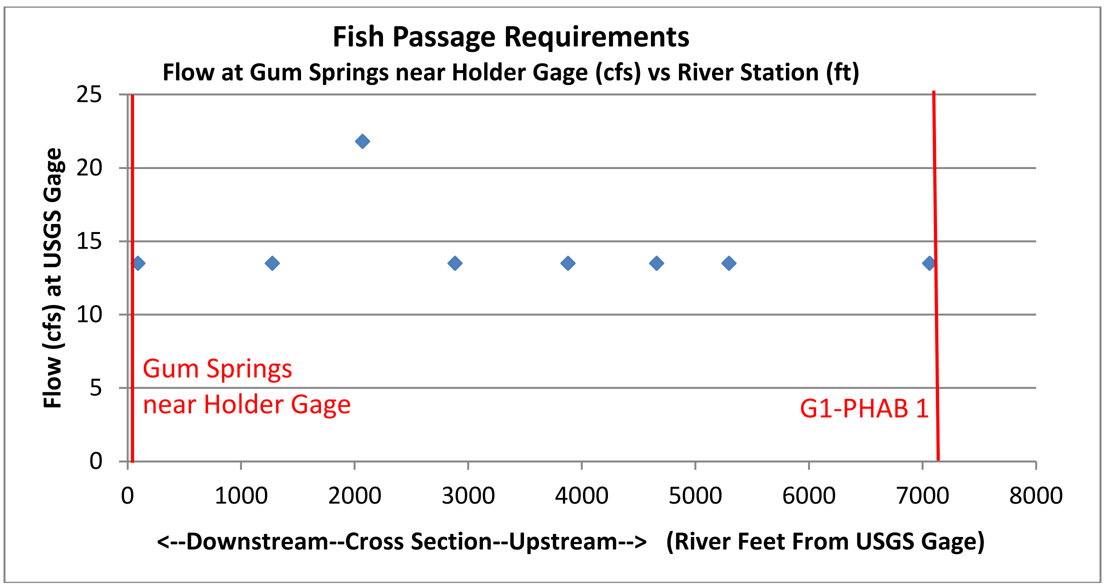

Figure 5-2. Flow required at the Gum Springs near Holder USGS gage site to inundate the deepest part of the channel at HEC-RAS model cross-sections in Gum Slough Spring Run to a depth of 0.6 feet. This figure is an update of Figure 8-1 included in the revised 2011 report.

5.3.1.2 Wetted Perimeter

Output from the updated HEC-RAS model simulation was used to create wetted perimeter versus discharge plots for each of the HEC-RAS cross-sections of Gum Slough Spring Run. To assist in the identification of potential wetted perimeter inflection points, only the low end of the modeled flows were plotted. These updated plots are presented below and replace Figure 7-6 included in Section 7.7.1 of the revised 2011 report, as well as the plots included in the Wetted Perimeter Appendix.

There was no apparent lowest perimeter inflection point (LWPIP) for the four most upstream cross-sections (G1-PHAB 1, G2, G3, or G4) (Figures 5-3 through 5-6); therefore, the LWPIP was established at 14 cfs, the lowest modeled flow at the Gum Springs near Holder USGS gage.

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However, LWPIPs were noted at the four most downstream cross-sections; all corresponded with a flow of 43 cfs at the USGS gage (Figures 5-7 through 5-10).

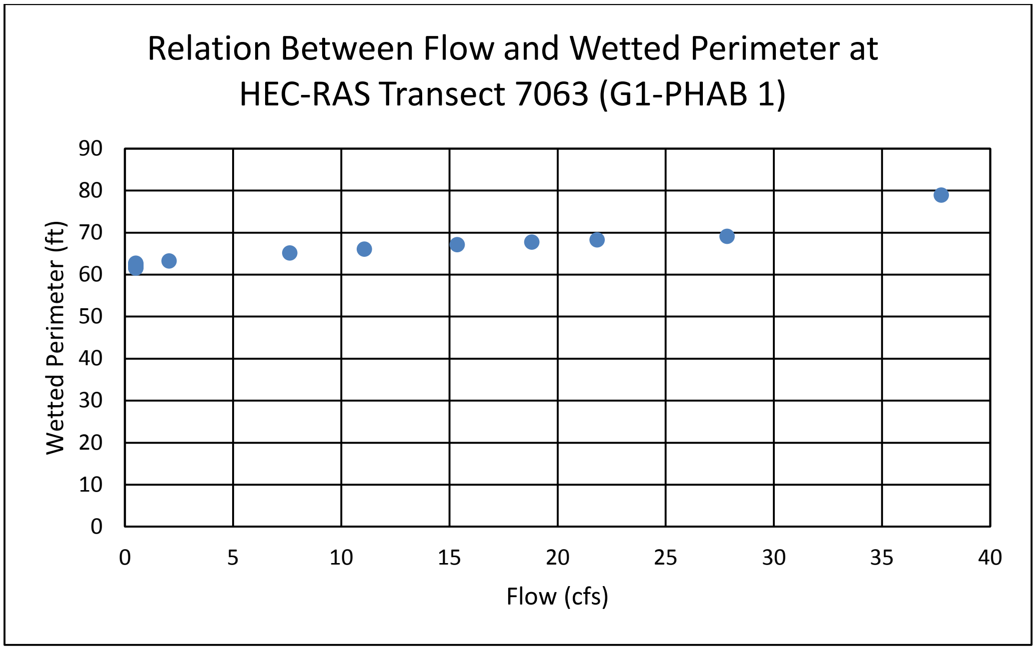

Figure 5-3. Wetted perimeter versus discharge at HEC-RAS model station number 7063 (G1-PHAB 1) in Gum Slough Spring Run. This figure is an update of Figure 7-6 included in the revised 2011 report.

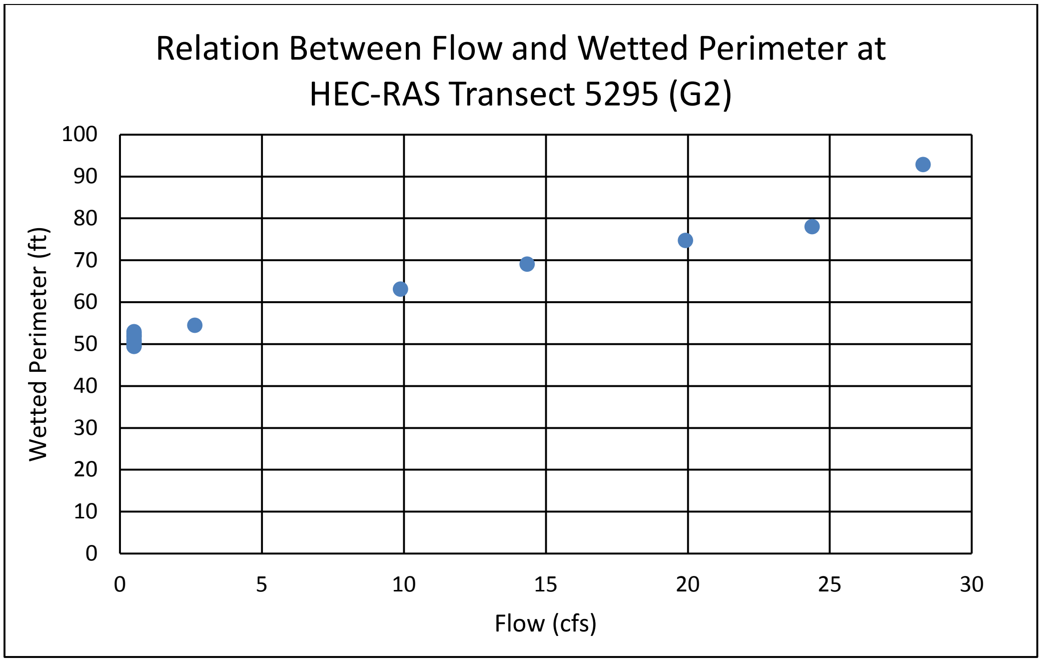

Figure 5-4. Wetted perimeter versus discharge at HEC-RAS model station number 5295 (G2) in Gum Slough Spring Run. This figure is an update of the figures included in the Wetted Perimeter Appendix of the revised 2011 report.

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Adding an arrow on these graphs to denote where you called the point of inflection would help the reader's understanding.

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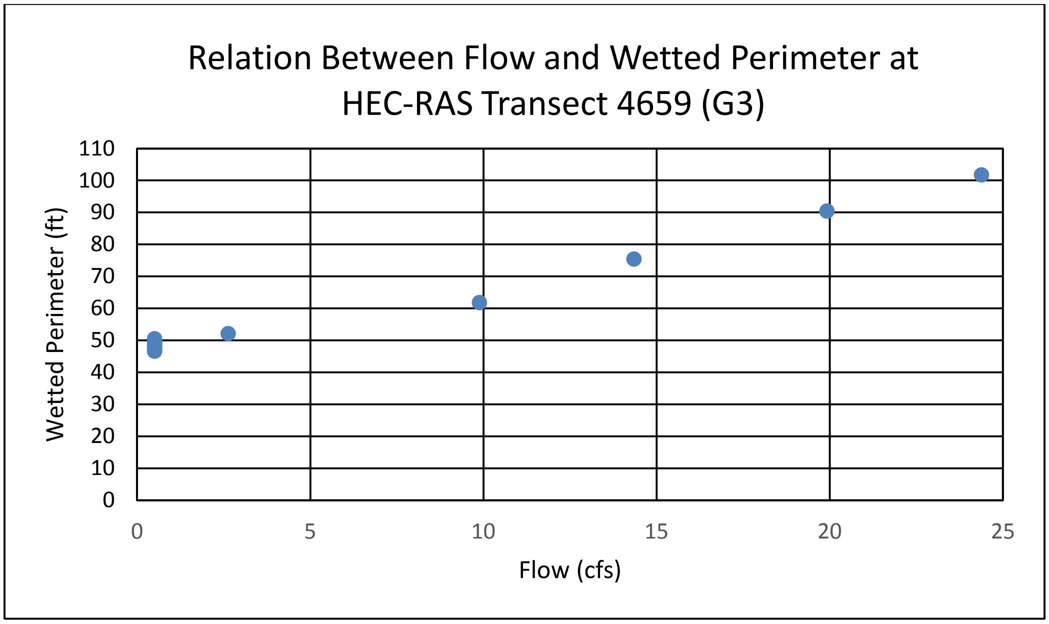

Figure 5-5. Wetted perimeter versus discharge at HEC-RAS model station number 4659 (G3) in Gum Slough Spring Run. This figure is an update of the figures included in the Wetted Perimeter Appendix of the revised 2011 report.

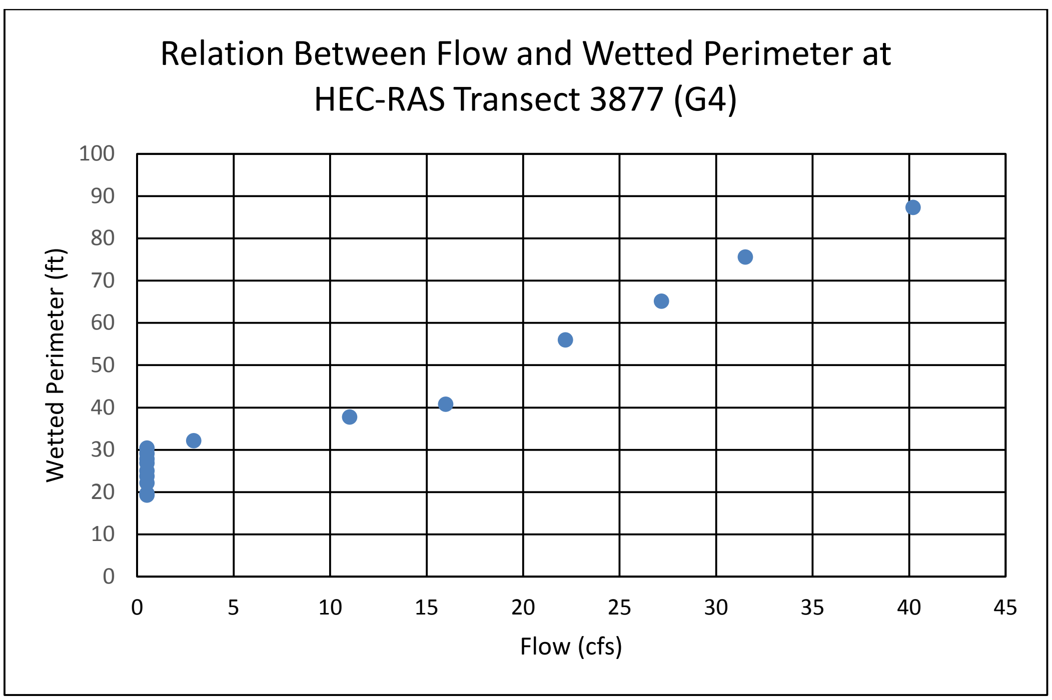

Figure 5-6. Wetted perimeter versus discharge at HEC-RAS model station number 3877 (G4) in Gum Slough Spring Run. This figure is an update of the figures included in the Wetted Perimeter Appendix of the revised 2011 report.

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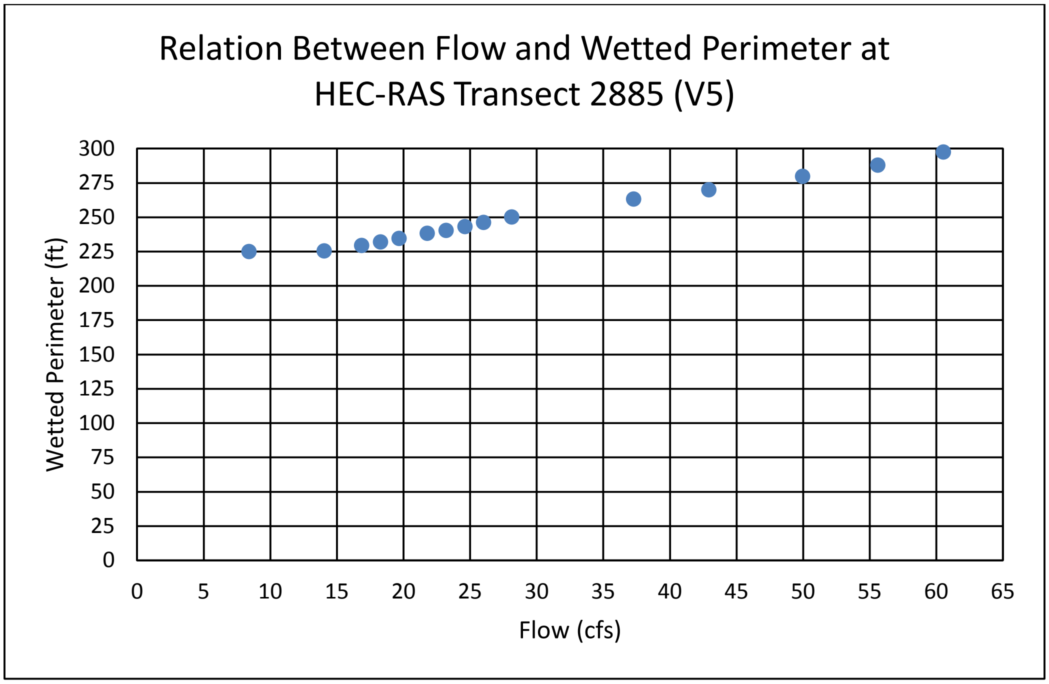

Figure 5-7. Wetted perimeter versus discharge at HEC-RAS model station number 2885 (V5) in Gum Slough Spring Run. This figure is an update of the figures included in the Wetted Perimeter Appendix of the revised 2011 report.

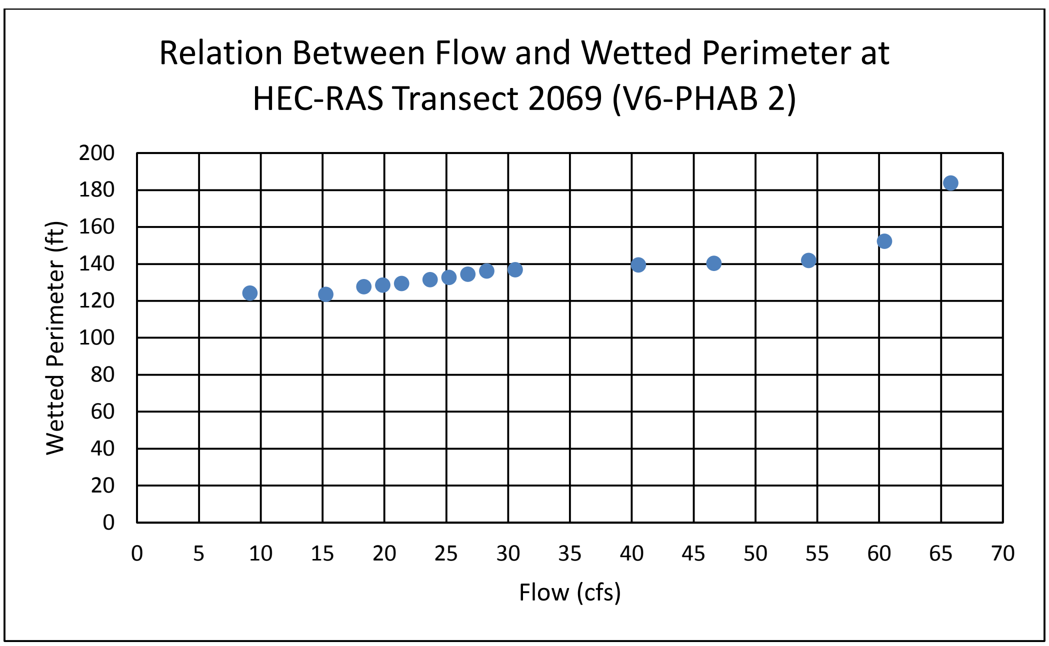

Figure 5-8. Wetted perimeter versus discharge at HEC-RAS model station number 2069 (V6-PHAB 2) in Gum Slough Spring Run. This figure is an update of the figures included in the Wetted Perimeter Appendix of the revised 2011 report.

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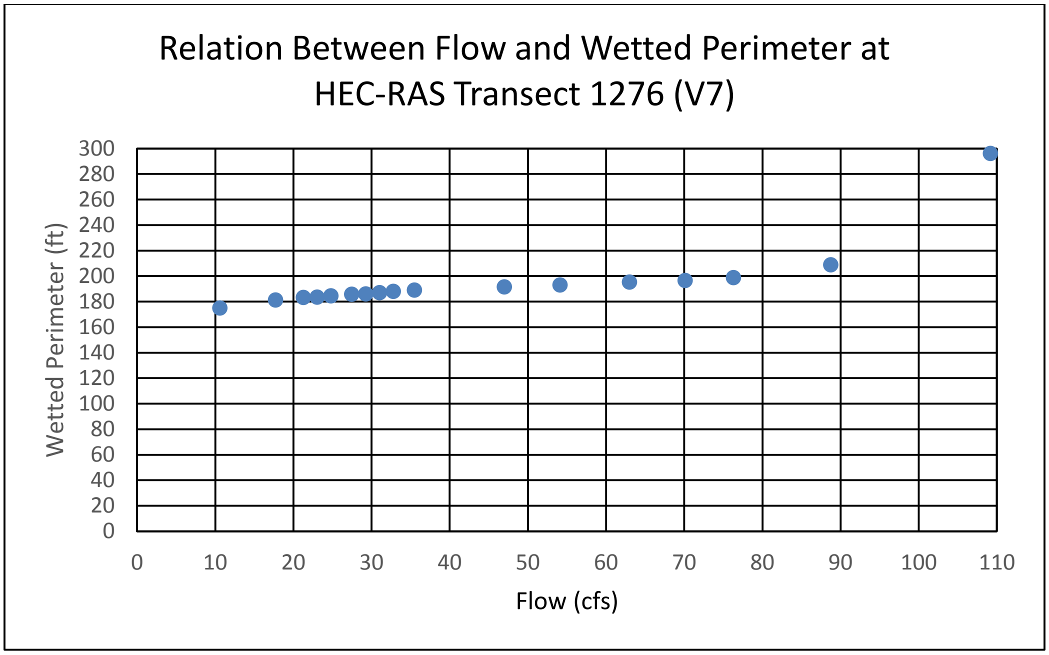

Figure 5-9. Wetted perimeter versus discharge at HEC-RAS model station number 1276 (V7) in Gum Slough Spring Run. This figure is an update of the figures included in the Wetted Perimeter Appendix of the revised 2011 report.

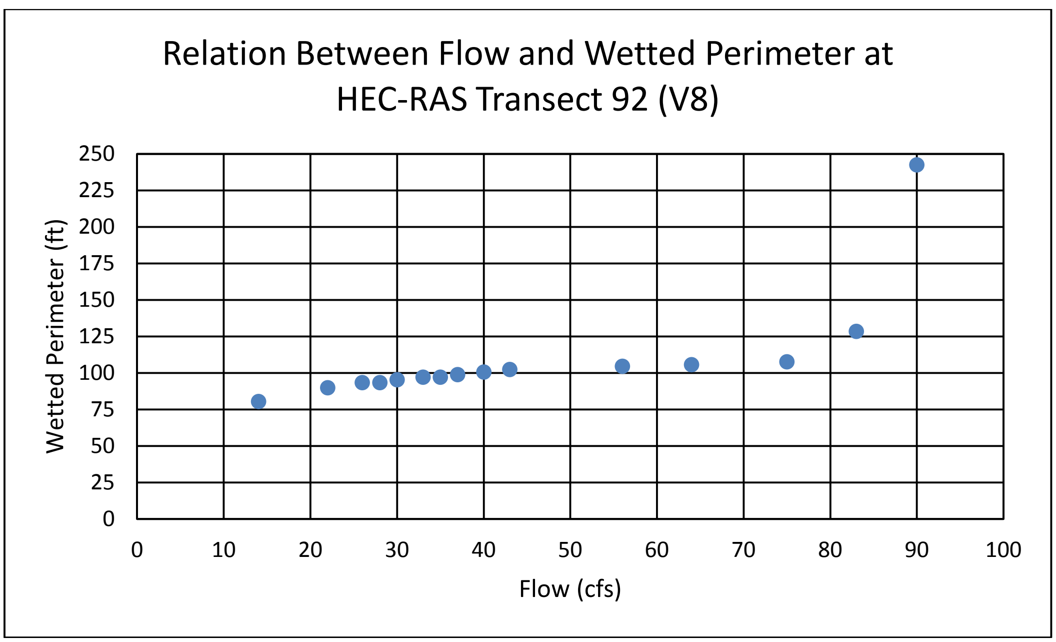

Figure 5-10. Wetted perimeter versus discharge at HEC-RAS model station number 92 (V8-USGS GAGE) in Gum Slough Spring Run. This figure is an update of the figures included in the Wetted Perimeter Appendix of the revised 2011 report.

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Figure 5-11 shows the flows necessary at the USGS Gum Springs near Holder gage site to inundate the lowest wetted perimeter inflection point at each cross-section in the HEC-RAS model. A flow of 14 cfs at the USGS near Holder gage was used to define the LWPIP criterion. Therefore, the low-flow threshold of 14 cfs was established since both the fish passage and LWPIP criteria were equal, and this flow is expected to provide protection of values associated with both criteria.

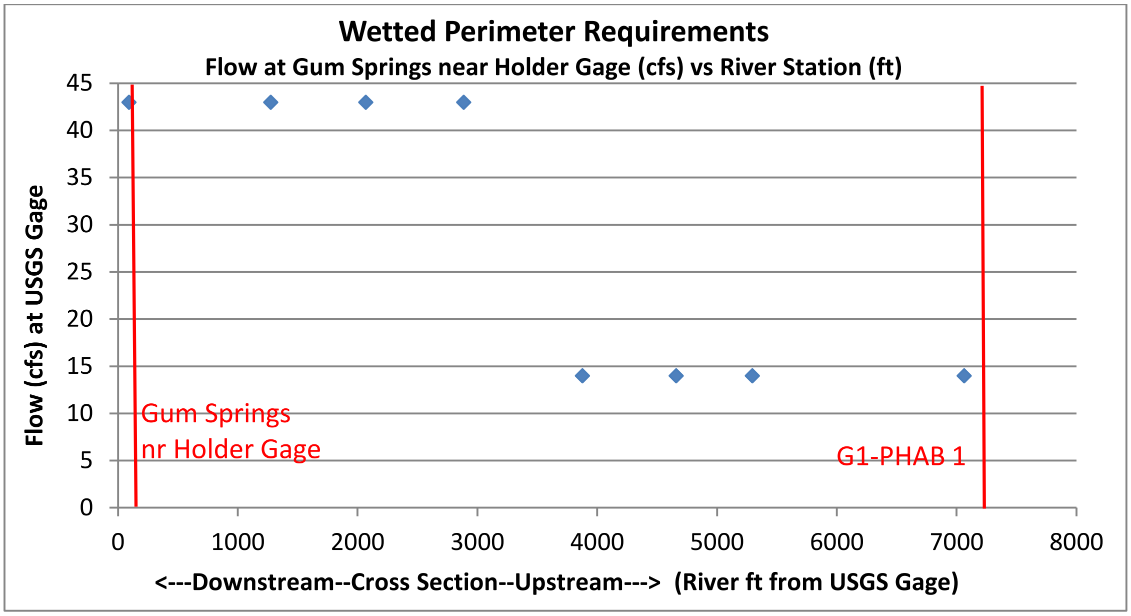

Figure 5-11. Flow required at the Gum Springs near Holder USGS gage site to inundate the lowest wetted perimeter inflection point at HEC-RAS model cross-sections in Gum Slough Spring Run. This figure is an update of Figure 8-2 included in the revised 2011 report.

5.3.2 Summary of Updated Woody Habitat Protection Criteria Results

Using the updated HEC-RAS model simulation results, the updated allowable percent withdrawal for exposed roots and snags for each cross-section was updated from the values presented in the original 2011 report (Table 5-4). However, to be more representative of the entire spring run, a median value was calculated for these criteria (versus mean values calculated in the original 2011 report).[1] Therefore, the updated revised allowable percent withdrawals for exposed roots and snags are seven and 23 percent at the Gum Springs near Holder gage, respectively. The woody habitat inundation criterion is, therefore, defined as the more conservative value of seven percent maximum allowable flow reduction.

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Table 5-4. Mean elevation of instream woody habitats (exposed roots and snags) at various instream habitat sites, corresponding flows at the Gum Springs near Holder USGS gage required for inundation of the mean elevations, and maximum percent-of-flow reductions associated with less than a 15% reduction in the number of days flow sufficient to inundate the mean habitat elevations. This table is an update of Table 8-6 included in the revised 2011 report.

Habitat	Site	Mean Elevation (ft. NAVD)	S.D.	Flow (cfs) at Gum Springs @ Holder Gage Required for Inundation	Allowable Percent of Flow Reduction
Exposed Roots	Veg 1	37.98	1.06	14	73
Exposed Roots	Veg 2	41.66	0.97	87	6
Exposed Roots	Veg 3	42.15	0.74	113	9
Exposed Roots	Veg 4	41.42	1.18	127	6
Exposed Roots	Veg 5	41.28	1.93	123	5
Exposed Roots	Veg 6	40.47	1.73	76	8
Exposed Roots	Veg 7	39.96	1.10	59	14
Exposed Roots	Veg 8	40.12	1.19	84	6
Mean					**16**
Median					**7**
Snags	Veg 1	37.93	1.01	14	73
Snags	Veg 2	40.57	1.46	59	14
Snags	Veg 3	40.73	1.63	59	14
Snags	Veg 4	41.21	1.31	112	10
Snags	Veg 5	40.03	2.61	45	24
Snags	Veg 6	40.00	1.68	47	22
Snags	Veg 7	39.71	1.19	44	25
Snags	Veg 8	38.89	2.12	22	57
Mean					**30**
Median					**23**

5.4 Additional Criterion – Ecosystem Metabolism

Ecosystem metabolism, which is an estimate of the overall biological function of an aquatic system, was evaluated in the synoptic study of Gum Slough Spring Run conducted from October 2010 through September 2011 (Wetland Solutions, Inc. 2011). Data were collected during the study to determine the relationship between photosynthetic efficiency, an important ecosystem function, and total discharge of the Gum Slough Springs Group. The equation developed for this relationship from the study is as follows:

$$\text{Average Photosynthetic Efficiency (\%)} = 0.0904[\text{Flow (cfs)}]^{0.6861}$$

Using the equation listed above, a 15 percent loss in photosynthetic efficiency is equal to a 21 percent loss in flow.

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CHAPTER 6 – UPDATED MINIMUM FLOW RECOMMENDATIONS FOR GUM SLOUGH SPRING RUN

Previously proposed minimum flows for Gum Slough Spring Run are presented in Section 8.6 of the revised 2011 report; however, they have been updated based on the updated analyses presented in this addendum. Table 6-1 summarizes the updated minimum flows criteria based on the updated PHABSIM analyses, analyses based on the updated HEC-RAS model simulations, and the addition of a new criterion. The minimum flows criteria include flow rates that were considered for development of a low-flow threshold for flows at the USGS Gum Springs near Holder gage and allowable percent-of-flow reductions for withdrawal-corrected flows at the gage site.

Table 6-1. Flow threshold or allowable flow reduction recommendations for each analysis/ criterion. This table is an update of Table 8-7 included in the revised 2011 report.

Criterion	Measure/Goal	Flow Threshold (cfs) or Maximum Allowable Flow Reduction (percent)
Fish Passage	Maintain depth of 0.6 feet across shoals	14 cfs
Wetted Perimeter	Maximize inundated river channel	14 cfs
Fish and Benthic Macroinvertebrate Habitat	Avoid reductions >15 percent for various taxonomic groups	6 percent
Snags	Avoid reductions >15 percent in snag availability	23 percent
Exposed Roots	Avoid reductions >15 percent in root availability	7 percent
Ecosystem Metabolism	Avoid reductions >15 percent in photosynthetic efficiency	21 percent

Based on the most restrictive allowable flow reduction and low-flow threshold criteria, and using the term “natural flows” to correspond with historic flows that are corrected for groundwater withdrawal impacts, the updated minimum flow recommendations for Gum Slough Spring Run are as follows.

> *Minimum Flows for Gum Spring Slough Spring Run are based on the natural flow at the USGS Gum Springs near Holder, FL gage (the “Holder” gage). Natural flow is defined as flow that would exist in the absence of withdrawal impacts. The Minimum Flow for Gum Springs Slough Spring Run is 94% of the natural flow as measured at the Holder gage. In addition, the Minimum Flow for Gum Spring Slough Spring Run is flow-based. No surface water withdrawal from the system will be permitted that would cumulatively cause the natural flow to be reduced below the Minimum Low-Flow Threshold of 14 cfs.*

Note that rule language developed for incorporation into the District’s MFLs and Rates of Flow Rules (Chapter 40D-8, F.A.C) may differ slightly from the descriptive language presented above and may be expected to identify and be applicable to all springs discharging to Gum Slough Spring Run. Also, it may be anticipated that the rule language may specify that the District will, within a

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The recommended minimum flow for the spring and the minimum low-flow threshold for cut-off of surface water withdrawals both seem reasonable and well supported.

specified number of years, re-evaluate minimum flows that are adopted for the system. This latter rule directive may be appropriate based on the current availability of flow records for the spring run.

Figure 6-1 illustrates the historical flows at the USGS Gum Springs near Holder gage site on an annual basis corrected for withdrawal impacts along with flows that could result from maximum withdrawal impacts that would be allowed based on the updated minimum flow recommendations for the system. The recommended Low-Flow Threshold is also depicted in the figure.

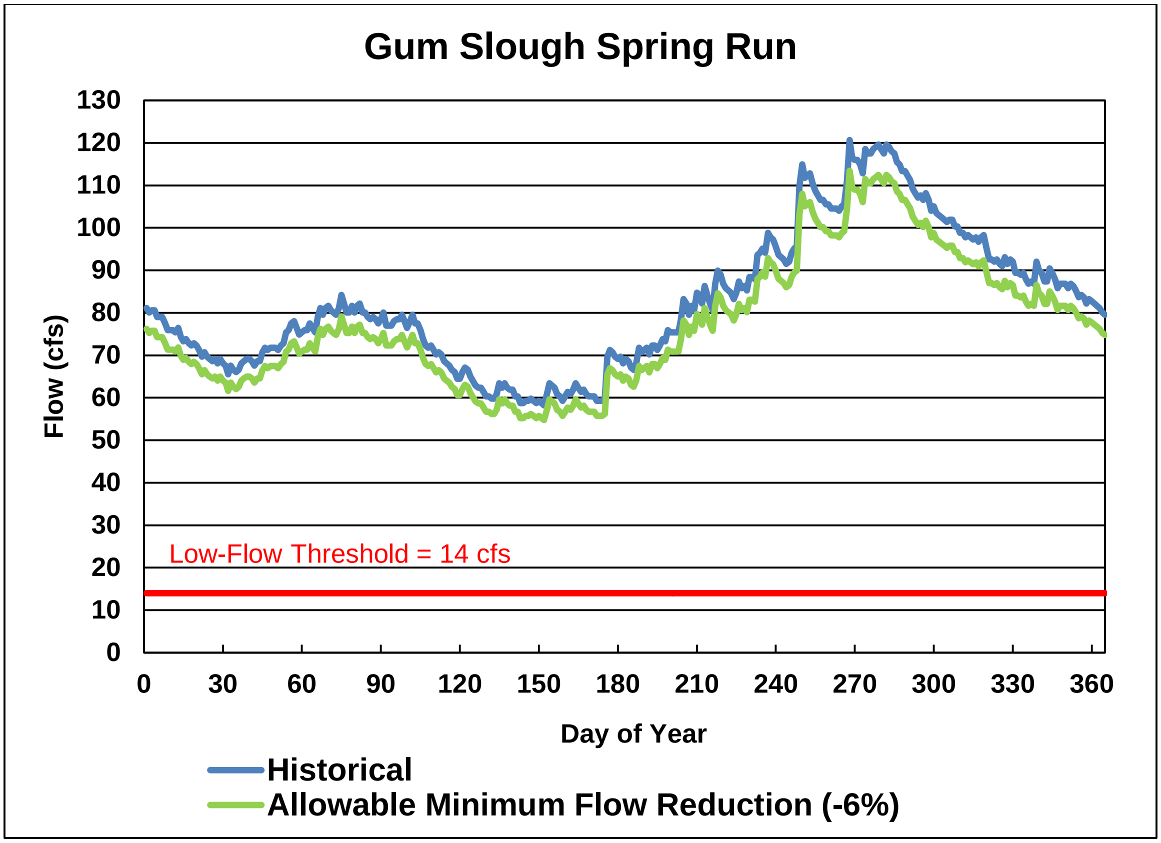

Figure 6-1. Median historical daily flows (corrected for withdrawal impacts) at the Gum Springs near Holder USGS gage site from October 2003 through September 2013, and flows corresponding to historical flows reduced by six percent. This figure is an update of Figure 8-9 included in the revised 2011 report.

The updated minimum flow recommendations for Gum Slough Spring Run are protective of all relevant environmental values identified for consideration in the Water Resource Implementation Rule when establishing minimum flows and levels (see Rule 62-40.473, F.A.C.). The methods used for their development are largely habitat based and includes the maintenance of minimum water depths in the spring run for fish passage, maintenance of water depths above inflection points in the wetted perimeter of the channel to maximize aquatic habitat for fish and wildlife with the least amount of flow, and protection of wetland and in-channel habitat, including woody habitats and exposed roots, for fish, invertebrates, and wildlife. The recommended minimum flows are protective of several environmental values identified in the Water Resource Implementation Rule, including recreation in and on the water, fish and wildlife habitats and the passage of fish, transfer of detrital material, aesthetic and scenic attributes, filtration and absorption of nutrients

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and other pollutants, and water quality. In addition, the environmental value, maintenance of freshwater storage and supply, is also expected to be protected by the proposed minimum flows based on inclusion of conditions in water use permits that stipulate that permitted withdrawals will not lead to violation of adopted minimum flows and levels.

Two environmental values identified in the Water Resource Implementation Rule, were not considered relevant to development of proposed minimum flows for Gum Slough Spring Run. Estuarine resources were not considered relevant for the spring run based on its hydrologic isolation from the estuarine reaches of the downstream Withlacoochee River. Sediment loads were similarly not considered relevant for minimum flows development because the discharge in Gum Slough Spring Run is dominated by springflow rather than surface water runoff.

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Your conclusion that these relevant environmental values are expected to be protected by the proposed minimum flow is reasonably supported by your analyses (summary shown in Table 6-1).

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Sediment loads would seem to be important in this spring run. Movement of sediment, particularly finer sediment (detritus) would seem to be very important for the microbial foodweb which supports downstream foodwebs (macroinvertebrates and fish). We do not agree that sediment loads would be irrelevant in this spring run. The rationale presented here is very weak.

CHAPTER 7 – CONCLUSION

Because the original minimum flows analyses for Gum Slough Spring Run described in a 2011 revised report were based on a relatively short flow record, a decision was made to gather more information to support more robust minimum flow recommendations for the system. The flow record was increased from seven to ten years, and the previously peer-reviewed analyses used for the original minimum flows determination were repeated.

Results of the new analyses yielded an updated minimum flow recommendation that would allow up to a six percent reduction in flows due to water withdrawals, based on a potential 15 percent loss of habitat for adult spotted sunfish in the spring run. The updated minimum flow recommendation also includes the recommended stipulation that surface water withdrawals are prohibited from depressing flows below 14 cfs.

Updated groundwater modeling results indicated that the predicted streamflow decline for Gum Slough Spring Run at the USGS Gum Springs near Holder gage site under current pumping conditions is approximately 3.4 percent. Based on this information, a recovery strategy is not required for the proposed minimum flows.

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Minimum flow and low flow cut-off appear to be protective and their development is well supported.

CHAPTER 8 – LITERATURE CITED

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Appendix

Technical Memorandum from Intera, Inc. Regarding Additional Gum Slough Springs Run HEC-RAS Model Simulations

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M E M O R A N D U M

To: Gary Williams

Copy: Tammy Hinkle

From: Renee Murch

Date: February 7, 2014

Re: Gum Springs, Additional Predictive Simulations

INTRODUCTION

Gum Springs, the headwaters of Gum Slough, is located approximately six miles northeast of the Withlacoochee River in northwest Sumter County. In 2010, a steady state HEC-RAS model of Gum Slough was constructed for use in Minimum Flows and Levels (MFL) development (INTERA, 2010). The results of the predictive simulations will be utilized by the District for MFL analyses. Since the 2010 modeling effort utilized data observed through July 25, 2010, it was desired by the District to run additional simulations of the steady state Gum Springs model using the best available flow and stage data that extends through September 30, 2013. For this modeling effort, two sets of percentile flows were calculated based on the available United States Geological Survey (USGS) recorded data. This technical memorandum documents the resulting flows and simulated stages at each cross section based on the calculated percentile flows and calibrated HEC-RAS model.

USGS Gauge Data

The USGS Gum Springs at Holder gauge data was obtained from the USGS for use in predictive simulations. The gauge record begins on October 1, 2003. Data utilized for this analysis extends to September 30, 2013. The flow record for the gauge is shown in Figure 1. The average flow for the period of record is 87.6 cubic feet per second (cfs), with flow ranging from 5.1 cfs to 520 cfs for the period of record. Both flow and stage were obtained from the USGS. Stage data was utilized as a boundary condition for the predictive simulations, and is discussed at length in later sections. Although the datum of the USGS gauge was undetermined, based on information provided by the District, the gauge datum was estimated at 30.98 feet NAVD. It should be noted that impacts to the gauge from groundwater pumping were estimated by the District to be equal to approximately 4-percent of the gauged flow. Thus, a correction of 4-percent of the gauged flow was applied to the observed USGS record in order to estimate pre-development flows. Thus, the working time series for the modeling effort was a corrected USGS time series, which was equal to the observed USGS time series with an additional 4-percent of observed daily flow.

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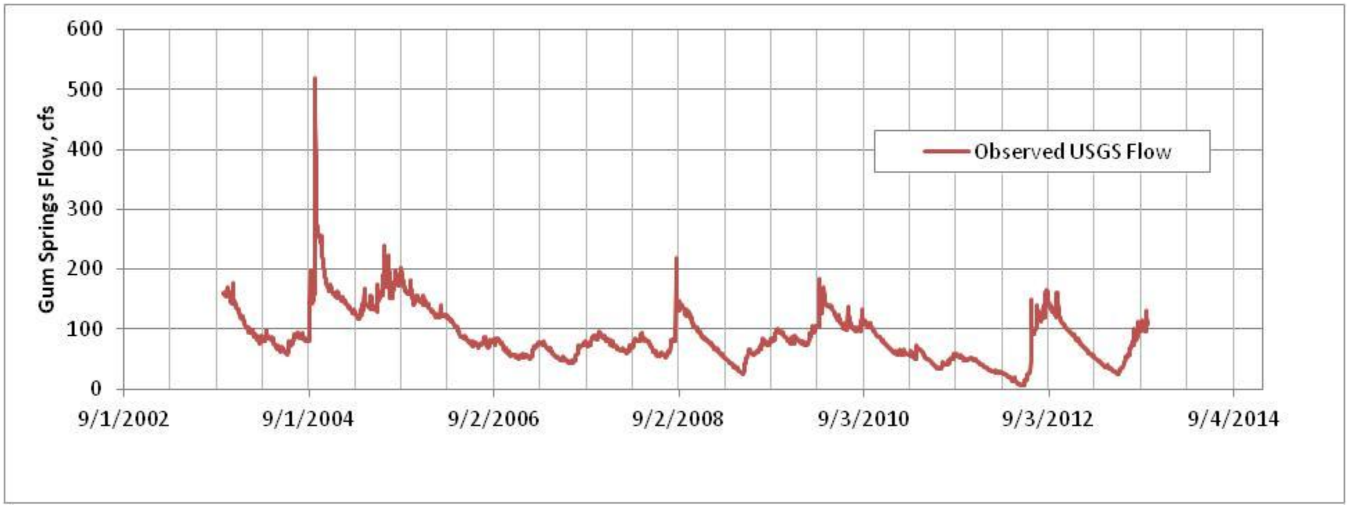

Figure 1. Gum Springs at Holder (USGS #02312764) Flow Record

Flow Regression for Long Term Record

Since it was desired to have a long term record to utilize for developing flow percentiles for Gum Slough, a statistical model was developed between the Gum Springs at Holder gauge and the Rainbow Springs group gauge in order to estimate long term flow at Gum Springs. The location of the spring groups is shown in Figure 2. Rainbow Springs group has a much more extensive period of record, beginning on January 1, 1965. A linear regression was developed for the period of overlap of the Rainbow Springs Group flow data with the corrected Gum Springs flow data, from October 1, 2003 to September 30, 2013 (Figure 3). The linear regression was compared to the observed flow at Gum Springs to determine the goodness of fit (Figure 4). As shown in the figure, the linear regression estimates average and low flows (flows less than 200 cfs) well. In addition, the shape of the hydrograph is well represented. Although the linear regression does not estimate high flows well, high flows (flows greater than 200 cfs) represent a small portion of the record. Thus, the linear regression was utilized to construct a long term record for Gum Springs group (Figure 5). For the long term record, USGS observed flows were utilized when available (after October 1, 2003) and flows prior to October 1, 2003 were calculated using the regression between Gum Springs group and Rainbow Springs group.

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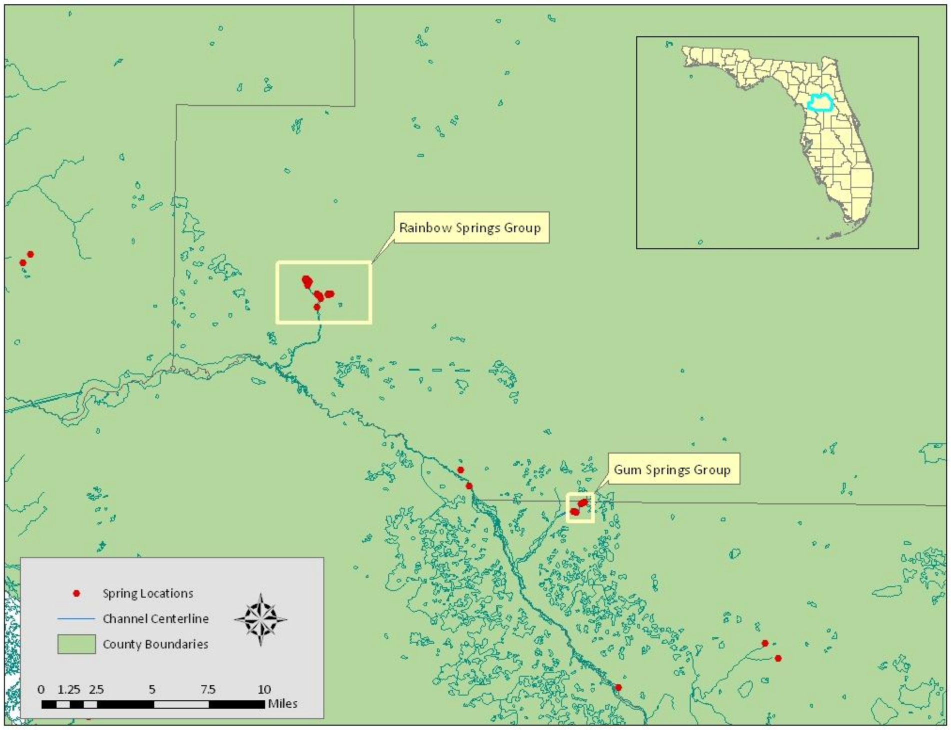

Figure 2. Gum Springs Group and Rainbow Springs Group

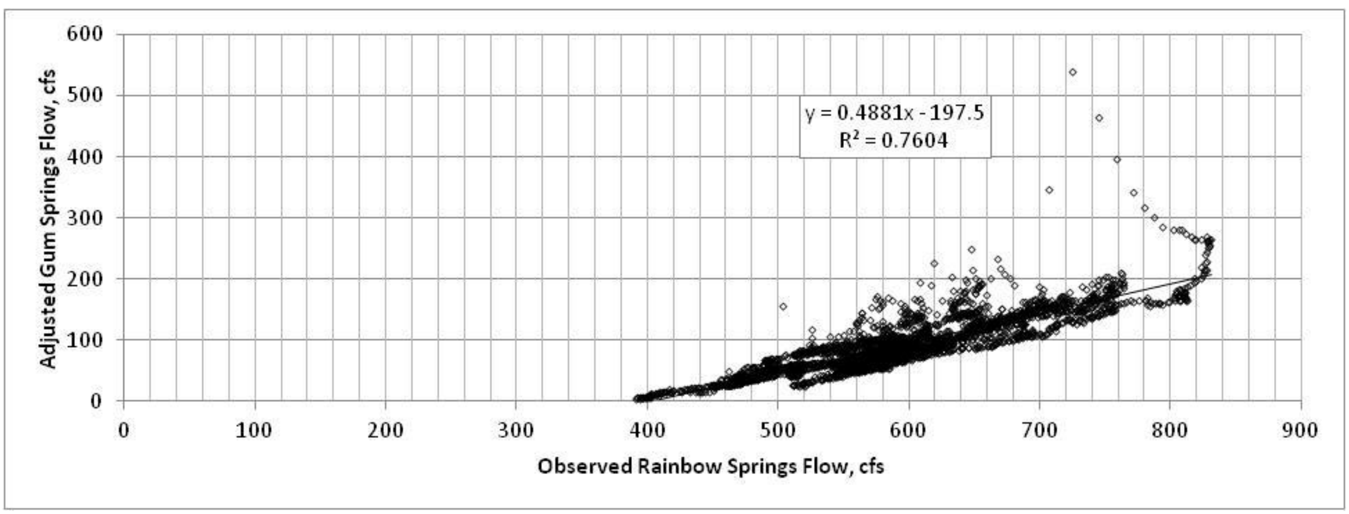

Figure 3. Gum Springs Statistical Model

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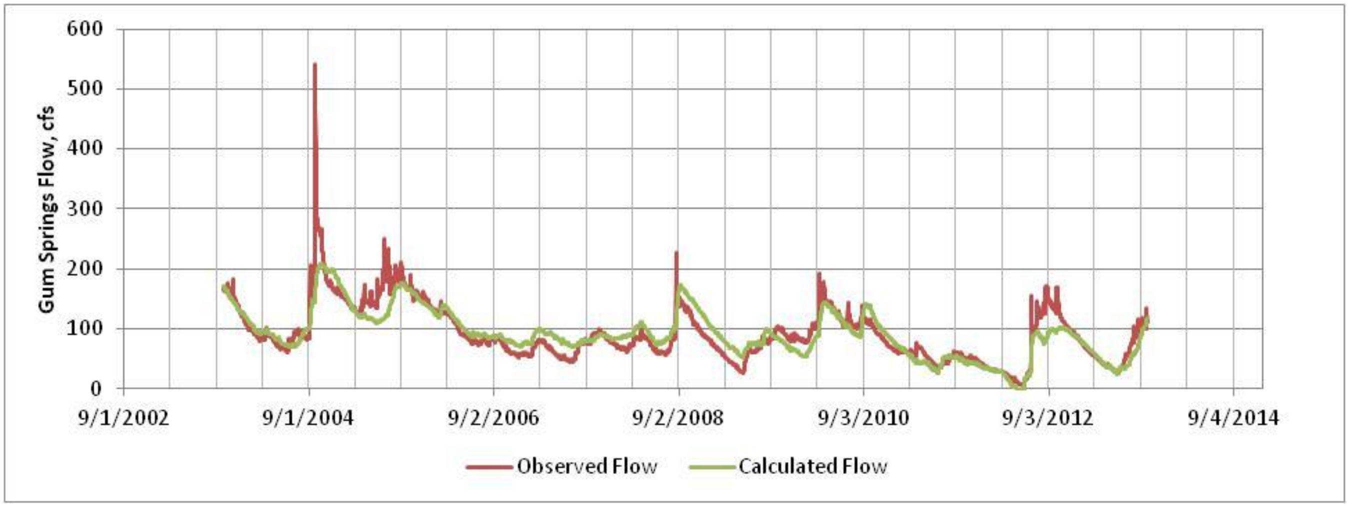

Figure 4. Gum Springs Observed and Calculated Flow

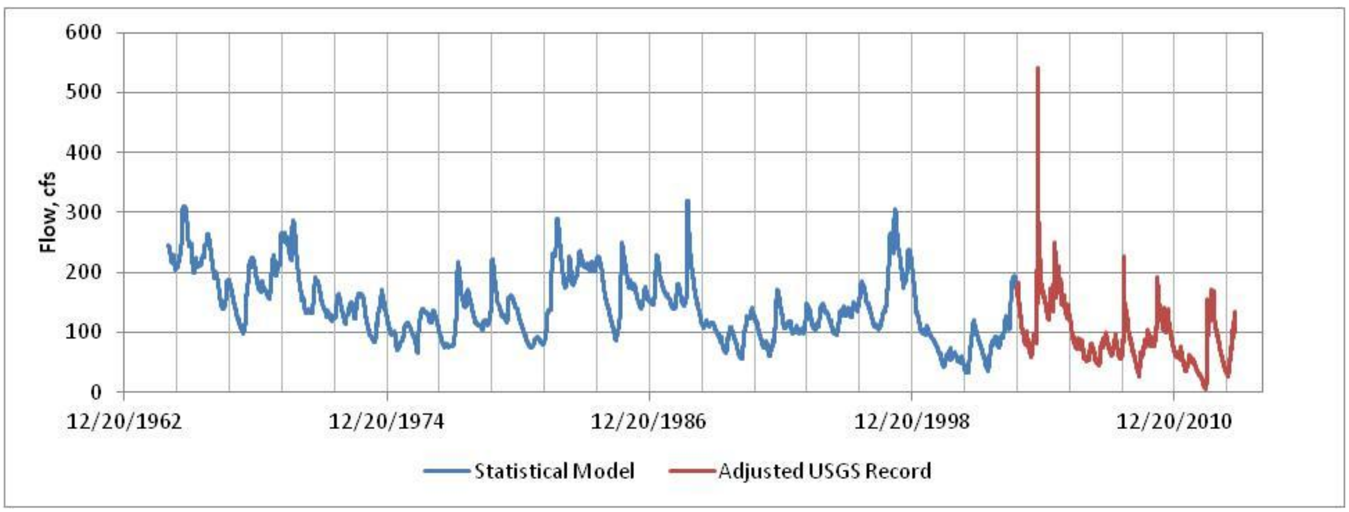

Figure 5. Gum Springs Long Term Record

PREDICTIVE SIMULATIONS

It was desired by the District to run predictive simulations for incremental percentile flows. Percentile flows are based on the development of a probability of exceedance plot using the entire flow record. Using the flow record, flows are ranked in ascending order, and the corresponding probability of exceedance can be calculated. For a given flow with a rank of r, the probability of exceedance can be calculated as:

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$$p = \left(1 - \frac{r}{n}\right) \qquad (1)$$

Where n = the total number of observations

Since the USGS Gum Springs record is fairly short, a long term flow record was also developed using the statistical relationship between the corrected USGS flows at Gum Springs and Rainbow Springs group. Flow percentiles were developed both the corrected USGS record and the record composed of the long term regression and the corrected USGS flow record (Figure 6 and Table 1).

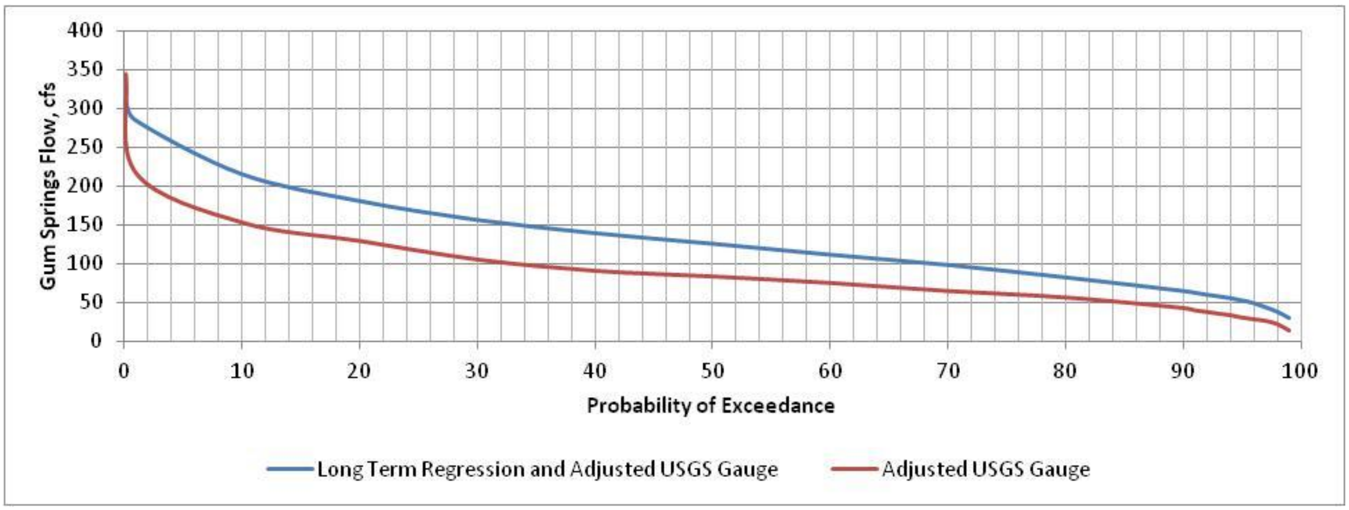

Figure 6. Gum Springs Flow Percentiles

As shown in the figure and table, there are slight differences in the percentile flows between the two distributions. The distribution developed using the USGS record is, in essence, a sample of the long term record beginning in 2003. It was desired to simulate every 10th percentile of flow for percent exceedance greater than 10, and every percentile of flow for percent exceedance less than 10. For the sake of completeness and for ease of use by the District, both sets of percentile flows shown in Figure 6 were simulated in the model.

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Table 1. Gum Springs Flow Percent Exceedance, cfs

Percent Exceedance	Long Term Regression and Adjusted USGS Gauge	Adjusted USGS Gauge
99	30.2	13.5
98	38.3	21.8
97	44.1	26.0
96	49.5	28.1
95	52.9	30.2
94	55.8	33.3
93	58.2	35.4
92	60.3	37.4
91	62.8	39.5
90	65.1	42.6
80	82.7	56.2
70	98.8	64.5
60	112.0	74.9
50	126.1	83.2
40	139.8	90.5
30	156.9	105.0
20	181.3	129.0
10	215.9	152.7
1	285.2	215.8

In addition to a downstream flow boundary condition, it was necessary to develop flow profile for each percentile flow. The flow profile describes the increase in flow from upstream to downstream. One intensive set of flow measurements was made by the District on February 26, 2010, and was provided to INTERA in a spreadsheet (GSR Flow Measurements with Water Surface.xlsx, shown in Table 2). This dataset (which was also used for model calibration) was utilized to determine the percent of downstream boundary flow observed at each of the eight cross sections. In addition to this intensive field survey, additional flow measurements were taken by the District during various flow regimes (high, medium and low flows) at two locations. This data was analyzed in order to determine how the percent of total flow at each station varies with the total flow volume.

Three flow measurements representing high, medium, and low flow taken near the headspring are 7own in Figure 28. As shown in the figure, as the total flow in Gum Slough decreases, the flow at Gum Springs decreases. Using the regression equation shown in the figure, when there is no flow at Gum Springs (y=0), the flow at the downstream gauge is approximately 37.74 cubic feet per second (cfs). This agrees with anecdotal data from homeowners who live along the slough. A second set of flow measurements was taken near River Station 2884.6, as shown in

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Figure 8. Both of these flow dependent relationships were used to develop flow profiles along the channel.

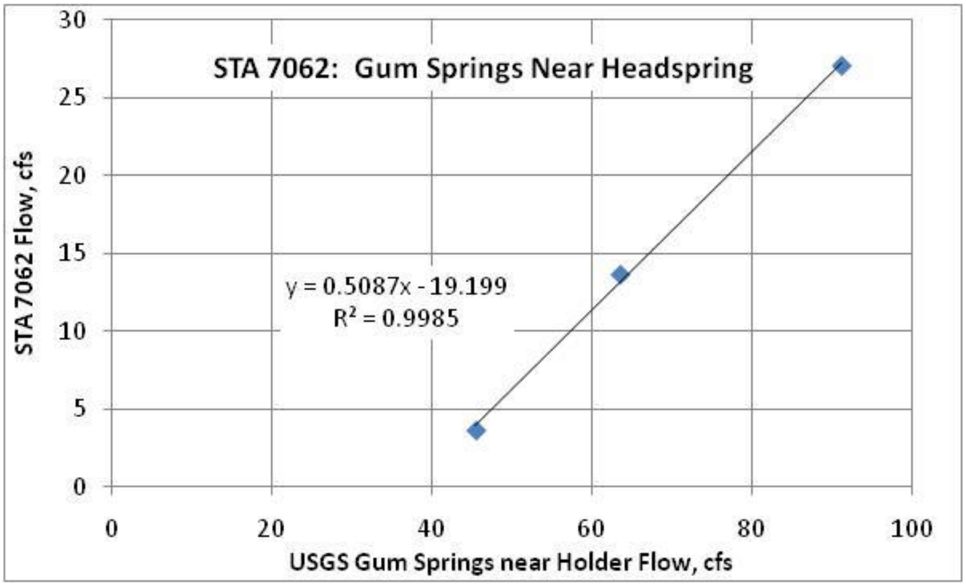

Figure 7. Gum Springs Near Headspring Flow Measurements

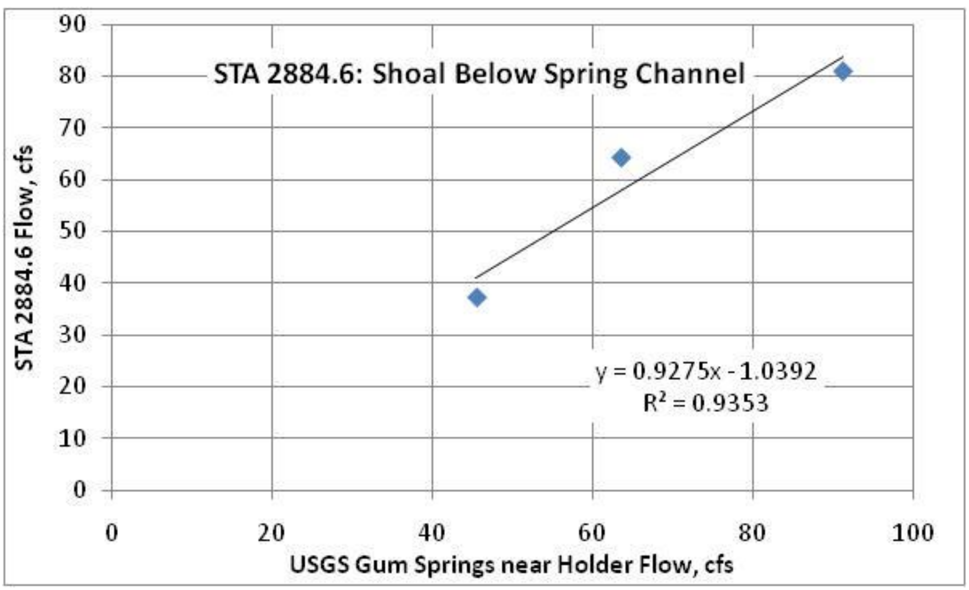

Figure 8. Shoal Below Spring Channel Flow Measurements

In order to use the above relationships for each station along Gum Slough, scale factors were developed for the six cross sections where flow measurements were not taken in order to apply observed flow relationships to the additional cross sections. Scale factors were determined using the flow regimes shown in Table 1 and comparing the percent of the total flow at each station. The scale factor (shown in Table 2) was determined by dividing the flow at the station of interest

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by the nearest upstream station where the flow variability was measured (either Station 7062 or Station 2884.5).

Table 2. Cross Section Scale Factors

River Station	Percent flow	Scale Factor	Nearest Upstream Station
7062.824	26.21	1	7062.824
5294.539	33.98	1.296	7062.824
4658.976	33.98	1.296	7062.824
3877.225	37.86	1.444	7062.824
2884.558	66.99	1	2884.558
2068.989	72.82	1.087	2884.558
1275.955	84.47	1.260	2884.558
92.21291	100	1.493	2884.558

To determine the flow at each station, the regression equations shown in Figures 7 and 8 were applied to Stations 7062.824 and 2884.558. For the case of Station 7062.824, when the flow was less than 37.7 cfs, there was negligible flow at the station. After the flows at the two known locations were determined, the flows at the additional locations were calculated by multiplying the known flow by the scale factors shown in Table 2. After these flows were determined, a mass correction was applied at each station based on the difference between the flows calculated with the regressions and the flows recorded during the intensive survey. The application of this correction ensured that mass was conserved throughout the slough. The flow profiles for each data set (the USGS record and the combined USGS/regression record) are shown in Figures 9 and 10 and Tables 3 and 4. In each graph, the flow at 103 cfs (shown in yellow) represents the flow measurements taken during the intensive field survey by the District. As shown in the figures, all other flow profiles are essentially scaled representations of this flow profile, taking into account the spring flow inflow reductions with decreased total measured flow at the gauge.

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Table 3. Adjusted USGS Flow Record Exceedance Flows

Cross Section Name		**G1**	**G2**	**G3**	**G4**	**V5**	**V6**	**V7**	**V8**
River Station		7062.8	5294.5	4659.0	3877.2	2884.6	2069.0	1276.0	92.2
Flow Exceedance, cfs	99th	0.0	0.0	0.0	0.0	8.4	9.1	10.6	14.0
	98th	0.0	0.0	0.0	0.0	14.0	15.3	17.7	22.0
	97th	0.0	0.0	0.0	0.0	16.9	18.3	21.2	26.0
	96th	0.0	0.0	0.0	0.0	18.3	19.8	23.0	28.0
	95th	0.0	0.0	0.0	0.0	19.7	21.4	24.8	30.0
	94th	0.0	0.0	0.0	0.0	21.8	23.7	27.5	32.5
	93rd	0.0	0.0	0.0	0.0	23.2	25.2	29.2	34.6
	92nd	0.0	0.0	0.0	0.0	24.6	26.7	31.0	36.7
	91st	0.0	0.0	0.0	0.0	26.0	28.3	32.8	40.0
	90th	2.0	2.6	2.6	2.9	28.1	30.6	35.5	43.0
	80th	7.6	9.9	9.9	11.0	37.3	40.5	47.0	55.6
	70th	11.1	14.3	14.3	16.0	42.9	46.6	54.1	64.1
	60th	15.4	19.9	19.9	22.2	50.0	54.3	63.0	74.6
	50th	18.8	24.4	24.4	27.2	55.6	60.4	70.1	83.0
	40th	21.8	28.3	28.3	31.5	60.5	65.8	76.3	90.3
	30th	27.8	36.1	36.1	40.2	70.4	76.5	88.7	105.1
	20th	37.7	48.9	48.9	54.5	86.6	94.1	109.2	129.2
	10th	47.5	61.6	61.6	68.7	102.6	111.6	129.4	153.2
	1st	73.7	95.5	95.5	106.4	145.4	158.0	183.3	216.0

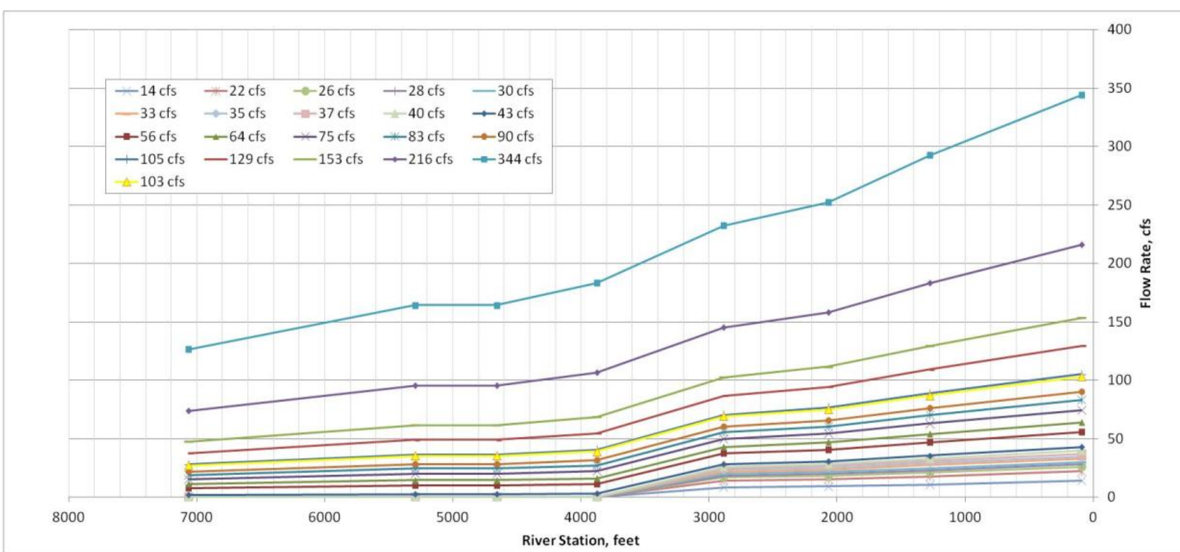

Figure 9. Adjusted USGS Record: Flow Profiles

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Table 4. Adjusted Regression and USGS Flow Record Exceedance Flows

Cross Section Name		G1	G2	G3	G4	V5	V6	V7	V8
River Station		7062.8	5294.5	4659.0	3877.2	2884.6	2069.0	1276.0	92.2
Flow Exceedance, cfs	99th	0.0	0.0	0.0	0.0	19.7	21.4	24.8	30.0
	98th	0.0	0.0	0.0	0.0	25.1	27.3	31.7	37.5
	97th	0.0	0.0	0.0	0.0	29.1	31.6	36.7	44.0
	96th	0.0	0.0	0.0	0.0	32.8	35.6	41.3	48.9
	95th	0.0	0.0	0.0	0.0	35.1	38.1	44.2	53.0
	94th	0.0	0.0	0.0	0.0	37.0	40.3	46.7	56.0
	93rd	0.0	0.0	0.0	0.0	38.7	42.1	48.8	57.7
	92nd	0.0	0.0	0.0	0.0	40.1	43.6	50.6	59.9
	91st	0.0	0.0	0.0	0.0	41.8	45.4	52.7	63.0
	90th	11.3	14.7	14.7	16.3	43.3	47.1	54.6	64.7
	80th	18.6	24.1	24.1	26.8	55.2	60.0	69.6	83.0
	70th	25.2	32.7	32.7	36.5	66.1	71.9	83.4	98.7
	60th	30.7	39.8	39.8	44.3	75.1	81.6	94.7	112.1
	50th	36.6	47.4	47.4	52.8	84.7	92.0	106.7	126.4
	40th	42.2	54.7	54.7	61.0	93.9	102.1	118.4	140.2
	30th	49.3	63.9	63.9	71.2	105.5	114.7	133.0	157.5
	20th	59.4	77.0	77.0	85.8	122.0	132.6	153.8	181.0
	10th	73.7	95.6	95.6	106.5	145.5	158.1	183.4	216.0
	1st	102.4	132.7	132.7	147.9	192.4	209.2	242.6	285.0

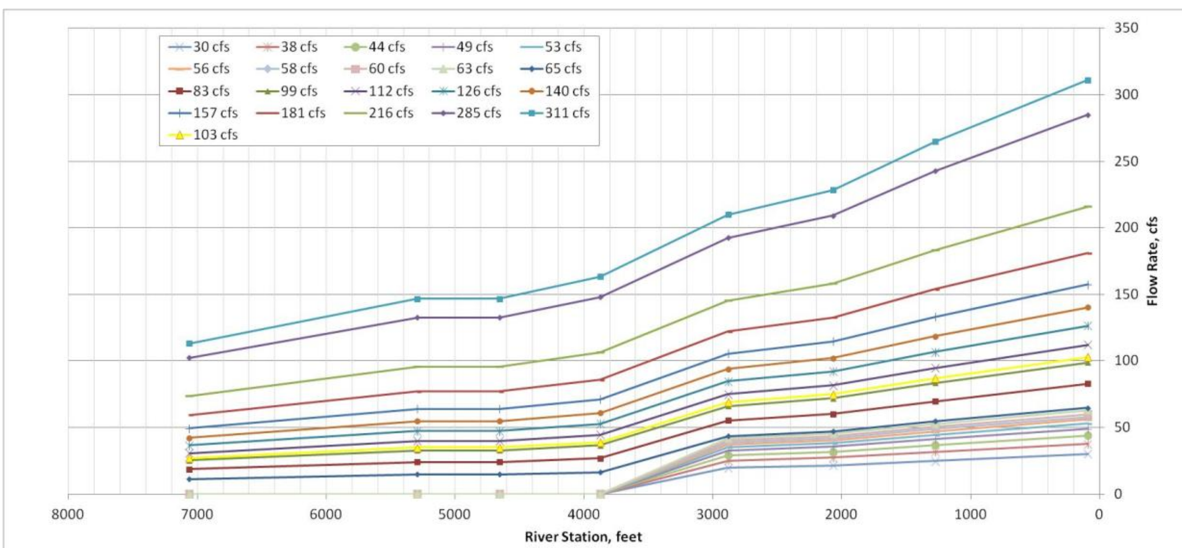

Figure 10. Adjusted Regression and USGS Record: Flow Profiles

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Boundary Conditions: Downstream Stage

In order to run predictive simulations, a downstream stage boundary condition is needed. A rating curve for the gauge was developed based on the adjusted USGS record (Figure 11). Based on the rating curve and the percentile flows shown in Tables 12 and 13, the stage boundary condition was calculated for each percentile flow based on the regression equation shown in the figure. The resulting boundary conditions for each percentile flow are shown in Table 14.

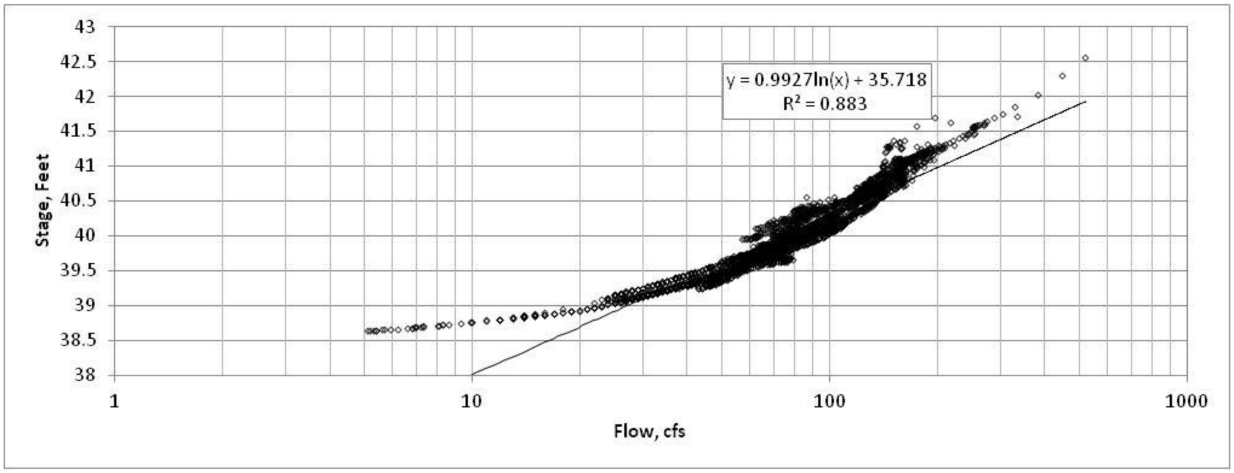

Figure 11. Gum Springs at Holder Rating Curve

Table 5. Predictive Simulation: Downstream Stage Boundary

Flow Exceedance	Adjusted USGS Record, Stage, ft	Adjusted Long Term Record, Stage, ft
1	38.3	39.1
2	38.8	39.3
3	39.0	39.5
4	39.0	39.6
5	39.1	39.7
6	39.2	39.7
7	39.2	39.7
8	39.3	39.8
9	39.4	39.8
10	39.5	39.9
20	39.7	40.1
30	39.8	40.3
40	40.0	40.4
50	40.1	40.5
60	40.2	40.6
70	40.3	40.7
80	40.5	40.9
90	40.7	41.1
99	41.1	41.3

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Predictive Simulation Data Set 1: USGS Flow Record

Predictive simulations were run using the flows derived from the adjusted USGS flow record (shown in Figure 9) and the calculated stage boundary conditions. The resulting water surface profiles are shown in Figure 12. Simulated stages at each cross section are shown in Table 6.

Table 6. Adjusted USGS Record: Simulated Stages (ft.)

Percent Exceedance	***Cross Section Name***							
	V8	***V7***	***V6***	***G5***	***G4***	***G3***	***G2***	***G1***
WS USGS1	38.3	38.5	39.5	39.5	39.5	39.5	39.5	39.5
WS USGS2	38.8	39.0	39.5	39.5	39.5	39.5	39.5	39.5
WS USGS3	39.0	39.2	39.5	39.6	39.6	39.6	39.6	39.6
WS USGS4	39.0	39.2	39.6	39.6	39.6	39.6	39.6	39.6
WS USGS5	39.1	39.3	39.6	39.7	39.7	39.7	39.7	39.7
WS USGS6	39.2	39.4	39.7	39.7	39.8	39.8	39.8	39.8
WS USGS7	39.2	39.4	39.7	39.8	39.8	39.8	39.8	39.8
WS USGS8	39.3	39.5	39.8	39.8	39.9	39.9	39.9	39.9
WS USGS9	39.4	39.6	39.9	39.9	39.9	39.9	39.9	39.9
WS USGS10	39.5	39.7	39.9	40.0	40.0	40.1	40.1	40.1
WS USGS20	39.7	39.9	40.2	40.2	40.3	40.6	40.7	40.8
WS USGS30	39.8	40.0	40.3	40.4	40.4	40.9	41.0	41.1
WS USGS40	40.0	40.3	40.5	40.6	40.6	41.2	41.4	41.4
WS USGS50	40.1	40.4	40.6	40.7	40.7	41.4	41.6	41.6
WS USGS60	40.2	40.5	40.7	40.8	40.9	41.6	41.7	41.8
WS USGS70	40.3	40.6	40.9	41.0	41.1	41.8	42.0	42.1
WS USGS80	40.5	40.9	41.3	41.4	41.5	42.3	42.5	42.7
WS USGS90	40.7	41.3	41.6	41.7	41.8	42.5	42.7	42.9
WS USGS99	41.1	41.6	41.9	42.0	42.1	42.7	43.0	43.3

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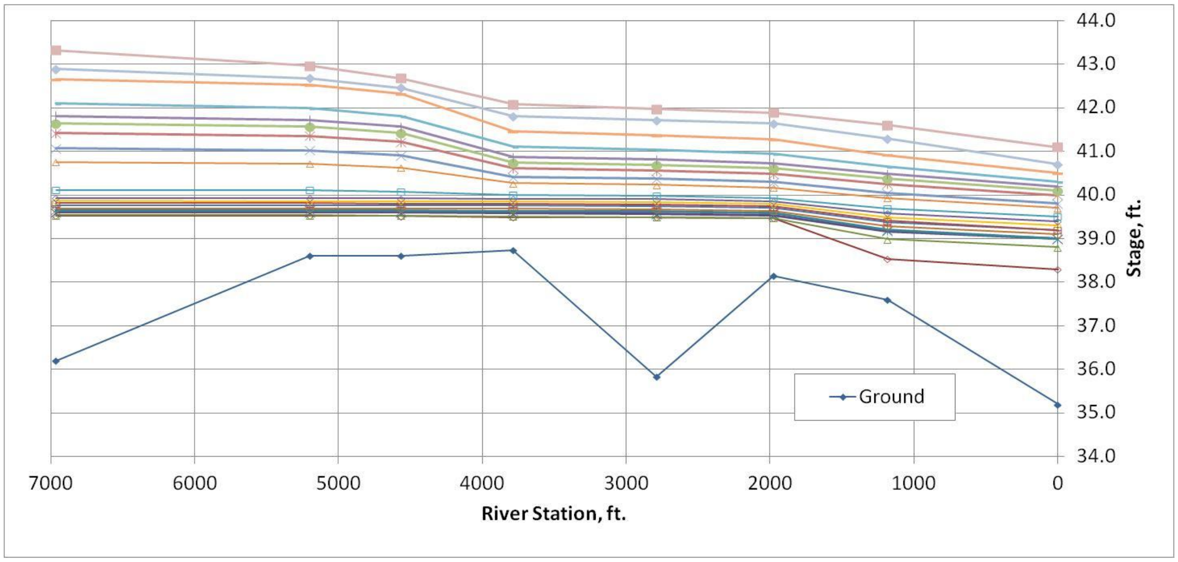

Figure 12. Adjusted USGS Record: Water Surface Profiles

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Predictive Simulation Data Set 2: Regression Record

Predictive simulations were run using the flows derived from the adjusted long term flow record (shown in Figure 10) and the calculated stage boundary conditions. The resulting water surface profiles are shown in Figure 13. Simulated stages at each cross section are shown in Table 7.

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Table 7. Adjusted Long Term Record: Simulated Stages (ft.)

Percent Exceedance	*Cross Section Name*							
	V8	**V7**	**V6**	**G5**	**G4**	**G3**	**G2**	**G1**
WS REG1	39.1	39.3	39.6	39.7	39.7	39.7	39.7	39.7
WS REG2	39.3	39.5	39.8	39.9	39.9	39.9	39.9	39.9
WS REG3	39.5	39.7	40.0	40.0	40.0	40.0	40.0	40.0
WS REG4	39.6	39.8	40.1	40.1	40.1	40.1	40.1	40.1
WS REG5	39.7	39.9	40.1	40.2	40.2	40.2	40.2	40.2
WS REG6	39.7	39.9	40.2	40.2	40.3	40.3	40.3	40.3
WS REG7	39.7	39.9	40.2	40.3	40.3	40.3	40.3	40.3
WS REG8	39.8	40.0	40.3	40.3	40.3	40.3	40.3	40.3
WS REG9	39.8	40.0	40.3	40.4	40.4	40.4	40.4	40.4
WS REG10	39.9	40.1	40.4	40.4	40.5	40.9	41.1	41.1
WS REG20	40.1	40.4	40.6	40.7	40.7	41.4	41.6	41.6
WS REG30	40.3	40.6	40.9	41.0	41.0	41.7	41.9	42.0
WS REG40	40.4	40.8	41.1	41.2	41.3	42.0	42.1	42.3
WS REG50	40.5	40.9	41.3	41.3	41.4	42.3	42.5	42.6
WS REG60	40.6	41.0	41.4	41.5	41.6	42.4	42.6	42.8
WS REG70	40.7	41.3	41.7	41.7	41.8	42.5	42.7	42.9
WS REG80	40.9	41.4	41.8	41.8	41.9	42.6	42.8	43.1
WS REG90	41.1	41.6	41.9	42.0	42.1	42.7	43.0	43.3
WS REG99	41.3	41.8	42.1	42.2	42.3	42.8	43.2	43.7

This page contains no comments

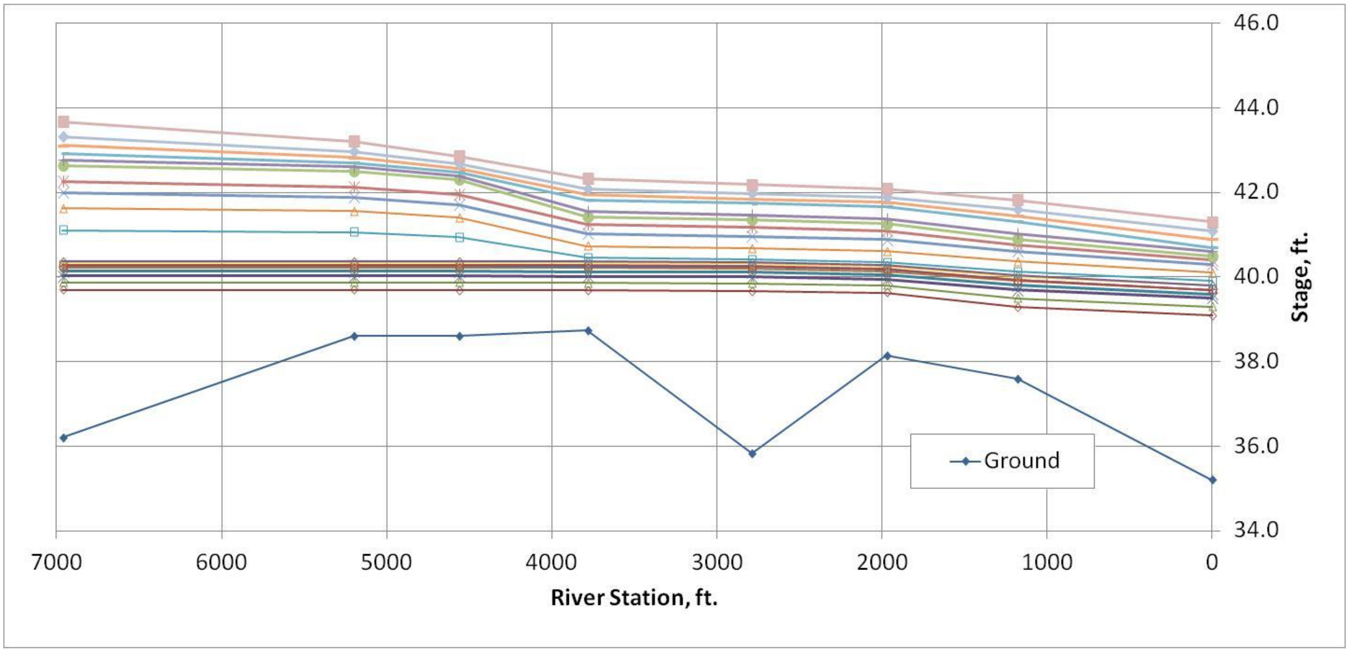

Figure 13. Adjusted Long Term Record: Water Surface Profiles

REFERENCES

INTERA (2010). *Gum Springs Run: HEC-RAS Steady State Model Development.* Final Report Submitted to the Southwest Florida Water Management District.

This page contains no comments

From:	Doug Leeper
To:	Kym Holzwart; Ron Basso; Nathan Johnson
Cc:	MaryMargaret C. Hull; Kevin P. Wills; Chris Zajac; Veronica Craw; Jennette Seachrist; Eric DeHaven; "jason@jasonsgolfcarts.com"
Subject:	Gum Spring MFLs Inquiry
Date:	Wednesday, February 24, 2016 4:43:00 PM

Greetings:

Received a phone inquiry from Jason Hood today regarding the proposed MFLs for Gum Slough Spring Run. Here's a brief summary of the questions/issues we discussed and his comments.

1. He asked about the status of minimum levels development for the upper and middle segments of the Withlacoochee River and suggested that the District consider adopting minimum levels for these river segments prior to adoption of minimum levels for Gum Slough Spring Run.
2. He noted that flow from the headspring in the Gum Slough system may cease during droughts and asked whether the number of historical no-flow days has been evaluated. Similarly he asked if the number of no-flow days that could be expected under a flow regime that meets the proposed minimum flow requirements has been evaluated.
3. He noted that during low rainfall periods, water in the Withlacoochee River is typically clear and likely derived primarily from spring flows and other groundwater discharge. Based on this observation, he asked whether potential effects of a 6% reduction in flows in Gum Slough Spring Run would result in flows within the Withlacoochee River that are lower than the 150 cfs low flow threshold that has been proposed for the U.S. Geological Survey gage site in the river at Holder.
4. He inquired about evaluations of water surface elevations that were conducted to support development of the proposed minimum flows.

Doug Leeper
MFLs Program Lead
Natural Systems and Restoration Bureau
Southwest Florida Water Management District
2379 Broad Street
Brooksville, FL 34609
1-800-423-1476, ext. 4272
352-796-7211, ext. 4272
doug.leeper@watermatters.org

From: Jason"s Golf Carts
To: Doug Leeper
Cc: jason@jasonsgolfcarts.com
Subject: RE: Gum Spring MFLs Inquiry
Date: Wednesday, February 24, 2016 5:22:26 PM
Attachments: image001.png

Doug,

My primary concern, that was left out of your summary, was regarding the Withlacoochee MFL.

The Withlacoochee MFL report was completed and received a very favorable peer review in 2010. The cost of that study, if my memory serves me correctly, was around $700,000. It has still not been adopted and, if not adopted very soon, will need to be completely redone. It is currently on the Priority List for 2020. By 2020, the report and all analysis will be useless. An additional 10 years with no protection of the river and an approximate ¾ of a million dollars thrown down the drain is a tough pill for those of us in the public to swallow. This concern is in addition to my thought that the Withlacoochee MFL should be adopted prior to Gum or Rainbow.

Thanks again,

Jason

JGC
Jason's Golf Carts
www.JasonsGolfCarts.com
(352) 279-0324 (Call or Text)

From: Doug Leeper [mailto:Doug.Leeper@swfwmd.state.fl.us]
Sent: Wednesday, February 24, 2016 4:43 PM
To: Kym Holzwart <Kym.Holzwart@swfwmd.state.fl.us>; Ron Basso <Ron.Basso@swfwmd.state.fl.us>; Nathan Johnson <Nathan.Johnson@swfwmd.state.fl.us>
Cc: MaryMargaret C. Hull <MaryMargaret.Hull@swfwmd.state.fl.us>; Kevin P. Wills <Kevin.Wills@swfwmd.state.fl.us>; Chris Zajac <Chris.Zajac@swfwmd.state.fl.us>; Veronica Craw <Veronica.Craw@swfwmd.state.fl.us>; Jennette Seachrist <Jennette.Seachrist@swfwmd.state.fl.us>; Eric DeHaven <Eric.Dehaven@swfwmd.state.fl.us>; jason@jasonsgolfcarts.com
Subject: Gum Spring MFLs Inquiry

Greetings:

Received a phone inquiry from Jason Hood today regarding the proposed MFLs for Gum Slough

Spring Run. Here's a brief summary of the questions/issues we discussed and his comments.

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2. He noted that flow from the headspring in the Gum Slough system may cease during droughts and asked whether the number of historical no-flow days has been evaluated. Similarly he asked if the number of no-flow days that could be expected under a flow regime that meets the proposed minimum flow requirements has been evaluated.
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4. He inquired about evaluations of water surface elevations that were conducted to support development of the proposed minimum flows.

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352-796-7211, ext. 4272
doug.leeper@watermatters.org

From:	Linda K. Bystrak
To:	Doug Leeper
Cc:	Nancy Christman
Subject:	RE: Inquiry about The Villages
Date:	Saturday, February 27, 2016 12:55:56 PM
Attachments:	SS flow.docx

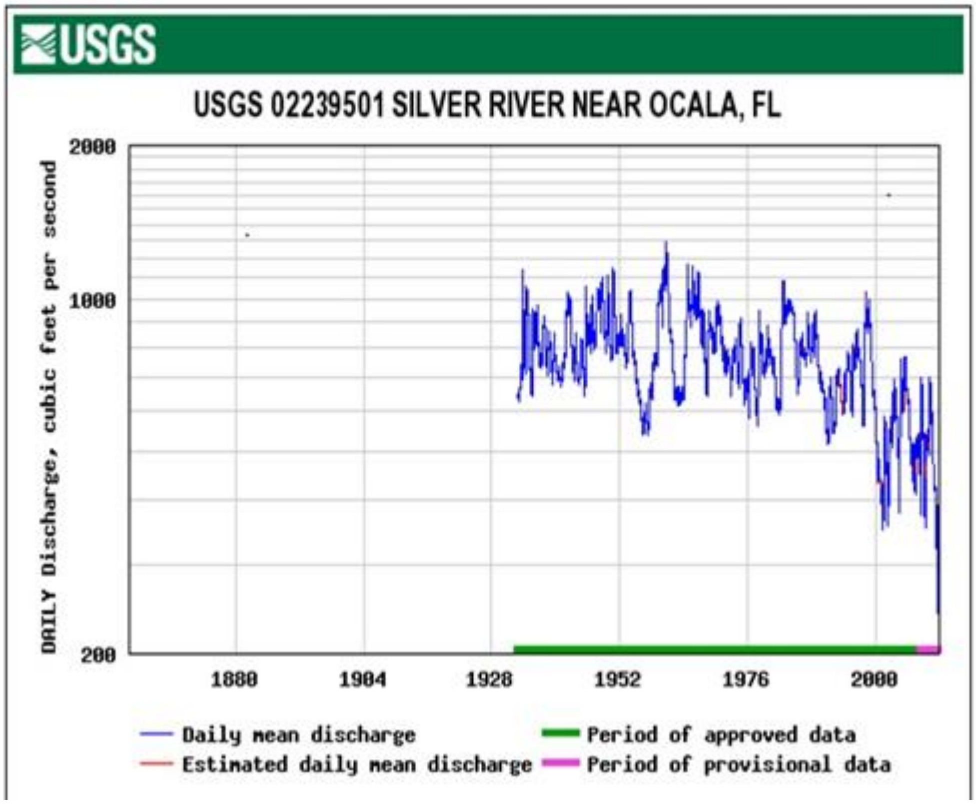
Thanks for your response to my questions about the Villages. According to the Villages staff they are already using 19mgd. I assume that is from both SJRWMD and SWFWMD. They also have a LFA well for irrigation and blend that water with their reclaim and storm water in 250+ retention ponds connected by underground pipes, for irrigation of their 2 doz golf courses plus common areas, and some private lawns. But I assume you already know this plus more. They have at least another 20,000? More homes to build, so they need more water. The newest SWFWMD N. Region plan indicates that 10mgd + 25 mgd could also be withdrawn from the Withlacoochee River and sent to the Villages. Add that to the 6cfs withdraw that SWFWMD could allow from Gum Slough springshed, and it starts to add up. There is also a possibility that water from the Ocklawaha near Gary Morse hunting retreat east of the Villages could be piped to the Villages. The portion of the Villages located in SJRWMD should be required to also use all of their reclaim water, before either WMD gives any more permits to the Villages. They should also be required to follow the same irrigation guidelines as those used in the SWFWMD part of the Villages. I understand that some Village residents are upset because the Village golf courses and common areas are too often being irrigated during rain events, in order to prevent flooding of their retention ponds into surrounding homes. Perhaps the Villages should consider water towers for their excess storm water storage? ASR of this water could contaminate their aquifer. Irrigating during a rain storm does not set a good example for the residents about the need for more water conservation.

Developers view the I-75 corridor north of Bushnell to Gainesville as a "water rich area" to be exploited for more houses. 6,000 more new homes are being proposed for the Wildwood area, including one called "Wildwood Springs". The SJRWMD land up to the Sumter line is designated an "area of critical concern". But over that line and into SWFWMD there is no such designation. You may want to rethink that option. I would also suggest that both districts form a special committee to collect all the current CUP and surface water withdraw proposals from both districts that involve Lake, Sumter and Marion counties and look at the possible cumulative effects on the aquifer and surface water levels. FDEP may be recommending new wastewater treatment facilities in that area because of the springs BMAPS. Water supply should also be a factor in the BMAPs even though DEP wants to ignore it. You cannot separate water quality from quantity.

An increase of 6cfs instead of 3cfs withdrawal from Gum Slough is too large of an increase considering the future growth proposed for its springshed and the adjoining Silver springshed. Gum Sloughs springshed adjoins both Rainbow and Silvers', and the limestone pipelines between them cannot be ignored. I would also suggest that SWFWMD and SJRWMD pay a consultant to make a map of the "cone of influence" under and surrounding the Villages, before any more surface water or ground water permits are issued in that area by either WMD.

Linda Bystrak

PS- please see attachment


USGS
USGS 02239501 SILVER RIVER NEAR OCALA, FL
DAILY Discharge, cubic feet per second
2000
1000
200
1880
1904
1928
1952
1976
2000
Daily mean discharge
Estimated daily mean discharge
Period of approved data
Period of provisional data

From:	hculp@floridaspringsinstitute.org
To:	Doug Leeper
Cc:	Robert Beltran; Drew.Bartlett@dep.state.fl.us; giattina.jim@epa.gov; Cara S. Martin
Subject:	Additional Comments Concerning Establishment of Minimum Flows and Levels for the Gum Slough Spring Run in Sumter and Marion Counties, Florida
Date:	Thursday, February 25, 2016 9:58:25 AM
Attachments:	2016.02-25 Gum Slough_Leeper FINAL.pdf
Importance:	High

Good morning Mr. Leeper,

Please find FSI's additional comments concerning establishment of Minimum Flows and Levels for the Gum Slough Spring Run in Sumter and Marion Counties, Florida. Thank you.

Heather A. Culp, Esq.
Associate Director, Howard T. Odum Florida Springs Institute
hculp@floridaspringsinstitute.org
Office: (386) 462-1003
Cell: (727) 859-2736
Fax: (386) 462-3196
Website Facebook Twitter Google+

Please consider the environment before printing this email.

Howard T. Odum
FLORIDA SPRINGS INSTITUTE

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HIGH SPRINGS, FL 32643
386.454.2427
386.454.9369 (FAX)

February 25, 2016

Mr. Doug Leeper
MFLs Program Lead
Natural Systems & Restoration Bureau
Southwest Florida Water Management District
2379 Broad Street
Brooksville, Florida 34604

Subject: Additional Comments Concerning Establishment of Minimum Flows and Levels (MFLs) for the Gum Slough Spring Run in Sumter and Marion Counties, Florida

Dear Mr. Leeper:

The Howard T. Odum Florida Springs Institute (FSI) thanks you and Kym Holzwart for coming to our office in High Springs and describing the revisions to the proposed MFLs for Gum Slough Spring Run (Gum Slough) to me and to Dr. Todd Kincaid, recognized expert in hydrogeology/groundwater flow modeling and member of FSI's advisory panel.

In addition to the concerns previously described in my letter to Dr. Gary Williams dated April 16, 2012 (see attached), the FSI offers the following observations and recommendations to the Governing Board as they decide on adoption of a protective set of MFLs for the Gum Slough Springs System.

FSI generally supports the establishment of MFLs that are cognizant of the unique qualities and values of Florida springs and especially those springs that are designated as Outstanding Florida Waters. In that regard the ideal MFL is one that mandates that historic flows be maintained in perpetuity and allows no significant human-induced change in spring flows. FSI recognizes that such an MFL would allow no net extraction of groundwater and is not realistic given the current extent of urban and agricultural development in Florida. However, based on best available scientific data FSI has concluded that spring flow is the most influential forcing function affecting springs health. For this reason, state policy should be to maintain ample spring flows to minimize ecological harm to these precious resources.

For this reason, FSI recommends that the Governing Board establish the allowable level of Gum Slough flow reduction at 3 percent rather than the 6 percent recommended by District staff. This level of allowable harm has considerable precedence based on the Governing Board's prior establishment of MFLs at Homosassa and Chassahowitzka Springs.

When establishing protective MFLs it is essential to compare existing flow conditions to historic baseline flows that are representative of predevelopment conditions that were minimally altered due to anthropogenic factors. This has been the state-of-the-art since the District established the first lake MFLs in the early 1990s.

In the case of the proposed Gum Slough Springs MFLs, your staff did task their consultant, INTERA, to establish a true baseline for Gum Slough spring flows. INTERA's analysis found that a long period-of-record flow database from a nearby spring (Rainbow) allowed accurate estimates of historic flows at Gum Slough back to 1965, a time of significantly lower groundwater extractions. The result of INTERA's work was the determination that median flows at Gum Slough declined from more than 180 cfs during the 1960s decade to less than 90 cfs during the most recent decade, an observed flow decline of more than 50 percent (Figure 1). Unfortunately, your staff chose to ignore this result because their Northern District Groundwater Flow Model (NDM v. 4.0) estimated Gum Slough flow declines of only 3.4 percent due to groundwater pumping.

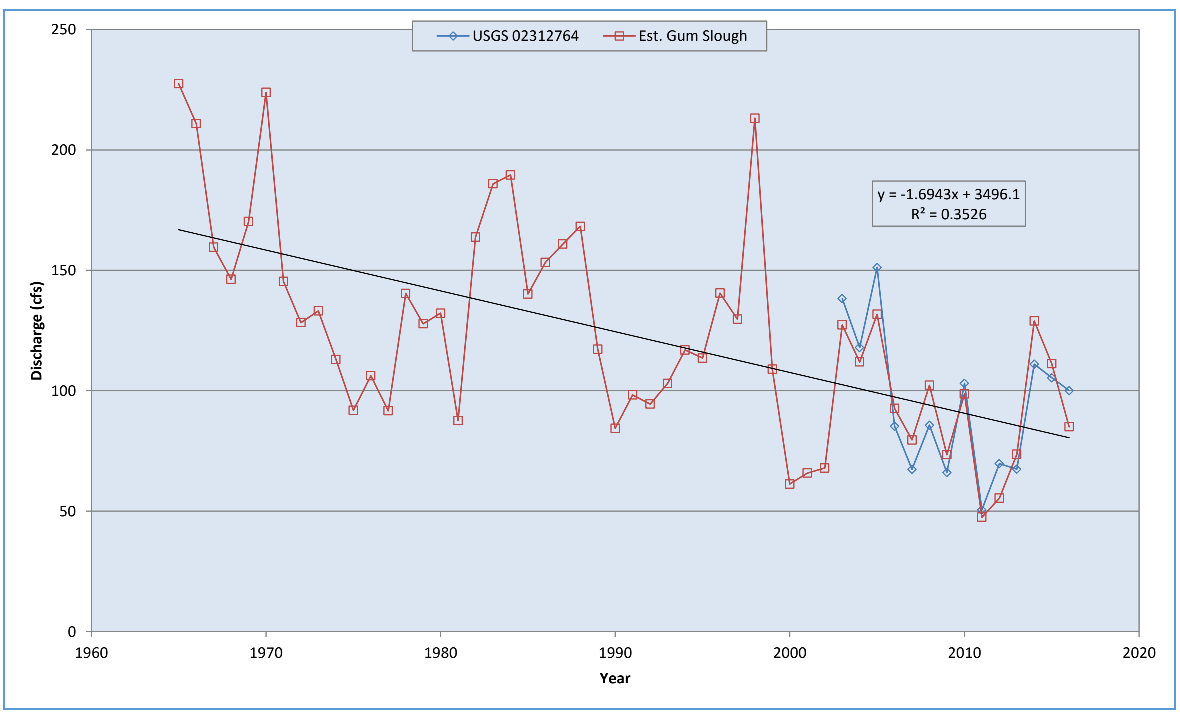

Figure 1. Gum Slough long-term annual average flow record. Flow data prior to 2003 are estimated based on the correlation between annual flows at Rainbow Springs and Gum Slough ($y=0.4403x-173.54$, $R^2=0.83$).

Groundwater flow modeling by District staff using the NDM indicates that the effect of existing groundwater pumping is an average 3.4 percent flow reduction in Gum Slough. This model estimate is not credible given INTERA's analysis presented above that indicates actual average flow declines at Gum Slough are closer to 50 percent. The obvious discrepancy between these two estimates of average flow decline begs resolution based on an independent data/model review.

The staff's February 9, 2016 Gum Slough MFL PowerPoint presentation provides a data summary that allows a ready comparison between NDM predictions and actual groundwater pumping data. District records indicate that an average of 461 MGD of groundwater was pumped in the 10,000 square mile NDM domain in 2010. However, NDM estimates provided by the District indicate that resulting springflow reductions for all of the major spring groups in the model domain (Silver, Rainbow, Gum, Kings Bay, Homosassa, Chassahowitzka, and Weeki Wachee) were only 41 MGD for the same time period.

It is a basic scientific fact that mass is conserved, including the amount of water entering and exiting the Floridan Aquifer. Over annual periods of minor net fluctuations in aquifer levels, recharge from rainfall and from human activities must be equal to discharge, including pumping and spring flow. In other words, a gallon of groundwater that is extracted and consumed, for example by evaporation during lawn watering, is one less gallon that will emerge from the aquifer as spring flow. While a relatively small portion of the 461 MGD pumped does return to the aquifer as recharge, the NDM model estimates of reduced spring flows are an order-of-magnitude low. This result indicates that the NDM groundwater flow estimates are greatly underestimating reality.

In summary, we renew our previous recommendations concerning the Gum Slough MFLs in the attached letter and offer the following additional recommendations to the District's Governing Board for consideration:

- Reduce the level of allowable harm in the Gum Slough Spring Run MFL to no more than a 3 percent flow reduction;
- Direct District staff to include the INTERA estimate of the actual predevelopment flow baseline for Gum Slough to at least the 1960s conditions;
- Direct District staff to describe in detail the limitations of the Northern District Groundwater Flow Model version 4.0 as a regulatory tool for establishing estimates of the effects of groundwater pumping on spring flows and provide the Governing Board with a statistically-based estimate of the uncertainty around the model-predicted spring flow reductions for the District's springs;
- Conduct an independent review of the suitability of the NFM as compared to empirical data and re-evaluate the model's suitability for estimating the effects of groundwater pumping on individual spring flows and MFLs;
- Establish a recovery plan for Gum Slough that restores average spring flows to at least 97 percent of true 1960 baseline conditions; and

- Implement a comprehensive on-going monitoring program at Gum Slough to document springs ecological health as average flows are restored.

FSI and the citizens of Florida thank the Governing Board for their consideration of the information presented in this letter and for implementing recommendations that will favor recovery of Gum Slough to at least 97 percent of its historic health and vigor.

If you have any questions or comments about these concerns and recommendations, please feel free to call me to discuss.

Sincerely,

Robert L. Knight, Ph.D., Director
Howard T. Odum Florida Springs Institute
(386) 454-2427
bknight@floridaspringsinstitute.org

Cc by email:

Michael Babb, Chair, SWFWMD Governing Board
Randall Maggard, Vice Chair, SWFWMD Governing Board
Jeffrey Adams, Secretary, SWFWMD Governing Board
David Dunbar, Treasurer, SWFWMD Governing Board
H. Paul Senft, Jr., Former Chair, SWFWMD Governing Board
Ed Armstrong, SWFWMD Governing Board
Bryan Beswick, SWFWMD Governing Board
Thomas Bronson, SWFWMD Governing Board
Wendy Griffin, SWFWMD Governing Board
John Henslick, SWFWMD Governing Board
George Mann, SWFWMD Governing Board
Michael Moran, SWFWMD Governing Board
Kelly Rice, SWFWMD Governing Board
Robert Beltran, Executive Director, SWFWMD
Drew Bartlett, FDEP
Jim Giattina, USEPA

Enclosure

Howard T. Odum
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5302 NW 156TH AVE
GAINESVILLE, FL 32653
386.462.1003
386.462.3196 (FAX)

Gary Williams, Ph.D.
Southwest Florida Water Management District
2379 Broad Street
Brooksville, Florida 34604

April 16, 2012

Dear Mr. Williams:

Subject: Recommendations for Establishing Minimum Flows and Levels (MFLs) for the Gum Slough Spring Run in Sumter and Marion Counties, Florida

The Howard T. Odum Florida Springs Institute (FSI) is a private, non-profit organization dedicated to restoration and protection of Florida's springs through the development of sound science and effective management. As Director of the FSI and a professional springs ecologist, I am providing these comments and recommendations concerning establishment of technically sound and protective MFLs for the important first-magnitude Gum Slough Spring Run (Gum Slough) spring system.

The FSI has a number of concerns about the draft MFLs developed by the District for Gum Slough. General concerns include the following:

- The Northern District Water Resource Assessment Project (NDWRAP) groundwater flow and transport model is not a suitable tool for assessing the effects of groundwater pumping at Gum Slough. The scale of the NDWRAP model is regional (more than 10,000 square miles) and is not appropriate for making accurate water level and flow estimates at the local scale represented by Gum Slough (one model cell out of more than 40,000 grid cells). For example, in the HydroGeologic report the model developers state with reference to the model's limitations: "A 6-percent error resulted between the steady-state observed and simulated spring discharges and a 15-percent error resulted between observed and simulated base flow." The observed error in the model overwhelms the level of model precision assumed in this draft MFL that assumes a flow reduction of 9 percent or less will not cause significant harm at Gum Slough.

- Standard engineering practice and available tools/analytical methods were not fully used to estimate existing anthropogenic impacts at Gum Slough.
- The District has not responded to critical comments from the peer review panel, or comments previously provided by the Florida Geological Survey and the FSI.
- Anecdotal evidence of worsening ecological conditions provided by adjacent landowners and professional guides/naturalists who have a long familiarity with Gum Slough has not been adequately considered to assess the effects of the increasing local development/groundwater uses in the springshed.
- The District's MFL procedure assumes that a 15-percent habitat change constitutes significant harm. By the District's own admission, this value is arbitrary and needs to be confirmed through an ongoing District-financed study. This unscientific approach is biased towards allowing significant harm to occur in fragile aquatic ecosystems such as Gum Slough.
- The District's MFL methodology does not acknowledge or account for the imprecise nature of the model predictions (PHABSIM and NDWRAP models) that form its foundation, and does not incorporate any assumed statistical error or margin of safety to protect the public's interest in maintaining healthy aquatic resources.

To rectify these deficiencies in this draft MFL, the FSI respectfully requests that the District incorporate the following additional analyses/revisions before finalizing the Gum Slough MFL report and presenting it for Governing Board approval:

1. Prepare an empirical water balance for the Gum Slough springshed, independent of the NDWRAP model that provides individual estimates of historic and current recharge, groundwater pumping, and resulting spring flow.
2. Redefine "significant harm" for the Gum Slough ecosystem more conservatively by utilizing existing data and consideration of all ten human use and water resource values required by Section 62-40.473, Florida Administrative Code. Two examples include data recently published in the Gum Slough reported funded by the Florida Fish and Wildlife Conservation Commission (FWC), ***An Ecosystem-Level Study of Florida Springs – Part II: Gum Slough Springs Ecosystem Characterization*** (WSI 2011), that documents the relationship between spring flow and photosynthetic efficiency; the observed inverse statistical relationship between spring flow and spring nitrate concentrations illustrated by the District at the public meeting on April 4, 2012; and a longer modeled flow regime based on standard regression analysis

between rainfall, well levels, and Gum Slough flows as recommended at the April 4 meeting.

3. Estimate the likely margin-of-error in the NDWRAP model estimates of existing Gum Slough flow reduction impacts and incorporate those into the allowable flow changes incorporated in the Gum Slough MFL.
4. Incorporate an appropriate margin of error to account for uncertainty in this and all future District MFLs.

The District should let the public and the Governing Board know that existing flows in Gum Slough are 18 cfs, the lowest flow on record. If the recommended draft MFL is approved by the District, this MFL authorizes a cumulative 50% reduction in flows at a time of crisis when the upper half of the spring run and at least three named springs have zero flow. This situation surely cannot be conceived to be in the public's or the environment's best interest. Recent record low flows at Gum Slough illustrate the fact that this spring run has highly variable flows and that the short period-of-record available at the USGS station is insufficient to develop a protective MFL at Gum Slough without incorporation of a safety factor. Additionally, existing permitted human groundwater withdrawals in the Gum Slough springshed may already be exceeding the capacity of rainfall and recharge to provide adequate water to protect this natural system.

In summary, the FSI offers the following specific recommendations to the District concerning finalization of the Gum Slough MFL:

- The Gum Slough MFL should be set at "no additional harm" until additional relevant hydrologic and ecological data can be collected and analyzed.
- A recovery or provisional MFL should be adopted by the Governing Board as soon as possible to protect this important resource from additional significant harm.
- No additional consumptive use permits should be issued within the historic Gum Slough springshed and existing permits should be reviewed to evaluate their effects on the aquatic/wetland ecosystem.
- The District should commit to continuing ecological studies of Gum Slough with an updated assessment of existing harm within the next ten years.

On behalf of the FSI, I would like to thank the District for considering these and other informed comments concerning this MFL decision. The FSI recognizes that sound MFLs provide an important balance between water for our ecological resources and water that can be safely withdrawn for essential and efficient human uses. The best available science is needed to accurately and clearly identify the appropriate balance between these two competing water needs.

This letter offers recommendations that are intended to help the District Governing Board make a sound and defensible MFL decision at Gum Slough.

We urge the District to "Do No Harm" when establishing this MFL. If the District errs on the side of the spring, they will have helped preserve one of Florida's irreplaceable natural wonders; if, on the other hand, the District errs on the side of greater water withdrawals, future generations will have lost one more precious natural resource.

If you have any questions or comments about these recommendations, please feel free to call me to discuss.

Sincerely,

Robert L. Knight, Ph.D.,

Director Howard T. Odum Florida Springs Institute

MEETING SUMMARY

Southwest Florida Water Management District
Proposed Minimum Flows for Gum Slough Spring Run Public Workshop
Marion Oaks Community Center, Ocala, Florida
February 25, 2016

The Southwest Florida Water Management District hosted a public workshop on proposed minimum flows for Gum Slough Spring Run in Marion and Sumter Counties. The workshop was held from 4:00 to 6:00 p.m. at the Marion Oaks Community Center, which is located at 294 Marion Oaks Lake in Ocala, Florida. The meeting was advertised in the Florida Administrative Register, local newspapers, and on the District's web site. In addition, numerous interested parties and local government staff and officials were notified of the meeting and a press release was made available to the regional media.

A total of 12 stakeholders attended the public workshop. Several District representatives were also in attendance, including: Chris Zajac, Senior Government Affairs Program Manager; Kym Rouse Holzwart, Senior Environmental Scientist; Ron Basso, Chief Hydrogeologist; Nathan Johnson, Groundwater Engineer; Doug Leeper, MFLs Program Lead; Yonas Ghile, Senior Environmental Scientist; Eric DeHaven, Resource Management Assistant Director; Kevin Wills, Senior Economist; and Randy Emberg, Video Production Engineer.

Copies of the District reports titled *Proposed Minimum Flows for Gum Slough Spring Run, Addendum, Final Draft, Version 2*, dated February 2016, and *Proposed Minimum Flows and Levels for the Gum Slough Spring Run, Final Report*, *Revised October 2011*, were made available for use during the meeting. As part of an informational slide presentation, meeting participants were informed about: the District's Minimum Flows and Levels Program; proposed minimum flows for Gum Slough Spring Run; hydrologic changes to Gum Slough Spring Run; and staff's plans to recommend District Governing Board approval of proposed minimum flows. Meeting participants were made aware of the various opportunities available for stakeholder input on the proposed minimum flows, including: providing oral or written comment during the workshop (a comment card was available); providing written or oral input to District staff via telephone, email or letter; and providing input directly to the District Governing Board during the March 29, 2016 Board meeting, when staff expects to present proposed minimum levels to the Board for approval.

One workshop participant suggested that the allowable withdrawal-related flow reduction associated with the proposed minimum flow be reduced from 6% to 3%. A summary of additional comments and questions discussed during the workshop is provided below. The workshop agenda, the meeting sign-in sheet, and comment cards submitted by two participants are included as attachments to this meeting summary.

Workshop Participant Comments and Questions

1. A participant asked whether withdrawals from the Lower Floridan aquifer were included in the cumulative withdrawals included in the groundwater flow modeling conducted to support development of the proposed minimum flow. The participant also asked about the number of Lower Floridan aquifer withdrawals in the region.

   Response: Staff noted that Lower Floridan aquifer withdrawals were included in the multi-layer Northern District model that was used for the analyses. Staff further noted that the only Lower Floridan aquifer withdrawals within the Southwest Florida Water Management District portion of the model domain are located at the Villages of Sumter County as they use this source for irrigation. There are many more LFA withdrawals further east within the portion of *the model domain lying within the St. Johns River Water Management District. The vast majority of withdrawals in the model are located within the Upper Floridan aquifer.*

2. Referring to a recent newspaper article on projected regional population increases, a participant asked whether population increases and presumed increases in water supply demand were accounted for in the minimum flow analyses.

   Response: Staff noted that state-approved population projection information was used for the analyses supporting the proposed minimum flows. Staff noted that these estimates are routinely updated on a five-year cycle and are used for water supply planning purposes as well as for development of minimum flows and levels.

3. A participant noted that the draft minimum flows report for the spring run system includes numerous references to assumptions regarding environmental values that were considered for development of the proposed minimum flow. He suggested that report text associated with these references could be revised to better convey the District's consideration of the environmental values for the spring system.

   Response: The text of Chapter 2 of the draft addendum, which describes the environmental values that must be considered when developing minimum flows and levels, includes the word "assumed" on three occasions. The text will be revised as suggested.

3. A participant asked whether the allowable 6% flow reduction was applicable on a long-term or short-term basis.

   Response: Staff noted that allowable withdrawal-related flow reductions associated with established minimum flows are developed to address long-term conditions within priority water bodies. Staff added that in some cases, established minimum flows also include low-flow thresholds that may serve as a short-term limit on surface water withdrawals from flowing water systems, such as Gum Slough Spring Run.

4. A participant suggested that the District should continue to explore opportunities to partner with others, including permit holders, to enhance data collection that would support development or refinement of minimum flows. Cost-sharing with or requiring permit holders to install new monitoring wells were identified as examples of this type of effort.

5. A participant noted that the appendix to the draft 2016 addendum report on proposed minimum flows for the spring system includes a figure depicting a long-term flow record for Gum Slough Spring Run and questioned why that record, which indicates historical flows higher than those during recent years, was not used to support development of the proposed minimum flows. The participant further noted that the period-of-record used for hydrologic data supporting minimum flows development may affect analytical results supporting development of minimum flow recommendations.

   Response: Staff noted that the figure referenced by the participant is included as Figure 5 in the appendix to the draft 2016 addendum report. It includes measured Gum Slough Spring Run flow records (adjusted for withdrawal impact) for the period from October 2003 through September 2013 and records prior to this period that were developed using a statistical (regression) model to predict flow records for the spring run based on flows at Rainbow Springs. Staff noted that, as shown in Figures 4 in the report appendix, the statistical model was not considered to be a very robust tool for predicting flows within the Gum Slough Spring Run, and for this reason, the long-term flow record illustrated in Figure 5 in the addendum report appendix was not used for the minimum flow analyses.

Staff also noted that analyses summarized in the draft 2016 addendum report led to revision of the allowable withdrawal-related flow reduction from the previous value of 9% to 6%. Staff added that the currently proposed, allowable flow reduction is more conservative, i.e., more protective of the environmental values associated with the spring run, and that the revised minimum flow recommendation is based on analyses that included flows for the period from 2010 through 2013 that were lower than those used for the previous analyses.

Finally, staff noted that they plan to recommend that the Governing Board consider reevaluation of minimum flows that are established for Gum Slough Spring Run within ten years of the their establishment. This will allow for: collection of additional measured flow records to supplement the exiting measured flow record, potential refinement of modeling that could be used to develop long-term flow records for the spring system, and development and application of additional analytical methods that may be used to support minimum flows development.

PUBLIC WORKSHOP
Sign-In Sheet

Southwest Florida Water Management District
WATERMATTERS.ORG • 1-800-423-1476

Name	Address/City/ZIP	Phone	Email Address
Dan Hilliard	?	352-527-0023	2Buntings@Comcast.net
Ron Basso			
David Watson	City of Wildwood	352-330-1346	dwatson@wildwood-fl.gov
Doug Andrews	Marion County Utilities	352-307-4624	
Linda Bystrak	110 Oak Ridg Dr, Leesburg	352-357-2207	linda@bystrak.com
Dwane L Carlton	Ocala		dcarlton@wrelease ocala.com
MATT TEBOW	OCALA, FLORIDA	352-286-5491	MATT.TEBOW@kimley-Horn.com
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Trey Arnett	Arnett Environmental	352-753-4747	TArnett@ArnettEnvironmental.com
Judy Smith		352-454 0735	
JASON DAVISON	FFBF	352-672-1160	jason.davison@FFbF.org
Kim Dinkins	Marion County	438-2683 343-	kimberleigh.dinkins@marioncountyfl.org

Comment Card

Southwest Florida
Water Management District
WATERMATTERS.ORG · 1-800-423-1476

Meeting Date: 3/25/15 Meeting Location: Marion

Name: Linda Bystrak Phone: 352-357-7207

Mailing Address: City/Zip: 34788

Email Address: linda@bystrak.com

Questions and/or Comments:

Permission to display graph from addendum appendix

FSI Rep. ☆

Comment Card

Southwest Florida
Water Management District
WATERMATTERS.ORG · 1-800-423-1476

Meeting Date: 2-25-11 Meeting Location: MARION OAKS CCF

Name: DAN HILLIARD Phone: 352-527-0023

Mailing Address: City/Zip:

Email Address: 2BUNTINGS @ COMCAST.NET

Questions and/or Comments:

ASSUMPTIONS / DATA

From:	Anne Harvey Holbrook
To:	Doug Leeper
Cc:	Katie Tripp
Subject:	SMC Comments Regarding Gum Slough MFL
Date:	Wednesday, March 16, 2016 3:39:41 PM
Attachments:	SMC Gum Slough Comments.pdf

Hello Mr. Leeper,

Attached please find Save the Manatee Club's comments regarding the proposed minimum flows and levels for Gum Slough Spring Run addendum final draft. Please do not hesitate to contact me with any questions you may have regarding these comments.

Regards,

Anne Harvey Holbrook, JD, MS
Staff Attorney
Save the Manatee Club
500 N. Maitland Ave.
Maitland, FL 32751
Mobile: 803-629-5003
Office: 407-539-0990
e-mail: aharvey@savethemanatee.org
Adopt-A-Manatee! Go to: savethemanatee.org/adopt

Save the Manatee® Club

The Voice for Manatees Since 1981

Mr. Doug Leeper
MFLs Program Lead
Natural Systems & Restoration Bureau
Southwest Florida Water Management District
2379 Broad Street
Brooksville, Florida 34604
Doug.Leeper@watermatters.org

March 16, 2016

Re: Comments Concerning Minimum Flows and Levels Final Draft and Addendum for Gum Slough

Save the Manatee Club

Save the Manatee Club ("SMC") is an award-winning national 501(c)(3) scientific and advocacy nonprofit, established in 1981 by singer and activist Jimmy Buffett and former Senator Bob Graham. SMC represents 11,000 members and supporters throughout the state and an additional 33,000 nationwide in efforts to protect endangered manatees and their aquatic habitat from threats posed by human activity, including habitat destruction and water quality degradation. It is with this mission in mind that we offer these comments regarding the final MFL and Addendum for the Gum Slough Spring Run. SMC has previously submitted comments on the original 2011 Draft MFL. We incorporate those comments here by reference, and offer the following additional recommendations for your consideration.

Gum Slough Spring Run Final Draft MFL and Addendum

SMC appreciates the efforts the District has made to develop a more protective MFL based on more complete data and a more accurate assessment of the ecological needs of the system. However, SMC is concerned that the proposed six percent reduction in natural flow is still insufficiently protective of the public interest in the non-consumptive and environmental uses of Gum Slough, and urges the District to instead adopt a 3 percent or lower target reduction.

Gum Slough and Springs are designated as Outstanding Florida Waters, 62-302.700 Fla. Admin. Code, and therefore may not be degraded except in limited circumstances that are found to be in the public interest. 62-4.242, Fla. Admin. Code. A six percent reduction in flow rates is insufficiently protective of the public's interest in the ecological, recreational, and aesthetic functions of the spring and slough.

The six percent reduction continues to be based on an arbitrary fifteen percent loss of habitat threshold for significant harm. Peer review quotes provided in the District's own September 2011 presentation on Springs Coast Minimum Flows and Levels public workshop on significant harm confirm that the fifteen percent threshold is an arbitrary designation. Though fifteen percent does certainly qualify as significant harm, significant harm may nevertheless be incurred at much lower thresholds depending on the system. SMC contests the validity of this fifteen percent threshold for Gum Slough, and urges the District to redefine significant harm in the context of the ten human use and water resource values described by 62-40.473(1), Fla. Admin. Code, including considering the impacts of flow reductions on recreation, fish and wildlife habitat, sediment loads, aesthetic and scenic attributes, nutrient filtration, overall water quality, and the maintenance of freshwater supply to the system. In particular, the District must consider the high flow variability of the spring system, especially in the upper springs, where no-flow conditions occurred in 2000 and 2012. An insufficiently protective MFL risks exacerbating low- and no-flow conditions.

The proposed six percent flow rate reduction is especially questionable in light of the District's use of the Northern District Model, Version 4.0 (NDM) for calculating flow rate reductions and groundwater consumption. The NDM, according to calculations by the Florida Springs Institute, underestimates the effect of groundwater withdrawals on spring flow rates by an order of magnitude.

In order to preserve the non-consumptive uses and environmental values associated with springs ecology as required by 62-40.473, Fla. Admin. Code, MFLs should be set relative to historical baseline levels representative of minimally altered conditions. An analysis of historical conditions from nearby Rainbow Spring enabled the District's consultant, INTERA, to conclude that historical flows at Gum Slough during the mid-1960s were approximately 180 cubic feet per second (cfs), compared with modern flows of approximately 90cfs, representing a fifty percent decline from historical flows. However, the NDM, on which the District chose to rely instead, estimates reductions of only 3.4 percent relative to historical rates. The District must, at a minimum, resolve the discrepancy between the two estimates to ensure that it establishes an MFL sufficiently protective to preserve non-consumptive and environmental uses in the public interest, and must establish and disclose to the public the margin of error surrounding its use of the Northern District Model. In the meantime, SMC requests the District to exercise caution and establish the allowable levels of flow reduction for Gum Slough at three percent or lower.

Lastly, the MFL Addendum and Final Draft does not include a Recovery Plan for Gum Slough, concluding, likely erroneously based on the NDM flow reduction estimates of 3.4 percent, that the target MFL of 6 percent is being met. As previously discussed, the INTERA analysis indicates the actual decline may be closer to fifty percent relative to historical rates. Therefore, even in the event that the District does not establish a more protective flow rate reduction, it must still establish a Recovery Plan, as required by 62-40.473(5), Fla. Admin. Code. The Plan must include practical measures, monitoring parameters, and an enforceable timetable for restoring spring flows to at least 97 percent of 1960s baseline conditions.

Thank you for your consideration. If you have any questions regarding our concerns and recommendations, please do not hesitate to contact me at aholbrook@savethemanatee.org to discuss these comments further.

Regards,

Anne Harvey Holbrook, JD, MS
Staff Attorney
Save the Manatee Club

FLORIDA SPRINGS COUNCIL

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Mr. Michael A. Babb, Chair
Governing Board, Southwest Florida Water Management District
2379 Broad Street
Brooksville, FL 34604-6899

March 28, 2016

Re: Florida Springs Council Comments Concerning Gum Slough Minimum Flows and Levels

Dear Chairman Babb and Members of the Governing Board,

We thank the District staff and Governing Board members for this opportunity to offer comments to the record on the subject rule development. Development of staff recommendations has been a long arduous process which illustrates the sometimes problematic nature of the undertaking.

We find the revised recommendations from staff (Addendum FINAL DRAFT, Version 2) to maintain a minimum of 94% of historic flow a substantial improvement over the original position. Modification of the previous peer reviewed recommendation of 91% of flow is a rational step in the process if for no other reason than the period of record suggests a 9% taking of system flow can be reasonably construed to result in no flow scenarios during prolonged drought.

There remain issues at hand with the documented findings which are within the authority of the Governing Board to address and they are presented herein without priority implied. We ask that they be carefully considered prior to making a final decision regarding this proposed rule.

1. While not unique to this system, or the fault of staff, the data base for the Gum Slough system is scant. It is notable that staff constructed flow analysis based on the long term historical record from Rainbow Springs coupled with more recent Gum Slough basin data. Relevant to this point is that given only a few additional years of local data, staff determined that an increase in flow protection was warranted, hence the recommended change from 9% to 6% flow reduction in the proposed rule. What this suggests is that an enhanced data set, even for a relatively short time period had significant influence on staff recommendations.

It is recognized that MFL rule development is based on the “best available information”, but the question is raised as to whether the data set is adequate to allow the Board to make a well-founded decision. If there remains uncertainty about quality of the data set it is prudent to err on the side of caution and consider additional buffer until a more substantial data base exists.

2. The core NDM program is not intended to model the complexity of Florida's karst geology for a site specific evaluation. In fact, there are cautions within the NORTHERN DISTRICT GROUNDWATER FLOW MODEL; VERSION 4.0 (HydroGeoLogic, Inc.) Section 4.7 which specifically address this issue. See the following excerpts from the Model Limitations section.

"Potential users of the NDM should note that because of recognized data deficiencies, model simulation is more appropriate at the sub-regional and regional scales rather than at the local or site-specific scales for simulation of hydrologic conditions."

No objection is presented adverse to NDM 4 for its broader intended application, but we are greatly concerned that the small size of the Gum Slough Basin presents potential conflict with the cautionary note above. The basis of this concern is found within further dialog which follows:

"A 6-percent error resulted between the steady-state observed and simulated spring discharges and a 4-percent error resulted between observed and simulated base flow."

"Even though the model appears to adequately represent the general groundwater-flow patterns and fluxes within the Northern District, there are some areas within the model domain where model errors are significant."

Table 4.7 lists steady-state simulated and observed spring discharge rates in the Northern District Model domain. The range of error listed for discharge in the table ranges from 0% to 190% for the population. The error for Gum and Alligator Springs is 4% and 14% respectively. We note the larger percentage errors are generally associated with lower volume flow systems and there appears to be an inverse correlation between flow and magnitude of the error. This presents a degree of uncertainty which suggests that great caution is warranted in development of these rules, and with specificity for the Gum Slough system.

The Florida Springs Council (FSC) views protection of spring systems as a highest priority action due to their favorable support of sustainable economic activity and overall benefit to the people of the state. We are supportive of the MFL intent and processes used to formulate attendant rules. At the same time, we recognize limitations and constraints associated with the process and as a result find need for great caution in developing such rules. As example; in transition from NDM3 to NDM4, District staff found significant error in the earlier version which was used to develop MFL Rules for Chassahowitzka and Homosassa Springs.

NDM3 estimated anthropogenic related flow reductions of 1.1 % on the Homosassa River system and 0.9% on the Chassahowitzka River system. NDM4 estimated anthropogenic related flow reductions 2.2% on the Homosassa River system and 1.7% on the Chassahowitzka River system. Model estimates with such incongruity (~100%) do not inspire confidence.

Considering HydroGeoLogic's acknowledged 6% inaccuracy of the NDM's ability to predict spring specific discharges, we strongly urge extreme caution on all MFL rule development based on the NDM macro-model.

There is uncertainty associated with data set limitations and model function in the process at hand. The District is constrained in its regulation for a variety of reasons, one of which is the threshold at which permitting for consumptive use is required. While staff can estimate consumption of groundwater via private wells, the District has little regulatory authority over such development activity. Commitment of a segment of groundwater supply for beneficial use is a largely irrevocable act. Such action(s) based on thin data sets or razor thin margins of calculation presents potential for significant and lasting harm to Gum Slough Spring and other spring systems across the region.

The District's mandated Areas of Responsibility include the protection of natural systems. It is our sincere belief that regulatory actions such as MFL rules are best viewed and constructed as an act of perpetuity, not something that requires recurrent maintenance or recovery actions. There are other water supply sources within the Northern Region which can support beneficial use with far less potential for adverse impact.

Recommendations:

1. The FSC recommends that a shorter review cycle for this rule be considered. We suggest that in light of the magnitude of amendment to the proposed rule by staff over the course of its development, that a period of 5-7 years is more appropriate.

2. We recommend that no additional flow reduction be allowed, holding the line at a maximum of 3 cfs reduction to average system flows. The recommendation is not made lightly. We recognize staff estimates of anthropogenic impact currently stand at 3.4% of average flow or approximately 3 cfs. This

recommended moratorium on issuance of additional groundwater pumping permits is warranted based on the analysis of baseline flows by Intera and District staff and on the described imprecision of the NDM v.4. Such a limit will provide a buffer until additional data or enhanced modeling substantiates rule modification to the contrary.

Sincerely,

Dan Hilliard

Dan Hilliard, Chairman
Florida Springs Council
352.327.0023
2buntings@comcast.net

CC: Doug Leeper, Chief Environmental Scientist, SWFWMD
Kym Holzwart, Senior Environmental Scientist, SWFWMD

Marion County
Board of County Commissioners

McPherson Governmental Complex

601 SE 25th Ave.
Ocala, FL 34471
Phone: 352-438-2323
Fax: 352-438-2324

March 28, 2016

VIA HAND DELIVERY

Michael A. Babb, Chairman
Southwest Florida Water Management District
2379 Broad Street
Brooksville, FL 34604

RE: Minimum Flows for Gum Slough Spring Run

Dear Chairman Babb:

Marion County offers its support of the proposed Minimum Flows for Gum Slough Spring Run. The results are a reflection of a comprehensive effort by Southwest Florida Water Management District's technical team. Of great benefit was the opportunity that availed itself to extend the period of record and further analyze the system. While confirming much of the original results, it allowed refinements that promote the necessary protection of our critical water and ecological resources.

We appreciate being included in this process and as a key stakeholder, participating in these water management district initiatives. As always, do not hesitate to call on me or any of the Marion County staff with any questions or concerns you may have.

Sincerely,

Kathy Bryant

Kathy Bryant
Chairman

Sid Flannery's presentation to SWFWMD Governing Board, March 29, 2016
Minimum flows for Gum Slough Run Springs

Hello, I'm Johnny Cash (ha ha). I live in the Tampa metropolitan area. As you may know, I worked for the District for nearly 30 years specializing in minimum flows, retiring as a Chief Environmental Scientist a year and a half ago.

I support the adoption of the proposed rule, but strongly recommend that the District maintain some flexibility in how compliance with the rule is periodically assessed.

The rule language is fairly simple, essentially saying that springflow cannot be reduced by more than 6 percent. However, the rule does not describe how compliance with minimum flows is to be assessed, and that is every bit as important

For the assessment of minimum flows for Gum Slough, the District is relying on the Northern District groundwater flow model, a large, regional three-dimensional groundwater model that was developed in conjunction with the St. Johns River WMD and other parties.

The District used the Northern District model to simulate the effects of groundwater withdrawals on Gum Slough for an average hydrologic year. This type of simulation provides very useful information and should be a fundamental tool used in determining minimum flow compliance.

However, in some cases, there should also be an assessment of the effects on groundwater withdrawals on the frequency and duration low and zero flows, not just flows under average hydrologic conditions.

Gum Slough virtually quit flowing in the year 2012. There was 5 cfs at the downstream end of the springs group, but the uppermost headsprings actually ceased flowing, with pronounced impacts to the water quality and biology of those springs and the upper reaches of the spring run.

The District minimum flows report makes the valid case that prolonged multi-year rainfall deficits had much to do with the flow declines observed in Gum Slough. However, the model indicated there was also a small effect of groundwater withdrawals on springflow, which could change if groundwater withdrawals increase in the region.

By all means, the Northern District model should be used with the defined protocol as a fundamental tool for assessing minimum flow compliance. However, it should be emphasized that models do not produce data, but rather model output, which are subject to error.

In that regard, the District should also employ other analytical tools to evaluate minimum flow compliance if there is a potential for groundwater withdrawals to cause adverse impacts to the ecology of the spring ecosystem.

The District should periodically perform trend analyses for flow in Gum Slough, and examine statistical relationships between rainfall, groundwater pumping, groundwater levels, and springflow to evaluate if these relationships are showing shifts over time.

If springflow is declining, consideration should given to developing a more localized numerical groundwater model specific to Gum Slough, with smaller grid cells and increased use of data from Gum Slough and the nearby groundwater system. Such a localized model should be run under transient conditions, so that the relative effects of climate and groundwater use can be examined for different seasons and hydrologic conditions.

Again, for minimum flow compliance, the District should evaluate the effects of water use on the frequency and duration of low and zero flows, if evidence indicates that the prolonged occurrence of these low flows is causing significant harm to the spring run ecosystem.

Kym Holzwart

From:	Chris Zajac
Sent:	Thursday, March 31, 2016 1:38 PM
To:	Doug Leeper
Cc:	Ron Basso; Kym Holzwart; Eric DeHaven; Jennette Seachrist
Subject:	RE: SWFWMD double talk

Thanks Doug.

From: Doug Leeper
Sent: Thursday, March 31, 2016 1:02 PM
To: Chris Zajac <Chris.Zajac@swfwmd.state.fl.us>
Cc: Ron Basso <Ron.Basso@swfwmd.state.fl.us>; Kym Holzwart <Kym.Holzwart@swfwmd.state.fl.us>; Eric DeHaven <Eric.Dehaven@swfwmd.state.fl.us>; Jennette Seachrist <Jennette.Seachrist@swfwmd.state.fl.us>
Subject: RE: SWFWMD double talk

Chris:

Here's some information pertaining to Ms. Bystrak's comments that you may want to share with Ms. Wright.

- The proposed minimum flow for Gum Slough Spring Run approved by the District Governing Board is 94% of the natural flow as measured at the U.S. Geological Survey gage site in the run. Natural flow is defined as the flow that would exist in the absence of water withdrawal impacts. The proposed minimum flow would, therefore, potentially allow for ground or surface water withdrawals that individually or cumulatively reduce natural flows in the spring run by up to 6%.
- The proposed minimum flows would also limit surface water withdrawals from individually or cumulatively reducing flows at the U.S. Geological Survey gage site in the run below 43 cubic feet per second.
- Groundwater withdrawals currently reduce the natural flow of the Gum Slough Spring Run by 3.4 percent. Therefore an additional allowable flow reduction of up to 2.6 percent could occur without violation of the proposed minimum flows.
- The long-term flow record included as an attachment to Ms. Bystrak's email includes measured flows in red corrected for withdrawal impacts and simulated flows in blue. The simulated flows were developed using a statistical (regression) model to predict flow records for the spring run based on flows at Rainbow Springs. Staff notes that the statistical model was not considered to be a very robust tool for predicting flows within the Gum Slough Spring Run, and for this reason, the long-term flow record was not used for development of minimum flow recommendations. Staff does, however, acknowledges long-term trends in springflow in many area systems that are associated with rainfall trends. Also, through simple water-budget calculations using measured information, staff has demonstrated how relatively minor changes in rainfall can results in substantial changes in springflow in Gum Slough Spring Run.

Doug Leeper
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doug.leeper@watermatters.org

From: Chris Zajac
Sent: Thursday, March 31, 2016 10:57 AM
To: Doug Leeper <Doug.Leeper@swfwmd.state.fl.us>
Cc: Kym Holzwart <Kym.Holzwart@swfwmd.state.fl.us>; Ron Basso <Ron.Basso@swfwmd.state.fl.us>; Eric DeHaven <Eric.Dehaven@swfwmd.state.fl.us>; Jennette Seachrist <Jennette.Seachrist@swfwmd.state.fl.us>
Subject: FW: SWFWMD double talk

Doug,

Can you send me a short response to Ms. Bystraks' comments below that I can share with Shannon? Particularly her comment about "allowing 3.4 mgd to be withdrawn", and "historic flow since 1963". I spoke to Shannon at length yesterday to bring her up to speed on the MFL and will be providing the documents later this morning. Shannon and her staff have been working with Ms. Bystrak regarding airboat complaints on the spring run.

From: Wright, Shannon [mailto:shannon.wright@MyFWC.com]
Sent: Wednesday, March 30, 2016 3:06 PM
To: Chris Zajac <Chris.Zajac@swfwmd.state.fl.us>
Subject: FW: SWFWMD double talk

Thank you Chris for taking the time today to explain. Here is the email I spoke of.
Congratulations again!!
Thanks,
Shannon

From: Hale, Marty
Sent: Wednesday, March 30, 2016 9:15 AM
To: Wright, Shannon <shannon.wright@MyFWC.com>
Subject: FW: SWFWMD double talk

Hi Shannon,

I thought you would appreciate this email from Linda Bystrak. Linda is an Audubon Board member and served on the Lake County Water Authority board for a while. I receive her emails periodically and will pass the appropriate ones along as I get them. Very good day yesterday, we were glad to assist!

Marty

From: Linda K. Bystrak [mailto:linda@bystrak.com]
Sent: Tuesday, March 29, 2016 2:34 PM
To: Linda K. Bystrak <linda@bystrak.com>
Subject: FW: SWFWMD double talk

THE SWFWMD board meeting began today at 9:30 AM with a declaration of their commitment to protect our Springs, but by 11:30 AM all that was a forgotten as they voted unanimously to allow an average of 3.4mgd to be with drawn from one of their most beautiful springs, Gum Springs, Just over 4 miles off the Withlacoochee River, this once beautiful group of springs had an average flow of over 180 cfs. Today the average flow is about 88cfs, based on only 10 years (2003-2013) of its historic record of flow since 1963. It has lost over 50% of its former average flow. Now the Board has approved an additional 6% of its current average flow or 3.4mgd to be removed as groundwater for more homes to be built.

Who in the audience endorsed this plan? The chairman of the Marion Co. BOCC, a representative of the Northern Water Supply Plan, and a representative of the Villages Water Supply office. Who opposed the plan? A retired hydrologist, a representative of the FL Springs Council, and myself, representing those kayakers who love Gum Slough. In 2011 and 2012 there wasn't enough water in the spring run for us to paddle to the headspring. Even a short video clip of the deplorable condition of the springs failed to move the Board members. Once again, another WMD is using "double talk" to confuse the public, by claiming to be the guardians of our springs.

Linda Bystrak
A FL Kayaker

Kym Holzwart

From: Sid Flannery <sidflannery22@gmail.com>
Sent: Wednesday, March 30, 2016 7:33 AM
To: Eric DeHaven; Ron Basso; Doug Leeper; Kym Holzwart
Subject: Gum Slough follow-up, not within my three minutes
Attachments: Sid Flannery's Gum Slough Board presentation.doc

Hello Eric, Ron, Doug, Kym,

It was good seeing each of you yesterday and I was glad to support adoption of the Gum Slough minimum flow rule, with the comments I offered. It seems that both District staff and the Board are of the opinion that the flows from Gum Slough should be carefully managed using the best available information. Congratulations on getting Board approval.

I have attached a WORD file of my comments from yesterday's Board meeting that have some grammatical corrections from what I sent Ron yesterday. I was determined to keep my comments within three minutes, so I pared down a few points I wanted to make. They are offered below, first for Doug and Kym and then for Ron. At least one of them is pretty obvious.

<u>For Doug and Kym,</u>

1. Needless to say, continue to fund the USGS flow gaging station on Gum Slough Spring Run.

2. I believe Kym told me that staff put into next years budget or work plan a program to make periodic instantaneous flow measurements in the Gum Slough Run between the springs or springs groups. That would be great, as it would help determine how much flow comes out of the various springs or springs groups. If that could be done quarterly, or even semi-annually, it would be very valuable.

I believe Kym also said water quality would be monitored. Sounds good, but I wonder how much variation there will be. Even semi-annually might be enough.

What I think would be very valuable would be estimates of filamentous algae coverage. This could be done using a quick technique, possibly photographic and visual estimates of coverage. Hopefully something that could be done within the same work day, or on a following day, as the flow measurements. Again, quarterly, or semi-annually, should be good.

<u>For Ron</u>

It seems like minimum flow reports for springs should discuss the calibration results of the most recent version of the Northern District model for the spring in question. It is too late now for Gum Slough, but should be presented for Rainbow Springs if those calibration values are available.

Second, I was surprised that the peer review report for Gum Slough did not discuss application of the Northern District model for the evaluation of existing and potential future effects of groundwater withdrawals on the minimum flow. It seems that at least a discussion of the Northern District model for that purpose should be in the scope for peer review panels for springs minimum flows.

Ron sent to me the peer review report that Stewart and Upchurch did for SWFWMD about the Silver Springs minimum flow work by St. Johns River WMD. I have not read it thoroughly - but am assuming that Stewart reviewed application of the most recent version of the Northern District model that was agreed to by both SFWMD and SJRWMD.

It seems like future SWFWMD minimum flows reports for springs should provide a discussion and references for any peer review studies that have discussed application of the Northern District model for minimum flows purposes.

Thanks all folks. Thanks very much for your patience!

Sid

Kym Holzwart

From:	Doug Leeper
Sent:	Friday, March 04, 2016 11:39 AM
To:	Linda K. Bystrak
Cc:	nchristman@sjrwmd.com
Subject:	RE: Inquiry about The Villages
Attachments:	SS flow.docx

Ms. Bystrak:

Thanks for your comments on the District's proposed minimum flows for Gum Slough Spring Run and other suggestions included in your email sent on February 27, 2016. District staff appreciate the opportunity to consider comments such as those you've provided as we develop draft rule amendments associated with minimum flows for the spring system. Staff will make your comments and all other stakeholder input on the proposed minimum flows available to the District Governing Board to support their planned discussion of proposed minimum flows amendments for the spring system during the Board meeting scheduled to be held on March 29, 2016 at the District Headquarters in Brooksville.

Doug Leeper
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doug.leeper@watermatters.org

From: Linda K. Bystrak [mailto:linda@bystrak.com]
Sent: Saturday, February 27, 2016 12:56 PM
To: Doug Leeper <Doug.Leeper@swfwmd.state.fl.us>
Cc: Nancy Christman <nchristman@sjrwmd.com>
Subject: RE: Inquiry about The Villages

Thanks for your response to my questions about the Villages. According to the Villages staff they are already using 19mgd. I assume that is from both SJRWMD and SWFWMD. They also have a LFA well for irrigation and blend that water with their reclaim and storm water in 250+ retention ponds connected by underground pipes, for irrigation of their 2 doz golf courses plus common areas, and some private lawns. But I assume you already know this plus more. They have at least another 20,000? More homes to build, so they need more water. The newest SWFWMD N. Region plan indicates that 10mgd + 25 mgd could also be withdrawn from the Withlacoochee River and sent to the Villages. Add that to the 6cfs withdraw that SWFWMD could allow from Gum Slough springshed, and it starts to add up. There is also a possibility that water from the Ocklawaha near Gary Morse hunting retreat east of the Villages could be piped to the Villages. The portion of the Villages located in SJRWMD should be required to also use all of their reclaim water, before either WMD gives any more permits to the Villages. They should also be required to follow the same irrigation guidelines as those used in the SWFWMD part of the Villages. I understand that some Village residents are upset because the Village golf courses and common areas are too often being irrigated during rain events, in order to prevent flooding of their retention ponds into surrounding homes. Perhaps the Villages should consider water towers for their excess storm water storage? ASR of this water could contaminate their aquifer. Irrigating during a rain storm does not set a good example for the residents about the need for more water conservation.

Developers view the I-75 corridor north of Bushnell to Gainesville as a "water rich area" to be exploited for more houses. 6,000 more new homes are being proposed for the Wildwood area, including one called "Wildwood Springs". The SJRWMD land up to the Sumter line is designated an "area of critical concern". But over that line and into SWFWMD there is no such designation. You may want to rethink that option. I would also suggest that both districts form a special committee to collect all the current CUP and surface water withdraw proposals from both districts that involve Lake, Sumter and Marion counties and look at the possible cumulative effects on the aquifer and surface water levels. FDEP may be recommending new wastewater treatment facilities in that area because of the springs BMAPS. Water supply should also be a factor in the BMAPs even though DEP wants to ignore it. You cannot separate water quality from quantity.

An increase of 6cfs instead of 3cfs withdrawal from Gum Slough is too large of an increase considering the future growth proposed for its springshed and the adjoining Silver springshed. Gum Sloughs springshed adjoins both Rainbow and Silvers', and the limestone pipelines between them cannot be ignored. I would also suggest that SWFWMD and SJRWMD pay a consultant to make a map of the "cone of influence" under and surrounding the Villages, before any more surface water or ground water permits are issued in that area by either WMD.

Linda Bystrak
PS- please see attachment

Appendix 2

Technical Memorandum from Intera, Inc. Regarding Additional Gum Slough Springs Run HEC-RAS Model Simulations

INTERA Incorporated
4111 Land O' Lakes Blvd., Suite 104
Land O' Lakes, Florida 34639 USA
813.527.6999

MEMORANDUM

To: Gary Williams

Copy: Tammy Hinkle

From: Renee Murch

Date: February 7, 2014

Re: Gum Springs, Additional Predictive Simulations

INTRODUCTION

Gum Springs, the headwaters of Gum Slough, is located approximately six miles northeast of the Withlacoochee River in northwest Sumter County. In 2010, a steady state HEC-RAS model of Gum Slough was constructed for use in Minimum Flows and Levels (MFL) development (INTERA, 2010). The results of the predictive simulations will be utilized by the District for MFL analyses. Since the 2010 modeling effort utilized data observed through July 25, 2010, it was desired by the District to run additional simulations of the steady state Gum Springs model using the best available flow and stage data that extends through September 30, 2013. For this modeling effort, two sets of percentile flows were calculated based on the available United States Geological Survey (USGS) recorded data. This technical memorandum documents the resulting flows and simulated stages at each cross section based on the calculated percentile flows and calibrated HEC-RAS model.

USGS Gauge Data

The USGS Gum Springs at Holder gauge data was obtained from the USGS for use in predictive simulations. The gauge record begins on October 1, 2003. Data utilized for this analysis extends to September 30, 2013. The flow record for the gauge is shown in Figure 1. The average flow for the period of record is 87.6 cubic feet per second (cfs), with flow ranging from 5.1 cfs to 520 cfs for the period of record. Both flow and stage were obtained from the USGS. Stage data was utilized as a boundary condition for the predictive simulations, and is discussed at length in later sections. Although the datum of the USGS gauge was undetermined, based on information provided by the District, the gauge datum was estimated at 30.98 feet NAVD. It should be noted that impacts to the gauge from groundwater pumping were estimated by the District to be equal to approximately 4-percent of the gauged flow. Thus, a correction of 4-percent of the gauged flow was applied to the observed USGS record in order to estimate pre-development flows. Thus, the working time series for the modeling effort was a corrected USGS time series, which was equal to the observed USGS time series with an additional 4-percent of observed daily flow.

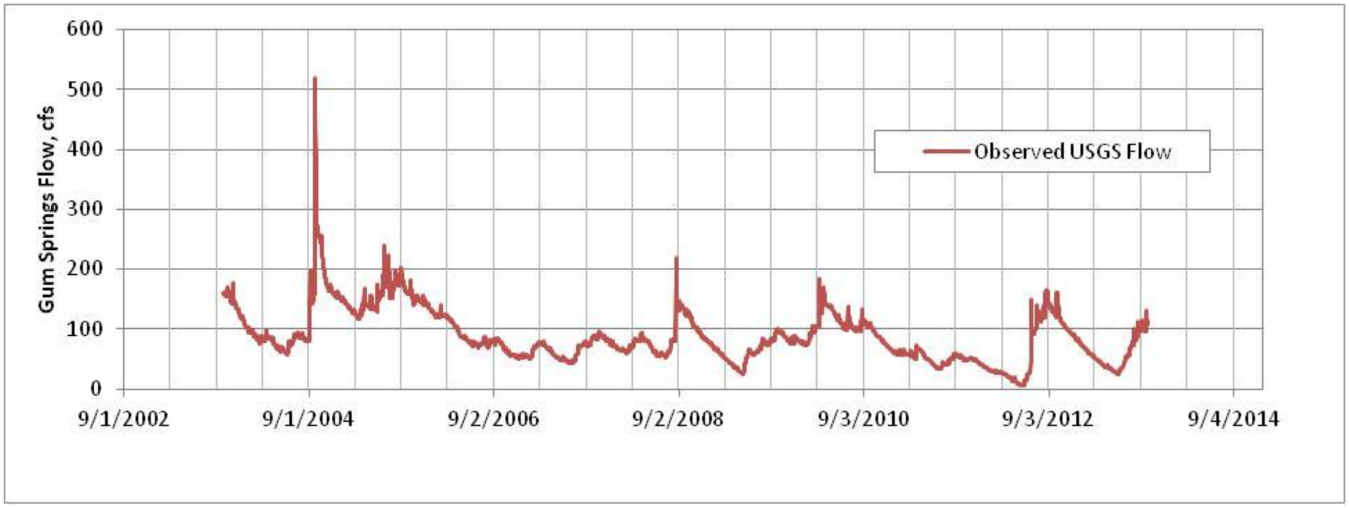

Figure 1. Gum Springs at Holder (USGS #02312764) Flow Record

Flow Regression for Long Term Record

Since it was desired to have a long term record to utilize for developing flow percentiles for Gum Slough, a statistical model was developed between the Gum Springs at Holder gauge and the Rainbow Springs group gauge in order to estimate long term flow at Gum Springs. The location of the spring groups is shown in Figure 2. Rainbow Springs group has a much more extensive period of record, beginning on January 1, 1965. A linear regression was developed for the period of overlap of the Rainbow Springs Group flow data with the corrected Gum Springs flow data, from October 1, 2003 to September 30, 2013 (Figure 3). The linear regression was compared to the observed flow at Gum Springs to determine the goodness of fit (Figure 4). As shown in the figure, the linear regression estimates average and low flows (flows less than 200 cfs) well. In addition, the shape of the hydrograph is well represented. Although the linear regression does not estimate high flows well, high flows (flows greater than 200 cfs) represent a small portion of the record. Thus, the linear regression was utilized to construct a long term record for Gum Springs group (Figure 5). For the long term record, USGS observed flows were utilized when available (after October 1, 2003) and flows prior to October 1, 2003 were calculated using the regression between Gum Springs group and Rainbow Springs group.

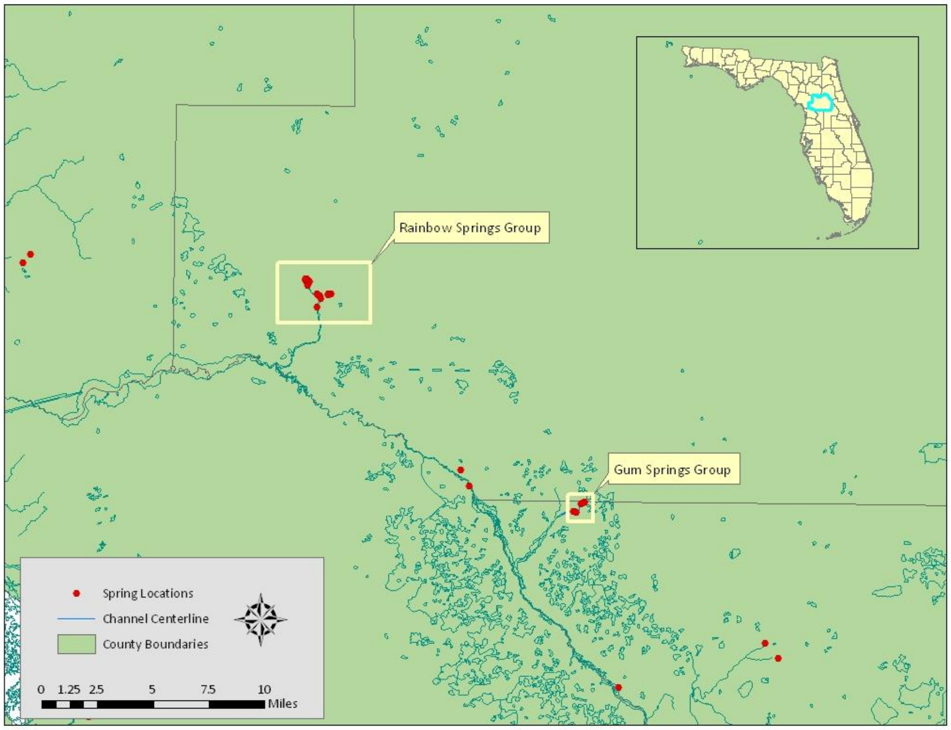

Figure 2. Gum Springs Group and Rainbow Springs Group

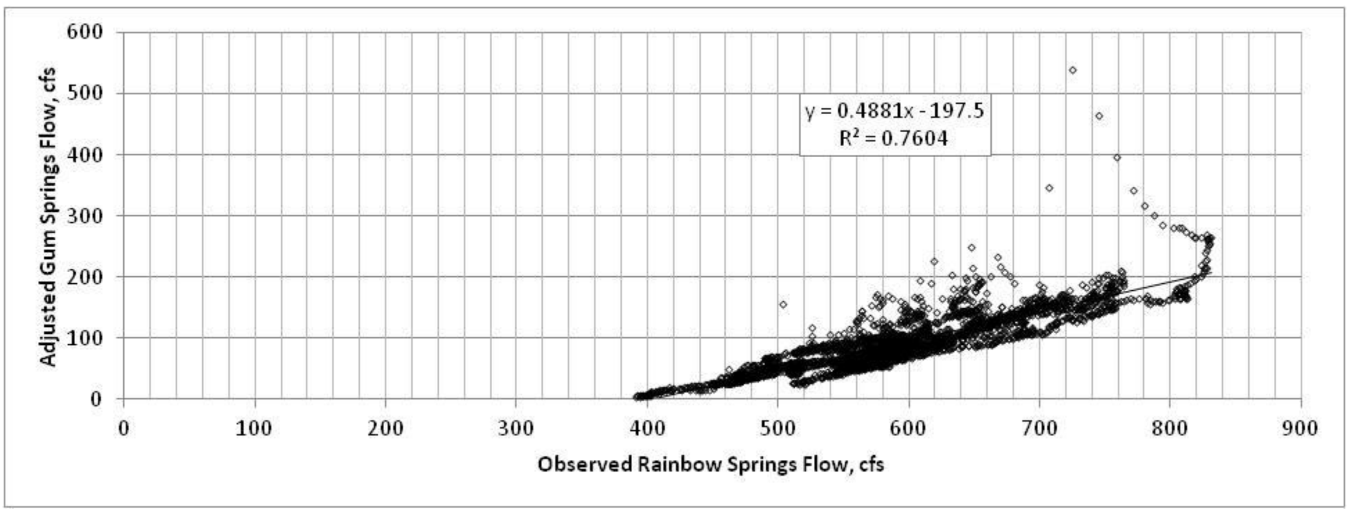

Figure 3. Gum Springs Statistical Model

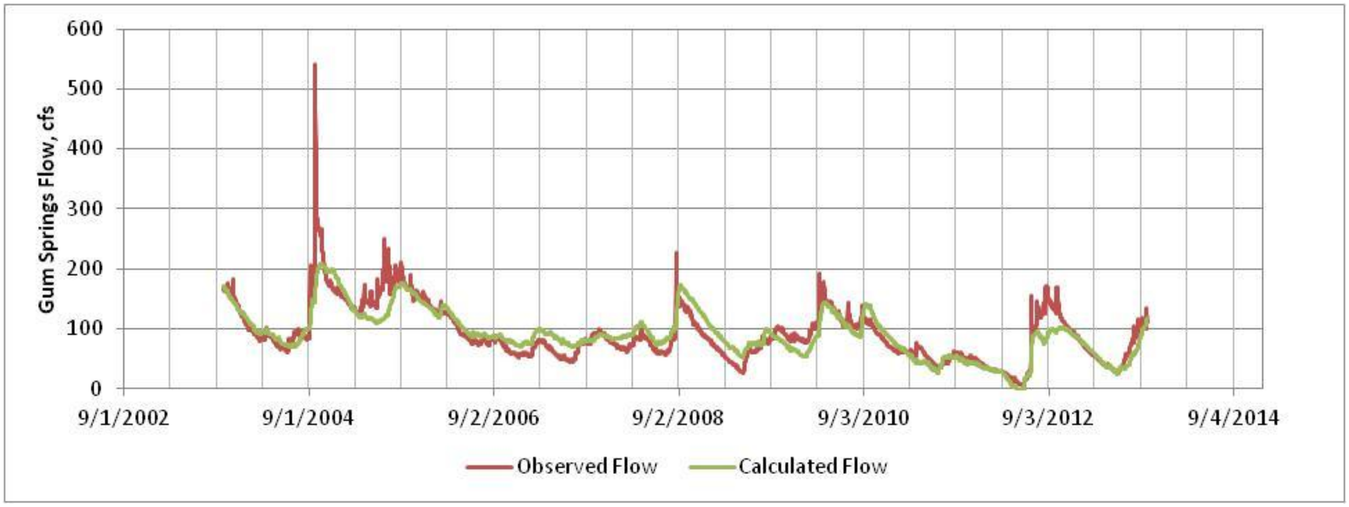

Figure 4. Gum Springs Observed and Calculated Flow

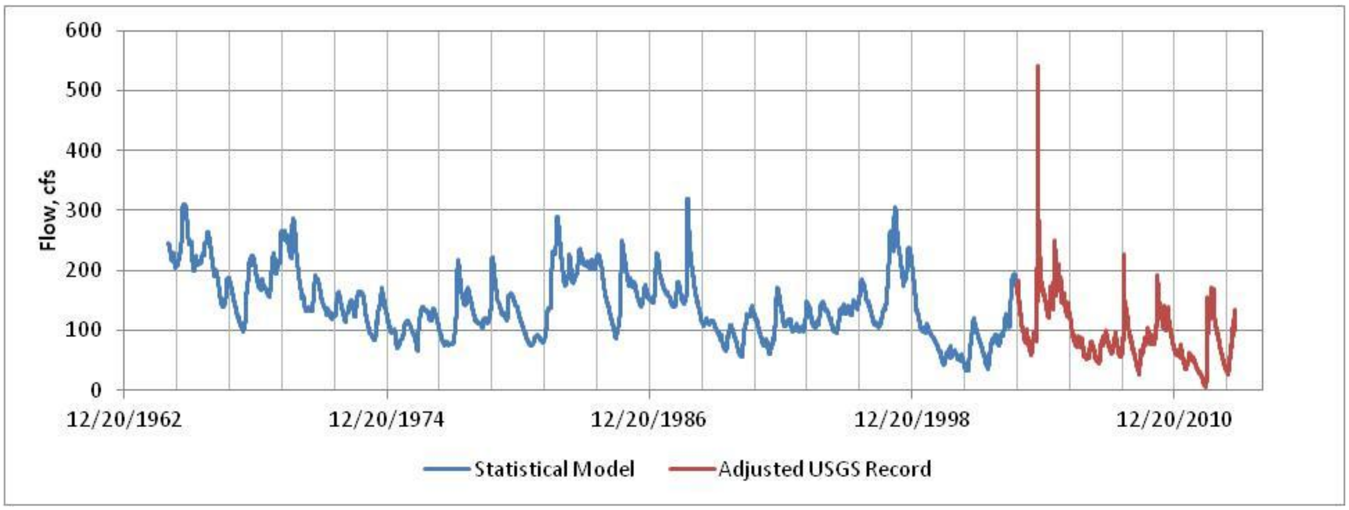

Figure 5. Gum Springs Long Term Record

PREDICTIVE SIMULATIONS

It was desired by the District to run predictive simulations for incremental percentile flows. Percentile flows are based on the development of a probability of exceedance plot using the entire flow record. Using the flow record, flows are ranked in ascending order, and the corresponding probability of exceedance can be calculated. For a given flow with a rank of r, the probability of exceedance can be calculated as:

$$p = \left(1 - \frac{r}{n}\right) \qquad (1)$$

Where n = the total number of observations

Since the USGS Gum Springs record is fairly short, a long term flow record was also developed using the statistical relationship between the corrected USGS flows at Gum Springs and Rainbow Springs group. Flow percentiles were developed both the corrected USGS record and the record composed of the long term regression and the corrected USGS flow record (Figure 6 and Table 1).

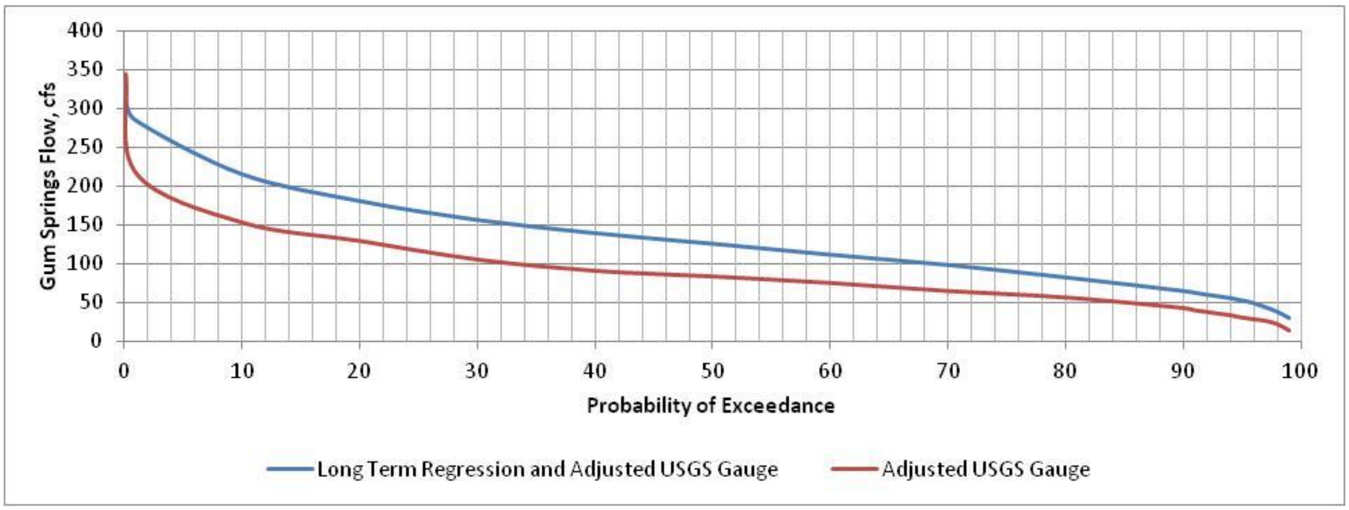

Figure 6. Gum Springs Flow Percentiles

As shown in the figure and table, there are slight differences in the percentile flows between the two distributions. The distribution developed using the USGS record is, in essence, a sample of the long term record beginning in 2003. It was desired to simulate every 10th percentile of flow for percent exceedance greater than 10, and every percentile of flow for percent exceedance less than 10. For the sake of completeness and for ease of use by the District, both sets of percentile flows shown in Figure 6 were simulated in the model.

Table 1. Gum Springs Flow Percent Exceedance, cfs

Percent Exceedance	Long Term Regression and Adjusted USGS Gauge	Adjusted USGS Gauge
99	30.2	13.5
98	38.3	21.8
97	44.1	26.0
96	49.5	28.1
95	52.9	30.2
94	55.8	33.3
93	58.2	35.4
92	60.3	37.4
91	62.8	39.5
90	65.1	42.6
80	82.7	56.2
70	98.8	64.5
60	112.0	74.9
50	126.1	83.2
40	139.8	90.5
30	156.9	105.0
20	181.3	129.0
10	215.9	152.7
1	285.2	215.8

In addition to a downstream flow boundary condition, it was necessary to develop flow profile for each percentile flow. The flow profile describes the increase in flow from upstream to downstream. One intensive set of flow measurements was made by the District on February 26, 2010, and was provided to INTERA in a spreadsheet (GSR Flow Measurements with Water Surface.xlsx, shown in Table 2). This dataset (which was also used for model calibration) was utilized to determine the percent of downstream boundary flow observed at each of the eight cross sections. In addition to this intensive field survey, additional flow measurements were taken by the District during various flow regimes (high, medium and low flows) at two locations. This data was analyzed in order to determine how the percent of total flow at each station varies with the total flow volume.

Three flow measurements representing high, medium, and low flow taken near the headspring are 7own in Figure 28. As shown in the figure, as the total flow in Gum Slough decreases, the flow at Gum Springs decreases. Using the regression equation shown in the figure, when there is no flow at Gum Springs (y=0), the flow at the downstream gauge is approximately 37.74 cubic feet per second (cfs). This agrees with anecdotal data from homeowners who live along the slough. A second set of flow measurements was taken near River Station 2884.6, as shown in

Figure 8. Both of these flow dependent relationships were used to develop flow profiles along the channel.

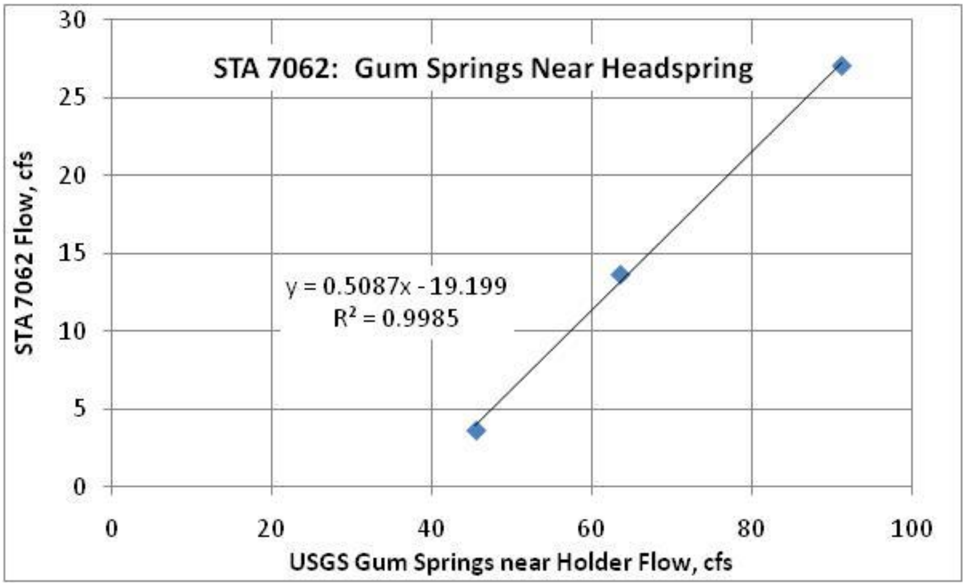

Figure 7. Gum Springs Near Headspring Flow Measurements

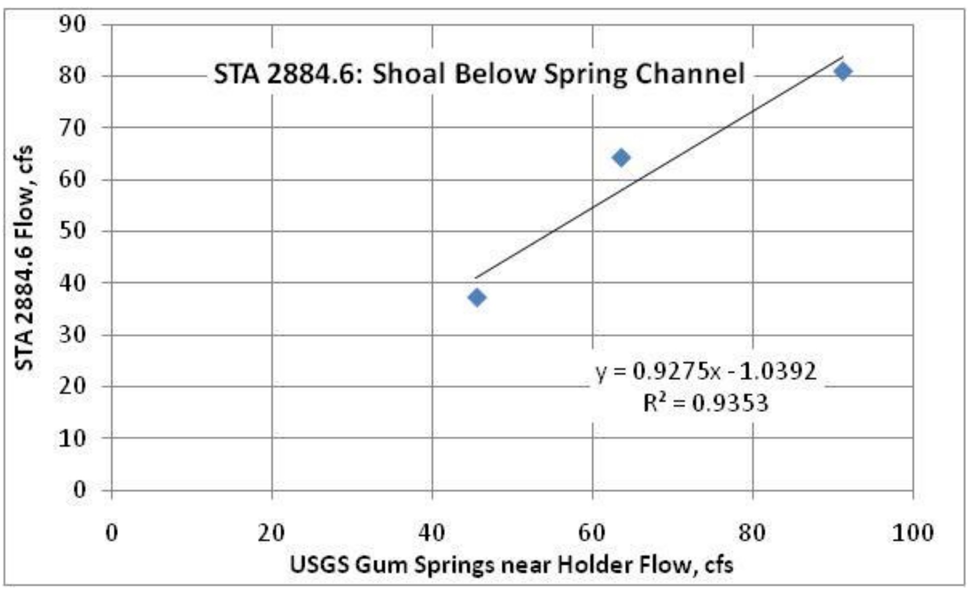

Figure 8. Shoal Below Spring Channel Flow Measurements

In order to use the above relationships for each station along Gum Slough, scale factors were developed for the six cross sections where flow measurements were not taken in order to apply observed flow relationships to the additional cross sections. Scale factors were determined using the flow regimes shown in Table 1 and comparing the percent of the total flow at each station. The scale factor (shown in Table 2) was determined by dividing the flow at the station of interest by the nearest upstream station where the flow variability was measured (either Station 7062 or Station 2884.5).

Table 2. Cross Section Scale Factors

River Station	Percent flow	Scale Factor	Nearest Upstream Station
7062.824	26.21	1	7062.824
5294.539	33.98	1.296	7062.824
4658.976	33.98	1.296	7062.824
3877.225	37.86	1.444	7062.824
2884.558	66.99	1	2884.558
2068.989	72.82	1.087	2884.558
1275.955	84.47	1.260	2884.558
92.21291	100	1.493	2884.558

To determine the flow at each station, the regression equations shown in Figures 7 and 8 were applied to Stations 7062.824 and 2884.558. For the case of Station 7062.824, when the flow was less than 37.7 cfs, there was negligible flow at the station. After the flows at the two known locations were determined, the flows at the additional locations were calculated by multiplying the known flow by the scale factors shown in Table 2. After these flows were determined, a mass correction was applied at each station based on the difference between the flows calculated with the regressions and the flows recorded during the intensive survey. The application of this correction ensured that mass was conserved throughout the slough. The flow profiles for each data set (the USGS record and the combined USGS/regression record) are shown in Figures 9 and 10 and Tables 3 and 4. In each graph, the flow at 103 cfs (shown in yellow) represents the flow measurements taken during the intensive field survey by the District. As shown in the figures, all other flow profiles are essentially scaled representations of this flow profile, taking into account the spring flow inflow reductions with decreased total measured flow at the gauge.

Table 3. Adjusted USGS Flow Record Exceedance Flows

Cross Section Name		**G1**	**G2**	**G3**	**G4**	**V5**	**V6**	**V7**	**V8**
River Station		7062.8	5294.5	4659.0	3877.2	2884.6	2069.0	1276.0	92.2
Flow Exceedance, cfs	99th	0.0	0.0	0.0	0.0	8.4	9.1	10.6	14.0
	98th	0.0	0.0	0.0	0.0	14.0	15.3	17.7	22.0
	97th	0.0	0.0	0.0	0.0	16.9	18.3	21.2	26.0
	96th	0.0	0.0	0.0	0.0	18.3	19.8	23.0	28.0
	95th	0.0	0.0	0.0	0.0	19.7	21.4	24.8	30.0
	94th	0.0	0.0	0.0	0.0	21.8	23.7	27.5	32.5
	93rd	0.0	0.0	0.0	0.0	23.2	25.2	29.2	34.6
	92nd	0.0	0.0	0.0	0.0	24.6	26.7	31.0	36.7
	91st	0.0	0.0	0.0	0.0	26.0	28.3	32.8	40.0
	90th	2.0	2.6	2.6	2.9	28.1	30.6	35.5	43.0
	80th	7.6	9.9	9.9	11.0	37.3	40.5	47.0	55.6
	70th	11.1	14.3	14.3	16.0	42.9	46.6	54.1	64.1
	60th	15.4	19.9	19.9	22.2	50.0	54.3	63.0	74.6
	50th	18.8	24.4	24.4	27.2	55.6	60.4	70.1	83.0
	40th	21.8	28.3	28.3	31.5	60.5	65.8	76.3	90.3
	30th	27.8	36.1	36.1	40.2	70.4	76.5	88.7	105.1
	20th	37.7	48.9	48.9	54.5	86.6	94.1	109.2	129.2
	10th	47.5	61.6	61.6	68.7	102.6	111.6	129.4	153.2
	1st	73.7	95.5	95.5	106.4	145.4	158.0	183.3	216.0

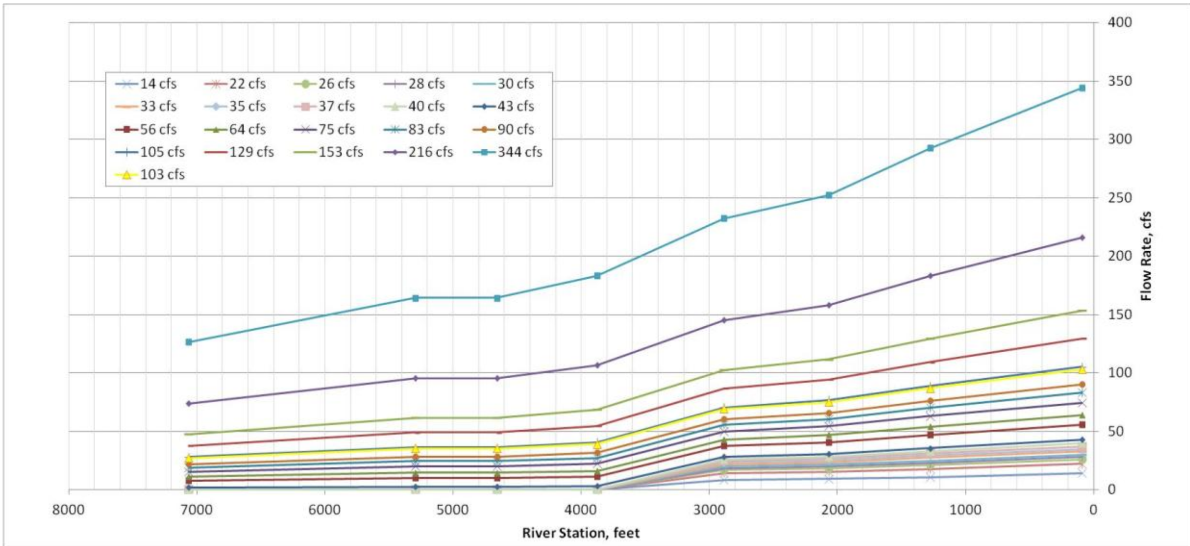

Figure 9. Adjusted USGS Record: Flow Profiles

Table 4. Adjusted Regression and USGS Flow Record Exceedance Flows

Cross Section Name		G1	G2	G3	G4	V5	V6	V7	V8
River Station		7062.8	5294.5	4659.0	3877.2	2884.6	2069.0	1276.0	92.2
Flow Exceedance, cfs	99th	0.0	0.0	0.0	0.0	19.7	21.4	24.8	30.0
	98th	0.0	0.0	0.0	0.0	25.1	27.3	31.7	37.5
	97th	0.0	0.0	0.0	0.0	29.1	31.6	36.7	44.0
	96th	0.0	0.0	0.0	0.0	32.8	35.6	41.3	48.9
	95th	0.0	0.0	0.0	0.0	35.1	38.1	44.2	53.0
	94th	0.0	0.0	0.0	0.0	37.0	40.3	46.7	56.0
	93rd	0.0	0.0	0.0	0.0	38.7	42.1	48.8	57.7
	92nd	0.0	0.0	0.0	0.0	40.1	43.6	50.6	59.9
	91st	0.0	0.0	0.0	0.0	41.8	45.4	52.7	63.0
	90th	11.3	14.7	14.7	16.3	43.3	47.1	54.6	64.7
	80th	18.6	24.1	24.1	26.8	55.2	60.0	69.6	83.0
	70th	25.2	32.7	32.7	36.5	66.1	71.9	83.4	98.7
	60th	30.7	39.8	39.8	44.3	75.1	81.6	94.7	112.1
	50th	36.6	47.4	47.4	52.8	84.7	92.0	106.7	126.4
	40th	42.2	54.7	54.7	61.0	93.9	102.1	118.4	140.2
	30th	49.3	63.9	63.9	71.2	105.5	114.7	133.0	157.5
	20th	59.4	77.0	77.0	85.8	122.0	132.6	153.8	181.0
	10th	73.7	95.6	95.6	106.5	145.5	158.1	183.4	216.0
	1st	102.4	132.7	132.7	147.9	192.4	209.2	242.6	285.0

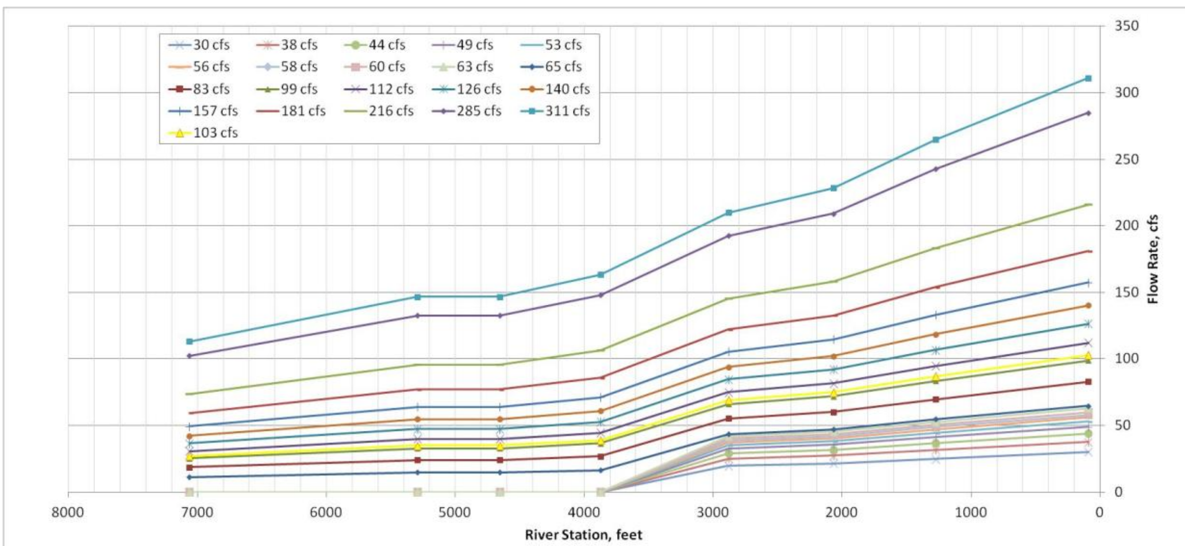

Figure 10. Adjusted Regression and USGS Record: Flow Profiles

Boundary Conditions: Downstream Stage

In order to run predictive simulations, a downstream stage boundary condition is needed. A rating curve for the gauge was developed based on the adjusted USGS record (Figure 11). Based on the rating curve and the percentile flows shown in Tables 12 and 13, the stage boundary condition was calculated for each percentile flow based on the regression equation shown in the figure. The resulting boundary conditions for each percentile flow are shown in Table 14.

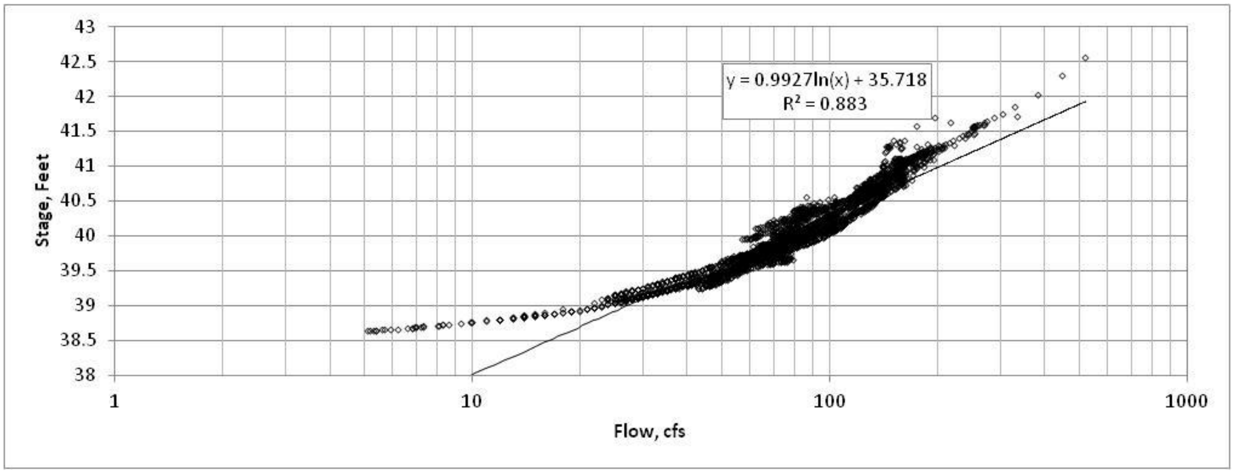

Figure 11. Gum Springs at Holder Rating Curve

Table 5. Predictive Simulation: Downstream Stage Boundary

Flow Exceedance	Adjusted USGS Record, Stage, ft	Adjusted Long Term Record, Stage, ft
1	38.3	39.1
2	38.8	39.3
3	39.0	39.5
4	39.0	39.6
5	39.1	39.7
6	39.2	39.7
7	39.2	39.7
8	39.3	39.8
9	39.4	39.8
10	39.5	39.9
20	39.7	40.1
30	39.8	40.3
40	40.0	40.4
50	40.1	40.5
60	40.2	40.6
70	40.3	40.7
80	40.5	40.9
90	40.7	41.1
99	41.1	41.3

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Predictive Simulation Data Set 1: USGS Flow Record

Predictive simulations were run using the flows derived from the adjusted USGS flow record (shown in Figure 9) and the calculated stage boundary conditions. The resulting water surface profiles are shown in Figure 12. Simulated stages at each cross section are shown in Table 6.

Table 6. Adjusted USGS Record: Simulated Stages (ft.)

Percent Exceedance	***Cross Section Name***							
	V8	***V7***	***V6***	***G5***	***G4***	***G3***	***G2***	***G1***
WS USGS1	38.3	38.5	39.5	39.5	39.5	39.5	39.5	39.5
WS USGS2	38.8	39.0	39.5	39.5	39.5	39.5	39.5	39.5
WS USGS3	39.0	39.2	39.5	39.6	39.6	39.6	39.6	39.6
WS USGS4	39.0	39.2	39.6	39.6	39.6	39.6	39.6	39.6
WS USGS5	39.1	39.3	39.6	39.7	39.7	39.7	39.7	39.7
WS USGS6	39.2	39.4	39.7	39.7	39.8	39.8	39.8	39.8
WS USGS7	39.2	39.4	39.7	39.8	39.8	39.8	39.8	39.8
WS USGS8	39.3	39.5	39.8	39.8	39.9	39.9	39.9	39.9
WS USGS9	39.4	39.6	39.9	39.9	39.9	39.9	39.9	39.9
WS USGS10	39.5	39.7	39.9	40.0	40.0	40.1	40.1	40.1
WS USGS20	39.7	39.9	40.2	40.2	40.3	40.6	40.7	40.8
WS USGS30	39.8	40.0	40.3	40.4	40.4	40.9	41.0	41.1
WS USGS40	40.0	40.3	40.5	40.6	40.6	41.2	41.4	41.4
WS USGS50	40.1	40.4	40.6	40.7	40.7	41.4	41.6	41.6
WS USGS60	40.2	40.5	40.7	40.8	40.9	41.6	41.7	41.8
WS USGS70	40.3	40.6	40.9	41.0	41.1	41.8	42.0	42.1
WS USGS80	40.5	40.9	41.3	41.4	41.5	42.3	42.5	42.7
WS USGS90	40.7	41.3	41.6	41.7	41.8	42.5	42.7	42.9
WS USGS99	41.1	41.6	41.9	42.0	42.1	42.7	43.0	43.3

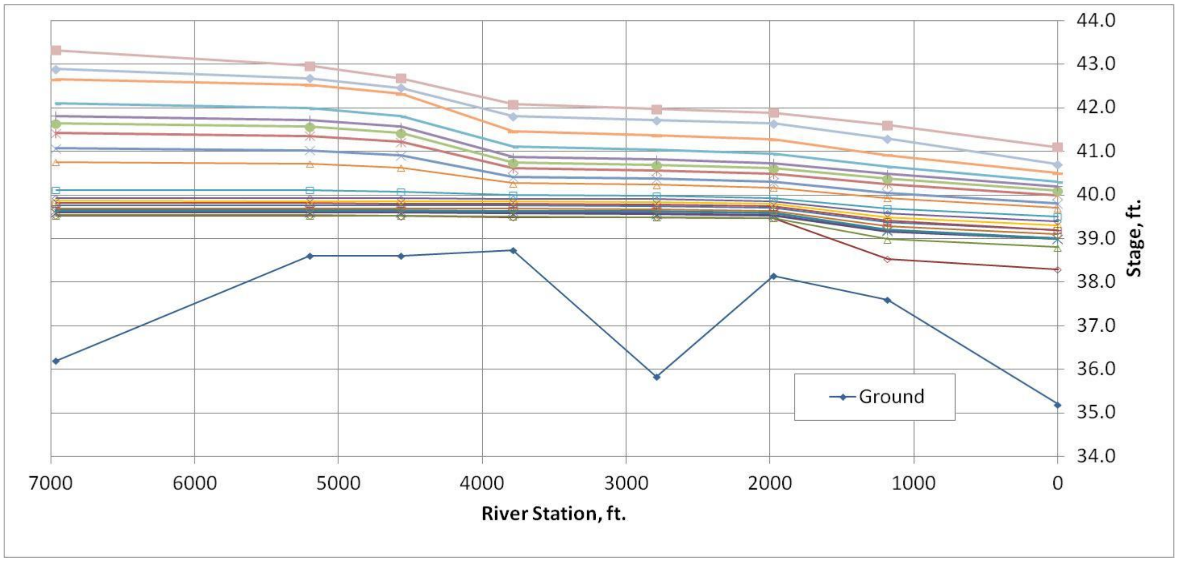

Figure 12. Adjusted USGS Record: Water Surface Profiles

Predictive Simulation Data Set 2: Regression Record

Predictive simulations were run using the flows derived from the adjusted long term flow record (shown in Figure 10) and the calculated stage boundary conditions. The resulting water surface profiles are shown in Figure 13. Simulated stages at each cross section are shown in Table 7.

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Table 7. Adjusted Long Term Record: Simulated Stages (ft.)

Percent Exceedance	Cross Section Name							
	V8	V7	V6	G5	G4	G3	G2	G1
WS REG1	39.1	39.3	39.6	39.7	39.7	39.7	39.7	39.7
WS REG2	39.3	39.5	39.8	39.9	39.9	39.9	39.9	39.9
WS REG3	39.5	39.7	40.0	40.0	40.0	40.0	40.0	40.0
WS REG4	39.6	39.8	40.1	40.1	40.1	40.1	40.1	40.1
WS REG5	39.7	39.9	40.1	40.2	40.2	40.2	40.2	40.2
WS REG6	39.7	39.9	40.2	40.2	40.3	40.3	40.3	40.3
WS REG7	39.7	39.9	40.2	40.3	40.3	40.3	40.3	40.3
WS REG8	39.8	40.0	40.3	40.3	40.3	40.3	40.3	40.3
WS REG9	39.8	40.0	40.3	40.4	40.4	40.4	40.4	40.4
WS REG10	39.9	40.1	40.4	40.4	40.5	40.9	41.1	41.1
WS REG20	40.1	40.4	40.6	40.7	40.7	41.4	41.6	41.6
WS REG30	40.3	40.6	40.9	41.0	41.0	41.7	41.9	42.0
WS REG40	40.4	40.8	41.1	41.2	41.3	42.0	42.1	42.3
WS REG50	40.5	40.9	41.3	41.3	41.4	42.3	42.5	42.6
WS REG60	40.6	41.0	41.4	41.5	41.6	42.4	42.6	42.8
WS REG70	40.7	41.3	41.7	41.7	41.8	42.5	42.7	42.9
WS REG80	40.9	41.4	41.8	41.8	41.9	42.6	42.8	43.1
WS REG90	41.1	41.6	41.9	42.0	42.1	42.7	43.0	43.3
WS REG99	41.3	41.8	42.1	42.2	42.3	42.8	43.2	43.7

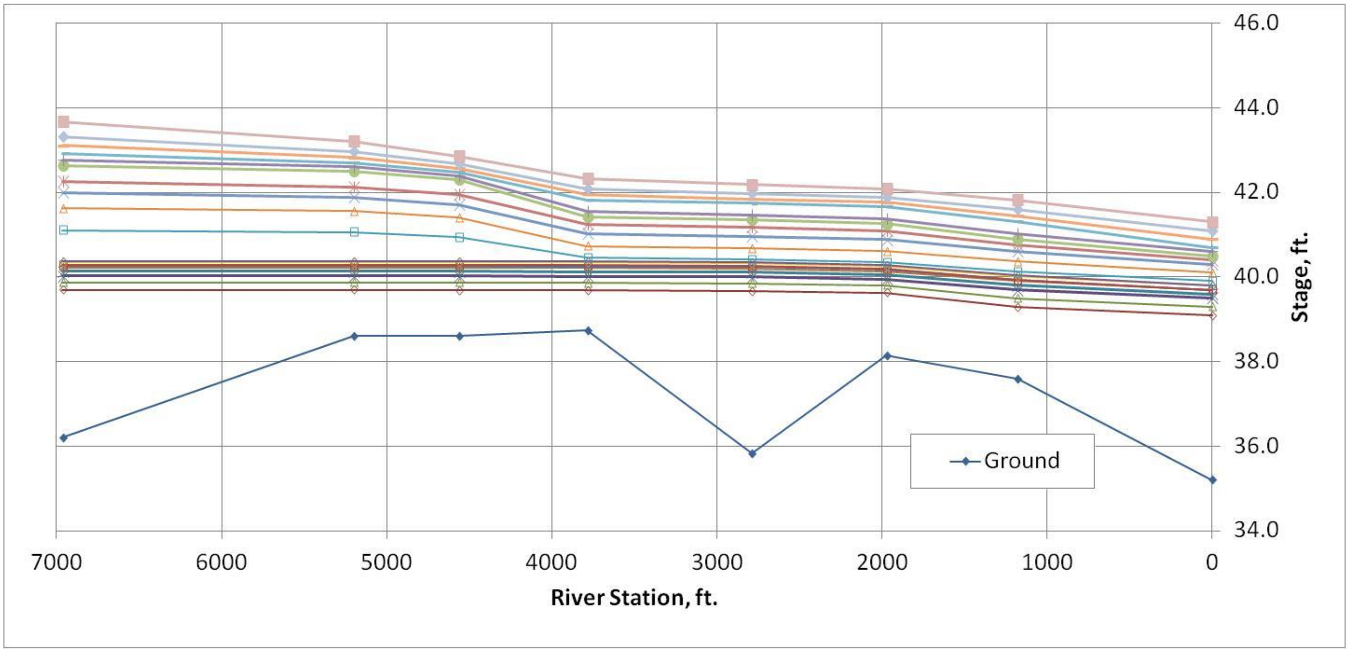

Figure 13. Adjusted Long Term Record: Water Surface Profiles

REFERENCES

INTERA (2010). *Gum Springs Run: HEC-RAS Steady State Model Development.* Final Report Submitted to the Southwest Florida Water Management District.