QUALITY ASSURANCE PROJECT PLAN (QAPP)

Pre-Implementation Stormwater Volume Monitoring for Large Scale Low Impact Development Implementation

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Prepared for:
District Department of the Environment

Prepared by:
Friends of Rock Creek's Environment (FORCE)
LimnoTech

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1. PROJECT MANAGEMENT

This Quality Assurance Project Plan has been prepared to address quality assurance issues related to tasks in Grant Agreement 10G-10-NFWF-WPD04, *Friends of Rock Creek's Environment Pre-Implementation Stormwater Volume Monitoring for Large Scale Low Impact Development Implementation.* This Grant was issued by the District of Columbia Department of the Environment (DDOE) to Friends of Rock Creek's Environment (FORCE). FORCE has in turn subcontracted with LimnoTech to provide technical services under this agreement. LimnoTech has subcontracted with ADS to provide the sewer monitoring devices and to maintain the devices during the course of the project.

1.1 Distribution

This document will be distributed to the following DDOE, FORCE, LimnoTech, and ADS staff involved in the project.

Table 1 QAPP Distribution List

John Wasiutynski *DDOE Grant Manager*	District Department of the Environment 1200 1st Street, NE 6th floor Washington, DC 20002 202-535-1844 (voice) 202-535-1373 (fax)
Brian Busiek, P.E. *LimnoTech Project Manager*	LimnoTech 1705 DeSales St, NW Suite 600 Washington, DC 20036 202-833-9140 (voice) 202-833-9094 (fax)
Ryan O'Banion *LimnoTech Technical Staff*	LimnoTech 1705 DeSales St, NW Suite 600 Washington, DC 20036 202-833-9140 (voice) 202-833-9094 (fax)
Brad Udvardy, P.E. *LimnoTech Technical Staff*	LimnoTech 1705 DeSales St, NW Suite 600 Washington, DC 20036 202-833-9140 (voice) 202-833-9094 (fax)
Kraig Moodie *ADS Project Manager*	ADS Environmental Services LLC 443-250-8583

1.2 Project/Task Organization

The key individuals for ensuring that the project work meets all QA and QC objectives are **John Wasiutynski** from DDOE; **Brian Busiek**, **Ryan O'Banion and Brad Udvardy** from LimnoTech; and **Kraig Moodie** from ADS.

DDOE QA/QC Responsibilities
John Wasiutynski will provide the overall project oversight as the DDOE Grant Manager. He will be responsible for the review and final approval of all deliverables. Mr. Wasiutynski's responsibilities include reviewing and approving the project work plan and QAPP, and reviewing and approving all contractor deliverables.

FORCE QA/QC Responsibilities
FORCE will not have responsibility for QA/QC during this project

LimnoTech QA/QC Responsibilities
Brian Busiek is the Project Manager for LimnoTech. Mr. Busiek will be responsible for implementing the QAPP during the project and for reviewing all deliverables. He will also manage ADS, who will be subcontracted to install and maintain the flow monitoring equipment. **Ryan O'Banion** and **Brad Udvardy** have been assigned as technical staff to this project. They will be responsible for collecting and reviewing the data; ensuring that it is complete, reasonable, and usable for the project; evaluating potential data collection and/or transmission problems; identifying fixes for any data problems; and documenting all data collection, storage, manipulation, and evaluation methods and QA/QC procedures in the project final report.

ADS QA/QC Responsibilities
Kraig Moodie from ADS will be the Project Lead for ADS. Mr. Moodie will be responsible for properly installing and maintaining the flow meters, including ensuring that they are calibrated properly and that the data is transmitted as required. ADS has its own QAPP for these procedures, and Mr. Moodie will ensure that this QAPP is implemented during this project. ADS' QAPP is included as an attachment to this document and is included herein by reference.

1.3 Problem Definition/Background

This project consists of five tasks:

1. Prepare a QAPP

2. Site and install monitoring stations in four sewersheds

3. Collect stormwater monitoring and rainfall data

4. Maintain monitoring equipment

5. Report on work and results

The goal of these tasks is to collect data on rainfall and flow in the selected sewers to allow a determination of the baseline relationship between the amount of rainfall and the runoff generated at that location.

In order to establish this relationship, specific steps must be taken. These steps are summarized below:

1. **Determine the sewersheds to be monitored**. The sewersheds to be monitored must be chosen so as to meet the goals of the study. The demonstration sewersheds must be able to accommodate the installation of low impact development (LID) techniques and practices. The control sewershed must be similar to at least one of the demonstration sewersheds in terms of surface and subsurface characteristics so that it will provide a good comparison to the demonstration sewersheds. All sewersheds must be within close proximity to a rain gage so that rainfall can be estimated for the sewersheds.

2. **Identify the specific locations within the sewersheds to install flow monitoring devices**. The sewer monitoring devices must be installed at a location within the pipe that allows an accurate estimate of the impervious area served by the pipe at that monitoring location, as well as the volume of flow coming in from upstream of the monitoring location (if any).

3. **Install and calibrate flow monitoring devices**. The flow monitoring devices must be installed and calibrated so that data generated from the devices can be converted into accurate estimates of flow in the pipe.

4. **Establish data transmission system**. The data from the flow monitoring devices must be stored and transmitted accurately to ensure that no data is lost.

5. **Maintain flow monitors**. The sewer monitoring devices must be maintained on a regular basis to ensure that they retain accurate calibration and that they are collecting a complete and accurate record of the flow through the pipe.

6. **Collect flow data**. Complete and accurate flow data must be collected from each flow monitoring device to establish the flow in the pipe that corresponds to the rainfall data from that location.

7. **Collect rainfall data**. Complete and accurate rainfall data must be collected from each location to establish the rainfall that corresponds to the flow in the sewer pipe from that location.

8. **Analyze the data to establish the baseline relationship between the amount of rainfall and the runoff generated at that location**. Accurate calculations must be used to convert the meter measurements into flow values. Subsequently, appropriate analytical and/or comparative methods must be used to establish the relationship of observed rainfall to observed flow in the pipe for each monitoring location.

1.4 Project/Task Description

This section describes how data can be used to solve the problems, make the decisions, or achieve the necessary outcomes that were presented in Section 1.3. The goals are to specify the types of data that may be used in key components of the project; provide an overview of how candidate potential data sources will be identified; and provide an overview of the criteria for accepting data for use in the study, with their intended uses and any special needs (*i.e.*, personnel, hardware/software) associated with accessing and working with these data.

The key data components for each task are discussed below.

1. **Determine the sewersheds to be monitored**. While the overall nature of this task is subjective and relies on best professional judgment, the task does require data on the surface and subsurface characteristics of the potential monitoring stations. This data will come from geographic information system (GIS) data layers and sewer maps and models. These data will be accessed from various District of Columbia government sources and/or internal LimnoTech data. The sewersheds will also be evaluated during site visits to ensure that they meet the project objectives.

   Because the objectives of this task are subjective, there is not a need to perform QA/QC on this task or on any data collected during, or used in, the task.

2. **Identify the specific locations within the sewersheds to install flow monitoring devices**. The objective of this task is to identify specific locations in the sewersheds where metering devices can be installed to record accurate data that is representative of the runoff generated in that sewershed. Data on the various inputs to the sewer system (*i.e.*, upstream flows, inflows from storm drains and other inlets, etc.) will be collected from the same information sources as in Task 1 above. In addition, the exact locations of the flow meters will be determined during their installation in Task 3, and the meters will be calibrated to reflect the flows at their specific location.

   As with Task 1, the overall nature of this task is subjective and relies on best professional judgment. Therefore, there is not a need to perform QA/QC on this task or on any data collected during, or used in, the task.

3. **Install and calibrate flow monitoring devices**. The objective of this task is to install and calibrate the meters to reflect the flows at their specific location. LimnoTech's subcontractor ADS is responsible for installing and calibrating the flow meters. ADS has a QAPP for meter calibration, and that QAPP is incorporated herein by reference. This QAPP is provided in Attachments A and B.

   LimnoTech will review ADS's QAPP to ensure that it covers all required topics and that it is integrated properly into the overall QAPP for the project. There will be no need for additional QA/QC on this task.

4. **Establish data transmission system**. The objective of this task is to ensure that data from the flow meters is transmitted accurately and consistently from the field into a data storage system at LimnoTech. LimnoTech's subcontractor ADS is responsible for setting up the data transmission system. ADS has a QAPP for this transmission system, and that QAPP is incorporated herein by reference. This QAPP is provided in Attachments A and B.

   LimnoTech will check the connection from the flow meters to the data storage system on a daily basis. If problems are encountered (*e.g.*, no connection; missing data), LimnoTech will contact ADS to investigate and rectify the problem.

5. **Maintain flow monitors**. The objective of this task is to maintain the flow meters to ensure that they continue collecting accurate information during the life of the project. LimnoTech's subcontractor ADS is responsible for maintaining the flow meters. ADS has a standard QAPP that includes maintenance protocols, and that QAPP is incorporated herein by reference. This QAPP is provided in Attachments A and B.

   LimnoTech will review ADS's QAPP to ensure that it covers all required topics and that it is integrated properly into the overall QAPP for the project. There will be no need for additional QA/QC on this task.

6. **Collect flow data**. Complete and accurate flow data must be collected from each monitoring device to establish the flow in the pipe that corresponds to the rainfall data from that location. This is a critical step in the project because analysis of the flow data is the sole method through which the project objectives are achieved. Therefore, it is of utmost importance to ensure that the data are meeting objectives by performing various QA/QC evaluations on the data at various points as it is collected.

   The data collected will include all primary data as well as the calculated flow. This will include recording multiple velocities, signal gains, fault conditions, and primary and secondary depths. Recording of primary data makes it possible to identify and debug problems as they occur and often allows "bad" data to be recovered and corrected when a problem is found.

   Remote data collection via a wireless modem will be performed on a continuous basis. Logged data will be collected periodically through regular site visits. Collected data will undergo a basic screening at the time of collection, with a more comprehensive data review to be performed on a biweekly basis. The review will include the components described below.

   <u>QA/QC at the Time of Data Collection:</u>

   - *Screening of data for meter down time*. This involves a check of the data for a "no signal" condition from the meter or negative, zero, or maximum span flow values where such values are unreasonable.

- *Data plotting*. This involves developing weekly plots of primary data and calculated flow to note trends, negatives, zeros, etc.

Bi-weekly QA/QC:

- *Cross-comparison with rainfall records.* Collected rainfall data will be used to identify periods when flows are likely to be affected by rainwater collection in combined systems, or infiltration/inflow in separated systems.

- *Comparison with previous data.* After a reasonably long record of data has been established, an average dry weather flow line can be calculated which can be used to perform a "reasonableness" check on current flow data, and to identify trends in data.

- *Review of calibration data.* Review results of field calibrations and make changes to predicted flows as necessary to reflect current calibration results.

- *Data Plotting*. LimnoTech will prepare monthly plots of calculated flows and will compare the month's flows with previous averages and rainfall events.

Other data checks may be included to verify the quality of primary data being used to calculate flow. This will include comparison of primary and secondary levels to screen for large (> 5%) discrepancies, checks for the reasonableness of velocity data, and screening for unacceptable levels of other diagnostic parameters (*e.g.* gains for ultrasonic transit-time transducers). ADS and LimnoTech will be jointly responsible for the real-time and bi-weekly QA/QC.

7. **Collect rainfall data**. The objective of this task is to collect accurate rainfall data that can be used to help establish a rainfall/flow relationship for each sewershed. LimnoTech will install and maintain the rain gauges. LimnoTech will coordinate with DDOE to identify locations for installation of the rain gauges.

   LimnoTech will use tipping bucket rainfall gauges outfitted with data collection software. During the initial installation, LimnoTech will calibrate the rain gauges by filling them with known amounts of water and ensuring that the readings are accurate. LimnoTech will monitor rainfall data during the course of the project to ensure it is of acceptable quality. Rainfall data will be collected twice per month by manually downloading data from the data collection software. The data will be checked to ensure that it is being collected comprehensively and accurately. The check will including ensuring that data are being reported and that they appear to be "reasonable" (*e.g.*, that no rainfall was reported if it did not rain on that specific day, or that rainfall totals appear to be in line with the prevailing weather). Rainfall will be also checked for accuracy using one or more potential data checking methods, including empirical comparisons with weather data and rainfall totals from published sources and comparison with other rain gages.

8. **Analyze the data to establish the baseline relationship between the amount of rainfall and the runoff generated at that location**. The objective of this task is to

evaluate the flow monitoring and rainfall data, determine its usability, and then determine a relationship between rainfall and flow.

Determining the usability of the flow and rainfall data is a critical step in this project. While LimnoTech and its subcontractor ADS have designed the data collection process to minimize potential problems with the accurate collection of flow and rainfall data, data gaps and/or inaccurate measurements may still occur. LimnoTech staff will evaluate all flow and rainfall data to determine its usability prior to using the data for any subsequent analyses. There are no specific criteria for these data, but LimnoTech staff will evaluate all data and use their best professional judgment to determine its usability. LimnoTech professional staff are highly familiar with these types of data, and they have a number of different data checks and methods for evaluating the data that they could employ to support the decision-making process.

All evaluations of data usability will be thoroughly documented in the project report. Once the usability of the data is established, LimnoTech will use statistical and graphical tools to establish the relationship between rainfall and runoff at each location. Similarly to the evaluation of data usability, there are no specific criteria for determining the strength of the relationship between rainfall and runoff. LimnoTech staff will use best professional judgment based on tools such as regression analysis, data plots, etc. to determine this relationship. LimnoTech professional staff are highly familiar using these types of data to establish rainfall/runoff relationships. All methods and procedures used to develop the rainfall/runoff relationships will be thoroughly documented in the project report so as to make them transparent and reproducible.

Accurate calculations must be used to convert the meter measurements into flow values. Subsequently, appropriate analytical and/or comparative methods must be used to establish the relationship of observed rainfall to observed flow in the pipe for each monitoring location.

1.5 Quality Objectives and Criteria

The QA/QC goals for this project are

- *Accuracy*—all data will be collected in a manner to ensure the highest level of accuracy. Data collection devices will be calibrated and maintained on a regular basis.

- *Completeness*—all data will be checked to ensure completeness. Specifically, flow metering data will be checked on a daily basis to ensure that it is being transmitted from the monitoring devices. Rain gage data will be checked on a regular basis.

- *Thoroughness*—all elements of the study will be carried out and documented in a thorough manner.

- *Consistency*—all work will be performed and documented in a consistent manner.

- *Transparency*—the documentation will make it clear the sources of the data used, the assumptions used, and the results obtained.

There are no specific acceptance criteria for any of the data used in these tasks. All data will be evaluated to determine its usability, and all data collection methods, QA/QC processes, and decisions on data usability will be documented in the final project report.

The flow monitoring data has the highest probability of potential data problems. While there are no specific data acceptance criteria for these data, all of these data are inspected for logical errors or omissions. As discussed above, any evaluations or decisions on the usability of these data will be recorded in the project report.

1.6 Special Training/Certification

Pertinent QA/QC issues are identified on a project basis and periodically reviewed as required. The project is also audited by LimnoTech's Contracts Administrator.
This project will be performed by engineering and scientific staff with technical backgrounds and experience in the collection and evaluation of flow and rainfall monitoring data. LimnoTech's Project Manager, Brian Busiek, is a Professional Engineer certified in the District of Columbia.

ADS' training and certification is discussed in their QAPP (Attachments A and B).

1.7 Documentation and Records

All data collection, evaluation, and QA/QC activities completed as part of this project will be summarized in a final project report. This report will discuss data collection and evaluation methods, QA/QC procedures performed throughout the project, the quality of the data collected, and the impact of data quality on the project objectives. The report will also include a description of the types of project records that were maintained and the project documents that were prepared. In addition, any problems or issues with data collection or quality will be noted in the Monthly Progress Reports.

The Project Manager will document and maintain records of all data analyses and evaluations. Electronic records will be stored in a file structure that can be easily identified and accessed. Computers will be backed up in accordance with a routine schedule and computer files will be archived at an off site location, beyond the expected date of completion of the project. Copies of all records and documents relevant to the project will be sent to the DDOE Project Manager at the completion of the project. These records will include:

- Contract and technical project information

- QAPP
- Results of QA/QC procedures

If any change(s) in this QAPP are required during the study, a memo will be sent to each person on the distribution list describing the change(s), following approval by the DDOE Project Manager. The memos will be attached to the QAPP. Deviations from planned procedures will be documented and corrective measures implemented.

2. DATA ACQUISITION

2.1 Direct Measurements

LimnoTech will collect direct measurements of flow for use in this project. LimnoTech and its subcontractor ADS are directly responsible for setting up and maintaining the flow meters used to collect flow data, and therefore LimnoTech has direct control over the quality of these data.

2.2 Indirect Measurements

LimnoTech will not collect indirect/secondary data for use in this project.

2.3 Data Management

Data for this project will consist of flow and rainfall data generated from direct monitoring devices. These devices will log these data electronically on their own internal memories. Data will be transmitted directly from the monitoring devices to the LimnoTech computer system via wireless modem. The data will then be loaded into a Microsoft Access database designed specifically for this project. The Access database will have a structure and internal data validation procedures to assist in identifying any data problems as the data are loaded. The Access database will be thoroughly documented through identification of data tables and data fields. Data will be extracted from the database to perform evaluations to establish the relationship between rainfall and flow.

There is redundancy built into this data storage method. Data will be stored on both the data collection device and in a central data depository on LimnoTech's computer server. If any data are lost from the LimnoTech server, they can be re-loaded from the original data collection device. In addition, LimnoTech's server is backed up into an archived file on a regular basis.

Data management methods, including methods for collecting, storing, and using data during this project, will be documented in the project report.

3. ASSESSMENT AND OVERSIGHT

LimnoTech will include information about data QA/QC issues in the Monthly Progress Reports so the DDOE Project Manager will be well-informed of on-going QA/QC activities. The DDOE Project Manager will schedule meetings/teleconferences as necessary to discuss QA/QC issues on the project. The purpose of these meetings/calls will be to monitor that the procedures outlined herein are being adhered to.

3.1 Assessments and Response Actions

The primary objective of the tasks being conducted under this project is to collect accurate flow and rainfall information from multiple sewersheds to provide data to allow a determination of the baseline relationship between the amount of rainfall and the runoff generated at that location. LimnoTech will be performing regular QA/QC on the flow data as it is collected to evaluate its ability to meet the project objectives. These QA/QC checks will include evaluations of the completeness and accuracy of the data. LimnoTech will perform similar QA/QC checks on the rainfall data. If problems are detected in the flow data through the QA/QC checks, corrective actions will be taken to rectify the issues. Potential corrective actions for the flow monitoring data may include recalibrating or replacing meters; moving meters to different locations within the sewershed, adding additional meters, or performing other fixes, as appropriate, to ensure accurate collection of data. Potential corrective actions for the rainfall may include replacing gages; moving gages to different locations; or performing other fixes, as appropriate, to ensure accurate data collection.

The methods used to establish the baseline relationship between the amount of rainfall and the runoff generated at a location will be based on graphical representations of the data and the development of mathematical representations of the data (such as relationship curves). Methods for establishing these relationships will be explained fully in the text of the project report. The report will also include an assessment of the quality of the data and its usefulness/validity for use in meeting the project objectives.

3.2 Reports to Management

There are no reports to management which are required to address QA/QC on these tasks.

4. DATA VALIDATION AND USABILITY

4.1 Data Review, Verification and Validation

All data used in this project will be collected directly by LimnoTech and its subcontractor ADS. Therefore, there is no need to verify data coming from exterior data sources. Our methods for reviewing directly-collected data are discussed in detail above and will be documented in the project report. Because our staff will use their best professional judgment to evaluate the usability of all data, there is no need to specifically validate data for this project.

4.2 Verification and Validation Methods

No statistical procedures are used to verify or validate data used in these tasks. As discussed in the sections above, LimnoTech staff will use their best professional judgment to evaluate the usability of data, but there is no specific need to validate the data using statistical or other procedures.

4.3 Reconciliation with User Requirements

The data used for each of these tasks are adequate to fulfill the task's requirements. The project has been designed to include direct collection of data designed to meet the requirements of the project objectives. LimnoTech will also perform QA/QC on the data as it is collected to ensure that it will meet user requirements, and any data collection deficiencies can be corrected throughout the life of the project to ensure that the data meets user requirements.

5. REFERENCES

None.

ATTACHMENTS

Attachment A – ADS Quality Assurance Project Plan
Attachment B – ADS Data Analysis Work Instruction

ATTACHMENT A
ADS QUALITY ASSURANCE PROJECT PLAN

1. Scope of Work

ADS will support LimnoTech in performing flow monitoring in four sewersheds in Washington, DC. ADS will install, calibrate, and maintain flow monitors in all four sewersheds, and will report data to LimnoTech for their use in calculating flow in the sewers. ADS will also perform quality assurance and quality control during the project to ensure that comprehensive, accurate data is produced.

2. Safety Plan

ADS has an integrated, comprehensive safety process that is part of everything we do in the field and in the office. The safety process encompasses training, audits, equipment and procedures, and ensures compliance with federal, state and local requirements. Training includes confined space entry certification, personal protective equipment, bloodborne pathogens, gas meter operation, hazard communication, defensive driving, and first aid/CPR. Field personnel receive a comprehensive physical examination biannually. Audits are performed routinely and any non conformance is corrected immediately. ADS is very proud of its safety record, which has led to an Insurance Experience Modification Rating (EMR) below 0.75 and a BLS injury rate consistently lower than industry standards.

References for ADS field personnel include our internal Field Safety Manual and a project safety management notebook. In addition, all project personnel will be specifically trained in any special local requirements. Each field crew carries all necessary communications, safety and traffic control equipment. All rigging used for confined space entry and non-entry retrieval meets or exceeds OSHA specifications.

3. Site Investigations

The ADS Team will analyze the flow meter installation sites for suitability, and will document each site investigation with a Site Investigation Report. We will evaluate and record:

- Traffic and access safety and conditions, “locked gate/key” status
- Manhole entry and physical safety conditions and structure physical condition, special seasonal/weather requirements
- Atmosphere hazards
- GPS coordinates (cross-check with scouting report)
- Suitability for wireless communication
- Verify and catalog entering and exiting pipes, sizes, materials
- Acoustic noise, EMF noise impacts

- Evidence of surcharging
- Acquire images: local setting, top shot, influent view, effluent view
- Hydraulic conditions, including subcritical/supercritical flow, surging, standing waves, side-line flow, asymmetry, intermittent turbulence, root/debris interferences
- Pipe suitability for installations, including collapse, irregular or unacceptable pipe/channel configurations, grease clogging, hardened or packed grit in the invert
- Need for cleaning, root removal, both upstream and downstream
- Prepare a CADD sketch of manhole plan and profile, selected sensor arrangement and placement

Site Investigation Reports will summarize the inspection data and determine safety and hydraulic suitability, establishing whether the site is: acceptable; conditionally acceptable based on entry requirements, cleaning or sensor installation adaptations, or; unacceptable, alternative site required.

4. Monitoring Equipment

ADS has the most reliable sewer flow monitor in the industry for this application. The ADS flow monitoring technology currently incorporates 22 patents and/or patents pending, which provides the best possible results in sewer flow applications. The ADS Flowshark is the most advanced area velocity monitor available today and offers the following features and benefits:

- Stable and reliable system platform;
- Quad-redundant ultrasonic level sensor for reduced downtime and increased reliability;
- Low-profile digital doppler velocity and pressure sensors;
- Remote data collection via cellular communications package;
- Advanced Data processing Services for comprehensive and flexible reporting.

In addition to all of the enhanced capabilities outlined in the attached specification sheet, ADS developers have designed an exciting new technology into the latest ADS flow monitor

5. Flow Monitor Installation

Each installation will be performed based on the accepted Site Investigation Report and recommendations, and documented with an Installation Report. Specific installation issues to be addressed and documented in the Installation Report will include:

- Time/date, crew personnel identity, field computer, specific equipment requirements
- Re-acquired and recorded GPS coordinates at each field visit
- O_2/LEL meter readings, CSE permit and authorization
- Monitor and sensor type and serial numbers
- Ring install/special or direct mount details
- Site measurement vertical datum identification and description. This is usually crown of pipe for circular pipes, but may vary for odd-shaped or large pipes where access to conduit crown or invert is compromised
- Depth sensor placement, longitudinal and clock position, surcharge sensor type and mounting details and measurements from datum
- Velocity sensor placement, longitudinal and clock position
- Silt at time of installation
- All installation calibration parameters, hardware and software settings, offsets, coefficients, precision class of field measurements
- Hand-held velocity meter used serial number
- Velocity profile results
- Odd-irregular pipe cross section
- Pipe measurement confirmation

A digital Site sheet will be prepared and submitted within two weeks continuous data have been acquired, when all parameters have been finalized, and preliminary balancing issues have been identified and resolved.

6. Flow Monitor Calibration

The ADS Team will conduct field calibrations:

Ultrasonic (Primary) Depth - Depth calibration must be verified at both the low and high ends of the dry-weather depth range; this may require nighttime site visits for calibration at many sites. Vertical pipe diameter will be verified at each site entry. Indicated ultrasonic depth will be checked against field measurement made by field technician to a tolerance of ¼ inch. Silt depth will be verified at each site entry or monthly, whichever is more frequent. Sites with particular silt variances will be identified and flagged for frequent checking.

Doppler Velocity – Velocity will be verified with point velocity measurements using a hand-held magnetic velocity meter; the meter will be calibrated to zero by bucket test at beginning and end of each day, and as necessary during site visits when velocity instability is evidenced. Single point velocity measurements will be acquired for depths of flow less than 3 inches, with a four-point velocity profile for depths between 3 and 5 inches, and with a three-column velocity profile for depths greater than 5 inches. Average velocity established by these field measurements will be considered the standard average velocity, and velocity calibration parameters will be adjusted to rectify the monitor average velocity to the average field velocity.

Pressure (Secondary) Depth or Ultrasonic Surcharge – Flow depth greater than vertical pipe diameter will be measured by either vented pressure transducer or surcharge-mounted ultrasonic sensor. Depth measurements by primary and secondary devices will be recorded, compared and resolved. Any instances of persistent discrepancies between primary and secondary depth will be tracked, investigated and resolved by adjustments or replacements. Adaptive placements of secondary depth sensors are a frequent source of questionable depth data; they must be carefully documented in the installation and calibration process, and verified repeatedly.

7. Routine and Preventative Maintenance

ADS will conduct routine and preventative maintenance on the flow monitors on a weekly basis. The field manager will visit each location on a weekly basis and reconfirm that the monitor is in proper working condition. The field manager will also perform routine maintenance, which includes cleaning depth and velocity sensors, and checking the installation to make sure that the ring is secure in the pipe. The ADS data analyst will also review the collected data on a weekly basis throughout the monitoring period. During each data review, ADS will look for indications of sensor fouling, low battery voltage, sensor failure, sensor damage, data accuracy concerns and poor hydraulic performance at the site. If any of these conditions is identified, then the appropriate service task will be assigned and dispatched as soon as possible. Flow meters will also be recalibrated if necessary based on these data checks.

8. Data Review

Data will be reviewed each week upon collection. The scattergraph pattern will be compared against past weeks/months data, and potential problem sites passed along to the hydraulic engineers for immediate evaluation. A randomly-selected ten percent of “non-problem” sites will also be turned over. Hydraulic engineers will check the scattergraphs for shifts evidencing accumulating or dwindling silt, downstream obstructions evidencing cleaning needs, shifting velocity due to failing sensor, erratic depth due to failing pressure sensors or fouled ultrasonic sensors, “orbiting” due to upstream pump station changes. Hydrographs will be checked for agreement of redundant depth sensors, velocity spikes and dropouts, balance against upstream and downstream monitors. The hydraulic engineers will generate service orders for sensor or monitor replacement, or parameter adjustments, cross-check the schematic diagrams.

9. Data Collection, Processing and Reporting

All data will be collected through two separate systems by the ADS project team. The first system is manual data collection. Field crews will visit the monitoring locations on a weekly basis. The crews will collect and review depth and velocity data on-site to reduce the potential for data loss. Then in-house data analysts will review, edit and finalize the data using our desk top software Profile. The second system is automatic data collection. Raw data will be transmitted from the flow monitoring units and posted on ADS’ Intelliserve system. This system will allow for access by LimnoTech and other project team members as needed during the course of the project. In addition, ADS will post all edited and finalized data to the Intelliserve site on a monthly basis.

10. Data Analysis

ADS’s QA/QC for data analysis is provided in Attachment B.

ATTACHMENT B
DATA ANALYSIS WORK INSTRUCTION

Data Analysis Work Instruction

1.0 Purpose:

This work instruction describes how ADS field personnel and data analysts work together to prepare for projects, acquire data from flow meters, edit data, apply adjustments, calculate final flow quantities, and perform quality assurance on either long-term flow monitor installations or temporary flow monitoring projects.

2.0 Application:

2.1 Project managers have certain responsibilities to assure that data analysts understand project requirements. Project managers are ultimately responsible for the results of their projects in terms of cost, scope, schedule, and quality.

2.2 Field Managers are responsible for providing key inputs to data analysts and for assuring the proper operation of meters during a project.

2.3 Field Representatives are responsible for performing on-site activities such as collecting data and performing field confirmations.

2.4 Data analysts are responsible for gathering necessary inputs, setting up sites in ADS software, dealing with erroneous data, applying proper gains and offsets, and balancing sites.

2.5 The Data Analysis Trainer/QC Specialist is responsible for conducting data analyst audits upon **request** and forwarding the audit results to the Quality Manager.

3.0 General:

3.1 Inputs to the data finalization process:

- Sewer maps
- Contract
- Location information files (LIFs)
- Pipe tables
- Service records
- Contract deliverables list
- Schematics
- Site reports
- Meeting minutes
- Project notebook/Work Plan
- Daily reports
- Master List
- Site photographs
- Site visit records
- Raw flow data
- Site confirmations
- Rain gauge data
- Velocity profile data
- Velocity hardware logs
- Collect logs
- WWTP flow data
- Pump station flow data

3.2 All data processing will be performed in the ADS approved Analysis software unless software limits dictate otherwise.

3.3 The performance criteria for final data are the following:

3.3.1 All outliers will be flagged or reconstituted so that no outliers are contained in the final data. An outlier is a data point on a valid and repeatable Scattergraph that lies away from the overwhelming majority of the data and cannot be verified as a valid hydraulic occurrence. Outliers are indications of measurement error.

3.3.2 A valid confirmation is one that is within the field accuracy of a given depth measurement and average velocity is within two standard deviations of the final data set. Valid confirmations are defined in document 684003 Flow Meter Site Confirmations.

3.3.3 The flow monitor network should be in balance. That is, downstream sites should record more flows than upstream sites and the patterns of flow will be consistent with known hydraulic conditions, unless an outfall, overflow, or cross-connection structure is located between the upstream and downstream location.

4.0 Instructions:

4.1 The Data Analyst (DA) will gather all necessary inputs (see paragraph 3.1). It is the Project Manager and Field Manager's responsibility to provide the inputs. Necessary inputs should be provided within one week of first round data collects.

4.2 The DA will familiarize his/her self with the requirements of the project.

4.2.1 The DA will attend the external meeting unless it is economically impractical to travel to the location of the meeting. The DA will be copied on all minutes and/or notes of external kickoff meetings.

4.2.2 The DA will attend all internal kickoff meetings if possible. The DA will be copied on all minutes of internal kickoff meetings.

4.2.3 The Project Manager will provide a copy of the approved project Work Plan to the DA.

4.2.4 The Project Manager will provide a copy of, or access to, the contract.

4.3 The Field Manager (FM) will provide the DA with a schematic of the monitored sites and will provide access to system maps indicating delineation of basin or mini-systems, monitor locations, and rain gauge locations.

4.4 The DA will import Location Information Files (LIFs) into approved Analysis Software. The Field Manager is responsible for providing these files and for the accuracy of the data contained in the LIFs. The DA will review the LIFs against Site Reports and report any discrepancies to the Field Manager for clarification.

4.5 The DA will create pipe tables in approved Analysis Software with the Installation Generator module. For typical round pipes, the pipe tables will be imported from field computers and verified by the DA. For odd-shaped pipes, the DA will create the tables from construction drawings, if available, otherwise from field measurements. Once pipe tables are established, the DA must authorize any pipe changes made by field personnel.

4.6 The schematic must be entered upon receipt of the first collection of data or within one week of receipt from the Field Manager. It is the Field Manger's responsibility to provide a network schematic to the DA before the first round of data collects.

4.6.1 The DA will document in the Data Review Checklist or LDR and investigate all unusual net flow patterns, for example, patterns that are not diurnal in a residential area.

4.7 The DA will collect and review field logs. This requires the following:

4.7.1 The DA will review the crew Site Visit Logs as they become available.

4.7.2 The DA will compare field confirmation measurements to the instantaneous firings of the ADS meter.

4.7.3 The DA will calculate and record gains based on field confirmation measurements when atypical hydraulic conditions exist or meter data is not available.

4.7.4 The DA will review available field crew notes from the Site Visit logs and the dailies.

4.7.5 The DA will have access to the Daily Reports from the crew leaders. The FM will assure that the DA has copies of these reports or has unrestricted access to the reports.

4.7.6 The DA will have access to service records. On long-term meters, this means that the FM will provide copies of, or unrestricted access to, the service database.

4.8 The DA will consolidate flow and rain data.

4.8.1 Field Representatives are responsible for collecting temporary flow monitor and rain gauges at least once per week. Field Representatives must review the collected data using ADS SiteDr software immediately after the collection, while still at the monitoring site. If a hardware failure is detected in the on-site review, the Field Representative must repair or replace the equipment before leaving the site.

4.8.2 Field Managers are responsible for transmitting manually collected monitor and rain gauge data to the DA within 24 hours of collection.

4.8.3 Field Managers are responsible for transmitting the FM log within 48 hours of data collection.

4.8.4 Data Analysts must consolidate raw data into the central database within 72 working hours of receipt.

4.8.5 Long-term meters with installed telemetry must be collected at least twice per week.

4.9 The DA must review all data soon (no later than 4 days) after it is consolidated.

4.9.1 The DA will analyze data patterns using Hydrographs and Scattergraphs to assess if the patterns are consistent with functioning equipment and valid hydraulics. Reference material regarding valid Scattergraph patterns is available from the Data Analysis Trainer/QC specialist.

4.9.2 The DA will compare meter data to field confirmations. ADS will maintain two valid confirmations as defined in section 3.3.2 for each typical monitoring site.

4.9.3 The DA will analyze the correlation tables to determine that field confirmation readings are consistent with the meter readings taken nearest in time to the field readings.

4.9.4 The DA will flag field confirmation readings that are invalid as indicated by his/her analysis. The DA will inform the Field Manager if additional field confirmations are necessary in order to maintain two valid confirmations as defined in section 3.3.2 in flow regimes that are sustained for at least seven days.

4.9.5 The DA will specifically look for indications of malfunctioning equipment, weak batteries, and questionable changes in meter parameters.

4.9.6 The DA will prepare documentation of sites requiring further field service. The DA will give this documentation to the Field Manager. The Field Manager is responsible for the completion of the field service work indicated on the request.

4.10 The DA must create and maintain an archive of ALL raw data. This may be done in one of four ways. Intelliserve data is automatically backed up by redundant servers. Data not collected through Intelliserve can be exported from approved Analysis Software and then imported into a backup database. Temporary meter data (bin files) may be archived for re-processing. Long-term meter data may be backed up using approved analysis software redundant batch collects. Whatever method is chosen, there must always be a retrievable copy of the raw meter data, as it existed before it was edited.

4.11 The DA will edit depth data between rounds of data collects.

4.11.1 The DA will calibrate pressure depth when it is necessary. In meters running ADS' MLI software, this will usually be unnecessary, as the software will automatically calibrate pressure sensors.

4.11.2 The DA will create the DFINAL entity in approved Analysis software by choosing which raw depth entity(s) to use for the time period of the edit.

4.11.3 Interpolation over longer contiguous periods requires the approval of a Project Engineer, Senior Data Analyst, or person authorized by a Data Manager.

4.11.4 The DA will adjust surcharge depths to full pipe if necessary.

4.11.5 Silt levels should be entered based on consistent quantity of flow, and not based on the date and time of the silt measurement or the beginning of the month. It is sometimes hard to tell when the silt level changed so an average based on several measurements over time should be used if possible.

4.12 The DA will perform rough balancing no later than one week after the first round of data is received.

4.12.1 The DA will use a default gain of .90 to calculate VFINAL and ultimately QFINAL using the continuity equation.

4.12.2 The DA will document and investigate all significant negative net flows.

4.13 The DA will perform steps 4.6 through 4.12 above on a routine cycle until a data delivery is due. When a delivery is due, such as the end of a temporary flow monitoring project or a monthly submittal on a long-term service contract, the editing steps contained in 4.14 through 4.25 below will be performed.

4.14 The DA will determine and apply average to peak ratios.

4.14.1 In the absence of empirical average and peak velocity data, the DA will use a default ratio of .90.

4.14.2 The DA will use average to peak ratios calculated from field measurements when the resulting ratio is valid in Fieldscan and/or consistent with other field measurements.

4.14.3 Average to peak ratios less than 0.70 requires additional supporting field measurements. An average to peak ratio of more than 1.0 is not valid.

4.14.4 The presence of a net flow imbalance is not sufficient that the average to peak ratio needs adjustment. The DA will adjust the ratio to solve balancing problems only after a 2nd opinion from a Project Engineer, Senior Data Analyst, or person authorized by a Data Manager confirms that an average to peak ratio adjustment is defensible.

4.15 The DA will calculate and apply gains to velocity data.

4.15.1 The DA will use the average of gains automatically calculated in from valid confirmations (as defined in section 3.3.2) in the approved Analysis Software unless the conditions are highly variable. If conditions are highly variable, then gains calculated in approved Analysis software will be compared to gains manually calculated from site visit logs or site confirmation records.

The gain should not be changed based on one confirmation. Gain changes should be entered based on consistent quantity of flow, and not based on the time of the calibration or the beginning of the month.

4.15.2 If the gain calculated in approved Analysis software approved Analysis software is more than +/- .05 away from the manually calculated gains from site visit records, then the manually calculated gain will be applied.

4.15.3 If both the approved Analysis software calculation and the manual calculation are questionable or not available, then the DA will apply a gain which is equal to the average to peak ratio. If the average to peak ratio is questionable or not available then a default of .90 will be used.

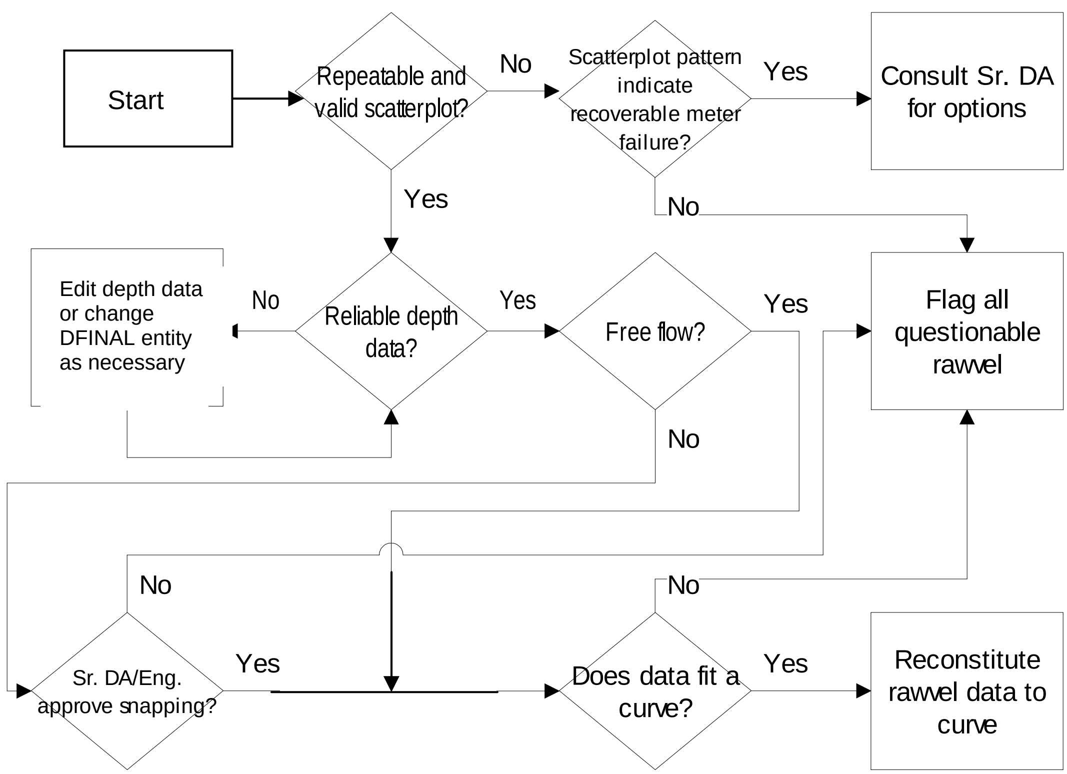
4.15.4 Gains greater than 1.20 or less than .70 must be documented with corroborating evidence showing the site peculiarities that would produce such unusual gains.

4.15.5 The presence of a net flow imbalance is not sufficient evidence that the gain needs adjustment. The DA will adjust the gain to solve balancing problems only after a 2nd opinion from a Project Engineer, Senior Data Analyst or person authorized by a Data Manager confirms that a gain adjustment is defensible.

4.16.6In cases or varying downstream hydraulics, SIMK tables may be considered. SIMK applies a varying average to peak ratio/velocity gain over a range of depths, based on varying hydraulic patterns.

4.16 The DA will review and update the DFINAL entity and depth offsets before editing RAW velocity data.

4.17 The DA will edit or flag data based on the following decision flowchart.



For long periods of depth downtime, curvefit can be used, but must be approved by a Project Engineer, Senior DA, or person authorized by a Data Manager.

4.18 The DA will calculate Manning's Hydraulic Coefficients (HC). This is accomplished in approved Analysis software software. Manning's formula will produce reliable flow quantities only under free flow conditions with no obstruction or "sag". Because of these limitations, the

DA will not pursue further confirmations to attempt to force-fit a Manning's curve to the data.

4.19 The DA will select final flow equations and calculate the QFINAL entity.

4.19.1 Whenever reliable velocity data exists, the DA will use the continuity equation to calculate flow quantities.

4.19.2 The Manning formula may be used to estimate flow quantities only when the continuity equation cannot be applied due to missing data, free flow conditions exist, and Manning's quantity can be reconciled to continuity quantity both before and after the period of missing data.

4.20 The DA will perform a final inspection of the data.

4.20.1 The DA will review at least the DFINAL, VFINAL, and QFINAL entities on a hydrograph for anomalies and consistency.

4.20.2 The DA will review a Scattergraph comparing the final depth and velocity entities, DFINAL and VFINAL that includes a plot of field confirmation measurements. At least two valid field measurements should lie within all final flow regimes.

4.20.3 For temporary metering projects, the final review will include all data for the monitoring period. For long-term projects, the review will encompass a rolling 3-month period of data. Data will be reviewed using Location Data Reviewer (LDR).

4.21 The DA will perform a final balance.

4.21.1 The DA will check for negative net flows. If negative net flows exist, the DA will troubleshoot the problem using any or all techniques contained in this procedure.

4.21.2 The DA will examine flow patterns. If upstream and downstream patterns are dissimilar, then the DA will investigate to either correct errors or document the conditions that justify the unusual flow patterns.

4.22 The DA will compare final flow data quantities (QFINAL) to other available sources of flow data such as treatment plant or pump station records. This independent data will be requested from the client during kickoff meetings. The DA will document all order of magnitude differences in independent data and provide this information to the engineer. The engineer will determine if this information will be included in the final report.

4.23 All final data and reports submitted by DAI level must be reviewed. A Data Manager may determine the necessity of review for DA level II and above, however data reviews for specific sites are required on the request of analysts at DA level II and above.

Reviews will follow the items specified in LDR and/or Data Review Checklist. Reviews may be conducted by Project Engineers, Senior Data Analysts, or persons authorized by Data Managers.

4.24 The DA will generate the final report for FlowView, if possible (FlowView does not handle some units of measure). The DA is responsible for ensuring the final report meets all requirements contained in the contract and work plan.

4.25 The DA will archive all data for future reference.

4.25.1 Data must be maintained for a minimum of five years.

4.25.2 All reports will be archived to a CD/DVD (2 copies). One copy will be stored at the corporate office and the 2nd off premises. An additional copy may be sent to the Regional office upon request. The Regional office copy may be provided by email, FTP upload or other approved means.

All LT flow data and temporary flow data (for studies exceeding 90 days), will be archived each quarter to a DVD or CD-ROM. The backup must be complete within 30 days of the end of the quarter.

At least 2 copies of the Project folder, containing raw data, final data, reports, schematics and site sheets along with other electronic information provided to the analyst will be copied to CD-ROM or DVD once a project is completed and the contract fulfilled. The analyst needs to verify we have these backup prior to removing the folder from the DA server. One copy will be stored in the corporate office and another off premises.

5.0 References:

QI-603206, Flow Meter Site Confirmations

QI-603207, Velocity Meter Maintenance

QI-603185, Pocket Guide: Flow Monitor Site Confirmation

QF-603209, Data Review Checklist

ADS ENVIRONMENTAL SERVICES

Quality Work Instruction

Data Analysis Work Instruction

ATTACHMENT Site Finalization Flowchart