APPENDIX C

PRELIMINARY ANALYSIS OF ALTERNATIVES

PLANNED TEMPORARY DEVIATION 1981 LAKE KISSIMMEE, CRYPRESS, AND HATCHINEHA (KCH)

INTERIM REGULATION SCHEDULE

OSCEOLA AND POLK COUNTIES, FLORIDA

Preliminary Analysis of Alternative Temporary Deviation Operations for Lake Kissimmee-Cypress-Hatchineha

13-Feb-2020

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Hydrology and Hydraulics Bureau
South Florida Water Management District

Purpose

Analysis Purpose:

To provide simulation results to inform decision on selection of best alternative operation for the proposed temporary deviation. The analysis will evaluate alternative operations (using simulation modeling) that aim to reduce flows to the Kissimmee River to enable the contractor to perform post-Hurricane Irma repair work.

Temporary Deviation Purpose (per M. Nasuti's 7-Feb-2020 email):

The intent of the planned temporary deviation is to limit Lake Kissimmee releases to no more than ~~1,000~~ 900 cubic feet per second (cfs) until 1 June in order to facilitate Kissimmee River Restoration (KRR) construction in Reach 2, which is located south of S-65. This is necessary because flows greater than ~~1,000~~ 900 cfs as measured at ~~S-65~~ S-65A cause water to rise out of the Kissimmee River bank, and prevents the contractor from working at the construction site. The planned temporary deviation will provide operational flexibility to the SFWMD, increasing the likelihood of providing flows within the optimum range for Corps construction.

Simulation Assumptions

- Use the Upper Kissimmee – Operations Simulation (UK-OPS) Model (v3.12)
- Position Analysis mode starting each 1-yr simulation on 1-Feb
- 49 1-year simulations (1965-2013)
- Initial (1-Feb) stage conditions:
  - E. Lake Toho: 54.30 feet, NGVD (TOHOEE+)
  - Lake Toho: 54.56 feet, NGVD (LTOHOW AVG)
  - Lake KCH: 51.69 feet, NGVD (LKISS AVG)
- Baseline Simulation operating assumptions consistent with mid-February, 2020, operations planning simulations (SFWMD Position Analysis)
  - Includes the approved East Lake Toho Drawdown regulation schedule and pump operation
  - No Winter/spring Fish & Wildlife recession operations for East Lake Toho
  - Lake Toho uses Fish & Wildlife recession line starting 7-Feb (54.55') to 31-May (52.00’)
  - Lake KCH Zone B operations informed by the 2019 wet season discharge plan developed by the SFWMD with input from the USFWS & FFWCC (IS-14-50.0-300)

Upper Kissimmee – Operations Simulation (UK-OPS) Model

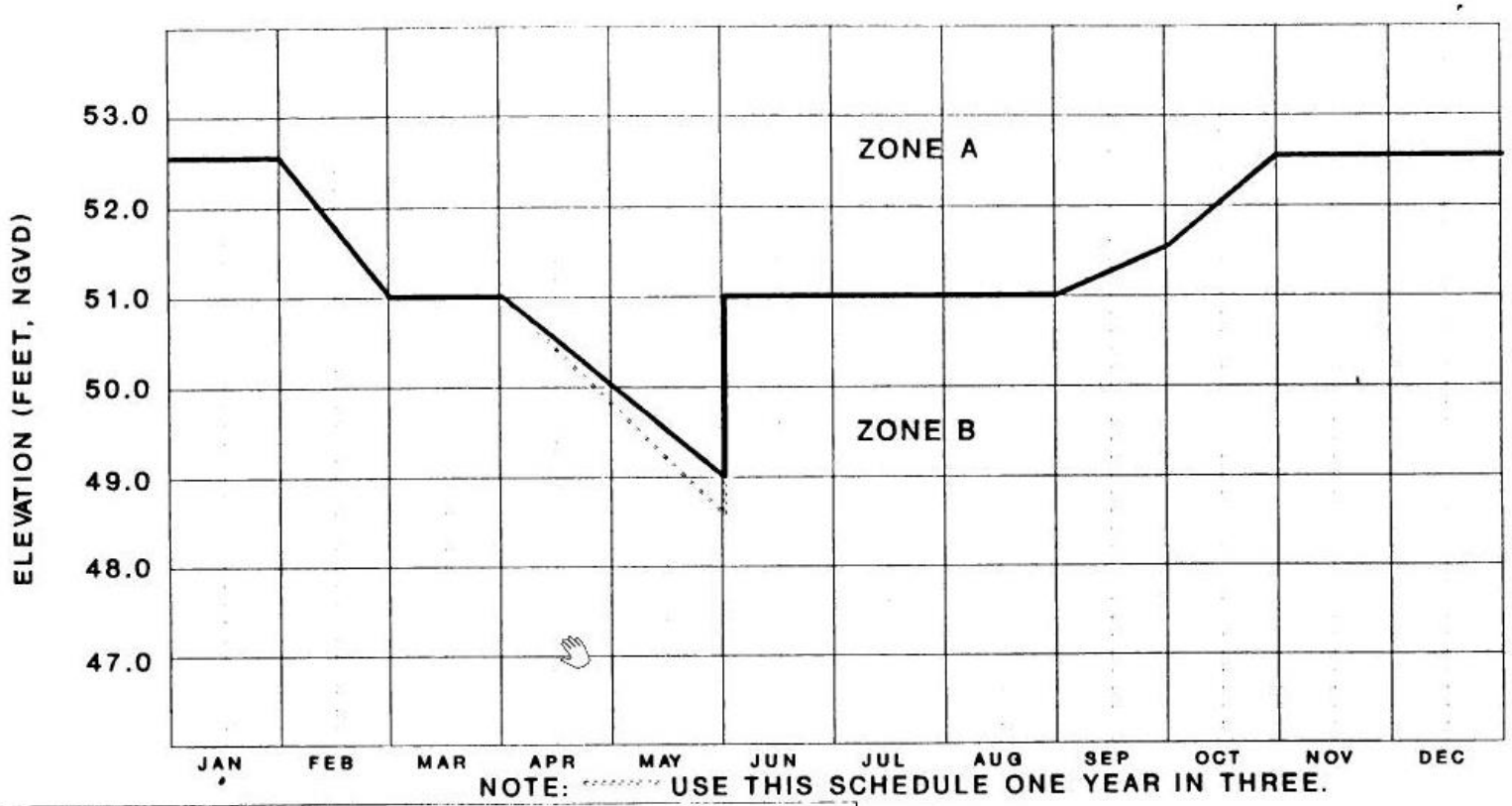
- Purpose:
  - Originally designed to quickly test alternative operating strategies for East Lake Toho (ETO), Lake Toho (TOH), and Lakes Kissimmee, Cypress, & Hatchineha (KCH)
  - Modified to serve as a water use permit evaluation tool to evaluate the effects of proposed water supply withdrawals subject to water reservation rule criteria
- Simple water budget routing model using a daily timestep
  - Use historical (1965-2013) Lake O stage and outflows with water balance (continuity) equation to calculate net inflows
  - Use the calculated net inflows to simulate stages and releases resulting from specified lake operating rules and/or proposed water withdrawals
  - Not a detailed hydraulic model; structure hydraulics is approximated
- Developed using Microsoft Excel®
- < 3.5 minute run time on 1.60GHz processor with 16 GB RAM using 32-bit Excel 2013
- Broad variety of hydrologic performance metrics automatically produced
- Peer-reviewed in 2019; final documentation report available in early 2020

Simulations *(see graphics following this slide)*

- Base
  - Current ops for East Lake Toho (ETO), Lake Toho (TOH), and Lakes Kissimmee, Cypress & Hatchineha (KCH)
  - Considered as the no-action (default) alternative for comparing with Temporary Deviation Alternatives
- ALT1
  - Modify KCH regulation schedule to transition linearly from elevation 52.5’ on 1-Feb to elev. 51.0’ on 1-Jun
  - Modify zone-discharge operation to limit S-65A flows to 900 cfs for stages below top of schedule (+0.5’)
  - if KCH stage exceeds the top of the schedule (+0.5’), then discharges jump to 3,000 cfs and increase linearly to 11,000 cfs for stages 0.3 feet above the top of the schedule (+0.5’)
- ALT2
  - Modify KCH regulation schedule to transition linearly from elevation 52.5’ on 1-Apr to elev. 51.0’ on 1-Aug
  - Same zone-discharge operation as ALT1
- ALT3
  - Modify KCH regulation schedule to transition linearly from elevation 52.5’ on 1-Jun to elev. 51.0’ on 1-Aug
  - Same zone-discharge operation as ALT1

Lake Kissimmee, Hatchineha & Cypress Regulation schedule authorized December 1981

{page 7-6 (below) & Figure 7-8 (left) from USACE 1994 Master Water Control Manual for Kissimmee River-Lake Istokpoga Basin}



ZONE	RELEASES S-65
A	3,000 CFS UP TO DESIGN CAPACITY (11,000CFS) WITHOUT EXCEEDING DESIGN CONDITIONS DOWNSTREAM. WHEN THE LAKE IS WITHIN 0.5 FT. OF DESIRED STAGE, FORECASTS WILL THEN BE MADE AND RELEASES STARTED TO BRING THE LAKE BACK DOWN TO SCHEDULE WITHIN 15 DAYS.
B	TO MAINTAIN MINIMUM FLOWS.

CENTRAL AND SOUTHERN FLORIDA
KISSIMMEE RIVER BASIN
LAKE KISSIMMEE,
HATCHINEHA & CYPRESS
INTERIM REGULATION SCHEDULE
U S ARMY ENGINEER DISTRICT JACKSONVILLE
CORPS OF ENGINEERS, JACKSONVILLE, FLA
DATED: 1 DECEMBER 1981

FIGURE 7-8

h. Lakes Kissimmee, Hatchineha, and Cypress are regulated by a single structure, S-65 located at the outlet of Lake Kissimmee at the head of C-38. The lakes are regulated between elevations 48.5 and 52.5 ft., NGVD on a seasonally varying schedule. The current regulation schedule is shown on Figure 7-8. S-65 consists of a spillway for regulating stages and a navigation lock. Discharge from S-65 will vary between 3,000 and 11,000 cfs according to downstream conditions. When local inflow into C-38 is equal to or greater than design runoff, S-65 will be limited to a firm discharge capacity of 3,000 cfs and a secondary capacity of 8,000 cfs. (Firm capacity is that capacity available at any time). After local inflow subsides, discharge from S-65 could increase to 11,000 cfs depending on downstream capacity. In addition to the spillway and lock structures, there is a culvert structure located through the tieback levee at the natural channel of the Kissimmee River and serves as a water supply for the existing river.

(1) Flood Control. When the stage in the lakes is in Zone A on the regulation schedule (Figure 7-8), releases of 3,000 cfs minimum can be made at anytime. During design flood conditions, discharge from S-65 will vary between 3,000 and 11,000 cfs according to downstream conditions. When local inflow to C-38 is equal to or greater than design flood runoff, S-65 will limit discharge to 3,000 cfs. After local inflow subsides, discharge from S-65 could increase to 11,000 cfs depending on downstream capacity. When the lake stage is higher than 0.5 ft. above the scheduled stage, forecasts will be made and releases started to return the lake to schedule within 15 days.

(2) Normal Operation. Lake Kissimmee is normally regulated between elevations 49.0 and 52.5 ft., NGVD according to a seasonally varying schedule. One year in three the lake is regulated between 48.5 ft. and 52.5 ft., NGVD for fish and wildlife enhancement. The current regulation schedule is shown on Figure 7-8. When the lake stage is in Zone B, releases may be made to maintain downstream flows for water supply, navigation, and environmental purposes.

Current KCH Zone B Operations

- SFWMD Zone B operations designed to benefit the Kissimmee River and upstream lakes
- Seasonal operations determined twice yearly via interagency planning meetings
- Top of Regulation Schedule (Zone A) consistent with 1981 Regulation Schedule

SOUTH FLORIDA WATER MANAGEMENT DISTRICT

Kissimmee Basin 2019 Wet Season

Stage and Discharge Guidance for Wet Season 2019.

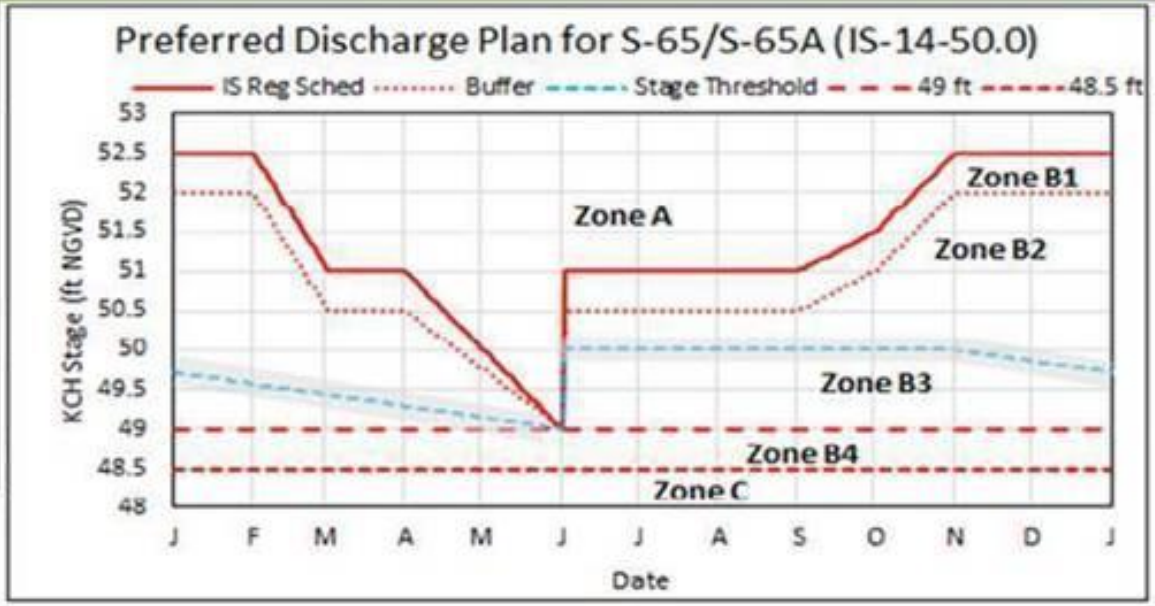
Zone	KCH Stage (ft NGVD)	S-65/S-65A Discharge*
A	Above regulation schedule line.	Flood control releases as needed with no limits on the rate of discharge change.
B1	In flood control buffer zone (0.5 ft below the schedule line).	Adjust S-65 discharge so that S-65A discharge is between 1400 cfs at the buffer zone line and 3000 cfs at the schedule line.
B2	Between the Flood Control Buffer and the 50.0 ft line.	Adjust S-65 discharge to maintain at least 1400 cfs at S-65A. Use ± 0.2 ft buffer (gray band) above and below the 50.0 ft line to decide when to begin ramping up to 1400 cfs or down to 300 cfs; do not continue reducing discharge if stage rises back to or above the threshold stage line.
B3	Between the 50.0 ft line and 49 ft.	Adjust S-65 discharge to maintain at least 300 cfs at S-65A.
B4	Between 48.5 ft to 49 ft.	Adjust S-65 discharge to maintain S-65A discharge between 0 cfs at 48.5 ft and 300 cfs at 49 ft.
C	Below 48.5 ft.	0 cfs.

*Changes in discharge should not exceed limits in inset table below.

Discharge Rate of Change Limits for S65/S65A (revised 7/11/18).

Q (cfs)	Maximum rate of increase (cfs/day)	Maximum rate of decrease (cfs/day)
0-300	50	-50
301-650	75	-75
651-1400	150	-150
1401-3000	300	-600
>3000	1000	-2000

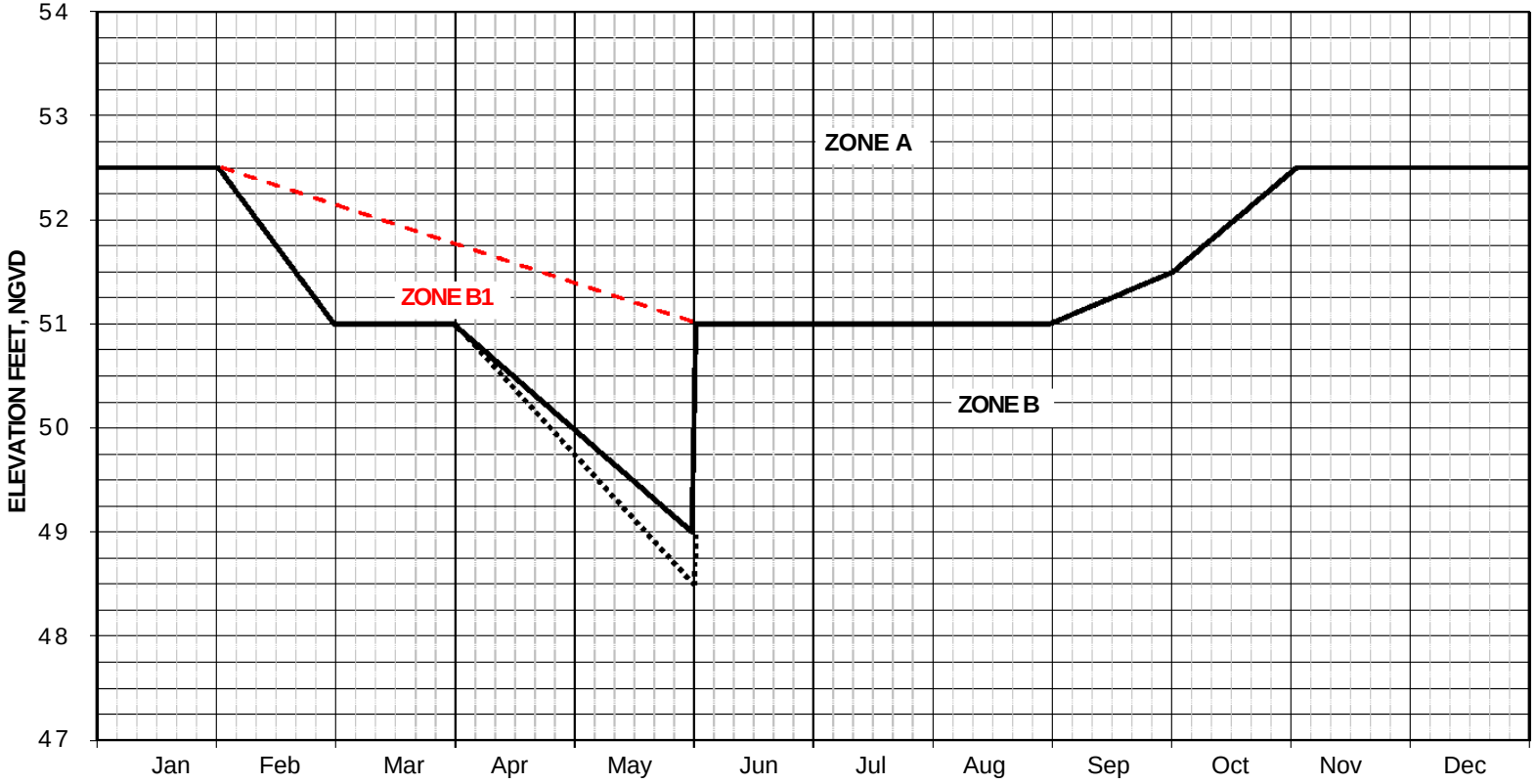
Revised 5/16/2019



Other Considerations
- When possible, limit lake ascension rate in the Jun 1 - Aug 15 window to 0.5 ft per 14 days in Lakes Kissimmee, Cypress, Hatchineha (S-65), East Toho (S-59) and Toho (S-61).
- If outlook is for extreme dry conditions meet with KB staff to discuss modifications to this plan.

Figure 11. The 2019 Wet Season Discharge Plan for S-65/S-65A.

ALTERNATIVE 1
LAKES KISSIMMEE, HATCHINEHA, and CYPRESS



NOTE: ---- USE THIS SCHEDULE ONE YEAR IN THREE.

ZONE	RELEASES S-65
A	3,000 CFS UP TO DESIGN CAPACITY (11,000 CFS) WITHOUT EXCEEDING DESIGN CONDITIONS DOWNSTREAM. WHEN THE LAKE IS WITHIN 0.5 FT. OF DESIRED STAGE, FORECASTS WILL THEN BE MADE AND RELEASES STARTED TO BRING THE LAKE BACK DOWN TO SCHEDULE WITHIN 15 DAYS.
B	TO MAINTAIN MINIMUM FLOWS
B1	TO MAINTAIN MINIMUM FLOWS. CONSIDER ENVIRONMENTAL RECOMMENDATIONS.

CENTRAL AND SOUTHERN FLORIDA
KISSIMMEE RIVER BASIN

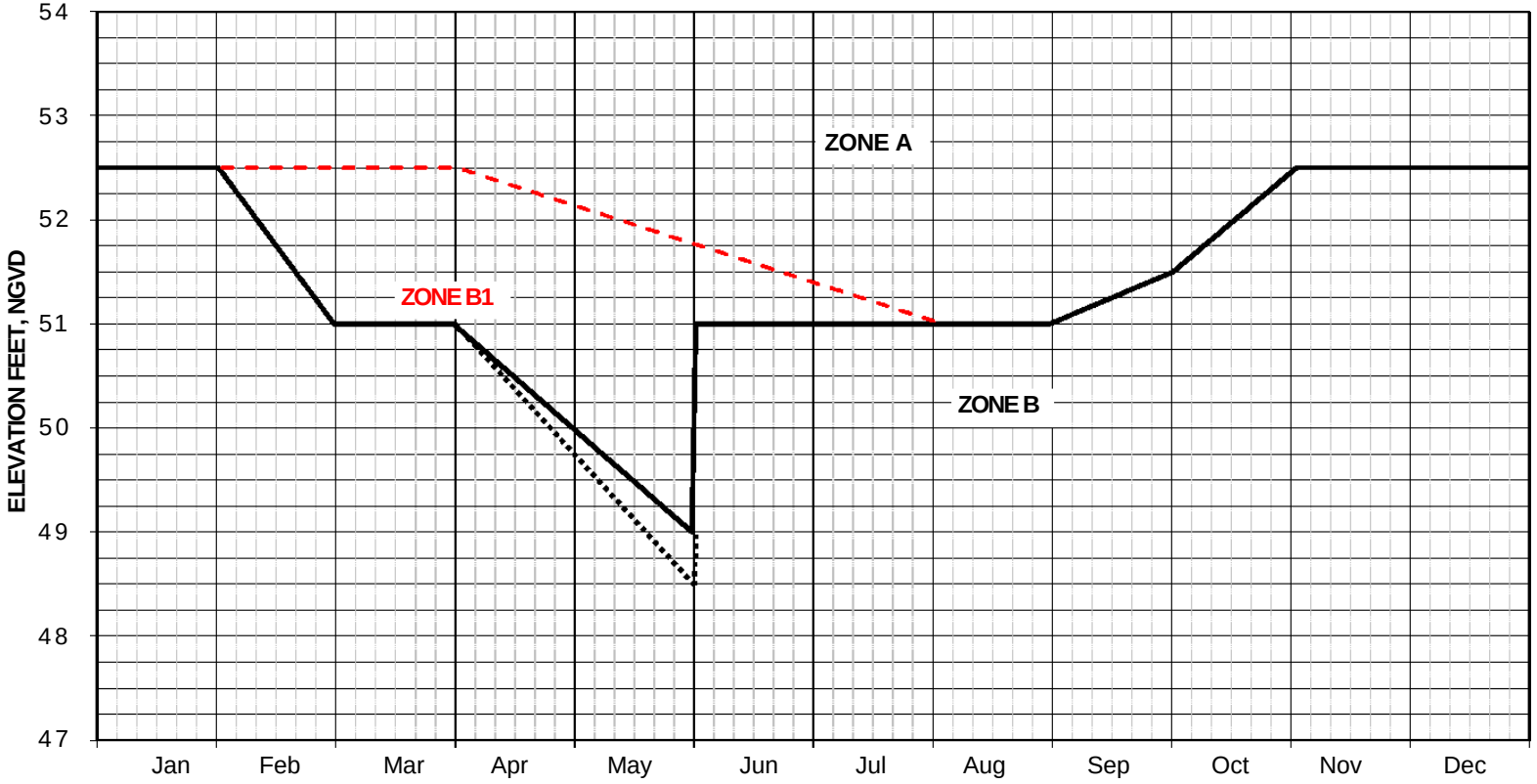
LAKE KISSIMMEE,
HATCHINEHA & CYPRESS
INTERIM REGULATION SCHEDULE

US ARMY ENGINEER DISTRICT
JACKSONVILLE FL

DATED: 11 FEBRARY 2020

ALT_1

ALTERNATIVE 2
LAKES KISSIMMEE, HATCHINEHA, and CYPRESS



NOTE: ---- USE THIS SCHEDULE ONE YEAR IN THREE.

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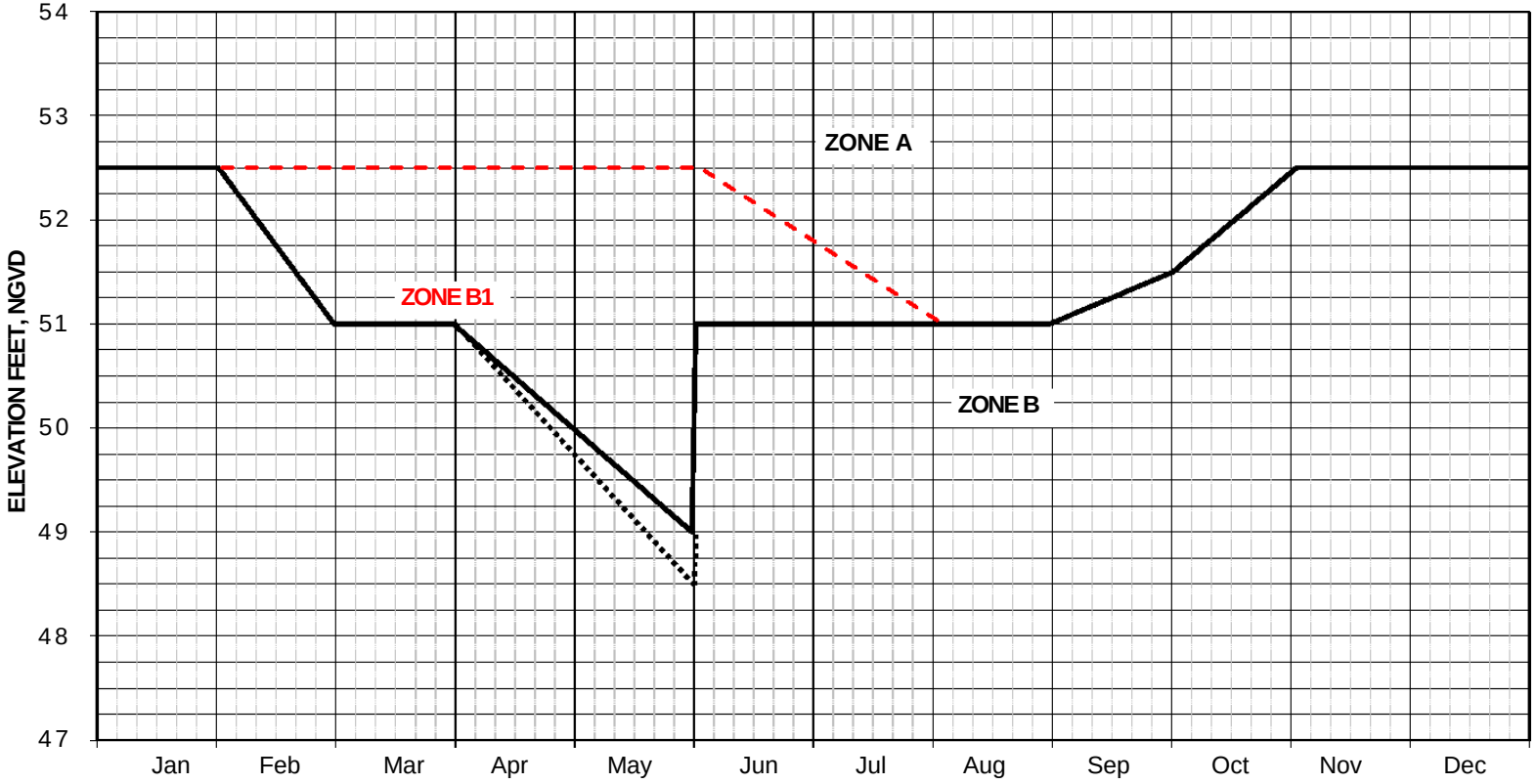
CENTRAL AND SOUTHERN FLORIDA
KISSIMMEE RIVER BASIN

LAKE KISSIMMEE,
HATCHINEHA & CYPRESS
INTERIM REGULATION SCHEDULE

US ARMY ENGINEER DISTRICT
JACKSONVILLE FL

DATED: 11 FEBRARY 2020
ALT_2

ALTERNATIVE 3
LAKES KISSIMMEE, HATCHINEHA, and CYPRESS



NOTE: ---- USE THIS SCHEDULE ONE YEAR IN THREE.

ZONE	RELEASES S-65
A	3,000 CFS UP TO DESIGN CAPACITY (11,000 CFS) WITHOUT EXCEEDING DESIGN CONDITIONS DOWNSTREAM. WHEN THE LAKE IS WITHIN 0.5 FT. OF DESIRED STAGE, FORECASTS WILL THEN BE MADE AND RELEASES STARTED TO BRING THE LAKE BACK DOWN TO SCHEDULE WITHIN 15 DAYS.
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CENTRAL AND SOUTHERN FLORIDA
KISSIMMEE RIVER BASIN

LAKE KISSIMMEE,
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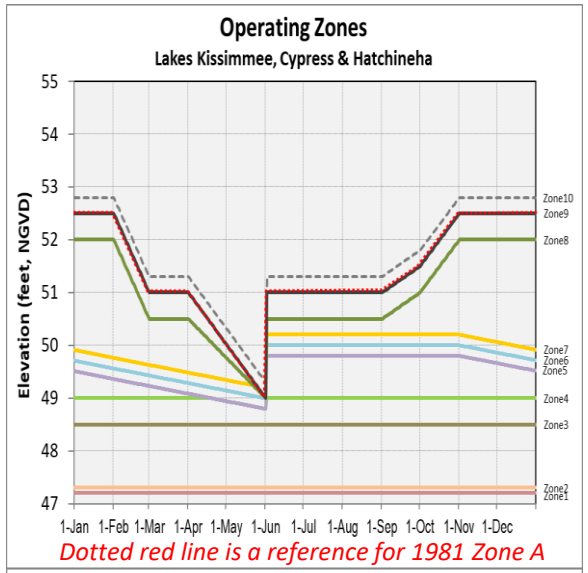
INTERIM REGULATION SCHEDULE

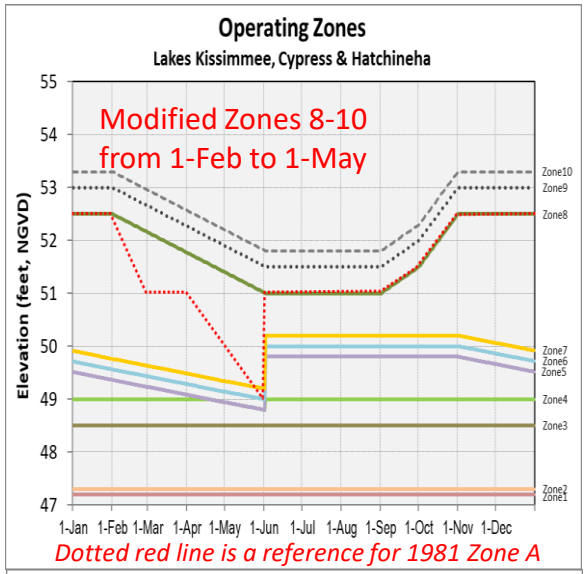
US ARMY ENGINEER DISTRICT
JACKSONVILLE FL

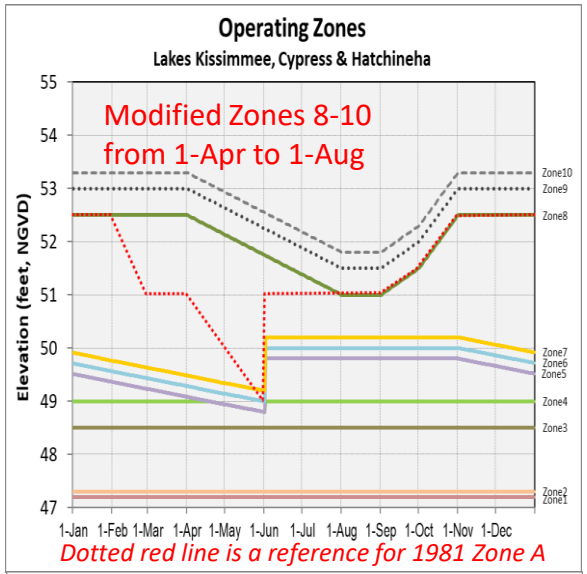
DATED: 11 FEBRARY 2020
ALT_3

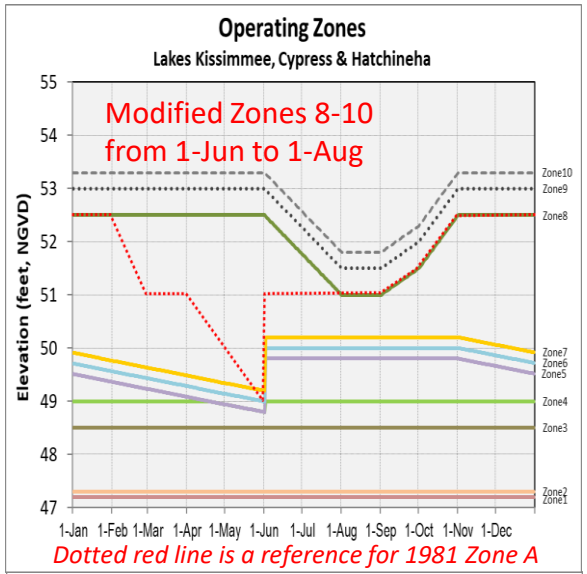
Lakes KCH Regulation Schedules & Zone-Discharge Operations

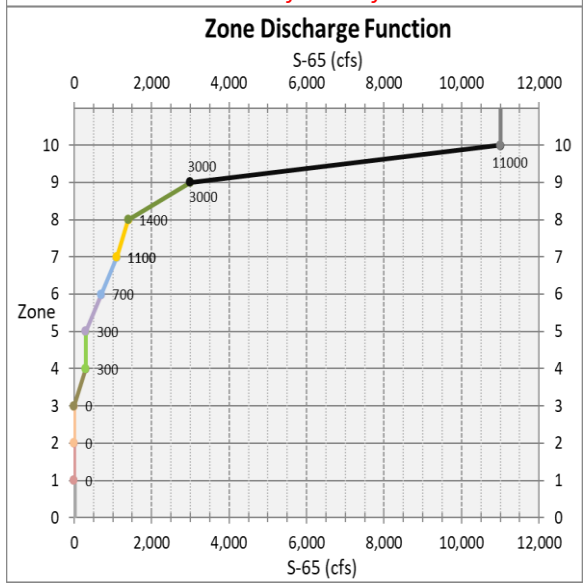
Input Specifications to the UK-OPS Model

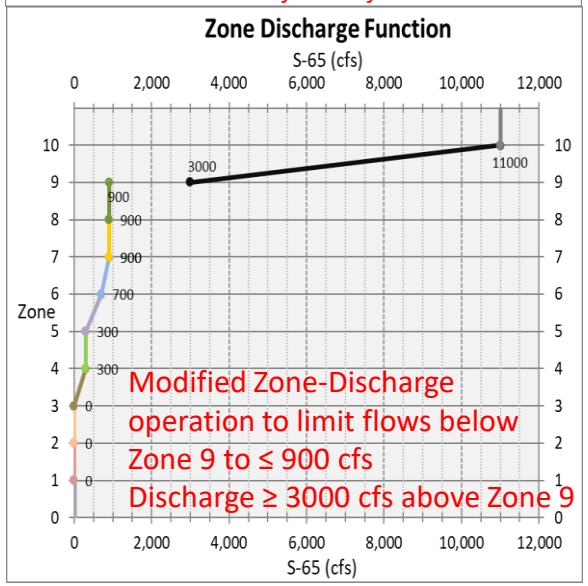


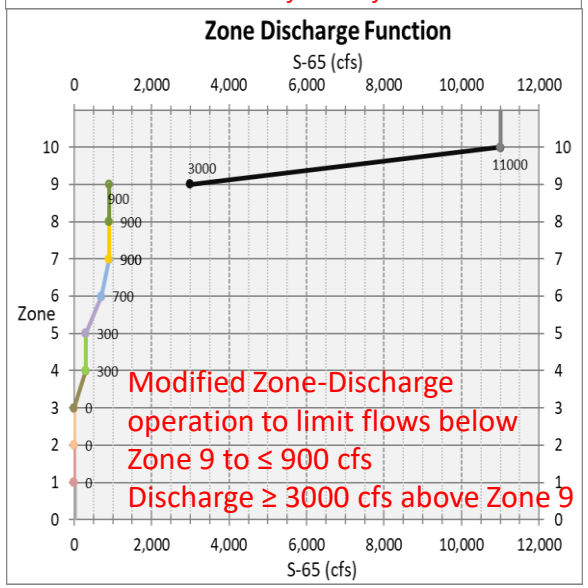


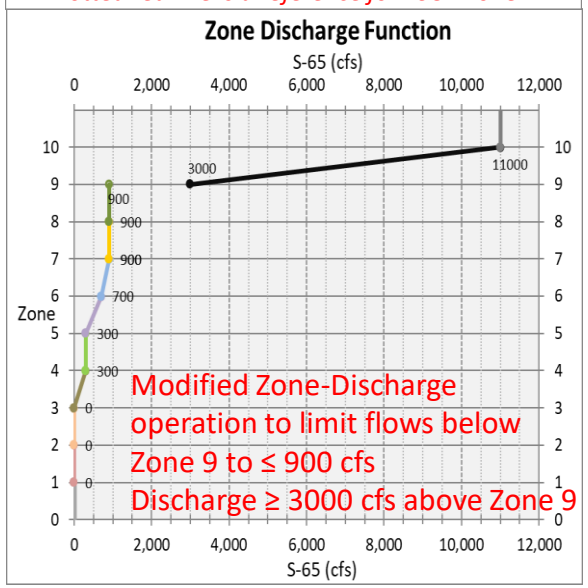








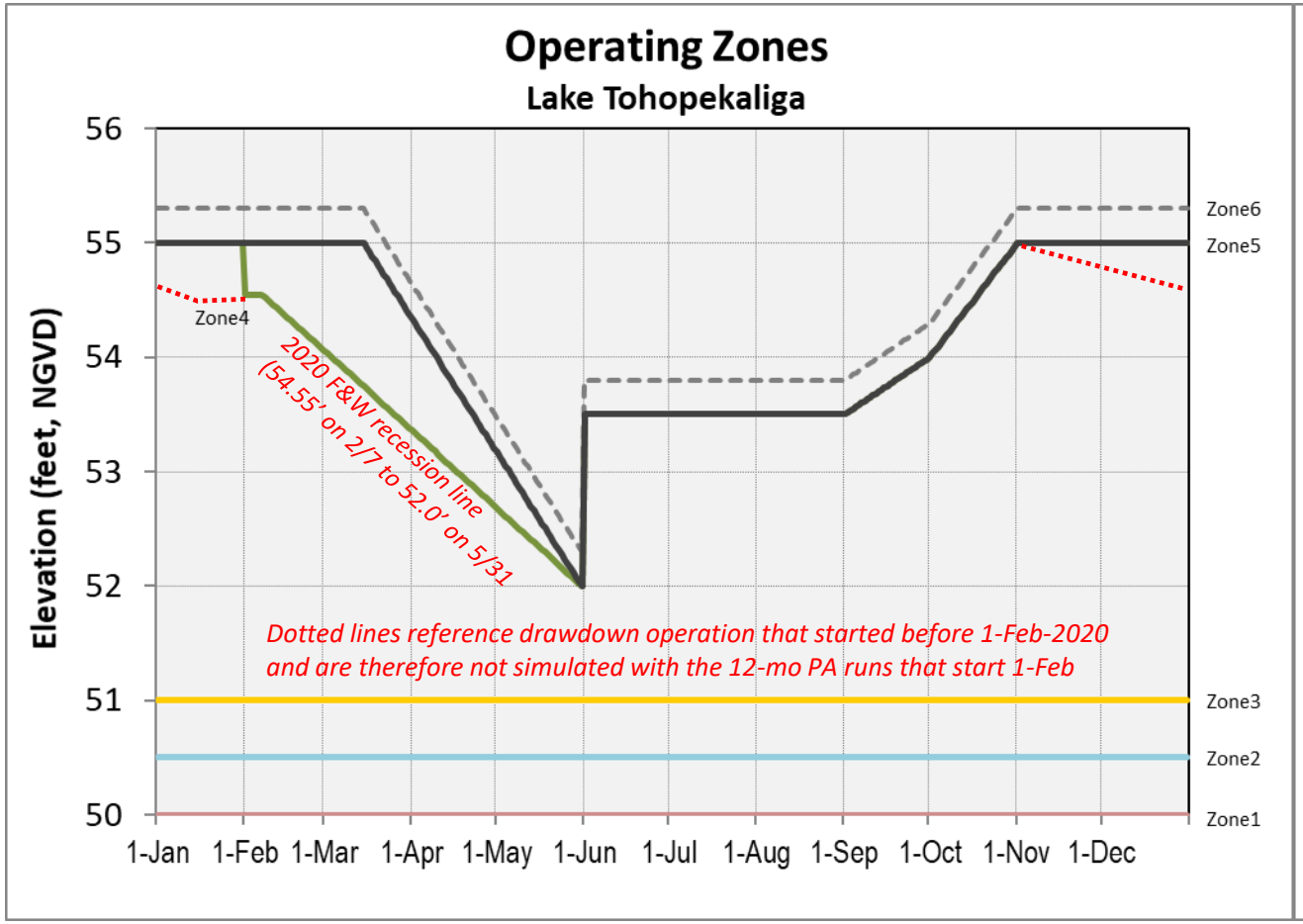


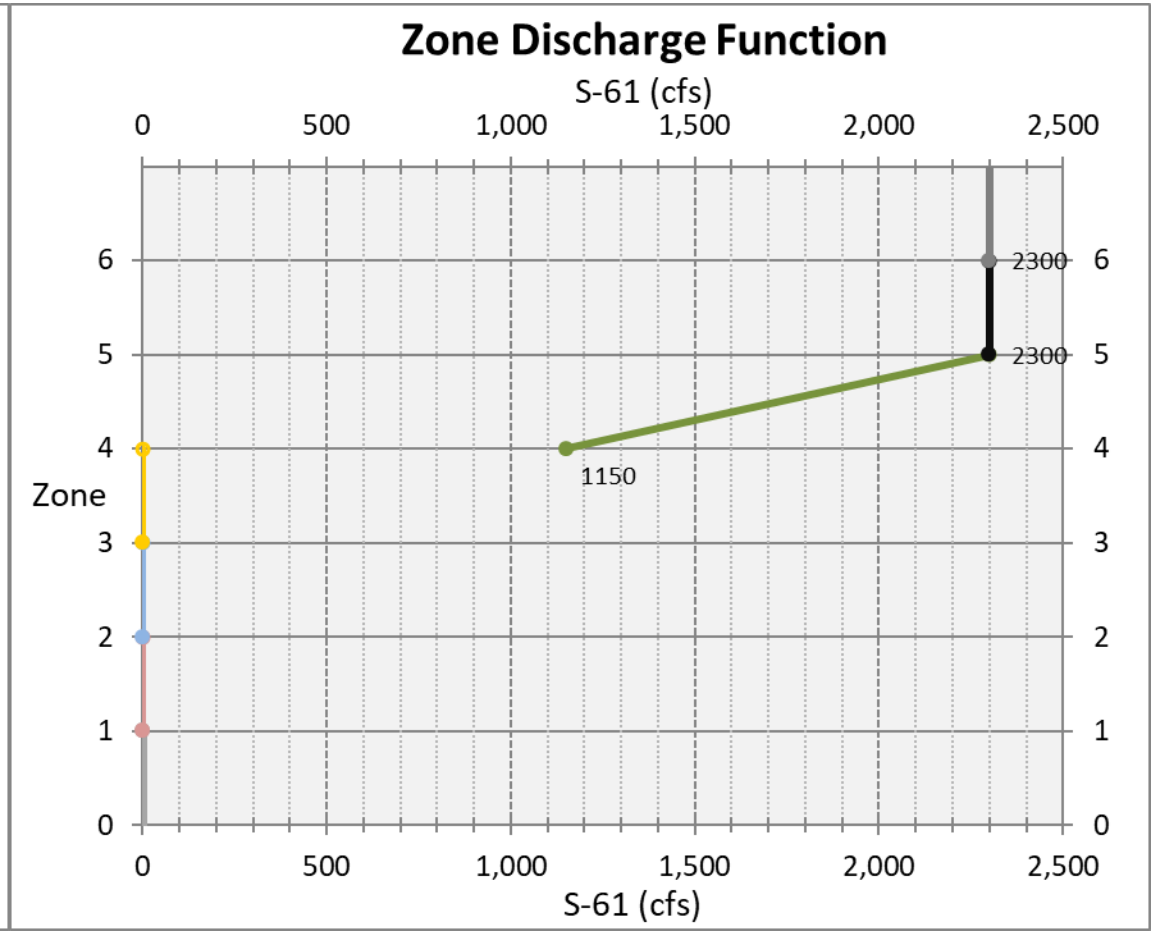


Base | ALT1 | ALT2 | ALT3

Lake TOH Regulation Schedules & Zone-Discharge Operations

Input Specifications to the UK-OPS Model

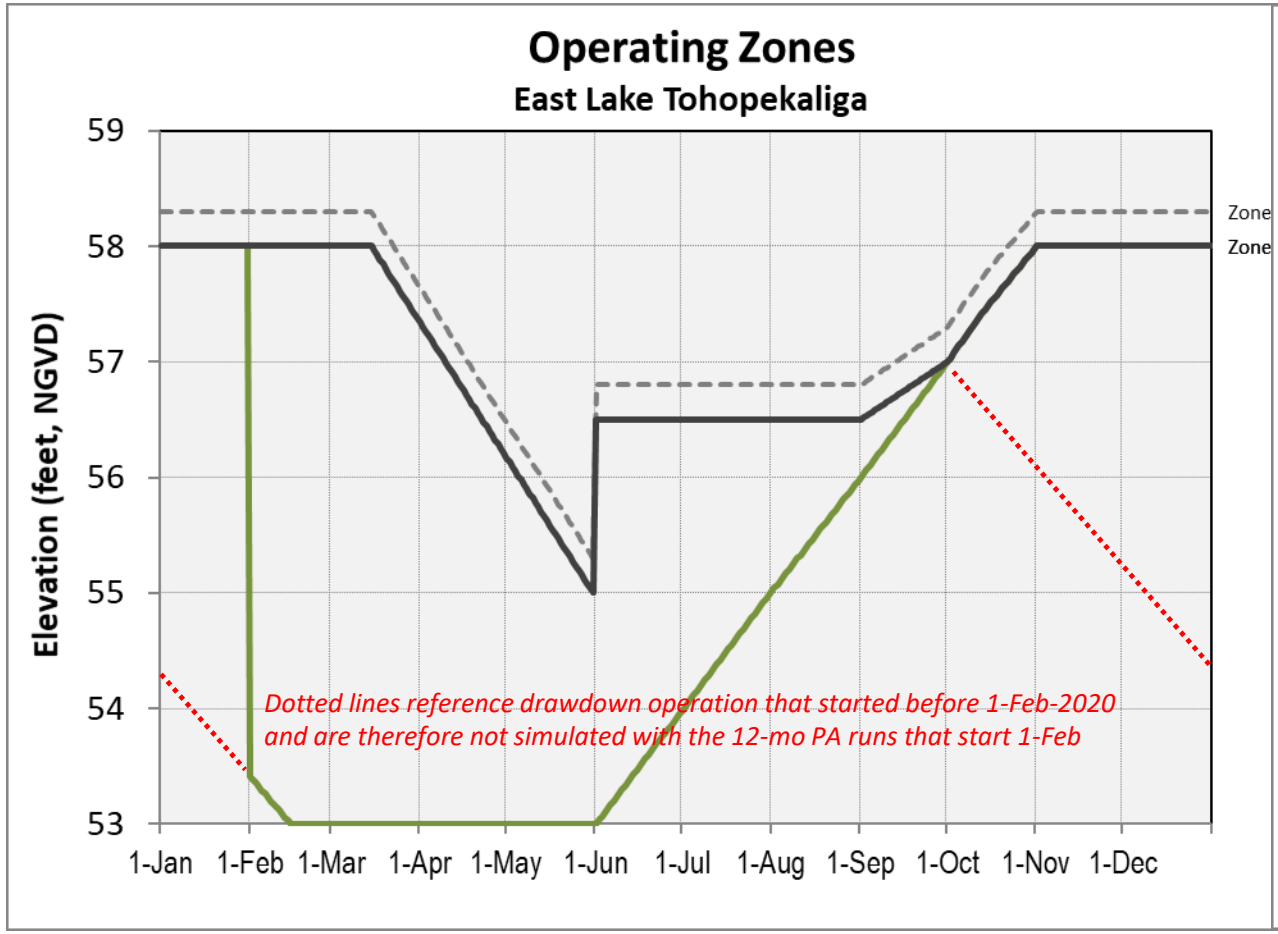


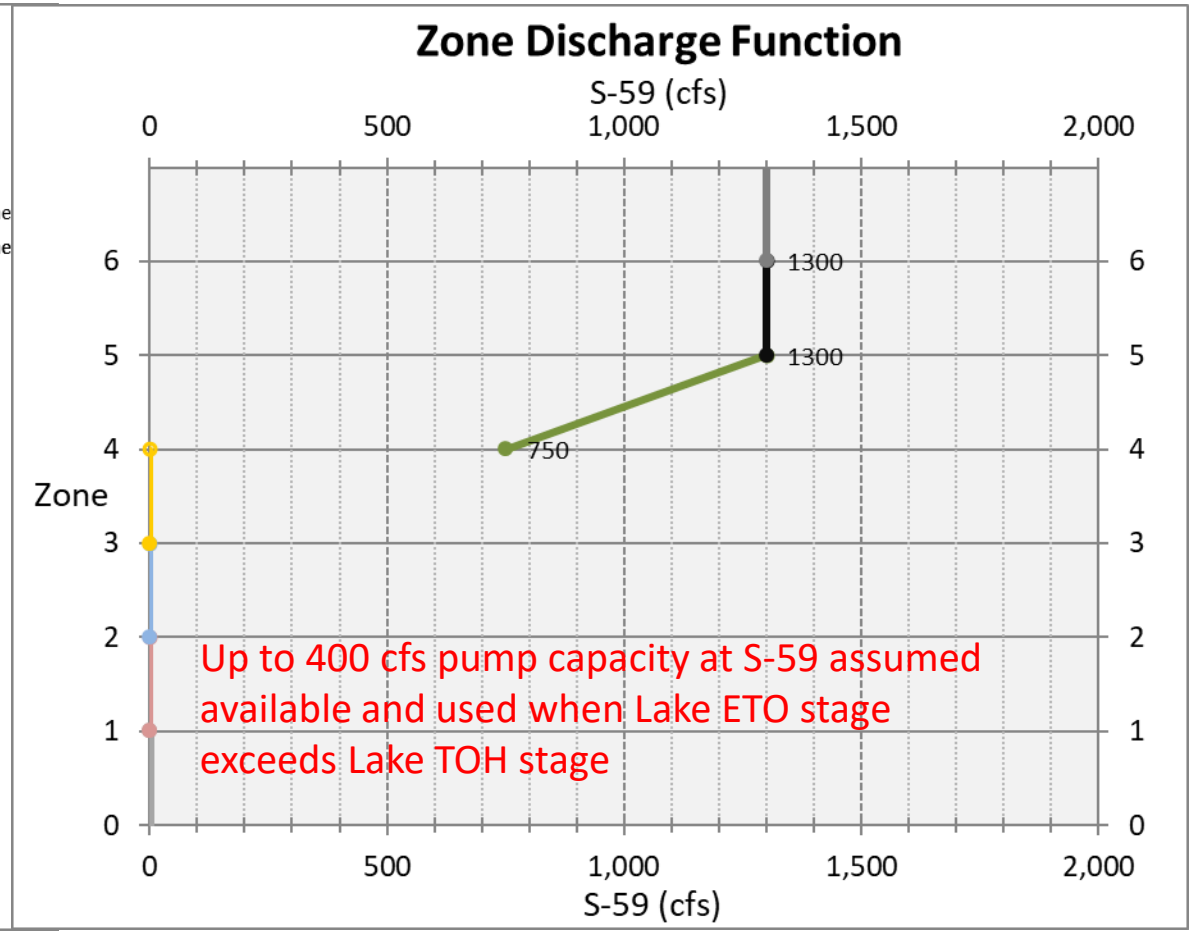


TOH operations assumptions same for Base and Alternatives

Lake ETO Regulation Schedules & Zone-Discharge Operations

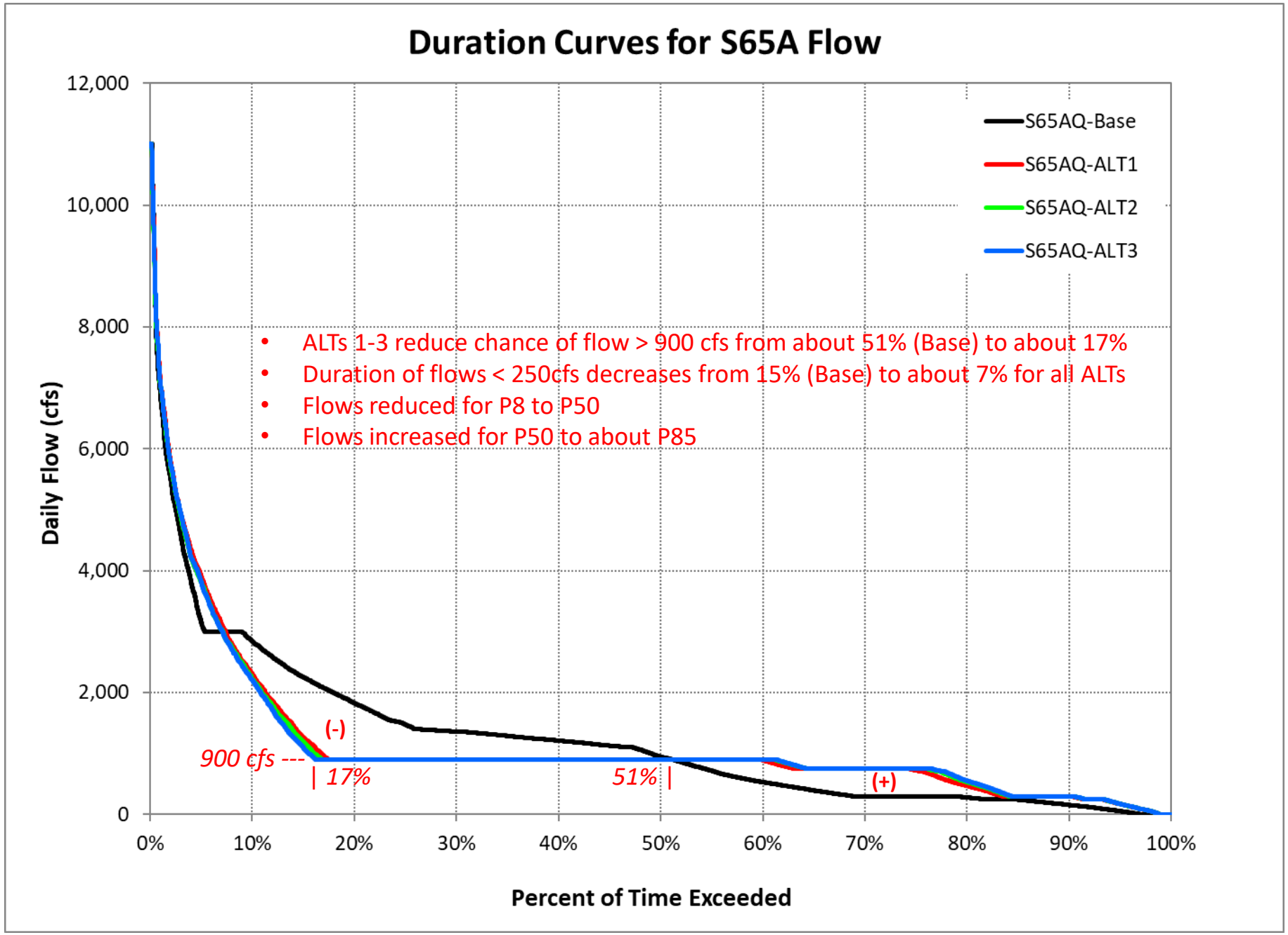
Input Specifications to the UK-OPS Model

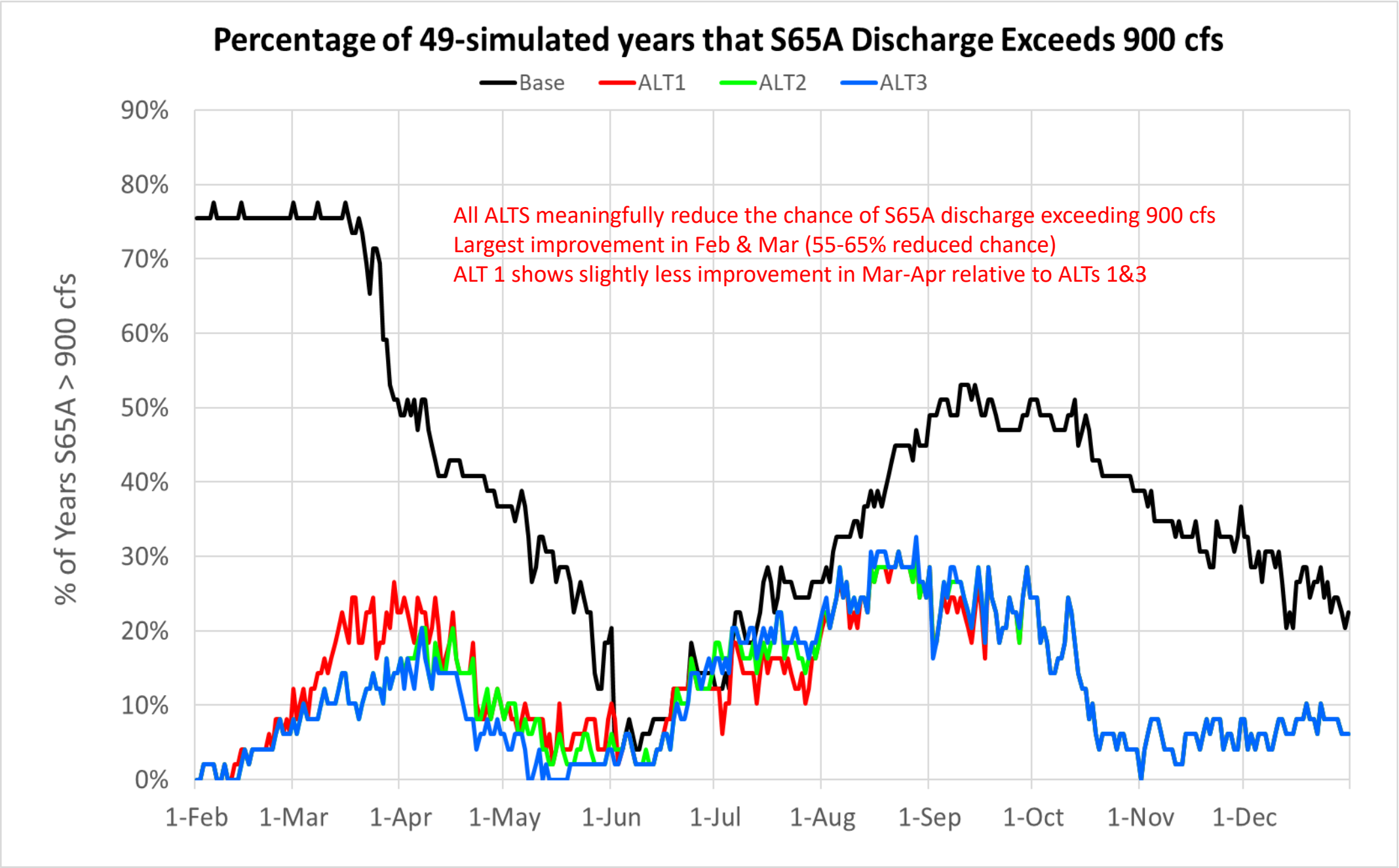


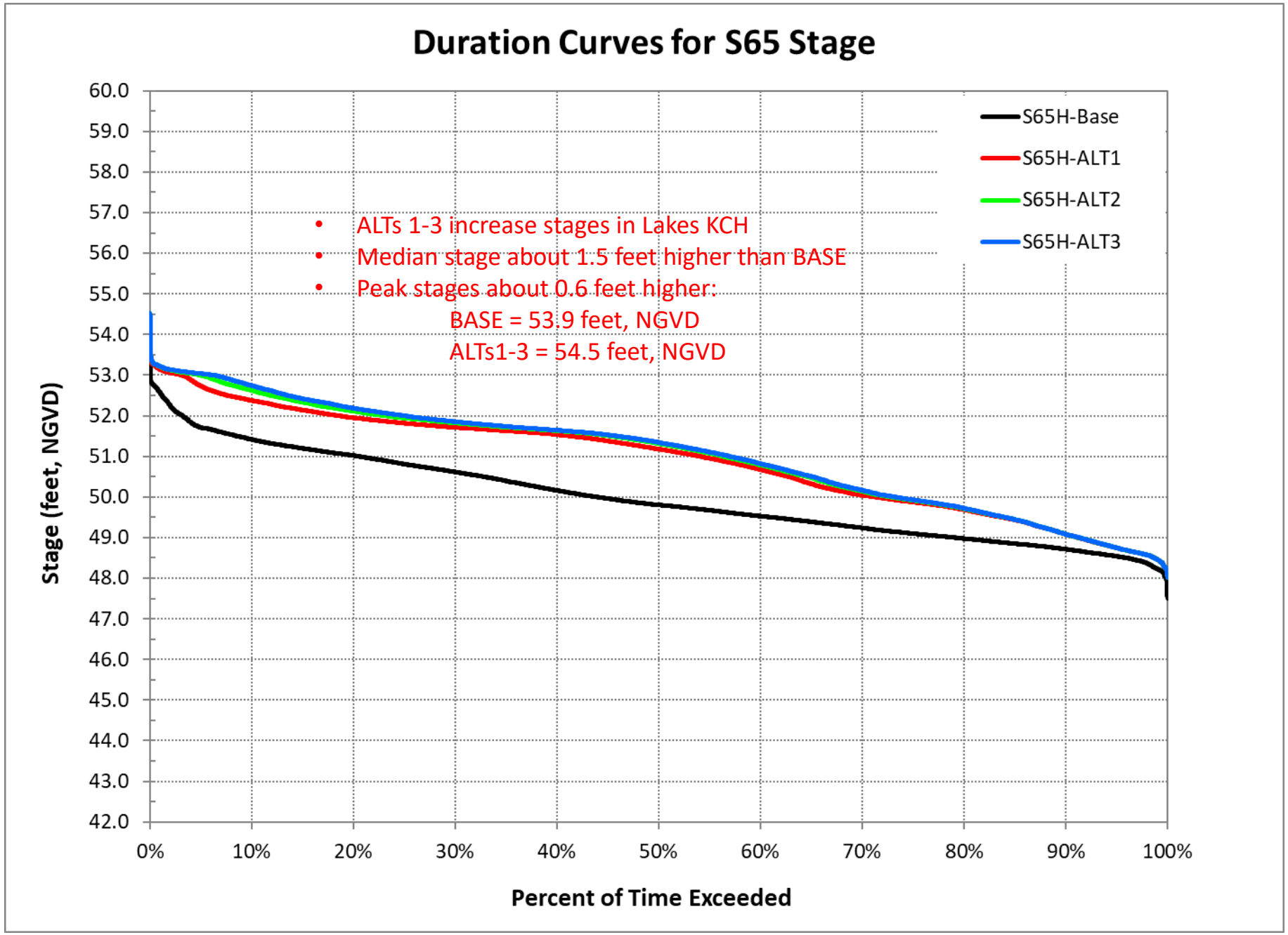


ETO operations assumptions same for Base and Alternatives

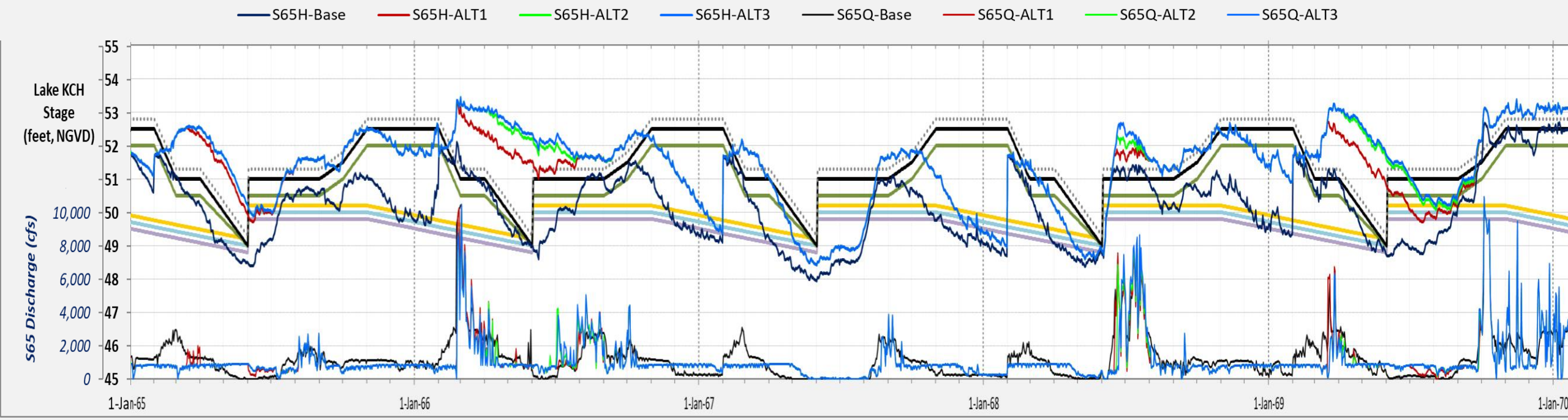
Simulation Results

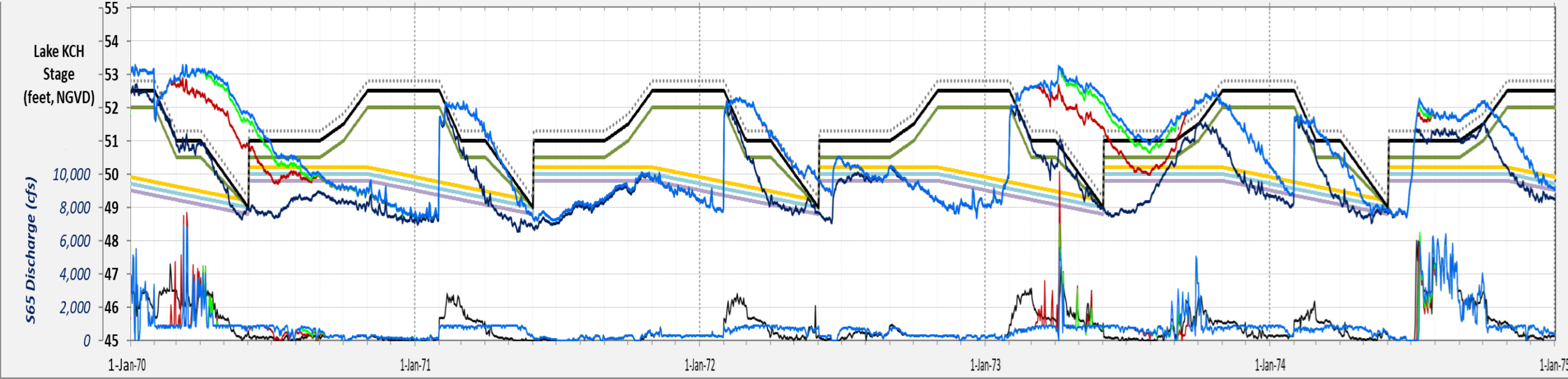

Duration Curves for S65A Flow
12,000
10,000
8,000
6,000
4,000
2,000
0
Daily Flow (cfs)
0%
10%
20%
30%
40%
50%
60%
70%
80%
90%
100%
Percent of Time Exceeded
S65AQ-Base
S65AQ-ALT1
S65AQ-ALT2
S65AQ-ALT3
• ALTs 1-3 reduce chance of flow > 900 cfs from about 51% (Base) to about 17%
• Duration of flows < 250cfs decreases from 15% (Base) to about 7% for all ALTs
• Flows reduced for P8 to P50
• Flows increased for P50 to about P85
(-)
900 cfs ---
| 17%
51% |
(+)


Percentage of 49-simulated years that S65A Discharge Exceeds 900 cfs
Base
ALT1
ALT2
ALT3
All ALTS meaningfully reduce the chance of S65A discharge exceeding 900 cfs
Largest improvement in Feb & Mar (55-65% reduced chance)
ALT 1 shows slightly less improvement in Mar-Apr relative to ALTs 1&3
% of Years S65A > 900 cfs
90%
80%
70%
60%
50%
40%
30%
20%
10%
0%
1-Feb
1-Mar
1-Apr
1-May
1-Jun
1-Jul
1-Aug
1-Sep
1-Oct
1-Nov
1-Dec

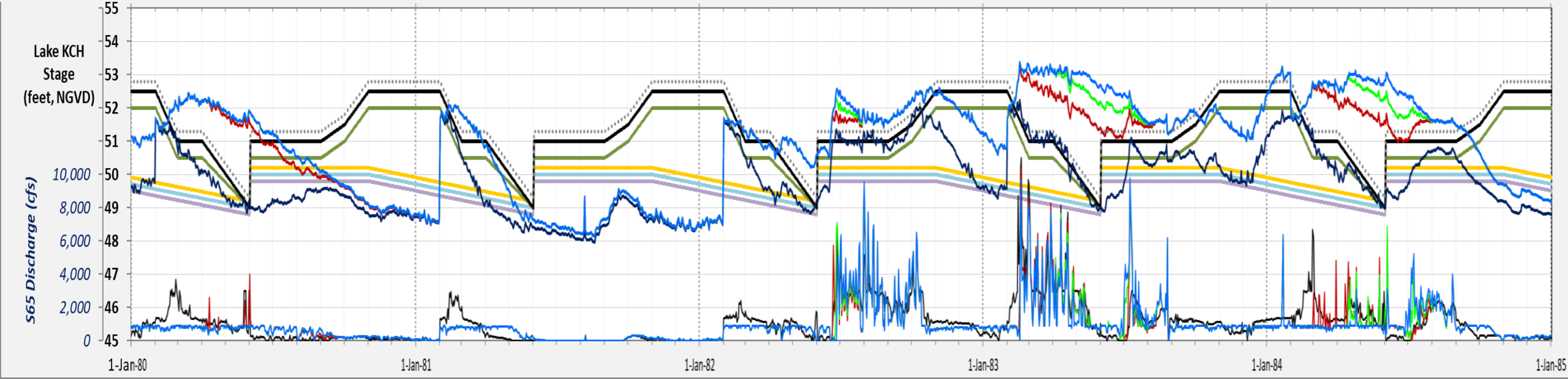

Duration Curves for S65 Stage
S65H-Base
S65H-ALT1
S65H-ALT2
S65H-ALT3
• ALTs 1-3 increase stages in Lakes KCH
• Median stage about 1.5 feet higher than BASE
• Peak stages about 0.6 feet higher:
BASE = 53.9 feet, NGVD
ALTs1-3 = 54.5 feet, NGVD
Stage (feet, NGVD)
60.0
59.0
58.0
57.0
56.0
55.0
54.0
53.0
52.0
51.0
50.0
49.0
48.0
47.0
46.0
45.0
44.0
43.0
42.0
0%
10%
20%
30%
40%
50%
60%
70%
80%
90%
100%
Percent of Time Exceeded

Lake Kissimmee-Cypress-Hatchineha Stage and Discharge Hydrographs 1965-1974

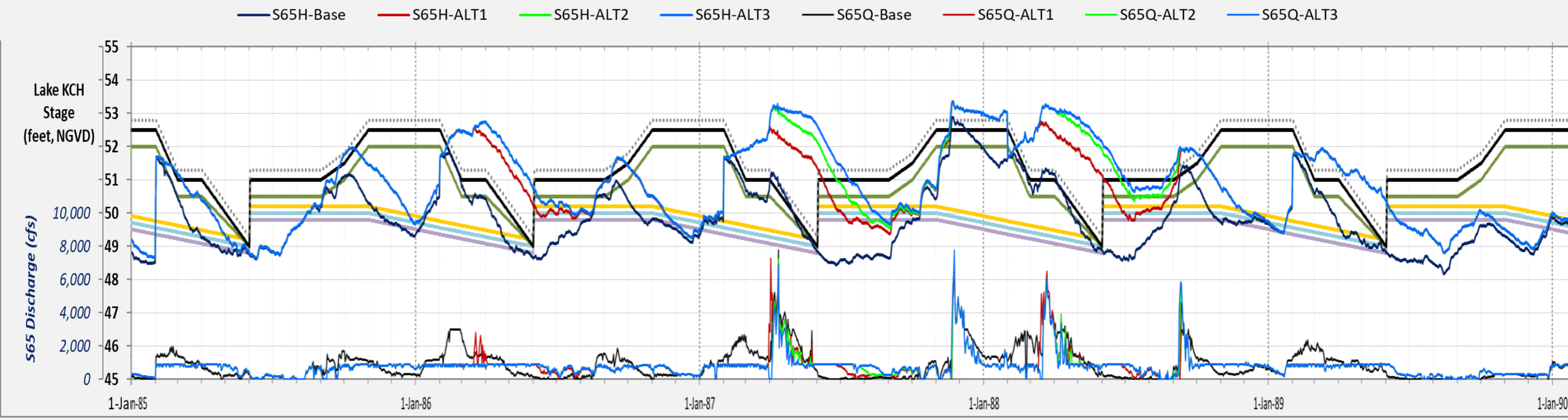


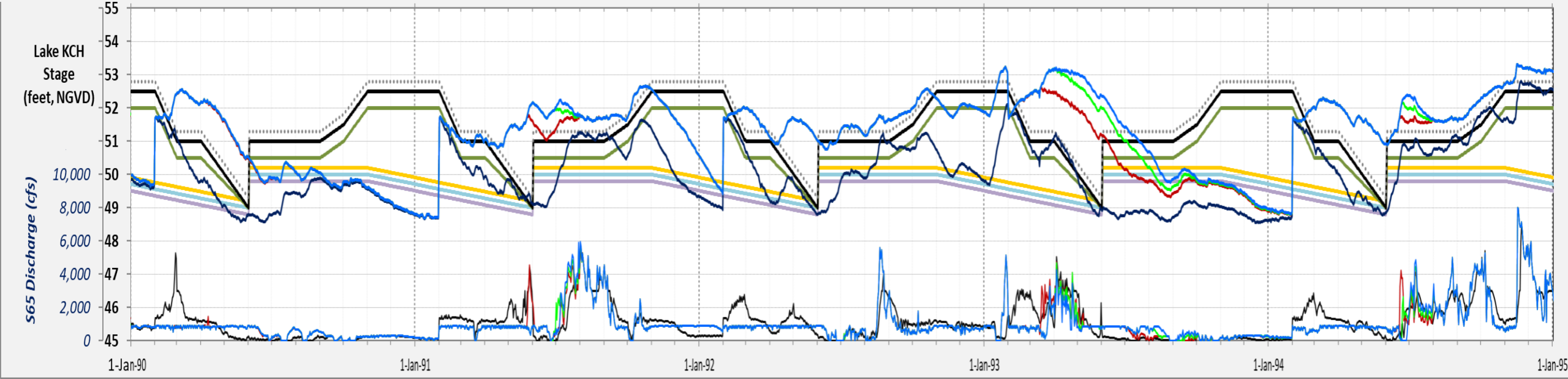


Lake Kissimmee-Cypress-Hatchineha Stage and Discharge Hydrographs 1975-1984

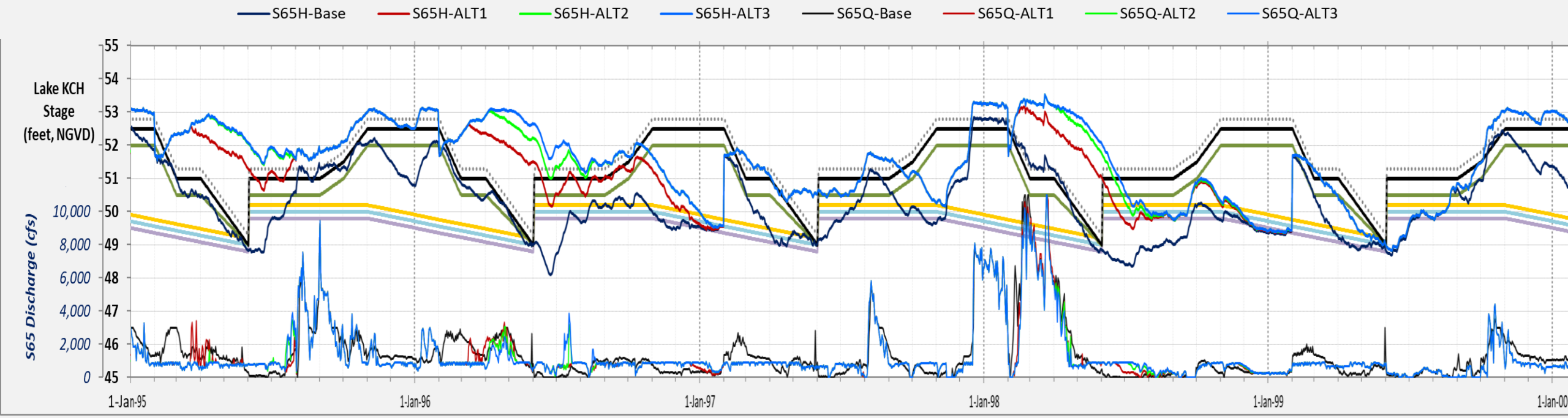


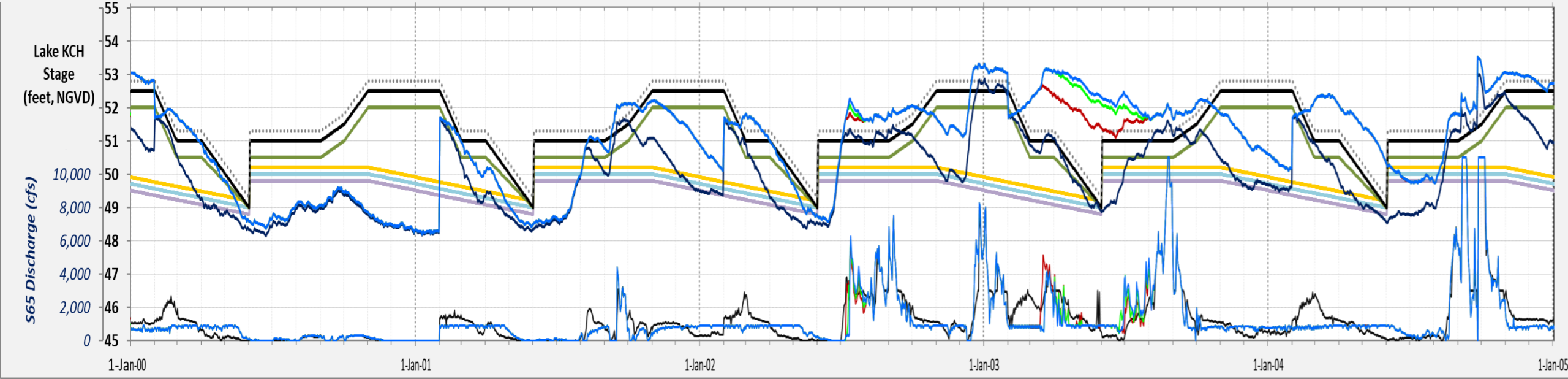
Lake Kissimmee-Cypress-Hatchineha Stage and Discharge Hydrographs 1985-1994



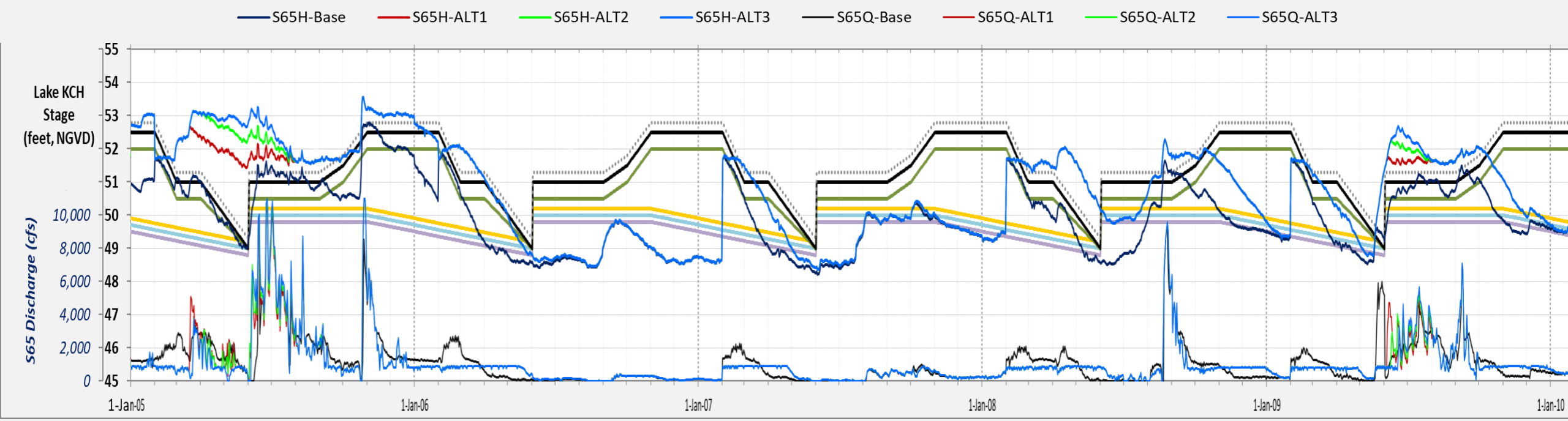


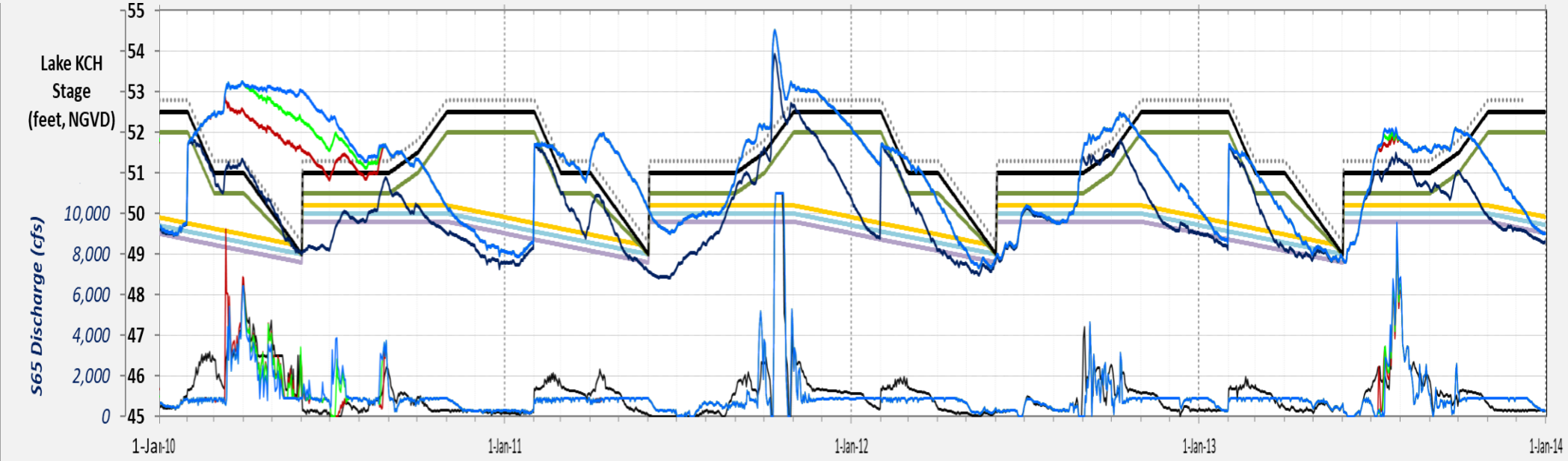
Lake Kissimmee-Cypress-Hatchineha Stage and Discharge Hydrographs 1995-2004

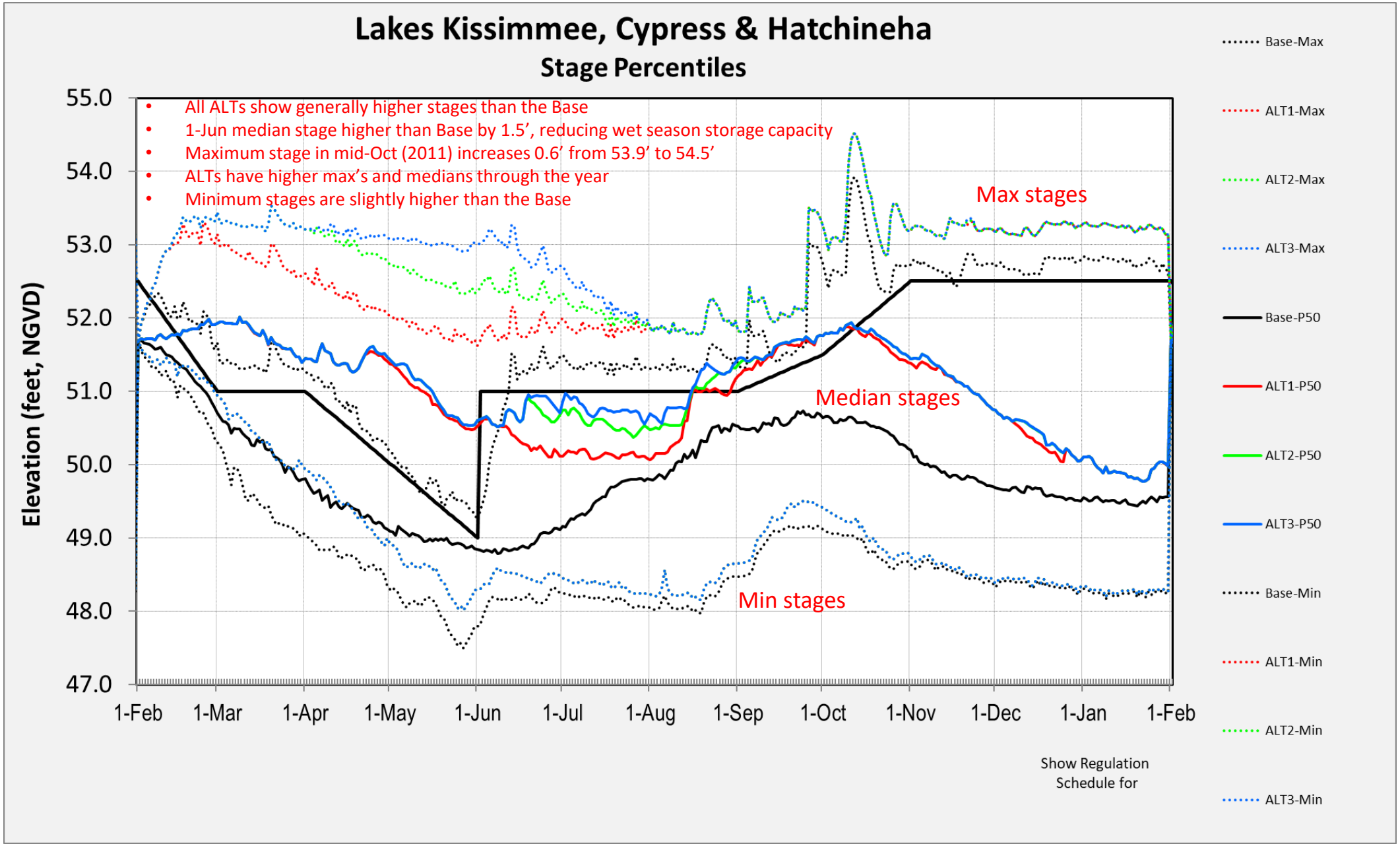


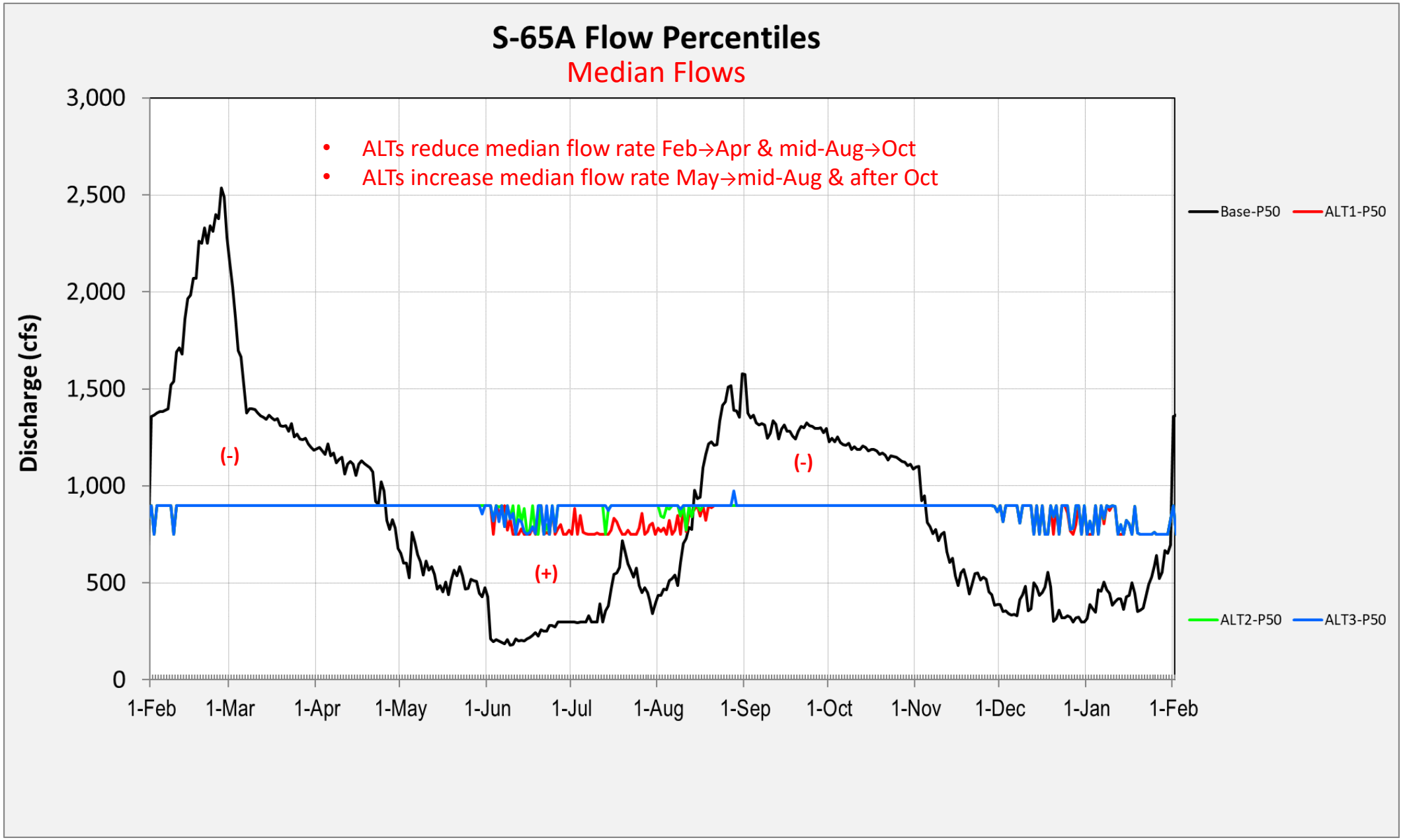


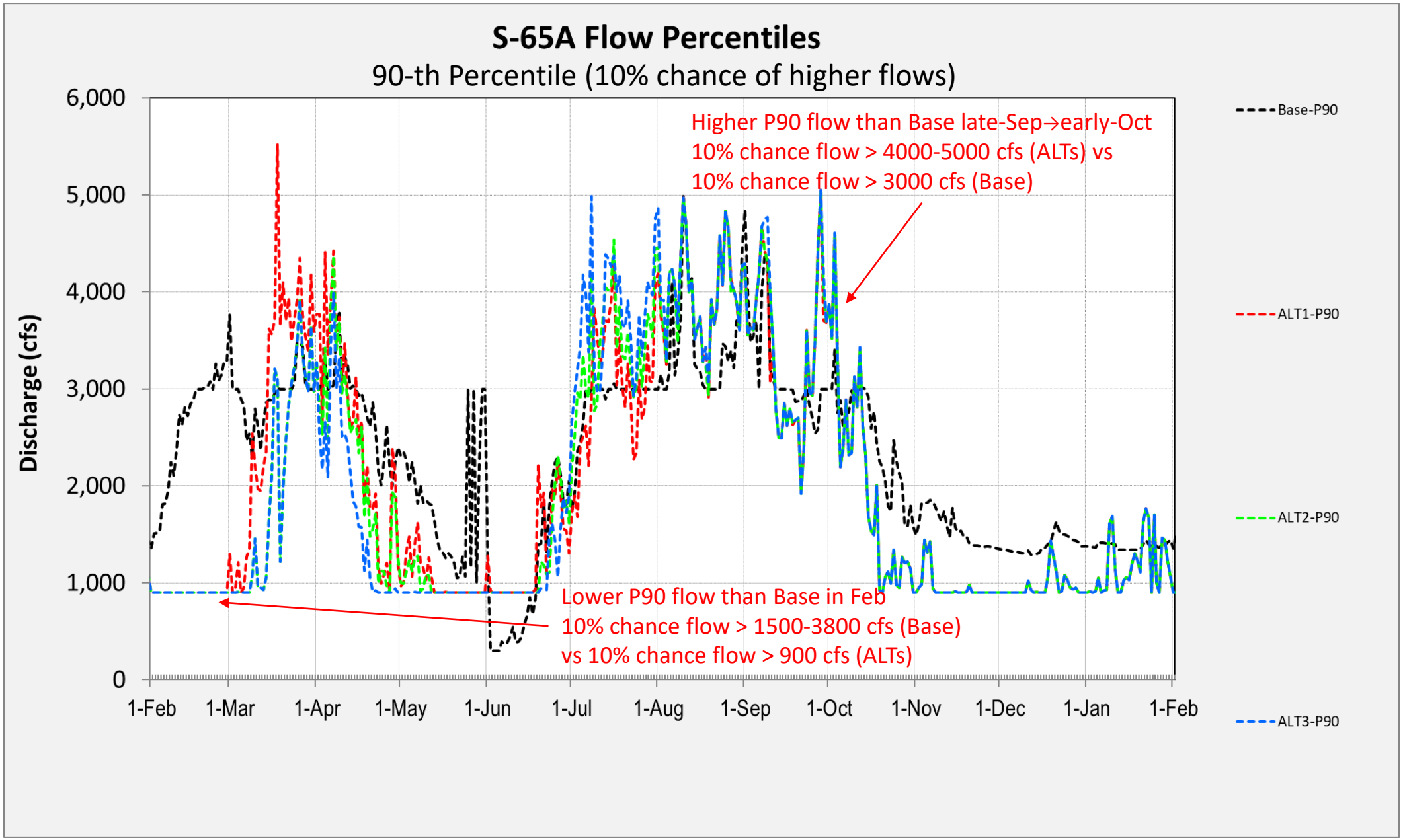
Lake Kissimmee-Cypress-Hatchineha Stage and Discharge Hydrographs 2005-2013






Lakes Kissimmee, Cypress & Hatchineha
Stage Percentiles
All ALTs show generally higher stages than the Base
1-Jun median stage higher than Base by 1.5', reducing wet season storage capacity
Maximum stage in mid-Oct (2011) increases 0.6' from 53.9' to 54.5'
ALTs have higher max's and medians through the year
Minimum stages are slightly higher than the Base
Max stages
Median stages
Min stages
Elevation (feet, NGVD)
55.0
54.0
53.0
52.0
51.0
50.0
49.0
48.0
47.0
1-Feb
1-Mar
1-Apr
1-May
1-Jun
1-Jul
1-Aug
1-Sep
1-Oct
1-Nov
1-Dec
1-Jan
1-Feb
Show Regulation Schedule for
Base-Max
ALT1-Max
ALT2-Max
ALT3-Max
Base-P50
ALT1-P50
ALT2-P50
ALT3-P50
Base-Min
ALT1-Min
ALT2-Min
ALT3-Min


S-65A Flow Percentiles
Median Flows
ALTs reduce median flow rate Feb→Apr & mid-Aug→Oct
ALTs increase median flow rate May→mid-Aug & after Oct
Discharge (cfs)
3,000
2,500
2,000
1,500
1,000
500
0
(-)
(+)
(-)
1-Feb
1-Mar
1-Apr
1-May
1-Jun
1-Jul
1-Aug
1-Sep
1-Oct
1-Nov
1-Dec
1-Jan
1-Feb
Base-P50
ALT1-P50
ALT2-P50
ALT3-P50


S-65A Flow Percentiles
90-th Percentile (10% chance of higher flows)
Discharge (cfs)
6,000
5,000
4,000
3,000
2,000
1,000
0
1-Feb
1-Mar
1-Apr
1-May
1-Jun
1-Jul
1-Aug
1-Sep
1-Oct
1-Nov
1-Dec
1-Jan
1-Feb
Higher P90 flow than Base late-Sep→early-Oct
10% chance flow > 4000-5000 cfs (ALTs) vs
10% chance flow > 3000 cfs (Base)
Lower P90 flow than Base in Feb
10% chance flow > 1500-3800 cfs (Base)
vs 10% chance flow > 900 cfs (ALTs)
Base-P90
ALT1-P90
ALT2-P90
ALT3-P90

Summary

- All 3 alternatives meaningfully reduce the chance of S65A discharge exceeding 900 cfs
  - Overall chance of S65A flow > 900 cfs dropped from about 51% (Base) to about 17%
  - Largest improvement in Feb & Mar (55-65% reduction in chance of flow > 900 cfs)
  - ALT 1 shows slightly less improvement in Mar-Apr relative to ALTs 2&3
  - Duration of low S-65A flows < 250 cfs decreased from 15% (Base) to about 7% for all ALTs (improved low flow performance for the Kissimmee River)
- Increased flooding risk associated with higher wet season stages in Lakes KCH
  - Median stage for all alternatives on 6/1 is about 1.5 feet higher than the Base. This decrease in storage capacity at the start of the wet season presents a risk to flood protection for the region influenced by KCH stages
  - Max stage in the wet season for all alternatives increased 0.5' from 53.9' to 54.4' (2011)
- Further analysis of results is necessary to determine the best alternative
  - Apparent trade-off between chance of S65A exceeding 900 cfs and increased flood risk

- *Note: The UK-OPS Model does not simulate detailed structure hydraulics including the maximum gate opening criteria (MAGO); so it is possible that the model may over-estimate S-65 and S-65A capacity. This could lead to over-estimation of peak flows and under-estimation of peak KCH stages. If detailed hydraulic analysis is needed, use a model like Mike SHE/11.*