Quality Assurance Project Plan

Aquatic Invertebrate Bioassessment Monitoring in the Eastern Sierra Nevada

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Quality Assurance Project Plan

Aquatic Invertebrate Bioassessment Monitoring in the Eastern Sierra Nevada: Development of Biological Criteria for Stream Water Quality and Evaluations of Environmental Impacts and Restoration Projects in the Lahontan Region (for the Lahontan Regional Water Quality Control Board)

Program Leader:
David B. Herbst, Ph.D.
Research Biologist
Sierra Nevada Aquatic Research Laboratory
University of California
Route 1, Box 198
Mammoth Lakes, CA 93546
(760) 935-4536
email: herbst@lifesci.ucsb.edu

LRWQCB Project Officer:
Thomas Suk
Lahontan Regional Water Quality Conrol Board
2501 South Lake Tahoe Blvd.
South Lake Tahoe, CA 96150
(530) 542-5419

Problem Definition and Background

Problem Statement. Stream water quality conditions have often been evaluated using chemical criteria, and habitat conditions evaluated using measures of the physical form and stability of channels and riparian vegetation present. These features provide useful information on the environmental setting of streams but fail to evaluate the biological health or integrity of stream ecosystems. A direct measure of the ecological suitability of aquatic habitats can be obtained by sampling the varied forms of life found on the stream bottom. Aquatic insects and other invertebrates are the most common organisms used for such biological assessments. Some of these organisms can live and even thrive under polluted conditions but many others require a clean water environment to survive. The various types of organisms present can be used as indicators of the health of the habitat. Bioassessment is a tool for measuring stream water and habitat quality based on the kinds of organisms living there.

Stream biomonitoring has been used throughout the United States and Canada in recent years to determine whether chemical water quality standards match biological conditions. Often it has been found that biomonitoring measures provide a more complete method for detecting impaired water quality or demonstrating improvements in environmental quality. Most states now use stream invertebrates as a regular part of monitoring programs. Several states (Ohio, Maine, North Carolina, and Florida) have established regional reference streams as biological standards for use in determining water quality compliance. These programs are resulting in better means for detecting pollution, guiding abatement projects, and promoting cleaner streams. Volunteer monitoring groups also are becoming active through community programs such as "adopt-a-stream", local school education projects, and stream restoration work. The objectives of the biomonitoring program described here are to provide guidance for developing biological criteria for water quality in the Lahontan Region (Figure 1, map location), refine use and comparability of bioassessment methods, develop a database of reference streams for evaluating pollution problems in this region, and apply data produced to monitoring of ambient water quality and the progress of restoration projects. Bioassessment data will also be used to aid in identifying and prioritizing water bodies for total maximum daily load (TMDL) development, evaluating TMDL-listed streams, and setting biological targets for guiding management and improvement of water quality.

The Lahontan Region encompasses drainages on the eastern slope of the Sierra Nevada and includes many pristine watersheds but also a variety of point- and nonpoint-source pollution problems. Among the land uses that may contribute to water pollution are roads and slope erosion, livestock grazing, drainage from abandoned mines, stream flow diversions, channelization, and timber harvest. Erosion and sedimentation are primary problems but are difficult to detect and evaluate with only chemical or physical assessments. Bioassessment collections of the bottom-dwelling organisms of streams are useful in detecting changes related to sedimentation because scouring and burial of the stream-bed habitat can affect basic aquatic life uses of this environment. Aquatic life use alteration is based on changes in the number of different types of invertebrates (diversity), and their relative tolerance of environmental impacts and pollution (sensitivity). Monitoring stream invertebrates in comparison to reference sites (areas having little or no impact but similar physical setting) and/or over time within targeted sites permits an estimate of impact problems or recovery under changing land use. The method may be used together with traditional stream channel and riparian monitoring to provide a tool that measures the response of stream life to habitat changes. When pollution does not originate from a single point ("non-point"), it can be difficult to

measure using chemical methods because this type of pollution usually does not occur continuously and could be missed in a single water sample. Problems may also exist upstream of a location and not be reflected in the channel or riparian conditions at that site. The advantage of using stream invertebrates is that they live in the stream and experience everything that flows over and around them and so incorporate and embody changes in water quality that occur in both local and upstream areas of the watershed.

Intended Use of Data. The UC-SNARL/Herbst laboratory has collected bioassessment data on hundreds of stream study sites in the eastern Sierra Nevada since 1992. Sites have been located primarily in Mono County but extend south into Inyo County, north into Alpine, El Dorado, Placer and Nevada Counties of California, and east into Douglas and Lyon Counties of Nevada. Data from these sites include physical, chemical and biological data and have been directed at evaluating a variety of land use and pollution issues including livestock grazing, acid mine drainage, and habitat restoration projects. The intended uses of these data and those collected within the scope of this QAPP are for several purposes:

- Develop appropriate regional biological standards or reference stream conditions (using samples from a network of minimal-impaired streams) for different classes of stream types. This database may be used as guidance in determining the status of streams that may have degraded ecological integrity relative to the defined standards or biocriteria. The biocriteria may then be used to assess the extent of degradation (or absence of impact) and a target for gauging the progress/success of ecological recovery following restoration or management actions taken.

- Provide site-specific baseline data for evaluating local restoration projects or management programs directed at alleviating specific pollution source problems. Examples include livestock grazing management (fencing, rest-rotation, varied stocking levels) on the West Walker River and Upper Owens River; acid mine drainage in the Leviathan Mine watershed (chemical treatments of storage ponds), channel restoration on the Upper Truckee River (erosion control), and TMDL target development for sediment problems in selected watersheds (e.g. Squaw Creek, Heavenly Valley Creek).

- Evaluate biological integrity of streams exposed to varied levels of livestock grazing and related habitat alteration. Data would be used to develop specific diagnostic indicators and monitoring strategies for guiding the identification of streams with degraded ecosystems and tracking changes under different management practices. This work has been supported by the USEPA and serves as the foundation for the bioassessment program of the Lahontan RWQCB.

Project / Task Description

General overview of projects. As indicated above, ongoing projects and those initiated in 2000 include development of a reference stream database for establishing biological criteria, and the monitoring of several specific pollution problems and restoration progress. Protocols and plans covered by this QAPP include previous work (from 1996 on) and the following projects:

Projects and Timetable.

Project Activity	Start and Expected Completion Dates
Biocriteria development based on sampling of selected reference sites for the Lahontan Region	1999 - Ongoing
Monitoring of grazing management stream restoration on (1) West Walker River and tributaries – baseline, reference, management contrasts, (2) Bagley Valley Creek channel reconstruction pre- and post-project study, (3) Bridgeport Valley reservoir tributaries	(1) 1999 – 2002 (2) 1999 – 2004 (3) 2000 – 2001
Monitoring of erosion control and stream restoration on the Upper Truckee River – baseline, references, and longitudinal contrasts	1998 - 2001
Comparisons of 3 field and laboratory sampling bioassessment methods used in (1) the Lahontan Region protocol (UC-SNARL), (2) the California Standard Bioassessment Protocol (CSBP of California Department of Fish and Game), and (3) RIVPACS- US Forest Service protocol (C.P. Hawkins, Utah State Univ.). Data will be compared for measures of diversity and community structure, statistical properties, applications of data sets, and potential conversions between data.	2000 - 2002
Monitoring of acid mine drainage and mitigations at Leviathan Mine (Alpine County)	1995 - Ongoing
TMDL biological targets for Squaw Creek (Placer County)	2000 - 2002
TMDL scoping for the upper Owens River (Mono County)	1999 - 2001

Measurement Quality Objectives (listing of representative measures)

A. Data Precision, Accuracy, Measurement Range (selected **chemical** parameters)

Matrix	Parameter	Measurement Range	Accuracy	Precision
Water	Conductivity	0-20 mS	±1%	±1%
Water	Dissolved O_2	0-10 mg/L	±0.2 mg/L	±0.4 mg/L
Water	Turbidity	0-999 NTU	±2%	±1%
Water	Alkalinity	0-200 mg/L	±4 mg/L	±4 mg/L
Water	pH	0-14	±0.01	±0.10

Data Precision, Accuracy, Measurement Range (<u>selected **habitat** parameters</u>), <u>continued</u>

Matrix	Parameter	Measurement Range	Accuracy	Precision
Stream Channel	substrate composition	0 – 100%	Est. ±10%	Est. ±10%
Stream Channel	embeddedness	0-100%	Est. ±10%	Est. ±10%
Stream Channel	Riparian cover	0-100%	Est. ±10%	Est. ±10%
Stream Channel	Current velocity	0.05-15 m/sec	Est. ±10%	Est. ±10%

*accuracy and precision based on representative data sets for between-site, multi-year sampling

Data Precision, Accuracy, Measurement Range (<u>selected **biological** parameters</u>), <u>continued</u>

Matrix	Parameter	Measurement Range	Accuracy	Precision
Stream Bed	Diversity	undefined	70-95% of site mean collected in samples 1-4. Regression projects 70% of true diversity in 5 samples for n=100.	±12%
Stream Bed	Relative Density	0.000 – 1.000	Underestimate (10-20%?)	±31%
Stream Bed	EPT Index	undefined	Similar to diversity	±11%
Stream Bed	Biotic Index	0.00 – 10.00	±10%	±10%

*accuracy and precision based on estimates from representative data sets for between-site, multi-year sampling for 5 replicate macroinvertebrate samples per site.

B. Data Representativeness

Water quality measures and habitat features in general are within 10% or less of representing the actual values in nature. Measures of diversity (total and component) are likely to be underestimates but by no more than 30% of true richness and this due entirely to rare taxa or those not present in riffle habitat zones. Density is also underestimated, likely by about 10-20% due to incomplete capture of some organisms (but use of 250 micron mesh net improves upon other common collection methods). Index values based on relative abundance are as accurate as precision estimates since they are based on community composition (relative abundance).

C. Data Comparability

The habitat survey methods for the chemical and physical environment are similar and comparable to other quantitative habitat descriptions. The invertebrate sampling methods differ from common used techniques such as River InVertebrate Prediction And Classification System and California Stream Bioassessment Protocol as follows: finer mesh net (250 micron), replication (5 samples/site), and subsampling (split samples, 250 organism minimum count). Synoptic sampling using all three of the methods has been conducted and analysis will permit comparison of the output of the data sets for sensitivity in detecting habitat alteration, and calibration of the method employed here to the RIVPACS and CSBP procedures (permitting conversion to the equivalent data set).

D. Data Completeness (for each study reach unit)

In each year of stream surveys to date the target number of sites and planned collections have been equaled or exceeded. Actual processing of samples and data analysis in the laboratory has been delayed in some instances (e.g. Leviathan mine year 2000 data, 60-75% completed by target date; full completion 4 months late).

Training Requirements and Certification

Field and laboratory technicians are provided with this QAPP document and with detailed SOPs for all protocols used in field habitat surveys and laboratory sample processing. Prior to each field season the project supervisor involves all personnel in a training session on each protocol used in physical habitat, chemical, and biological surveys. Technicians review with one another and the supervisor all protocols, conduct practice sampling, and maintain copies of all SOPs and their own field notes. Field QC involves regular reviews of sample collection, preservation, and labeling. Laboratory training involves QC checking of all samples sorted during an initial trial period. When QC of sorts has met standards (<5% remnant), then 20% (1 of 5) samples are checked for completeness of removal thereafter. Log sheets are used to track who conducted sorts, QC checks, hours spent on each sort and date, subsample splits, number of animals recovered and number in remnant check. These data are used for feedback on sorting rate and quality. Each technician maintains a notebook with copies of keys, notes, and illustrations. All identified sample replicates are reviewed with supervisor during QC checks (each taxa ID verified, changed, or deleted). The eventual goal is to reduce this from 100% to 20% QC of identifications. Regular work performance evaluations are

conducted to certify compliance with the QC goals of rate and quality of completing field and laboratory tasks.

Documentation and Records

Records of field stream surveys are maintained on standard forms (attached) for each stream site studied (using "rite-in-the-rain" waterproof paper). All field records are entered on data forms at the time of the survey. All laboratory records are also maintained on standard forms (attached) in the form of sample processing logs, data sheets for the determination of chlorophyll and organic matter (see attached protocol sheets), and lists of all taxa identified. Each individual taxon identified has an associated certainty level for the confidence placed on the determination - 1= unambiguous distinctive set of traits, 2= ambiguous but probable, 3= uncertain ID, specimens immature or in poor condition and/or keys ambiguous. Vouchers one of five sample replicates, and for each invertebrate taxon are maintained in an archived laboratory collection. Records on data forms are kept both in files and transferred to Excel spreadsheets for analysis. Data are not yet stored as an EDAS-STORET database (Excel spreadsheets at present) but future plans are to convert to ACCESS or EDAS data archiving.

Sampling Process Design

Regional reference site selection criteria:

Minimal upstream land use disturbance in watershed above sample reach, gradient less than or near 4% where possible, elevation 5,000 – 8,000 feet, stream orders 1-4, Sierra Nevada and Great Basin ecoregions. In addition to reference sampling, surveys of a variety of impacted sites are also part of the monitoring database.

Subject Watersheds: (south to north, eastern slopes Sierra Nevada)
    Upper Owens River
    Mono Lake basin
    East Walker River
    West Walker River
    East Carson River
    West Carson River
    Lake Tahoe basin
    Lower Truckee River

Sampling Methods Requirements

Refer to detailed SOPs and datasheets attached to QAPP – below is a summary overview of the monitoring surveys and laboratory methods:

The data gathered consist of physical habitat surveys and biological sampling of benthic macroinvertebrates. Each site was defined as a 150-meter length study reach, located by GPS-UTM coordinates and elevation (near lower end of each site). The longitudinal distribution and length of riffle and pool habitats were first defined then used to determine random sample locations for benthic macroinvertebrates from riffle habitat. Slope over the reach was measured with a survey transit and stadia rod, and sinuosity was estimated from the shortest linear distance between the bottom and top marker flags for the reach (or aerial photographs of 500-1000 meters of stream length centered on the study reach when stream length was greater than 40 widths). Physical habitat was measured over the length of each reach using 15 transects spaced at 10 meter intervals. Water depth, substrate type and current velocity were measured at five equidistant points on each transect along with stream width, bank structure (cover/substrate type and stability rating), riparian canopy cover, and bank angle. Bank structure between water level and bankfull channel level was rated as open, vegetated, or armored (rock or log), and as stable or eroded (evidence of collapse or scour scars). Bank angles were scored as shallow, moderate, or undercut (<30°, 30-90°, and >90°, respectively), and riparian cover was estimated from vegetation reflected on a grid in a concave mirror densiometer (sum of grid points for measurements taken at each stream edge and at mid-stream facing up- and downstream). The type and amount of riparian vegetation along the reach was also estimated by qualitative visual evaluation. The embeddedness of cobble size substrate was estimated as the volume of the rock buried by silt or fine sand for 25 cobbles (encountered during transect surveys or supplemented with random selected cobbles). Discharge was calculated from each transect as the sum of one-fifth the width times depth and current velocity at each of the five transect points, and averaged. Basic water chemistry and related measures consisted of dissolved oxygen, conductivity, pH, temperature, and turbidity. Documentation also included photographs taken at mid-stream looking upstream at 0, 50, and 100 meters, and downstream at 150 meters.

Biological sampling consisted of 5 replicate benthic samples taken in riffle zones with a 30-cm wide D-frame kick-net. Each replicate was comprised of a composite of 3 30x30 cm sample areas taken across the riffle transect or over riffle areas of varied depth, substrate and current. This composite of microhabitats provides a more representative sampling and reduces the variability among replicate samples. Samples were processed in the field by washing and removing large organic and rock debris in sample buckets followed by repeated elutriation of the sample to remove invertebrates from remnant sand and gravel debris. Remaining debris was inspected in a shallow white pan to remove any remaining cased caddisflies (e.g. Glossosomatidae), snails or other molluscs. Elutriated and inspected sample fractions were then preserved in ethanol, and a small volume of rose bengal stain added to aid in lab processing. Invertebrate field samples were subsampled in the laboratory using a rotating drum splitter, sorted from subsamples under a magnifying visor and microscope, and identified to the lowest practical taxonomic level possible (usually genus; species when possible based on the availability of taxonomic keys, except for oligochaetes and ostracods). Nematodes and copepods were excluded because they could not be sampled in a representative way (but presence noted). A minimum count of 250 organisms was removed from each replicate for identification (in practice averaging about 300-500).

The benthic food resources of stream invertebrates were also quantified in sampling of organic matter and algae. Particulate organic matter was sampled using a 250-micron mesh D-frame net, sampling stream bottom riffles as above for invertebrates (3 replicate riffle samples). These samples were poured through a 1-mm screen, with the retained wood and leaf particle debris then weighed as a wet biomass measure of coarse particulate organic matter (CPOM). The fine fraction passing through the screen (particle range 250 microns to 1000 microns) was collected in a 100-micron mesh aquarium net, placed in a sample vial, preserved with formalin, and then dried and ashed in a muffle furnace at the laboratory to quantify ash-free dry mass of fine particulate organic matter (FPOM).

Algal periphyton was quantified by scrubbing attached algae off rock surfaces using a wire brush, homogenizing the algae removed using a large syringe, and subsampling the homogenate for (a) chlorophyll-a by filtration through 1-micron pore-

size glass fiber filters, and (b) archival of algae for cell counts and taxonomic identifications (preserved in formalin and Lugol's stain). This was performed on three replicate cobble-size rocks from mid-stream riffle habitats. The area of each rock was estimated from measures of length, width, height and circumference, and the chlorophyll-a per area determined by extraction of stored frozen filters in ethanol and reading light absorbance of the extract in a fluorometer relative to a standard curve.

Appended to the QAPP are the following standard field and laboratory data sheets and protocols, assuring that information is collected consistently:

Appendix 1: Standard Data Forms
- Physical habitat field survey sheet
- Lab sample processing and identification log
- Invertebrate identification bench sheet
- Algal chlorophyll worksheet
- Organic matter AFDM worksheet
- Algae AFDM worksheet
- Habitat summary sheet

Appendix 2: Field and Laboratory Standard Operating Procedures:
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- CPOM-FPOM and periphyton sampling SOPs
- Laboratory sample processing SOPs
- Water chemistry sampling SOPs

Sample Handling and Custody Requirements

Samples collected in the field and returned to the laboratory include 5 replicate benthic invertebrate samples (labeled with stream, site name, date and replicate number), three algal periphyton samples on GF/A filters and three 20 ml samples of algal homogenate preserved in formalin for taxonomic analysis, three samples of FPOM preserved in formalin, and one sample of adult aquatic insects collected from stream-side net sweeps. Upon return to the laboratory, benthic samples were stored in cabinets according to project along with formalin-preserved algae and FPOM, and algal filters were stored frozen until chlorophyll analysis. All samples were in the custody of the SNARL research operation at all times (field and lab) from the time of collection to completion of processing, identification and analysis. Benthic samples are tracked using

a log sheet indicating when samples are processed (including time required, splits and total number of organisms recovered), with initials for who conducted the processing and identifications, and who performed quality control checks of processing and identifications. Chain-of-custody forms have not been used to date but will be developed for transferring samples to external laboratories for identification confirmation checks.

Analytical Methods Requirements

Refer to detailed SOPs (appended) for all methods used in field surveys and laboratory analysis. For physical habitat measures, general references used as background for SOPs were *Stream Hydrology: An Introduction for Ecologists* (Gordon et al. 1992; Wiley Publishers), and *Monitoring Guidelines to Evaluate Effects of Forestry Activities on Streams in the Pacific Northwest and Alaska* (MacDonald, 1991; USEPA, Water Division EPA/910/9-91-001). For laboratory methods (e.g. FPOM, AFDM, Chl-a determinations), the general references used were *Limnological Analyses*, 2nd edition (Wetzel and Likens, 1991; Springer-Verlag), and *Methods in Stream Ecology* (Hauer and Lamberti, 1996; Academic Press).

Quality Control Requirements

Field and laboratory quality control measures include extensive training sessions in habitat surveys prior to each field season, rotation and cross-checks between observers in paired teams to ensure uniformity in how measures are taken and recorded, supervisor oversight of all technicians, use of standardized data forms for all records, and availability of written protocol sheets for all procedures. Replicate samples (5 benthic, 3 algae, 3 organic matter) are currently taken at each site surveyed, cross-checks of field data forms are made at the end of each survey, 100% sort checks during lab processing of samples (reduced to 20% when <5% error rate achieved), and 100% re-identification checks with the lab supervisor (Herbst) are routine. Voucher and reference collections for 20% of samples and 100% of specimens are maintained in designated and centralized collections. Errors detected during QC are addressed through initialed corrections of data forms and periodic re-training sessions.

Instrument / Equipment Testing, Inspection, and Maintenance Requirements

        The primary equipment employed in the field and lab that require maintenance are Great Atlantic impeller-type current meters, conductivity meters, GPS units, fluorometer, alkalinity kit, dissolved oxygen kit, and a Helige-Orbeco turbidimeter. As needed, this equipment is inspected for proper function, replacement of parts, batteries, re-filling of solutions, and stored at room temperature and dry conditions. In the field, extra parts and redundant supplies are carried to attend to any malfunctions.

Instrument Calibration and Frequency

        Regular calibration of field and laboratory instruments is conducted prior to the field season, and then at 2-3 week intervals, each before each laboratory use, for:

(1) Oakton pH/Con-10 combined probe meter used in field surveys involves 3-point pH calibration (at 4.0, 7.0, and 10.0), conductivity checks with standards, and temperature checks against ASTM thermometers. Prior to measurement of pH, temperature and conductivity, a 15 minute equilibration of the calibrated Oakton pH/Con-10 combined probe meter is done before recording readings.

(2) Great Atlantic "Ohio-style" current meter, gauged against ratings curves produced by rotation rate of a propeller-based meter.

(3) Helige-Orbeco Turbidimeter calibrated using standard solutions of suspended particles.

(4) GPS units are tested against maps at known locations.

(5) The Fluorometer (Turner model) is calibrated for chlorophyll-a measurements against a standard curve derived from spectrophotometer-determined stock solution dilutions of fresh spinach or lettuce leaf extracts in ethanol.

Inspection and Acceptance Requirements for Supplies

        All shipments received are checked to be certain the packing slip is complete and matches the materials ordered (supplies or equipment). Standard supplies are stored in designated areas. Most ordering is from the following sources: Fisher Scientific, Forestry Suppliers, and BioQuip. D-frame nets are made of 250 micron mesh nitex netting and

are fabricated under specific design (18" length, tapered bag) from Research Nets (Washington), using pole and frame ordered from Wards Scientific.

Data Acquisition Requirements

Data collected from other sources includes use of USGS 7.5 minute maps, aerial photos or orthoquads in some cases, agency management records (US Forest Service, Bureau of Land Management, National Park Service, Soil Conservation Service, California Department of Fish and Game, USGS discharge monitoring data), and sometimes information provide by private land owners who have given access permission.

Data Management

Data records are taken on standardized forms for all field and laboratory procedures. After QC checks, habitat and invertebrate identification data are recorded on spreadsheets (Excel) for analysis. During data entry, sum totals of column entries on field or lab bench sheets are checked against those sums on the spreadsheet columns. When there is no agreement, or when clear data outliers are found on analysis, both the sheets and electronic versions are checked for consistency and corrections made as needed. Back-up records of all field and labsheets are kept as photocopies, stored on 2 computers in different locations, and saved to storage media (zip disks or CD).

Assessment and Response Actions

Field and laboratory personnel are evaluated on a regular review at 3-month intervals. These evaluations include performance in terms of productivity, accuracy, independence, team-work, and capability. Audits of equipment and analysis occur during QC checks, data management steps, and comparisons of data quality objectives with actual log records and data products. Corrective actions for assessment not meeting objectives are described above.

Reports

 Reports are produced as required and specified by contracts for various projects. Each report is first produced as a draft for review by the funding source and any individuals or organizations specified by the source. This review is usually complete after 30 days, after which revisions are made and the final report generated for distribution to the funding source and any others specified. Progress reports are made quarterly to the project manager at the Lahontan Regional Water Quality Control Board. Other reporting times vary by organization providing funding. Reports generally follow the structure of a scientific paper but often include conclusions and recommendations relevant to management applications of the data. Extensive graphs and appended taxonomic lists are often included so that the data source may be inspected.

Data Review, Validation and Verification Requirements

 Responsibility for data review and qualification is done by the program leader (D. Herbst) and program manager (T. Suk). This process involves use of the QAPP for defining acceptance or rejection of the data results and conclusions produced.

Validation and Verification Methods

 Refer to QC sections above, assessment, data management, reporting, reviews, and appended SOPs.

Reconciliation with Data Quality Objectives

 Correspondence of data produced with data quality indicators specified in the QAPP are reviewed during analysis of data sets. Various corrective actions, as specified in the preceding sections, will be used to address any problems detected. If revisions of the QAPP are necessary, this document will be re-drafted and submitted to the appropriate agency QA officers for approval.