River Instream Flow Stewards (RIFLS) Quality Assurance Project Plan

(Revised)

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Approval Page

River Instream Flow Stewards (RIFLS)
Massachusetts Department of Fish & Game, Division of Ecological Restoration

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2. Program Organization

Figure 1: Organizational Chart

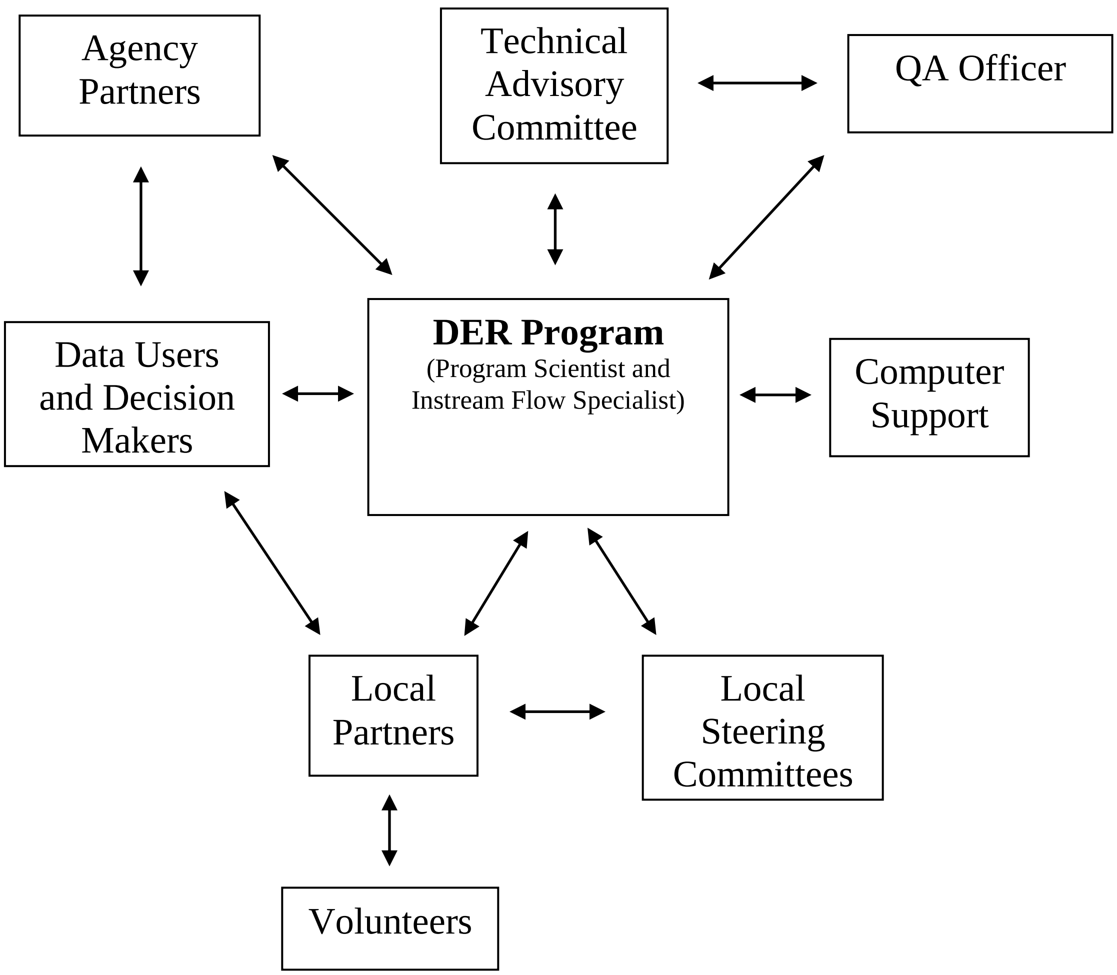


Table 1: Program Partners and Responsibilities

Title	Responsibilities
DER Program	Manage finances; develop project scopes; provide data clearinghouse; maintain website; coordinate with program partners; conduct technical fieldwork; review and analyze data; provide streamflow recommendations; and plan and implement projects to improve the ecological integrity of rivers, streams, and adjacent lands throughout Massachusetts.
Program Scientist (DER Program)	Direct all program activities; oversee development and evaluation of data quality objectives; oversees maintenance and purchase of equipment; coordinate technical advisory committee; facilitate the establishment of Local Steering Committees; serve as primary liaison with volunteer groups; develop, maintain, and distribute rating curves; facilitate action planning meetings and implementation efforts; train volunteers; and assume local partner's responsibilities (below) when no association or similar group is able to fulfill them.
Instream Flow Specialist(s) (DER Program)	Assist with all program activities; collect and evaluate field data; maintain equipment; install staff gages; participate in technical advisory committee meetings; facilitate the establishment of the Local Steering Committees; coordinate with volunteer groups; develop, maintain, and distribute rating curves; facilitate action planning meeting and implementation efforts; train volunteers; and assume local partner's responsibilities (below) when no association or similar group is able to fulfill them.
Technical Advisory Committee	Assist with development of program objectives, data quality objectives, and methods; oversee project assessment; facilitate implementation of action plans when possible; and use data and case studies to inform state water policies where appropriate.
QA Officer	Verify annually that data quality objectives have been met.
Agency Partners	Provide data describing biological, chemical, and physical condition of study rivers and streams; agree upon monitoring locations, develop monitoring and analytical methods, and exchange information.
Computer Support	Host RIFLS website and database; troubleshoot website and database problems; and coordinate with DER staff on upgrades to database and website as necessary.
Local Partner	Identify and manage volunteers; facilitate local steering committee activities; schedule training sessions; notify Program Scientist and Instream Flow Specialist of site conditions as necessary; manage and review volunteer data entry; submit data to website at specified intervals; coordinate action planning meetings; participate in developing restoration strategies; lead implementation efforts whenever possible; and serve as primary local contact.
Local Steering Committee	Assist Local Partner in developing the project study design and identifying volunteers; assist and guide volunteers and Local Partner in reporting findings; attend action planning meetings; participate in developing restoration strategies; and implement action plan recommendations.

Volunteers	Attend training session; record stream water level at specified time intervals; record and notify Local Partner and/or Program Scientist and Instream Flow Specialist of any pertinent changes or problems at the site; enter raw data at RIFLS website or provide to Local Partner; attend action planning meetings; participate in developing restoration strategies; and assist in implementing action plan recommendations.
Data Users and Decision Makers	Access and review water level and/or streamflow data, and monitoring site information via the RIFLS website or other means; consider the importance of natural flow regimes in maintaining and sustaining healthy rivers, streams, and adjacent lands; and incorporate streamflow considerations in natural resource decisions, such as land use planning and lake management guidance.

3. Introduction

The mission of the Massachusetts Division of Ecological Restoration ("DER") is to restore and protect the health and integrity of the Commonwealth's rivers, wetlands and watersheds for the benefit of people, fish and wildlife. DER operates on the belief that local action is the key to river protection, and works with local citizens, town officials, watershed-based groups, and other partners toward the shared goals of assessment, restoration, and protection of rivers and their ecosystems. DER provides training, technical assistance, publications, funding, and special programs to help achieve this mission.

Since 2003, DER has provided streamflow monitoring support to volunteers around Massachusetts through the River Instream Flow Stewards (RIFLS) program. The program is a natural extension of DER' other citizen-based monitoring programs such as Adopt-A-Stream and other volunteer-based water quality monitoring efforts. The RIFLS program collects streamflow data, evaluates flow and ecological conditions, assesses and promotes implementation of flow restoration strategies, informs local constituencies, and raises general awareness about streamflow issues in the Commonwealth. These tasks are essential components of river protection and support DER' core mission. A map of all RIFLS monitoring sites and table of volunteer groups is provided in Appendix A.

This Quality Assurance Project Plan (QAPP) was developed in consultation with the Massachusetts Guidebook to Quality Assurance Project Plans (MA DEP 2001). It is a revision of the original RIFLS QAPP (2003), which outlined a series of steps to be performed as part of the pilot phase of the program. At this time, all of those steps have been accomplished, the pilot phase has concluded, and the program has moved into an operational mode. Information concerning the conclusion of the pilot phase is presented Appendix B.

Changes made in this version of the QAPP:

- clarify the roles and responsibility of volunteers and staff in more detail;
- elaborate on data assessment procedures;
- provide a mechanism for dropping sites with insufficient volunteer involvement to accomplish the goals;
- introduce a phased approach to instream flow monitoring, assessment and restoration;
- update flow and discharge measurement equipment and procedures, including transfer of primary rating curve development from USGS to DER staff; and
- elaborate on the role of volunteer Certification Training.

These changes are discussed in greater detail below.

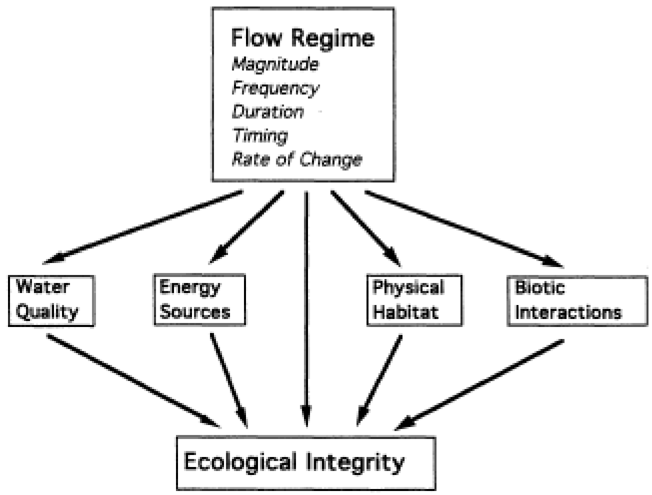
4. Problem Definition and Background

Over the last several decades there has been increasing interest in maintaining and restoring "natural flow regimes," or the volume and timing of streamflow that would be expected in rivers without significant human-induced impacts (Poff et al. 1997; Richter et al. 1996). Alteration of flow regimes is often regarded as the most serious threat to the ecological integrity of rivers, streams, and adjacent wetlands (Bunn and Arthington 2002). Watershed development rapidly alters the natural relationships between rainfall, runoff, storage, routing, and streamflow, which are drivers of channel formation and maintenance, habitat, water quality, and biological community structure. Furthermore, changes in the abiotic template and biological community structure may impair the ecological processes of streams and rivers, with important implications for the good and services (e.g. instream water purification) upon which human societies depend (Meyer 1997). Potential symptoms and consequences of human-induced changes to the natural flow regime include:

- Reduced base flows (i.e. flow that is sustained by groundwater inputs alone) that concentrate pollutants, increase temperatures, decrease dissolved oxygen concentrations, contribute to algal blooms, limit in-stream habitat, and cause river fragmentation.
- Reduced or increased flow variability that encourages the spread of invasive and nuisance species, and alters the density and diversity of native and desirable biota.
- Conversion of lotic to lentic habitat (i.e. impoundments) that creates conditions unfavorable to fluvial species of fish and encourages dominance by generalist species.
- Altered timing and magnitude of high and low flow periods that disrupt natural biological signals (e.g. spawning and migration cues) with significant impacts to species growth, reproduction, and distribution (McCully 1996).
- Increased magnitude and frequency of scouring, pollutant-laden high flows that cause geomorphic instability and reduce available habitat through channel simplification and loss of instream features.

For these and many other reasons, streamflow has been described as the "master variable" that regulates the ecological integrity of rivers and streams (Poff et al. 1997). While historical flow-related management or restoration has been somewhat limited in scope - focusing on only minimum flows - there is today almost universal acknowledgement that a full range of flow conditions with natural variability is key to river health. The figure below summarizes the key components of a flow regime and the relationship to key drivers of ecological integrity (Poff et al. 1997).

Figure 2: General Relationship between Flow Regime and Ecological Integrity



Concerns about changes to the natural flow regime in Massachusetts' highly valued water resources – and the associated negative consequences - have grown in recent years. Unsustainable water withdrawals, interbasin transfers, impoundments, centuries of watershed development and more recently, climate change, have significantly altered the hydrology and ecology of Massachusetts rivers and streams (MA DEM 2001; MA DER Program 2002). In response to these concerns, the Massachusetts Water Resources Commission and regulatory agencies initiated a number of efforts to evaluate and address these issues. These efforts included the development of interbasin transfer performance standards, a statewide drought management plan, outdoor water use guidelines, updated water conservation standards, and the identification of hydrologically "stressed" basins. The Commission is working to develop statewide streamflow standards by late fall of 2010.. Thus far, these actions have been inadequate to date to protect and restore streamflows across the state. In 2007, stream segments downstream of flowing water segments in many parts of the state were again observed to lack adequate flow conditions or to have no-flow conditions caused by human alteration of flow regimes (Kearns 2008).

As efforts to characterize the full nature and extent of altered flow regimes has moved forward, one impediment to conducting a comprehensive and accurate assessment is a lack of basic information about streamflow conditions. While the United States Geological Survey (USGS) maintains a network of flow gages across the state, most of these are located on major rivers or large tributaries. Most small rivers, tributaries, and the upper reaches of many large rivers are not monitored for flow conditions. These smaller rivers, streams, and tributaries are most vulnerable to altered watershed conditions. Increased data on streamflow in these waterways are needed to better understand current conditions and inform natural resource management.

5. Program Description and Goals

The RIFLS program is a collaborative effort to assess, evaluate, and address streamflow issues, raise awareness, and interact with decision makers for sound policies regarding sustainable water management across Massachusetts that are protective of aquatic ecosystem integrity. It is based primarily upon partnerships between DER staff and local stakeholders, including individual volunteers, watershed organizations, and municipal programs, and also includes coordination and interaction with state and federal agencies involved in streamflow and water management issues.

At the core of the RIFLS program is the collection and evaluation of streamflow data for those rivers and streams without such prior data (i.e. USGS stream gaging stations). Sites are chosen based on a variety of factors including DER staff capacity, level of volunteer participation and active partners, level of threat to riverine resources, technical feasibility and geographic coverage, among others. Data collection is performed primarily via a network of volunteers, with significant technical support from DER. Data evaluation is primarily performed by trained DER staff and scientists from partner agencies and programs. Monitoring locations and objectives are identified and developed in concert between DER staff and local partners (i.e. watershed organizations). DER staff is responsible for installing staff gages, making discharge measurements, overseeing development of hydrologic rating curves, and providing training to volunteers. RIFLS volunteers are primarily responsible for recording water level measurements based upon visual observation of staff gages and entering that data into an online database (housed on the RIFLS website) and local partners work together to work through issues that may arise during the course of monitoring, evaluate monitoring results once sufficient data are collected and develop and evaluate flow restoration strategies when necessary through an action-planning process.

Select volunteers may complete a RIFLS Certification course co-hosted by DER and USGS staff to learn to make discharge measurements. The course includes a 2 hour classroom orientation to discharge measurements and equipment, followed by a one day hands-on field course learning to identify a suitable river cross-section for streamflow measurement, make accurate width, depth and velocity measurements using a variety of equipment, calculating streamflow from field data and using the discharge measurements to check the validity of existing rating curves. During the field training day, volunteers make a discharge measurement at an existing USGS real-time gage site and compare their results to the USGS gage's streamflow value as a quality control check. Once trained, Certified volunteers may make annual discharge measurements to verify the validity of rating curves developed by DER staff. These data are forwarded to DER staff and flagged as volunteer-collected discharge measurements. If a measurement plots more than 15% off the rating curve, DER staff discuss possible sources of error with the volunteer and may accompany the volunteer on another discharge measurement. If a rating shift is apparent, DER staff work with the volunteer to fix the problem or re-rate the gage.

While the goals for individual RIFLS sites and associated groups vary (e.g. to determine if a municipal well is depleting streamflow), the overall goals of the RIFLS program are consistent, and include:

1. Increase citizen awareness of streamflow problems, possible causes, methods of analysis and solutions for protection and restoration of more natural flow regimes.
2. Help volunteers meet their own project objectives, complement established volunteer water quality monitoring programs, implement action plans and strengthen the network of people interested and active in streamflow, river, and watershed restoration and protection.
3. Enable and support the collection and dissemination of streamflow data of a consistent and useful quality on smaller Massachusetts rivers and streams to supplement the USGS streamflow monitoring network and further our understanding of conditions in smaller rivers.

4. Enable the management of streamflows across the state based on sound river-specific data.
5. Identify and implement river restoration strategies.
6. Identify streams where more intensive scientific investigation is needed to assess the degree of hydrologic stress and enable appropriate solutions to be developed.

6. Measurement Quality Goals

Obtaining high quality data is critical to the success of the RIFLS program. For RIFLS monitoring projects, two types of measurement data are commonly collected: (1) stream water level (stage) data collected by volunteers; and, (2) stream discharge measurements made by DER staff during hydrologic surveys. In order to assess the quality of these data, it is important to consider precision, accuracy, representativeness, completeness, and comparability. A brief description of each data quality indicator is provided below (borrowed from Schoen and Warren 2006), followed by a discussion of how these quality aspects apply to each type of RIFLS data.

- **Precision** is the degree of agreement among repeated field measurements of the same indicator and gives information about the consistency of your methods. It is typically defined as relative percent difference (RPD).
- **Accuracy** is a measure of confidence that describes how close a measurement is to its "true" or expected value.
- **Representativeness** is the extent to which measurements actually represent the true environmental condition. Parameters such as site selection (including location of sampling point within the water column), time, and frequency of sample collection can all play a role in determining how representative a sample is.
- **Comparability** is the extent to which data can be compared between sample locations or periods of time within a project, or between different projects.
- **Completeness** is the comparison between the amounts of valid or usable data the program originally intended to collect versus how much was actually collected.

RIFLS program objectives for **precision** and **accuracy** are presented below in Table 2. The accuracy of discharge measurements is based in large part upon the accuracy of the velocity meters employed. To achieve the data quality objectives for discharge measurements, the most appropriate methods and equipment will be used based on input from the QA Officer. A few common methods that could be used to meet the ±15% accuracy and precision objectives are listed below with their ranges of use and precision specifications for individual velocity measurements. Both DEP and USGS list accuracy and precision ranges of ±15% for discharge estimates derived from velocities measured with these types of equipment.

Table 2: Objectives for Precision and Accuracy

Parameter	Units	Accuracy	Precision
Water Level (for volunteer-read staff gages)	Feet (ft)	+/- 0.01 ft *	10%
Water Level (for water level loggers)	Feet (ft)	+/- 0.01 ft	Typically 0.2% of full scale of measurement
Discharge	Cubic feet per second (cfs)	15%	15%**
Minimum Number of Measurements for Rating Curve	Minimum number	6	6

* This target for precision was developed by comparing pressure-transducer data with volunteer readings from the same location during the pilot phase of this program, and assigning a reasonable range of accuracy on the part of volunteers.
** The 15% precision objective applies for the wade-in cross-sectional method (MassDEP, 2005; refer to Appendix C). For very low flows where precise velocity measurements are more difficult using the wade-in velocity meter method, DER staff will use the USGS protocol of assigning a data quality (good, fair, poor) to each discharge estimate to indicate its precision. These labels will be used during the development of rating curves to determine the size of error bars for each discharge measurement point below 0.10 cubic feet per second (cfs), consistent with USGS methods.

Table 3: RIFLS Program Velocity Meters

Method / Meter	Range of Use	Precision (±)	Information Source
Pygmy Meter	0.05 – 3.0 fps*	2%	www.gpi-hydro.com/meters.htm
Price AA meter	0.2 – 25 fps	2%	www.gpi-hydro.com/meters.htm
Marsh-McBirney Flomate 2000	-0.5 to +20 fps	2%	www.marsh-mcbirney.com/Products/2000.htm

* The range of use may be expanded up to ~ 15 fps using an electronic flow indicator (i.e. Aquacalc unit).

RIFLS monitoring sites are often established at particular locations in watersheds to evaluate specific flow related issues. In some situations, **representativeness** for the entire watershed may not be the goal (although streamflow at any point along a river is representative of the entire upstream watershed). For example, monitoring sites may be installed above and below municipal wells, or below recreational impoundments in order to evaluate the effects of these stressors on streamflow. In these situations, the monitoring location would not be representative of the entire upstream watershed, but rather of the river segment affected by well pumping or dam management. In other situations, a river may be monitored to provide baseline or reference condition data, and monitoring sites may be located appropriately to be more representative of the entire system, beyond the influence of a single stressor (such as a municipal well). The temporal frequency of monitoring also effects how representative the data are of true water level and flow conditions in a river. Goals for monitoring frequency are discussed below under completeness.

The **comparability** of the data collected can be assured by using known protocols, documenting methods, clearly providing monitoring site locations, specifying volunteer training requirements, recording times and dates, and storing datasets and photographs so that future stream gaging can produce comparable data by following similar procedures. These procedures are also followed to provide data that are comparable to other flow monitoring methods (e.g. for cases where RIFLS monitoring sites are converted to USGS stream gaging stations). In many cases, RIFLS staff gages (see section 11) are installed to be as permanent as possible to allow use into the future.

RIFLS monitoring often attempts to maximize the **completeness** of the dataset, but this may be limited by volunteer resources and individual site objectives. To provide data sets that are of sufficient completeness to allow for most hydrologic evaluations, RIFLS volunteers are requested to collect water level data on a daily basis. At a minimum, water level readings should be collected weekly. If monitoring is performed on a less frequent basis than weekly, the data are considered to be poorly representative of temporal variations in actual water level (and streamflow). In those cases where data collection is too infrequent to meet site objectives, DER may elect to terminate monitoring at the location in question after consultation with the Local Partner. In terms of rating curve development, RIFLS staff attempts to perform discharge surveys for the entire range of observed water level conditions at each site. However, extreme high flow events may not be surveyed due to safety concerns, and as such, some rating curves may be limited in term of completeness at the upper end.

7. Training Requirements/Certification

Training is required for **DER staff** (Program Scientist, Instream Flow Specialist(s)) in order to ensure proper hydrologic field measurements, familiarity with current hydrologic science, and the ability to manage streamflow monitoring efforts. The ability to accurately measure streamflow will be confirmed once a year by DER staff making discharge measurements alongside USGS staff and/or at one or more real-time USGS monitoring stations. Training is successful when these discharge estimates fall within 15% of those estimated by the USGS personnel or the real-time stream gage.

One-time training is required for all **volunteers** who participate in the RIFLS program. Volunteer training is conducted by DER staff and covers the following topics (refer to Appendices H and I for more information):

1. Overview of the functions and values of the natural flow regime and the adverse impacts resulting from a disruption of that regime;
2. The volunteer's role in assisting the long term management and planning of water resources and the importance of high quality data collection, including how to read staff gages;
3. Relevant hydrological terms and current statewide issues concerning streamflow;
4. An explanation of rating curves;
5. Safety considerations;
6. An overview of the site selection process and features or changes that could alter the rating curve;

7. A discussion of the local sites chosen for streamflow monitoring and the local project objectives;
8. Who to contact if site conditions change;
9. Data collection (i.e. how to read a staff gauge) and data entry QA/QC;
10. Use of the RIFLS website for data entry and/or retrieval including who to contact if the volunteer has questions, suggestions, or problems fulfilling their recording obligation; and,
11. Explanation of how and what the data collected by the volunteer will be used for both locally and state-wide, what products will result and how frequently (i.e. reports, website availability and updates, email contact, newsletter articles, etc.).

In addition to the standard required volunteer training outlined above, additional training (known as **RIFLS Certification Training**) may be provided to select volunteers or Local Partners to make discharge measurements, interpret the continuing accuracy of the rating curves previously developed by DER staff for their sites, and provide the basic training to new volunteers within their organization**.** This additional level of training is provided by DER and USGS staff, and consists of a two-hour evening classroom session and an all day field training workshop. Topics covered in each session include:

Classroom Training:

- Overview of rating curves;
- Overview of discharge measurement theory;
- Introduction to field equipment and measurement methods;
- Sample discharge calculation from field data;
- Dry run of volunteer training presentation;
- Field day logistics; and,
- Questions and answers.

Field Day Training:

- Review of field methods and theory of discharge measurements;
- Introduction to multiple types of velocity meters;;
- Water safety;
- Site selection techniques;
- Discharge measurement techniques; and,
- Discharge calculation.

8. Safety Considerations

Safety considerations for field work are a key consideration for both DER staff and RIFLS volunteers. DER staff follow standard USGS water safety procedures as identified in USGS training sessions and as described in USGS Water Supply Paper 2175 (Rantz 1982; Appendix D), and generally work in pairs.

For volunteers, a safety plan is included in the volunteer training manual (Appendix I) provided during the training session. The safety plan includes informing someone before going to the site, bringing a first aid kit and cell phone along, and describing common field hazards such as ticks, poison ivy, weather, etc. Volunteers are not expected to enter the water at any time to read a staff gage. However, some volunteers may volunteer to enter the water periodically to clean staff gauges and are instructed on water safety precautions. Select volunteers who complete the RIFLS Certification Training are instructed on water safety precautions and protocols by USGS and DER personnel during the field training session.

9. Documentation and Records

The RIFLS program generates records and documents related to field data collection, data processing, training, and planning. DER maintains documentation and records related to all aspects of the RIFLS program. Volunteer training attendance sheets, rating curves, rating tables, original discharge measurements, and staff gage surveys are stored at the DER office (refer to Appendix E for sample worksheets). Electronic records including spreadsheets, rating tables, digital photographs, correspondence, and reports are maintained at the DER office on Department of Fish & Game network storage drives; these drives are backed up and archived daily.

The Local Partner keeps copies of the volunteer training attendance sheet, rating curves and rating tables at the local office. Water level data are recorded in the field by volunteers, who then enter the data into an online database via the RIFLS website, and retain the original data. The online database is backed up daily and archived.

Samples of the following documents kept by the RIFLS program are provided in Appendix E:

- Field Discharge Measurement Spreadsheet
- Field Survey Datasheet
- Attendance Sheets (i.e. to document volunteer training)
- Rating Curve and Table

10. Monitoring Process Design

RIFLS monitoring sites and projects are developed, maintained, and evaluated pursuant to the following framework. Not all phases will apply to every site and/or project, because monitoring objectives, partner capabilities, and DER resources may vary. However, in general, these phases are considered the key steps of progression in the RIFLS program for any given site or project.

Table 4: Typical RIFLS Project Progression

Phase	Purpose	Examples of Key Tasks
1	Scoping and feasibility	Identify and discuss suspected flow problems, form research questions, form monitoring teams and steering committees, evaluate monitoring locations, collect background data, develop monitoring schedules and responsibilities.
2	Initial investigation	Install staff gages, perform hydrologic surveys and construct rating curves, perform volunteer training, monitor water level, construct web pages for new sites, perform data entry and QA/QC.
3	Preliminary assessment	Compile and evaluate water level and flow data (1-year minimum of data), conduct action planning meeting with stakeholders, plan for future monitoring needs/objectives, review findings and consider how data answer/support original research questions.
4	Advanced investigation	Continue or relocate monitoring sites to address new or continuing research questions, maintain rating curves, collect water level data, deploy water level loggers if appropriate (i.e. higher resolution data are required), supplement existing biological, chemical, and/or physical data to provide (if necessary) a more holistic understanding of river health.
5	Advanced analyses	Use streamflow data to evaluate degree of departure from natural flow conditions using (for example) MA Water Resource Commission's Index Streamflow Methods (MA DCR, 2008). Evaluate how flow-related stressors are impacting the ecological condition of the river. Assess the ability of alternative water management scenarios to solve the flow problems identified. Refer sites to partner agencies or groups for additional monitoring and analysis as needed.
6	Flow restoration / management	Implement strategies to address unnatural streamflow characteristics identified in phase 5; for example, dam management plans to improve flow conditions downstream of managed impoundments.

To help organize the analytical options associated with Phase 5, DER may develop a 'diagnostic toolbox' that lists and describes the possible options for in-house or contracted hydrologic evaluations. Similarly, DER may develop a 'treatment toolbox' that describes the various options available for addressing unnatural and problematic streamflow issues for Phase 6. Both the diagnostic and treatment toolboxes may be periodically updated to reflect new developments and experiences, and may be posted to the RIFLS website. The purpose of both toolboxes is to facilitate an understanding of possible avenues for analysis and restoration as RIFLS monitoring sites progress through the above-referenced classification structure.

11. Monitoring Methods

A standard set of methods, described below, are employed to ensure consistent collection of water level and stream discharge data at all monitoring locations. These include (1) the selection of staff gage locations and installation techniques, (2) water level data collection, (3) discharge data collection, and (4) rating curve development.

<u>11.1 Staff gage siting and installation techniques</u>
The number and general locations of staff gages necessary to meet project objectives are identified in cooperation between DER staff and appropriate volunteers, local steering committee members, and TAC members or agency staff, based on the following programmatic and technical criteria:

- Interested and committed volunteers;
- Streamflow issues, such as water supply withdrawals or lake level manipulations that affect downstream flows; or reference river conditions to be used during evaluation of hydrologic alteration
- Potential for data to be used to advocate for flow restoration;
- Ecological concerns (fisheries, habitat, rare species, etc.);
- Other organization or agency interest; and,
- Technical feasibility:
    - Stream can be safely waded at high flows;
    - Safe and easy access for volunteers; and
    - Well-defined channel with minimal turbulence on a straight section of river to facilitate discharge measurements.
    - DER staff time capacity.

USGS style metal staff gages are installed by the Program Scientist and/or Instream Flow Specialist(s) on a fixed object, such as a bridge abutment or large boulder, whenever possible. If a fixed object in a desirable location is not available, gages are installed on metal pipe pounded into the stream bed at least 3 feet or until stable. Staff gages are leveled (using a hand level) during installation to ensure that water level is parallel with measurement increments on the gage. The height of the each gage is surveyed relative to local benchmarks by DER staff. Pipe installations are resurveyed annually or more often, if warranted, for movement. Gages mounted on bridge abutments or large boulders are surveyed as needed if movement or vandalism is suspected. The Program Scientist and/or Instream Flow Specialist use a portable Global Positioning System (GPS) unit (Magellan model 20) to log the location of each staff gage installed. GPS coordinates for each site are considered acceptable when a minimum of 3 satellites are available during the field check. Gages are cleaned with a stiff brush or pad by volunteers and/or DER staff if they become too dirty to read. Gages that are vandalized or otherwise damaged may be repaired with ceramic paint if they are still legible, or replaced re-surveyed by DER staff if necessary.

Figure 3: Examples of RIFLS Staff Gage Installations

Billings Brook (Sharon)

Beartown Brook (Lee)

<u>11.2 Water level data</u>

Water level data are collected by volunteers or DER staff by visual inspection of staff gages installed at monitoring locations. Volunteers read staff gages from the bank or roadside, using binoculars if necessary, in a location providing direct line of site to the gage that is parallel to the water level. Volunteers inspect staff gages for damage, movement, and look for changes to the hydraulic control that may affect the rating curve during each observation. Any problems noted are reported to the Program Scientist and/or Instream Flow Specialist(s), recorded in field notebooks, and noted in the comments field in the RIFLS database. Volunteers record water level data from the staff gages on a daily to weekly basis when the river is not iced over by more than 50% (at which time rating curves are no longer accurate).

Water level loggers may be deployed to collect higher-resolution water level data based upon monitoring project needs, technical, and financial feasibility. Installation and maintenance methods follow manufacturers' recommendations. Water level data are downloaded by the Program Scientist or Instream Flow Specialist(s), reviewed for potentials errors, archived, adjusted to the local datum if needed and uploaded to the RIFLS database. Batteries are changed as needed in the field, generally every 3-4 months. Water level logger models currently in use include:

Table 5. Water Level Logger Specifications

Meter Model	Global Waters Water Level Logger (WL15 and WL16)	Onset Hobo Water Level Logger
Accuracy (%)	0.0025 %	0.075 % - 0.015%
Depth Range (ft)	0 - 15	0 - 13
Barometric Pressure Compensation	Vented cable automatically adjusts data	Separate unit plus software to adjust raw data
Manufacturer's website	www.globalw.com	www.onsetcomp.com
Temperature output (degrees F)	Some units	All units
Temperature accuracy	1 %	± 0.67 degrees F

11.3 Stream discharge data

The Program Scientist and Instream Flow Specialist(s), and in some cases RIFLS certified volunteers, make discharge measurements according to the MA DEP Standard Operating Procedures (DEP 2005, see Appendix C) for flow measurement, and the USGS protocol for measurement of stream discharge by the current meter method (USGS 1982; see Appendix D.). Both of these documents contain highly detailed information concerning stream discharge measurement methods; a majority of these details are not reiterated herein, but are available in the Appendices C and D, respectively (see Table 5 for typical equipment used). Data collected during discharge surveys (including tape distance, water depth, and velocity) are recorded on field data sheets (Appendix E). If an Aquacalc unit is employed to record velocity measurements during discharge surveys, then the data are downloaded from the Aquacalc unit, and archived electronically by the Program Scientist or Instream Flow Specialist(s). Discharge measurements made by certified volunteers are flagged as volunteer-collected data in the database. If these points fall more than 15% off the existing rating curve, DER staff discuss possible sources of error with the volunteer and may accompany the volunteer on another discharge measurement. If a rating shift is apparent, DER staff work with the local volunteer to re-rate the site.

Discharge surveys typically include two separate measurements for quality control purposes (see Section 12). The comparability of duplicate measurements is based upon an approximately fixed water level during the period of streamflow measurement. Occasionally, a discharge survey may be performed during a storm event, particularly to capture high flow measurements. Duplicate measurements in these situations may not be feasible if water level is changing rapidly. In these specific situations, the Program Scientist or Instream Flow Specialist(s) may elect not to perform duplicate measurements, but instead use the data collected from a single discharge measurement. In all circumstances, water level is carefully recorded from the staff gage immediately before and after the discharge survey.

All measurements are made in safely wadeable streams using a velocity meter appropriate for the range of observed flows, unless otherwise noted. When water velocity or depth is too great to perform a wading discharge measurement, DER may employ standard bridge measurement techniques per standard USGS methods (USGS 1984, Volume I, Section 5). If the range of expected depths and velocities is expected to exceed the accepted range for conventional meters, the Program Scientist consults with the QA Officer and Local Partner to determine whether a suitable alternative method can be arranged.

Table 6: Typical Discharge Survey Field Equipment

Equipment	Purpose
Tape measure (English units)	Measure stream width and locate velocity measurement point
1' metal stakes	Secure tape measure across stream
Flotation device	Safety precaution during high flows
Digital camera	Record site conditions for reference
Waders	Personal safety
Waterproof data sheets	Record data and notes
Pencils	Record data and notes
Handheld Computer (Palm pilot, optional)	Evaluate fit of measurement point on existing rating curves in the field; record data and notes
Wadeable Discharge Measurement:	
Velocity meter	Measure water velocity
Top setting wading rod	Stabilize velocity meter and measure depth
AquaCalc digital readout or stopwatch and headphones	Count rotations of velocity meter
Bridge Board Discharge Measurement	
Bridge Board	Stabilize equipment balanced on bridge railing.
Sounding Reel	Hold velocity meter and measures water depth and depth of meter.
Price AA velocity meter	Measure water velocity.
Sounding Weight	Stabilize velocity meter in water column.

The technical feasibility of making discharge measurements at each site will be judged based on the following criteria:

- Laminar flow;
- Straight channel segment (i.e. not on a bend);
- Sufficient water depths (> 0.25 ft for Pygmy meters, > 0.5 ft for Price meters)for velocity meter to function properly; and,
- Safely wadeable and accessible river segment, or suitable conditions for bridge board (i.e. bridge is over a laminar flowing section of river with adequate depth for velocity meter, safe bridge access exists for staff, bridge is preferably equipped with a railing to balance the bridge board on, and there are no obstructions to deploying the velocity meter).

11.4 Rating curve development

At least six discharge measurements are made for each monitoring site over a range of streamflows sufficient to develop a rating curve using standard USGS procedures for drawing the curve. Preliminary curves may be developed for specific immediate needs with the caveat that they do not meet the RIFLS QAPP standards until the final curve is developed. A final curve may be developed with fewer than 6 discharge measurements only if a rating shift is detected before 6 measurements are made and the existing measurements cover the majority of the range of depths observed during the time period for which the curve will be used. Once a sufficient number of discharge surveys have been performed, the Program Scientist or Instream Flow Specialist develop the rating curve using the same graphical software used by the USGS. DER staff are trained in the use of the rating curve development software (Aquarius) by USGS staff and consult with USGS as needed to verify that curves are accurate. The Program Scientist or Instream Flow Specialist then uploads the rating table into the RIFLS online database.

Conversion of volunteer-collected water level data to final discharge data is performed for all sites by DER staff through the online database. The Program Scientist or Instream Flow Specialist(s) provides the rating curve and a tabular output of the rating curve to Volunteers, Local Partners or other data users when requested. Once a rating curve is developed, DER staff makes at least one discharge measurement per site annually under base flow conditions to check the continued applicability of the existing rating curve. In situations where RIFLS Certification Training (see Section 7) has been provided, the trained Local Partner or Volunteer may perform the annual check to determine the condition of the existing rating curve using equipment borrowed from the RIFLS program, or their own similar equipment that meets RIFLS QAPP standards. If the discharge measurement made by the Local Partner indicates a potential rating shift (i.e. does not fall within 15% of the existing rating curve), then DER staff will perform a discharge measurement to further investigate a potential rating shift.

If the rating curve changes due to changes in the downstream hydraulic control or shape of the river channel, RIFLS staff make additional discharge estimates as needed to develop a new rating curve, inform the volunteers and/or Local Partner and update the website stage-discharge conversion table as needed.

12. Quality Control Requirements

To evaluate **discharge data** and measure the repeatability of cross-sectional area measurements, water velocity readings, and the use of the flow calculation spreadsheet(s), discharge surveys shall include one set of duplicate area and velocity readings taken immediately after the primary set of. The relative percent difference (%RPD) between the two calculated flow estimates will measure the overall precision of the flow data (including "error" due to natural temporal and sampling variability). Duplicate measurements are performed by DER staff by simply switching responsibilities so that different persons are doing different tasks.

DER staff may elect to perform a single discharge measurement – in lieu of the duplicate measurement protocol described above – in special circumstances, including during rain events (see Section 11.3), and at locations where a rating curve is partially or completely constructed and the water level in question is already included in the range of recorded values. For the latter situation, a single measurement will be considered acceptable if it falls within 15% of the existing rating curve, and a duplicate measurement will not be performed. If the single measurement falls outside of the existing rating curve by more than 15%, then a second discharge survey will be performed. Discharge measurements conducted by certified volunteers must meet the same data quality objectives. If volunteer data is greater than 15% off the rating curve, RIFLS staff discuss possible sources of error with the volunteer. If an obvious source of error is determined the volunteer wil repeat the measurement. If not, a RIFLS staff member will accompany the volunteer during another measurement to determine whether the volunteer's technique is adequate.

All field data are double-checked when electronically entered. The accuracy of the discharge measurements is determined visually through quality of the rating curve (i.e. how closely data points fit the rating curve). Outlying discharge measurements are inspected for possible sources of error from field datasheets. If no reasonable explanation is found or if the data point is found to be inaccurate, another measurement is made at approximately the same water level to complete the rating curve. If problems defining the rating curve persist, then a new curve is constructed or the site is discontinued and another location pursued. Final rating curves are reviewed by the USGS QA Officer.

Water level data that are recorded and entered by volunteers into the on-line database are reviewed for reasonableness by the Local Partner on a monthly basis. DER staff also periodically reviews water level and field note data that have been entered on-line, at least annually. The most common method for quality control is visual review using figures available on the RIFLS web site; this review helps identify potential errors in data entry. When a potential error is identified, the local partner or DER staff review the 'comments' field for possible explanations. If no explanation is found, the Volunteer who entered the data is contacted. The Volunteer then reviews field notes to determine whether a data entry error has occurred. DER staff makes appropriate changes to the online data record. If the data cannot be explained through field observations or conversations with the original observer, then the point will be flagged as a possible error and used at the discretion of the user. Original log books used to record field data are kept by the Local Partner for reference and as a backup to the electronic database.

Field audits of volunteer stage height data are no longer conducted to save staff time. During the pilot period, many volunteers were audited by RIFLS staff for accuracy of stage height measurement. In addition, several automatic water level loggers were deployed during the initial year to compare volunteer versus electronic stage height measurements. Data were generally found to be within 0.02 ft, with a few larger errors during highly turbulent high flow periods. This level of accuracy (± 0.02 ft) is assumed for all volunteers unless outlying data points from a single volunteer are identified. In this case, RIFLS staff works with the volunteer to correct the problem.

13. Equipment Maintenance and Calibration

Staff gages are visually inspected at each reading for debris, biofilm, ice or other material that might hinder accurate water level measurement. If necessary, cleaning is performed by DER staff or local volunteers using a coarse brush. Volunteers inspect staff gages for damage, movement, and changes to the hydraulic control that may affect the rating curve during each observation and report any significant changes to the Program Scientist or Instream Flow Specialist(s). In response, DER staff may request additional information or photos, conduct a site visit, adjust or discard affected data points and/or request volunteers to discontinue monitoring until the problem can be resolved.

Water level loggers are maintained and calibrated per manufacturer's recommendations. DER staff inspects cables, the water level sensor, and/or the data logging unit for damage or movement during every site visit. Batteries are changed as necessary. Desktop review of downloaded data is also used to assist DER staff to identify water level 'shifts' or indications that the sensor location may have changed or that the unit may have malfunctioned.

Velocity meters are visually inspected before and after each discharge measurement. Calibration checks are performed pursuant to manufacturer's recommendations, which differ based upon the meter employed. When the Pygmy or Price AA velocity meters are used, spin tests are performed in the field and recorded on the Discharge Measurement Field Sheet to evaluate meter calibration. The Pygmy meter is considered adequately calibrated if it spins freely in the air for at least 30 seconds and the Price AA is considered adequately calibrated if it spins for at least 2 minutes. When the Marsh-McBirney (electromagnetic) flow meter is used, calibration is checked and the meter cleaned monthly or more frequently if necessary. Calibration is checked by allowing water to settle to a standstill in a 5-gallon bucket, then reading instantaneous velocity. If the velocity reading is not zero, then the meter is recalibrated using the manufacturer's recommended procedure.

Oil, spare replacement parts (pins, screws, batteries), and cleaning supplies are kept on hand for minor field maintenance and repairs. Any field repairs are noted on the Discharge Measurement Field Sheet. Other repairs require expert reconditioning.

14. Additional Data collected for RIFLS sites

Several types of data are utilized by the RIFLS programs and are not obtained through field monitoring activities, including precipitation and watershed drainage area. The RIFLS website offers the opportunity to combine local precipitation data with observed water levels and discharges to aid in the interpretation of streamflow data. Daily precipitation data are obtained from a variety of sources, some in electronic format and others in hard copy. All data is compiled electronically and uploaded to the website. Each site uses the nearest precipitation dataset, generally from climate stations located within 15 miles. Watershed drainage area is determined using a Geographic Information System or using USGS Streamstats using the GPS coordinates of each site.

15. Data Management

DER maintains a web-based database to store and manage all data collected by the RIFLS program. DER staff constructs and maintains a web page for each new RIFLS site and manages day-to-day maintenance of the database. The data are accessible to the public via an internet based portal (www.RIFLS.org) which allows volunteers to enter, view and download site data and to view images such as site photos and topographic maps of the watershed. The general public is not permitted to modify data.

Any changes that are made to raw data in the database during QA/QC checks are noted in the "comments" field with an explanation of the reason for the change and description of the change that was made. Problems with the website functionality are resolved by computer support staff as soon as possible. The electronic database is backed up daily off-site.

16. Data Review and Validation

The Program Scientist or Instream Flow Specialist(s) reviews volunteer data for comments or other indications of erroneous data, graphically checks water level data for outliers (i.e. points that are unreasonably high or low for the stream size, weather conditions, expected seasonal water level, or preceding or following measurements) and discards unreasonable data where field observations indicate a problem. Best professional judgment is often used to evaluate data quality. Statistical evaluation for outliers may be used to further identify erroneous data. DER staff reviews the online data for quality assurance at least once a year or when modifications to rating curves are made as new discharge measurements are incorporated. If any outlying data points are identified, the Program Scientist or Instream Flow Specialist(s) contacts the volunteer monitor to discuss possible explanations (refer to Section 12). If the data cannot be explained through field observations or conversations with the original observer the point is flagged as a possible error.

17. Assessment and Response Actions

Data from each site, including rating curves, volunteer-collected water level data, and calculated discharge data are evaluated based on the data quality objectives presented in Section 6 (Measurement Quality Goals). If data quality objectives are not met, limits on the use of the data based on its precision and accuracy will be determined by the Program Scientist and Instream Flow Specialist(s) in consultation with the QA officer and described in RIFLS reports and on site web pages.

Local project objectives are evaluated during **action planning meetings**, which are held on an approximately annual basis or as needed, and include DER staff, the Local Partner, Volunteers and other interested parties as appropriate. If data quality or quantity objectives are not met, possible corrective actions are determined, such as moving the gage to a better site, selecting different sites or rivers to meet the same objective, recording measurements more frequently, recruiting additional volunteers, or using a different method for measuring discharge. Discussion at the action planning meeting identifies who will follow up on other actions that improve streamflow protection or restoration of more natural flow regimes. Select cases may be presented to the Technical Advisory Committee for input and assistance in identifying problems, recommending solutions, or pooling additional resources. The Technical Advisory Committee may also be briefed on cases that have regional or statewide significance for ecological health or natural resource policy implications.

The DER Program believes that volunteer streamflow monitoring should not only produce useful data, but should also lead to river restoration and protection activities. **Local steering committees** are therefore established for each project to involve local officials and other interested individuals in the process and facilitate communication and resource protection activities in the watershed. RIFLS Local Steering Committees are useful vehicles for developing hypotheses, disseminating findings, brainstorming solutions and enabling the implementation of priority streamflow restoration and protection activities as a result of volunteer streamflow monitoring and action planning efforts. These committees provide further opportunity to assess the success and progress on RIFLS projects on a case by case basis.

The overall success of the RIFLS program will be determined by the following indicators:

- Number of individual project objectives achieved;
- Number of active RIFLS groups;
- Number of volunteers trained;
- Number of action planning meetings held;
- Number of action plan items pursued by RIFLS groups;
- Program evaluations completed periodically by RIFLS volunteers;
- Number of active Technical Advisory Committee members and level of participation;
- Number of website hits for data entry, viewing and reports;
- Number of requests for streamflow data from regulators, planners, consultants, and restoration agencies; and
- Number of rating curves developed and maintained, and number of water level data points recorded by volunteers.

The Program Scientist will confer with the QA Officer as necessary to discuss any problems that occur and what corrective actions are needed to maintain program integrity. In addition, the Program Scientist and Instream Flow Specialist(s) shall meet regularly to review and discuss all aspects of the program and identify necessary program modifications for future monitoring activities; and such modification shall be brought before the TAC. Corrective actions may include retraining or replacing volunteers; rewriting the volunteer training manual; alteration of monitoring schedules or sites; or other actions deemed necessary. All problems discovered and program modifications made shall be documented in project or program specific records. If modifications require changes to the Quality Assurance Project Plan, these changes shall be submitted to the TAC, USGS and DEP for review.

18. Reports

An annual program summary will be prepared to describe the data quantity collected, comparison to data quality objectives, any corrective actions taken and any unusual observations or problems encountered for each active site. A narrative description of the objectives, issues and actions taken by select RIFLS groups is also included as an educational tool for other groups. In addition, any significant evaluation, management, and restoration actions undertaken in the past year are discussed in the report. Annual reports from 2004 to 2007 are included in Appendix F.

19. References

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Appendix A

Map of RIFLS Sites
and
Table of Volunteer Groups

Appendix B

Final report on the completion of the RIFLS pilot project

Appendix C

MA DEP Flow Measurement Standard Operating Procedures (SOP)

Appendix D

USGS Water Supply Paper 2175

Appendix E

List of Documents and Records

Appendix F

RIFLS Annual Reports (2004-2007)

Appendix G

RIFLS Recruitment Brochure

Appendix H

RIFLS Training Presentation

Appendix I

RIFLS Volunteer Manual

Appendix J

Attendance Sheet

Appendix K

Discharge Measurement Datasheet

Appendix L

Survey Datasheet