Attachment 1

HAZEN AND SAWYER
Environmental Engineers & Scientists

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APRIL 24, 2012

Mr. Ed Holland
Orange Water and Sewer Authority
Director of Planning
400 Jones Ferry Road
PO Box 366
Carrboro, NC 27510-2001

Re: Update of Cary-Durham-OWASA Risk Model
H&S Job No: 30164

Dear Mr. Holland:

Hazen and Sawyer is pleased to provide professional engineering consulting services, as requested, to assist OWASA in updating the Cary-Durham-OWASA Risk Model. As you know, Reed Palmer and Casey Caldwell developed this computer model under the direction of Professor Greg Characklis at UNC between 2005 and 2008, and Reed revised some of the model settings during risk analyses performed for OWASA in 2009.

Scope of Services

The services to be performed under this assignment are as follows:

1. Perform the following model updates:
    a. Streamflow database through 2011.
    b. Current Cary-OWASA-Durham demand projections and monthly demand profiles, as furnished by OWASA.
    c. Use a CAWTF capacity of 56 mgd in the 2016 and 2025 scenarios and 64 mgd in the 2035 scenario.
    d. Incorporate 3 mgd minimum WTP constraint on OWASA's reservoir drawdowns during periods when OWASA purchases water from Cary/Durham.
2. Run all scenarios using demand and capacity projections for 2016, 2025, and 2035
3. Model with and without peak season (May-Sept) purchase blackouts.
4. Assume 10 mgd (rather than 11 mgd) Cary→Durham transfer capacity year-round.
5. Run the model for the 1990-2011 period with actual streamflow data as well as for the following two extreme drought scenarios:

a. 12-month continuation of the 2001-02 drought (as recently estimated in OWASA's "what if the drought had continued" graphs; and
b. 30% reduction of all 1990-2011 streamflows.

6. Run the model under 3 purchase trigger options:

a. No purchases
b. Durham and OWASA request purchases at their respective 2% risk levels (OWASA's Stage 1 trigger)
c. Durham and OWASA request purchases at their respective 10% risk levels (OWASA's Stage 2 trigger)

7. Incorporate estimated demand reductions achieved through mandatory conservation in all model runs.

The above modeling effort will involve a total of 54 separate model runs, as follows:

- Three (3) streamflow scenarios (actual 1990-2011, 30% reduction, and 2001-02 drought extended)
- Three (3) purchase trigger scenarios (no purchases, purchase at 2% risk, and purchase at 10% risk)
- Three (3) simulation dates (2016, 2025, and 2035)
- Two (2) seasonal purchase options (May-Sept only, except for "emergency drawdown conditions, and no seasonal purchase restrictions)
- Total number of scenarios: 3 x 3 x 3 x 2 = 54

Information to be Furnished by OWASA

In addition to providing the water demand projections and monthly demand profiles specified above under paragraph I.b, OWASA will confirm the following modeling assumptions:

1. 14.5 percent process loss during treatment of Jordan Lake water at the CAWTP.
2. Water transfers (sales) from Durham to Chatham County will be assumed to be offset by the use of Durham's Teer Quarry, which has not been part of the existing model and will not be added at this time.
3. Demand reductions under OWASA and Durham Water Shortage Response Plans if different from those submitted to DWR.

Deliverables

Hazen and Sawyer will deliver to OWASA via email a brief descriptive report, of up to three pages, summarizing the findings of the above analyses, plus one-page summary tables of results for Cary, Durham, and OWASA, respectively. The report and summary tables will be similar to those provided to OWASA in Hazen and Sawyer's June 2009 *OWASA Long-Term Water Supply Plan Update, Interim Water Purchases* report (copy attached). Hazen and Sawyer will also deliver to OWASA, in Excel format, time-series computer outputs of predicted reservoir storage levels (% full) under the various scenarios.

Compensation

OWASA will compensate Hazen and Sawyer for all services under this contract. Total billings will not exceed the total amount stated below under Basis of Compensation without the written permission of OWASA.

An estimate of Hazen and Sawyer's hourly effort for this assignment is attached hereto. Hazen and Sawyer will invoice each hour of actual service on the basis of a direct charge at current employee payroll cost—including base salary, vacations, sick leave, holidays, payroll taxes, and insurance and pension plan—times the multiplier stated below under Basis of Compensation.

Mileage costs directly chargeable to this project shall be billed at the CONSULTANT's standard employee reimbursement rate, as established by the Internal Revenue Service from time to time. Other incidental project expenses, if any, will be billed at actual cost; invoices shall include copies of receipts.

BASIS OF COMPENSATION

Service Category	Salary Cost Multiplier	Cost Ceiling	Lump Sum
All services and deliverables	2.33	$42,000	N/A

Total amount payable under this Agreement: $42,000

Schedule

It is understood that the schedule for this assignment may be affected by factors outside of the control of Hazen and Sawyer, including necessary coordination with and input from OWASA and other stakeholders. To the fullest extent of work under our control, we will endeavor to complete the tasks outlined hereinbefore within approximately twenty (20) weeks of receipt of authorization to proceed from OWASA.

It is our pleasure to assist OWASA on this important planning assignment. We look forward to receiving a Purchase Order authorizing this work.

Very truly yours,
HAZEN AND SAWYER, P.C.

James McCarthy, P.E.
Senior Associate

Enclosures
Cc: Mr. R. Palmer
Mr. D.L Cordell

OWASA Risk Modeling in Support of Purchase Contract Negotiations with Cary and Durham
April 20, 2011 (54 Model Run) Revision

Task Description	Contingency Percentage	Model Set-ups	Model Executions	Coding, debugging and runtime Hours	Extraction and Formatting Hours	Report Preparation	Total Hours
Review existing state of OWASA model		0	various tests	4	0	0	4
Model Parameter Adjustment		0	various tests	12	0	4	16
Re-tool demand patterns to set monthly patterns		0	various tests	16	0	1	17
Add WSRP for Durham and OWASA		0	various tests	32	0	4	36
Execute 54 Model Runs		54	54	48	60	40	148
Contingency for coding and analysis	**25%**	-	-	28	15	12	55
Update Hydrologic database		0	various tests	16			16
Contingency for Hydrologic Update	**100%**		-	16			16
Review	**5%**						15
Total				**172**	**75**	**61**	**323**
Not to Exceed Fee @	**$130/hr**						**$42,000**

Coding tasks

Update streamflow database

Make sure we have appropriate risk charts for Durham and OWASA for Demands requested

Cary process loss to 14.5%

Put in 3 mgd JFR WTP low treatment limit

Winter transfer & year-round transfer coding

Retool demand patterns to use repeating monthly demnad factors

Streamflow reduction

Jordan Lake Allocation limits (confirm)

Create modified inflow pattern for 2001-2003 for 3rd set of runs

Add WSRP stages and demand reduction for Durham and OWASA (OWASA has different triggers for each demand level)

OWASA Long-Term Water Supply Plan Update
Interim Water Purchases

Tables 1 and 2 summarize the results of modeling for 11 additional interim water purchase scenarios by OWASA from Cary/Apex (see also attached June 09 Modeling Summary.xls excel file). These results are based on the three-utility computer model developed by Reed Palmer and Casey Caldwell under the direction of Professor Greg Characklis at UNC between 2005 and 2008. The report entitled "Optimizing Water Supplies through Inter-Utility Transfer Agreements," Caldwell and Characklis, July 8, 2008, includes a detailed discussion of this model. The following is a list of key model settings, assumptions, and changes:

- The model functions on a weekly time-step and was executed using an 18-year hydrologic sequence from 1990 – 2007.
- The risk threshold charts for OWASA used to trigger water purchases were developed using an 82-year hydrologic sequence from 1926 – 2007.
- Cary's WTP capacity is not limiting for these scenarios. Cary's demand was kept low while the water treatment capacity was increased to create a situation in which OWASA always had the opportunity to purchase up to 7 MGD when the 2.5% risk tolerance threshold was exceeded.
- The simulation of Durham's water system was effectively turned off and as a result there are no situations where the two utilities (OWASA and Durham) would be forced to share either excess water treatment plant capacity at Cary or pipeline capacity between Cary and Durham.
- Water purchases were available year-round.
- The model feature that limits OWASA's total withdrawals from Jordan Lake to no more than 1825 MG (365 days x 5 MGD) over any consecutive 52-week period was retained for the first set of results presented. This limit is consistent with OWASA's 5% water supply allocation on Jordan Lake. This constraint was limiting in simulation year 13 (corresponding to hydrologic year 2002) for scenarios in which demand was greater than or equal to 12 MGD and risk tolerance was 2.5%. With a pipeline capacity limitation of 7 MGD, it takes at least 33 weeks for this constraint to become limiting. Because the drought of 2007 was only severe for the second half of the calendar year, this constraint did not become limiting. However, it is reasonable to expect that it could have become limiting in the high demand scenarios during the first quarter of hydrologic 2008, before the drought broke, if the model were extended to include 2008 hydrology.
- The results for purchase volume by year also indicate any year in which withdrawals exceeded 746 MG within any six month period. These cases are indicated because 746 MG is the volume equivalent of 5% of Jordan Lake's water supply storage and when withdrawal rates exceed 5 MGD, as they do in these scenarios, there is a possibility that OWASA's Jordan Lake water supply pool could be exhausted prior to withdrawing 1825 MG over 52 weeks. In lieu of integrating a model of the Jordan Lake water supply pool into this model, this indicator merely serves as an indicator that significant withdrawals are occurring and possibly at a rate that is more rapid than the water supply pool is being recharged.

- A minor change to the model incorporated for these simulations was to eliminate purchases made when OWASA's reservoir system is nearly full (within 50 MG). This only made a difference at the 14 MGD demand scenario, since this was the only scenario in the 9-14 MGD range for which the risk of failure exceeds 2.5% over a significant portion of the year even when the reservoirs are full. In other words, this is the only scenario in which the purchase algorithm would request a transfer when the reservoirs were almost full. Prior to this change, the model would still disallow purchases when the reservoirs were completely full at the end of the previous week, but not if they were any amount below full. This change simply puts a small buffer into that algorithm because it seems reasonable to assume that OWASA would not choose to purchase water from elsewhere when its own reservoirs are close to spill levels. This change would have had a negligible impact on the results presented in February for the 14 MGD scenario because the seasonal purchase conditions disallowed transfers in summer months (when relative risk tends to be higher), and the competition for capacity with Durham resulted in lower transfer rates.
- Based on 2005-2007 plant data, it is assumed that process loss is equivalent to 12% of finished water production at the Cary/Apex facility. This loss is included in each utility's tally of withdrawals from Jordan Lake. For example, if OWASA were to use all of its 1825 MG allocation during a 52 week period, it would have received a treated water total of 1629 MG.
- Tables 3 and 4 contain results for simulations with the same assumptions as those described above with the exception that withdrawals are not restricted based on OWASA's Jordan Lake allocation.

Table 1: Summary of Results

OWASA Interim Water Purchases Modeling Summary

Reduced Streamflow (25% less than historic hydrologic history 1990 - 2007)

	9 MGD			11.5 MGD			14 MGD		
	No Purchases	2.5%		No Purchases	2.5%		No Purchases	2.5%	
System Reliability	100.00%	100.00%	100.00%	99.57%	100.00%	100.00%	97.54%	99.68%	99.68%
Failures (Weeks below 20% storage)	0	0	0	4	0	0	23	3	3
Lowest Storage Level	39.0%	39.0%	39.0%	13.1%	29.5%	25.7%	0.0%	16.4%	15.9%
Percentage of Years with Purchases	N/A	6%	0%	N/A	32%	11%	N/A	100%	72%
Average Purchase Weeks Per Year	N/A	0.1	0.0	N/A	2.3	1.7	N/A	14.9	6.1
Maximum Purchase Weeks in any year	N/A	1	0	N/A	25	23	N/A	31	35
Average Purchase Volume per Year (MG)	N/A	1	0	N/A	73	50	N/A	532	215
Purchase Volume in Max Year (MG)	N/A	17	0	N/A	906	786	N/A	1288	1404
% Purchases limited to <5MGD by WTP capacity	N/A	0.0%	0.0%	N/A	9.3%	12.9%	N/A	0.7%	3.6%
% Purchases limited to <5MGD by infrastructure competition	N/A	100.0%	0.0%	N/A	41.9%	35.5%	N/A	25.7%	35.5%
Total Interruptions as % of requests	N/A	100.0%	0.0%	N/A	51.2%	48.4%	N/A	26.5%	39.1%

OWASA Interim Water Purchases Modeling Summary

Reduced Streamflow (25% less than historic hydrologic history 1990 - 2007)

	9 MGD			11.5 MGD			14 MGD		
	No Purchases	2.5%		No Purchases	2.5%		No Purchases	2.5%	
System Reliability	100.00%	100.00%	100.00%	98.16%	99.89%	99.36%	96.02%	98.29%	98.18%
Failures (Weeks below 20% storage)	0	0	0	17	1	6	46	16	17
Lowest Storage Level	23.1%	32.5%	32.1%	0.0%	16.3%	14.7%	0.0%	0.0%	0.0%
Percentage of Years with Purchases	N/A	6%	6%	N/A	39%	17%	N/A	100%	78%
Average Purchase Weeks Per Year	N/A	0.6	0.6	N/A	4.3	2.9	N/A	20.5	10.1
Maximum Purchase Weeks in any year	N/A	15	15	N/A	38	31	N/A	40	33
Average Purchase Volume per Year (MG)	N/A	20	19	N/A	124	98	N/A	744	362
Purchase Volume in Max Year (MG)	N/A	359	333	N/A	1269	1041	N/A	1579	1298
% Purchases limited to <5MGD by WTP capacity	N/A	35.3%	50.0%	N/A	5.1%	7.4%	N/A	0.8%	1.7%
% Purchases limited to <5MGD by infrastructure competition	N/A	11.8%	12.5%	N/A	43.6%	33.3%	N/A	23.2%	35.6%
Total Interruptions as % of requests	N/A	47.1%	62.5%	N/A	48.7%	40.7%	N/A	24.0%	37.2%

Modeling Assumptions
Transfer Capacity to OWASA is pipeline limited to 7 MGD
Transfer Capacity to Durahm is pipeline limited to 11 MGD
Durham Risk Chart is based on internal demand (not including Chatham obligation)
Both utilities assume same level of risk tolerance in each simulation (i.e. if OWASA is tolerant to 5% risk of failure within 52 weeks, Durham operates at 5% tolerance as w
Cary treatment capacity is 40 mgd, 64 mgd, and 72 mgd corresponding to Demand Targets Years of 2011, 2024, and 2030
Risk charts were produced with 12 month (52 week) forward outlook
The reduced streamflow scenarios were run with unrevised risk charts (i.e. produced with actual 82 year hydrologic record, not reduced by 25%)
When both Durham and OWASA request transfers, capacity is shared as described in Casey's work
Use of Purchases was limited to 1825 MG and 3650 MG on a 52 week running average, for OWASA and Durham respectively
Assumed a 15% buffer to account for weekly model and process loss for treated water Jordan Lake
Assumed a 12% process loss for the utility's withdrawal limit from Jordan Lake (withdrawals are 12% higher than treated water production)