RES 17-06

MEMORANDUM

TO: Jayantha Obeysekera, Director, HSM

THROUGH: Luis Cadavid, Sr. Supervising Engineer, HSM
Ken Tarboton, Sr. Supervising Engineer, HSM

FROM: Raul Novoa, Staff Engineer, HSM
Alaa Ali, Sr. Engineer, HSM

DATE: April 12, 2000

SUBJECT: Special Investigation: Alternative D13R without Lake Belt Reservoirs and ASRs

Definition of Simulation

The Restudy preferred alternative relies heavily on storage features to provide the ability to carry over excess water from wet years to dry years. In this investigation, the degree to which the preferred alternative relies on aquifer storage and deep inground reservoirs in the Lake Belt region is assessed by simulation of the following three scenarios that remove features from alternative D13R (AD13R): (1) both the North and Central Lake Belt Reservoirs are removed (NOLKBTs), (2) all Aquifer Storage and Recovery (ASR) components are removed (NOASRs), and (3) the North and Central Lake Belt Reservoirs in conjunction with all ASR components are removed (NOBOTH). Version 3.5 of the South Florida Water Management Model (SFWMM) was used for the simulations.

Background

The North Lake Belt and Central Lake Belt Storage Areas (NLBSA and CLBSA) are in-ground reservoirs with perimeter seepage barriers. The NLBSA has a storage area of 4500 acres with up to 20 feet of working storage for a total volumetric capacity of 90,000 ac-ft (the SFWMM assumes 5120 acres of surface area with water levels adjusted to simulate equivalent working storage volumes). The reservoir captures a portion of runoff from C-6, western C-11 and C-9 basins and uses the stored water to maintain stages during the dry season in the C-9, C-6, C-7, C-4 and C-2 Canals and to provide deliveries to Biscayne Bay to aid in meeting salinity targets. The CLBSA has a storage area of 5200 acres with up to 36 feet of working storage for a total volumetric capacity of 187,200 ac-ft. The reservoir receives excess water from Water Conservation Areas (WCA) 2B, 3A and 3B. The stored water is provided to Northeast Shark River Slough (NESRS) when it is needed and available. The SFWMM representation of canal and structure features with the Lake Belt storage areas in place is shown in Figure 1, and without the Lake Belt storage areas in Figure 2.

Aquifer Storage and Recovery systems provide regional storage with larger carry over capacity than surface reservoirs because they do not have evapotranspiration losses (as modeled, there is no limit on the bubble size). Excess water is pumped into the aquifer during wet periods and it is removed by pumping from the aquifer during dry periods. Alternative D13R has the capacity to pump 1665 MGD into aquifer storage. This includes 1000 MGD around Lake Okeechobee (LOK), 220 MGD at the Caloosahatchee Reservoir, 170 MGD along the C-51 canal, 150 MGD at the Site 1 impoundment, 50 MGD at the WPB water catchment area, and 75 MGD at the PBC Agricultural Reserve Reservoir. In the simulations without ASR, the entire ASR capacity was removed.

Major Findings

Lake Belt Storage Areas Removed

- The dependence of the Lower East Coast Service Area 3 (LECSA3) on the regional system (LOK and the WCAs) for water supply increases, thereby also increasing the frequency of undesirable low stages in
Lake Okeechobee. Demands not met in the Lake Okeechobee Service Areas (LOSA), Caloosahatchee and St. Lucie basins increased 1-2% and water shortages increased in all service areas due to lower lake stages.

- Flows to Biscayne Bay via Snake Creek and Miami River increased with C9 and C6 basin runoff going to Biscayne Bay rather than to the North Lake Belt Reservoir. Flows to Central Biscayne Bay, which received a contribution from the North Lake Belt Reservoir, decrease.

- Without the Central Lake Belt Reservoir to provide dry season flows to Everglades National Park, the frequency of drawdowns in Northeast Shark River Slough more than doubles and the mean annual hydroperiod is reduced from 98 to 94%.

**Aquifer Storage and Recovery Systems Removed**

- The frequency of higher high stages and lower low stages in Lake Okeechobee increases, thereby also increasing regulatory discharges to the estuaries and increasing the number of undesirable high and low LOK events. Demands not met in the LOSA, Caloosahatchee and St. Lucie basins increased 6-10% and water shortages increased in all service areas due to lower lake stages.

- The dependence of the Lower East Coast Service Area 1 (LECSA1) on the regional system for water supply increases with removal of ASR.

**Detailed Evaluation**

- The NOLKBTs simulation shows an increase in the dependence on LOK and the WCAs for water supply to the Lower East Coast Service Area 3 (LECSA3) (Fig. 3) with an increase of 40 kac-ft/yr (from 49 in AD13R to 89 kac-ft/yr). Deliveries from LOK and the WCAs to the Lower East Coast Service Areas 1 and 2 (LECSA1 and LECSA2) are unaffected in the NOLKBTs simulation. In contrast, the NOASRs simulation shows an increase in the dependence on LOK and the WCAs for water supply to the LECSA1 with an increase of 21 kac-ft/yr (from 31 in AD13R to 52 kac-ft/yr). Deliveries from LOK and the WCAs to the LECSA2 and LECSA3 are unaffected in the NOASRs simulation. The increases are even more pronounced when comparing the water supply deliveries during the five drought years (Fig. 4). The NOLKBTs simulation shows an increase of 82 kac-ft/yr (from 148 in AD13R to 230 kac-ft/yr) for water supply to the LECSA3 and the NOASRs simulation shows an increase of 66 kac-ft/yr (from 66 in AD13R to 132 kac-ft/yr) for water supply to the LECSA1. These results indicate the importance of the Lake Belt Reservoirs and the ASR systems to the regional water resources in LECSA3 and LECSA1 respectively.

- The LOK stage duration curve (Fig. 5) shows that the lake stages decreased during dry periods (up to 0.4 ft) in the NOLKBTs simulation. The number of undesirable LOK stage events (Fig. 6) increased by one (from 1 in AD13R to 2) for lake stage less than 11 ft for longer than 100 days. In the NOASRs simulation, high lake stages increased (up to 1.0 ft) and low lake stages decreased (up to 0.9 ft). The total number of undesirable LOK stage events increased by five (from 4 in AD13R to 9). The number of times the LOK stage was greater than 17 ft for longer than 50 days increased by two (from 2 in AD13R to 4); the number of times the LOK stage was greater than 15 ft for longer than 2 years increased by two (from 0 in AD13R to 2); and the number of times the LOK stage was less than 11 ft for longer than 100 days increased by one (from 1 in AD13R to 2). In the NOBOTH simulation, high lake stages increased (up to 1.0 ft) and low lake stages decreased (up to 1.1 ft). The number of undesirable LOK stage events was identical to the NOASRs simulation for each of the criteria.

- The higher high lake stages in the NOASRs simulation caused an increase in regulatory discharges from LOK to the WCAs and the Caloosahatchee and St. Lucie Estuaries (Fig. 7). Regulatory discharges from LOK increased by 32 kac-ft/yr (from 13 in AD13R to 45 kac-ft/yr) to the Caloosahatchee Estuary and by 27 kac-ft/yr (from 11 in AD13R to 38 kac-ft/yr) to the St. Lucie Estuary. The higher high lake stages and lower low lake stages caused the total number of times that the salinity envelope criteria was not met
to increase by 15 (from 47 in AD13R to 62) for the Caloosahatchee Estuary (Fig. 8) and by 8 (from 84 in AD13R to 92) for the St. Lucie Estuary (Fig. 9). Regulatory releases from Lake Okeechobee directly to the WCAs increased by 104 kac-ft/yr (from 101 in AD13R to 205 kac-ft/yr).

- The mean annual demands not met in the EAA and other LOSA areas (Fig. 10) increased by one percent in the NOLKBTs simulation (from 5 in AD13R to 6% in the EAA, and from 4 in AD13R to 5% in other LOSA areas). In the NOASRs simulation, the demands not met increased by six percent in the EAA and other LOSA areas (from 5 in AD13R to 11% in the EAA, and from 4 in AD13R to 10% in other LOSA areas). The C43 basin demand not met (Fig. 11) increased from 2.8% in AD13R to 3.6% in NOLKBTs, to 10.1% in NOASRs, and to 11.3% in NOBOTH. The C44 basin demand not met (Fig. 12) increased from 6.6% in AD13R to 8.6% in NOLKBTs, to 16.7% in NOASRs, and to 19.1% in NOBOTH.

- In the NOLKBTs simulation, the number of months of simulated water supply Phase 1 cutbacks in Northern Palm Beach County and LECSA1 (Fig. 13) increased from 14 in AD13R to 20 in NOLKBTs, and to 33 in NOASRs and NOBOTH. For LECSA2, the number of months increased from 21 in AD13R to 26 in NOLKBTs, and to 40 in NOASRs and NOBOTH. For LECSA3, the number of months increased from 19 in AD13R to 25 in NOLKBTs, and to 38 in NOASRs and NOBOTH. All the increases in the number of months of cutbacks were due to lower lake stages in Lake Okeechobee.

- In the NOLKBTs simulation, mean annual surface flows into Snake Creek and Miami River (Fig. 14) increased by 70 kac-ft (from 84 in AD13R to 154 kac-ft) and by 51 ac-ft (from 49 in AD13R to 100 kac-ft) respectively, due to C9 and C6 basin runoff being sent to Biscayne Bay rather than to the North Lake Belt Reservoir. Mean annual surface flows into Central Bay, which received a contribution from the North Lake Belt Reservoir in AD13R, decreased by 26 kac-ft (from 193 in AD13R to 167 kac-ft) with the reservoir removed. The NOASRs simulation shows no change from AD13R in surface flows to Biscayne Bay.

- The Inundation Duration Summary (Table 1) shows a decrease in the average annual hydroperiod in Indicator Region 11 (NE Shark River Slough) from 98% in AD13R to 94% in NOLKBTs. The number of continuous inundation events in IR11 increased from 6 to 15 during the period of simulation. The average annual hydroperiod also decreased in WCA3B, from 99% in AD13R to 96% for IR15 (West WCA3B) and from 98% in AD13R to 93% for IR16 (East WCA3B). Similar decreases are seen in the Pennsuco Wetlands. The High and Low Water Summaries (Tables 2 and 3) indicates an increase in both high water and low water events in the Pennsuco Wetlands (IR52 – North, and IR53 – South). In IR52 the number of high water and low water events increased from 8 and 3 in AD13R to 16 and 11 respectively. In IR53 the number of high water and low water events increased from 9 and 4 in AD13R to 13 and 12 respectively.

RN/AA
c: Luis Cadavid
    Ray Santee
    Ken Tarboton
Fig. 1 - SFWMM representation of canals, structures and storage in the Lake Belt area for AD13R
Fig. 2 - SFWMM representation of canals, structures and storage in the Lake Belt area with Lake Belt storage areas removed
Fig. 3 – Average Annual Regional System Water Supply Deliveries to LEC Service Areas for the 1965 – 1995 simulation

Note: Supply RECEIVED from LOK may be less than what is DELIVERED at LOK due to conveyance constraints. Regional System is comprised of LOK and WCAs.
Fig. 4 – Mean Annual Regional System Water Supply Deliveries to LEC Service Areas for the five Drought years (71,75,81,85,89)

Note: Supply RECEIVED from LOK may be less than what is DELIVERED at LOK due to conveyance constraints. Regional System is comprised of LOK and WCAs.
Fig. 5 – Lake Okeechobee Stage Duration Curves

Lake Stage (ft NGVD)

Percent Time Equaled or Exceeded

AD13RDEC
NOLKB Ts
NOASRs
NOBOTH

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SFWMM V3.5
Fig. 6 – Number of Undesireable Lake Okeechobee Stage Events


- # Times Stage > 17 ft. for > 50 days
- # Times Stage > 16 ft. for > 1 year
- # Times Stage > 15 ft. for > 2 years
- # Times Stage < 12 ft. for > 1 year
- # Times Stage < 11 ft. for > 100 days

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Fig. 7 – Mean Annual Flood Control Releases from Lake Okeechobee for the 31 yr (1965 – 1995) Simulation

Note: Although regulatory (flood control) discharges are summarized here in mean annual values, they do not occur every year. Typically they occur in 2–4 consecutive years and may not occur for up to 7 consecutive years.
Fig. 8 – Number of times Salinity Envelope Criteria were NOT met for the Calooshatchee Estuary (mean monthly flows 1965 – 1995)

- Number of months flow < 300cfs from C−43 & Lok regulatory releases during the dry season (Nov–May)
- Number of months flow > 2800cfs from C−43 Basin (Jan–Dec)
- Additional Number of months flow > 2800cfs due to LOK Regulatory Releases (Jan–Dec)

Each data label represents the number of times the minimum (< 300cfs) & maximum (> 2800cfs) discharge criteria were not met for 1, 2, 3,... consecutive months.
Fig. 9 – Number of times Salinity Envelope Criteria were NOT met for the St. Lucie Estuary

- Number of months avg flow < 350cfs
- Number of times 14-day moving avg flow > 1600cfs for >=14 days from local basins *
- Additional # of times 14-day moving avg flow > 1600cfs for >=14 days from LOK Regulatory Releases

Each data label represents the number of times the minimum (<350cfs) & maximum (>1600cfs) discharge criteria were not met for 1, 2, 3, ..., consecutive months & 14-day periods, respectively.

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SFWMM V3.5
Fig. 10 – Mean Annual EAA/LOSA Supplemental Irrigation: Demands and Demands Not Met for the 1965 – 1995 Simulation Period

*Other Lake Service SubAreas (S236, S4, L8, C43, C44, and Seminole Indians (Brighton & Big Cypress)).
Fig. 11 – C43 Basin Regional Irrigation Supply and Demand Not Met

Means for the 1965 to 1995 Simulation Period

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<th>Component</th>
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Note: Percentages summarize the fraction of the mean annual irrigation demand not met.

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SFWMM V3.5
Fig. 12 – C44 Basin Regional Irrigation Supply and Demand Not Met

Means for the 1965 to 1995 Simulation Period

Note: Percentages summarize the fraction of the mean annual irrigation demand not met.

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SFWMM V3.5
Fig. 13 – Number of Months of Simulated Water Supply Cutbacks for the 1965 – 1995 Simulation Period

Note: Phase 1 water restrictions could be induced by a) Lake stage in Supply Side Management Zone (indicated by upper data label), b) Local Trigger well stages (lower data label), and c) Dry season criteria (indicated by middle data label).
Fig. 14 – Simulated Mean Annual Surface Flows Discharged into Biscayne Bay for the 1965 – 1995 simulation period

Note: Snake Creek=S29; North Bay=G58+S28+S27; Miami River=S26+S25B+S25; Central=G97+S22+S123; South=S21+S21A+S20F+S20G; Barnes Sound=S197

Targets for Central and South Bay reflect a 30% increase in mean annual dry season flows over the 95 Base

Targets for Snake Creek reflect a minimum monthly flow volume of 13,300 ac–ft (x 5 months for wet season and x 7 months for dry season) to maintain salinity levels below 20 ppt.
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<th>Events</th>
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#Table 2 − High Water Summary for Indicator Regions

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Notes: #events = number of events with depths continuously greater than the criterion over the period of record
Avg Duration of High Water Events = \(\frac{\text{sum(days over criterion)}}{\#events}\)
Avg Annual Duration of High Water(Percent) = \(100 \times \frac{\text{sum(weeks over criterion)}}{52 \times \#years}\)
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Notes:  
#events = number of events with depths continuously less than the criterion over the period of record  
Avg Duration of Low Water Events = \( \frac{\text{sum(days below criterion)}}{7} \)/#events  
Avg Annual Duration of Low Water(Percent) = 100 x \( \frac{\text{sum(weeks below criterion)}}{52 x \#years} \)