

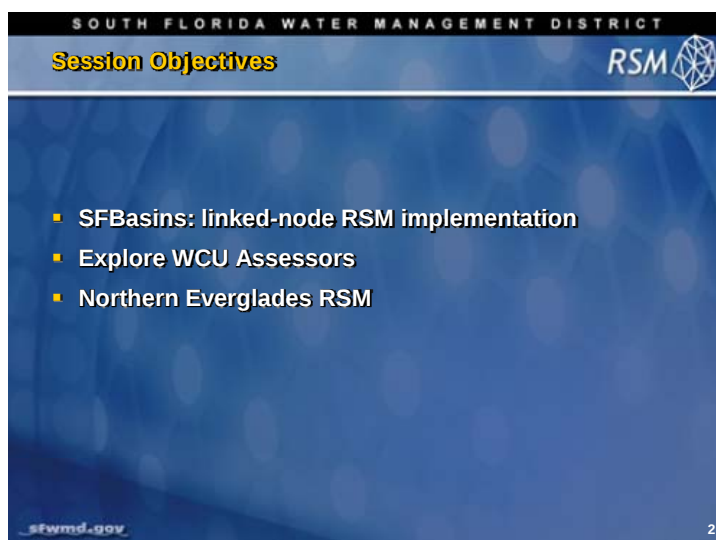


Lecture 16: Management Simulation Engine (MSE): Linked Node Implementation

This lesson provides a more detailed presentation of the mseNetwork and an application in the Northern Everglades RSM (NERSM)

**NOTE:****Additional Resources**

A number of additional MSE reference materials can be found in the labs/lab16_assessor directory



Session Objectives

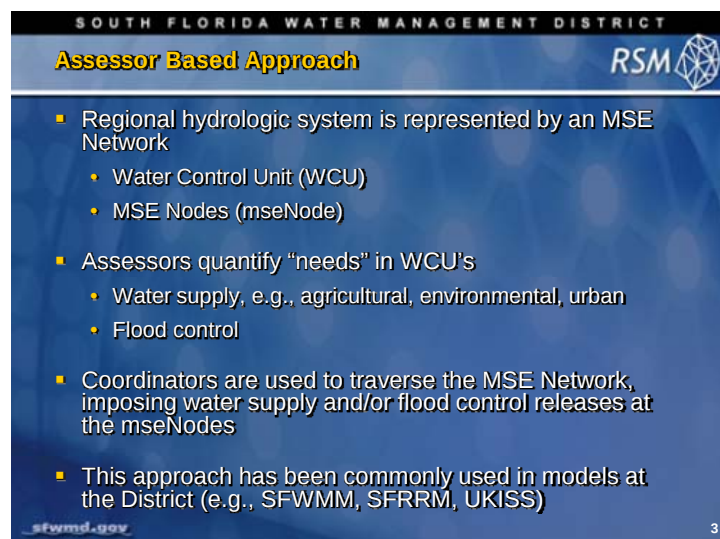
- SFBasins: linked-node RSM implementation
- Explore WCU Assessors
- Northern Everglades RSM

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In this session, the linked-node implementation of the RSM will be discussed. The linked-node implementation of the RSM focuses on simulating the water management rules for the selected water control units (WCUs). The domain is represented by a series of lakes or basins. This implementation of the RSM uses simplified hydrology but implements the complete set of management rules to test alternative plan formulations. Complexity in the hydrology is only added where necessary.

The key component of the linked-node RSM is the WCU assessors. The assessors are used to determine how much water should be between WCUs based on flood control, water supply and environmental requirements.

The Northern Everglades RSM is the most complete implementation of the linked-node RSM. This implementation of the RSM simulates the Kissimmee upper basin, the lower Kissimmee River, Taylor Creek/Nubbins Slough, Indian Prairie/Lake Istokpoga and Fishing Eating Creek.

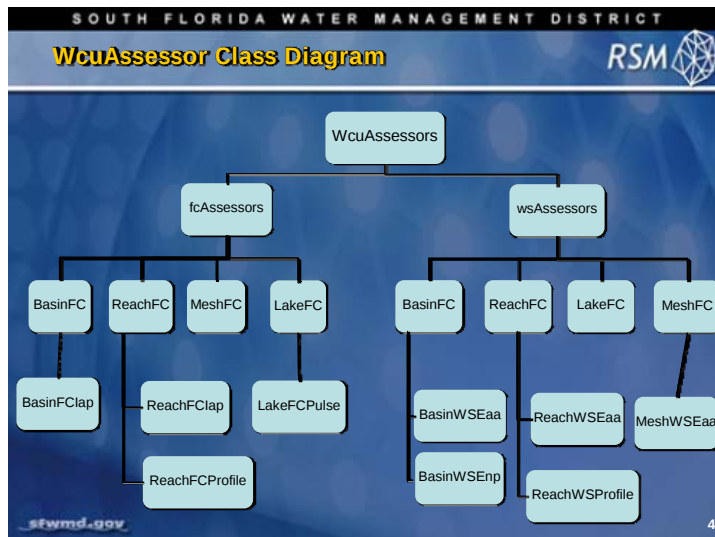


Assessor Based Approach

- Regional hydrologic system is represented by an MSE Network
 - Water Control Unit (WCU)
 - MSE Nodes (mseNode)
- Assessors quantify "needs" in WCU's
 - Water supply, e.g., agricultural, environmental, urban
 - Flood control
- Coordinators are used to traverse the MSE Network, imposing water supply and/or flood control releases at the mseNodes
- This approach has been commonly used in models at the District (e.g., SFWMM, SFRRM, UKISS)

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The linked-node RSM is implemented using the MSE network with assessors to determine the regional needs. The WCUs represent the lakes and basins in the system which is represented by the MSE nodes. The inflows/outflows from the associated watersheds are represented by HPMs and external boundary conditions. Assessors are used to quantify the need (flood control, water supply, etc) in each WCU. Coordinators are used to meet the needs of the WCUs regionally through coordinated releases at managed structures in the MSE Network. This approach has been implemented through other models used in south Florida.



These are the available assessors. This is the basic C++ object diagram for assessors. Under the flood control (FC) objects there is a need for specialized methods and procedures for the FC functions of the different waterbodies. Any kind of waterbody that can be assigned as a WCU needs a set of functions for FC. This is good for the generic waterbodies. For special WCUs specific assessors or “packages” are developed. When a new set of rules for water supply (WS), environmental enhancement (EE) or FC are required, we first need to understand what the rules are

and how they are meant to be implemented. Then we need to know how the rules affect the flow at the inlets and outlets. Once we know that, we go to the base assessors to see if it fits any currently available tools. If an assessor is similar, we can develop a variant of that assessor. One advantage to this approach is that once a set of rules is created into an object, it is available for any of the different assessors to access. Another important method available through the wcuAssessor is the profiler. The profiler assesses all of the inflows/outflows for a reach and estimates what the profile of the canal will be. It uses that information to help determine what the WCU inflows and outflows ought to be. As different approaches are developed for managing water resources in the future, there will be greater use of these methods. There is a one-to-one correspondence between these assessors and the input xml.

WcuAssessors for Water Supply

- Demand generally defined as the volume of water required to lift water level in WCU up to a maintLevel
- Demand distributed to multiple WCU inlets based on inlet rules:
 - “equalshare” (default) – split equally
 - “capacityweighted” – split based relative inlet capacity
 - “priorityorder” – order specified by inletPriority on mseNode
- Allocations based on outlet rules:
 - “equalshare” (default) – the same percent reduction applied to to all water supply outlets
 - “priorityorder” – full releases made in order, until supply is exhausted. Order defined by wsPriority on <inlet>
- Alternative demand and allocation methods handled by “packages”:
 - “losa” – agricultural demand in the Lake Okeechobee Service Area
 - “losaA” – agricultural and estuary demand in Caloosahatchee basin with Lake Okeechobee and C-43 reservoir interaction
 - “losaB” – agricultural in St Lucie basin

The water supply assessor determines the amount of water necessary to maintain the specific water level in the WCU. There are several options for applying the WS assessors. These include alternative methods of applying the demand among multiple inlets and similarly for multiple outlets. Specific “packages” have been created for selected structures and WCUs for applying a specific set of flow equations and management rules. The parameters and the input time series for the packages are specified in the input XML.

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WcuAssessors for Flood Control



- Excess is generally defined as the volume above an fcLevel
- Flood control releases to multiple outlets are governed by outlet rules:
 - “capacityweighted” (default) – distribution based on relative outlet capacity
 - “priorityorder” – fcPriority defined on mseNode
- Alternative excess definitions and outlet rules are handled through packages:
 - “pulse” – pulse releases from Lake Okeechobee
 - “losaA” – Caloosahatchee basin with reservoir interaction
 - “ukiss” – Upper Kissimmee lake releases
 - lkissQTW – tailwater effects for Lower Kissimmee
 - lkissQTW_reg – tailwater effects and regulation schedule
 - dimAnal – flow equations based on dimensional analysis

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The FC assessor determines the amount of water that needs to be released from the WCU. Where there are multiple outlets the amount of water released through each outlet is determined by the weighted design capacity of each structure or by management defined priority. For selected WCUs there are specific packages of management rules and structure flow equations. These include the following:

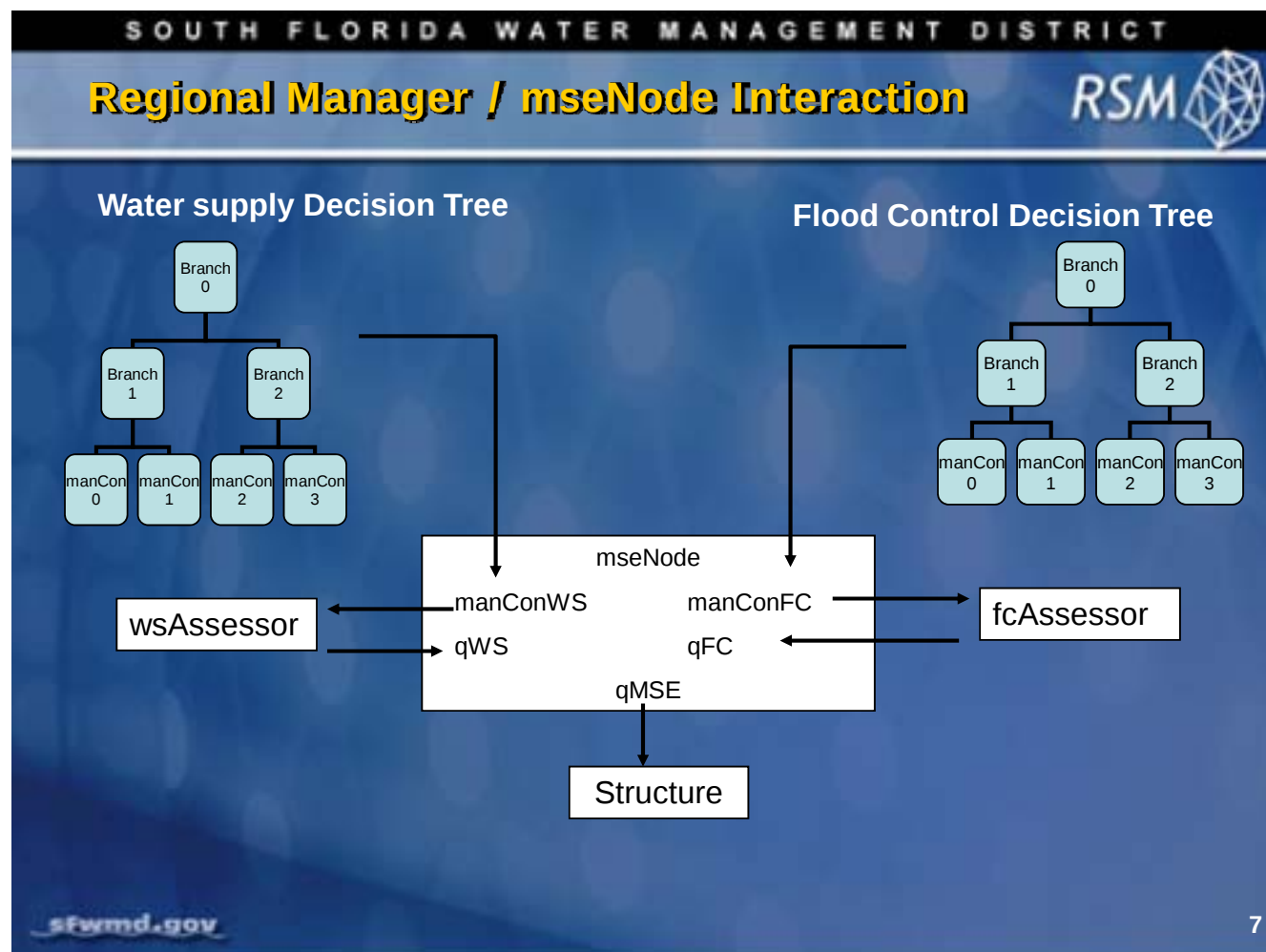
flowProg - District’s FLOW program

ukiss – original KROUTE model (Fan, 1986) aka FLOW

ukissA - ukiss package with a user specified tail water head feature

ukissB - ukiss package with modifications to address large fluctuations and unrealistic flow estimates when tailwater > crest elevation (EarthTech and Hydrologics, 2006). Currently used in kub model for all spillways

dimAnal - flow equations based on dimensional analysis (Ansar et al, 2005)



The regional managers are used to implement the regulation schedules and regional management rules for flood control, water supply and environmental protection. The regional management is implemented through decision trees. At each mseNode the wsAssessor and the fcAssessor determine the amount of flow at each structure and the regional manager determines whether the structure is open or closed based on the beginning of the time step state variable values.

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AssessorCoordinator

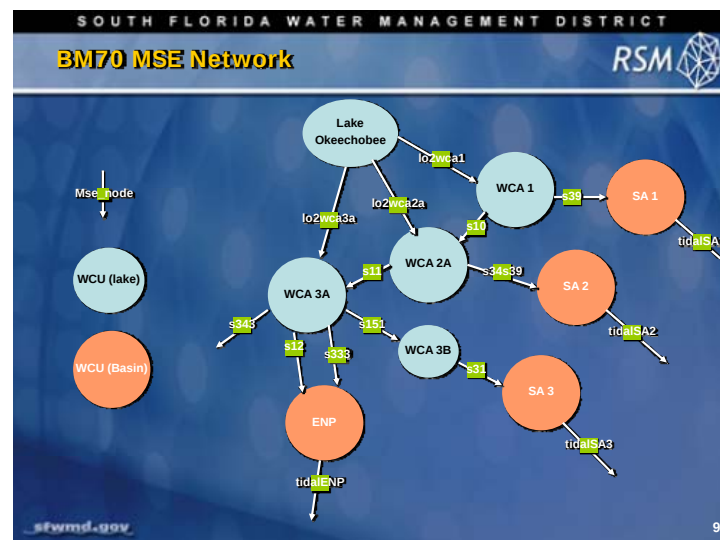
RSM

- Coordinates the processing of assessors
 - User specifies the order in a list
- Water supply
 - Set initial demand on water supply inlet(s)
 - Processed downstream to upstream
 - Set allocated flow on water supply outlet(s)
 - Processed upstream to downstream
- Flood Control
 - Set release on flood control outlet(s)
 - Processed upstream to downstream
 - "fcRecursion" levels can be set to assess downstream impacts

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The assessor coordinator determines the order in which the water supply and flood control features are implemented. This may be obvious in a linear series of lakes and basins but more complicated where there are branches and multiple inflows to Lake Okeechobee (LOK). The inlet and outlet releases serve as boundary flows to upstream and downstream WCUs. The `<fcAssessor>` and `<wsAssessor>` specifications are distributed in the MSE Network with their respective WCU.



This is an illustration of the MSE Network approach used in the linked-node RSM for refining the configuration of the water management system. The system is defined as a set of lakes and basins connected by the MSE nodes. This is fully defined by the MSE network. The XML files are presented in benchmark BM70.

There are several types of assessors used in this benchmark. There are assessors for determining water supply using various methods, such as comparing current water levels with defined schedules, time series on constant values. There are FC assessors for

lakes. The processes are different from those FC assessors used for basins and meshes. There are specific assessors made for selected WCUs; one specific FC assessor which was developed for WCA-3A. There are multiple outlets and there is a specific rule for determining how much water is released through the specific structures for WCA-3A. On the source code side, there is a subclass of the FC assessors that contains the specific rules. On the XML side, there are additional specifications for the BasinFC assessor. This code exists for the basin waterbody, but not for a mesh. The AssessorCoordinator will handle them the same way in the order presented in the XML input file. There are FC assessors for each of the waterbodies. There are WS assessors for selected waterbodies. The AssessorCoordinator implements the appropriate assessors in order. A comprehensive linked-node RSM is being developed to include all major operations within the Central and Southern Florida Flood Control Project (CSFFCP).

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Linked-node RSM: XML blocks

RSM

- **Control**
- **lakes**
- **basins**
- **watermovers**
- **mse_network: mse_units & mse_nodes**
- **assessors: special assessors & assessor coordinator**
- **rule curves**
- **regionalManagers: decision trees**
- **Output**
 - **monitors**
 - **budgetpackages**

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The typical linked-node RSM implementation contains these XML blocks. The HSE components contain the description of the waterbodies used in the mse_units are commonly lakes and basins, as well as the watermovers which are managed by the MSE. The MSE consists of the mse_network which describes the WCUs in the <mse_unit> elements and <mse_node> elements.

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Lakes

```

<!-- lake specifications for Water Conservation Area 1 -->

<lake id="102" head0="17.07">
  &wcal_stgsto;
  &wcal_stgarea;
  <refet>
    <dss file="tsdata/weather.dss"
      pn="/SFRRM/WCA/EVAPI//1DAY/COE ESTIMATE/"
      mult="0.0833" units="inches">
    </dss>
  </refet>
  <rain><const value="0.0"></const></rain>
</lake>
<hpmEntry id="102"><lakeET package="pan-variableArea"> 1.0 </lakeET></hpmEntry>

<lakesource lakeID="102" label="wcal_mds">
  <dss file="tsdata/bcFlows.dss"
    pn="/sfrmm/cal/delta storage//1day/1.3 prep model/"
    mult="0.5042" units="acft" type="per-aver" />
</lakesource>

<!-- eaa to wcal flows -->
<lakesource id="10033" lakeID="102" label="s5as">
  <dss file="tsdata/flowways2.dss"
    pn="/FLOWWAY/S5AS/FLOW//1DAY/ORIG/" mult="0.5042" units="acft" type="per-aver" />
</lakesource>

<lakesource id="10034" lakeID="102" label="s6">
  <dss file="tsdata/flowways2.dss"
    pn="/FLOWWAY/S6/FLOW//1DAY/ORIG/" mult="0.5042" units="acft" type="per-aver" />
</lakesource>

```

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The typical lake specification includes the stage-volume and stage-area relationships, appropriate rainfall and refET sources data. The **<hpmEntry>** provides the evaporation function for the lake based on the lake area. There can be boundary condition inflows and outflows that are included as historical time series, outputs from other models are rule curves containing design flows.

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Basins

RSM

```
<!-- basin specifications for Service Area 1 -->
<basin id="8006" label="sa1" area="65.340e+06" initial_head="14.0"
      elev="17.0">
  <sv>
    10.0    0.0
    17.0  91.48e+06
    20.0 287.50e+06
  </sv>

  <!-- rainfall and reference ET are defined as a tsNode -->
  <rain>  <const value="0.0" /> </rain>
  <refet> <const value="0.0" /> </refet>
</basin>
```



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The basins are defined in a similar way in the XML files. There is a stage-volume relationship that defines the water storage at different stages taking into account the change in topography in the basin and the storage capacity of the soil, microtopography and the surficial aquifer. The surface area may be fixed or it may be adjusted for the area of the reservoirs and STAs implemented in the basin. In this case the data was taken from the South Florida Regional Routing Model: with the base at 10.0 ft and the average land surface (elev) at 17.0 ft. The storage is 1500 ac-ft (65.34e06 ft) and "active groundwater storage" with 0.2 ft/ft soil the storage and the land surface is 65.34e06 ft². In this instance the rain and refET are set to zero and the net runoff for the basin is applied as a boundary condition (not shown).

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Watermovers

```

<watermovers>
  <!-- Lake Okeechobee outlets -->
  <canal wmID="801" id1="101" id2="102" package="ormWPB" label="lo2wca1" />
  <canal wmID="802" id1="101" id2="103" package="ormNNR" label="lo2wca2a" />

  <!-- Water Conservation Area 1 outlets -->
  <specWM wmID="811" id1="102" id2="8006" package="ormS39" label="s39" />
  <specWM wmID="812" id1="102" id2="103" package="ormS10" label="s10">
    <rcmonitor id="16" /> </specWM>

  <!-- Service Area 1 outlets -->
  <specWM wmID="813" id1="8006" id2="9999" package="designCap" label="tidalSA1">
    <A> 10000 </A> </specWM>
  <specWM wmID="817" id1="8006" id2="9999" package="designCap" label="salDemandNode">
    <A> 10000 </A> </specWM>

  <single_control id1="105" id2="106" wmID="821" control="105" cutoff="8.0"
    gravflow="yes" revflow="no" label="l67gap">
    5.5 0.0
    8.0 0.0
    11.0 500.0
    20.0 500.0
  </single_control>
    
```

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The watermovers include specialized watermovers **<specWM>** which are controlled mse_nodes and typically are assigned a design capacity. Other **<specWM>** are managed using specific “packages” that contain specific structure equations and local management constraints that have been published in various SFWMD and USCAE documents. Other watermovers are defined by the canals on which they occur and the specific calculation packages for allowable structure discharge based on the available capacity. It is also possible to use simple watermovers such as **<single_control>**, modeling a simple pump. Each of these watermovers except the pumps are managed using the mse_network.

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MSE network

```

<mse_network name="run25 Network" type="simple">
  <version/>
  <mse_nodes>
    <mse_node name="lo2wca1" watermover="lo2wca1" purpose="wsfc" assessed="yes" managed="yes"> </mse_node>
    <mse_node name="s39" watermover="s39" purpose="wsfc" assessed="yes" managed="yes" fcPriority="1"/>
    <mse_node name="s10" watermover="s10" | purpose="fc" assessed="yes" managed="yes" fcPriority="1">
      <twHeadLimit><rc id="9" /> </twHeadLimit>
    </mse_node>
    ...
  </mse_nodes>

  <mse_units>
    <mse_unit name="wca1">
      <lakes> 102 </lakes>
      <inlet> "lo2wca1" </inlet>
      <inlet> "hillsboroCanal" </inlet>
      <outlet> "s10" </outlet>
      <outlet> "s39" </outlet>
      <localLevel> <const value="14.0" /> </localLevel>
      <fcLevel> <rc id="16" /> </fcLevel>
      <fcAssessor asmtID="1002" />
      <wsAssessor asmtID="2002" package="dmndTS" >
        <dssmonitor quantity="flow" file="tsdata/dmndFlows.dss" pn="/SFWMM/BMP/REPLWATER//1DAY/RULE/" />
      </wsAssessor>
      ...
    </mse_unit>
  </mse_units>

```

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The MSE network is composed of a group of WCUs described by **<mse_units>** and the connecting watermovers representing structures at **<mse_nodes>**. The **<mse_nodes>** identify the associated watermover, the purpose of the MSE node and whether the node is assessed and managed.

The **<mse_unit>** identifies the type of WCU; lake or basin, inlets, outlets, control levels and the associated assessors. For the FC assessor the standard default assessor is applied. For the WS assessor, a specific package, dmndTS, is applied as a time series of flows provided by the SFWMM model output to the water supply requirements for WCA1. For this package the maintenance level is not provided.

Specialized Assessors



```

<!-- =====
                        Assessor for S12 flood control release
===== -->
<statassessor asmtID="901" package="TwoPointInterp" >
  <A> 1125 0 </A>
  <B> <rcmonitor id="13" /></B>
  <C> <rcmonitor id="12" /></C>
  <D><lakemonitor id="105" attr="head" /></D>
</statassessor>
<!-- =====
                        Assessor for S333 flood control release
===== -->
<LinWeightedConst asmtID="902" value="1375">
  <A><rcmonitor id="13" /></A>
  <B><rcmonitor id="12" /></B>
  <target><lakemonitor id="105" attr="head" /></target>
</LinWeightedConst>
<!-- =====
                        Assessor for S31 flood control release
===== -->
<TEMultiplier asmtID="903">
  <tableEntries>
    0.10    0.0
    0.17    0.25
    0.23    0.50
  </tableEntries>
  <A><tsmonitor id="7"/></A>
  <B><wmmonitor wmID="808" attr="maxflow" /></B>
</TEMultiplier>

```

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The first assessor, **<statassessor>**, is the state assessor with the two point interpolation package. This assessor will assign the flow to the mseNode based on the location of the lake head between the two rule curve values for that day and then apply that ratio to the flow range of 0 to 1125.

The second assessor, **<LinWeightedConst>**, is similar to the first assessor except the range of possible flows is not provided and the assessor outputs a value between 0 and 1.

The third assessor, **<TEMultiplier>**, is the table entry assessor. In this case the maxflow is reduced by 0%, 25% or 50% based on whether the **<tsmonitor>**, which monitors rainfall, exceeds the values in the table.

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Specialized Assessors

```

<pulseRelease asmtID="911" ntwkID="99" wcu="lo" node="s308" levels="3">
  <pulseHydrograph name="level1" package="wse" manCon="6" >
    <decisionTreeEntry managerID="1" name="s308" />
    <hydrograph days="10">
      1200 1600 1400 1000 700
      600 400 400 0 0
    </hydrograph>
  </pulseHydrograph>
  <pulseHydrograph name="level2" package="wse" manCon="5" >
    <decisionTreeEntry managerID="1" name="s308" />
    <hydrograph days="10">
      1500 2000 1800 1200 900
      700 500 500 400 0
    </hydrograph>
  </pulseHydrograph>
  <pulseHydrograph name="level3" package="wse" manCon="4" >
    <decisionTreeEntry managerID="1" name="s308" />
    <hydrograph days="10">
      1800 2400 2100 1500 1000
      900 600 600 400 400
    </hydrograph>
  <!-- maximum pulse release -->
  <manCon id="4" purpose="floodcontrol" label="Level 3 Pulse Release" >
    <const value="2400" /></manCon>

  <manCon id="5" purpose="floodcontrol" label="Level 2 Pulse Release" >
    <const value="2000" /></manCon>

  <manCon id="6" purpose="floodcontrol" label="Level 1 Pulse Release" >
    <const value="1600" /></manCon>

```

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The **<pulseRelease>** assessors are used to set the flow release from a selected waterbody (LOK) based on the WSE decision tree (see slide 25-26). This is for managing the flows at structure "s308". Depending on the lake level and other conditions, pulse releases are initiated from the lake and the pulses consist of specific flows over a ten day period. This example demonstrates the flexibility of the assessor construct for setting flows for individual structures.

Rulecurves



```
<rulecurves>
  <!-- Rule Curves for Water Conservation Area 1 -->
  <rcentry id="8" label="wcal A1" xunits="1day" yunits="ft" type="inst-val" cycle="1year">
    01jan 18.170
    13may 16.750
    07jul 16.750
    24sep 18.500
    30nov 18.500
    31dec 18.170
  </rcentry>

  <rcentry id="16" label="wcal level 1" xunits="1day" yunits="ft" type="inst-val" cycle="1year">
    01jan 17.17
    13may 15.75
    07jul 15.75
    24sep 17.50
    30nov 17.50
    31dec 17.17
  </rcentry>
```

Rule curves are used to represent cyclic stage schedules for lakes, water conservation areas, reservoirs and STAs. These typically allow for a higher stage during the dry season.

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Regional managers

```

<decisionTree name="lo2wca3a_fc" ntwkID="99" mseNode="lo2wca3a">

  <branch id="0" true="branch-1" false="manCon-0">
    <ABInequalityTest mode="GE">
      <A> <lakemonitor id="101" attr="head" /></A>
      <B> <rcmonitor id="6" /></B>
    </ABInequalityTest>
  </branch>

  <branch id="1" true="branch-2" false="manCon-0">
    <ABInequalityTest mode="LE">
      <A> <lakemonitor id="105" attr="head" /></A>
      <B> <rcmonitor id="10" /></B>
    </ABInequalityTest>
  </branch>

  <branch id="2" true="manCon-0" false="manCon-1">
    <ABInequalityTest mode="GT">
      <A> <tsmonitor id="5" /></A>
      <B> <const value="0.0" /></B>
    </ABInequalityTest>
  </branch>

  <manCon id="0" purpose="floodcontrol"> <const value="0.0" /></manCon>
  <manCon id="1" purpose="floodcontrol"> <const value="10e10" /></manCon>
</decisionTree>

```

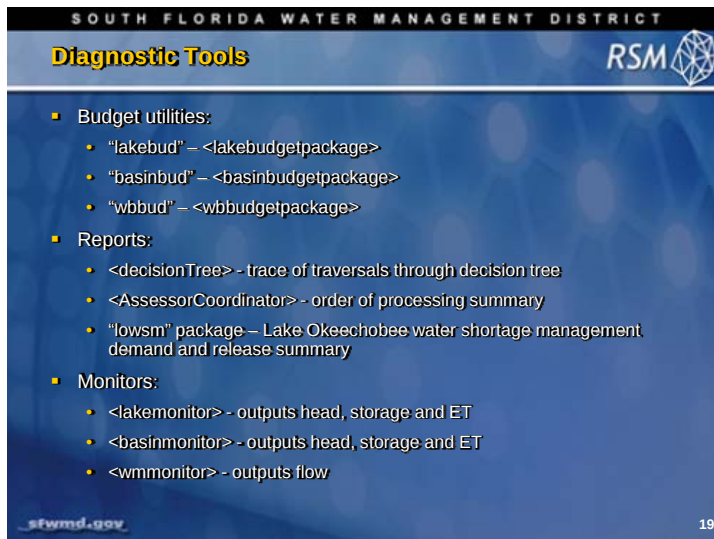
} **Test Lake Level**

} **Test receiving waterbody level (WCA-3A)**

} **Test for local flooding in Miami basin**

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This is decision tree for LOK to WCA-3a flow-way from Benchmark 70. This XML code describes a decision tree which specifies the management constraints applied to the release of water. This decision tree controls how much flood control water can be passed from a lake to a WCA. First, the level in LOK is compared to a rule curve for the stage schedule. If the stage is below the curve ($A < B$) control passes to manCon-0 which sets the flow to zero. If stage is greater than the curve, the stage in WCA-3A is compared to the regulation stage schedule. If the stage is greater than the rule curve, manCon is set to zero. If stage is less than the rule curve, control is passed to the last decision test. If the tsmonitor is greater than zero the manCon is set to zero, otherwise the manCon returns a very high value, essentially setting the flow control to the highest possible value.



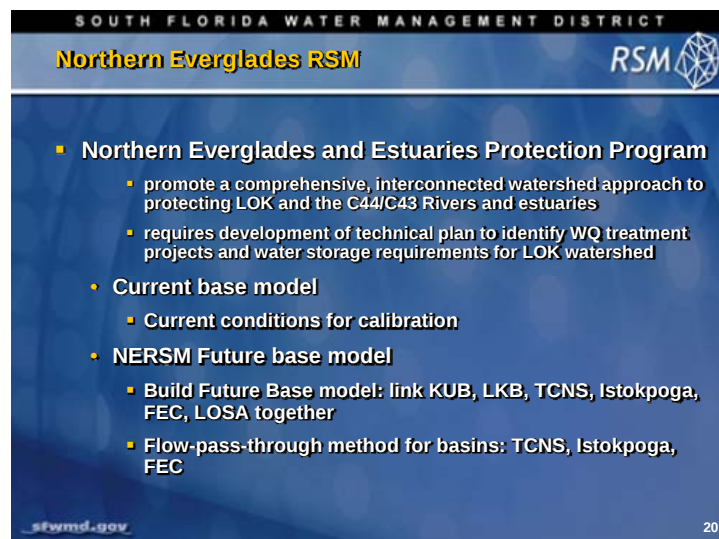
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Diagnostic Tools RSM

- Budget utilities:
 - "lakebud" – <lakebudgetpackage>
 - "basinbud" – <basinbudgetpackage>
 - "wbbud" – <wbbudgetpackage>
- Reports:
 - <decisionTree> - trace of traversals through decision tree
 - <AssessorCoordinator> - order of processing summary
 - "lowsm" package – Lake Okeechobee water shortage management demand and release summary
- Monitors:
 - <lakemonitor> - outputs head, storage and ET
 - <basinmonitor> - outputs head, storage and ET
 - <wmmmonitor> - outputs flow

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There are several outputs that are useful for monitoring the performance of the model as well as determining where there are problems with the model. The budget utilities are used to check the water budgets for each of the WCUs to ensure that the results are appropriate. There are several reports that document the structure flow decisions and implementation of the various structure or WCU specific packages. These are useful because of the complexity of the decisions and wide variety of possible system states. The standard monitors are available for all state variables and dynamic variables.



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Northern Everglades RSM RSM

- Northern Everglades and Estuaries Protection Program
 - promote a comprehensive, interconnected watershed approach to protecting LOK and the C44/C43 Rivers and estuaries
 - requires development of technical plan to identify WQ treatment projects and water storage requirements for LOK watershed
- Current base model
 - Current conditions for calibration
- NERSM Future base model
 - Build Future Base model: link KUB, LKB, TCNS, Istokpoga, FEC, LOSA together
 - Flow-pass-through method for basins: TCNS, Istokpoga, FEC

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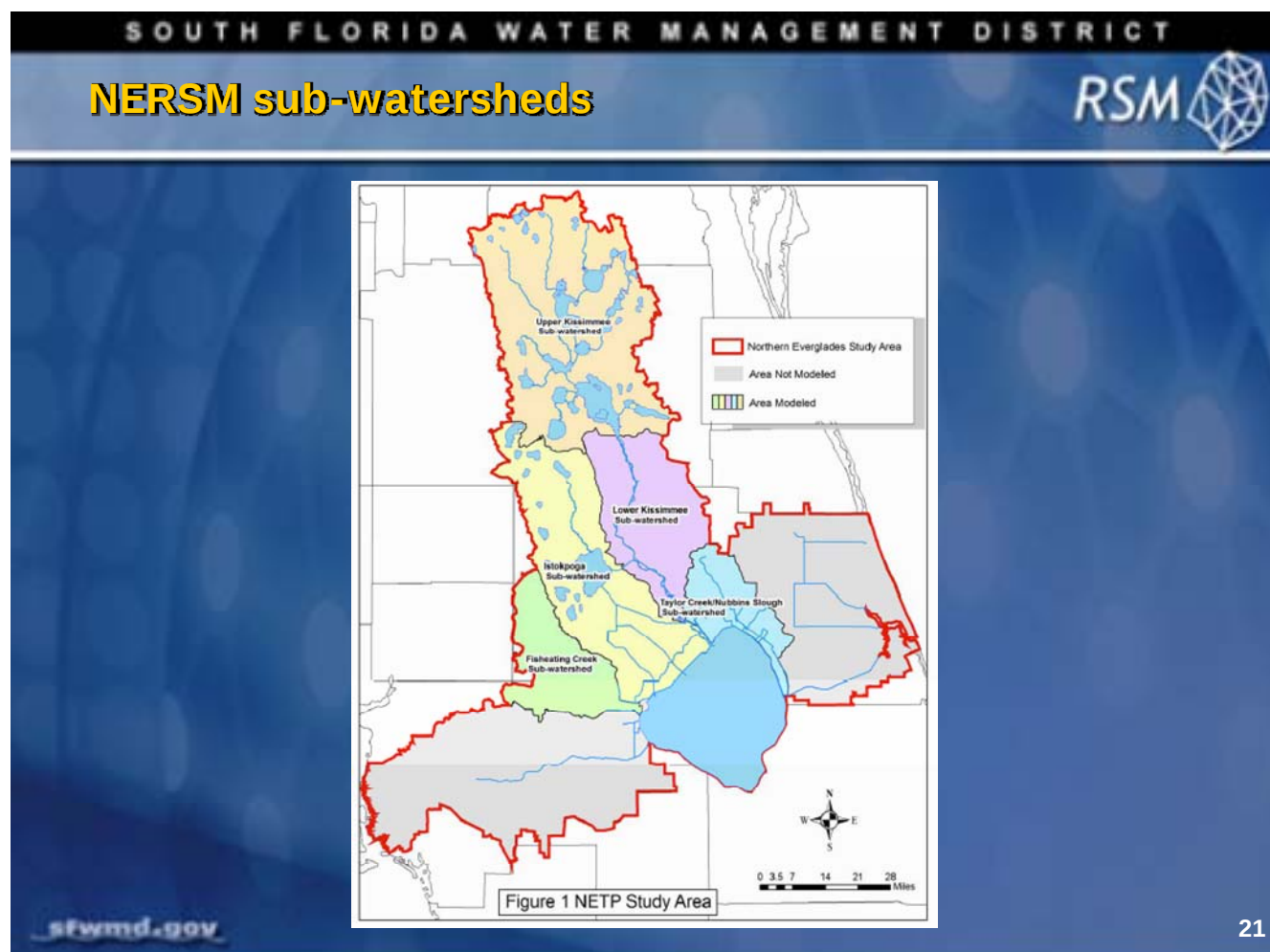
The model should reflect conditions around the year 2015 when all Acceler8 projects are in place. The future condition also assumes that the Kissimmee River Restoration and the Kissimmee River Headwaters Revitalization projects are in place.

Basins: flow-pass-through method. Taylor Creek/Nubbin Slough; Lake Istokpoga Basin; Fisheating Creek Basin are all simulated as flow-pass-through: historical flow is imposed as boundary conditions. The basin is not simulated in the model due to the lack of detailed topography in this

region. The flow will pass through the basin and discharge into LOK. Historical flow patterns from these basins into LOK are assumed to be preserved while simulating management measures.

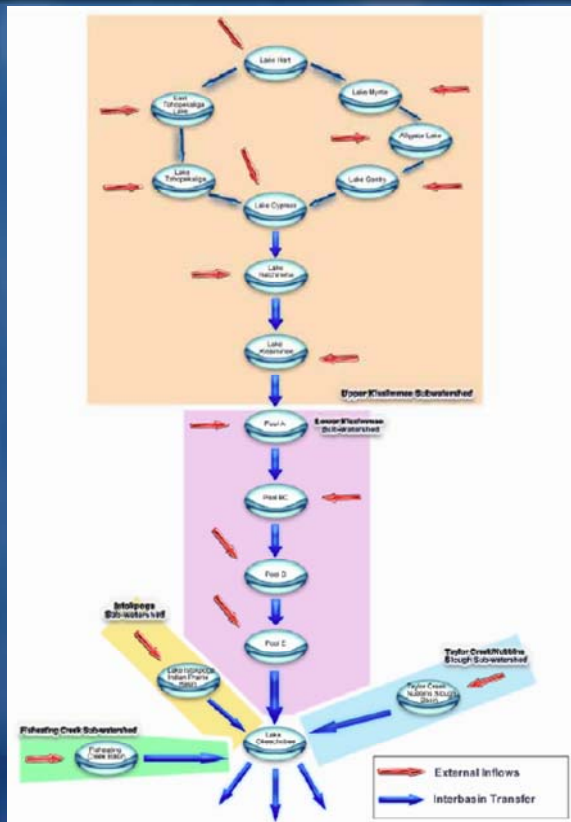
In different alternatives, the flow in the basin will be diverted to reservoirs and STAs. Rainfall-runoff relationships and drainage/routing characteristics within a sub-watershed are assumed not to change from before to after management measures are operational. The volume of divertible runoff from a management measure, such as a reservoir, is equal to the total historical sub-watershed outflow reduced by the ratio of the total footprint of the management measure and total area of the sub-watershed.

More details on the plan and the modeling can be found at <https://my.sfwmd.gov/northerneverglades>.



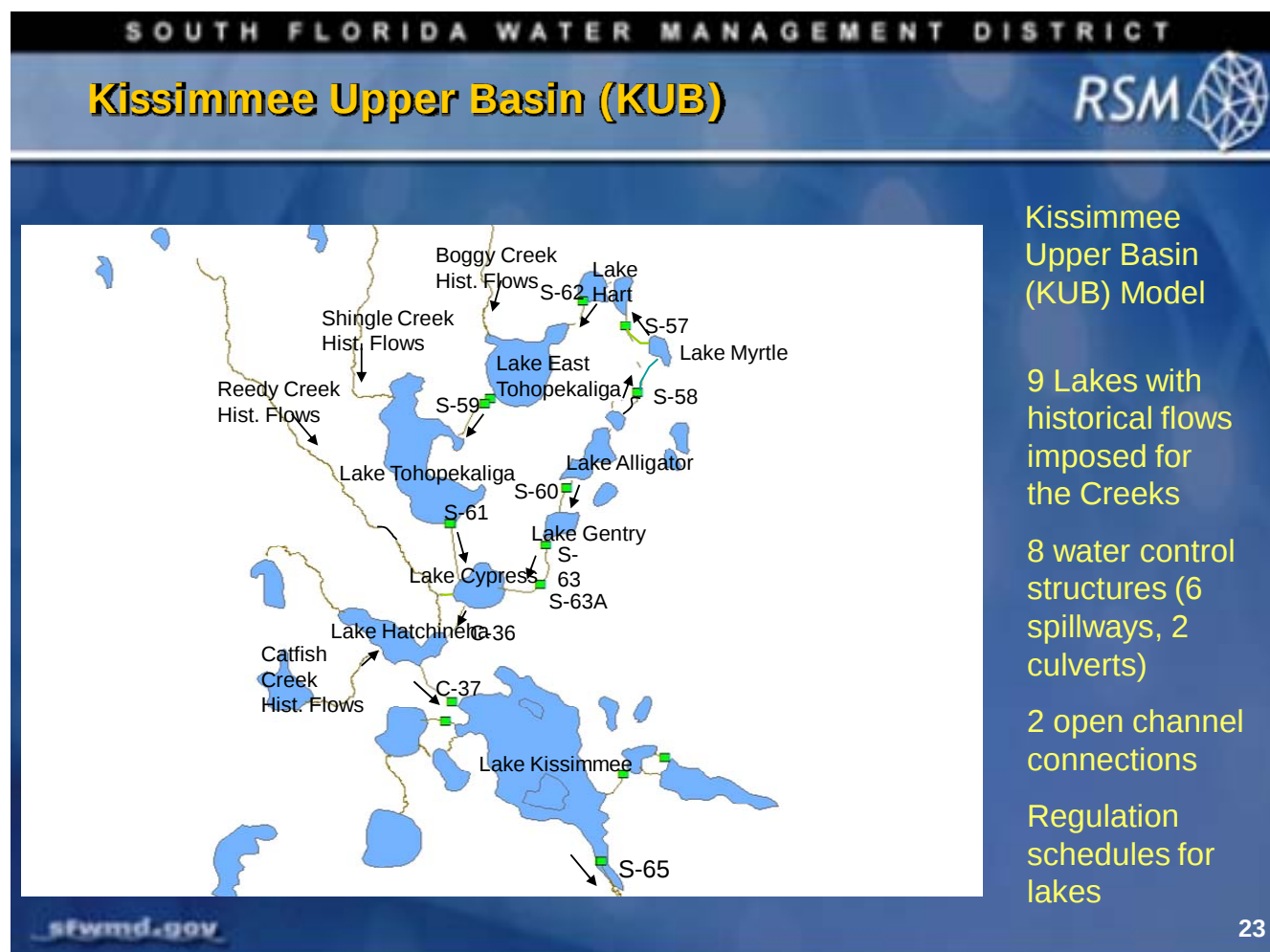
The Northern Everglades model simulates the five basins of the Northern Everglades region as well as LOK. The estuarine basins are not included in this version of the model. The model should reflect conditions around the year 2015 when all Acceler8 projects are in place. The future condition also assumes that the Kissimmee River Restoration and the Kissimmee River Headwaters Revitalization projects are in place. Period of simulation is 1970 to 2005. Model timestep is daily.

NERSM: link-node representation

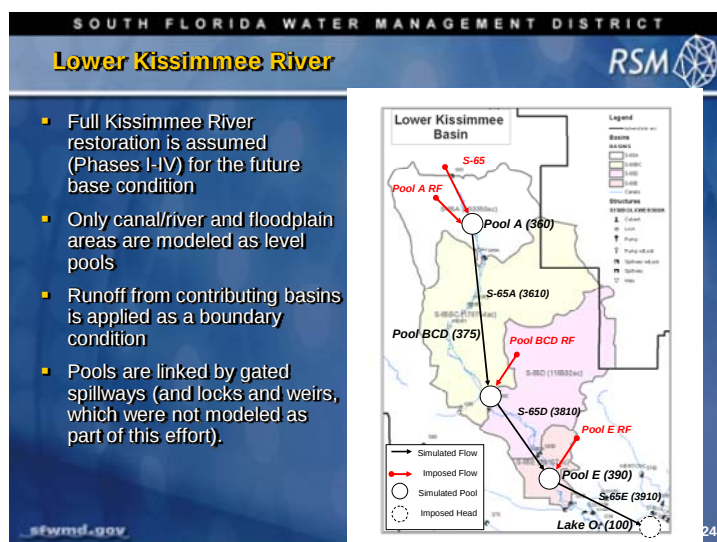


22

NERSM – basin budget/link-node implementation of the RSM. It is the first regional model that links the simulation of the Kissimmee Upper Chain of Lakes to the simulation of LOK. The various components of the system will be represented by lakes and basins with watershed inflows as boundary conditions.



The Kissimmee Upper Basin (KUB) model is designed to simulate the lake system in the Upper Kissimmee basin. Lakes are assumed to be level pools and storage routing is based on mass balance. Watershed inflows to the lakes were based on the datasets developed as a part of the calibration of the UKISSWIN model. Historical flows obtained from USGS for Shingle, Boggy, Reedy and Catfish creeks were also imposed as boundary conditions for the lakes Toho, East Toho, Cypress and Hatchineha. For Reedy Creek the flow split was assumed to be 70% into Lake Hatchineha and 30% into Lake Cypress. The KUB model simulates the management of the KUB lakes and canal system with a set of management rules implemented in the model as regulation schedules, gate operation criteria, and rules of operation of the water control structures. Rainfall and ET data were derived from the time series developed for the SFWMM (extended “super grid”) for the climatic period of record 1970-2005.



Level pool approximation is reasonable for Pools A & E, where the main conveyance element is the channelized Kissimmee River. However, river head drops on the restored portion of the river (Pool BCD) are expected to be significant.

Steady-state HEC-RAS model results show that lateral inflows (runoff) have a minor effect on the S-Q-H relationships for the pools (EarthTech, 2006). A single SV relationship was selected for each channelized pool by assuming no lateral inflows and the flows through the pool are equal to the design flow of the upstream

structure.

For the restored portion of the Kissimmee River (Pool BC), these relationships were further manipulated and defined in terms of average heads at the upstream and downstream ends of the pool.

Based on the HEC-RAS simulations, flows through Pool BCD are only dependent on S-65A TW stages (a mild slope condition develops where water depth approaches normal depth at the upstream end of the reach, i.e. Manning's equation applies). Therefore, a Q-TW relationship was used at S-65A to account for local tailwater constraints.

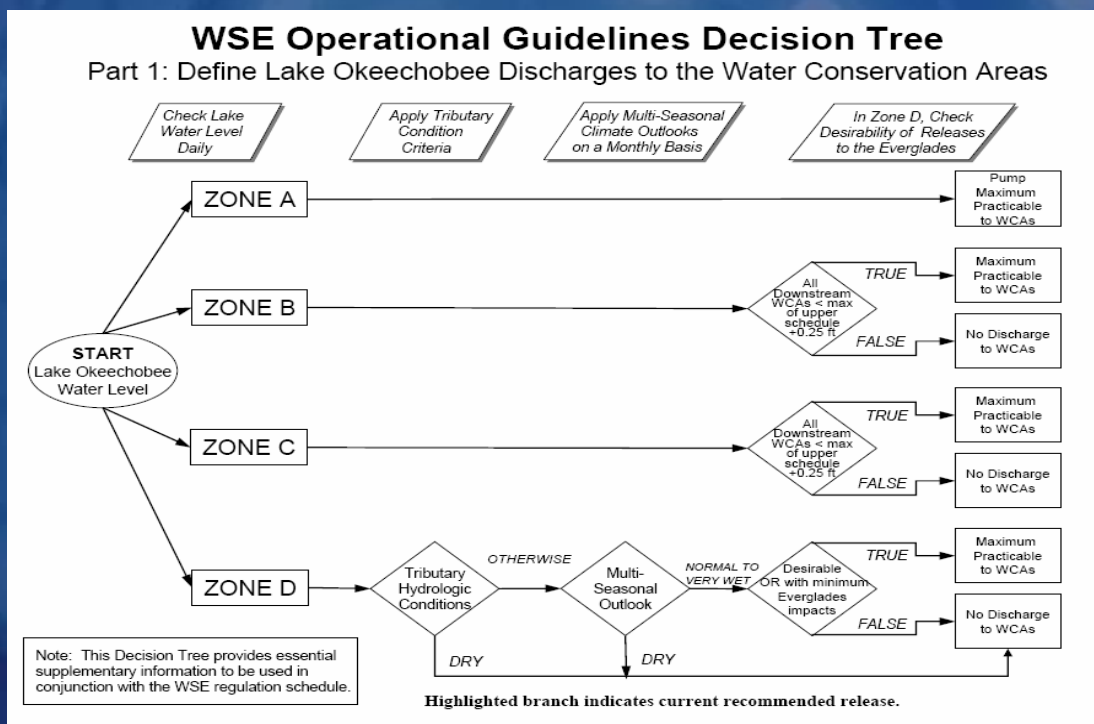
Consistent with the SFWMM methodology for translating S-65 into S-65E flows, lateral inflows were estimated based on historical S-65E – S-65 flows (9.8 in/yr). Runoff was prorated based on each contributing basin area and the resulting time series were imposed as boundary conditions to each level-pool.

Rainfall obtained from the 1914-2005 2-mi x 2-mi rainfall binary developed for the SFWMM.

Reference ET obtained from the 1948-2005 2-mi x 2-mi binary file based on the FAO-56 Penman-Monteith reference equation.

Spillways are simulated based on new District rating curves developed from dimensional analysis (Ansar et al., 2005) and MAGO curves. Spillways are operated primarily for flood control, but in the future S-65D will also be operated to meet hydroperiod objectives in the restored Pool BCD.

Lake Okeechobee management

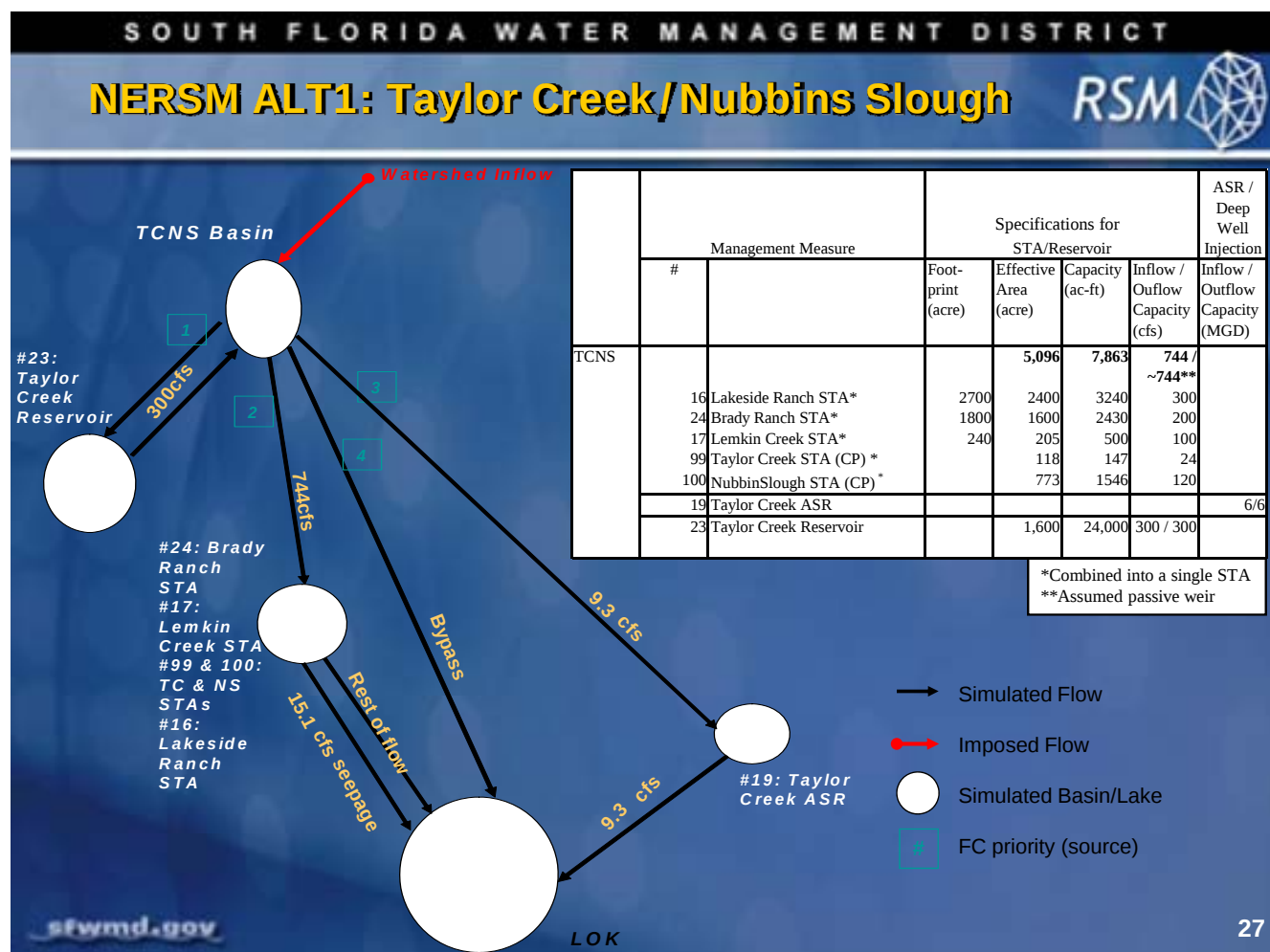


25

The decision tree for LOK water release comes in two parts, discharges to the water conservation areas and discharges to the estuaries (next slide).



[No notes provided for this slide.]



27

Several alternative plan formulations for future projects to improve water supply and water quality in the Northern Everglades watershed. Each alternative simulated several “management measures” defined as structural or water management changes to the system. The alternative 1, ALT1, management measures for Taylor Creek/Nubbins Slough includes several STAs, an ARS and a reservoir. The STAs are combined together into a single STA for modeling purposes. The system is simulated as one basin (TCNS) and several lakes. The NETP required the simulation of four alternative groups of “management measures” to improve water supply and water quality in the Northern Everglades. This discussion includes the management measures for Alternative 1.



NOTE:

The seven management measures identified in the table are grouped into three features in the model. The table can be found on the Northern Everglades website at http://www.sfwmd.gov/portal/page/portal/pg_grp_sfwmd_koe/pg_sfwmd_koe_northerneverglades in Appendix B (Northern Everglades Regional Simulation Model) of the Lake Okeechobee Watershed Construction Project, Phase II Technical Plan.

SOUTH FLORIDA WATER MANAGEMENT DISTRICT

MSE network: mse_nodes

```

<!-- to Taylor Creek Reservoir: 300cfs -->
  <mse_node name="tcnsResIn" watermover="tcnsResIn" purpose="fc" managed="yes" fcPriority="1"/>

<!-- to tcns lump STA: 300 + 444 = 744 cfs -->
  <mse_node name="tcns_lump_StaIn" watermover="tcns_lump_StaIn" purpose="fc" managed="yes" fcPriority="2"/>

<!-- to Taylor Creek ASR: 9.3cfs -->
  <mse_node name="tcnsAsrIn" watermover="tcnsAsrIn" purpose="fc" managed="yes" fcPriority="3"/>

<!-- Taylor Creek Reservoir to basin: 300cfs -->
  <mse_node name="tcnsResOut" watermover="tcnsResOut" purpose="wsfc" managed="yes">
    <minflow purpose="ws"> <const value="300" /> </minflow>
  </mse_node>

<!-- tcns lump STA to LOK: 14.3cfs seepage -->
  <mse_node name="tcns_lump_spg" watermover="tcns_lump_spg" purpose="wsfc" managed="yes">
    <minflow purpose="ws"> <const value="14.3" /> </minflow>
  </mse_node>

  <mse_node name="lumptoLok" watermover="lumptoLok" purpose="fc" managed="yes"/>

<!-- Taylor Creek ASR to LOK: 9.3cfs -->
  <mse_node name="tcnsAsrOut" watermover="tcnsAsrOut" purpose="ws" managed="yes">
    <minflow purpose="ws"> <const value="9.3" /> </minflow>
  </mse_node>

<!-- TCNS basin to LOK: rest of the flow -->
  <mse_node name="tcnstoLok" watermover="tcnstoLok" purpose="fc" managed="yes" fcPriority="4"/>
        
```

28

The MSE network consists of the **<mse_nodes>** and the **<mse_units>**. Inlet structures into management measures are defined as flood control **<mse_node>**s. First priority is to send excess to Reservoirs, then to STAs, thirdly to ASR, and the remainder downstream to LOK. The outlet structures discharge from the **tcns_lump_StaIn** and **tcnsAsrOut** when the stage in LOK falls below the water supply envelope at a rate defined by the **<minflow>** capacity (here fixed as a constant but could be a scheduled flow defined by season). This flow is in addition to the passive weir flow defined in the table in slide 27. Outlet structures also discharging when emergency stage/depth is exceeded are defined as flood control **<mse_node>**s.

MSE network: mse_units



```
<mse_units>
  <mse_unit name="tcns">
    <basins> 501 </basins>
    <inlet> "tcnsResOut" </inlet>
    <outlet> "tcnsResIn" </outlet>
    <outlet> "tcns_lump_StaIn" </outlet>
    <outlet> "tcnsAsrIn" </outlet>
    <outlet> "tcnstoLok" </outlet>
    <fcLevel><const value="14.0" /> </fcLevel>
    <fcAssessor asmtID="500001"/>
    <wsAssessor asmtID="500201" inletRule="PriorityOrder" />
  </mse_unit>

  <mse_unit name="tcns_res">
    <lakes> 591 </lakes>
    <inlet> "tcnsResIn" </inlet>
    <outlet> "tcnsResOut" </outlet>
    <resLevel> <const value="35.6"/> </resLevel>
    <fullLevel> <const value="50.5"/> </fullLevel>
    <fcLevel> <const value="51.0"/> </fcLevel>
    <fcAssessor asmtID="500004" />
    <wsAssessor asmtID="500014" inletRule="PriorityOrder" />
  </mse_unit>
```

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There are four WCUs in the TCNS basin and here are two of those represented as **<mse_unit>**s. The management water levels are set for each of the **<mse_unit>**s. For flood control, outflows are triggered from management measures when its stage exceeds this level. For reservoirs, it is set to its emergency stage/depth and for the STA, it is set to 1.5 ft depth (outlet spillway crest elevation). The **<resLevel>** stops outflows from management measures when its stage goes below this level. This is set to a very low value to prevent management measures from drying up completely (e.g. 0.01 ft depth). The full level stops inflows into management measures when its stage exceeds this level. For the reservoir, it is set to the maximum allowable stage/depth (emergency stage/depth – 0.5 ft).

SOUTH FLORIDA WATER MANAGEMENT DISTRICT

MSE: lakes & basins

```

<lakes>
  <!-- Taylor Creek Reservoir -->
  <lake id="591" head0="35.6" label="tcns_res" package="cylinder">
    <cylinder bot="35.5" toparea="6.97E+07"/>
    <rain>
      <dss file="tsdata/tcns_rf_pet.dss" pn="/NETP/TCNS_new/RF//1DAY/AVERAGE/"
        mult="0.0833" units="INCHES" /> </rain>
    <refet>
      <dss file="tsdata/tcns_rf_pet.dss" pn="/SFWMM/TCNS/PET//1DAY/AVERAGE/"
        mult="0.0833" units="INCHES" /> </refet>
    </lake>
  <hpmEntry id="591"><lakeET package="pan-constantArea"> 0.85 1600 </lakeET></hpmEntry>

  <basin id="501" label="tcns" area="8.4320e+09" initial_head="14.0" elev="15.0">
    <sv>
      11.0 0.0000E+00
      12.0 2.2346E+08
      13.0 4.4964E+08
      14.0 7.8777E+08
      15.0 1.2687E+09
      16.0 2.8566E+09
      17.0 4.4974E+09
      18.0 6.1948E+09
    </sv>
  </basin>
  <basin_bc>
    <basinsource label="tcnsBC" id="50001" basinID="501" package="areaCorrected">
      <dss file="tsdata/tcns_hist.dss" pn="/SFWMM/TCNSQ/FLOW//1DAY/DBHYDRO/"
        mult="1.0" units="cfs"> </dss>
      <B> 591 593 </B>
    </basinsource>
  </basin_bc>

```

30

The TCNS basin includes a basin and three lakes. The lakes, reservoirs, STA and ASR are simulated using cylindrical **<lake>** waterbodies (stage and area are meaningless for ASR). Note: the initial head for the lake is in ft² while the initial area for the **<hpmEntry>** for calculating ET is in acres. The TCNS basin is defined by a fixed area and a stage-volume relationship. The runoff is provided by a boundary condition that provides historical runoff from the basin to the management measures that are located near the outlet to the lake. Runoff generated by the basin must be corrected based on the area occupied by the reservoirs/STAs in the basin (use package="areaCorrected" for basinsource). The element **** for **<basinsource>** provides the IDs for reservoirs/STAs located in the TCNS Basin: 591, Taylor Creek Reservoir; and 593, combined STAs.

NERSM Assessors



```
<mse_network name="NETP_alt!_mseNetwork"> <version/>
  <mse_units>

    <mse_unit name="tcns">
      <basins> 501 </basins>
      <inlet> "tcnsResOut" </inlet>
      <outlet> "tcnsResIn" </outlet>
      <outlet> "tcns_lump_StaIn" </outlet>
      <outlet> "tcnsAsrIn" </outlet>
      <outlet> "tcnstoLok" </outlet>
      <fcLevel><const value="14.0" /> </fcLevel>
      <fcAssessor asmtID="500001" outletRule="priorityorder"/>
      <wsAssessor asmtID="500201" inletRule="PriorityOrder"/>
    </mse_unit>

    <mse_unit name="tcns_res">
      <lakes> 591 </lakes>
      <inlet> "tcnsResIn" </inlet>
      <outlet> "tcnsResOut" </outlet>
      <resLevel> <const value="35.6"/> </resLevel>
      <fullLevel> <const value="50.5"/> </fullLevel>
      <fcLevel> <const value="51.0"/> </fcLevel>
      <fcAssessor asmtID="500004"/>
      <wsAssessor asmtID="500014" inletRule="PriorityOrder"/>
    </mse_unit>
  </mse_units>
```

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The FC and WS assessors used in the TCNS basin are the typical default assessors. As a typical **<mse_unit>**, the TCNS basin is defined as basin "501" with open inlet and several outlets. Notice that the TCNS basin is only managed for flood control level although the wsAssessor is included so that the basin can be used as a source for downstream water supply requirements. The reservoir is managed for water supply based on priority order. A review of the associated **<mse_node>**s would show the priority of each outlet.

SOUTH FLORIDA WATER MANAGEMENT DISTRICT

NERSM Assessors

RSM

```
<mse_unit name="PoolBCD">
  <lakes> 375 </lakes>
  <inlet> "S65A" </inlet>
  <outlet> "S65D" </outlet>
  <fcAssessor asmtID="375001" package="lkissQTW_reg" inletRule="CapacityTest">
    <!--HW versus Q relationship for S65D (kind of a regulation schedule)-->
    <A>
      28.7      0
      28.8      1000
      30.0      3000
      32.4      23500
    </A>
    <!-- Q versus TW relationship for S65A (a physical constraint)-->
    <B>
      100    40.94
      650    43.08
      1250   43.87
      2650   45.14
      4050   46.05
      5450   46.80
      6850   47.50
      8250   48.14
      15100  50.72
      22000  52.63
    </B>
  </fcAssessor>
</mse_unit>
```

32

The TCNS basin only has simple assessors. Here is an example of specialized assessor used for Pool BCD of the Lower Kissimmee River sub-basin. The flood control assessor is solved using a special package that sets the flow based on the tailwater and the headwater levels.

SOUTH FLORIDA WATER MANAGEMENT DISTRICT

Structure Simulation: watermovers

```

<!--=====Alternative 1 specific structures=====-->
<!--300cfs pump to Taylor Creek Reservoir-->
<specWM wmID="5004" id1="501" id2="591" package="designCap" label="tcnsResIn">
  <A> 300 </A>
</specWM>

<!--300cfs pump from Taylor Creek Reservoir to basin-->
<specWM wmID="5005" id1="591" id2="501" package="designCap" label="tcnsResOut">
  <A> 300 </A>
</specWM>

<!--300 + 444 = 744 cfs pump to TCNS lump STA-->
<specWM wmID="5008" id1="501" id2="593" package="designCap" label="tcns_lump_StaIn">
  <A> 744 </A>
</specWM>

<!--7 + 7.3 = 14.3 cfs seepage from lump STA to LOK-->
<specWM wmID="5009" id1="593" id2="100" package="designCap" label="tcns_lump_spg">
  <A> 14.3 </A>
</specWM>

<!-- must insert tcns Lumped STA to LOK: lumptoLok as Broad-crested weir here!!! -->
<genxweir wmID="5010" id1="593" id2="100" fcoeff="3.05" bcoeff="0.0"
  |crestelev="25.62" crestlen="250" dpower="1.5" spower="0.0" label="lumptoLok"/>

```

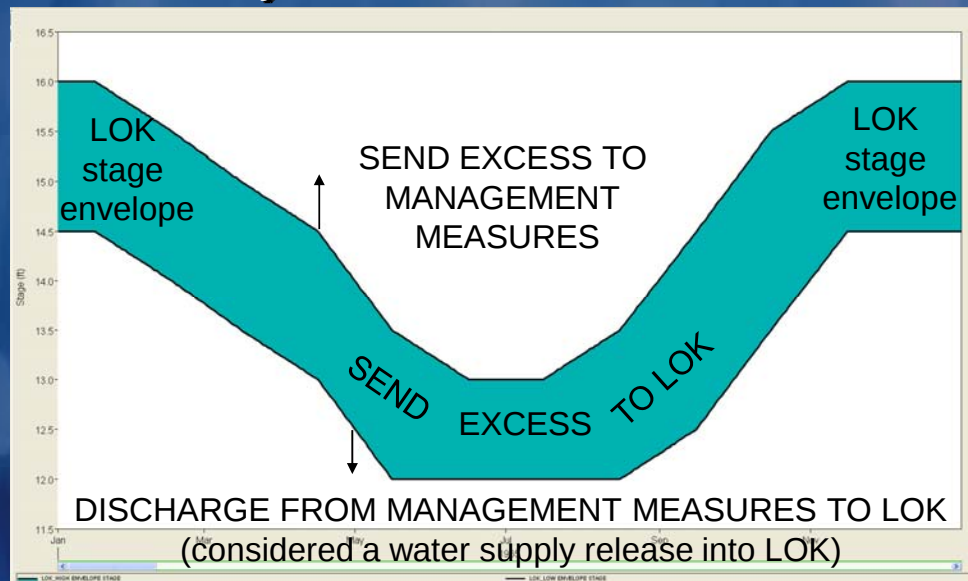
33

Based on the results from the FC and the WS assessors, the MSE nodes set the appropriate flows at the managed structures between the WCUs. Inlet/outlet structures for reservoirs, inlet structures/seepage for STAs, are simulated with a special watermover of constant capacity. This example shows four special watermovers with capacities of 300, 300, 744, and 14.3. The **<genxweir>** is an unmanaged structure in the basin.

Regional Managers: Operations background



- Local basin operations are based on LOK stage as a remote trigger. Depending on LOK stage with respect to its envelope, basin excess and water in storage are routed differently.



34

The Regional Manager for the Northern Everglades is largely determined by the operation of LOK.

When LOK stage is greater than the high envelope line, local basin runoff/excess is sent to management measures. The first priority is to send excess to Reservoirs, then to STAs, thirdly to ASR, and the remainder downstream to LOK. If reservoir/STA stage/depth exceeds a specified maximum stage/depth (emergency stage/depth – 0.5 ft), inflows are not allowed. When LOK stage is less than low envelope line, local basin runoff/excess is discharged from management measures to LOK. When LOK stage is within the envelope, local runoff/excess water will be sent to LOK (through STAs as first priority or directly to LOK as second priority). In addition, if emergency stage/depth in reservoir/STA is exceeded, there is discharge from these facilities to LOK.

Decision trees



```
<decisionTree mseNode="tcnsResOut" name="tcnsResOut" ntwkID="99"
  report="./output_alt1/tcnsResOut_decisiontree_report">

  <!-- Check LOK low envelope stage -->
  <branch false="manCon-3" id="0" label="LOK low envelope stage" true="manCon-2">
    <ABInequalityTest mode="LT">
      <A> <lakemonitor attr="head" id="100"/> </A>
      <B>
        <dssmonitor quantity="stage" file="./tsdata/lok_stage_envelope.dss"
          pn="/NETP/LOK_LOW/STAGE//1DAY/ENVELOPE/"
          units="FT" type="PER-AVER">
        </dssmonitor>
      </B>
    </ABInequalityTest>
  </branch>

  <manCon id="2" label="lok_stg_low" purpose="watersupply"> <const value="300"/></manCon>
  <manCon id="3" label="no_flow" purpose="watersupply"> <const value="0"/></manCon>

</decisionTree>
```

Decision trees are designed and implemented with the regional managers, and they are setup for each management measure inlet/outlet to determine action based on LOK stage. Water management policies at the highest level and spanning multiple WCUs are done through Regional Managers. The decision tree places management constraints (manCon) to limit flood control or water supply releases at a mseNode to a value specified by the regional manager. This decision tree compares the lake levels determined by the **<lakemonitor>** identified in element **<A>** to the LOK stage time series provided by the **<dssmonitor>** in element ****. Based on the results the flow is set to 300 cfs or 0 cfs.

SOUTH FLORIDA WATER MANAGEMENT DISTRICT

Assessor Coordinator


```

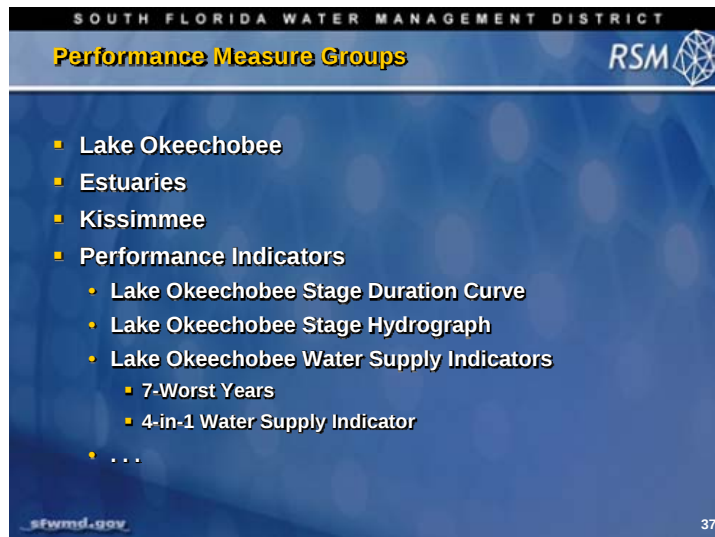
<!--FC assessors must be listed from upstream to downstream-->
<!--Then WS assessors must be listed from downstream to upstream-->

<AssessorCoordinator asmtID="1518" report="./output_atl1/assessor.rpt">
  <FCOrder>
    alligator myrtle hart gentry etoho toho cypress hatch kissimmee
    tcns tcns_res tcns_lump_sta tcns_asr
    IndianPrairie Istokpoga_Reservoir Istokpoga_STA
    PoolA PoolBCD PoolE Dummy_Node LOWP_Kissimmee_Res
    fisheating_creek
    lo c43res caloos stlucie_reg_env hillsboro nnr miami
  </FCOrder>

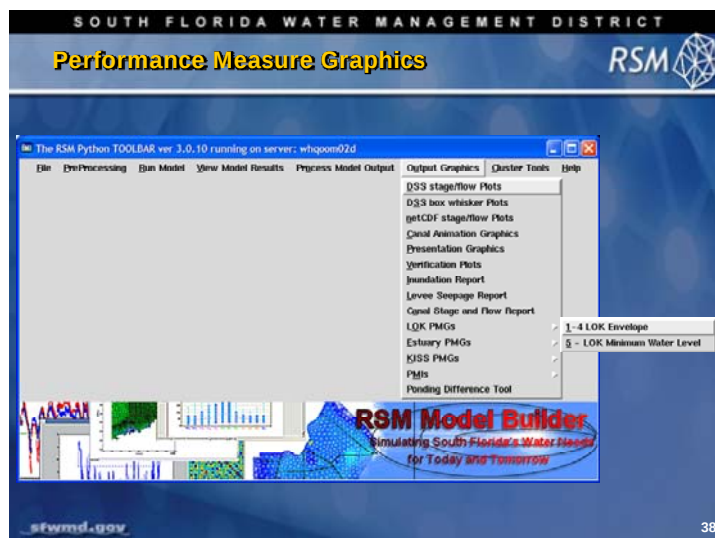
  <WSOrder>
    westcaloosa caloos c43res stlucie_reg_env l8 s4 s236 298d nelkshore nlkshore
    istok stlucie_ag eaa_ws lo
    tcns tcns_asr tcns_lump_sta tcns_res
    Istokpoga_Reservoir Seminole_Brighton_ASR Istokpoga_STA
    Dummy_Node LOWP_Kissimmee_Res Kissimmee_River_ASR PoolE Paradise_Run_ASR
  </WSOrder>
</AssessorCoordinator>
        
```


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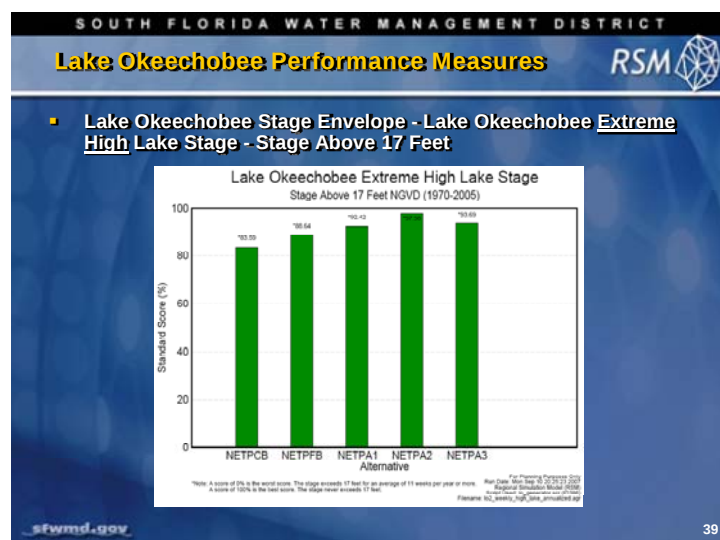
The Assessor Coordinator sets the order in which the mse_units will be resolved. The flood control order starts at the top of the system and the water supply coordinator starts at the bottom of the system. All branches are resolved before the solving the next mse_unit in order. The results of the assessors are output in the assessor report that is used for evaluating the assessors.



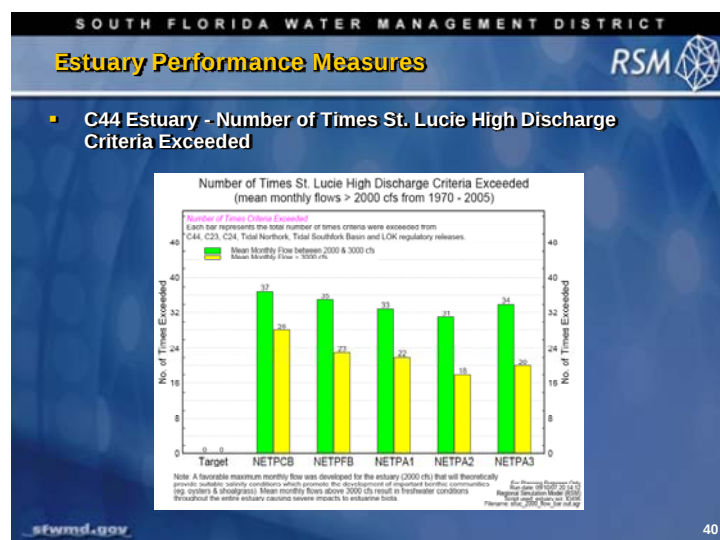
The important output from the NERSM is the presentation of the performance measures which are the model simulation results, system observations and targets that have been agreed upon by the stakeholders for evaluating alternative water resources management strategies. There are separate performance measures for the different parts of the system.



The output from the NERSM is post-processed using the RSM GUI Output Graphics utility to produce performance measure graphics using the standard output from the RSM.



This is an example of one Performance Measure for LOK for five different alternative plan formulations.



This is an example of one Performance Measure graphic for the St. Lucie estuary for five alternative plan formulations. The RSM GUI post-processor uses the data identified by the modeler to create the complete graphic for the stakeholder. The details on the creation of the Performance Measure graphics are described in the RSM GUI User Guide.

KNOWLEDGE ASSESSMENT

(pre- and post-lecture quiz to assess efficacy of training materials)

1. What is the purpose of the WcuAssessor?
2. What do special assessors do?
3. What are the ways the water supply requirements can be apportioned when there are multiple inlets?
4. What is the purpose of “packages”?
5. What is the source of the code used for the packages?
6. How are regional managers implemented?
7. What is the purpose of the Assessor Coordinator?
8. Which HSE features are used in the linked-node implementation of RSM?
9. What kinds of watermovers are typically used in linked-node RSM?
10. How are HPMs implemented in the Northern Everglades RSM?
11. What is the output from a decision tree?
12. What are the final outputs from an RSM implementation run?

Answers

1. The WcuAssessor determines the water supply, flood control or environmental water needs for a Water Control Unit.
2. Special assessors determine the amount of allowable flow through a structure based on special rules or schedules.
3. The water supply requirements can be apportioned as equal share, capacity weighted, or priority order.
4. Packages contain specialized code for assessors that apply to one or more WCUs and structure flow equation's associated mse_nodes.
5. The algorithms and structure flow equations implemented in the packages are typically obtained from other models and hydrologic investigations of selected areas.
6. The regional manager is implemented using decision trees to apply regulation schedules and flood control or water supply rules to determine structure flows.
7. The ordered list of WCUs in the Assessor Coordinator determines the order in which the water supply and flood control features are assessed.
8. The linked-node implementation of RSM uses the lakes, basins and watermovers from the HSE.
9. The common watermovers are specWM and genxweir.
10. The net runoff from local hydrology is implemented as a boundary condition and the NERSM simulates the impact of different management measures on the outflow from each basin.
11. The decision trees produce constraints that are applied to selected structure flows.
12. The final outputs of an RSM implementation run are the Performance Measures that show how well the RSM performed.



Lab 16: MSE Network and NERSM

Time Estimate: 4.0 hours

Training Objective: To gain knowledge of the Management Simulation Engine (MSE) Network and Northern Everglades Regional Simulation Model (NERSM)

The **Management Simulation Engine (MSE)** was developed to impose regional water management policies and rules on the hydrology of the regional system of canals and water management structures. The MSE constructs an abstraction of the system: **Water Control Units (WCUs)** to represent the basins and **MSE-node** to represent water control rules at the structures.

The MSE uses **assessors** to determine, from the **Hydrologic Simulation Engine (HSE)**, the amount of water that needs to be moved through each managed structure to meet the water supply needs and the flood control requirements of the system. The exercises in this lab are designed to review the basic mechanics of using the **MSE assessors**, the **MSE network** and the **SFBasins model**. The exercises also illustrate the effect of changing various system parameters on the behavior of the system.

**NOTE:**

For ease of navigation, you may wish to set an environment variable to the directory where you install the RSM code using the syntax

```
setenv RSM <path>
```

For SFWMD modelers, the path you should use for the NAS is:

```
/nw/oomdata_ws/nw/oom/sfrsm/workdirs/<username>/trunk
```

```
setenv RSM
```

```
/nw/oomdata_ws/nw/oom/sfrsm/workdirs/<username>/trunk
```

Once you have set the RSM environment variable to your trunk path, you can use \$RSM in any path statement, such as:

```
cd $RSM/benchmarks
```

Training files are currently located in the following directories:

```
INTERNAL_TRAINING
|
|___data
|   |___geographic
|   |___C111
|   |___rain+et
|   |___glades_lecsa
|   |___losa_eaa
|   |___BBCW
|
|___trunk
|   |___benchmarks
|   |___hpmbud
|
|___labs
```

Files for this lab are located in the **labs/lab16_assessor** directory. Additional materials in the directory include:

```
DRE - 223 .pdf
MSE_CONTROLLER.pdf
MSE_SUPERVISOR.pdf
bm70.ppt
NERSM_UserGuide.pdf
```

Activity 16.1 MSE_network and SFBasins Model in Benchmark 70

Overview

Activity 16.1 includes one exercise:

- **Exercise 16.1.1.** Review SFBasins RSM

The **MSE_network** was developed to simulate the **Kissimmee Valley** as a linked lake-basin implementation of the **Regional Simulation Model (RSM)**. There is no mesh or **HSE network**. The following exercise investigates the implementation of the **SFBasins RSM**.

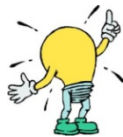
Exercise 16.1.1 Review SFBasins RSM

1. Copy Benchmark 70 to the lab16_assessor directory. All work for this activity will be done in the lab16_assessor/BM70 directory:

```
cp -r $RSM/trunk/benchmarks/BM70 $RSM/labs/lab16_assessor
```

2. Create a diagram (hand sketch) of the **MSENetwork** used in the **run25Network.xml** RSM in **BM70/mse/mseNetwork**. The diagram should include the **waterbodies** (lakes or basins), **nodes** and **boundary conditions**. Use bm70.ppt as a starting point.

HINT



See Lecture slide #9 if you need help getting started.

3. Place the appropriate **IDs** on the components.
4. Based on the evaluation of the information in the **<decisiontree>** element in file **BM70/mse/regionalmanagers/run25_regionlamanagers.xml**, under what conditions does flow occur at node lo2wca3a?
5. Run the model (run_25) using the **RSM Graphical User Interface (RSM GUI)**.
6. Create a new storage reservoir as a **<lake>** named "**res1**" that gets water from Lake Okeechobee and delivers the water to Service Area 1.
 - The reservoir should store 160,000 acre-feet at 16-foot depth
 - The flood control level should be set to 16 feet
 - The level below which water can be supplied is set at 1 foot
7. Evaluate the effect of the new reservoir on the **stage** in **Service Area 1**.
 - (Compare the stage without the reservoir to the stage following implementation of the reservoir.)

To create a new lake you will need the following components:

- A **rule curve** for **stage schedule** in the lake
 - Add the rule curve to the **run25_rulecurveshw.xml** file
- A **<lake>**
 - Create a **stage-storage relationship**
 - Create a **stage-area relationship**
 - Create a **reference potential evapotranspiration** file **<refet>**
 - Create a rainfall input equal to a constant value = "0"
 - Add the lake to the **run25_lakeshw.xml** file
 - One **<decisionTree>** (for the inlet) based on the **<decisionTree>** elements developed for the Water Conservation Areas (WCAs)
 - Add the **<decisionTree>** to the **run25_regionalmanagershw.xml** file
- Add an **inlet watermover** and an **outlet watermover**.
 - Use a **<specWM>** watermover that sets the maximum inlet water flow = **600** and outlet water flow = **1000**
 - Add the watermovers to the **run25_watermovershw.xml** file
- Add the reservoir to the **<AssessorCoordinator>** so the flood control and water supply needs of the reservoir are evaluated in the appropriate order. (Refer to discussion on the following page).
 - Create a monitor **<lakemonitor>** to see how your reservoir is performing and add the monitor to the **run25_outputhw.xml** file.
 - Add the two new nodes for the **<mse_nodes>** and WCU **<mse_unit>** to the **<mse_network>** element in the **run25Networkhw.xml** file.

HINT



It is useful to study the model components that affect other lakes to better understand which components are necessary for this model and how to specify those components.



NOTE:

Most of the watermovers in Run25 are specifically defined watermovers. The corresponding equations are available in the South Florida Water Management District Technical Publication 86-3 (DRE-223.pdf in the lab16_assessor directory).

8. Change the model run file and add the references to the modified files:

- **run25_lakeshw.xml**
- **run25_watermovershw.xml**
- **run25_rulecurveshw.xml**

- **run25_regionalmanagershw.xml**
- **run25_assessorshw.xml**
- **run25_outputhw.xml**

9. Change the **<runDescriptor="rn25_hw">**

10. Run the model

11. Review the resulting stage in **"res1"** and Service Area 1 (SA1) using HecDssVue.

The model determines the amount of flow for each of the nodes based on the decision tree, the controllers, the watermovers and the assessors. The **watermovers** determine the capacity of the structures based on upstream and downstream heads or they have a constant capacity. The **decision trees** are used to set the **"gain"** for each structure. In this example, decision trees determine if the structures should be open (very high flow rate) or closed. The **flood control assessors** and **water supply assessors** determine how much water must flow through each structure to meet the needs of the **WCU**. The controllers in this example set the range in flow at the structure with the flow determined by the assessors.

Flood Control Assessors

The **flood control assessor**, such as the one for **WCU "wca1"**

```
<LakeFC asmtID="1002" ntwkID="99" wcu="wca1" subnetID="1024" />
```

goes to the **mse_unit name="wca1"** in the **mse_network** and finds the flood control level:

```
<fcLevel name="lake110 fc"> <rc id="16" /> </fcLevel>
```

In this case the **flood control level** is a **rule curve** and determines if there is a need for flood control releases. The **assessor** calculates the amount of flow and proportions the discharge among the outlets for the **WCU** identified in the **<mse_unit>** element.

Water Supply Assessors

The **water supply assessors** determine the water supply need for the named **WCU** by determining the needs of the **<mse_unit>** defined in the **<mse_network>**. The water supply needs are determined by looking at the **maintenance level**

<maintlevel> for **<mse_units>** that are **<basins>** or the outlet requirements for downstream needs for **<mse_units>** that are **<lakes>**. The maintenance levels for the service areas are set to constant values, but they could be set to follow **rule curves**. These needs are applied to the **<inlets>** as an **"equalshare"**.

AssessCoordinator

The **<assessCoordinator>** is applied to the **flood control assessors** and the **water supply assessors** by first determining the flood control needs starting at the top of the network and working toward the ocean. The water supply needs are then assessed by starting at the bottom end of the network and working towards the top of the network. A second pass through the network is made from top to bottom checking the specified water supply releases with the **<decisiontree> constraints**, the **structure capacities** and the **lake storage capacities**. This process is iterated until the assigned flows for each of the structures converge.

Order of Assessors

When the assessors are placed in the **<assessors>** in the XML run file, they are placed in the order of assessment. For flood control, the reservoir is assessed with the lakes before the basins. For water supply, the reservoir is assessed after the basins. In both cases, the reservoir is assessed at a similar point in the sequence as Water Conservation Area #1 (WCA1).

Mse_network

In the **<mse_units>** it is necessary to specify the flood control water level **<fcLevel>**, above which water in the lake is drained off as rapidly as possible within the system constraints; and the local water level **<localLevel>**, below which there is a water supply requirement and no water can be discharged downstream.

Activity 16.2 Northern Everglades RSM

Overview

Activity 16.2 includes one exercise:

- **Exercise 16.2.1.** Add a reservoir for Taylor Creek – Nubbins Slough Basin.

Exercise 16.2.1 Add a reservoir for Taylor Creek–Nubbins Slough Basin

Build a “**Management Measure**” in **Taylor Creek and Nubbin Slough (TCNS) Basin**.

Specifically create the reservoir in **Fig. 16.1** and add it to the **mseNetwork**.

1. Follow the example for the reservoir in **netp_mseNetwork.xml**:

\$RSM/data/NERSM/Alt1_partial/mse/mseNetwork/netp_mseNetwork_alt1.xml

To make sure you get the names of inlet and outlet structures correct, check:

\$RSM/data/NERSM/Alt1_partial/hse/watermovers/tcns_watermovers_alt1.xml

- What corresponding changes should be made to **LOK inlet**?

2. Complete the watermovers for the TCNS Reservoir:

\$RSM/data/NERSM/Alt1_partial/hse/watermovers/tcns_watermovers_alt1.xml

- The watermover from the Lumped Stormwater Treatment Area to LOK (lumptoLok) is represented as a **<genxweir>**

- The watermover is named: lumptoLok and the watermover id (wmid): **5010**
- The equation used to solve **<genxweir>** is:

$$Q = C_d L (H_u - z_c)^a (H_u - H_d)^b$$

Q = Discharge (cfs)

C_d = weir discharge coefficient

L = weir crest length (ft)

z_c = weir crest elevation (ft)

H_u = upstream water level (ft)

H_d = downstream water level (ft)

a,b = constant exponents

Assume:

- **Q** = 744 cfs
- **C_d** = 3.05
- **$H_u - H_d$** ~ 1 ft
- **$H_u - z_c$** ~ 1 ft
 - $z_c = 24 + 1.62 = 25.62$ ft; **a** = 1.5; **b** = 0.0

Calculate **L**.

(Please check Page 44 in **NERSM_UserGuide.pdf** for specifying the genxweir)

- Create a **watermover** for the bypass flow from the **TCNS Basin** to **Lake Okeechobee** as a **<specwm> watermover** with the name "**tcnstoLok**" and **watermover ID: wmid="5013"**

- How would you define the structure capacity?

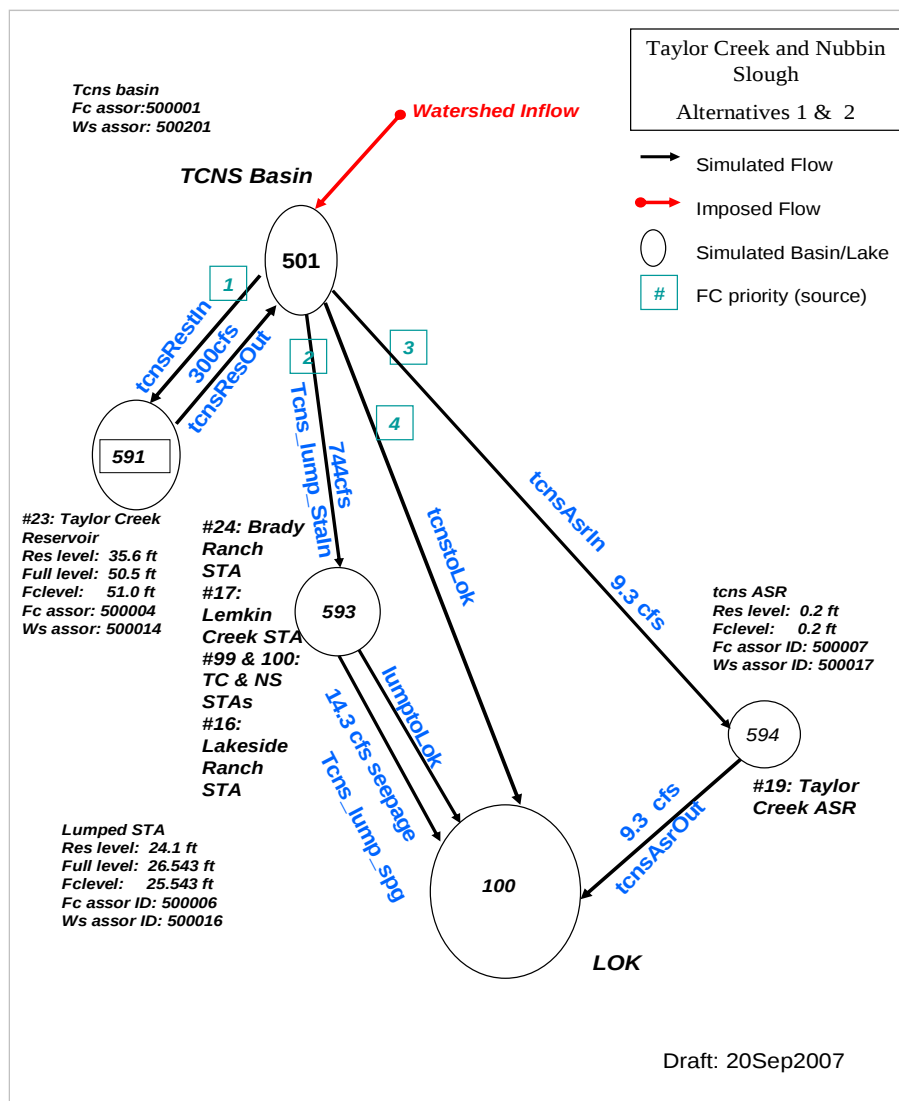


Figure 16.1 Schematic of Taylor Creek/ Nubbin Slough management measures

3. Set up a **regional manager** for **TCNS Reservoir inflow (tcnsResIn)** and **reservoir outflow (tcnsResOut)**:

\$RSM/data/NERSM/Alt1_partial/mse/regionalmanagers/tcns_res_in_alt1.xml
\$RSM/data/NERSM/Alt1_partial/mse/regionalmanagers/tcns_res_out_alt1.xml

- Implement the following operation rule of **Taylor Creek Reservoir (591)**:

When **LOK stage** is above the high envelope, **TCNS Basin** sends water through **tcnsResIn** to **Reservoir (flood control)**.

When **LOK stage** is below low envelope, **Reservoir** sends water through **tcnsResOut** to **TCNS basin** so that more water could be passed to **LOK (water supply)**.

See the **Istok reservoir example**:

\$RSM/data/NERSM/Alt1_partial/mse/regionalmanagers/istok_res_I17_in_alt1.xml
\$RSM/data/NERSM/Alt1_partial/mse/regionalmanagers/istok_res_I17_out_alt1.xml



NOTE:

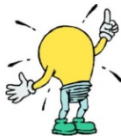
The first branch ID is always “0”. (If you have more than 1 branch, give different IDs to different branches.)

Make sure the structure name is consistent with the name in:
../tcns_watermovers_alt1.xml

Pay attention to structure capacity

4. Understand the **areaCorrected Package** set up in the basin. Open
\$RSM/data/NERSM/Alt1/hse/basins/tcns_basins_alt1.xml
- What is the subelement **<basinsource>** Part B **?**

HINT



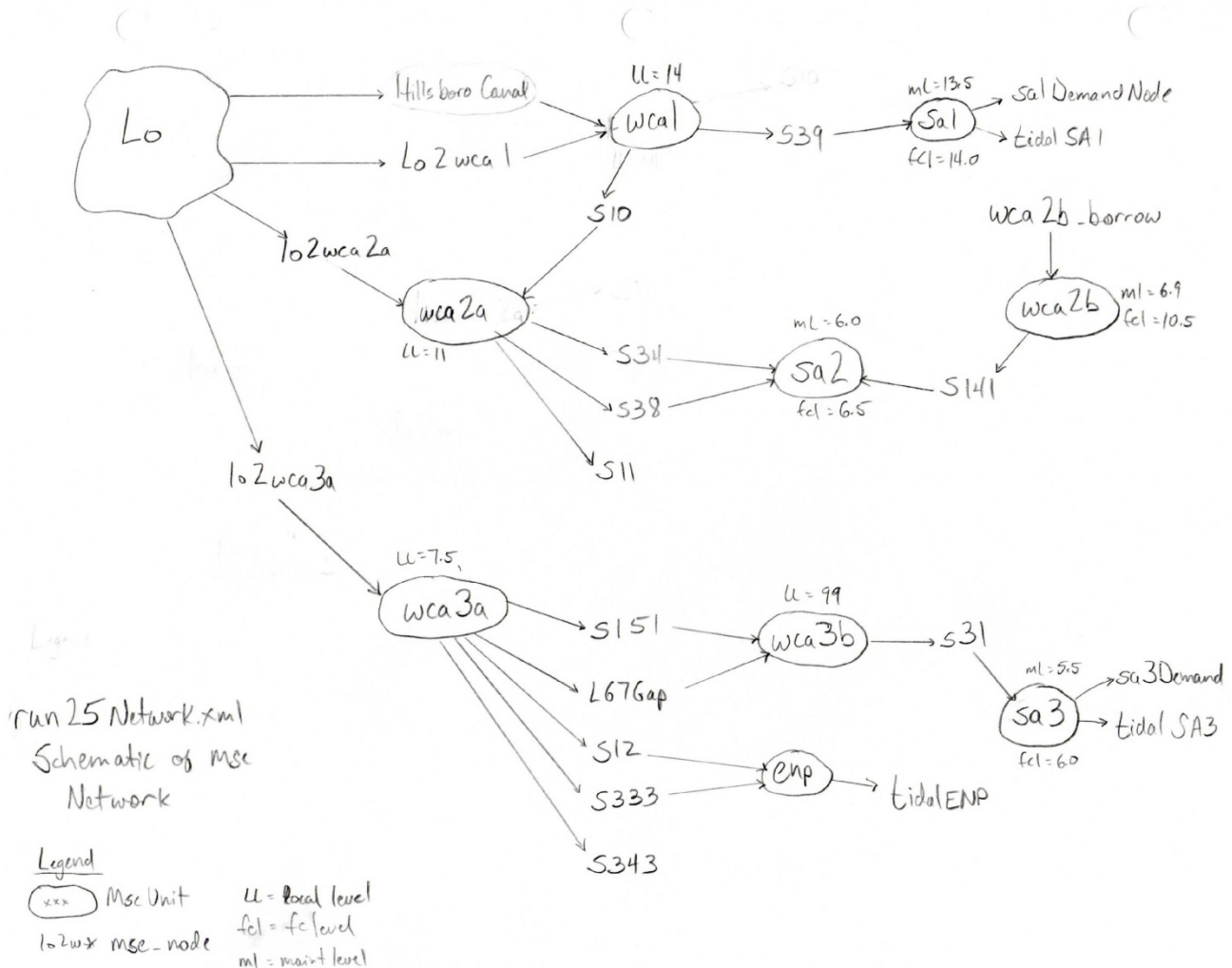
(Check NERSM User Manual Page 26 and Lecture 16 slide 30)

5. Run the model using the **RSM GUI** and display the **TCNS Reservoir stage, inflow** and **outflow** using **HecDssVue** utility.
- How frequently is the reservoir used in the scenario?
6. Display the **TCNS Reservoir outflow** and the **TCNS to Lake Okeechobee flow**.
- How much of the flow goes through the reservoir?

Answers for Lab 16

Exercise 16.1.1

2. Create a diagram (hand sketch) of the MSENetwork used in the run25Network.xml RSM in BM70/mse/mseNetwork. The diagram should include the waterbodies (lakes or basins).



4. Based on the evaluation of the information in the **<decisiontree>** element in file **BM70/mse/regionalmanagers/run25_regionlamanagers.xml**, under what conditions does flow occur at node **lo2wca3a**?

With the very jagged controls removed the head and discharge curves became much smoother, but retained the same pattern as before.

7. Compare the stage without the reservoir to the stage following implementation of the reservoir.

The stage in Service Area 1 increases from 14.0 to 14.7 ft in 1969.

Exercise 16.2.1**NOTE:**

The answers for this lab can be found in the lab16_assessor/answers9mse directory.

1. What corresponding changes should be made to **LOK inlet**?
The additional inputs from tcnsAsrOut, LumptoLok, tcnstoLok, and tcnslump_spg need to be added to the LOK inlet.
2. How would you define the structure capacity?
The capacity needs to be very large so it may handle all of the excess flow being sent to Lake Okeechobee.
4. What is the subelement <basinsource> Part B ?
The basin area is corrected by subtracting the areas of the reservoirs (Lake=591 and 593) that have been created in this basin.
5. How frequently is the reservoir used in the scenario?
Inflow to the reservoir is small (<10 cfs) but occurs nearly every year for periods throughout the summer months. Outflow is event-driven and occurs from zero to about 10 times per year, averaging 1 to 3 times per year. Outflow did not exceed approximately 300cfs.
6. How much of the flow goes through the reservoir?
Very little flow goes through the reservoir (<10%) on its way from TCNS to Lake Okeechobee.

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