APPENDIX D –

Model Weighting Description

Section 1. Introduction

This report provides a detailed account of the weighting of nodes and arcs in the Neuse River Basin model. OASIS operates using a linear program solver, which means that it tries to maximize the overall value of allocating water subject to the goals (which have associated weights) and constraints (which must be met). The general strategy with goal-setting is to assign weights to mimic the real-world operating goals. For example, setting a reservoir's storage weight higher than that of an unassociated demand downstream will prevent water from being released from that reservoir to meet the demand. Weighting is also used to properly dictate minimum releases and other flow targets.

In general, positive weights encourage action and negative weights discourage action. Storing water, meeting demand, and meeting flow targets all have positive weights. If pumping can be avoided in favor of gravity flow, the pumping arc will have a negative weight, the gravity flow arc a positive weight. The model solver will gain more points by allocating each increment of flow to the positive-weight arc.

Weighting is mostly relative. If the weight in storage (say 2) is higher than a weight for demand (say 1), the demand will not be met. Minimum flow weights are handled differently at times since they can be additive. If there are multiple minimum flow locations downstream of a reservoir, OASIS will assign value to the minimum releases based on the sum of those weights. So if there are three locations, each having a weight of 1, the model will get 3 points releasing water from an upstream reservoir to meet the minimum flows. If the storage weight is 2, then the reservoir will draw down to meet the minimum flows. Flow exceeding the minimum flow does not get any additional value. The user manual for OASIS provides more description on how model weighting works.

Reservoirs can have up to four zones to which weights can be assigned. The A zone is below dead storage (which is generally non-usable storage). Often this represents the sediment pool, which could be tapped in an emergency situation. The B zone is between dead storage and the lower rule curve . This zone may be usable depending on the purpose. It might be used to maintain minimum releases from the lake, but not used or avoided for water supply because the intake does not extend down to that zone or because the water quality is poor. The C zone is the zone between the lower and upper rules, in which the lakes normally operate. The D zone is above the upper rule curve and below the maximum storage and is usually reserved for flood storage. Note that some reservoirs, including those being modeled as run-of-river, may only need one storage zone. This can simplify the number of weights in larger systems, but is generally not recommended because the model may draw into dead storage, down to the minimum storage in the elevation-storage-area table (even though physically it would not be possible to do), if the storage weight is less than weights for other uses.

Each section of this document describes a portion of the model, progressing downstream.

Section 2. Eno River Area

The reservoirs on the Upper Eno are in the headwaters of the entire basin, and therefore proper weighting must be set up to prevent water being released to meet unrelated needs further downstream.

The reservoir storage weights in this area are:

		Storage Zone Weights			
Reservoir	**Node Number**	**A**	**B**	**C**	**D**
Orange Upstream Pond	010	1050			
WFER	050	1000	275	275	-10
Lake Orange	060	1000	275	275	-10
Corp. Lake	080	500			
Lake B. Johnston	100	500			

Other weights in the area include:

Description	Node/arc Number	Weight
WFER Min. Release	050.080	300
Orange Min. Release	060.080	300
Or-Alamance Demand	060	250
WFER_Ag Demand	52	1050
Or_Pond_Ag Demand	62	1100
Piedmont Minerals Demand	080	250
Hillsborough Demand	100	250
EnoDurha_Ag Demand	112	240
Hills. Channel Loss (Target)	110.107	+1000 -1000

The Orange Upstream Pond agricultural demand has the highest weight of 1100. This is higher than the Orange Pond weight to ensure that demand is met first before letting water flow downstream, including storage in Orange Pond. Orange Pond only has one zone (which is always assigned to the A-zone), and this weight is is set higher than that of Lake Orange to prevent releases when the pond is below full. The only reason the pond will draw down is net evaporation on the lake surface, which is modeled as a constraint and therefore does not use weights The B- and C- Zone storage weights on WFER and Lake Orange are lower than the weights for their respective minimum flows, but higher than the downstream demands, since the minimum release is dictated by the amount that can be withdrawn from the lakes to meet demands. Note that the weights for the zones are the same because the usable storage in these reservoirs includes everything from the top of dead storage to the top of the normal pool. For the D zone, weighting is usually negative in order to discourage storing water in this zone, which is commonly used for flood storage. Water will only be stored if there is a limit on downstream releases during a high inflow event.

Corporation Lake and Lake Ben Johnston only have one storage zone. The weights are higher than weights on uses immediately downstream because they are run of river reservoirs and should remain full. The weighting on the B- and C-zones on the upstream WFER and Lake Orange facilities is lower to ensure that water is withdrawn from this usable storage zone (excluding the A-zone for these reservoirs, which in this case represents dead storage) to keep Corporation Lake and Lake Ben Johnston full.

Weighting in OASIS can also be done with target commands, in which case a penalty is assigned for being above or below the target. A target is applied to the Eno River channel loss. Every unit of water in excess (+) of the computed target for channel loss is penalized a 1000 points and every unit of water below (-) the target is penalized a 1000 points. Since the penalty for going above or below is the same, the model will meet the computed channel loss exactly. Furthermore, because the overall value is higher than any other in the system, the computed channel loss will always be met before other “goals”.

All of the storage weights for this reach are higher than downstream weights (see following sections) to ensure that releases are not made to meet downstream needs (e.g., Falls Lake).

Section 3. Upstream of Falls

As with the Eno, these reservoirs are in the headwaters of the entire basin, and therefore proper weighting must be set up to prevent water being released to meet unrelated needs further downstream.

The reservoir storage weights in this area are:

		Storage Zone Weights			
Reservoir	**Node Number**	**A**	**B**	**C**	**D**
Lake Michie	140	500	250	250	-10
Little River Res.	200	500	250	250	-10
Lake Holt	250	500	250	250	-10
Lake Rogers	270	500	250	250	-10

Other weights in the area include:

Description	Node/arc Number	Weight
Durham Demand	162	300
SGWASA Demand	256	300
Creedmor Demand	060	300
Michie_Ag Demand	142	550
LitRes_Ag Demand	202	550
Little River min. release	200.205	350
Durham Res. Balance (Target)	140, 200	2

The storage weights on reservoirs are all set lower than their associated demands and/or minimum release requirements, which allow withdrawals to be made. It is assumed that the minimum release from the Little River Reservoir has priority over water supply withdrawals from the reservoir. Agricultural demands are weighted higher than lake withdrawals since they represent upstream irrigation withdrawals. For Durham’s reservoirs, a balancing target with a low weight attempts to bring down the two reservoirs proportionally, after other higher weight requirements have been met.

All of the storage weights for this reach are higher than downstream weights (see following sections) to ensure that releases are not made to meet downstream needs (e.g., Falls Lake).

Section 4. Falls and Beaverdam Lakes

The reservoir storage weights in this area are:

		Storage Zone Weights			
Reservoir	**Node Number**	**A**	**B**	**C**	**D**
Falls, Beaverdam	300, 230	200	200	50	-5

Other weights in the area include:

Description	Node/arc Number	Weight
Raleigh Demand	306	100
Falls_Ag Demand	302	230
Falls min. release	300.310	100
Clayton min. flow	630.640	125
Falls flood operation rules (target)	300	+50 -50
Downstream flood control (targets)	630.640, 780.790, 800.850	+10 -0
Beaverdam elevation (target)	230	+10000 -10000
Beaverdam release (targets)	230	+1000 -1000

The weights for Raleigh demand and demands between Falls and Clayton (see tables below) are higher than the C zone weight for Falls to ensure these demands are met. The Corps implicitly accounts for withdrawals between Falls and Clayton when determining what releases need to be made from Falls to meet the Clayton minimum flow. Raleigh's demand could also be met from Lake Benson, which only has a storage weight of 50. Note that there is also a constraint on Raleigh's demand, where the delivery will be zero from Falls Lake if the Falls water supply account is empty. A similar constraint is imposed on the minimum release from Falls if the Falls water quality account is empty.

All of the storage weights are higher than weights for demands downstream of Clayton (see following sections) to ensure that releases are not made for these demands.

The flood control targets are weighted such that the Corps' recommended flood control operations are followed. The goal is to store water in the lake to avoid causing flooding downstream. The downstream flood control targets are weighted lower, which means they have less priority than the elevation-based flood operating rules. However, the combined minimum release and Clayton minimum flow target weight is set high enough to ensure that those flows are always met.

The target for Beaverdam elevation applies when Falls Lake is at or above 249 feet. At this elevation, Beaverdam and Falls become one pool, and the weight ensures that that the elevations for both track the same at or above 249. The Beaverdam target for releases relate to the drought release protocol for transfers of water from Beaverdam into Falls.

Section 5. Middle Basin

The reservoir storage weights in this area are:

		Storage Zone Weights			
Reservoir	**Node Number**	**A**	**B**	**C**	**D**
Wake Forest Lake	290	500	250	250	-10
Crabtree impoundments	400 – 418, 422	250			
Lake Wheeler	420	500	50	50	-10
Lake Benson	440	500	50	40	-10
Lake Johnson	445	250			
Lake Raleigh	450	200			

Other weights in the area include:

Description	Node/arc Number	Weight
Swift Min. release	440.700	100
Burlington Ind. Demand	318	75
Clayton_Ag Demand	632	75
Middl_Ag Demand	480	30
Johnston Co. Demand	646	25
Smithfield Demand	666	25

The reservoirs all have weights higher than downstream demands. B- and C- zone Wheeler/Benson storage is weighted lower than the required minimum release. The storage weights in Benson and Wheeler are set up to allow, if the Raleigh withdrawal from this system is activated, to first draw down 2 feet from Benson, then release from Wheeler, and then draw down the rest of Benson; to prevent spill and maximize yield. Lakes Raleigh and Johnson are not being used for water supply in the basecase scenario and therefore only have one storage zone.

Section 6. Lower Basin

The reservoir storage weights in this area are:

		Storage Zone Weights			
Reservoir	**Node Number**	**A**	**B**	**C**	**D**
Buckhorn Reservoir	500	500	250	250	-10
Little River Reservoir (Raleigh Proposed)	740	250			

Other weights in the area include:

Description	Node/arc Number	Weight
Buckhorn Min. release	500.520	300
Buckhorn_Ag Demand	502	550
Wilson Demand	506	275
Litpr_Ag Demand	752	30
Progress E. Demand	766	25
Golds_Ag Demand	782	30
Goldsboro Demand	786	25
Kinst_Ag demand	802	30
NRWASA Demand	806	25
Weyer_Ag Demand	802	30
Weyer. Demand	906	25

On Contentnea Creek, Buckhorn's B- and C- Zone storage weights are lower than the minimum release requirement and the downstream Wilson demand, which allow the reservoir to be used for those purposes. The Buckhorn agricultural demand is weighted higher since it represents upstream irrigation withdrawals. Raleigh's proposed Little River Reservoir only has one storage zone because it is not active in the basecase (current) scenario. The other demands in this area are set lower to prevent any releases from upstream storage to meet demand.