# Spring Creek Watershed Protection Plan Modeling
# Quality Assurance Project Plan (QAPP)

Houston-Galveston Area Council (H-GAC)
Houston, Texas 77027

Funding Source:

Nonpoint Source (NPS) Program Clean Water Act (CWA) §319(h)
Prepared in cooperation with the
Texas Commission on Environmental Quality (TCEQ)
and the U.S. Environmental Protection Agency (EPA)
Federal ID #99614624
QTRAK#_____

Effective Period: Three years from date of final approval

Questions concerning this QAPP should be directed to:

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## SECTION A: PROJECT MANAGEMENT

### A1 Approval Page

By signing this document, signatories acknowledge their respective organizations' awareness of and adherence to requirements contained in this QAPP in accordance with roles and responsibilities as described in Section A4 Project/Task Organization and throughout.

**TCEQ**

**Monitoring Division**
Laboratory and Quality Assurance (QA) Section

_____

Sharon R. Coleman, TCEQ Quality QA Manager Date

_____

Sharon Coleman, Acting Lead TCEQ NPS QA Specialist (QAS) Date
QA Team

**Water Quality Planning Division**

_____

Faith Hambleton, TCEQ Team Leader Date
NPS Program

_____

Jessica Uramkin, TCEQ NPS QA Coordinator, Date
NPS Program

_____

Jessica Uramkin, TCEQ NPS Project Manager (PM) Date
NPS Program

**H-GAC**

| | |
|---|---|
| Rachel Windham Date<br>H-GAC PM | Jean Wright, Date<br>H-GAC QA Officer (QAO) |
| Thushara Ranatunga, Date<br>H-GAC Lead Modeler | Jessica Casillas, Date<br>H-GAC Data Manager |

H-GAC will secure written documentation from additional project participants stating the organization's awareness of and commitment to requirements contained in this QAPP and any amendments or revisions of this plan. H-GAC will maintain this documentation as part of the project's quality assurance records. This documentation will be available for review. Copies of this documentation will also be submitted as deliverables to the TCEQ NPS PM within 30 days of final TCEQ approval of the QAPP. (See sample letter in Appendix D of this document.)

## A2 TABLE OF CONTENTS

**List of Abbreviations**

| | |
|---|---|
| ASCII | American Standard Code for Information Exchange |
| AU | Assessment Unit |
| AVMA | American Veterinary Medicine Association |
| C&E | Community and Environmental Planning |
| CAP | Corrective Action Plan |
| CAR | Corrective Action Report |
| CRP | Clean Rivers Program |
| CSDGM | Content Standards for Digital Geospatial Metadata |
| CWA | Clean Water Act |
| DMP | Data Management Plan |
| DMR | Discharge Monitoring Report |
| DO | Dissolved Oxygen |
| DOS | Disk Operating System |
| EPA | United States Environmental Protection Agency |
| FGDC | Federal Geographic Data Committee |
| FTP | File Transfer Protocol |
| GIS | Geographic Information System |
| GPS | Global Positioning System |
| H-GAC | Houston-Galveston Area Council |
| LDC | Load Duration Curve |
| MS4 | Municipal Separate Storm Sewer System |
| NAD83 | North American Datum 1983 |
| NOAA | National Oceanic and Atmospheric Association |
| NPS | Nonpoint Source |
| OSSF | Onsite Sewage Facility |
| PM | Project Manager |
| QA | Quality Assurance |
| QA/QC | Quality Assurance/Quality Control |
| QAO | Quality Assurance Officer |
| QAPP | Quality Assurance Project Plan |
| QAS | Quality Assurance Specialist |
| SAS | Statistical Analysis Software |
| SDE | Spatial Database Engine |
| SELECT | Spatially Explicit Load Enrichment Calculation Tool |
| SSO | Sanitary Sewer Overflow |
| SWAT | Soil and Water Assessment Tool |
| SWQMIS | Surface Water Quality Monitoring Information System |
| TCEQ | Texas Commission on Environmental Quality |
| TPDES | Texas Pollutant Discharge Elimination System |
| TPWD | Texas Parks and Wildlife Department |
| TSSWCB | Texas State Soil and Water Conservation Board |
| USGS | United States Geological Survey |
| WPP | Watershed Protection Plan |

## A3 DISTRIBUTION LIST

The Lead NPS QAS will provide approved versions of this QAPP and any amendments or revisions of this plan to the TCEQ NPS PM. The TCEQ NPS PM will provide approved copies to the H-GAC PM and EPA Project Officer within two weeks of approval. The TCEQ NPS PM will document transmittal of the plan and maintain this documentation as part of the project's quality assurance records. This documentation will be available for review in the event of an audit.

**U.S. Environmental Protection Agency Region 6**
**Water Quality Protection Division**
**Assistance Program Branch**
**1445 Ross Avenue**
**Suite # 1200**
**Dallas, TX 75202-2733**

Anthony Suttice, Project Officer
(214) 665-8590

H-GAC will provide copies of this project plan and any amendments or revisions of this plan to each project participant defined in the list below. H-GAC will document receipt of the plan by each participant and maintain this documentation as part of the project's quality assurance records. This documentation will be available for review in the event of an audit.

**H-GAC**
**3555 Timmons Lane, Suite 120, Houston, Texas 77227**

Rachel Windham, H-GAC PM
(713) 993-2497

Jean Wright, H-GAC QAO
(713) 499-6660

Thushara Ranatunga, H-GAC Lead Modeler
(832) 681-2551

Jessica Casillas, H-GAC Data Manager
(713) 993-4594

## A4 PROJECT/TASK ORGANIZATION

### TCEQ

### Monitoring Division

**Sharon Coleman, Acting Lead TCEQ NPS QAS**
Assists the TCEQ NPS PM in QA related issues. Participates in the planning, development, approval, implementation, and maintenance of the QAPP. Determines conformance with program quality system requirements. Coordinates or performs audits, as deemed necessary and using a wide variety of assessment guidelines and tools. Concurs with proposed corrective actions and verifications. Provides technical expertise and/or consultation on quality services. Recommends to TCEQ management that work be stopped in order to safeguard project and programmatic objectives, worker safety, public health, or environmental protection.

### Water Quality Planning Division

**Faith Hambleton**
**TCEQ Team Leader, NPS Program**
Responsible for management and oversight of the TCEQ NPS Program. Oversees the development of QA guidance for the NPS program to be sure it is within pertinent frameworks of the TCEQ. Monitors the effectiveness of the program quality system. Reviews and approves all NPS projects, internal QA audits, program corrective actions, work plans, and contracts. Enforces program corrective action, as required. Ensures NPS personnel are fully trained and adequately staffed.

**Jessica Uramkin**
**TCEQ NPS PM**
Maintains a thorough knowledge of work activities, commitments, deliverables, and time frames associated with projects. Develops lines of communication and working relationships between the contractor, the TCEQ, and the EPA. Tracks deliverables to ensure that tasks are completed as specified in the contract. Responsible for ensuring that the project deliverables are submitted on time and are of acceptable quality and quantity to achieve project objectives. Serves on planning team for NPS projects. Participates in the development, approval, implementation, and maintenance of the QAPP. Conducts independent technical review of the QAPP to ensure compliance with project needs and requirements. Responsible for verifying that the approved QAPP is implemented by the contractor. Notifies the TCEQ Lead NPS QAS of particular circumstances which may adversely affect the quality of data derived from the collection and analysis of samples. Monitors and enforces corrective action.

**Jessica Uramkin**
**TCEQ NPS QA Coordinator**
Assists Lead QAS with NPS QA management. Serves as liaison between NPS management and Agency QA management. Responsible for NPS guidance development related to program quality assurance. Assists with development and maintenance of data management-related standard

operating procedures for NPS data management. Participates in the development, approval, implementation, and maintenance of the QAPP. Provides input and oversight regarding corrective actions. Maintains record of corrective actions.

**H-GAC**

**Rachel Windham**
**H-GAC PM**
Responsible for ensuring tasks and other requirements in the contract are executed on time and are of acceptable quality. Monitors and assesses the quality of work. Coordinates attendance at conference calls, training, meetings, and related project activities with the TCEQ. Responsible for verifying the QAPP is followed and the project is producing data of known and acceptable quality. Ensures adequate training and supervision of all monitoring and data collection activities. Complies with corrective action requirements.

**Jean Wright**
**H-GAC QAO**
Responsible for coordinating development and implementation of the QA program. Responsible for ensuring the most recent version of the NPS QAPP shell document is acquired from the TCEQ NPS PM and used for writing and maintaining the QAPP. Responsible for maintaining records of QAPP distribution, including appendices and amendments. Responsible for maintaining written records of sub-tier commitment to requirements specified in this QAPP. Responsible for identifying, receiving, and maintaining project quality assurance records. Responsible for coordinating with the TCEQ NPS PM to resolve QA- related issues. Notifies the H-GAC PM and TCEQ NPS PM of and documents particular circumstances which may adversely affect the quality of data. Responsible for validation and verification of all data modeled, collected, and acquired. Coordinates the research and review of technical QA material and data related to water quality monitoring system design and analytical techniques. Facilitates, conducts, and documents any technical systems audits.

**Thushara Ranatunga**
**H-GAC Lead Modeler**
The Lead Modeler is responsible for the operation of all computer models (e.g. Spatially Explicit Load Enrichment Calculation Tool (SELECT), Load Duration Curves (LDCs), etc.) and associated documentation of model operation. Responsible for accuracy of input data to models. Performs operation of the models to ensure valid results are being predicted. Responsible for formulating model input to reflect the scenarios and situations to be emulated by each model.

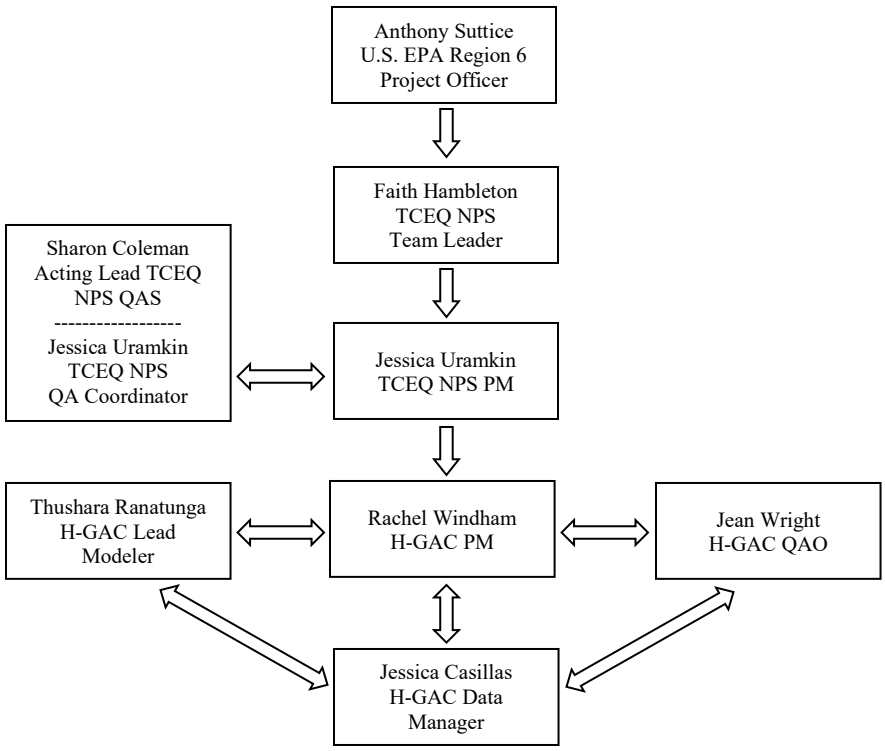
**Jessica Casillas**
**H-GAC Data Manager**
The Project Data Manager is responsible for acquisition and verification of data, documentation of data sources, ensuring the accuracy of data, and for the transfer of data to the TCEQ. Responsible for maintaining project quality assurance records. Oversees data management for the study. Performs data quality assurances prior to transfer of data to the TCEQ. Responsible for transferring data to the TCEQ in an acceptable format. Ensures data are submitted according to

work plan specifications. Provides the point of contact for the TCEQ Data Manager to resolve issues related to the data.

**EPA Region 6**

**Anthony Suttice**
**EPA Project Officer**
Responsible for managing the CWA Section 319 funded grant on behalf of EPA. Assists the TCEQ in approving projects that are consistent with the management goals designated under the State's NPS management plan and meet federal guidance. Coordinates the review of project workplans, draft deliverables, and works with the State in making these items approvable. Meets with the State at least annually to evaluate the progress of each project and when conditions permit, participates in a site visit on the project. Fosters communication within EPA by updating management and others, both verbally and in writing, on the progress of the State's program and on other issues as they arise. Assists in grant close-out procedures ensuring all deliverables have been satisfied prior to closing a grant.

**Figure A4.1. Organization Chart - Lines of Communication**




## A5 PROBLEM DEFINITION/BACKGROUND

Spring Creek (Segment 1008), a primary tributary of the West Fork of the San Jacinto River, flows 71.2 miles eastward from its headwaters in the prairies of Waller County to a confluence with Lake Houston (Figure A5.1). The Spring Creek Watershed is composed of the drainage area of Spring Creek and its unclassified segment tributaries Mill Creek (1008A), Upper Panther Branch (1008B), Lower Panther Branch (1008C), Metzler Creek (1008D), Bear Branch (1008E), Lake Woodlands (1008F), Willow Creek (1008H), Walnut Creek (1008I), Brushy Creek (1008J), Arnold Branch (1008K), Mink Branch (1008L), and Sulphur Branch (1008M) as well as a network of natural and manmade drainage channels. This watershed area spans approximately 439.9 square miles and includes portions of Grimes, Waller, Harris, and Montgomery Counties.

Land cover varies longitudinally and is characterized by heavy development and scattered wooded areas in the eastern third transitioning to lighter development, forest, and grasslands in the western reaches. Smaller cities such as Magnolia, Pinehurst, Stagecoach, Shenandoah, and Oak Ridge North intersect or are completely contained within the watershed area. Larger cities include Tomball, The Woodlands, Spring, and portions of the cities of Humble, Conroe, and Houston. The more urbanized eastern portion of the watershed is intersected by Interstate Highway 45 and the recently expanded Highway 99 runs along a large section of the watershed's southern border.

The principal water quality issues in the Spring Creek Watershed include recreational use impairments caused by high levels of *Escherichia coli* (*E. coli*), aquatic life use concerns for depressed dissolved oxygen (DO) levels, and general use concerns for high nutrient (nitrate and total phosphorous) levels that have been noted in several assessment units (AUs) in segments of Spring Creek and its tributaries (Table A5.1).

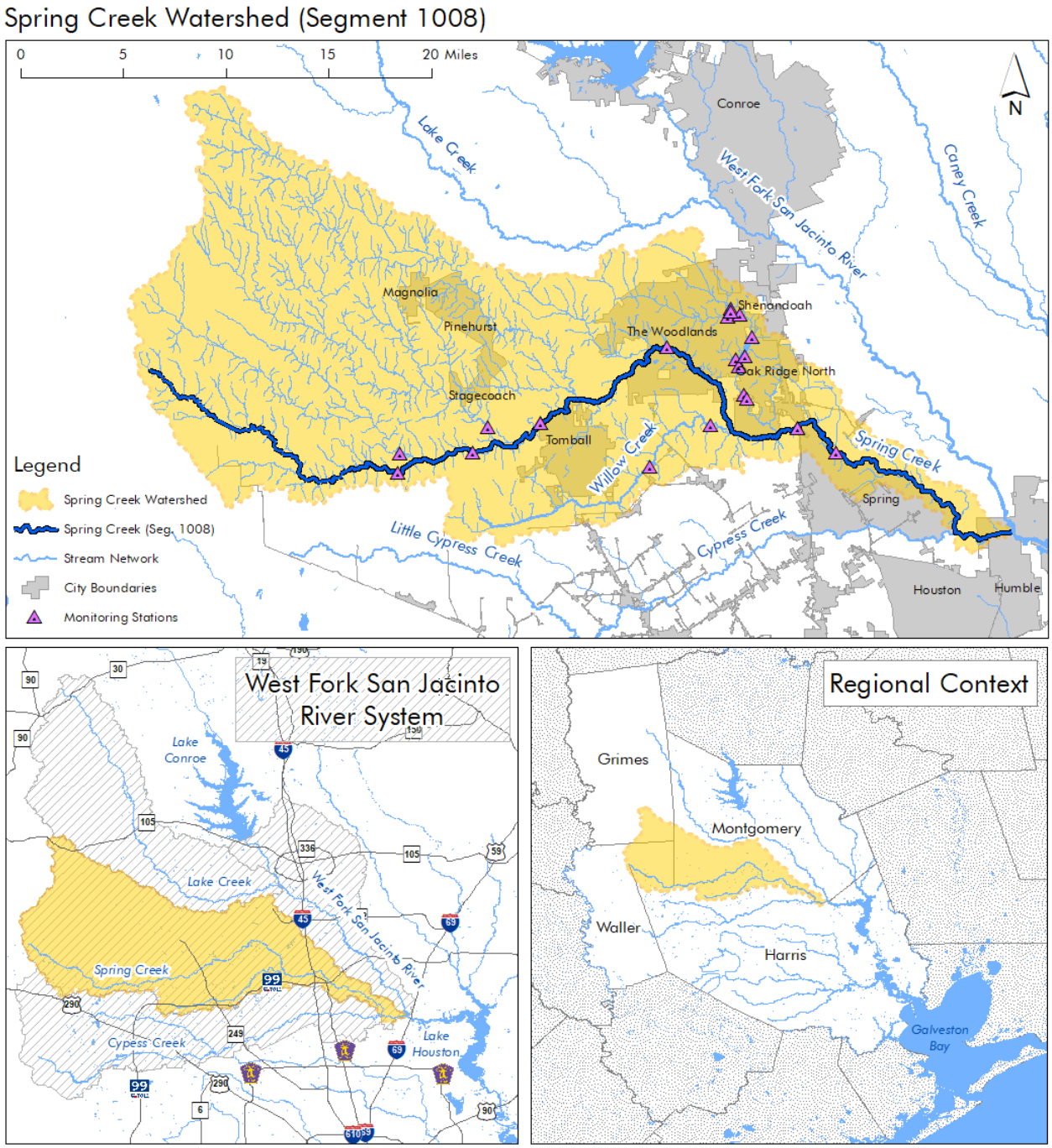



Figure A5.1 – The Spring Creek Watershed

Table A5.1 – Water Quality Issues in the Spring Creek Watershed[1]

| | **Impairments** | | | |
|---|---|---|---|---|
| **Segment** | **AU(s)** | **Parameter** | **Use** | **Category** |
| 1008 | 02, 03, 04 | *E. coli* | Recreation | 4a (all) |
| 1008C | 01, 02 | *E. coli* | Recreation | 4a (all) |
| 1008H | 01 | *E. coli* | Recreation | 4a |
| 1008I | 01 | *E. coli* | Recreation | 5a |
| 1008J | 01 | *E. coli* | Recreation | 5a |
| | **Concerns** | | | |
| **Segment** | **AU(s)** | **Parameter** | **Use** | **Level of Concern** |
| 1008 | 02 | Fish Community | Aquatic Life | CS |
| 1008 | 03, 04 | Nitrate | General | CS (all) |
| 1008 | 03, 04 | Total Phosphorus | General | CS (all) |
| 1008B | 01 | Cadmium | Aquatic Life | CN |
| 1008B | 01 | Nitrate | General | CS |
| 1008B | 01 | Total Phosphorus | General | CS |
| 1008C | 01, 02 | Nitrate | General | CS (all) |
| 1008C | 01, 02 | Total Phosphorus | General | CS (all) |
| 1008C | 02 | Depressed DO | Aquatic Life | CS |
| 1008F | 01 | Depressed DO | Aquatic Life | CS |
| 1008H | 01 | Nitrate | General | CS |
| 1008H | 01 | Total Phosphorus | General | CS |
| 1008I | 01 | Depressed DO | Aquatic Life | CS |
| 1008J | 01 | Depressed DO | Aquatic Life | CS |

Preliminary modeling and source characterization completed during a previous project[2] indicated that a mix of bacteria and nutrient sources contributed to issues in the watershed and were projected to increase in the future. The development of a watershed protection plan (WPP) for the Spring Creek Watershed will identify and further characterize causes and sources of pollution in the watershed through modeling efforts, as informed by stakeholder input and feedback, and identify management measures to address them.

To facilitate the development of the WPP, H-GAC needs to provide enough information to guide stakeholder discussion, characterize the causes and sources of pollution in the watershed, and identify the reductions needed to meet state standards, and additional information to achieve other water quality goals identified by the stakeholders[3]. The efforts outlined in this QAPP are designed

[1] The impairments and concerns represented in this table are based on the Draft 2018 Integrated Report as referenced at https://www.tceq.texas.gov/waterquality/assessment/18twqi/18txir.
[2] Preliminary water quality analyses, SELECT modeling for bacteria, geospatial load assessment methodology modeling for nutrient loading, and LDC analysis for bacteria and dissolved oxygen improvement were conducted between 2015 and 2018 under TCEQ nonpoint source grant project 582-15-56349 "West Fork, San Jacinto River and Lake Creek Watershed Protection Plan (WPP) and Characterization of Spring and Cypress Creek".
[3] Water quality goals for this WPP will always include compliance with state water quality standards. Compliance with state standards is always the primary purpose of the WPP, and the development of data therefore. Additional goals may be developed by the stakeholders as part of the public engagement process, for contaminants or issues for which standards and/or numeric criteria do not exist (nutrients, trash, etc.). Data generated under the efforts covered by this QAPP (water quality analysis, etc.) may assist stakeholders in identifying solutions that achieve multiple benefits, or coordinate efforts with existing programs.

to generate the information needed to guide decisions and allow for feedback and revision from the stakeholders. To ensure that the data generated (and subsequent decisions which rely on it) are defensible and of appropriate quality, H-GAC will conduct its modeling and data evaluation tasks in a manner consistent with this QAPP.

The purpose of the QAPP is to clearly delineate H-GAC's QA policy, management structure, and procedures to implement the QA requirements necessary to verify, calibrate, and validate the output of the modeling process associated with this project. This QAPP is reviewed and approved by the TCEQ to help ensure that the outputs and data generated for the purposes described within are of known quality and deemed accepted for their intended use. This process will facilitate the use of project outputs and data by the NPS program and other programs deemed appropriate by the TCEQ.

## A6 PROJECT/TASK DESCRIPTION AND SCHEDULE

The data needs described in A5 relate to characterizing water quality and updating or refining[1] data concerning causes and sources of pollution to guide stakeholder decisions in the development of the WPP. Based on a review of the concerns and impairments, bacteria, depressed DO, and high nutrient (nitrate and total phosphorous) levels are the water quality issues of greatest concern to the waterways.

Specifically, H-GAC will conduct modeling and data evaluation efforts to:

- evaluate trends and variability in current and historical water quality data, including the use of Statistical Analysis Software (SAS);
- refine and update previous modeling efforts to define the spatial distribution and amount of pollutant loading using the SELECT model; and
- update and refine the characterization of various pollutant concentrations in varying flow conditions and identify the bacteria reductions necessary to meet applicable standards instream using LDCs.

**Water Quality Analysis**
The acquisition and analysis of water quality data will be conducted for Spring Creek based on existing data in the Surface Water Quality Monitoring Information System (SWQMIS), data collected during the project under the Clean Rivers Program's (CRP) existing monitoring QAPP, and sanitary sewer overflow (SSO) and discharge monitoring reports (DMRs) from TCEQ data. SWQMIS/CRP data, indicator bacteria, nutrients, temperature, pH, chlorophyll-a, total suspended solids, flow, and DO data will be evaluated for trends, seasonal variation, and spatial patterns. Data for current 24-hour DO monitoring will be reviewed for at least one CRP site in each component watershed. For DMR/SSO data, H-GAC will update the DMR and SSO analyses conducted previously with data reported to TCEQ in the interim, comprising at least the last five years of

[1] All references to updating or refining water quality analyses or modeling efforts (SELECT, LDCs, etc.) should be taken to refer to the work completed under project 582-15-56349 "West Fork, San Jacinto River and Lake Creek Watershed Protection Plan (WPP) and Characterization of Spring and Cypress Creek" and its corresponding QAPP.

available data. This work will be completed in the timeframe between approval of the QAPP and Quarters 3 (Draft) and 8 (Final) of the contract. The output of this effort will be the acquired datasets, the trends and variability analyses, a report on the data to be used for updating modeling efforts, and a report on the trend and variability analyses results. This effort will identify trends, guide decision-making, and provide inputs for the SELECT and LDC modeling efforts.

**Load Characterization with SELECT**

The SELECT[1] model will be updated based on currently available data and stakeholder feedback. SELECT uses existing spatial data in a geographic information system (GIS) framework and literature values to characterize the extent and spatial distribution of bacteria sources. This methodology was originally selected for this purpose based on use in other similar projects and because they represented a good match between the level of precision needed for the project with the complexity of the model (and the resources available). Spatial data used in SELECT include land use/land cover, point sources, roads, hydrology/stream network, subwatershed boundaries, aerial imagery, Texas Pollutant Discharge Elimination System (TPDES) permit outfall locations (including wastewater treatment facilities [WWTFs], concentrated animal feeding operations, and municipal separate storm sewer [MS4s] permits), on-site sewage facility (OSSF) locations, soil data, census tracts, regional demographic projections (spatial), elevations, and other related watershed-specific spatial locations (impoundments, etc.). Non-spatial data, or spatial data not used wholly in a spatial context, will include agricultural census data, DMRs, SSO violation data, wildlife population data, and non-domestic animal population data (feral hogs). Literature values or assumptions[2] derived from data to be used will include population and loading rates for all sources, unpermitted septic system locations, pollutants in WWTF flows, and prevalence of specific sources in different land cover types. The existing SELECT analyses will be updated in the timeframe between approval of the QAPP and quarter 3 (Draft) and quarter 4 (Final) of the contract.

H-GAC will use SELECT to update analyses for the project area for current and future conditions. The updated analyses will be broken out by subwatershed. Assumptions and results will be reviewed with stakeholders, TCEQ, and other partners to ensure that they reflect local knowledge and provide an accurate reflection of loading in the watershed. The output of this effort will be updated visual displays of loading data, potential load estimates, and characterization of relative contribution by sources for current and future conditions. These outputs will guide stakeholder decisions concerning the identification and prioritization of management measures and serve as a basis for updating derived reduction targets in conjunction with the updated LDC analyses.

For all updated analyses, the scenarios will include a weighting factor in which loads generated within 100 meters of waterways will be weighted as 100%. Loads originating outside this “buffer”

[1] Additional information on the purpose, methodology, and use of the SELECT model from which this SELECT approach is derived can be found at https://ssl.tamu.edu/media/11291/select-aarin.pdf.

[2] Additional loading factors may be included based on stakeholder input, including conservative estimates of populations not able to be estimated through existing data (e.g. adding load for wildlife other than deer, or decreasing load from pets based on pet waste station usage).

area will be weighted as 25%. The "buffered" approach utilizes a weighting factor to accentuate the probability of proximate load to waterways having greater impact[1].

**Load Duration Curves**

This project effort will develop updated and revised LDCs[2] for bacteria and DO. The LDCs will be used to update derived load reductions for bacteria and to evaluate any patterns in exceedances of the water quality standard based on flow conditions for all constituents. This work will be completed in the timeframe between approval of the QAPP and Quarter 8 of the contract.

Updated LDCs will be completed for at least four stations in the project subwatersheds, utilizing quality assured water quality data from SWQMIS and/or CRP sources and flow data from United States Geological Survey (USGS) gauges[3]. For stations on stream segments without USGS gage flow data, H-GAC will employ the Soil and Water Assessment Tool (SWAT) if there is sufficient flow data available to calibrate a flow estimation model. The SWAT model creates a simple hydrological/runoff application that uses existing spatial and climate data to generate a 10-year period of estimated flow data. Prior to developing the LDCs, H-GAC will evaluate the preliminary information from water quality data analyses to confirm that selected LDC sites are appropriate for characterizing their respective water bodies. If additional or amended locations are needed after water quality data analysis is completed, this QAPP will be amended prior to work being initiated on amended locations. The outputs of the LDC analysis will be visual characterizations of the relationship between flow levels and constituent concentrations, and reduction estimates for constituent loading. The use of this effort will be to help identify variation in loading based on flow and to inform stakeholder decisions regarding scale and type of management measures. The USGS stream gauge and monitoring site locations for LDCs are summarized in Table A6.1.

**Table A6.1. LDC Monitoring Site Locations**

| Segment Name | Segment Number | Station Number | USGS Gage |
|---|---|---|---|
| Spring Creek at Tomball | 1008 | 11313 | 08068275 |
| Spring Creek at Spring | 1008 | 11314 | 08068500 |
| Lower Panther Branch | 1008C | 16627 | 08068450 |
| Willow Creek | 1008H | 11185 | 08068325 |
| Walnut Creek | 1008I | 20462 | No Gage |
| Brushy Creek | 1008J | 20463 | No Gage |

This modeling approach was chosen based on applicability of the models to the project questions; level of precision needed for development of the watershed protection plan; similarity to other

[1] SELECT does not account for the effects of proximity on bacteria transmission, which may skew source contribution ratios and impact stakeholder decisions. The weighting approach is based on previous WPP approaches (e.g., West Fork San Jacinto River and Cypress Creek) using some extent of the same approach, as developed by, and approved by, stakeholders.

[2] Additional information on the use and methodology of the load duration curve model being used for this and previous efforts can be found at https://www.epa.gov/sites/production/files/2015-07/documents/2007_08_23_tmdl_duration_curve_guide_aug2007.pdf .

[3] Other potential additional LDC sites include CRP monitoring stations 17489, 11312, 18868 and/or 11323 on Spring Creek, 20730 on Willow Creek, 16631 on Bear Branch, and 16629, 16630, 16632 and/or 16422 on Panther Branch.

WPP modeling efforts; and through discussions with TCEQ project staff. The fundamental goal of these modeling efforts remains to inform staff understanding of the watershed and stakeholder decisions. The timeline for these efforts is defined in the contractual agreement between H-GAC and TCEQ, as amended from time to time, and summarized in Table A6.2.

**Table A6.2. Modeling and Data Analysis Schedule of Deliverables**

| Contract Task No. | Deliverable | Due Date |
|---|---|---|
| 3.3 | Draft Data Analysis Summary Report | Quarter 3 of the Contract |
| 3.3 | Final Data Analysis Summary Report | Quarter 8 of the Contract |
| 4.1 | Load Duration Curve Update | Quarter 2 of the Contract, included in Modeling Report in Quarter 4 |
| 4.2 | SELECT Update | Quarter 3 of the Contract, included in Modeling Report in Quarter 4 |
| 4.3 | Draft Modeling Report | Quarter 4 of the Contract |
| 4.3 | Final Modeling Report | 30 days following TCEQ Comments |

This project started in October 2019 and is estimated to be completed in August 2021. No environmental data operations for this project will be conducted prior to the approval of this QAPP. All task and deliverable dates are estimates.

See Appendix A for the contract scope of work and schedule of deliverables associated with work defined in this QAPP.

## REVISIONS TO THE QAPP

### Amendments

Amendments to the QAPP must be approved to reflect changes in project organization, tasks, schedules, objectives, and methods; address deficiencies and nonconformances; improve operational efficiency; and accommodate unique or unanticipated circumstances. Requests for amendments are directed from the H-GAC PM to the TCEQ NPS PM in writing using the NPS QAPP Amendment Shell (Appendix E). The changes are effective immediately upon approval by the TCEQ QA Manager, TCEQ NPS PM, and TCEQ Lead QAS, or their designees.

Amendments to the QAPP and the reasons for the changes will be documented, and full copies of the amendments will be forwarded to all persons on the QAPP distribution list by the H-GAC QAO. Amendments shall be reviewed, approved, and incorporated into a revised QAPP during the annual revision process or within 120 days of the initial approval in cases of significant changes.

**Annual QAPP Reviews and Revisions**

This QAPP shall be reviewed in its entirety and certified annually by the H-GAC PM and the TCEQ NPS PM. A letter certifying this annual review must be submitted to the TCEQ NPS PM no later than 90 days prior to the QAPP anniversary date. Amendments approved since QAPP approval (or most recent annual review, if applicable) must be included as an attachment along with the letter. Only nonsubstantive changes not affecting the project design or quality or quantity of work to be performed can be included in the annual certification letter. This includes organizational changes or schedule changes based on a contract amendment that do not impact data deliverables. If changes beyond these are necessary, a QAPP amendment must be submitted and approved before the annual review may be certified. The TCEQ NPS PM is required to review the QAPP and provide certification of annual reviews to the TCEQ QA Manager and EPA Region 6 Project Officer no later than 30 days before QAPP anniversary dates. If the QAPP expires, work described within this document must be halted.

If the project will extend beyond the third QAPP anniversary date, a full QAPP revision is required. This is accomplished by submitting a cover letter, a document detailing changes made if any, and three full copies of the fully updated QAPP (including three sets of signature pages).

## A7 QUALITY OBJECTIVES AND CRITERIA FOR MODEL INPUTS/OUTPUTS

The general quality objectives for the project are to produce data analyses and updated modeling outcomes that accurately characterize conditions in the watershed and are a sufficient platform on which to base stakeholder decisions concerning the selection and scale of management measures. This is achieved using the best available data (quality-assured[1] as applicable), review of products and inputs with stakeholders and knowledgeable partners, and adhering to the preponderance of literature (as amended by reasonable stakeholder review) for modeling assumptions. These goals are fostered by continual and robust engagement with stakeholders, especially partners with specific technical experience.

Data quality objectives for each component effort are described below. For all acquired/existing data sources quality assured data from SWQMIS as collected through CRP or other submitting programs will be used if available.

**Water Quality Analysis**

The primary data quality objectives for this effort are to ensure data inputs are from quality assured sources, and that analysis outputs accurately reflect water quality trends in the watershed. The focus of the analyses are long-term trends, although short-term or seasonal trends may be reviewed based on a review of the available dataset, requirements of the stakeholders, and area-specific circumstances. Performance criteria for inputs are quality-assured status for water quality data (e.g.

[1] For the purpose of water quality trends analyses, modeling inputs, and in support of decision-making for the WPP, water quality data used will be limited to quality-assured data processed through a TNI-accredited lab, unless it meets an exception as indicated in 30 TAC, Chapter 25.6. Volunteer data (e.g. Texas Stream Team, or other non-accredited lab data) will only be used for anecdotal purposes or for general watershed information.

data collected under existing TCEQ/EPA approved QAPP or another similar source). Data that is not quality assured may be used to help characterize the watershed in a qualitative sense, or as indicators where additional analysis may be needed, but will not be considered equal to data produced under a QAPP. These data sources will not be used for the water quality analyses or mingled with quality-assured data, but only for informal/informative review of potential problem areas not covered by formal monitoring.

Performance criteria for outputs include a proper data management trail (per Appendix E and relevant document retention requirements of this QAPP) of the data evaluation process, and trends/variability analyses that properly utilized SAS methods (See Appendix E), performed by experienced staff. The outputs will be acceptable if the performance criteria are met (this is a qualitative measure, as no calibration or validation of data other than initial validation in submission to SWMQIS is performed on these analyses). The intended use of these outputs will be to display water quality trends for stakeholder decision-making processes, including the development of pollutant reduction targets based on the results of the SELECT modeling outputs.

Hardware and software to be used will conform to industry standards (e.g. Microsoft Office products and SAS utilized in a Windows 7 environment). Configuration of SAS analyses will be based on similar water quality analyses conducted by CRP staff using the same data management and data evaluation processes and tools to ensure the data is comparable with those of other regional and regulatory efforts.

Data completeness will be evaluated based on whether all existing data as submitted to SWQMIS has been used. Data representativeness will be based on whether all available data from stations in the watershed is utilized, thus representing the broadest picture of conditions throughout the area.

Trend analysis will include assessment of which ambient monitoring constituents have statistically significant trends. Information about each constituent will include the number of samples evaluated. Evaluation of constituents will be based on their respective water quality standard numeric criteria or equivalent measure (e.g., screening level). Analyses will mirror the approach taken in the development of water quality trends analyses for these waterways under the West Fork San Jacinto River and Lake Creek WPP analysis effort and related QAPP. Because the data and methods to be used have previously been reviewed as part of quality-assured processed, no appreciable bias in the data is expected. Systemic bias in water quality sampling data is based on skewing of data collection to daylight hours. Systemic uncertainty is found in the lack of continuous data (i.e. periodic grab samples under CRP, etc.). However, these sources of uncertainty are endemic to monitoring programs, and are not expected to produce serious issues for data analysis acceptability.

**Load Characterization with SELECT**

The primary data quality objectives for this effort are to ensure data inputs are from the best available sources (quality assured or industry standard), that assumptions are scientifically defensible and vetted by stakeholders, and that outputs are driven by appropriate data and stakeholder review. Performance criteria for inputs are that they represent the best available data, and in the case of data sources which may differ from place to place, the most locally-appropriate

data (e.g. deer population numbers for the specific area as opposed to a statewide average). All spatial data used in SELECT is from sources that are quality-assured or are widely-used data products appropriate for this task. Performance criteria for outputs include modeling outcomes that are sufficient to guide stakeholder discussion, and which are demonstrably defensible based on the source and vetting of data and assumptions. The outputs will be acceptable if these criteria are met (this is a qualitative measure, as no model calibration or validation of data other than initial validation in submission to SWMQIS is performed for SELECT). The intended uses of these outputs will be to generate potential pollutant load estimates and characterize their spatial relationship, and to guide stakeholder discussions of the scope of management measures. Hardware and software to be used will conform to industry standard (e.g. Microsoft Office products, and the SELECT model utilized in a Windows/ArcGIS environment). Configuration of SELECT assumptions analyses will be based on similar SELECT analyses to ensure the data is comparable with those of other regional and regulatory efforts.

Data completeness will be based on whether enough data is available to generate loads using SELECT. Data representativeness will be evaluated based on whether spatial data and assumptions are indicative of conditions throughout the watersheds. Because the selection of assumptions and the stakeholder review process can introduce some subjectivity in decision-making, some level of bias in the outcomes is expected. Bias will be considered reasonable if modifications to outputs or assumptions are based on reasonable expectations that local knowledge or data is more appropriate than more general values. Systemic uncertainty is inherent to the use of assumptions and literature value. However, these sources of uncertainty are endemic to SELECT modeling and do not compromise the objectives for this modeling effort. SELECT is not intended to be a model of a precision level that would be impacted by these levels of bias and/or uncertainty. Table A7.1 indicates all foreseeable assumptions or literature values that will be applied to the models.

**Table A7.1 Modeling Assumptions**

| Assumption/ Literature Value | Model | Review with Stakeholders? | Source | Value |
|---|---|---|---|---|
| Feral Hog Density | SELECT | Yes | Texas A&M AgriLife Research (AgriLife) Densities | AgriLife has used a variety of hog densities, with a generic Texas range of 1.3-2.5 hogs per square mile[1], depending on land cover type. This value is expected to be heavily modified by local stakeholders to reflect area or subwatershed populations. |

[1] http://irnr.tamu.edu/media/355507/sp-472.pdf

| **Assumption/ Literature Value** | **Model** | **Review with Stakeholders?** | **Source** | **Value** |
|---|---|---|---|---|
| Livestock Populations | SELECT | Yes | United States Department of Agriculture National Agricultural Statistics Service (NASS) Agricultural Census Data (most recent) | County-level data is used to derive a ratio of animals per land cover type. This ratio is then applied to the area of the watershed in each county. |
| OSSFs Number and Location | SELECT | Yes | H-GAC OSSF Database | Permitted systems are based on actual location data. Unpermitted systems are based on occupied locations outside of service areas, without permitted OSSFs. |
| OSSF Failure Rates | SELECT | Yes | H-GAC OSSF Data, Stakeholder Input | As these rates are highly variable by location, failure rates will be heavily modified by stakeholder (especially Authorized Agent) input. An estimated 15% failure rate was used in preliminary SELECT outputs. |
| Animal Excretion/Bacterial Densities | SELECT | No | Literature Value | Based on values indicated in Teague, 2009[1]. |
| WWTF Discharge Concentrations | SELECT | Yes | DMR Data from Each Plant (TCEQ) | Geomean of DMR data, using an assumed 60% of permitted flow as daily average flow to determine total load. |
| Land Cover Change | SELECT | Yes | H-GAC Regional Demographic Projections | Proprietary data used in most regional WPPs. |

[1] "Spatially explicit load enrichment calculation tool to identify potential *E. coli* sources in watersheds." A. Teague, et al. 2009. http://ssl.tamu.edu/media/11291/select-aarin.pdf

| **Assumption/ Literature Value** | **Model** | **Review with Stakeholders?** | **Source** | **Value** |
|---|---|---|---|---|
| Pet Populations | SELECT | Yes | American Veterinary Medicine Association (AVMA) | AVMA estimates of household ownership (0.8 pets/household) used as a starting figure, multiplied by number of households. This will be modified by stakeholders and area-specific reconnaissance. A decrease factor in load may be applied if pet waste station/pet bag use is found to be common in the watershed, based on research and stakeholder input. |
| Deer Populations | SELECT | Yes | Texas Parks and Wildlife Department (TPWD) | TPWD Resource Management Unit (RMU) data is used to define regional deer population estimates, which are applied to appropriate land cover types, as in Teague, 2009. |
| Bird Populations/Fecal Concentrations | SELECT | Yes | TPWD, Stakeholders, EPA, Texas State Soil and Water Conservation Board (TSSWCB) | Bird populations are based primarily on TPWD staff knowledge (if available) and stakeholder knowledge. Of primary concern are the presence of colonial rookeries, swallow nesting sites over water, gulls concentrated at landfills, and other large concentrations of birds. EPA and TSSWCB values[1] for |

[1] Based on studies referenced by EPA and TSSWCB, including http://www.ncbi.nlm.nih.gov/pmc/articles/PMC2771205/ and http://www.tsswcb.texas.gov/files/docs/BBBB_Report_23Sep13_Clean.pdf

| Assumption/ Literature Value | Model | Review with Stakeholders? | Source | Value |
|---|---|---|---|---|
| | | | | bird fecal rates are used if stakeholder input indicates substantial, or substantially proximate (swallow colonies over bridges, etc.), numbers of birds exist on an annual basis to model. Values dependent on species of concern. |
| WWTF Outfall Locations | SELECT | No | TCEQ Spatial Data | WWTF outfalls are spatially explicit data. |
| Other Wildlife | SELECT | Yes | TPWD, Stakeholder input | If data for other wildlife populations exist, it will be considered for inclusion with stakeholders. If it does not, a conservative background load expressed as a percent of total may be applied based on stakeholder input and microbial source tracking studies in the state and local area. |

**Load Duration Curves**

The primary data quality objectives for this effort are to ensure data inputs are from quality assured sources; that modeling assumptions are based on the existing LDCs from the preliminary runs, best available literature, and best professional judgment; and that outputs reflect load durations and related reduction needs (for bacteria) in a manner that is reflective of the diverse conditions of the project area. Performance criteria for inputs are quality-assured status for water quality data (e.g. data collected under existing TCEQ/EPA approved QAPP or other similar source) and outputs from the preliminary LDC runs. Performance criteria for outputs include a proper data management trail of the data evaluation process, and LDC analysis using established methods[1], performed by experienced staff. The outputs will be acceptable if these criteria are met (this is a qualitative measure, as no calibration or validation of data other than initial validation in submission to SWMQIS is performed on these analyses).

[1] http://www.epa.gov/tmdl/approach-using-load-duration-curves-development-tmdls

The intended use of these outputs will be to develop updated bacteria reductions, and define impacts to bacteria, DO and related constituents under various flow conditions. Hardware and software to be used will conform to industry standards (e.g. Microsoft Office products and LDC approaches [LoadEst, et al.] utilized in a Windows 7 environment). Configuration of LDC assumptions will be based on TCEQ guidance and the existing preliminary analyses to ensure the data is comparable with those of other regional and regulatory efforts. However, specific configuration of assumptions will be based on best available data, professional judgment, and stakeholder review. Data completeness will be based on whether enough data is available to generate updated LDCs. Data representativeness will be evaluated based on whether selected LDC sites have enough data for an update and are representative of the watersheds in general. Because the selection of assumptions and the stakeholder review process can introduce some subjectivity in decision-making, some level of bias in the outcomes is expected. Bias will be considered reasonable if modifications to outputs or assumptions are based on reasonable expectations that local knowledge or data is more appropriate than more general values or specific choices (e.g., level of reduction to be used in relation to bacteria). Systemic uncertainty is inherent to the simplicity of the model and the complexity of real-world systems. However, these sources of uncertainty are endemic to LDC modeling and do not compromise the objectives for this modeling effort. LDCs are not intended to be a modeling approach of a precision level that would be impacted by these levels of bias and/or uncertainty. If insufficient USGS flow data is available, estimated flow data will be projected using SWAT. The data objectives for the estimated flow conform to the same intended uses as the other LDC inputs and outputs. The intent of estimating flow is to provide stakeholders with information for an area that may otherwise not have enough flow data on which to base an LDC.

## A8 SPECIAL TRAINING REQUIREMENTS/CERTIFICATION

No formal certification is required for the efforts to be conducted under this QAPP. The modeling and project management staff have conducted previous training in all modeling and data evaluation efforts discussed. Any additional staff members that conduct work under this project will have, or receive, training specific to their work.

The lead modeler and project manager have conducted SELECT and LDC analyses (including the potential use of SWAT in general and for the specific purpose of generating flow data) on a variety of watershed projects including preliminary runs for this watershed and have attended multiple formal training events on SELECT and LDCs. Additionally, they have advanced knowledge of data quality needs and objectives common to modeling approaches in general based on experience and training. The SWAT tool will use existing data resources, and staff are already trained in its use and application for these purposes, so no additional training is required if it needs to be employed, after a QAPP amendment.

The data manager and QAO for this project are the H-GAC lead staff for CRP data analysis, and have extensive training in data management, quality assurance, and SAS operation (data manager). They routinely attend training specific to SWQMIS procedures, and/or SAS operation. Their daily activities have heavy focus on this type of data analysis and quality assurance. Records of educational credentials, training, demonstrations of competency, assessments, and corrective

actions are retained by project management and are available for review.

All staff members have worked with QAPPs under prior projects. No additional training is expected to be needed to complete the project efforts.

## A9 DOCUMENTS AND RECORDS

All digital and paper documentation for the project is kept for a period of seven years. The H-GAC PM has final responsibility for ensuring project files are compiled in accordance with this QAPP. The QAO and Data Manager will ensure that the PM has appropriate documentation for water quality data analyses and records for data from acquired data sources including but not limited to SWQMIS and CRP data. The Lead Modeler will ensure that all modeling records, notes, literature referenced, and other records from modeling efforts are maintained during the project and relinquished to the PM for proper retention. Electronic data on the project computers and the network server are backed up daily to the network drive and weekly to external storage. In the event of a catastrophic systems failure, the tapes can be used to restore the data in less than one day's time. Data generated on the day of the failure may be lost but can be reproduced from raw data in most cases. Quarterly progress reports disseminated to the individuals listed in section A3 will note activities conducted in connection with the water quality modeling project, items or areas identified as potential problems, and any variations or supplements to the QAPP.

In addition to general information regarding data and modeling activities, any stakeholder input received, or notes generated regarding input, will be included with modeling files and project documentation.

**Modeling Log**
Modeling notes created by the Lead Modeler will be recorded electronically with model files, on paper, or in a separate electronic file (e.g., Word document). All electronic files will be stored in the same folder as the modeling files, and all paper files will be retained by the modeler until the end of the project. At that time, they will be included with project files maintained by the PM.

The Lead Modeler will document reasons for model selection not already identified in this QAPP, references for model assumptions (and adjustments thereof), stakeholder feedback, and model runs. The level of detail will be sufficient to allow another modeler to duplicate the modeling method given the same data and model.

The documents and records that describe, specify, report, or certify activities, requirements, procedures, or results for this project and the items and materials that furnish objective evidence of the quality of items or activities are listed in Table A9.1. All project staff will develop and retain documentation as described in Table A9.1.

**Table A9.1 Project Documents and Records**

| Document/Record | Location | Retention*[a] | Form*[b] |
|---|---|---|---|
| QAPPs, amendments, and appendices | H-GAC | 7 years | Paper/Electronic |
| QAPP distribution documentation | H-GAC | 7 years | Paper/Electronic |

| **Document/Record** | **Location** | **Retention*[a]** | **Form*[b]** |
|---|---|---|---|
| Standard Operating Procedures | H-GAC | 7 years | Paper/Electronic |
| Model User's Manual or Guide (including application-specific versions) | H-GAC | 7 years | Paper/Electronic |
| Assessment reports for acquired data | H-GAC | 7 years | Paper/Electronic |
| Raw data files | H-GAC | 7 years | Paper/Electronic |
| Model input files | H-GAC | 7 years | Electronic |
| Model output files | H-GAC | 7 years | Electronic |
| Code Verification Reports | H-GAC | 7 years | Paper |
| Interim results from iterative calibration runs | H-GAC | 7 years | Electronic |
| Calibration Report | H-GAC | 7 years | Paper |
| Model Assessment Reports | H-GAC | 7 years | Paper |
| Progress report/CAR/final report/data | H-GAC/TCEQ | 3 years | Paper/Electronic |

*a – After the close of the project
*b – Electronic files should be American Standard Code for Information Interchange Disk Operating System (ASCII DOS) pipe delimited text files or Microsoft Word/Excel; model input and output files can be archived in the format used by the modeling software, provided the capability of conversion to ASCII DOS pipe delimited text files or Microsoft Word/Excel (TCEQ compatible version) is maintained over the time of retention.

The TCEQ may request records at any time and/or elect to take possession of records at the end of the specified retention period.

## SECTION B: MEASUREMENT AND DATA ACQUISITION

The primary source of data for these data analysis and modeling efforts will be SWQMIS data produced under previous QAPPs (e.g. CRP data, etc.).

### B1 SAMPLING PROCESS DESIGN
Not Relevant.

### B2 SAMPLING METHODS
Not Relevant.

### B3 SAMPLE HANDLING AND CUSTODY
Not Relevant.

### B4 ANALYTICAL METHODS
Methods of analysis used for this effort are described in Section A6.

### B5 QUALITY CONTROL
Quality control and acceptance criteria for data and analyses used in this effort are described in Section A7.

### B6 INSTRUMENT/EQUIPMENT TESTING, INSPECTION AND MAINTENANCE
Not Relevant.

### B7 MODEL CALIBRATION
No formal calibration (or sensitivity analysis) is used for the data analyses (SAS), SELECT, or standard LDCs. Informal adjustment of the model inputs or outputs may be applied based on stakeholder feedback and more specific local knowledge compared to general assumptions.

### B8 INSPECTION/ACCEPTANCE OF SUPPLIES AND CONSUMABLES
Not Relevant.

### B9 NON-DIRECT MEASUREMENTS (DATA ACQUISITION REQUIREMENTS)

The modeling and water quality data analysis efforts described in this QAPP will make use of non-direct/acquired data from a variety of sources. The sources and their characteristics are included in Table B9.1.

The primary sources of data for model development are:

- Water quality monitoring data from SWQMIS;
- DMRs, SSO violation data, other permit reporting data from TCEQ databases;
- Regional demographic forecasting data created by H-GAC;
- OSSF location data created by H-GAC for TCEQ;
- Developed data (LDC runs, etc.) from the preliminary modeling effort for this watershed[1];

[1] As produced under the "West Fork, San Jacinto River and Lake Creek Watershed Protection Plan (WPP) and

- Spatial datasets and databases created by other state and federal agencies (e.g. National Oceanic and Atmospheric Administration [NOAA] land cover data, USGS flow data, precipitation data, etc.); and
- Literature values for model assumptions (see Table A7.1[1]).

All non-direct data being used has been previously deemed to be acceptable acquired data sources under other QAPP efforts or was prepared under QAPP coverage. In all instances, the best available data in terms of quality, quality control, and comparability with other QAPP covered modeling efforts have been selected for use.

**Ambient Water Quality Data**

No data will be collected specifically for this project nor submitted for inclusion in SWQMIS. The collection and qualification of the TCEQ and USGS data are addressed in the TCEQ Surface Water Quality Monitoring QAPP[2]. The collection and qualification of the Texas CRP data are addressed in the Texas CRP QAPPs[3]. Data acquired for this project will include those parameters described in section A6 as well as any other data needed to update the characterization of the watershed; develop, operate, or validate models; or meet other user requirements. These data include conventional parameters, field parameters, bacteriological parameters, and biased sampling conducted under special projects.

TCEQ's SWQMIS is the largest and most complete repository for water quality data collected under accepted QAPP procedures in the State of Texas and was selected for that reason for these efforts. The water quality data to be acquired for this project will include routine water quality data collected by TCEQ and sampling partners such as the CRP, the United States Geologic Survey (USGS), and the Texas State Soil and Water Conservation Board, including available 'non-qualified,' routine or special study, ambient, fixed station water quality data and associated field parameters.

The FY2020-2021 CRP QAPP Section B9 explains which TCEQ method codes are used to describe comparable parameters contributing to the CRP dataset. Sections A7, B5 and Appendix A of the FY2020-2021 CRP QAPP also describe limits of quantitation and the process by which analytical results reported to the CRP are required to reflect parameter ranges in excess of those limits. Assessments of CRP data conducted under the Basin Highlights Report(s) and Basin Summary Report falling within this project timeline may be used to supplement analyses conducted under this project. All CRP work is conducted under its own QAPP and is not intended to be covered under this QAPP. However, the data, staff, and processes used are identical to those intended for this project.

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Characterization of Spring and Cypress Creek" and its corresponding QAPP.

[1] Table A7.1 includes preliminary model assumptions and literature values. Additional values, assumptions, or modifications thereof may be utilized depending on stakeholder input. The project modeling process relies strongly on working with stakeholders to refine assumptions to best suit local conditions and knowledge.

[2] www.tceq.state.tx.us/waterquality/monitoring/swqm_guides.html

[3] www.tceq.texas.gov/waterquality/clean-rivers/qa/index.html

**TCEQ Permit and Violation Data**
This project will make use of data from TPDES and other permittees acquired and maintained by TCEQ. This will include DMRs, SSO violation data, TPDES permit information and compliance history, and other data relevant to TCEQ or EPA-permitted facilities in the watershed. This data is assumed to be of acceptable quality based on inclusion in TCEQ- or EPA-approved datasets, including those prepared by H-GAC for TCEQ under QAPP-covered efforts funded by 604(b) Water Quality Management Plan projects. H-GAC will work with TCEQ staff to identify, acquire, and update these data sources.

**Regional Demographic Forecasting**
H-GAC conducts regional demographic forecasting as part of a quality-assured effort. Data to be used for this project include current and future population projections, land cover change projections, and household and job change projections. This data source is the standard for the region and is used in comparable QAPP-covered planning efforts as well as broader regional planning efforts.

**OSSF Location Data**
H-GAC maintains a spatial database of permitted OSSF locations for the region, including the project area. This database was developed and maintained under a TCEQ-approved QAPP as part of an ongoing Clean Water Act 604(b) Water Quality Management Plan partnership between H-GAC and TCEQ.

**Existing Modeling**
The SELECT and LDC data for the existing preliminary modeling efforts for this watershed will be used as a basis for updating and revising SELECT and LDCs, as described in A6. These LDCs were developed under approved QAPP coverage.

**Geospatial Data**
The H-GAC Community and Environmental Planning Department's (C&E) Data Management Plan (DMP; Appendix E) outlines how both tabular (non-geographic) and spatial (geographic) datasets are captured, manipulated, analyzed, stored, and displayed within the Geospatial/ GIS environment as it relates to sharing of data, development of geospatial applications, cartography, and underlying GIS resources (see Appendix E for more detail). Existing geospatial data resources at H-GAC will be combined with additional data from appropriate local, regional, state, and federal organizations as needed. Geospatial data used for modeling exercise will be of acceptable quality based on the data quality objectives of this project and will have been published with appropriate metadata. The publishing of geospatial data by various organizations implies that the data is of known quality, that is has been subject to review and approval by the publishing organization and has required metadata to prove its accuracy and completeness.

All outside data sources will be reviewed to determine level of quality, compatibility, and completeness. Procedures used to collect these outside sources will also be reviewed to determine compatibility and determine level of sampling bias and uncertainty. Generally, data used from outside sources will be acceptable if it was collected under an existing QAPP, published in peer review literature or if sufficient and documented quality assurance/quality control (QA/QC) procedures were employed during project data collection and analysis.

H-GAC utilizes ESRI's ArcGIS 10 platform for all geospatial analysis and mapping needs. The ESRI ArcGIS 10.X platform includes integrated Python programming capabilities, which allows for the creation of programming scripts or batch programs to improve efficiency and documentation of processes. The Python programming language is an Open Source platform and is freely distributable.

Derived GIS layer data from other QAPP-covered CRP assessments (e.g. potential sources of contamination in a watershed identified under a Basin Highlights Report or Basin Summary Report) may be utilized if it is of equal or greater adherence with the data quality objectives for this project.

**Modeling Assumptions and Literature Values**

The SELECT and LDC models rely on a mix of actual measurements and assumptions/literature values. The potential application of the SWAT model to generate a simple hydrological runoff estimation relies on values internal to the model, but its inputs are shared with the other modeling applications (e.g. hydrologic unit code boundaries, land cover, etc.) Some model values are integral to the models, while others can be modified or are based on local data/accounts. Literature values intended to be used for these modeling efforts include rate, volume and character of fecal deposition by various sources; event mean bacteria concentrations specific to land cover types; nutrient loading characteristics of land cover types; source population estimates (e.g. number of feral hogs per mile) and impacts of various best management practices. Selection of literature values will show preference to peer-reviewed scientific literature, most locality-specific references, and currency of reference, as modified by agency and stakeholder feedback. User-selected assumptions for SELECT include the use of the buffer approach in discounting loading outside a defined buffer distance from the waterway, and the distribution of some sources for which data is not specific to the watershed (e.g. cattle populations based on county-level data).

**Other Data**

Data used for qualitative assessment, stakeholder discussion, and watershed characterization not related to modeling efforts covered under this QAPP may include Texas Stream Team volunteer monitoring data, spatial data generated by the Trust for Public Land as part of the West Fork San Jacinto River Watershed Greenprint project, and other local data as encountered during the course of the WPP development project. These data sources are not intended to be used directly for the modeling efforts covered under this QAPP, but may influence staff and stakeholder decisions regarding assumptions, etc.

**Table B9.1 Non-Direct Measurements**

| Type of Measurement or Analysis | Type of Data (time series, rate, constant, statistic, taxa, etc.) | Units | Source (web link when available) | Quality Assurance Documentation | Use | Date Range |
|---|---|---|---|---|---|---|
| Ambient water quality monitoring data | Periodic water quality | Various | SWQMIS | www.tceq.state.tx.us/ waterquality/ monitoring/swqm_guides.html | Used as observed values for modeling efforts | Various, depending on station |
| DMRs | Periodic water quality reporting | Various | TPDES permittees via TCEQ | N/A | Used to characterize WWTF loading | Various, depending on station |
| SSO violation data | Episodic violation reporting | Various | TPDES permittees via TCEQ | N/A | Used to characterize collection system loading | Various, depending on station |
| Regional growth forecast | Modeled projections | Various | H-GAC | http://www.h-gac.com/regional-growth-forecast/documents/read-documentation.pdf | Used to characterize land cover and population change | 2015-2040 |
| OSSF locations | Spatial database | Individual OSSF records | H-GAC | Completed under H-GAC Regional Geospatial Data QAPP | Used to characterize OSSF loads | Various-2019 |
| Existing LDCs | Model outputs | Various | H-GAC | Completed under the West Fork San Jacinto River and Lake Creek QAPP | Used to inform LDC update | Various |
| Existing SELECT outputs | Model outputs | Various | H-GAC | Completed under the West Fork San Jacinto River and Lake Creek QAPP | Used to inform SELECT update | Various |
| GIS layers | Geospatial datasets | Various | Various | The quality assurance processes are specific to the individual layers. More information on the quality of geospatial source data follows this chart. | Used to develop models and for cartographic purposes | Various |
| Literature values | Various | Various | Various | The quality assurance for the studies and other methods that developed literature values are specific to each value, as noted in project reports. | Used to develop models/tools | Various |

Existing geospatial data available from various local, regional, state, and federal organizations may be used for project cartographic and illustrative purposes. These types may include land use, precipitation, soil type, ecoregion, TCEQ monitoring location, TCEQ permitted outfall, gage location, city/county/state boundary, stream hydrology, reservoir, drought, road, watershed, municipal separate storm sewer system, urbanized area, basin, railroad, recreational area, area landmark, aerial photography, and park information. The above data come from the following reliable sources: USGS, Texas Natural Resource Information System, TCEQ, TSSWCB, USGS, U.S. Department of Agriculture National Resources Conservation Service, TPWD, EPA, NOAA, General Land Office, and U.S. Census Bureau. Geospatial data from these sources are accepted for use in project maps based on the reputability of these data sources and the fact that there are no known comparable sources for these data. Geospatial data will be cited in reports.

As the project progresses, additional data sources and/or data types may be identified as necessary to complete project tasks. Once identified, H-GAC will notify the TCEQ NPS PM and request approval prior to use. If data will be analyzed or used for any purposes beyond cartographic or illustrative purposes, the QAPP must be amended and approved prior to use. All approved data sources will be clearly documented where such data sources are reported (e.g. technical documents, technical reports, and final reports).

## B10 DATA MANAGEMENT AND HARDWARE/SOFTWARE CONFIGURATION

Data evaluated, acquired, produced, or maintained under this QAPP will be handled in accordance with the DMP (attached as Appendix E). H-GAC uses this DMP for all related water quality efforts requiring QAPP coverage (e.g., CRP).

### B10 (A) Data Management

H-GAC data management procedures are discussed at length in Appendix E.

**Data Dictionary**
H-GAC standard data terminology and definitions are discussed at length in Appendix E.

**Migration/Transfer/Conversion**
Migration, transfer, and conversion of data, as well as data history and model outputs, are discussed at length in Appendix E.

**Information Dissemination**
Project updates will be provided to the TCEQ NPS PM in progress reports and the information will be made available at stakeholder meetings. Input data and model outputs resulting from the project described in this QAPP will be accessible to the general public and the TCEQ. Additional procedures are discussed at length in Appendix E.

### B10 (b) Hardware/Software Configuration

**Archives/Data Retention**

Complete original data sets are archived on permanent media (tape drives) and retained on-site by H-GAC for a retention period specified in Table A9.1 Project Documents and Records. Additional discussion of archiving procedure is indicated in Appendix E.

**Backup/Disaster Recovery**

All work and file storage takes place on a shared network drive(s) which are continuously backed up on the network servers and archived on a regular basis. In the event of a catastrophic systems failure, the archival backups can be used to restore the data in less than one day's time. Data generated on the day of the failure may be lost but can be reproduced from raw data in most cases.

# SECTION C: ASSESSMENT AND OVERSIGHT

## C1 ASSESSMENTS AND RESPONSE ACTIONS

The following table presents types of assessments and response action for activities applicable to this QAPP.

**Table C1.1 Assessments and Response Actions**

| Assessment Activity | Approximate Schedule | Responsible Party | Scope | Response Requirements |
|---|---|---|---|---|
| Status Monitoring Oversight, etc. | Continuous | H-GAC<br>PM | Monitoring of the project status and records to ensure QAPP requirements are being fulfilled. Monitoring and review of subcontractor's performance and data quality | Report to TCEQ in Quarterly/Monthly Report.<br>Ensure project requirements are being fulfilled. |
| Technical Systems Audit | Dates to be determined by TCEQ | TCEQ QAS | The assessment will be tailored in accordance with objectives needed to assure compliance with the QAPP | 30 days to respond in writing to the TCEQ to address corrective actions |

### Internal Assessment

Since this project is primarily a modeling endeavor, traditional performance and system audits are not appropriate. Instead, the data generated as part of the modeling results will be evaluated during the validation and model output interpretation processes. H-GAC and the TCEQ NPS Program will continually assess model performance as described in the validation and calibration processes, and by evaluation of tasks listed in Section D.

Modeling data and project deliverables will be internally quality controlled by the TCEQ NPS PM's in-house review. The TCEQ NPS PM will maintain overall responsibility for examining the contracted work to ensure methodologies and processes are consistent with the procedures outlined in this QAPP.

### Corrective Action

Deficiencies are any unauthorized deviations from the approved QAPP and procedures referenced in the QAPP. Deficiencies may invalidate resulting data. All deficiencies from the QAPP require documentation of the nonconformance and corrective action. Deficiencies must be documented in a Corrective Action Plan (CAP; Appendix B) and corrected in a timely manner. Corrective action may include the need for additional model runs. Deficiencies are documented in logbooks, field data sheets, etc. by field, laboratory, or modeling staff. It is the responsibility of the H-GAC PM, in consultation with the H-GAC QAO and H-GAC Data Manager, to ensure that the actions and resolutions to the problems are documented and that records are maintained

in accordance with this QAPP.

Nonconformances must be communicated to the TCEQ NPS PM immediately via email. A CAP Form (See Appendix B for the form and an example) must be submitted to the TCEQ NPS PM within 14 days of the deficiency occurring. The TCEQ NPS PM will send the CAP to the QA Coordinator who will then email the CAP to the Lead NPS QAS (and TCEQ Data Management & Analysis Data Manager if data quality is affected) within 30 days of the initial notice of deficiency per TCEQ Quality Management Plan and after it is accepted by the TCEQ NPS PM. The deficiency must also be communicated to the TCEQ NPS PM through the Corrective Action Status Table (Appendix C) to be included with the quarterly progress report.

The H-GAC PM is responsible for implementing and tracking corrective actions. All CAPs will be documented on the Corrective Action Status Table, which will be submitted to the TCEQ NPS PM with the quarterly progress report for review and approval. Records of TCEQ audit findings and corrective actions are maintained by both the TCEQ and the H-GAC QAO. Documentation of corrective action to address audit findings will be submitted to the TCEQ within 30 days of receipt of audit report.

If audit findings and corrective actions cannot be resolved, then the authority and responsibility for terminating work are specified in the TCEQ Quality Management Plan and in agreements in contracts between participating organizations.

### Corrective Action Plans

CAPs should:

- Identify the deficiency, problem, nonconformity, or undesirable situation
- Identify immediate remedial actions if possible
- Identify the underlying cause(s) of the problem
- Identify whether the problem is likely to recur, or occur in other areas
- Include a description of the need for Corrective Action
- Include a description of cause(s), determine solution, and propose an action plan
- Identify personnel responsible for action
- Establish timelines and provide a schedule
- Document the corrective action

## C2 REPORTS TO MANAGEMENT

### Reports to H-GAC Project Management

H-GAC project staff will report to the H-GAC PM on an ongoing basis, but at a frequency no less than once a week. These reports will be informal unless corrective action, relevant modeling notes, or other documentation as discussed in this QAPP apply.

### Reports to TCEQ Project Management

Progress Report – Submittal of progress reports will be at least quarterly. Format of the submitted

progress report will be as specified in the contract or work orders. Reports should provide enough information so the TCEQ NPS PM can evaluate the modeling effort.

Water Quality Trends Analysis Report – H-GAC will submit a water quality Trends Analysis Report subsequent to the water quality trends analysis in quarters 3 (Draft) and 8 (Final) respectively.

Modeling Report – H-GAC will submit a Modeling report at the culmination of modeling activities in quarter 3 (Draft) and 30 days after TCEQ comments are received (Final).

Watershed Protection Plan – H-GAC will submit to TCEQ a WPP for Spring Creek subsequent to stakeholder approval of the draft WPP in quarter 8 of the contract.

Final Report – H-GAC will submit a final report, in the form of a Final Quarterly Progress Report with substantive summary of the project, within 15 days of the end of the last fiscal quarter of the project. Any comments from TCEQ will be summarized in a comment response document in the interim.

CAP – Identifies any deficiencies and nonconformances. The cause(s) and program impacts are discussed. The completed corrective actions are documented, and the report is submitted to the TCEQ NPS PM within 14 days of the deficiency occurring.

Audit Report and Response – Following any audit performed by the H-GAC a report of findings, recommendations, and responses are sent to the TCEQ NPS PM in the quarterly/monthly progress report. Such reports will include model performance assessments, calibration, and validation performance determination.

**Reports by TCEQ Project Management**

Contractor Evaluation – H-GAC is evaluated in a Contractor Evaluation by the TCEQ annually for compliance with administrative and programmatic standards. Results of the evaluation are submitted to the TCEQ Financial Administration Division, Procurements and Contracts Section.

## SECTION D: DATA VALIDATION AND USABILITY

**Validation** - Validation is an extension of the calibration process that reduces uncertainty. The rates and settings developed during calibration are checked for adequacy using data set(s) that represent the modeled water body under different conditions than were observed during the calibration data set. The rates then, if necessary, are adjusted further so that they can represent all data sets. Validation is the comparison of the modeled results with independently derived numerical observations from the simulated environment. Model validation is an extension of the calibration process. Its purpose is to assure that the calibrated model properly assesses the range of variables and conditions that are expected within the simulation.

## D1 DEPARTURES FROM VALIDATION CRITERIA

The water quality data analyses, SELECT, and load duration curves are not calibrated models, and are not predictive of instream water quality conditions[1].

Departure from established criteria may impact the accuracy of model outputs. Sources of discrepancy may be insufficiency of available data and/or locally applicable assumptions. However, given the intended uses of the data (i.e. to facilitate stakeholder decision-making on a broad basis) these potential discrepancies are not expected to have an appreciable impact on model results.

## D2 VALIDATION METHODS

Data collected by the TCEQ, the USGS, Texas CRP partners, and other listed sources have been verified and validated according to the requirements of the respective programs prior to their use in this project. Data compilations created for this project will be electronically and/or visually screened for errors. For more information on data management procedures see Appendix E.

### Model Validation

The water quality data analyses are not subject to model validation. The SAS outputs are reviewed by H-GAC staff, as part of normal data management procedures.

LDCs are also not validated in a traditional sense, as they are not predictive models. The results of LDC runs are similarly validated by H-GAC staff, and through review with TCEQ project staff and stakeholders. Because LDCs are descriptive rather than predictive, no validation against additional data is possible.

The SELECT runs are predictive of potential load, but without linkage to observed data (i.e. they are not predictive of instream concentrations.) SELECT results are not calibrated to observed data because potential load is not a measurable/measured constituent. Non-technical validation of SELECT inputs and outputs is primarily based on H-GAC, TCEQ, and stakeholder review of model assumptions and outputs. Criteria in these reviews include the applicability and sufficiency of assumptions and subjective comparison of model outputs with local conditions as experienced by stakeholders. This process is not intended as a technical validation.

[1] Future scenarios projected under SELECT are based on regional demographic projections but are only predictive of potential loads. They cannot be calibrated against observed values, as they do not predict ambient water quality conditions.

## D3 RECONCILIATION WITH USER REQUIREMENTS

The primary purposes of the data outputs from these analysis and updated modeling efforts are to characterize the conditions in the watershed and guide stakeholder decision-making. The user requirements for WPP development are to provide a high-level understanding of the causes and sources of pollutants in spatial and flow contexts. The modeling framework developed for this project will be used to evaluate contaminant loading in the Spring Creek watershed. It will provide information pertaining to historical trends in water quality[1], updated relationship of pollutant loads to flow regimes and bacteria reductions (LDCs), and updated potential loading from pollutant within the watershed (SELECT). These analyses will provide critical information for the stakeholders to support the development of the Spring Creek WPP.

The user requirements do not assume a detailed and complex hydrologic model with predictive linkage between source loading and instream concentrations. Source load reduction projections sufficient to guide stakeholder decisions will be obtained by applying load reduction percentages generated through updated LDCs to source loads generated in updated SELECT analyses.

The outputs will be evaluated at several levels. First, H-GAC project staff will review outputs for obvious inconsistencies and errors, for compliance with QAPP procedures, and against best professional judgment. Secondly, outputs will be reviewed with TCEQ project staff. Lastly, outputs will be reviewed with stakeholders and technical advisors to ensure local input is acquired and incorporated as appropriate. Additional review will follow revised model runs and scenarios. The final data will be reviewed to ensure that it meets the requirements as described in this QAPP. CARs will be initiated in cases where invalid or incorrect data have been detected. Data that have been reviewed, verified, and validated will be summarized for their ability to meet the data quality objectives of the project and the informational needs of water quality agency decision-makers. The sufficiency of the data to support stakeholder requirements will be based on review of the data with the stakeholders and agency staff.

Some limitations are assumed for the use of the model outputs. The usability of the updated modeling results will be limited to their intended purposes as part of an EPA 9-element WPP development process. The model results are not intended or designed to provide a level of accuracy or precision beyond what is described or the stated ability of the models. Model results are not intended to be used for legal purposes, to describe property conditions in lieu of environmental assessments, or to be used for other official purpose not stated in this QAPP. The design of the modeling approach is intended to allow the flexibility, as described, to incorporate stakeholder input on assumptions, outputs, and specific locales or events in the watershed.

[1] The methodology, uses, and data types for the water quality trends analysis are described in detail in Section A7, under the subsection Water Quality Analysis.

# APPENDIX A. CONTRACT SCOPE OF WORK AND SCHEDULE OF DELIVERABLES

TCEQ Contract No.: 582-20-10159

## SCOPE OF WORK

The Spring Creek (Segment 1008) Watershed covers 284 square miles of Harris, Montgomery, Waller, and Grimes counties. It includes a mix of land uses, from urbanizing areas in its eastern extent, to rural prairieland at the western headwaters. Spring Creek is impaired for bacteria on the 2014 Texas Integrated Report of Surface Water Quality and has concerns for elevated nutrients. Spring Creek is one of four water bodies in the West Fork San Jacinto River system being addressed through the WPP process. The other water bodies include Cypress Creek (Segment 1009), West Fork San Jacinto River (Segment 1004), and Lake Creek (Segment 1015).

This project will engage stakeholders to develop a WPP to address impairments, concerns, and stakeholder-identified water quality priorities in the Spring Creek Watershed. The WPP will be developed to conform to the United States Environmental Protection Agency's (EPA) nine-key-element watershed-based plan (WBP) standard and will utilize existing preliminary characterization data as a starting point for technical analysis.

The Performing Party will establish and facilitate a watershed stakeholder partnership in the project area and hold regular stakeholder meetings, coordinate between local partners, and promote the project to the public via the press, direct contact, and other appropriate means. Existing water quality analysis will be updated with additional acquired data. The Performing Party will refine modeling analyses from the characterization study (conducted as part of TCEQ Contract 582-15-56349) utilizing stakeholder review and update data sources as needed. The modeling will inform stakeholder decisions by indicating the potential causes and extent of, and required reductions associated with, water quality issues.

**Task 1: Project Administration**

**Objective:** To effectively administer, coordinate, and monitor all work performed under this project, including technical and financial supervision and preparation of status reports.

**Subtask 1.1: Project Oversight** — The Performing Party will provide technical and fiscal oversight of the staff and/or subgrantee(s)/subcontractor(s) to ensure Tasks and Deliverables are acceptable and completed as scheduled and within budget. With the TCEQ Project Manager's authorization, the Performing Party may secure the services of subgrantee(s)/subcontractor(s). Project oversight status will be provided to the TCEQ Project Manager with the Quarterly Progress Reports (QPRs).

**Subtask 1.2: QPRs** — The Performing Party will submit QPRs by the 15th of the month following each state fiscal quarter (Sept - Nov, Dec - Feb, March - May, June - August) for review by the TCEQ Project Manager and incorporation into the EPA's Grant Reporting and Tracking System. QPRs will include reporting on status of Deliverables and proposed revisions to due dates, narrative description of progress by Task, and status of nonconformances and corrective actions. A template for the QPR will be provided to the Performing Party by the TCEQ Project Manager.

**Subtask 1.3: Reimbursement Forms** — The Performing Party will submit Reimbursement Forms to the TCEQ Contract Manager in accordance with Special Terms and Conditions, Article 5, 8. Invoice Submittal.

**Subtask 1.4: Contract Communication** — The Performing Party will participate in a post-award meeting with TCEQ within 30 days of Contract execution.

The Performing Party will maintain regular telephone and/or e-mail communication with the TCEQ Project Manager regarding the status and progress of the project and any matters that require attention between QPRs. Communications will include a quarterly conference call to discuss Project Tasks, financial status, Quality Assurance Project Plan (QAPP), correction actions and any other matters that require attention. The TCEQ Project Manager may request additional information from the Performing Party prior to the call or meeting. The Performing Party will submit meeting notes (action items at a minimum) to the TCEQ Project Manager within seven days of the meeting or call.

The quarterly conference call held the first quarter of each fiscal year of the project will be used to discuss, at a minimum, any staff changes, the previous year's performance, budget estimates, invoicing issues, quality assurance issues, overall project progress, and a plan for the current fiscal year. The Performing Party will submit meeting notes (action items at a minimum) to the TCEQ Project Manager within seven days of the meeting or call.

**Subtask 1.5: Coordination Call with EPA** — The Performing Party will participate in a conference call with EPA upon request by TCEQ and EPA to share progress on goals, measures of success, challenges, and draft documents.

**Subtask 1.6: Annual Report Article** — The Performing Party will provide an article for the Nonpoint Source (NPS) Annual Report upon request by TCEQ. The article will include a summary of the project, photos, and describe the activities of the past fiscal year.

**Subtask 1.7: Contract Budget Updates** — The Performing Party will discuss annual fiscal year budgets with the TCEQ Project Manager on a quarterly basis. Starting in the second year of the project, the Performing Party will provide an Annual Budget Update that details state fiscal year spending projections as associated with planned project activities. Updates will be revised when fiscal year spending projections change by ten percent or more, or upon request by the TCEQ

Project Manager. The update in the final year of the project will include a budget for all remaining project activities. The template for the Annual Budget Update will be provided by the TCEQ Project Manager.

**Deliverables:**

- QPRs
- Reimbursement forms
- Post-Award Meeting and notes
- Conference call notes and action items
- EPA coordination call (upon request)
- Annual Report article and pictures (upon request)
- Contract Budget updates
- Annual Budget updates

**Task 2: Quality Assurance**

**Objective:** To refine, document, and implement Data Quality Objectives (DQOs) and Quality Assurance/Quality Control activities that ensure data of known and acceptable quality are generated by this project.

**Subtask 2.1: QAPP Planning Meetings** — The Performing Party will schedule a QAPP planning meeting with the TCEQ Project Manager, Quality Assurance (QA) staff, technical staff, and contractors within 30 days of Contract execution, to implement a systematic planning process based on the elements in the TCEQ NPS QAPP Shell. The information developed during this meeting will be incorporated into a QAPP. The storage location of data records, and how data will be coded, will also be determined during these meetings. The Performing Party may conduct additional meetings to determine whether changes to an existing QAPP are needed.

**Subtask 2.2: Modeling and Data Acquisition QAPP** — The Performing Party will develop and submit to TCEQ a QAPP with project-specific DQOs and other components consistent with the following documents:

TCEQ NPS QAPP Shell(s)
EPA Requirements for QAPPs (QA/R5)
EPA Guidance for QAPP for Modeling QA/G-5M
EPA Guidance for Geospatial Data QAPPs (QA/G-5G)
EPA QAPP Requirements for Secondary Data Research Projects
TCEQ Surface Water Quality Monitoring (SWQM) Procedures

The Performing Party will develop a new QAPP in consultation with the TCEQ Project Manager, QA staff, and contractors. The Performing Party will submit the QAPP to the TCEQ at least 120 days prior to the scheduled initiation of environmental data operations. The QAPP will be fully approved and signed by TCEQ before any environmental data operations begin.

Activities covered under this QAPP:

- Data acquisition, map development, updating modeling, water quality data analysis

Tasks covered under this QAPP:

- Tasks 2, 3, 4, 6, and 7

Tasks NOT covered under this QAPP:

- Tasks 1 and 5

**Subtask 2.3: QAPP Annual Reviews and Revisions** — The Performing Party will submit documentation certifying its annual review of QAPPs at least 90 days prior to the QAPP anniversary date. Amendments approved since the initial QAPP approval or a subsequent certified annual review (if applicable) will be submitted along with the certification. If extensive changes to a QAPP are necessary, a full revision is required. Once the TCEQ certifies the annual review or approves the full revision, the QAPP effective period is extended an additional year. No work described in a QAPP will be conducted outside the effective period of the QAPP.

**Subtask 2.4: QAPP Amendments** — The Performing Party will submit Amendments when changes to QAPPs are necessary. Amendments should be submitted at least 90 days prior to the scheduled initiation of changes. A justification, summary of changes, and detail of changes will be provided with the Amendment. The Performing Party will ensure that changes conveyed within Amendments are not implemented until the Amendment is fully approved by the TCEQ.

**Deliverables:**

- QAPP planning meeting notes
- Draft and final modeling and data acquisition QAPP
- QAPP annual reviews and revisions
- Draft and final QAPP Amendments

**Task 3: Water Quality Data Acquisition and Evaluation**

**Objective:** To acquire and evaluate water quality data needed to complete the Spring Creek WPP and update existing water quality analyses for the West Fork San Jacinto River (Segment 1004), Lake Creek (Segment 1015), and Cypress Creek (Segment 1009) watersheds.

**Subtask 3.1: Ambient Water Quality Trends Analysis** — The Performing Party will acquire and evaluate ongoing or routine ambient sampling data from monitoring stations in Spring Creek. The data will be used for purposes of evaluating water quality trends in Spring Creek and updating bacteria modeling. The data was initially collected under an approved Clean Rivers Program (CRP) QAPP and submitted to Surface Water Quality Monitoring Information System (SWQMIS) by the CRP.

The Performing Party will also acquire, evaluate, and analyze ambient water quality data to update existing water quality analyses for the West Fork San Jacinto, Lake Creek, and Cypress Creek watersheds.

Data to be acquired may include dissolved oxygen (DO), temperature, pH, nutrients, chlorophyll-*a*, bacteria, total suspended solids, flow, and other constituents and may be approved in an amendment to the QAPP. The Performing Party will evaluate data trends in indicator bacteria, applicable nutrients, and DO Levels. Analyses will look for general trends toward or away from compliance, seasonal variation, and any other aspect defined as pertinent by the Performing Party, TCEQ, and local partners during the development of the project.

**Subtask 3.2: Discharge Monitoring Reports (DMR) and Sanitary Sewer Overflows (SSO) Analysis** — The Performing Party will acquire DMR and SSO data for the last five years for permitted wastewater entities in the Spring Creek, West Fork San Jacinto, Lake Creek, and Cypress Creek watersheds. The Performing Party will evaluate the data for trends in volume by year, volume by cause, number of events by year, and number of events by cause for each reporting permitted entity. The data evaluations for Spring Creek will be used to update the Spring Creek water analyses and modeling to support development of the WPP. The data evaluations for these segments will be used to inform stakeholder discussions and decisions.

**Subtask 3.3: Data Analysis Summary Report** — The Performing Party will develop a report describing, detailing, and summarizing all data evaluations to be presented in the Spring Creek WPP. The report will document the data acquired, the evaluation methodologies, and the analysis results.

The Performing Party will also develop a separate report for the West Fork San Jacinto, Lake Creek, and Cypress Creek watersheds. The report will document the data acquired, the evaluation methodologies, and the analysis results.

**Deliverables:**

- Ambient water quality analyses for Spring Creek, West Fork San Jacinto, Lake Creek, and Cypress Creek watersheds
- DMR and SSO analyses for Spring Creek, West Fork San Jacinto, Lake Creek, and Cypress Creek watersheds
- Data Analysis Summary Report for the Spring Creek WPP
- Data Analysis Update Report for West Fork San Jacinto, Lake Creek, and Cypress Creek watersheds

**Task 4: Modeling**

**Objective:** To update and revise preliminary modeling results for the Spring Creek Watershed to identify extent, causes, and spatial distribution of bacterial contamination and reduction goals.

**Subtask 4.1: Load Duration Curves (LDCs)** — The Performing Party will update existing LDCs as needed for indicator bacteria in the Spring Creek Watershed to further define conditions under which loading is occurring and calculate the pollutant load reductions needed to meet water quality standards, or screening levels, or to continue meeting standards in the Spring Creek Watershed. The LDCs developed as part of the Spring Creek Characterization Report will be used as the starting point for subtask efforts. This analysis will be used to satisfy Element B of EPA's nine-key-element criteria for WBPs.

**Subtask 4.2: Spatially Explicit Load Enrichment Calculation Tool (SELECT)** — The Performing Party will update the existing SELECT model for Spring Creek to include the most current version of its data sources as appropriate and to revise findings based on stakeholder feedback. SELECT will be used in the WPP to identify the relative prominence of bacteria sources, their spatial distribution, and the total potential bacteria load to the watershed. Both current and future condition runs will be updated. This analysis will be used to satisfy Element A of EPA's nine-key-element criteria for WBPs.

**Subtask 4.3: Modeling Report** — The Performing Party will develop a report detailing activities conducted under this Task and summarize the results of the modeling for inclusion in the Final Report.

**Deliverables:**

- Update existing LDCs
- Update existing SELECT
- Draft and Final Modeling Report

**Task 5: Watershed Stakeholder Coordination**

**Objective:** To engage and maintain a stakeholder group representative of interests in the watershed for the purpose of developing and implementing the WPP and coordinating related efforts.

**Subtask 5.1: Public Participation Plan (PPP)** — The Performing Party will develop a PPP that details the strategy for engaging the public and stakeholders in the watershed planning process for the Spring Creek watershed. The PPP will, at a minimum, include 1) stakeholder group ground rules, 2) stakeholder group structure (i.e., steering committee, work groups) and membership, 3) stakeholder meetings topic/purpose and tentative schedule, and 4) a targeted outreach plan to increase public participation in the process.

**Subtask 5.2: Spring Creek Watershed Partnership Formation** — The Performing Party will compile and maintain a database of watershed stakeholders and affected parties for use in engaging the public in the watershed planning process for each primary subwatershed outreach area. A stakeholder group (the Spring Creek Watershed Partnership) will be established from this list and other interested parties and will represent a diverse cross section of the Spring Creek Watershed's stakeholders.

**Subtask 5.3: Communication with Stakeholders** — The Performing Party will facilitate communication with stakeholders to engage the public and affected entities in the watershed planning process, with assistance from local organizations helping to advertise and host meetings. The Performing Party will utilize all appropriate communication mechanisms including direct mail, e-mail, a project website, and mass media (print, radio, television). The Performing Party will submit all project-related content in any educational materials and publications to TCEQ for review and approval at least two-weeks prior to distribution.

**Subtask 5.4: Stakeholder Facilitation** — The Performing Party will facilitate public participation and stakeholder involvement in the watershed planning process specifically through project meetings and related outreach activities.

The Performing Party will coordinate meetings, secure meeting locations, and prepare and disseminate meeting notices and agendas. Meeting summaries will be prepared and posted to the project website within 30 days of a meeting. At a minimum, meetings will be held on a bi-monthly frequency. However, if more meetings are deemed necessary, they will be scheduled accordingly. The Performing Party will provide meeting presentations, notices, agendas, and meeting summaries to TCEQ for review and approval at least two weeks prior to public dissemination.

The Performing Party will maintain a record of individuals and organizations invited to meetings, as well as a sign-in sheet of attendees. The Performing Party will maintain a record of public comments via meeting notes and coordinate with Partners to document responses to stakeholders.

**Subtask 5.5: Attend Public Meetings** — The Performing Party will attend and participate in other public meetings as appropriate to communicate project goals, activities, and accomplishments to affected parties. Such meetings may include, but are not limited to, city councils, county commissioners' courts, regional water supply planning, environmental flows, CRP Basin Steering Committee and coordinated monitoring, local soil and water conservation districts, Galveston Bay Council and subcommittee meetings, and other appropriate meetings of important watershed stakeholder groups. Written approval from the TCEQ Project Manager will be required prior to attendance. It is estimated there will be at least six of these meetings.

**Subtask 5.6: Education and Outreach Events** — The Performing Party will host a series of at least four education and outreach events whose purpose is to engage stakeholders, raise general awareness of watershed issues, or address specific water quality concerns raised in the WPP development process. The events include, but are not limited to: 1) an on-site sewage facility workshop for homeowners and 2) a Partner program specific to watershed protection, chosen based on partner availability (e.g., Texas Watershed Stewards, etc.)

The Performing Party will also seek to support and coordinate with Partners holding events and meetings that are relevant to the WPP. The Performing Party will work with Partners and request that they consider the project watershed as a venue for related events during the project term.

**Subtask 5.7: Watershed Stakeholder Coordination Task Report** — The Performing Party will produce a report summarizing stakeholder involvement in the watershed planning process.

**Deliverables:**

- Draft and Final PPP
- Stakeholder contact list
- Documentation of communication with stakeholders
- Documentation of bi-monthly stakeholder meetings, including notices, materials, presentations, agendas, attendance lists, and summaries
- Agenda and presentation summaries of at least six other public meetings attended
- Documentation of at least four education and outreach events
- Draft and Final Watershed Stakeholder Coordination Task Report

**Task 6: Watershed Protection Plan Development**

**Objective:** The Performing Party will facilitate the development of a WPP for Spring Creek through a stakeholder-driven process. The WPP will satisfy EPA's nine-key-element criteria.

**Subtask 6.1: WPP Development** — The Performing Party, in collaboration with project Partners, will develop a WPP for the Spring Creek Watershed that satisfies EPA's *Nine Key Elements for WBPs* as described in EPA's *2013 Guidance*. The WPP will address all parameters of impairment and concerns as listed in the *2014 Texas Integrated Report of Surface Water Quality* (TCEQ may make exceptions for parameters not typically associated with NPS pollution). The WPP will be based on decisions made by stakeholders through the watershed planning process (Tasks 5 and 6) and incorporate findings from project technical evaluations (Tasks 3 and 4). The WPP will be designed to achieve the load allocations identified by modeling results and approved by the stakeholders. The Performing Party will facilitate public review and stakeholder approval of the WPP.

Prior to drafting the WPP, a detailed outline will be developed by the Performing Party. The Performing Party will work with stakeholders to identify information that satisfies EPA's requirements for a nine-key-element WBP. The WPP will:

1. Identify and quantify existing pollutant loadings that need to be controlled;
2. Determine pollutant load reductions needed to meet water quality standards;
3. Identify management practices to achieve water quality standards;
4. Estimate technical and financial assistance needed to implement the plan;
5. Describe the information and education component needed to implement the plan;
6. Develop an implementation schedule;
7. Describe interim measurable milestones for management measure implementation;
8. Describe water quality evaluation criteria; and,
9. Describe a monitoring program to assess water quality conditions.

**Subtask 6.2: Review and Approval Process** — The Performing Party will develop a detailed outline, timeline, and stakeholder document review plan at the beginning of the project. The review plan will include submittal of multiple interim partial drafts for review by stakeholders and TCEQ. Stakeholders and TCEQ will approve the WPP before it is submitted to EPA for review. The Performing Party will work with stakeholders and TCEQ to address any EPA comments. The Performing Party will release a draft of the WPP to the stakeholder group and address any comments that may be received. TCEQ will submit a Final WPP with all comments addressed to EPA. The Performing Party will develop an Executive Summary of the WPP.

**Subtask 6.3: Executive Summary and WPP Distribution** — The Performing Party will develop an executive summary style document based on the WPP. The Performing Party will make available the WPP and the Executive Summary documents to stakeholders. Four hard copies and one electronic copy of the final approved WPP will be submitted to TCEQ.

**Deliverables:**

- Develop WPP
- WPP timeline and document review plan
- Draft and Revised nine-key-element WPP to stakeholders and the TCEQ
- Documentation of stakeholder approval of the WPP
- Draft nine-key-element WPP to EPA
- Response to EPA comments
- Final nine-key-element WPP to EPA
- Executive Summary
- Documentation of Executive Summary and Final WPP made available to stakeholders
- Four hard copies and one electronic copy of final WPP submitted to the TCEQ

**Task 7: Final Report**

**Objective:** To produce a Final Report that summarizes all activities completed. The Final Report must describe project activities, identify and discuss the extent to which project goals and purposes have been achieved, and state the amount of funds spent on the project.

**Subtask 7.1: Final Report** — The Performing Party must submit the final QPR as the Final Report. This final QPR must follow the template provided by the TCEQ Project Manager and must summarize all project activities.

**Deliverables:**

- Final QPR as Final Report

TCEQ Contract No.: 582-20-10159

## SCHEDULE OF DELIVERABLES

| Task No. | Task Deliverable | Due Date |
|---|---|---|
| **1 Project Administration** | | |
| 1.2 | QPRs | The 15th of the month following each state fiscal quarter |
| 1.3 | Reimbursement forms | See Special Terms and Conditions, Article 5, 8. Invoice Submittal |
| 1.4 | Post-Award Meeting and notes | Meeting within 30 days of Contract execution; meeting notes within two days of meeting |
| 1.4 | Conference call notes and action items | Quarterly, notes within seven days of meeting |
| 1.5 | EPA coordination call | Upon request |
| 1.6 | Annual Report article and pictures | Upon request |
| 1.7 | Contract Budget updates | Discussed quarterly and updated as needed |
| 1.7 | Annual Budget updates | Quarters 5 and 9 |
| **2 Quality Assurance** | | |
| 2.1 | QAPP planning meetings notes | Meeting within 30 days of Contract execution |
| 2.2 | Draft modeling and data acquisition QAPP | At least 120 days prior to the scheduled initiation of environmental data operations |
| 2.2 | Final modeling and data acquisition QAPP | 30 days prior to the scheduled initiation of environmental data operations |
| 2.3 | QAPP annual reviews and revisions | At least 90 days prior to the QAPP approval anniversary |
| 2.4 | Draft QAPP Amendments | At least 90 days prior to the scheduled initiation of changes or additions to activities listed in the current QAPP |
| 2.4 | Final QAPP Amendments | Within 30 days of receipt of TCEQ comments |
| **3 Water Quality Data Acquisition and Evaluation** | | |
| 3.1 | Ambient water quality analyses for Spring Creek | Quarter 2 |
| 3.1 | Ambient water quality analyses for Spring Creek (update) | Quarter 8, documented in the Data Analysis Summary Report |
| 3.1 | Ambient water quality analyses for West Fork San Jacinto, Lake Creek, and Cypress Creek watersheds | Quarter 8, documented in the Data Analysis Summary Report |
| 3.2 | DMR and SSO analysis for Spring Creek | Quarter 2 |
| 3.2 | DMR and SSO analysis for Spring Creek (update) | Quarter 8, documented in the Data Analysis Summary Report |
| 3.2 | DMR and SSO analysis for West Fork San Jacinto, Lake Creek, and Cypress Creek watersheds | Quarter 8, documented in the Data Analysis Summary Report |
| 3.3 | Data Analysis Summary Report for Spring Creek | Quarter 3 |
| 3.3 | Data Analysis Summary Report for Spring Creek (update) | Quarter 8 |

| | | |
|---|---|---|
| 3.3 | Data Analysis Summary Report for West Fork San Jacinto, Lake Creek, and Cypress Creek watersheds | Quarter 8 |
| **4 Modeling** | | |
| 4.1 | Update existing LDCs | Quarter 2 |
| 4.2 | Update existing SELECT | Quarter 3 |
| 4.3 | Draft Modeling Report | Quarter 4 |
| 4.3 | Final Modeling Report | 30 days following TCEQ comments on the Draft Modeling Report |
| **5 Watershed Stakeholder Coordination** | | |
| 5.1 | Draft PPP | Quarter 1 |
| 5.1 | Final PPP | 30 days following TCEQ comments on the Draft PPP |
| 5.2 | Stakeholder contact list | Quarters 1 and 5 |
| 5.3 | Documentation of communication with stakeholders; mail, email, PSA, media announcements, website | Quarters 1-8 |
| 5.4 | Documentation of bi-monthly stakeholder meeting, including notices, materials, presentations, agendas, attendance lists, and summaries | Quarters 2-8, documented within 30 days to TCEQ, and summarized in QPRs |
| 5.5 | Agenda and presentation summaries of other public meetings attended | Quarters 2-8, at least six events documented within 30 days to TCEQ, and summarized in QPRs |
| 5.6 | Documentation of education and outreach events | Quarters 3-8, summaries of at least four events within 30 days of the event |
| 5.7 | Draft Watershed Stakeholder Coordination Task Report | Quarter 8 |
| 5.7 | Final Watershed Stakeholder Coordination Task Report | Quarter 8 |
| **6 WPP Development** | | |
| 6.1 | Develop WPP | Quarterly updates in QPRs |
| 6.2 | WPP timeline and document review plan | Quarter 1 |
| 6.2 | Draft nine-element WPP to stakeholders and the TCEQ | Quarter 7 |
| 6.2 | Revised nine-element WPP to stakeholders and the TCEQ | Revisions to be completed 30 days after receipt of each set of comments from TCEQ |
| 6.2 | Documentation of stakeholder approval of the WPP | Quarter 8 |
| 6.2 | Draft nine-element WPP to EPA | Following stakeholder approval of the TCEQ-approved revised WPP |
| 6.2 | Revised nine-element WPP to EPA | 30 days following receipt of comments from EPA |
| 6.3 | Draft Executive Summary | Quarter 8 |
| 6.3 | Final Executive Summary | 30 days following receipt of comments from TCEQ on the Draft Executive Summary |

| | | |
|---|---|---|
| 6.3 | Documentation of Executive Summary and Final WPP made available to stakeholders | Quarter 8 |
| 6.3 | Four hard copies and one electronic copy of final WPP submitted to TCEQ | Quarter 8 |
| **7 Final Report** | | |
| 7.1 | Final approved QPR as Final Report | The 15th of the month following the final state fiscal quarter of the project |

# APPENDIX B. CORRECTIVE ACTION PLAN FORM

APPENDIX B - CORRECTIVE ACTION PLAN FORM

| **Nonconformance Report and Corrective Action Plan** |
|---|
| **QAPP Title:**_____<br>**QAPP Contractor:** _____<br>**Issued by:**_____ **Date of Occurrence:**_____<br>**Report No.:**_____ **Date Issued:**_____ |
| **Description of deficiency** |
| **Root Cause of deficiency** |
| **Programmatic Impact of deficiency** |
| **Does the seriousness of the deficiency require immediate reporting to the TCEQ? If so, when was it reported?** |
| **Corrective Action to address the deficiency and prevent its recurrence** |
| **Proposed Completion Date for Each Action** |
| **Individual(s) Responsible for Each Action** |
| **Method of Verification** |
| **Date Corrective Action Plan Closed?** |

**Example Corrective Action Plan Form**

| **Nonconformance Report and Corrective Action Plan** |
|---|
| **QAPP Title:** Watershed Protection Plan Implementation – LID BMP Monitoring QAPP<br>**QAPP Contractor:** River Authority<br>**Issued by:** Jane Doe **Date of Occurrence:** 7/15/2014<br>**Report No.:** 1 **Date Issued:** 7/25/2014 |
| **Description of deficiency**<br>The pavement monitoring station at the university is measuring a larger runoff volume than is estimated possible. Runoff measured is higher than the total precipitation volume calculated by multiplying the catchment area by the precipitation measured at the site. |
| **Root Cause of deficiency**<br>(1) It is possible that the drainage area was not measured accurately, it may be larger.<br>(2) The outfall of the monitoring station might not adequately allow runoff to flow through causing pooling around the flow-measuring point. The accumulation of non-flowing water could be confounding the flow meter since its physical principal of measurement is hydrostatic pressure caused by water depth. |
| **Programmatic Impact of deficiency**<br>The illogical results of the pavement runoff measurement indicate that further calibration of the equipment is necessary. Data collected at this event are not able to be used in analysis or results. |
| **Does the seriousness of the deficiency require immediate reporting to the TCEQ? If so, when was it?**<br>Yes, it was reported to the TCEQ NPS PM via email on 7/18/2014. |
| **Corrective Action to address the deficiency and prevent its recurrence**<br>A survey will be conducted on the site to determine the ridge of the catchment area.<br>A wider and deeper channel will be dug out at the monitoring point outfall to ensure all the flow drains away from the measuring point. Storm event runoff will not be measured at this site until this work has been completed. |
| **Proposed Completion Date for Each Action**<br>8/15/2014 |
| **Individual(s) Responsible for Each Action**<br>David Lopez, Contractor PM |
| **Method of Verification**<br>Results of the catchment area survey will be emailed to the TCEQ NPS PM.<br>Photos of the modified measurement site will be emailed to the TCEQ NPS PM. |
| **Date Corrective Action Plan Closed?**<br>*The TCEQ NPS PM will provide a closed date once the corrective action has been verified.* |

# APPENDIX C. CORRECTIVE ACTION PLAN STATUS FORM

**Corrective Action Status Table**

| Corrective Action # | Date Issued | Description of Deficiency | Action Taken | Date Closed |
|---|---|---|---|---|
| | | | | |
| | | | | |
| | | | | |
| | | | | |
| | | | | |

**Corrective Action Status Table Example**

| Corrective Action # | Date Issued | Description of Deficiency | Action Taken | Date Closed |
|---|---|---|---|---|
| 1 | 7/25/2014 | Runoff measured at pavement was greater than total area runoff. | The area is being surveyed to ensure the catchment area size is correct. The monitoring station location is being modified to ensure runoff flows through properly. | |
| 2 | 8/1/2014 | Sample residual insufficient for analysis of TSS. | Data estimated but questionable, not will not be submitted to TCEQ. | 8/8/2014 |
| | | | | |
| | | | | |
| | | | | |

# APPENDIX D. ADHERENCE LETTER

**Appendix D. Example Letter to Document Adherence to the QAPP**

TO: *(name)*
*(organization)*

FROM: Rachel Windham
Houston-Galveston Area Council (H-GAC))

RE: H-GAC, Spring Creek Watershed Protection Plan Modeling QAPP

Please sign and return this form by (*date*) to:

Rachel Windham
3555 Timmons Lane, Suite 120
Houston, TX 77027

I acknowledge receipt of the "Spring Creek Watershed Protection Plan Modeling QAPP". I understand the document describes quality assurance, quality control, data management, and reporting, and other technical activities that must be implemented to ensure the results of work performed will satisfy stated performance criteria.

My signature on this document signifies that I have read and will comply with the document contents pertaining to my program. Furthermore, I will ensure that all staff members participating in modeling activities will be required to familiarize themselves with the document contents and adhere to them as well.

_____

Signature Date

# APPENDIX E. DATA MANAGEMENT PLAN

# GEOSPATIAL DATA MANAGEMENT PLAN

Community and Environmental Planning Department
Houston-Galveston Area Council
3555 Timmons Lane
Houston, TX 77277

February 2019

## INTRODUCTION

The Geospatial Data Management Plan (GDMP) outlines the standard policies and procedures for data management within the Community and Environmental Planning (C&E) Department. The GDMP covers the management of both tabular (non-geographic) and spatial (geographic) datasets. Its primary purpose is to ensure the efficient access and maintenance of these datasets within the C&E Geospatial/Geographic Information Systems (GIS) environment.

GIS technology provides a systematic means to capture, manipulate, analyze, store and display spatially referenced data. GIS supports a wide variety of applications ranging from site assessments, environmental planning, urban planning, and spatial analysis to support organizational strategies. In general, GIS supports the overall departmental goals of guiding regional planning, enhancing the quality of the region's natural environment, and public education through outreach programs. The C&E GIS team supports various programs within the C&E department through data development, spatial analysis, geospatial applications development, cartography in support of departmental goals.

The GDMP is considered a dynamic working document which responds to changing technology, funding, staffing, and project requirements. Consequently, the GDMP is reviewed on an annual basis and amended as necessary.

## GEOSPATIAL SERVICES

The following section explains the geospatial services provided by the H-GAC C&E GIS team as it relates to the sharing of data, development of geospatial applications, cartography, and underlying GIS resources. The C&E GIS team is responsible for the development of data and sharing of many publicly viable datasets, developing geospatial applications, cartography, and coordination of maintenance of underlying geospatial hardware and software for C&E.

The C&E GIS team maintains a centralized geospatial warehouse (C&E Spatial Database Engine (SDE)), an online mapping platform for web-based geospatial applications (Mapping Application), and a file transfer protocol (FTP) download site (Data Clearinghouse). The C&E spatial database engine (SDE) utilizes ESRI's ArcSDE software running on a Microsoft SQL server relational database management system. The mapping application uses ESRI's ArcGIS.com & ArcGIS Server platform running on .NET. The Data Clearinghouse is an FTP server (h-gac.sharefile.com) that provides C&E with storage space where it can post publicly available datasets for downloading.

The C&E SDE, Mapping Application, and Data Clearinghouse platforms are installed by the H-GAC Data Services department (Data Services), with Data Services maintaining only the lower-level technology components such as the physical hardware, software installation, and low-level server and relational database management system functions. All upgrades and maintenance are coordinated by the C&E GIS Manager. All geospatial content stored in the C&E SDE, the Data Clearinghouse, and Mapping Application, are the responsibility of the C&E GIS staff, which resides within the C&E Socio-Economic Modeling program. However, Data Service department maintains some of the other GIS data such as transportation, 911 address, and workforce solutions, and stored in a separate SDE that everybody in H-GAC has access to them. A detailed

schematic of the geospatial technical architecture and how the various systems are interconnected can be found in the *System Architecture* section below.

**DATA SHARING**

The C&E SDE serves as the primary internal repository for geospatial data, metadata, and other information relevant to the activities and goals of the C&E department. All GIS users within C&E Socio-Economic Modeling program and users from other H-GAC departments are provided *Editor* access to data in the C&E SDE. All other users have only viewer access to data in the C&E SDE. H-GAC C&E staffs without *Editor* access to the C&E SDE server can access a copy of the geospatial data through a separate server that houses imported versions of the original SDE data to develop GIS layers for project specific editing. This system ensures that the original formatting of geospatial data on the C&E SDE remains unchanged. All user access privileges are assigned by the C&E GIS Manager based upon business needs, GIS skills, and role within the organization. No users outside of the C&E department have editor level access to any GIS data in the C&E SDE, and in some instances there are datasets that are viewable by only C&E GIS users. Instructions for connecting to the C&E SDE are provided to authorized users.

Datasets determined to be viable for publication to the public are exported to the Data Clearinghouse, thereby allowing the general public widespread access to this information via the internet. Members of the public may view metadata and download any of the datasets that are posted to the Data Clearinghouse. In some instances, these datasets are used in web-based interactive mapping applications and can be accessed online via the Mapping Server's services directory, or accessible via the Data Clearinghouse for downloading. The data sharing through downloading is facilitated through H-GAC's Sharefile system. All public C&E GIS data, applications, cartographic products, and the C&E map services directory can be accessed via "GIS, Imagery, & Online Mapping Tools" section of the H-GAC website. A screen shot of the website can be found in Appendix E.7.

**GEOSPATIAL APPLICATIONS**

The C&E department has made a strategic decision to incorporate internet-based mapping applications into its deliverables for many programs and projects. Before, the results of most projects consisted of a large-format map printed on a plotter up to 48"x36" in diameter. This form of cartography although still useful in many settings, did not allow programs to communicate results to the public or external organizations that had an interest in our analysis results. By taking results from C&E projects and coupling this with base map data and imagery, C&E has been able to share the results of projects to a far greater audience and has created opportunities whereby map layers published on the C&E mapping server can be utilized in other organizations mapping applications.

Currently there are two platforms upon which C&E provides web-based mapping solutions. The first platform is based on the JavaScript programming technology, and all mapping applications developed using this platform run on various operational systems including Windows, MacOS, ISO, and Android. This platform is intended to provide users with a graphics rich user interface whereby the map can be navigated, layers turned on/off, and information obtained on each feature. In some instances, features have links to additional resources such as

photos of monitoring stations, external websites, and detailed reports. This mapping application technology allows the users to display its information on different screen-size devices including desktop, laptop, tablet, and mobile phone.

The second platform utilizes the capabilities of the ArcServer/Arcgis.com platform to allow users to directly access map layers published on the mapping server. This method of delivery is called 'streaming' and allows end users access to individual map layers and geoprocessing tools published on the server. Typical users of this method of delivery are other GIS users using ArcMap GIS, whereby they can connect directly to our ArcServer platform for read-only access and view our map layers. Other instances whereby www.arcgis.com's users may utilize this method is where they are including our map layers in their own mapping applications.

**MAPPING AND CARTOGRAPHIC PRODUCTS**

The C&E produces a variety of static cartographic maps for the region because of project activities and for general usage. To facilitate the sharing of these maps in an electronic format, C&E has implemented a Map Book as part of their C&E GIS page. Maps can be downloaded in multiple formats. The C&E Map Book can be accessed via our C&E GIS page at https://www.h-gac.com/map-book/default.aspx.

**SYSTEM RESOURCES/SYSTEM ARCHITECTURE**

The C&E department uses an integrated architecture to support the development, analysis, and dissemination of spatial information. The diagram below (Figure B.1) illustrates this system architecture at a high level. The goal of the overall system is to allow for a streamlined workflow to develop/maintain data, optimize the data for use in online applications, and the consumption of applications via multiple platforms.

Currently the C&E GIS platform supports sharing of geospatial data via the ArcServer mapping server platform. This allows end users internally or externally to consume map layers and geoprocessing tools via GIS desktop, mobile, tablet, or interactive applications.
In some instances, applications are configured with public feedback and volunteer GIS workflows that allow the C&E GIS team to obtain information for the public on various geographic features in the region. This public feedback loop allows C&E to investigate feedback and verify its validity prior to incorporating the information into the data warehouse.

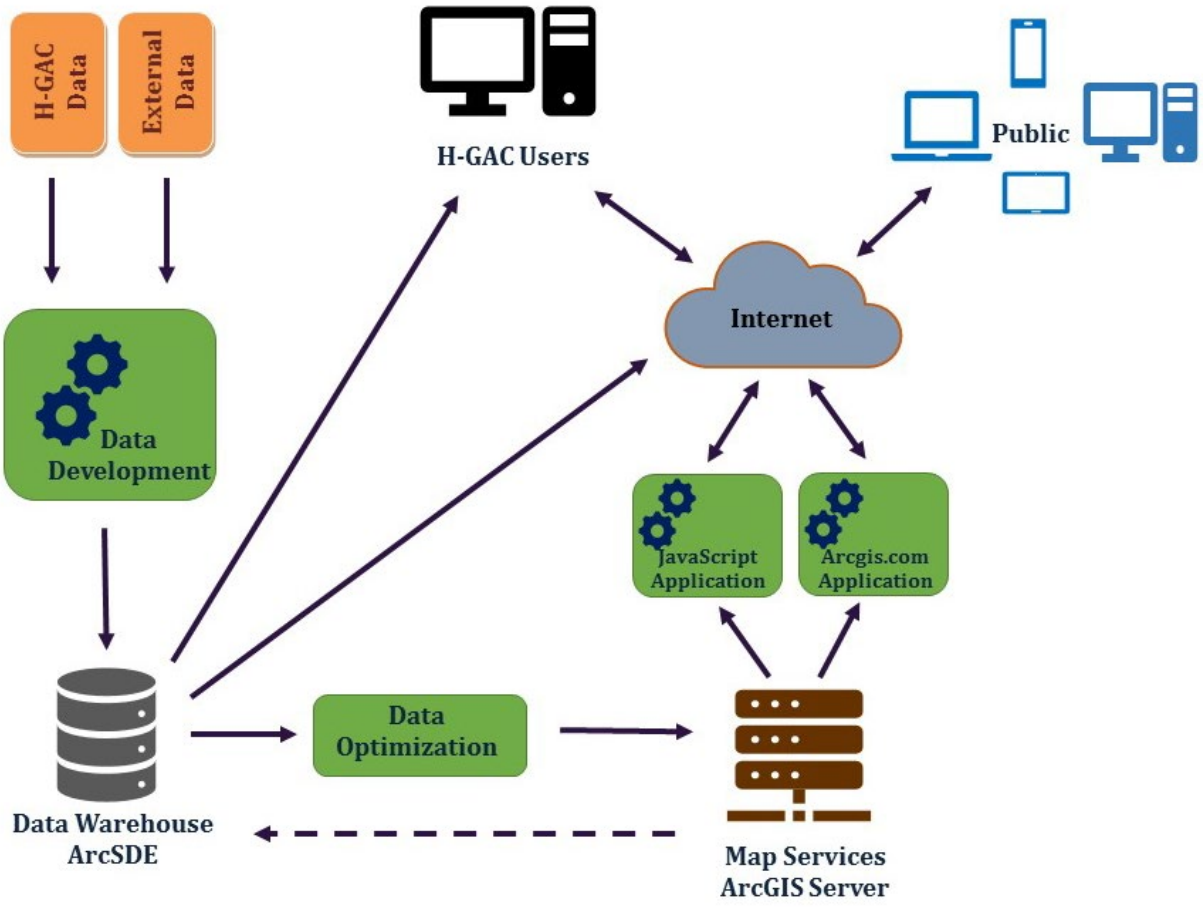



**Figure B.1: H-GAC Geospatial System Architecture**

**HARDWARE**
The configuration of the hardware used by staff that performs GIS and data Management work is a distributed network. This network consists of several PC's which are connected to central file servers. The department also uses a central web mapping server for online mapping applications.

A complete listing of departmental hardware is found in Appendix E.3.

**SOFTWARE**
The C&E department relies upon the H-GAC Data Services department (Data Services) for its end user workstation configuration, installation, and maintenance. Each workstation for users comes with the Microsoft Office software package which includes Outlook (e-mail), Word (word processing), Excel (spreadsheets), PowerPoint (presentations), and in some instances Access (desktop database) should the user require desktop database capabilities. Each workstation is pre-configured and setup to operate within the H-GAC internal network and has access to central servers for file storage.

The C&E GIS staff utilizes ESRI's ArcGIS 10.5 platform for all geospatial analysis and mapping needs. In addition, as needed, the staff also utilizes the SAS and ENVI software platforms for further analysis and data development as deemed necessary. The ESRI ArcGIS 10.5 platform

includes integrated Python programming capabilities, which allows for the creation of programming scripts or batch programs to improve efficiency and documentation of processes. The Python programming language is an Open Source platform and is freely distributable.

The centralized SDE is also provided by ESRI and provided for a centralized geospatial database where GIS staff can store geospatial data for either read-only or editable access by GIS users in the C&E department. The C&E GIS staff maintains access privileges to the SDE datasets and assigns individual users to various SDE access groups to grant approved accessed to data in the SDE. The SDE is considered the central warehouse where GIS users can go to for geospatial data to use in their analysis or mapping projects.

The software products currently used to accomplish the department's data management objectives are listed in Appendix E.4.

**PROGRAMMING LANGUAGES**
Programming services will be provided on an as needed and resource available basis. All programming efforts will follow a standard procedure from needs assessment, program planning, development and testing, to refinement and documentation. The principal programming languages to be used in task automation and project customization will depend on the nature of the need and the current state of the technology. At this time, all web-based GIS applications are developed using the ESRI ArcGIS Server platform, and user interface components to that platform are developed using the ESRI JavaScript API. Automated data development and analysis workflows utilize the Python programming language and the SAS programming platform as needed.

**DATA**
Department staff members will be consulted annually to determine priority needs for data management. Based on this consultation, specific data sets will be acquired or further developed for the various program areas represented in the department. The current list of department-specific data sets is shown in Appendix E.5.

A separate database lists all datasets regularly obtained from external sources, contact information, as well as the frequency of the datasets availability, and its cost. This database is developed using Microsoft Excel and is available to the C&E GIS team for tracking when updates to dataset may be available.

**PERSONNEL**
The Data Management staff will be responsible for the maintenance and development of the C&E SDE, mapping server, geospatial applications, C&E GIS page, and Data Clearinghouse. These data management responsibilities cover a wide range from original data creation, acquisition and integration, data archiving and distribution. Additional responsibilities include enhancing the geographic extent, feature attributes, and metadata of the datasets.
The C&E GIS team is comprised of 9 full-time GIS and data analysis professionals. The C&E GIS team supports all programs within the C&E department, which include CRP/Water Quality, Sustainability, Economic Development, Solid Waste, Ped/Bike, Socio-Economic Modeling, and special project. The C&E GIS team is part of the Socio-Economic Modeling program within

C&E.

H-GAC's Data Services Department plays an indirect role in the implementation and maintenance of GDMP. The Data Services Department is responsible for managing the underlying hardware and network upon which C&E stores GIS data and implements GIS-based applications.

**TRAINING**

Training for all users of the system is a critical part of the GDMP. C&E staff directly responsible for data management will attend conferences, seminars, and software/hardware training courses as needed. H-GAC users of the system will be trained and/or receive technical support by the C&E GIS Manger and other C&E subject matter experts.

**BUDGET**

Budgetary requirements to sustain data management efforts will be reviewed annually.

**DATA MAINTENANCE, MANIPULATION, AND USE**

Quality Assurance/Quality Control
QA/QC is designed to standardize screening, documentation, entry, output, analysis, correction, and updating of data in the system. QA/QC will document those responsible for data and system maintenance.

**DATA LIMITATIONS**

Prior to the integration of data within the C&E SDE and posting to the Data Clearinghouse, a review of the data set will be completed to determine predefined data limitations such as missing values, different sampling frequencies, multiple measurements, analytical uncertainty, censored or unavailable data, and duplicated data with existing data sets. After review of the data set, a report will be generated which records any errors detected and any corrections that may be necessary.

**DATA DEVELOPMENT PROTOCOL**

The C&E GIS staff works to update existing dataset, acquire new data, and perform geospatial analysis in support of various C&E programs. All new data generated from the result of an analysis is a candidate to be stored not only in the SDE as a new dataset, but also as a layer with a mapping application should the need arise. All data development and analysis are done internally to C&E, and at times leverages outside resources such as consultants, other non-profits whom H-GAC is partnering with, as well as with other H-GAC departments to obtain necessary data. Two datasets that the C&E department uses regularly outside the C&E SDE are the Data Services StarMap road centerline dataset and the Data Services aerial imagery database.

The C&E GIS staff uses a hybrid approach to conducting geospatial analysis. Much of the analysis being performed may need to be re-processed later as new versions of datasets become available, or as inputs to the analysis models are updated themselves. Thus, to minimize the time spent re-running analysis models, the C&E GIS staff utilizes the ESRI ArcGIS platform in conjunction with SAS and Python to develop repeatable and documented workflows. This approach saves more time than interactive methods whereby a user must remember the process

to follow, and then execute each step in the analysis independently.
Documentation related to data management efforts such as system evolution, structure, and procedures for use will be compiled and made available for the end user. Documentation will be made available online and in hard copy format.

**DATA INPUT**
Standard conventions for data input will be determined on a per project and/or individual data set basis. To ensure Year 2000 Compliance, all data sets with date/time fields will include a four-digit year (YYYY). Either of the following formats will be used: International Standard Date notation where the date field is represented as MM/DD/YYYY (Month/Day/Year), or an ordinal format where the date field is represented as YYYYDDD.

**DATA DICTIONARY**
A list of all H-GAC data available in either the C&E SDE or other agency wide SDE can be found in Appendix E.5.

**METADATA**
Metadata is data about the original source, quality, content, history, condition, and other characteristics of the geospatial data. All GIS datasets generated by H-GAC have been fully documented as per Federal Geographic Data Committee (FGDC) compliant metadata and follow Content Standards for Digital Geospatial Metadata (CSDGM) for all geospatial data. Similarly, data obtained from outside sources and used by H-GAC will include FGDC-compliant metadata from the source agency. Datasets without a known history and documented quality will be identified as provisional and used only when noted as such. The diagram below illustrates elements of the CSDGM standards (Figure B.2). This standard is applied to all Point, Line, Polygon, Raster, and Tabular data that are stored in the C&E SDE. The C&E GIS data manager and/or point of contact (designee) has the authorized access to edit/change the metadata when a new dataset is created or updated in the SDE. Metadata for each dataset in the C&E SDE is stored with the datasets and can be viewed by GIS users via their GIS desktop software. Any data provided for public download via the Data Clearinghouse also has a metadata html page that can be viewed via internet browsers.

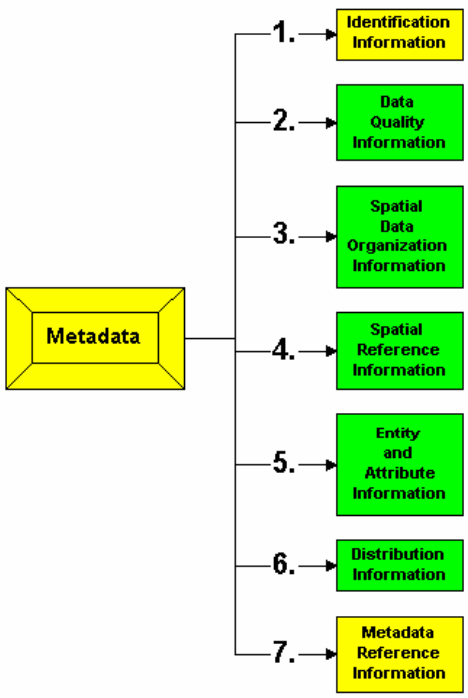



**Figure B.2: Elements of CSDGM Standards**

**DATA CONVERSION**

Data to be imported into the C&E SDE from hard copy, digital or by manual data entry, will follow a uniform conversion protocol to comply with the structure of current data sets. The type of data being converted will determine the protocol. All data is stored in ESRI geodatabase format within the C&E SDE, and when posted to the Data Clearinghouse the data is stored in the ESRI File Geodatabase file format, unless there is a specific requirement to provide the data in another format such as Shapefile or GIS Coverage.

**COORDINATE SYSTEMS**

The Texas Stateplane Coordinate System, North American Datum 1983 (NAD83) will be the standard for geographic data at H-GAC. This coordinate system is based on the Cartesian coordinate system, or rectangular coordinates. When receiving geographic data from other sources the data will be transformed into the Stateplane Coordinate System to ensure compatibility with current data sets.

When publishing mapping services for use in web-based GIS mapping applications, the Web Mercator Auxiliary Sphere projection is used for all Data Frame projections. However, the underlying GIS data within these mapping services still use the Texas Stateplane Coordinate System, NAD83 projection.

**DATA VALIDATION/DATA QUALITY CONTROL**

When data are received from any source, documentation will be created to include the source name, date received, format of data and a brief description of the contents. Data will be loaded onto the system from the media received and a review of the data will be made along with any corrections being made to the source documentation. An analysis will be made to determine the

means of data entry into the system whether it is only a stand-alone database, a number of linked tables, or a geographic database.

The data will be converted to the appropriate format for integration with the current system whether it is a conversion into Microsoft Access, Excel, SAS, or ESRI ArcGIS. The data will be visually examined to determine its validity and accuracy. If the data is invalid it will be corrected (if possible) otherwise the data will be incorporated into the C&E SDE, and then if applicable, posted to the Data Clearinghouse and used in conjunction with existing data. A QA/QC report of all procedures and a detailed description of how the data was incorporated into the current system (from the date received to the date of integration) will be generated.

**EQUIPMENT QUALITY CONTROL**
All printers, workstations, and server hardware and operating systems are maintained by the Data Services department, unless otherwise noted in Appendix E.3.

**GENEALOGY**
Upon receipt of data from outside sources, all data will be screened for integrity and completeness. After the preliminary evaluation of the data, a log of the data source, type and completeness is created and maintained with the associated data. A description of the data and the responsible personnel are documented.

**MIGRATION/TRANSFER**
A copy of every C&E generated GIS dataset will be housed in the C&E SDE which C&E GIS staff manage the contents and structure of datasets. The underlying hardware and network connections for the C&E SDE are maintained by the Data Services Department. Datasets that are of public interest will be placed in the Data Clearinghouse for public access. Transfer from the C&E SDE to the Data Clearinghouse will occur on an as needed basis following department QA/QC measures and is handled by the C&E GIS team.

**DATA SECURITY & ACCESS**
Data placed on the Data Clearinghouse will be available to those with Internet browsing and/or FTP capability. Data requests for non-public data from other agencies and the public will be evaluated on an individual basis. When the data requests are received, a preliminary evaluation of the deliverable will be determined and a timeline and cost if applicable will be provided to the requesting agency or individual.

GIS and tabular data will be secure through directory permissions. H-GAC will employ Firewall or Proxy Server Technology to filter and severely restrict access to internal networks and database systems. Virus protection will be implemented to ensure system and data integrity.

**ARCHIVES/BACKUP**
Each week the C&E GIS team runs a schedule backup program to store a copy of all C&E SDE datasets on a portable hard drive with resides in a secure location within the H-GAC office. In addition, Data Services backs up and archives C&E SDE data and server configuration at regular intervals.

**DISASTER RECOVERY**

In the event of a disaster, the C&E will have access to all C&E SDE data which is stored on the portable hard drive. The C&E GIS team will restore or provide needed data to GIS users from this portable hard drive until such as time that Data Services can restore the C&E SDE onto either a new server or a temporary server.

**APPENDICES**
**APPENDIX E.1 DATA SOURCE INFORMATION SHEET**
Data Title:

Source Agency:
Contact:
Title:
Address
Phone:

Data Description:
Data source:
Date created:
Accuracy:
Media:
Data items:

Description of data:

Format (specify what software)
Map:
Tabular:
Image:
Text:

Retrieval Procedure:

Command(s):

**APPENDIX E.2 DATA LOG SHEET**

Date received: _____

Report Prepared by: _____

Source Name and Phone: _____

Format: _____

Media: _____

Check the following steps to determine the validity of the data:

1. What is the extent of the geographic area? _____
_____

2. Structure (Circle One) Vector Raster

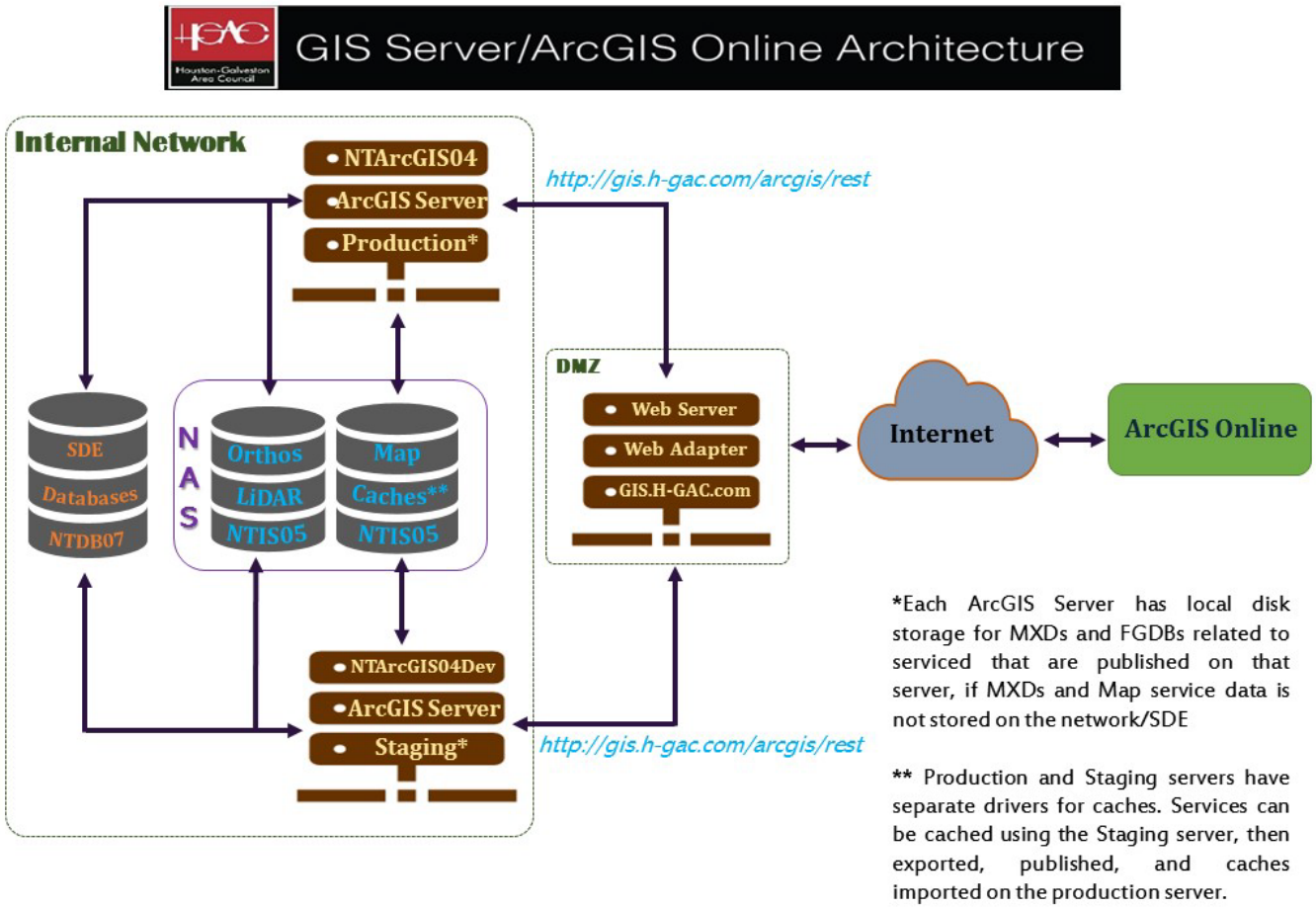
3. Scale? _____

4. Projection and Datum? _____

1. Do any of the key fields have missing values? If so, which parameters have missing values? Yes ___ No ___
_____
_____
_____

2. Any known duplicate records? Yes ___ No ___

**APPENDIX E.3 HARDWARE**
**FTP SERVER**
h-gac.sharefile.com
**MAPPING APPLICATION SERVERS**




**PLOTTERS, PRINTERS AND SCANNERS**
HP1055CM Plotter - Used by all H-GAC staff for large format printing of maps and schematics.
Xerox Workcenter 7845 and Cannon Advanced 4545 Printers and scanners. C&E maintains both printers.

**GLOBAL POSITIONING SYSTEM (GPS) UNITS**
The C&E Department possesses two GPS units.

**FAX EQUIPMENT**
Brother Intellifax 4750e. The C&E Department owns one fax machine.

## APPENDIX E.4 SOFTWARE

### OFFICE PRODUCTIVITY SOFTWARE
Microsoft Office 365 - Word, Excel, Access, PowerPoint, publisher, InfoPath and Outlook.

### GRAPHICS AND DESKTOP PUBLISHING
Adobe Illustrator (ver 8.01) – Graphics
Adobe Photoshop (ver 5.0) – Graphics
Camtasia Studio (ver 7.0) – Screen capture and video tutorial production

### PROGRAMMING
Microsoft Visual Studio – Web Mapping Development Tool.
Web AppBuilder for ArcGIS (ver 1.8) – Web-based GIS application development tool
SAS (ver 9.4) – Data development and analytics.

### GIS
ESRI ArcGIS (ver 10.5) – Computer mapping and database manipulation capable of using ArcView, ArcInfo, and ArcEditor licenses as needed.
ESRI ArcGIS Server (ver 10.2, SP3) – Internet Mapping Application Server.
ESRI ArcSDE (ver 10.2, SP1) – Spatial data warehouse.
ENVI Remote Sensing Data Analysis Package – Harris Geospatial

### DATA MANAGEMENT
Microsoft Access (365) - Relational Database.
SQL Server (2012) - Relational Database.

### OPERATING SYSTEMS
Windows 7 - PC working environment/Operating System
Windows 10 - PC working environment/Operating System
Windows 2012 & 2016 - Server Operating Systems

**APPENDIX E.5 DATA LIST**

**H-GAC SPATIAL DATA WAREHOUSE (SDE) DATASETS**

| Dataset Name | Type |
|---|---|
| ACE_2017\ACE_HEX_2017 | Polygon |
| ACE_2017\ACE_HEX_2017_pt | Point |
| Apartment_Input | Point |
| Appraisal_2014\BZ_2014_org | Polygon |
| Appraisal_2014\CH_2013_org | Polygon |
| Appraisal_2014\FB_2014_org | Polygon |
| Appraisal_2014\GV_2014_org | Polygon |
| Appraisal_2014\HR_2014_org | Polygon |
| Appraisal_2014\LB_2014_org | Polygon |
| Appraisal_2014\MG_2013_org | Polygon |
| Appraisal_2014\WA_2014_org | Polygon |
| Austin_County_Commissioner_Precincts | Polygon |
| Barker_and_Addicks_Reservoir_Watersheds | Polygon |
| BlueMap \ActivityPopulationDensity | Polygon |
| BlueMap \EmploymentDensity | Polygon |
| BlueMap \HouseholdPopulationDensity | Polygon |
| BlueMap \IntersectionDensity | Polygon |
| BlueMap \Jobs_Household_Ratio_1500 | Polygon |
| BlueMap \Jobs_Household_Ratio_above_1500 | Polygon |
| BlueMap\RoadwayDensity | Polygon |
| BlueMap_2000\ActivityPopulation_2000 | Polygon |
| BlueMap_2000\Employment_2000 | Polygon |
| BlueMap_2000\HouseholdPopulation_2000 | Polygon |
| BlueMap_2000\Intersection_2000 | Polygon |
| BlueMap_2000\Job_HH_Ratio_2000 | Polygon |
| BlueMap_2015\ActivityPopulation | Polygon |
| BlueMap_2015\Employment | Polygon |
| BlueMap_2015\HouseholdPopulation | Polygon |
| BlueMap_2015\Intersection | Polygon |
| BlueMap_2015\Job_HH_Ratio_above_2000 | Polygon |
| BlueMap_2016\Accessibility_Score_2016 | Polygon |
| BlueMap_2016\ActivityPopulation_2016 | Polygon |
| BlueMap_2016\Amenity_Index_2016 | Polygon |
| BlueMap_2016\Employment_2016 | Polygon |
| BlueMap_2016\HouseholdPopulation_2016 | Polygon |
| BlueMap_2016\Intersection_2016 | Polygon |
| BlueMap_2016\Job_HH_Ratio_2016 | Polygon |

| | |
|---|---|
| BlueMap_ActivityPopulation | Polygon |
| BlueMap_Comparison\HP_2000 | Polygon |
| BlueMap_Comparison\HP_2016 | Polygon |
| BlueMap_Comparison\INT_2000 | Polygon |
| BlueMap_Comparison\INT_2016 | Polygon |
| BlueMap_Comparison\J_2000 | Polygon |
| BlueMap_Comparison\J_2016 | Polygon |
| BlueMap_Comparison\JP_2000 | Polygon |
| BlueMap_Comparison\JP_2016 | Polygon |
| BlueMap_Comparison\Ratio_2000 | Polygon |
| BlueMap_Employment | Polygon |
| BLUEMAP_HEX | Polygon |
| BLUEMAP_HEX_2015 | Polygon |
| BLUEMAP_HEX_2016 | Polygon |
| BLUEMAP_HEX_2016_Pedestrian_Demand_Index | Polygon |
| BLUEMAP_Property_Value_HEX | Polygon |
| Brazoria_County_Commissioner_Precincts | Polygon |
| Brazos_Transit_District_Bus_Routes | Polyline |
| Brazos_Transit_District_Park_and_Rides | Point |
| Buildings | Point |
| Cedar_Bayou_Watershed_Project_Monitoring_Sites | Point |
| CensusTracts_MB | Polygon |
| Chambers_County_Commissioner_Precincts | Polygon |
| City_of_Conroe_ETJ | Polygon |
| City_of_Huntsville_ETJ | Polygon |
| City_of_Missouri_City_ETJ | Polygon |
| City_of_Pearland_ETJ | Polygon |
| City_of_Texas_City_ETJ | Polygon |
| Clean_Rivers_Public_Feedback | Point |
| Clean_Rivers_Public_Feedback__ATTACH | Table |
| COH_Boundaries | Polygon |
| COH_Boundaries_census | Polygon |
| COH_Boundaries_census_new | Polygon |
| CoH_Council_Districts | Polygon |
| CoH_ETJ | Polygon |
| CoH_Historical_Districts | Polygon |
| CoH_Police_Districts | Polygon |
| CoH_Street_Pavement_Edges | Polyline |
| CoH_Traffic_Signals | Point |
| CoH_Traffic_Signs | Point |

| | |
|---|---|
| Colorado_County_Commissioner_Precincts | Polygon |
| Colorado_Valley_Transit_Bus_Routes | Polyline |
| Connect_Transit_Bus_Routes | Polyline |
| Conroe_Transit_Bus_Routes | Polyline |
| Critical_Facilities_2017 | Point |
| CRP_HUC12_RPS_updated | Polygon |
| CRP_MonitoringStations_Subwatersheds | Polygon |
| CRP_Project_Areas | Polygon |
| EPA_Eco_Regions | Polygon |
| FEMA_Floodplains_DFIRM_Q3_2010 | Polygon |
| FEMA_Floodplains_NFHL_2015 | Polygon |
| Fort_Bend_County_Commissioner_Precincts | Polygon |
| Fort_Bend_Transit_Bus_Routes | Polyline |
| Galveston_Bay_Estuary_Program_Watersheds | Polygon |
| Galveston_County_Commissioner_Precincts | Polygon |
| Gulf_Of_Mexico | Polygon |
| Harris_County_Commissioner_Precincts | Polygon |
| Harris_County_Constable_Precincts | Polygon |
| Harris_County_FCD_Sub_Watersheds | Polygon |
| Harris_County_FCD_Watersheds | Polygon |
| Harris_County_Sheriff_Districts | Polygon |
| Harris_County_Transit_Bus_Routes | Polyline |
| Harris_County_Zones_58 | Polygon |
| HGAC_13_County_ACS_2014\BGs_2014 | Polygon |
| HGAC_13_County_ACS_2014\Census_Places_2014 | Point |
| HGAC_13_County_ACS_2014\Census_Tracts_2014 | Polygon |
| HGAC_13_County_ACS_2014\Counties_2014 | Polygon |
| HGAC_13_County_ACS_2014\Zips_2014 | Polygon |
| HGAC_13_County_ACS_2015\BGs_2015 | Polygon |
| HGAC_13_County_ACS_2015\BGs_Vulnerable_2015 | Polygon |
| HGAC_13_County_ACS_2015\Census_Places_2015 | Polygon |
| HGAC_13_County_ACS_2015\Census_Places_pt_2015 | Point |
| HGAC_13_County_ACS_2015\CEnsus_Tracts_2015 | Polygon |
| HGAC_13_County_ACS_2015\Counties_2015 | Polygon |
| HGAC_13_County_ACS_2015\Places_poly_2015 | Polygon |
| HGAC_13_County_ACS_2015\Zips_2015 | Polygon |
| HGAC_13_County_ACS_2015_Blockgroup_summary | Polygon |
| HGAC_13_County_ACS_2016\BGs_2016 | Polygon |
| HGAC_13_County_ACS_2016\BGs_Veterans_2016 | Polygon |
| HGAC_13_County_ACS_2016\BGs_Vulnerable_2016 | Polygon |
| HGAC_13_County_ACS_2016\Counties_2016 | Polygon |

| | |
|---|---|
| HGAC_13_County_ACS_2016\Counties_TX_Veterans_2016 | Polygon |
| HGAC_13_County_ACS_2016\ISDs_2016 | Polygon |
| HGAC_13_County_ACS_2016\Places_poly_2016 | Polygon |
| HGAC_13_County_ACS_2016\Places_pt_2016 | Point |
| HGAC_13_County_ACS_2016\Tracts_2016 | Polygon |
| HGAC_13_County_ACS_2016\Zips_2016 | Polygon |
| HGAC_13_County_ACS_2016_Blockgroup_summary | Polygon |
| HGAC_13_County_ACS_2017\BGs_2017 | Polygon |
| HGAC_13_County_ACS_2017\BGs_Vulnerable_2017 | Polygon |
| HGAC_13_County_ACS_2017\Counties_2017 | Polygon |
| HGAC_13_County_ACS_2017\ISDs_2017 | Polygon |
| HGAC_13_County_ACS_2017\Places_poly_2017 | Polygon |
| HGAC_13_County_ACS_2017\Places_pt_2017 | Point |
| HGAC_13_County_ACS_2017\Tracts_2017 | Polygon |
| HGAC_13_County_ACS_2017\Zips_2017 | Polygon |
| HGAC_13_County_ACS_2017_Housing\ACS_Housing_Counties_2017 | Polygon |
| HGAC_13_County_ACS_2017_Housing\ACS_Housing_Places_2017 | Polygon |
| HGAC_13_County_ACS_2017_Housing\ACS_Housing_Tracts_2017 | Polygon |
| HGAC_13_County_Airports | Point |
| HGAC_13_County_Airports_ParcelIDs | Table |
| HGAC_13_County_Brownfield_Sites | Point |
| HGAC_13_County_Closed_Landfill_Inventory | Point |
| HGAC_13_County_CRP_DO_Stations | Point |
| HGAC_13_County_CRP_Monitoring_Stations_2008 | Point |
| HGAC_13_County_CRP_Monitoring_Stations_2010 | Point |
| HGAC_13_County_CRP_Monitoring_Stations_2011 | Point |
| HGAC_13_County_CRP_Monitoring_Stations_2012 | Point |
| HGAC_13_County_CRP_Monitoring_Stations_2013 | Point |
| HGAC_13_County_CRP_Monitoring_Stations_2014 | Point |
| HGAC_13_County_CRP_Monitoring_Stations_2015 | Point |
| HGAC_13_County_CRP_Monitoring_Stations_2016 | Point |
| HGAC_13_County_CRP_Monitoring_Stations_2017 | Point |
| HGAC_13_County_CRP_Monitoring_Stations_Historical | Point |
| HGAC_13_County_Districts | Polygon |
| HGAC_13_County_Ecological_Mapping_System_TPWD_2015 | Polygon |
| HGAC_13_County_Farmland | Polygon |
| HGAC_13_County_Federal_Aid_Roads | Polyline |
| HGAC_13_County_FoodWaste_Composters | Point |
| HGAC_13_County_G1M | Polygon |
| HGAC_13_County_G3M | Polygon |

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|---|---|
| HGAC_13_County_G5M | Polygon |
| HGAC_13_County_Grocery_Stores | Point |
| HGAC_13_County_Landfill_Areas | Polygon |
| HGAC_13_County_Landfill_Areas_Historical | Polygon |
| HGAC_13_County_Landfills | Point |
| HGAC_13_County_Landfills_Historical | Point |
| HGAC_13_County_Libraries | Point |
| HGAC_13_County_Libraries_Parcel_Xref | Table |
| HGAC_13_County_MPC | Polygon |
| HGAC_13_County_OSSF_Permits | Point |
| HGAC_13_County_OSSF_Permits_2017 | Point |
| HGAC_13_County_OSSF_Permits_2018 | Point |
| HGAC_13_County_Parks | Point |
| HGAC_13_County_Parks_Awards | Table |
| HGAC_13_County_Parks_Features | Table |
| HGAC_13_County_Parks_Parcels | Table |
| HGAC_13_County_Plats | Polygon |
| HGAC_13_County_Recycle_Centers | Point |
| HGAC_13_County_Service_Area_Boundaries | Polygon |
| HGAC_13_County_Service_Area_Boundaries_2013 | Polygon |
| HGAC_13_County_Service_Area_Boundaries_2014 | Polygon |
| HGAC_13_County_Service_Area_Boundaries_2015 | Polygon |
| HGAC_13_County_Service_Area_Boundaries_2017 | Polygon |
| HGAC_13_County_Service_Area_Boundaries_Domestic_2018 | Polygon |
| HGAC_13_County_Soils | Polygon |
| HGAC_13_County_Superfund_NPL_Sites | Polygon |
| HGAC_13_County_Superfund_NPL_Sites_Pts | Point |
| HGAC_13_County_Wastewater_Outfall_Domestic_2018 | Point |
| HGAC_15_County_Aquifer_Recharge_Zones | Polygon |
| HGAC_15_County_Basins | Polygon |
| HGAC_15_County_Bio_Monitoring_Sites | Point |
| HGAC_15_County_CRP_Impairments | Table |
| HGAC_15_County_CRP_Lakes | Polygon |
| HGAC_15_County_CRP_Stream_End_Points | Point |
| HGAC_15_County_CRP_Streams | Polyline |
| HGAC_15_COUNTY_LAND_COVER_2015_10_CLASS | Raster |
| HGAC_15_COUNTY_LAND_COVER_2018_10_CLASS | Raster |
| HGAC_15_County_NHDPlusV2_Catchment_Boundary | Polygon |
| HGAC_15_County_Soils_2012 | Polygon |
| HGAC_15_County_Soils_2012_w_taxonomy | Polygon |

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|---|---|
| HGAC_15_County_Wastewater_Outfalls | Point |
| HGAC_15_County_Wastewater_Outfalls_2017 | Point |
| HGAC_15_County_Wastewater_Outfalls_Historical | Point |
| HGAC_15_County_Wastewater_Outfalls_Info | Table |
| HGAC_15_County_Water_Detailed_2018 | Polygon |
| HGAC_15_County_Watershed_Insets | Polygon |
| HGAC_15_County_Watershed_Signs | Point |
| HGAC_15_County_Watersheds | Polygon |
| HGAC_8_County_Bikeway_Needs | Polyline |
| HGAC_8_County_Bikeways | Polyline |
| HGAC_8_County_Comprehensive_Plan_2010_pts | Point |
| HGAC_8_County_Eco_Types | Polygon |
| HGAC_8_County_Forecast_Cities_h | Table |
| HGAC_8_County_Forecast_Cities_v | Table |
| HGAC_8_County_Forecast_Counties_h | Table |
| HGAC_8_County_Forecast_Counties_v | Table |
| HGAC_8_County_Forecast_G025M_h | Table |
| HGAC_8_County_Forecast_G1_h | Table |
| HGAC_8_County_Forecast_G10K_h | Table |
| HGAC_8_County_Forecast_G10K_v | Table |
| HGAC_8_County_Forecast_G1M_h | Table |
| HGAC_8_County_Forecast_G1M_v | Table |
| HGAC_8_COUNTY_FORECAST_LU_G1_H | Table |
| HGAC_8_County_Forecast_RAZ_h | Table |
| HGAC_8_County_Forecast_RAZ_v | Table |
| HGAC_8_County_Forecast_Region_v | Table |
| HGAC_8_County_Forecast_TAZ_h_2003 | Table |
| HGAC_8_County_Forecast_TAZ_v_2003 | Table |
| HGAC_8_County_Forecast_Tracts_h | Table |
| HGAC_8_County_Forecast_Tracts_v | Table |
| HGAC_8_County_Forecast_Zip_Codes_h | Table |
| HGAC_8_County_Forecast_Zip_Codes_v | Table |
| HGAC_8_County_G025M | Polygon |
| HGAC_8_County_G1 | Polygon |
| HGAC_8_County_G10 | Polygon |
| HGAC_8_County_G1M | Polygon |
| HGAC_8_County_PedBike_Improvement_Areas | Polygon |
| HGAC_8_County_PedBike_Improvement_Locations | Point |
| HGAC_8_County_Pedestrian_Pathways | Polyline |

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|---|---|
| HGAC_8_County_Sector_25 | Polygon |
| HGAC_8_County_Soils | Polygon |
| HGAC_8_County_Water | Polygon |
| HGAC_Airport_Runways | Polygon |
| HGAC_Airport_System | Point |
| HGAC_Art_of_Transportation | Point |
| HGAC_Bastrop_Bayou_Sub_Watersheds | Polygon |
| HGAC_Buy_Active_EndUsers | Point |
| HGAC_Buy_PO_EndUsers | Point |
| HGAC_City_Boundaries | Polygon |
| HGAC_City_Ordinance_Areas | Polygon |
| HGAC_COASTAL_VIGNETTE_RASTER | Raster |
| HGAC_Commissioner_Precincts | Polygon |
| HGAC_Contours_2_Feet | Polyline |
| HGAC_Contours_5_Feet | Polyline |
| HGAC_Counties_Coastline | Polygon |
| HGAC_Counties_Coastline_15C | Polygon |
| HGAC_Counties_Coastline_Boundary | Polygon |
| HGAC_Counties_Coastline_Boundary_15C | Polygon |
| HGAC_Counties_Political | Polygon |
| HGAC_Counties_Political_15C | Polygon |
| HGAC_Counties_Political_Boundary | Polygon |
| HGAC_Counties_Political_Boundary_15C | Polygon |
| HGAC_CRP_Watersheds | Polygon |
| HGAC_Dams | Point |
| HGAC_Election_Precincts_2010 | Polygon |
| HGAC_FM_Roads | Polyline |
| HGAC_HILLSHADE | Raster |
| HGAC_Hurricane_Dolly_Observations | Point |
| HGAC_Hurricane_Dolly_Track | Polyline |
| HGAC_Hurricane_Evacuation_Routes | Polyline |
| HGAC_Hurricane_Evacuation_Zip_Codes | Polygon |
| HGAC_Hurricane_Ike_High_Water_Measurements | Point |
| HGAC_Hurricane_Ike_Observations | Point |
| HGAC_HURRICANE_IKE_SALT_BURN_GULF_COAST | Raster |
| HGAC_Hurricane_Ike_Storm_Surge_Model | Polygon |
| HGAC_HURRICANE_IKE_STORM_SURGE_MODEL_RASTER | Raster |
| HGAC_Hurricane_Ike_Track | Polyline |
| HGAC_Lakes_AUs_2016 | Polygon |
| HGAC_Lakes_Segments_2016 | Polygon |

| | |
|---|---|
| HGAC_LAND_COVER_10_CLASS_2008 | Raster |
| HGAC_LAND_COVER_10_CLASS_ROADS_2008 | Raster |
| HGAC_LAND_COVER_3X3_MODE_FILTERED_2008 | Raster |
| HGAC_LAND_COVER_MERGED_6_CLASS_2008 | Raster |
| HGAC_Learning_Centers | Point |
| HGAC_LiDAR_Breakline | Polyline |
| HGAC_LiDAR_Contours_1_Foot | Polyline |
| HGAC_LiDAR_Spot_Elevation | Point |
| HGAC_Main_Railroads | Polyline |
| HGAC_Major_Lakes_and_Reserviors | Polygon |
| HGAC_Major_Rivers | Polyline |
| HGAC_Major_Rivers_15C | Polyline |
| HGAC_Major_Roads | Polyline |
| HGAC_Major_Roads_15C | Polyline |
| HGAC_MSWF_Managed_Lanes | Polyline |
| HGAC_MSWF_Traffic_Management_Strategies | Point |
| HGAC_NWR_Areas | Polygon |
| HGAC_Other_CRP_Monitoring_Stations | Point |
| HGAC_Pipelines | Polyline |
| HGAC_Raster_Extext | Polygon |
| HGAC_RAZ | Polygon |
| HGAC_Region_WWTF_Outfalls_FY17 | Point |
| HGAC_Sea_Level_Rise | Polygon |
| HGAC_Seaports | Point |
| HGAC_Sidewalks_Preliminary | Polyline |
| HGAC_State_Highways | Polyline |
| HGAC_State_Parks | Polygon |
| HGAC_Streams_AUs_2016 | Polyline |
| HGAC_Streams_Segments_2016 | Polyline |
| HGAC_TAZ_2954 | Polygon |
| HGAC_TAZ_5217 | Polygon |
| HGAC_TIRZ | Polygon |
| HGAC_Water | Polygon |
| HGAC_Water_15C | Polygon |
| HGAC_Water_Detailed | Polygon |
| HGAC_Workforce_DARS | Point |
| HGAC_Workforce_Offices | Point |
| HGAC_Workforce_Solutions\HGAC_Career_Offices | Point |
| HGAC_Workforce_Solutions\HGAC_Parole_Offices | Point |
| HGAC_Workforce_Solutions\HGAC_Re_Entry_Resources | Point |

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|---|---|
| HGAC_Workforce_Solutions\HGAC_Workforce_Centers | Point |
| HGAC_Workforce_Solutions\HGAC_Workforce_Solutions_Offices | Point |
| HGAC_Workforce_Solutions\HGAC_Workforce_Solutions_Offices_10mi_Demographics | Polygon |
| HGAC_Workforce_Solutions\HGAC_Workforce_Solutions_Offices_5mi_Demographics | Polygon |
| HGAC_Workforce_Solutions\HGAC_Workforce_Solutions_VR_Offices | Point |
| HGAC_Workforce_Solutions\HGAC_Workforce_Solutions_VR_Offices_10mi_Demographics | Polygon |
| HGAC_Workforce_Solutions\HGAC_Workforce_Solutions_VR_Offices_5mi_Demographics | Polygon |
| HGAC_Zip_Codes_2000 | Polygon |
| HGAC_Zip_Codes_2002 | Polygon |
| HGAC_Zip_Codes_2005 | Polygon |
| HGAC13_CountyTest | Polygon |
| Houston_Bcycle_Stations_2018 | Point |
| HR_Buildings_2013 | Table |
| HR_Parcels_2014 | Polygon |
| InfoGroup_Businesses_2014 | Point |
| InfoGroup_Businesses_2015 | Point |
| InfoGroup_Businesses_2016 | Point |
| InfoGroup_Businesses_2017 | Point |
| InfoGroup_Businesses_2018 | Point |
| InfoGroup_Businesses_Nix_2015 | Point |
| InfoGroup_Businesses_Nix_2016 | Point |
| InfoGroup_Businesses_Nix_2017 | Point |
| InfoGroup_Businesses_Nix_2018 | Point |
| InfoGroup_Businesses_Pre_2018 | Point |
| InfoGroup_Businesses_Suspect_2014 | Point |
| InfoGroup_Businesses_Suspect_2015 | Point |
| InfoGroup_Businesses_Suspect_2016 | Point |
| InfoGroup_Businesses_Suspect_2017 | Point |
| InfoGroup_Businesses_Suspect_2018 | Point |
| InfoGroup_Consumers_2014 | Point |
| InfoGroup_Consumers_2015 | Point |
| InfoGroup_Consumers_2016 | Point |
| InfoGroup_Consumers_2017 | Point |
| InfoGroup_Consumers_2018 | Point |
| Island_Transit_Bus_Routes | Polyline |
| Lambert_Grid | Polygon |
| LEHD\County_LEHD_09_15 | Polygon |
| LEHD\HEX_H1M_09_15 | Polygon |
| LEHD\HEX_LEHD_09_15 | Polygon |
| LEHD\Place_LEHD_09_15 | Polygon |

| | |
|---|---|
| LEHD\Tract_LEHD_09_15 | Polygon |
| Liberty_County_Commissioner_Precincts | Polygon |
| LID_Projects | Point |
| LiDAR_Grid_2008 | Polygon |
| LivableCenters | Polygon |
| Master_Parcels_Address_2014 | Point |
| Matagorda_County_Commissioner_Precincts | Polygon |
| Metro_Bus_Routes | Polyline |
| Metro_Bus_Stops | Point |
| Metro_LRT_Lines | Polyline |
| Metro_LRT_Stations | Point |
| Metro_MTA_Tax_Area | Polygon |
| Metro_Park_and_Rides | Point |
| METRO_Transit\METRO_Bus_Routes | Polyline |
| METRO_Transit\METRO_Bus_Routes_2018 | Polyline |
| METRO_Transit\METRO_LRT_Rail_Lines | Polyline |
| METRO_Transit\METRO_LRT_Rail_Lines_2018 | Polyline |
| METRO_Transit\METRO_Service_Area | Polygon |
| METRO_Transit\METRO_Service_Area_2018 | Polygon |
| METRO_Transit\METRO_Transit_Facilities | Point |
| METRO_Transit\METRO_Transit_Facilities_2018 | Point |
| Metro_Transit_Centers | Point |
| Model_Buildings | Point |
| Model_Buildings_2014 | Point |
| Model_Buildings_2017 | Point |
| Model_Buildings_2017_2 | Point |
| Model_Buildings_Rural | Point |
| Model_Buildings_Uses | Table |
| Model_Buildings_Uses_Rural | Table |
| Model_Parcels | Polygon |
| Model_Parcels_2014 | Polygon |
| Model_Parcels_2017 | Polygon |
| Model_Parcels_AcctNums | Table |
| Model_Parcels_AcctNums_Rural | Table |
| Model_Parcels_Addresses | Table |
| Model_Parcels_Addresses_Rural | Table |
| Model_Parcels_Features | Table |
| Model_Parcels_Features_Rural | Table |
| Model_Parcels_Forecast | Table |
| Model_Parcels_Forecast2020 | Table |

| | |
|---|---|
| Model_Parcels_Pts | Point |
| Model_Parcels_Removed_Merged | Polygon |
| Model_Parcels_Rural | Polygon |
| Model_Predictions_2018 | Polygon |
| Model_Predictions_v2018\BZ_Model_Predictions_v2018 | Polygon |
| Model_Predictions_v2018\CH_Model_Predictions_v2018 | Polygon |
| Model_Predictions_v2018\FB_Model_Predictions_v2018 | Polygon |
| Model_Predictions_v2018\GV_Model_Predictions_v2018 | Polygon |
| Model_Predictions_v2018\HR_Model_Predictions_v2018 | Polygon |
| Model_Predictions_v2018\HR_Model_Predictions_v2018_p1 | Polygon |
| Model_Predictions_v2018\HR_Model_Predictions_v2018_p2 | Polygon |
| Model_Predictions_v2018\HR_Model_Predictions_v2018_p3 | Polygon |
| Model_Predictions_v2018\LB_Model_Predictions_v2018 | Polygon |
| Model_Predictions_v2018\MG_Model_Predictions_v2018 | Polygon |
| Model_Predictions_v2018\WA_Model_Predictions_v2018 | Polygon |
| Montgomery_County_Commissioner_Precincts | Polygon |
| Montgomery_County_Zones_4 | Polygon |
| ND\BZ_Parcels_2013 | Polygon |
| ND\CH_Parcels_2013 | Polygon |
| ND\FB_Parcels_2013 | Polygon |
| ND\GV_Parcels_2013 | Polygon |
| ND\HR_Parcels_2013 | Polygon |
| ND\LB_Parcels_2013 | Polygon |
| ND\MG_Parcels_2013 | Polygon |
| ND\WA_Parcels_2013 | Polygon |
| NGS_Control_Stations | Point |
| NLCD_IMPERVIOUSNESS_2001 | Raster |
| NLCD_IMPERVIOUSNESS_2006 | Raster |
| NLCD_IMPERVIOUSNESS_2011 | Raster |
| NLCD_IMPERVIOUSNESS_CHANGE_2001_TO_2006 | Raster |
| NLCD_IMPERVIOUSNESS_CHANGE_2006_TO_2011 | Raster |
| NLCD_LAND_COVER_1992_19_CLASS | Raster |
| NLCD_LAND_COVER_1992_19_CLASS_CORRECTED | Raster |
| NLCD_LAND_COVER_2001_15_CLASS | Raster |
| NLCD_LAND_COVER_2006_15_CLASS | Raster |
| NLCD_LAND_COVER_2011_15_CLASS | Raster |
| NLCD_LAND_COVER_CHANGE_1992_TO_2011_9_CLASS | Raster |
| NLCD_TREE_CANOPY_2001 | Raster |
| NOAA_LAND_COVER_1996_22_CLASS | Raster |
| NOAA_LAND_COVER_2001_22_CLASS | Raster |

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|---|---|
| NOAA_LAND_COVER_2006_22_CLASS | Raster |
| NOAA_LAND_COVER_2011_15_CLASS | Raster |
| NOAA_LAND_COVER_2011_22_CLASS | Raster |
| NOAA_LAND_COVER_CHANGE_1996_TO_2010 | Raster |
| NOAA_Surge_MOM_Galveston_Bay | Polygon |
| NOAA_Surge_MOM_Matagorda_Bay | Polygon |
| NTAD_Raillines | Polyline |
| Occupational_Analysis\BlockGroups_OccupationAnalysis | Polygon |
| Occupational_Analysis\Counties_OccupationAnalysis | Polygon |
| Occupational_Analysis\Tracts_OccupationAnalysis | Polygon |
| Parcels | Polygon |
| Parcels_2014 | Polygon |
| Ped_Bike_Destinations_2010 | Point |
| Ped_Bike_Destinations_2014 | Point |
| Ped_Bike_Destinations_2017 | Point |
| POHA_Ship_Channel | Polygon |
| RGF_2014_Q3\Census_Tracts | Polygon |
| RGF_2014_Q3\Nine_SQM_Grid | Polygon |
| RGF_2014_Q3\One_SQM_Grid | Polygon |
| RGF_2014_Q3\Transportation_Analysis_Zones_2954 | Polygon |
| RGF_2014_Q3\Transportation_Analysis_Zones_5217 | Polygon |
| RGF_2014_Q4\Census_Tracts_1 | Polygon |
| RGF_2014_Q4\Nine_SQM_Grid_1 | Polygon |
| RGF_2014_Q4\One_SQM_Grid_1 | Polygon |
| RGF_2014_Q4\Transportation_Analysis_Zones_2954_1 | Polygon |
| RGF_2014_Q4\Transportation_Analysis_Zones_5217_1 | Polygon |
| RGF_2016\Forecast_Census_Tracts | Polygon |
| RGF_2016\Forecast_H3M | Polygon |
| RGF_2016\Forecast_TAZ2954 | Polygon |
| RGF_2016\Forecast_TAZ5217 | Polygon |
| RGF_2017\Current_Future_Land_Use | Polygon |
| RGF_2017\Forecast_Census_Tracts_2017 | Polygon |
| RGF_2017\Forecast_H3M_2017 | Polygon |
| RGF_2017\Forecast_TAZ5217_2017 | Polygon |
| RGF_2018\Announced_Changes_v2018 | Polygon |
| RGF_2018\Forecast_Census_Tracts_v2018 | Polygon |
| RGF_2018\Forecast_H3M_v2018 | Polygon |
| RGF_2018\Forecast_TAZ5217_v2018 | Polygon |
| RGF_2018\Model_Predictions_v2018 | Polygon |
| RGF_2018\Parcel_Land_Use_2045_v2018 | Polygon |
| RGF_2018\Parcel_Land_Use_current_v2018 | Polygon |

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|---|---|
| SEM_User_Input_Point | Point |
| SEM_User_Input_Polygon | Polygon |
| SEM_User_Input_Polyline | Polyline |
| Solid_Waste\Closed_Landfill_Inventory | Point |
| Solid_Waste\HHW_Centers | Point |
| Solid_Waste\Landfill_Areas | Polygon |
| Solid_Waste\Landfills | Point |
| Solid_Waste\Recycling_and_HHW_Centers | Point |
| Solid_Waste\Recycling_Centers | Point |
| STARMap\HGAC_StarMap_Addresses | Point |
| STARMap\HGAC_StarMap_Centerlines | Polyline |
| STARMap\HGAC_StarMap_ZipCodes | Polygon |
| Strava_Bike_Usage | Polyline |
| TCEQ_Regions | Polygon |
| TEA_Education_Service_Regions | Polygon |
| TEA_School_Districts_2015 | Polygon |
| TEA_Schools_2015 | Point |
| Texas_Area_Codes | Polygon |
| Texas_Coastal_Bathymetry | Point |
| Texas_Coastal_Vignette | Polygon |
| Texas_Coastal_Zone_Boundary | Polygon |
| Texas_Coastline_Boundary | Polygon |
| Texas_COG_Boundaries | Polygon |
| Texas_Counties_Coastline | Polygon |
| Texas_Counties_Political | Polygon |
| Texas_Groundwater_Conservation_Districts | Polygon |
| Texas_Highways | Polyline |
| Texas_Hurricane_Evacuation_Routes | Polyline |
| Texas_Impairment_Streams_2008 | Polyline |
| Texas_Impairment_Waterbodies_2008 | Polygon |
| Texas_Major_Aquifers | Polygon |
| Texas_Major_Rivers | Polyline |
| Texas_Map_Extent | Polygon |
| Texas_Minor_Aquifers | Polygon |
| Texas_National_Forests | Polygon |
| Texas_National_Parks | Polygon |
| Texas_Natural_Regions | Polygon |
| Texas_Political_Boundary | Polygon |
| Texas_Senate_Board_of_Education_Districts | Polygon |
| Texas_Stream_Team_Monitoring_Sites_2016 | Point |

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|---|---|
| Texas_Stream_Team_Monitoring_Sites_2018 | Point |
| Texas_Surface_Water_Rights_Diversion | Point |
| TEXAS_TERRAIN_COLOR_MAP | Raster |
| Texas_Zip_Codes_2005 | Polygon |
| The_Woodlands_Pathways | Polyline |
| TMDL_Watersheds | Polygon |
| TPW_State_Parks | Polygon |
| TPWD_13_County_LWRCRP_conservation_and_recreation_lands | Polygon |
| TxDOT_Highway_Milemarkers | Point |
| TxDOT_State_House_Districts_2018 | Polygon |
| TxDOT_State_Senate_Districts_2018 | Polygon |
| TxDOT_US_House_Districts_2018 | Polygon |
| US_State_Boundaries | Polygon |
| USCB_ACS_2016_5Yr_Block_Groups | Polygon |
| USCB_ACS_2016_5Yr_Counties | Polygon |
| USCB_ACS_2016_5Yr_Places | Polygon |
| USCB_ACS_2016_5Yr_Tracts | Polygon |
| USCB_ACS_2016_5Yr_Zip_Codes | Polygon |
| USCB_BlockGroups_1990 | Polygon |
| USCB_BlockGroups_2000 | Polygon |
| USCB_BlockGroups_2010 | Polygon |
| USCB_Blocks_2000 | Polygon |
| USCB_Blocks_2010 | Polygon |
| USCB_Metropolitan_Statistical_Area | Polygon |
| USCB_Places_2000 | Polygon |
| USCB_Places_2000_Pts | Point |
| USCB_Places_2010 | Polygon |
| USCB_Places_2010_Pts | Point |
| USCB_PSAP_Prep_CDPs_and_Cities | Polygon |
| USCB_PSAP_Prep_Tracts | Polygon |
| USCB_School_Districts_2010 | Polygon |
| USCB_Texas_113th_Congressional_Districts | Polygon |
| USCB_Texas_Census_BlockGroups_1990 | Polygon |
| USCB_Texas_Census_BlockGroups_2000 | Polygon |
| USCB_Texas_Census_BlockGroups_2010 | Polygon |
| USCB_Texas_Census_Blocks_2000 | Polygon |
| USCB_Texas_Census_Blocks_2010 | Polygon |
| USCB_Texas_Census_School_Districts_2010 | Polygon |
| USCB_Texas_Census_Tracts_1990 | Polygon |
| USCB_Texas_Census_Tracts_2000 | Polygon |
| USCB_Texas_Census_Tracts_2010 | Polygon |

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|---|---|
| USCB_Texas_Census_Urban_Areas_2009 | Polygon |
| USCB_Texas_State_House_Districts_2012 | Polygon |
| USCB_Texas_State_Senate_Districts_2012 | Polygon |
| USCB_Tracts_1970 | Polygon |
| USCB_Tracts_1980 | Polygon |
| USCB_Tracts_1990 | Polygon |
| USCB_Tracts_2000 | Polygon |
| USCB_Tracts_2010 | Polygon |
| USCB_Urban_Areas_1990 | Polygon |
| USCB_Urban_Areas_2000 | Polygon |
| USCB_Urban_Areas_2009 | Polygon |
| USCB_Urban_Areas_2010 | Polygon |
| USCB_Zip_Codes_2010 | Polygon |
| USFWS_15_County_Wetlands_2018 | Polygon |
| USFWS_Wetlands_2009 | Polygon |
| USFWS_Wetlands_2010 | Polygon |
| USFWS_Wetlands_2011 | Polygon |
| USFWS_Wetlands_2012 | Polygon |
| USGS_15_Minute_Quad | Polygon |
| USGS_24K_Quad | Polygon |
| USGS_DEM_10M | Raster |
| USGS_DOQQ_Grid | Polygon |
| USGS_HUC_10_Watersheds | Polygon |
| USGS_HUC_12_Sub_Watersheds | Polygon |
| USGS_HUC_6_Basins | Polygon |
| USGS_HUC_8_Sub_Basins | Polygon |
| USGS_River_Basins | Polygon |
| USGS_Stream_Gauges_2009 | Point |
| USGS_Stream_Gauges_2010 | Point |
| USGS_Stream_Gauges_2012 | Point |
| USGS_Stream_Gauges_2017 | Point |
| Walker_County_Commissioner_Precincts | Polygon |
| Waller_County_Commissioner_Precincts | Polygon |
| Wharton_County_Commissioner_Precincts | Polygon |
| World_Country_Boundaries | Polygon |

**C&E NON-SPATIAL DATA**
Ambient Surface Water Quality Monitoring
Wastewater Self-reporting Data
Parcel-Based Land Use, Attributes, and Valuation (9 counties)
Census Data

**APPENDIX E.6 DATA DICTIONARY**

| **Data Dictionary**<br>**Houston-Galveston Area Council**<br>**Community and Environmental Planning Department** |
|---|

| **General Information** | | |
|---|---|---|
| Thematic Layer Name | | |
| Feature Class | | |
| Topology | | |
| Table Name | | |
| Data Source | | |
| Report Prepared by | | |
| Phone | Fax | E-Mail |

| **Attribute Table** | | | | |
|---|---|---|---|---|
| | | | | |
| Variable | Begin Column | Item Name | Alternate Name | Item Definition |
| | | | | |
| | | | | |
| | | | | |
| | | | | |

| **Data History** |
|---|
| Source Agency |
| Originating Date |
| Originating Scale |

| **Status Information** |
|---|
| Percentage Complete |
| Planned Completion Date |
| Geographic Extent |
| Planned Enhancements |
| Known problems or limitations |

| **Maintenance Information** |
|---|
| Maintaining Office/Division/Section |
| Contact Name |
| Contact Telephone Number |
| Type of updates performed |
| Frequency of Updates |

| **Data Format Information** |
|---|
| |
| Data Format |
| Software/Version |
| Number of features/records |

| Total File Size |
|---|

| **Projection** |
|---|
| Geographic Projection: |
| Spheroid: |
| Zone: |
| Datum: |
| Units: |
| Fips Zone: |
| Quadrant: |
| X Shift: |
| Y Shift: |
| 1st Standard Parallel: |
| 2nd Standard Parallel: |
| Central Meridian: |
| Lat. of Projection Origin: |
| False Easting: |
| False Northing: |

| **Additional Documentation** |
|---|
| Quality Assurance Quality Control |
| Attribute Reports Available |
| Additional Documentation Available |

## APPENDIX E.7 H-GAC GIS DATA AND MAPPING APPLICATIONS