CITY OF HIGH POINT
AGENDA ITEM

Title: **Amendment 3– Watershed Assessment Framework,** Lake Modeling
Tetra Tech

From: Robby Stone – Public Services Director
Derrick Boone – Public Services Asst. Director

Meeting Date: July 18, 2022

Public Hearing: N/A

Advertising Date: N/A

Advertised By: On-Call

Attachments: Attachment A – Scope of Services – Amendment to Watershed Assessment Framework- Lake Modeling

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PURPOSE:
This amendment modifies the original agreement entered on July 24, 2020 (PO Number 103547) with Tetra Tech for Phase I of the project. Amendment #3 is necessary to continue developing the Integrated Watershed Assessment Framework (IWAF) that was co-designed by a team of City staff and Tetra Tech to meet multiple program needs for water-related project planning and program compliance.

BACKGROUND:
The City of High Point is responsible to its citizens and businesses for managing water quantity and quality while maintaining compliance with state and federal regulations. This involves managing stormwater runoff, treating wastewater, protecting water quality, providing water supply for drinking water and a recreational destination for people interested in boating, fishing, golfing, camping, and other outdoor activities. Water is recognized as a lifeline for current citizens and businesses, and the projected growth of the community, and therefore maintaining an effective and efficient water management framework is essential for the City of High Point. Phase 1 was started in July 2020 and the team (Tetratech, Engineering Services, Parks and Recreation, and Public Services) established goals of assessment across the departments, specified objectives under each goal, identified water quantity and water quality indicators related to each objective. Tetra Tech began Phase 2 of the project in April 2021 initiating construction of watershed models that cover the City of High Point Planning Area and watersheds draining to it. The scope of work under this amendment includes the following tasks:

Task 1 – Lake Model Development: develop lake models for City Lake and Oak Hollow Reservoir that are linked to the watershed model to support watershed and water supply protection management planning in the City.

Task 2 – Future Condition Analysis Integrated Watershed Assessment Framework (IWAF) Model Application: complete a future land use/cover and climate scenario with the watershed models and the lake models to provide information to support City management planning. The results will enable City staff to predict potential future impacts under current management programs and policies, and guide decisions for modifying those programs as needed for elements such as water supply protection, stormwater and flood management, comprehensive planning and ordinances for new development or redevelopment, and parks restoration project planning.

BUDGET IMPACT:
Funds for this are available in the FY 2022/2023 budget.

RECOMMENDATION / ACTION REQUESTED:
The Public Services Department recommends approval of Amendment No. 3 to Tetra Tech for $ 150,000.

Amendment to Integrated Watershed Assessment Framework Project

PO #103547

Scope of Work for Lake Modeling

July 1, 2022

TO BE PERFORMED FOR

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BY

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EXECUTIVE SUMMARY

This Amendment is required to continue developing the Integrated Watershed Assessment Framework (IWAF) co-designed by a team of City staff and Tetra Tech to meet multiple program needs for water-related project planning and program compliance. The original contract framework design phase was completed in March 2021, and in April 2022 the contract was amended to begin the development of a HSPF watershed model for the entire City Planning Area and watersheds draining to it. In September 2021 the project Scope was amended to support flood and stormwater model development, which is now underway for the Richland Creek watershed. The HSPF modeling was completed in early 2022 and documented in the "HSPF Watershed Model for High Point Area (DRAFT)" report (Tetra Tech, 2022). Under this Scope amendment, Tetra Tech will assist the City in two new primary technical tasks as follows:

> **Amendment Task 1 – Lake Model Development:** develop CE-QUAL-W2 lake models for City Lake and Oak Hollow Reservoir that are linked to the HSPF watershed model to support watershed and water supply protection management planning in the City.
>
> **Amendment Task 2 – Future Condition Analysis IWAF Model Application:** complete a future land use/cover and climate scenario with the HSPF and the lake models to provide information to support City management planning. The results will enable City staff to predict potential future impacts under current management programs and policies, and guide decisions for modifying those programs as needed for elements such as water supply protection, stormwater and flood management, comprehensive planning and ordinances for new development or redevelopment, and parks restoration project planning.

The cost for this next phase of the CE-QUAL-W2 model development and IWAF model application is $150,000 with anticipated completion by June 30, 2023.

1.0 BACKGROUND

The purpose of this Scope of Work (SOW) is to continue developing the IWAF framework initiated in July 2020. Under Phase 1 of the project, the City team and Tetra Tech worked collaboratively to establish overarching goals of watershed assessment across each of the participating departments, specify objectives under each goal, identify water quantity and water quality indicators related to each objective, select models that would support the objectives and produce the indicators to support decision-making for capital projects or operations, review the data available for developing the models, and identify gaps, and produce a model development plan optimized for the City of High Point. The Model Development Plan was completed in March 2021 (Tetra Tech, 2021).

Under the watershed assessment framework design, a linked watershed-lake modeling system is proposed for the City of High Point. The modeling system is envisioned to become the foundation for supporting water-related regulatory compliance and water infrastructure planning for the City of High Point. Tetra Tech began Phase 2 of the project in April 2021 initiating construction of HSPF watershed models that cover the City of High Point Planning Area and watersheds draining to it. The HSPF watershed modeling network was completed in early 2022 with results documented in "HSPF Watershed Model for High Point Area (DRAFT)" report (Tetra Tech, 2022).

The SOW under this amendment describes additional tasks to be performed under Phase 2 as a continuation of the framework elements that were defined by the City Team under Phase 1 of the project. Amendment Task 1 under this SOW will involve developing lake models for City Lake and Oak Hollow Reservoir that will be linked with the HSPF watershed model to support existing and future evaluation of hydrology and water quality impacts in the City Planning Area. Amendment Task 2 will then involve developing a model application scenario representing potential future land use/cover and climate, running the linked watershed-lake modeling system for the scenarios, and documenting the results to guide future management planning. For example, this analysis could support management decisions for City programs including water supply protection, comprehensive development planning and new ordinances, and stormwater management planning.

The two technical tasks are outlined below along with a corresponding project management and coordination task.

2.0 SCOPE OF WORK

2.1 AMENDMENT TASK 1 - LAKE MODEL DEVELOPMENT

The objective of this task is to develop lake models for City Lake and Oak Hollow Reservoir. Outputs from the calibrated HSPF watershed model will be used to derive input boundary conditions for the lake models (e.g., nutrient loads at the upstream boundary). The calibrated lake models can then be used for water quantity and quality analyses. The CE-QUAL-W2 model, a two-dimensional (longitudinal and vertical) hydrodynamic and water quality model (Wells, 2021), was selected for this purpose. CE-QUAL-W2 can simulate lake volume/level, nutrients, dissolved oxygen, algae, temperature, and CBOD. The latest version of CE-QUAL-W2 is Version 4.5 and it includes many enhancements compared to legacy versions.

2.1.1 Model Development

This task will include setting up CE-QUAL-W2 models for Oak Hollow and City Lake. The simulation period of the CE-QUAL-W2 model will be selected based on monitoring records for calibration and be within the HSPF simulation period (e.g., 2016-2020).

Data were previously compiled for the broader modeling effort for the City of High Point. However, recent data that can be used in the lake model development and calibration will be reviewed for incorporation. Categories of data needed for CE-QUAL-W2 model development include:

- Bathymetry data
- Initial conditions
- Boundary conditions
- Hydraulic parameters
- Kinetic parameters
- Calibration data

Bathymetry data, as well as other relevant information (e.g., locations of water quality monitoring sites) will be used to determine the computational grid cells of the model. The computational grid contains information on longitudinal, vertical, (i.e., layer height), and width spacing of each grid cell and slope.

Initial conditions and boundary conditions will be derived from the HSPF model and other viable data sources. Boundary conditions include upstream inflows, tributary inflows, distributed inflows, weather, and point source inflows. Outflows can also be specified as needed, including downstream outflows, lateral withdrawals, spillway design, etc. Atmosphere-water surface boundary conditions are required and include surface heat exchange, solar radiation, wind, and gas exchanges. Hourly time series for meteorological variables (e.g., solar radiation, air temperature) were already processed for weather zones within the HSPF model. Time series from the weather zone aligning with the lakes will be used as inputs to the CE-QUAL-W2 model. In addition, hourly wind direction will be calculated and input to the model to calculate horizontal and vertical velocities. Furthermore, outputs from HSPF will be used to develop input flow and water quality time series for upstream and tributary inflows. Initial parameter values will be set based on user guidance, relevant literature, similar CE-QUAL-W2 models, and best professional judgment. Parameters will then be adjusted during model calibration (Section 2.1.2).

2.1.2 Model Calibration

Model calibration will consist of comparing simulated water surface elevations, temperatures, and water quality constituents to in-lake monitoring records using visual tools and statistical metrics and adjusting parameter values iteratively (e.g., kinetic rates) to improve the fit to observations across sites and variables. State variables to be evaluated with available records include water temperature, dissolved oxygen, suspended solids, algae (chlorophyll *a*), BOD, and inorganic and organic nutrients. Iron and manganese can also be simulated by CE-QUAL-W2, which is of interest to the City for their drinking water intake quality; the sediment release routines of these variables are newer and have not been tested by the Tetra Tech modeling team. Thus, pending suitable data are available for parameterization and calibration, and there are sufficient project resources, the iron and manganese simulation will be tested.

Proposed Amendment Task 1 Deliverables (schedule)

1. CE-QUAL-W2 lake model development status update (within 160 days of NTP)
2. CE-QUAL-W2 lake modeling report (draft within 240 days of NTP)

2.2 AMENDMENT TASK 2 - BASELINE ANALYSIS IWAF MODEL APPLICATION

Tetra Tech will coordinate with City staff and other data resources to develop future land use/cover and climate for the regional High Point Planning Area and watersheds draining to it.

2.2.1 Future Condition Scenarios

Two scenarios will be completed as discussed further below:

1. Existing land use/cover and hindcast climate
2. Future land use/cover and future climate

The first scenario uses existing land use/cover that is already implemented in the HSPF model with hindcast climate. The second scenario provides the opportunity to comprehensively evaluate the impacts of land use and climate changes on water quality and quantity. Relative differences between the two scenarios will be summarized.

2.2.1.1 Potential Future Land Use/Cover

In 2020 the population of High Point was about 114,000 and the City has projected that by 2035 the population is expected to be about 131,000 (https://www.highpointnc.gov/2010/Population-Demographics). Changes in population instigate changes in land use/cover, such as building of new residential subdivisions along the outskirts of town and/or more concentrated development. Development can result in removal of natural land covers (e.g., forest) and lead to more impervious surfaces, which alters hydrologic and water quality dynamics on the landscape and in receiving waterbodies. The HSPF model was developed and calibrated to recent existing land use/cover as discussed in Tetra Tech (2022). This task will involve modeling potential future land use with the HSPF watershed model and CE-QUAL-W2 lake models.

Modeling future land use with the HSPF watershed model requires understanding the types of land uses that are being altered (e.g., forest to developed), the associated acreages of those changes, and the location of those changes. If the City of High Point has a future land use coverage (i.e., GIS shapefile for mapping), then it can potentially be used for the future land use scenario. If no potential future land use coverage is available, then assumptions about land use change will be made with input from the City. Tetra Tech will work with the City Planning Department to understand expectations for future build-out based on regulations, zoning, and other trends. No new land uses/covers will be added to the HSPF model and parameters will be maintained at their current calibrated values. Rather the land use/cover acreages within each model subbasin will be altered in the HSPF SCHEMATIC block, which routes pervious and impervious (PERLND and IMPLND) surfaces to reaches.

2.2.1.2 Potential Future Climate

Global average air temperatures are rising due to human activities and Global Climate Models (also called General Circulation Models; GCMs) are in general agreement that such increases will continue throughout the 21st century. GCM predictions regarding future precipitation patterns are more variable, but both the severity of intense rain events and the frequency of droughts are anticipated to worsen over the 21st century. Effective water resources planning needs to consider the risks associated with these potential changes to help ensure resiliency of the water sector. Assuming that the future will resemble the past can put communities more at-risk, and decisions made today can exacerbate or mitigate a community's vulnerability to local changes in climate. The risks and impacts of future climate vary by location and sector. Therefore, this task will include simulating potential future climate for the City of High Point with the linked HSPF watershed model and CE-QUAL-W2 lake models for City Lake and Oak Hollow.

This task will provide a quantitative assessment of the impacts of potential future climate on water quantity (e.g., water supply lake levels) and water quality (e.g., relative changes in nutrient loads on lake algae populations). GCMs predict future climate as a function of large-scale forcing, not date-specific weather series. Climate is defined as weather at a place averaged over a long-period of time, generally multiple decades, and GCM output must similarly be analyzed over a multi-decadal period. Therefore, Tetra Tech will work with the City to select a future period for evaluation, likely about three decades years long for the HSPF watershed model, such as 2025 to 2055 to support near-term planning. Due to the computationally intensive and lengthy model run time for a gridded CE-QUAL-W2 model, the lake simulation period is anticipated to be a subset of the future evaluation period simulated by HSPF.

Future climate projections are uncertain and are best used to describe potential future conditions to which adaptation may be needed. To select a potential climate future for the City, predicted relative change in mean annual temperature and mean annual precipitation will be assessed for available GCMs, for example by using USEPA's LASSO (Locating and Selecting Scenarios On-line) tool (beta tool under development at U.S. EPA Office of Research and Development, courtesy of Phillip Morefield). The tool performs automated annual and seasonal summaries of monthly-level spatially downscaled (4 km) GCM output from the Multivariate Constructed Analogs (MACA) CMIP5 archive (http://maca.northwestknowledge.net/). The relative change in annual average air temperature and annual precipitation compared to historic, hind-cast climate will be evaluated for the GCMs. From the assessment, a GCM that is near the ensemble mean for the region will be selected for modeling potential future climate.

HSPF and CE-QUAL-W2 input weather time series (e.g., precipitation, air temperature), will be derived from spatially downscaled GCM data for the selected "ensemble mean" scenario. The data will be processed to be in the needed model input formats and units. The first scenario will use hindcast climate from the selected GCM and this will serve as the baseline for determining relative changes. The second scenario will use futurecast climate from the selected GCM and future land use/cover. For each the scenario will be run first with HSPF, and then the boundary conditions for the lake models will be revised to reflect the HSPF results (e.g., flows and loads to the lakes). Then the scenario will be run for the lakes with the CE-QUAL-W2 models. Relative changes in variables of interest (e.g., growing season chlorophyll-a concentrations) from the hindcast to the futurecast simulation will be tabulated and summarized to support planning efforts.

2.2.2 Source Assessment and Impacts Analysis

Results from the existing condition (i.e., calibration models) and future climate scenarios will be tabulated and summarized. As part of this task, a loading assessment will be developed for sediment, phosphorus, and nitrogen for existing conditions with HSPF. This will provide information on pollutant loading hot spots and be useful for comparing relative loads for different sources. The impacts of future conditions on pollutant loading (sediment, nitrogen, and phosphorus) and lake water quality will be analyzed using the relative differences between the hindcast and futurecast scenarios discussed in Section 2.2.1.

Proposed Amendment Task 2 Deliverables (schedule)

1. Draft land use and climate scenario to discuss with City Team (schedule to be determined but look to complete prior to completion of CE-QUAL-W2 model development)
2. Draft analysis report (target 90 days after CE-QUAL-W2 and HSPF linkage and calibration completed)
3. Final analysis report (target 45 days after receiving input from City Team on draft results)

2.3 AMENDMENT TASK 3 - QUALITY ASSURANCE/QUALITY CONTROL, MEETINGS, CORRESPONDENCE, AND CONTRACT COORDINATION WITH THE CITY OF HIGH POINT

2.3.1 Quality Assurance/Quality Control

Throughout implementation of this scope of work, Quality Assurance/Quality Control (QA/QC) will be conducted by the technical team. To support and document QA/QC activities, a QA/QC spreadsheet will be maintained for the lake model development and linked watershed-lake modeling application. It will contain records of data sources used in model development, processing notes, QA/QC review requirements, QA/QC events led by a senior scientist/engineer/modeler, and QA/QC outcomes for the project.

2.3.2 Meetings

Tetra Tech will participate in up to 3 meetings with the City of High Point regarding the modeling and baseline analysis efforts under this SOW. These could potentially include model development update, model application scenario assumptions, and baseline analysis results discussion. Tetra Tech will collaborate with the City of High Point regarding the timing and content of these project meetings.

2.3.3 Correspondence and Contract Coordination

Tetra Tech will coordinate with the City of High Point to manage this contract and plan work under its provisions. This includes corresponding with City staff, planning work, estimating level of effort, tracking accounting, and preparing work summaries to accompany billing invoices.

Proposed Amendment Task 3 Deliverables (schedule)

1. Quality Assurance/Quality Control documentation (as requested by the City)
2. Project meetings and meeting summaries (via email within 1-5 days following calls/meetings)
3. Invoices and progress reports (monthly or as invoiced)

3.0 PROPOSED BUDGET

The proposed budget amendment for this SOW is $150,000, bringing the total cost approved for the IWAF project PO #103547 to $450,000. The amount represents a total not-to-exceed value without written approval from City contract manager. It is anticipated this will cover the development of the lake models in addition to the application of the linked watershed and lake modeling framework to establish a baseline analysis. However, completion of the modeling framework will take precedence and the application will begin as resources allow. Billing will be based on the following staff and rates as outlined in the master services contract for Tetra Tech with the City.

Estimated Budget Breakdown By Task

Task No	Task Description	Budget ($)
2.1	CE-QUAL-W2 Model Development	100,000
2.2	Baseline Analysis IWAF Model Application	35,000
2.3	QAQC, Meetings, Project and Contract Management	15,000
TOTAL		150,000

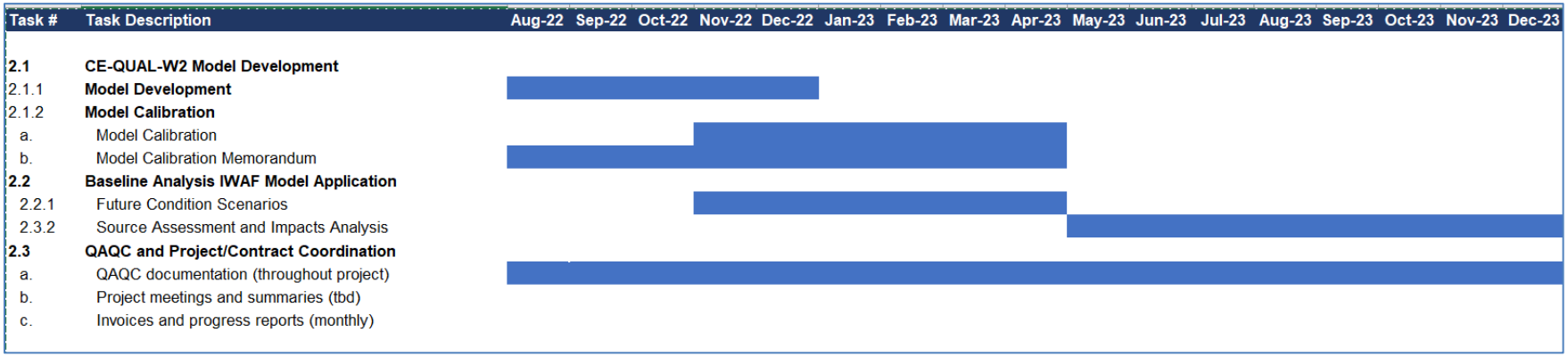
Time and Material rates for proposed staff (per Master Services Agreement)

Person	Role	Billing Category	Yr 5 ($/hr)
1. Trevor Clements	PM/Principal Manager	Principal Contract Manager	190
2. Jon Butcher	Principal Engineer	Principal Engineer	264
3. Holly Miller	Senior Planner	Senior Planner	185
4. Michelle Schmidt	Project Eng./Modeler	Project Engineer	151
5. Hillary Yonce	Project Scientist	Project Scientist	151
6. Afshin Shabani	Staff Engineer/Modeler	Staff Engineer	131
7. Allison Barker	Contract Administration	Contract Administration	102
8. Christina Buxton	Editor/Technician	Science Technician	92

Other direct costs (local travel, equipment/supplies) will be billed at cost plus 15% fee

4.0 SCHEDULE

The estimated schedule for lakes model development and baseline analysis for model application is outlined as follows. Resources to support the baseline analysis will depend on completing the CE-QUAL-W2 Lakes modeling effort within targeted ceiling for that effort.



5.0 REFERENCES

Tetra Tech. 2022. HSPF Watershed Model for High Point Area (DRAFT). Prepared for City of High Point by Tetra Tech, Research Triangle Park, North Carolina.

Tetra Tech. 2021. City of High Point Integrated Watershed Assessment Framework Model Development Plan. Prepared for City of High Point by Tetra Tech, Research Triangle Park, North Carolina.

Wells, S. 2021. CE-QUAL-W2: A Two-Dimensional, Laterally Averaged, Hydrodynamic and Water Quality Model, Version 4.5. User Manual: Part 1 Introduction, Model Download Package, How to Run the Model. Portland State University, Portland, Oregon. Retrieved from: www.cee.pdx.edu/w2/